Facial-Oral Tract Therapy (F.O.T.T.)

For Eating, Swallowing, Nonverbal Communication and Speech

Ricki Nusser-Müller-Busch
Karin Gampp Lehmann
Editors

Springer

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Facial-Oral Tract Therapy (F.O.T.T.)

established by Kay Coombes and colleagues

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Preface

Facial-Oral Tract Therapy (F.O.T.T.) has been used in Europe for the past 40 years. With improved long-term survival after severe brain injury, pioneers – including speech therapist Kay Coombes and colleagues – were challenged to provide new strategies for treating these patients. Based on the Bobath concept, Coombes developed F.O.T.T. to assess and treat impairments of the face and oral tract. The approach encompasses four main areas: eating, drinking and swallowing; oral hygiene; nonverbal communication; and breathing, phonation and speech.

F.O.T.T. is based on profound knowledge and understanding of the influence of posture and movement on facial-oral functions. This enables members of the rehabilitation team to detect, analyze and interpret changes in motor activity, including pathological behaviour. Depending on their capabilities, patients are guided to relearn and maintain a wide selection of different functions and to be as independent as possible. Therapy is designed to help patients experience posture and movement that is as normal as possible. Treatment makes use of activities of daily living to elicit and facilitate meaningful movements rather than abstract exercises. Therapists and nurses apply current knowledge of neurosciences and involve carers and relatives in the treatment process.

Dysphagia after brain lesions should not be treated in isolation from other impairments of the facial-oral tract! The patients need to learn more than just how to swallow again. They need to relearn to use their tongue to clean their teeth and oral cavity, to eat independently, to clear their throat, to spit out and swallow afterwards!

Many neurological conditions persist throughout life and require specialised long-term treatment. Breathing, airway protection, nutrition and oral hygiene are often critical issues in the care for severely impaired patients. The goal is to promote participation and to improve quality of life.

For years, we have been asked at international congresses and conferences to provide an English version of the established German-language book on F.O.T.T. The book covers a range of interconnected areas, including food intake, oral hygiene, facial expression, breathing and phonation. Special chapters are dedicated to sensorimotor learning, the treatment of children, tracheostomy tube management and the evaluation of the approach. This is a practice-oriented book rather than an exhaustive account. It is aimed at those working in the field of neurology including relatives and carers.

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Note to the Book

Facial-Oral Tract Therapy - F.O.T.T.® was protected by the founder of the approach Kay Coombes. In order not to interfere with the flow of reading, we have chosen the spelling without the trademark ®.

Acknowledgements

January 2019

First and foremost, the editors and authors would like to thank Kay Coombes!

With never-ending enthusiasm, she has taught us to appreciate the physiological miracle of the facial-oral tract and pursue its secrets. Her respect and consideration for patients and their families make her our role model. Everyone who can spend time with Kay Coombes learns that the affected person and their condition must be the focus, 24 hours a day. After the course she will continue to work late into the evening with difficult-to-treat patients. Those responsible for her punctual departure often come close to a nervous breakdown, attempting to keep taxi drivers in good mood, which then bring her hopelessly late to the airport. And if she has missed her flight to Birmingham yet again, good friends will decorate Kay's house with a large banner meanwhile:

» *Kay feeds the world!*

An approach evolves and grows through the diverse input of many individuals. Some of them tread the same path. The paths of others will cross or run parallel for a period of time. We are indebted to all the colleagues whose research, expertise, and critical questioning have contributed to the further development of the approach.

In particular, we would like to thank the adult and young patients from whom and with whom we can learn! Thanks are also due to the affected individuals and their relatives who gave us permission to publish photographs. This is not an easy decision to make, especially in today's digital world!

Many people have contributed either directly or indirectly to this book. We are especially grateful to

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- Dr. Sylvana Freyberg and the team from Springer Medicine Books Continental Europe & UK for their support

Of course, all remaining errors and faults are entirely our own.

Berlin, Germany — **Ricki Nusser-Müller-Busch**
Kehrsatz, Switzerland — **Karin Gampp Lehmann**

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Memberships

Swiss Physiotherapy Association (► www.physioswiss.ch)

Cranioswiss (► www.craniosuisse.ch)

S.I.G. Special Interest Group F.O.T.T.® international (► www.fott.eu/de/)

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'Earth Calling Daniel'

Daniel is a 22 year old patient in the Intermediate Care Unit following traumatic brain injury. Although his reactions are still very slow, he seems to understand and tries to speak but is not yet able to coordinate voice and speech movements. His swallowing frequency is also reduced. Oral nutrition is still out of question. His girlfriend is present during therapy.

To understand the following situation, it should be noted that Daniel calls his girlfriend by the nickname Earth.

Today Daniel is feeling tired. For the first time he stood upright during physiotherapy. Now he is well positioned in a wheelchair with his eyes closed. His girlfriend understandably has different expectations. "Earth calling Daniel... don't go to sleep, I'm here now..."

Treatment adheres to the principles of Facial-Oral Tract Therapy (F.O.T.T.):

Involvement of relatives in the therapy

The therapist, who by age could be Daniel's mother, assumes that the patient's girlfriend might contribute more effectively to ***increase his level of alertness****.*

Setting the scene

The therapist supports Daniel's background posture and guides his arm and hand to touch Earth's face, neck, arms and hands. A deep sigh is heard… ***Further input is required!***

The therapist designs a starting position for the girlfriend to get her involved in the treatment: Earth sits alongside Daniel and very close to him.

Facilitating the sensorimotor loop, taking environmental factors into account: context-related input – processing - output

After a time, she asks Earth to give Daniel a kiss and then – after a slightly ***prolonged processing time –*** *Daniel's* ***motor response*** *comes: weak but distinct activity of the orbicularis oris muscle, and the lips pucker.*

This path has proved successful! The therapist varies treatment according to the principles of motor learning: A combination of various repetitions seems appropriate.

Verbal input *is added to the previous tactile aids: 'Daniel should give Earth a kiss now.' Earth holds her face up – and Daniel kisses his Earth repeatedly!*

Evaluation

After evaluating the therapeutic situation, the therapist consistently decreases the level of support. She leaves the couple alone, because according to her hypothesis, Earth and Daniel will continue the therapy `hands-on´ and put the therapeutic experience into practice in daily life.

Hopefully Earth will be present tomorrow again...

Ricki Nusser-Müller-Busch

The F.O.T.T. Approach: Functional – Complex – Relevant for Daily Life

Ricki Nusser-Müller-Busch

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When brain damage occurs, it may cause various forms of swallowing disorders and speech dysfunctions. The goal of Facial-Oral Tract Therapy (F.O.T.T.), as developed by Kay Coombes and colleagues, is the integration and coordination of facial-oral functions. This enables the safe coordination of breathing, swallowing, voice, speech, facial expression, eating and drinking, and the efficient use of protective clearing measures, when required. In order to eat and drink safely again, many patients must relearn to adapt their postural control during daily activities, for example, transporting food to their mouths, using the tongue to remove residues from the oral cavity by coughing, swallowing or spitting out, etc.

» Know the normal! (Coombes 2002)

From the moment we get up, our bodies are engaged in activity without even thinking about it. We rarely consider how we get out of bed or what we need to move first to do so. We check our emails casually while eating breakfast. We chew, drink, and swallow without paying particular attention to posture and muscle tone. We drive to work and greet our colleagues, and we do all of this at a pace adapted to our individual phonation-breathing pattern. We could not say how many times we have swallowed or cleared our throat since we woke up.

The facial-oral functions are affected by posture and movement, and work together constantly, in coordination:

- We breathe while chewing, our breathing is paused or interrupted during swallowing, and we resume breathing thereafter.
- We usually swallow (or spit out) after coughing. We swallow after yawning or after spitting out water while brushing our teeth, and at convenient moments such as after a longer period of speaking.
- We even are able to speak when forming a bolus, in the oral phase of the swallowing sequence.
- Facial expressions alter constantly and support our verbal communication.

Note

We all, therapists, doctors, nurses, and relatives perform these movements and functions daily. But we rarely use this implicit, physical experience in our work, when examining and treating dysfunctions of the facial-oral tract.

Knowing the normal means:

- To perceive the occurrence and sequential interaction of breathing, swallowing, speaking, throat clearing, etc. during the course of the day, in ourselves and others.
- To use this neglected source of information as a feedforward potential in therapy to influence the sensorimotor performance in our patients!

1.1 Facial-Oral Functions

Conventional physiological descriptions consider the functions of swallowing, facial expression, speaking, or breathing separately as *acts*. F.O.T.T. provides an integrated perspective of *sequences* where the facial-oral functions interact constantly during the day (▪ Fig. 1.1).

Breathing, swallowing, eating, drinking, and speaking are essential facial-oral functions. Breathing and swallowing work and interact with other facial-oral functions and activities in a coordinated and mostly subcortical way around the clock.

1.1.1 Protective Mechanisms

- Breathing-swallowing coordination: Breathing and swallowing interact reciprocally. Due to brainstem circuits (Bolser et al. 2013), breathing is centrally interrupted during swallowing, usually followed by a brief, reflexive exhalation. This exhalation helps to detect risks in the airway caused by foreign particles and can be called the primary protective mechanism. Afterwards, breathing continues, and a

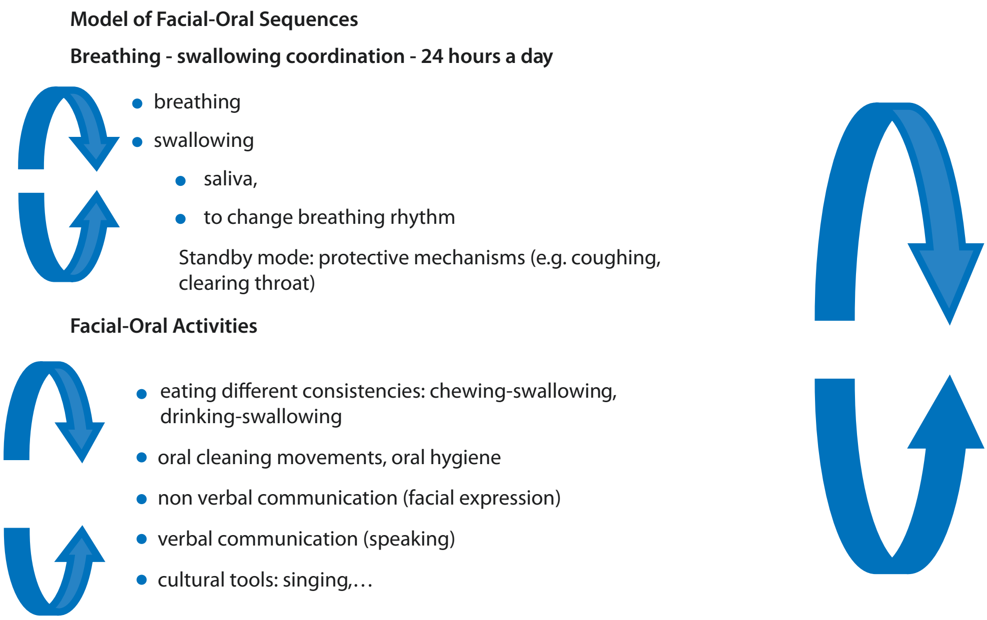

Fig. 1.1 Model of facial-oral sequences. Facial-oral functions alternate in coordination (arrow). They adapt to the context of the respective activity. (© Nusser-Müller-Busch 2019. All Rights Reserved)

change of breathing pattern may follow adapted to a new activity.
Other protective mechanisms may occur if the swallowing process is not successful.

- Subsequent clearing the oral cavity: After swallowing once, the tongue controls and collects residues in the oral cavity, which are swallowed afterwards and breathing continues.
- Clearing the throat: Clearing the throat transports particles upwards from the hypopharynx, necessarily followed by swallowing or spitting out. Then breathing continues.
- Coughing: If penetrated (into the larynx) or aspirated (in the lower airway below the vocal cords) material is sensed in the airway, coughing (after inhalation, forced exhalation, and loud release of air from the lungs due explosive opening of the closed glottis) ejects the residues to the oral cavity again, where they will be swallowed or spat out. After spitting out, usually a swallowing reaction follows and breathing continues.
- Gagging/vomiting: Gagging may be evoked by an object touching the back of the tongue or the back of the throat. The response is a contraction of the soft palate and a bilateral contraction of pharyngeal muscles while breathing is interrupted reflexively. After a moderate gagging, swallowing often occurs. Vomiting moves the stomach content reflexively with a strong expulsion via the pharynx to the oral cavity and/or nose. Afterwards usually a swallowing reaction follows and breathing continues.
- Sneezing: Sneezing removes foreign particles from the nasopharyngeal space by an explosive expulsion of air from the lungs through the nose and mouth. Sneezing also is often followed by a swallow reaction.

Note

Protective mechanisms and also yawning are often followed by a swallowing reaction and subsequent breathing.

Coughing on demand (as it is often used in dysphagia therapy) happens rarely in daily life. It should not be equated with an involuntary, reflexive cough in response to a hazardous irritant in the throat or airway, which is usually followed by a cleansing swallow. The sensorimotor loop is different between voluntary and involuntary coughing.

The assessment of a gag reaction in patients may be unreliable. In a test setting, a relatively large proportion of healthy participants (10% of women and 40% of men) showed no gag reaction (Logemann 1998).

The effectiveness of truly self-protective mechanisms, such as sneezing, coughing, gagging, is difficult to assess, as opposed to an assessment on demand. For example, self-protective gagging occurs only in dire situation and sometimes as a last resort.

Reflex versus Reaction

For decades, the Bobath concept for children (Neuro-Developmental Treatment, NDT, ► https://www.ndta.org/) and F.O.T.T. have referred to the *swallowing reaction* rather than the swallowing reflex, *a cough reaction* rather than a cough reflex, to a *gag reaction* rather than a gag reflex.

The central nervous system (CNS) responds and adapts reactively. Depending on the consistency and quantity, pharyngeal motor responses vary when either swallowing, for example liquid or a piece of bread.

Duysens et al. (1990) concluded that the reflexive/automatic part of the swallowing process changes with adaptation to different consistencies and bolus types. The neurally controlled motor responses become more differentiated in the course of development. Also coughing varies.

The American Speech-Language-Hearing Association (ASHA) also included this terminology in a policy statement, and promotes the term swallowing reaction (Robbins et al. 2008).

Many of the facial-oral functions are genetically determined. While nourishment is received via the umbilical cord, the embryo begins to swallow amniotic fluid from the 12th week of pregnancy. According to Hüther and Weser (2012), these movements are immanent to embryonic development and support the structuring of the body functions via use.

After birth, the newborn has to deal with gravity. Activities (the task-oriented use of functions) will influence the structures, for example the form of the face, teeth and mouth; and the individual prominence of muscles, such as the mentalis or masseter muscles.

» The function determines the form (Castillo Morales 1998)

During lifespan, functional activities become differentiated: from the newborn reflexive sucking of liquid food, to the perfected processing of solid consistencies and coordinated chewing, with its rotational components. This takes place through practice, also via imitation, and through communication with others. These actions are increasingly automated and unconscious. Only in case of an interruption or a problem, for example particularly solid food, choking or spilling liquid, these operations require special attention, which is then given immediately.

1.1.2 Postural Control and Facial-Oral Functions

The entire body is involved in the performance of facial-oral functions and their sequences during all activities (► Sect. 1.3, ► Chap. 4).

► Example

When sitting at the table and preparing to eat (pre-oral phase), we usually orient our eyes, head, and trunk toward the food in front of us. We have already learned to chew food and mix it with saliva; these activities are automated. The following swallowing is not just a "reflex" but also a *reactive response* to the processing of the bolus and its size and consistency. Swallowing of food commonly takes place with the head centered, but in certain situations it can also be performed with the head turned to the side.

If we take a sip from the cup of coffee while in bed, we automatically change our position in order to swallow safely. If we take a too large sip from the glass and choke, we may bend our upper body forward abruptly, supporting ourselves (*support reaction*), and blow the drink out (*protective reaction*). We hopefully will continue to cough up all residues until the airway is clear and a quiet, rhythmic breathing cycle is restored. ◄

To date, the influence of postural control on facial-oral functions and their coordination have barely been addressed in the scientific literature.

Schultheiss et al. (2015) investigated the effect of three different body positions (90°, 45°, 0°) on swallowing parameters in 21 healthy subjects (= 762 swallows) with a combined EMG/bioimpedance measurement system and a piezoelectric sensor. A change of body position influenced the range of motion and the speed of the laryngeal elevation significantly. The swallowing-breathing patterns (pre-oral and post-swallowing) changed from saliva to solid food of inspiration/swallow/inspiration to expiration/swallow/expiration.

Note

Model of Facial-Oral Sequences

The facial-oral functions alternate continuously during the 24 hours a day and over lifespan. They react and adapt to the specific activity and its context. Swallowing (and subsequent breathing) often occurs after coughing, sneezing, yawning, spitting out, and speaking sequences.

Knowing this, enables therapists and nurses to elicit or facilitate the appropriate motoric reactions.

1.2 Movement Behavior and Motor Learning

» The brain is a problem-solving machine (Mulder 2003)

1.2.1 Prerequisites for Motor Learning

The F.O.T.T. approach is based on further assumptions:

- The newborn is equipped with a large stock of automatic motions (Kandel et al. 2012). These rhythmic movements, for example, the sucking/swallowing, breathing, can be attributed to innate neural networks, so-called *central pattern generators* (CPGs).
- Once activated, CPGs constantly generate task-oriented moving patterns and motion sequences. Postnatally, these movements are repeated and varied thousands of times, for example, the tireless drive of small children learning to stand up from all-fours. This results in automated movements which can then be performed subcortically, rapidly, efficiently, and safely. Then, these movements no longer require cortical initiation (Paeth Rohlfs 2010).
- Movements in activities are always goal oriented. The central nervous system (CNS) enables to achieve goals and adapt our bodies to the respective task and environmental conditions. Incoming signals are weighted, and the specific gravity conditions are calculated, which are necessary for the successful accomplishment of the task in the respective position (standing, lying, sitting, etc.). Calculated accordingly, the impulses then direct the activation of the corresponding antagonists (reciprocal innervations; Horst 2011, Kandel 2007). The intramuscular coordination determines the task-specific recruitment of the corresponding muscle fiber types. Depending on the task, the muscles work concentrically (shortening), eccentrically (giving length), or statically (constant).
- Postural control adapts and optimizes our movements. Incoming information is selected and evaluated through comparison with our existing knowledge and experiences (*feedback*). These experiences serve as the base for the performance not only of comparable

and similar, but also of new movements. *Feedforward* mechanisms use this wealth of experience to anticipate and plan activities and their necessary movements (▶ Chap. 3).

- Humans learn through problem-solving, using the body's own (e.g., proprioceptive, visceral, vestibular) and environmental (e.g., auditory, olfactory, visual, postural) information (Mulder and Hochstenbach 2003). The existence of special neurons in primates, known as *mirror neurons*, suggests that these neurons mirror the behavior of the others, thus enabling the encoding of reactions as though the observers were acting themselves (Rizzolatti and Sinigaglia 2008).
- Contrary to previous assumptions, humans can continue to learn into old age.
- *Neuroplasticity* describes the ability of the CNS to undergo lifelong functional changes through activity-dependent potentiation or depression, axonal sprouting, and other triggers. This allows the brain to compensate for damages, a discovery which revolutionized our knowledge about the functioning of the CNS. Kleim and Jones (2008) identify 10 principles which appear to affect neuroplasticity positively, for example, use it or lose it, use it and improve it, repetition matters, intensity matters, and time matters.
- Factors such as *attention, concentration, cognition, memory, motivation, past experiences, knowledge*, and the environmental context influence the individual performance of tasks. The results are stored, and can be accessed and adapted when similar situations arise (Banduras 1986, Kandel 2007, ▶ Chap. 3).
- All this depends on personal factors such as general condition, constitution, occurrence of diseases, and the environmental factors of the individual.

1.2.2 Changes Following Brain Damage

Brain damage can dramatically change motor behavior and motor learning. The disturbed movement patterns in patients with tetra- /hemiparesis, hemiplegia, and ataxia have been described in the original work of Berta and Karel Bobath (1977a, b, 1990). The concept and treatment principles have been further developed by Davies (1994, 2000), Paeth Rohlfs (2010), and Bassoe Gjelsvik (2012). Vaughan-Graham et al. (2009, 2015) and WHO (2012) provided new insight into the clinical practice of the concept and put it in context with the International Classification of Functioning (ICF, WHO 2012).

Secondary Problems

Many patients with impaired postural control lose balance. In order to keep balance, muscles with slowly twitching – (Type I, *tonic fibers*) try to stabilize the body by shortening concentrically.

Note

Stiffness as a secondary or compensatory phenomenon can be caused by postural instability, lack of movement, immobilization, and confinement to bed (bedridden state). Stiffness hinders the face, mouth, throat, larynx, and esophagus from moving adapted to the task.

It does not matter to the brain whether the inputs are physiological or pathological in nature: When the brain no longer receives the usual physiological inputs after damage, movements and behavior change, and ultimately malfunctions occur. This can hinder the patients from acting and moving independently. As a result, patients depend on the help and competence of caregivers to regain lost skills and cope with life.

Note

The brain operates 24 hours a day and learns at all times!

Also, pathological movement patterns can be learned and acquired permanently.

Swallowing is performed by movement – speaking is performed by movement!

Recognizing facial-oral dysfunctions (also) as *movement disorders* is a key to evaluate and treat the movements of swallowing (in dysphagia) and speech (in dysarthria).

1.3 Conceptual Considerations

» Give help for a better life, not exercises. (Berta Bobath)

What to do

- If the impaired sensorimotor system produces pathological movement patterns?
- If posture and movement are primarily altered by paralysis or dysfunctions in tone, but also secondarily, due to stiffness, anxiety, and stress?
- If the body is not able to compensate?

1.3.1 Bobath Concept

» First look at what the patient can do in his daily life; afterwards record their deficits and begin treatment, in order to find out why the movement pattern is dysfunctional. (B. Bobath, quoted by Biewald 1999)

According to the International Bobath Instructors Training Association (IBITA), “the Bobath concept is the most widely used neurorehabilitation approach worldwide, and considers the impact of the neurological condition on the whole person within her/his individual context. The clinical application focuses on movement analysis with respect to selective movement, postural control and the role of sensory information to develop a movement diagnosis guiding treatment and evaluation” (ibita.org 2019).

Orientation toward Potential and Solutions

According to Berta Bobath (1907–1991), the goal of diagnostic assessment is not to establish the dysfunction, but to assess the problems which patients face in their daily life, what they are still able to do, and how their *potentials* be utilized best (▶ Chap. 11). Bobath’s conclusions were based on the systematic observation and knowledge of childhood learning. As a physiotherapist, she did not aim to strengthen certain muscles, but rather improve the coordination of posture and movement, and to obtain an adapted tone in activities of daily living (ADL). Her therapeutic focus emphasized the individual/patient in their surroundings and daily routine. In this way, activities (and their movement patterns) learned earlier may be remembered and potentially accessed. Therapeutic work in the context of daily living also offers greater potential for variation and repetition than any exercise program. Current approaches also propagate that *task-oriented* movement therapy is more effective than abstract exercises (Wulf 2007, Horst 2011, ▶ Chap. 3).

At the time, her approach to the person and her/his environment, which acknowledged the experiences, feelings, expectations, and particularly the attitude for learning, was unusual. This comprehensive approach which takes account of an individual’s context, meets the standards of the International Classification of Functioning, Disability and Health (ICF; WHO 2012). Alongside specific *personal* and *environmental factors, activity* and *participation* in social life should be included in any assessment of the functionality of an affected person, as well as in the subsequent therapy.

1.3.2 Ingredients for Therapy: Input – Activity – Variability – Relevance – Context

» Without activity there is no input, without input there is no adaptation, and without adaptation survival is impossible. Input, activity and adaptation are therefore the basic ingredients of recovery (Mulder and Hochstenbach 2003)

In neurosciences and movement sciences, input, activity, adaptation, and variability in a meaningful context are factors that determine our development and survival. These are the basic principles of motor learning and rehabilitation following peripheral or central damages. Mulder and Hochstenbach (2003) describe three prerequisites for optimal learning (▶ Overview 1.1).

Overview 1.1 Prerequisites for Optimal Learning

- Optimally adapted sensory information
- Variability of tasks
- Task-oriented training related to context

In terms of both quality and quantity, training must be tailored to the patient's needs and capabilities. Patients are trained individually to perform increasingly difficult tasks to help them utilize their full potential. It is necessary to provide a diverse and expanding range of sensory inputs under varying conditions (shaping). To avoid overburdening the patient, learning steps and difficulty levels should be cautiously increased and adapted to the desired goal.

1.3.3 Intensity of Therapy – Rest Periods

Robbins et al. (2008) stated that time-consuming training is not synonymous with effectiveness. Nurses and therapists in rehabilitation clinics sometimes encounter patients who endure an overly full, daily therapy marathon.

The necessity and importance of resting periods for the patient were already recognized by Berta Bobath and are currently the subject of investigation in medical training therapy. Studies from the sports sciences and learning sciences show that breaks help to learn more effectively.

Seidl et al. (2007) found evidence that particularly in the early phase of rehabilitation, learning capacity can be exhausted quickly. A decrease in the rate of swallowing was observed following a 60-minute treatment, which only normalized after a recovery period of 90 minutes (Seidl et al. 2007). Patients receiving additional therapies, for example, physiotherapy and occupational therapy, immediately after the swallowing treatment, may not be able to access more capacity due to exhaustion. The authors assume that rest breaks are necessary to enable the brain to process new information. However, further research is needed to establish the benefits of rest periods in neurorehabilitation.

Note

Rest breaks are essential for physical recovery. Comparing rehabilitation therapy with hard, physical labor, it can be surmised that the CNS requires time to process the stimuli and impressions it has experienced.

Further studies are needed to confirm the hypothesis that rest breaks are necessary for central processing.

1.4 F.O.T.T. Areas

Four main areas are concerned: nutrition (eating, drinking, and swallowing), nonverbal communication, breathing, voice and speech and oral hygiene.

1.4.1 F.O.T.T. Area: Nutrition – Eating, Drinking, and Swallowing

> Along with nutrition and pleasure, eating and drinking provides an opportunity for meeting day to day with our fellow human beings, and cultivating social contacts! (Müller ▶ Chap. 5)

When people meet and communicate, it is often in conjunction with a meal. This provides an opportunity to show appreciation, care, affection, and hospitality. Eating and drinking are an important part of human culture and a form of human communication on many different occasions, for example birthdays, marriages, funeral receptions. These facts also shape the F.O.T.T. view and approach.

Swallowing Sequence according to Coombes

The swallowing sequence (Coombes 1996) consists of four phases:

1. Pre-oral phase
2. Oral phase
   - Bolus formation
   - Bolus transport
3. Pharyngeal phase
4. Esophageal phase

Coombes emphasizes the significance of the *pre-oral phase* in assessment and treatment.

The pre-oral phase is a state of *sensorimotor readiness*, of planning the following activities. It involves anticipatory saliva production and possibly swallowing, in response to seeing and smelling. Postural control allows for an optimal alignment of head, shoulders, and trunk, promoting a stable foundation for manual dexterity, eye-hand coordination, arm movement, and coordinated adapted jaw opening, in any position. These operations “set the scene” (Mayston 2001) for phases such as the oral phase and influence timing and coordination of the pharyngeal phase.

Therapists must pay careful attention to the entire sequence of an activity, including the way it is initiated, for example: What happens in the pre-oral phase, *before* swallowing? What occurs *after* coughing or swallowing? Do patients breath in or breath out after swallowing? Do patients swallow after coughing, yawning, or is there no reaction? Techniques such as the F.O.T.T. tactile oral stimulation (▶ Sects. 1.5.3 and 6.2.4) are used to increase the quality and frequency of tongue movements and improve swallowing competence.

1.4.2 F.O.T.T. Area: Nonverbal Communication

Body language and facial expressions reveal much about humans. Feelings such as affection, fear, acceptance, or rejection are perceived without a spoken word. Anyone who has experienced the phenomenon of “love at first sight” will know. From infancy and childhood onward, learning is culture dependent, for example, how to interpret the nonverbal signs of others, how to respond through facial expressions, or to communicate feelings (▶ Chap. 7).

Many neurological patients have facial disturbances, especially during physically strenuous activities or multitasking:

- The facial expression is often rigid, and therefore appears unwelcoming.
- Facial movements are slow and often lacking in distinction.
- Asymmetry of the facial features, caused by facial paresis, is often intensified during action.
- The mouth may be open, causing a continuous flow of saliva, so-called drooling.
- Tongue protrusion causes saliva to be transported out of the mouth, rather than backwards into the throat.

All these symptoms affect communication negatively, often with social consequences.

Impairments of Facial expression should not be considered or treated in Isolation

Often the facial expression of a patient, for example, with constantly raised eyebrows, is part of an abnormal body pattern, which also includes a retracted jaw, “shortened neck”; weak, flexed trunk; and fixed posterior pelvic tilt. Working on facial movements alone and in a sitting position may perpetuate this body pattern. Sitting demands considerable postural control from the patient, potentially reducing the capacity for selective facial movements.

Changing the position by choosing a more appropriate position for treatment may indicate whether the raised forehead is part of an overall, compensatory pattern.

A more *supportive starting position*, such as side lying, is advantageous for many patients, as the weight of the head and trunk can rest on the supporting surface. The attention and capability of the patient can then be fully directed toward sensing and performing facial movements.

A *(supported) standing position* may be an option for some patients. Standing upright allows for a more physiological position of the neck and head (“long neck”) – and helps the patient to deal with gravity again (▶ Chaps. 4, 7, and 8).

1.4.3 F.O.T.T. Area: Breathing, Voice, and Speech

This F.O.T.T. area encompasses breathing, voice speech, and essential intermittent swallowing. Influencing/optimizing posture and tone enables more efficient breathing and speaking (► Chap. 8).

Central brain damage causes dysphagia and dysarthria (central disorders of respiration, phonation, and speech), either individually or in combination. As a result of pathological movement patterns and impaired postural control, the ability to perform selective movements is limited or distorted. The biomechanics often change in a compensatory manner. When patients with ataxia speak, often their head (usually punctum stabile) is in motion. The lower jaw (usually punctum mobile) is fixed and thus compensates for stabilization (► Chap. 4).

Note
Swallowing also occurs when speaking!

1.4.4 F.O.T.T. Area: Oral Hygiene

> The field of oral hygiene offers a therapeutic approach to problem analysis and the preparation of a treatment plan, in order to develop the most physiological movement patterns possible. (Daniela Jakobsen, personal communication)

The cleaning of the oral cavity and removal of oral residues is important for the safety of the patient, for example, to prevent aspiration pneumonia and to gain experience in the mouth area during the course of the day (► Chap. 6).

Note
Structured and therapeutically performed oral hygiene is optimal to elicit and facilitate the swallowing sequence in an ADL, for example, after spitting out water, by repetition and variation. Inputs are set clearly and in a structured manner.
The aim is also to develop the swallowing–breathing coordination and to deal with the occurrence of protective reactions.

The approach, the methods, and techniques are also appropriate for patients requiring long-term care, suffering from dementia, or receiving palliative care (Penner et al. 2010, German guidelines palliative care for patients with incurable cancer 2015).

1.4.5 F.O.T.T.: Tracheostomy Tube Management (TTM)

For many reasons, patients at risk of aspiration and mechanical ventilated patients are dependent on a cuffed tracheostomy tube (TT). The cuff of the TT may prevent these patients from aspiration-related complications, for example, pneumonia. The airflow bypasses the larynx and enters and exits through the TT opening.

Due to protection of the lower airway, a tube with an inflated cuff initially is a blessing! But the tube can become a curse for a variety of reasons. In therapy, we have to deal with several negative effects of the TT:

- A changed path of the airflow during breathing
- Altered protective mechanisms, for example, coughing
- Sometimes noticeable decrease in swallowing frequency
- Limitations on communication
- Complications such as tracheal stenosis, which may manifest later, even weeks after decannulation

A cuffed TT and/or a feeding tube may impede swallowing mechanically.

Overview 1.2 Prerequisites in Tracheostomy Tube Management

- Knowledge and fundamental skills relating to the effective care and management of the patient with TT, for example, suction techniques, changing of tube, care of the tracheostoma.

- The expertise of therapeutic skills: knowledge of airway changes and impacts on facial-oral functions, when using a tube. Facilitation of facial-oral movements and efficient clearing procedures during therapeutic-structured weaning, using speaking valves.
- Monitoring, observation, and evaluation of parameters, for example, oxygen saturation in the blood.

Knowledge about TTs and decannulation are becoming more widespread. However, simply deflating the cuff of a TT will not automatically lead to improvements in swallowing due to risk of aspiration. Seidl et al. (2002) showed that the combination of redirection of the expiratory airflow through the larynx, for example using a speaking valve and tactile oral stimulation significantly increased the swallowing frequency.

TTM focuses on the assessment and treatment of the altered posture and facial-oral sequences due to a TT. ▶ Chapters 9 and 10 illustrate the impairment of physiological processes and methods for their restoration.

1.5 F.O.T.T.: Approach – Principles – Methods – Techniques

1.5.1 F.O.T.T. Approach and Principles

F.O.T.T. is based on the Bobath concept and incorporates aspects of the Affolter model (Affolter and Bischofberger 1993) as well as current aspects of neurosciences.

Through clinical reasoning, the interprofessional team (e.g. physiotherapists, occupational therapists, speech therapists, nurses, doctors) provide targeted, therapeutically structured support in daily life (▶ Sect. 1.7.2). Relatives are welcomed, guided, and trained if they wish to be involved in the therapeutic way of supporting the patient. Principles are summarized in ▶ Overview 1.3.

Overview 1.3 The F.O.T.T. Approach and Principles

F.O.T.T. is
- Tailored to the individual patient and their environment
- ADL-oriented and concomitant with daily life
- Integrated into a 24-hour approach
- Interprofessional

The entire body is involved in the performance of facial-oral functions and activities.

F.O.T.T. starts as early as possible after brain injury, to enable patients to use their facial-oral functions as efficiently and effectively as possible.

1.5.2 Methods

In F.O.T.T., methods like activation, shaping, repetition, and variation are used in ADL to influence motor learning.

Activation

Different forms of activation are used:
- *Mobilization*: The patient moves or is moved within a postural set or into another postural set, passively or with facilitation/support. Depending on the task, the goal is to achieve adapted postural control, to gain more/different sensorimotor input, and a higher range of motion (ROM).
- *Facilitation*: It is a therapeutic method helping the patient to initiate, continue, and complete functional tasks. Various types of input (tactile/proprioceptive, visual, vestibular, somatosensory, and acoustic information) can be used to stimulate the motor system, for example, functional movements in the facial-oral tract. Facilitation is an active learning process, helping a person to overcome inertia and can be used, when the patient has inadequate motor behavior, lack of postural control, or problems to perform selective movements.

- *Elicitation*: Evoking of a movement, a function, behavior pattern, or an activity by an appropriate task or environment design. Elicitation is using position, support, and/or situation ("setting the scene") to draw out a functional response or reaction from the patient.
- *Guiding*: The therapist physically guides the patient's body and hands in problem-solving related to ADL, for example, dressing or having something to drink. Goals are to provide tactile/proprioceptive information to the patient, about the position of his/her body in the environment and the activity, and to improve the organization of perceptional processes in the brain (Affolter 1991).

Shaping

Shaping: Systematically increasing the level of difficulty of the tasks in order to achieve the optimal performance without overtaxing the patient.

Repetition and Variation

Repetition with variation means replicating an activity in another context. *Random practice* results in more effective motor learning and neural correlates (► Sect. 3.1).

1.5.3 Techniques

Techniques are procedures to facilitate a task by using the visual, proprioceptive, auditory, and vestibular input systems (Horst 2011).

Tactile Stimulation

Tactile, proprioceptive procedures make it possible to work with patients with reduced vigilance and problems in language comprehension.

Hands-on techniques and handling

Hands-on techniques can be implemented to support postural control and improve the biomechanical situation. These techniques aim to restore "the patient's sense of posture and movement," during handling and positioning (Bobath, quoted by Biewald 1999).

► Example

The patient lies on his left side for an hour.

Therapy begins with the alteration of this position (method: mobilization, technique: hands-on transfer). Using clear, tactile-proprioceptive, and vestibular input, the patient is moved onto his right side.

If any oral movements or signs of swallowing occur during the activity, transfer will be interrupted with the idea to elicit swallowing. The mandible will be stabilized by the jaw support grip. The lower jaw (biomechanical: punctum stabile) provides a stable reference for the tongue (punctum mobile) to initiate the tongue retraction movement for swallowing (Sticher and Gampp 2017).

Afterwards the transfer will be continued. Facial-oral work is continued once the patient has been positioned on his right side. ◄

F.O.T.T. stimulation: Tactile oral stimulation

Tactile oral stimulation aims to trigger a swallowing reaction via the subcortical path, for example, when the CNS perceives the saliva in the oral cavity and not because a therapist demands it (via the cognitive path). F.O.T.T. tactile oral stimulation involves structured tactile stimuli within the oral cavity, which vigilance-impaired or comatose patients and patients in palliative conditions are unable to produce themselves with their tongue, through speech movements or eating movements. The therapist's finger temporarily substitutes for the intraoral stimulation. This will often trigger an involuntary motor response, even an occasional swallow, without it being explicitly requested (► Sect. 6.2.4). The intention is to prevent sensory deprivation on one hand, and on the other hand these inputs can trigger motor responses, movements of the jaw, tongue, or even cause swallowing reactions.

Results of studies with transcranial magnetic stimulation show excitation potentials in the brain of healthy subjects during chewing and other facial-oral activities, and during F.O.T.T. tactile oral stimulation (Böggering 2008; Mütz 2009). Further studies are required to evaluate the effectiveness of these procedures.

Visual Stimulation

> Be a visual model Kay Coombes (personal communication)

Mirror neurons seem to decode observed activities of others without the aid of mind or language (Rizzolatti and Sinigaglia 2008). Although the theory of mirror neurons has been questioned (Pascolo et al. 2010), the phenomenon appears to play a role in child development, in how children learn by imitating. Also, the mental image of an action can produce an evoked potential in the CNS of the observer and activate neurons which help in the planning and performance of motor activity (Jeannerod 1997).

Therapists interact nonverbally by their facial expression, gesture and demonstrating, for example, the desired tongue motions, to make it easier for the patient to imitate and adopt the movements. Experience shows that in severely affected patients, imitating movements often leads to more success than following verbal instructions.

Verbal Stimulation

In terms of motor learning, studies suggest that a verbal instruction produces better results, if an *external focus* rather than an *internal focus* is provided. Wulf (2009 and Wulf et al. 2016) demonstrated that focusing attention on the goal to be reached (*what to do*) led to better results than consciously directing attention to the exact performance of a movement sequence (*how to do*) in golf players as well as patients with Parkinson's Syndrome. Different and more brain areas are activated and cross-linked by goal-directed tasks rather than by performing abstract movements.

Verbal instruction using an *external focus* conforms both to the ADL-oriented approach of F.O.T.T. and to current knowledge of motor learning (► Sect. 3.2.3).

Feedback – Timing

Depending on the patient's learning potential, we also must decide which kind of therapeutic feedback to the patient's performance should be provided – general or specific, qualitative or quantitative. This feedback can be verbal, visual (demonstration), or physical support (Muratori et al. 2013).

It is inappropriate to apply too many stimuli simultaneously, for example, verbal instructions plus guiding or facilitating.

Also, timing is important. After the task, patients must have time to evaluate their performance themselves, before therapeutic feedback is applied (Wulf 2007).

1.6 Challenges at Different Stages of Rehabilitation

> Meet the patients on their own terms! (Anonymous)

Emergency care and rehabilitation following a life-threatening incident has improved dramatically in recent years. Nowadays more people survive severe brain injuries. This creates new responsibilities and challenges for the medical and therapeutic professions. Also, the premorbid conditions and functional limitations of patients vary greatly, making it impossible to define a single, therapeutic procedure for all patients.

1.6.1 Intensive and Acute Phase

> Without information subjects are severely hindered in mastering novel tasks. This is an important point, particularly in the first stages of the rehabilitation process when, due to neurological damage, the person often can no longer trust his internal information. Failure to provide information will lead to markedly degraded learning, or to no learning at all. The therapist then becomes the most important source of external information. (Mulder and Hochstenbach 2003)

Thanks to the emergency care network used in many countries, patients are transferred to an intensive care unit (ICU) or stroke unit by ambulance or a rescue helicopter. Intensive care measures, such as long-term ventilation, tracheostomy, and sedation affect vigilance (alertness), protective airway mechanisms, nutrition, and communication capabilities. Nutrition in patients at nihil per os (NPO) must be defined, for example parenteral, enteral, via nasogastric tubes or PEG tube. The lack of physiological facial-oral input can lead to sensory deprivation, loss of movement initiation, and performance and secondary complications, such as biting reactions.

Warning

Swallowing frequency in sedated ICU patients is reduced. If this fact is ignored, it may cause the patient's lungs to fill with saliva within a short period after extubation. Recannulation and mechanical ventilation may then be a matter of life and death. The criteria for protection of the lower airway must be considered (Fig. 9.8).

Early onset therapy

Eating and drinking is often not indicated in the early stage. In the acute phase, the primary concern of the therapist is to avoid sensory deprivation and adverse reactions in the facial-oral tract (Nusser-Müller-Busch 2013). Early onset of F.O.T.T. enables severely affected (even comatose) patients to experience physiological movements adapted to their current state.

The therapist's hands are both sensor and assistant. They sense the motoric capabilities and needs of the patient, to provide stability and a supporting surface, and to facilitate selective movements. Priorities for therapy in the intensive care/acute phase are listed in ▶ Overview 1.4.

Eating and drinking is often not indicated in the early stage. In the acute phase, the primary concern of the therapist is to avoid sensory deprivation and adverse reactions in the facial-oral tract (Nusser-Müller-Busch 2013).

Overview 1.4 Therapy in the Intensive/Acute Phase

Adapted to the patient's level of vigilance, regular changes of position are offered, assisting the patient to sense and move differently.

Tactile/proprioceptive stimuli are applied:

- Placing him in a variety of positions, within a stable environment
- Moving his hands toward each other, in order to apply cream
- Bringing the hands to the face, in order to rest the head on the hands
- Guiding breathing manually
- Assisting and facilitating swallowing of saliva, whenever the first attempts occur
- Performing F.O.T.T. tactile oral stimulation to help patients feel the structures in their mouth and saliva and to elicit motor responses
- Performing oral hygiene procedures to keep the mouth clean and healthy, but also to stimulate facial, oral, or swallowing reactions and prevent oral deprivation or hypersensitivity

1.6.2 Rehabilitation Phase

The length of stay in an ICU is kept as short as possible. Many patients with TT and feeding tubes are transferred to peripheral wards or special departments for rehabilitation/departments for early rehabilitation (in some parts of Europe).

Before TTM can begin, the general condition and vital parameters of the patient, for example, the oxygen saturation must be assessed as sufficient. The cuff of a TT then can be deflated, and a speaking valve can be provided, in the beginning for short periods. Using a speaking valve, in which exhalation passes the physiological way through the larynx, allows residues in the larynx and pharynx to be sensed again. In neurologic patients this may lead to improved swallowing reactions and improved swallowing frequency (Seidl et al. 2002, ▶ Chaps. 9 and 10).

Initially (and occasionally later), severely affected patients may require two team members in co-therapy, for transfer, positioning, and support, or the implementation of efficient therapy (◘ Fig. 6.21a–c).

In various positions, including sitting or supported standing, movements for chewing, transporting, swallowing, phonation, speech can be developed, improved, and shaped again (▶ Chaps. 4, 5, 6, 7, 8, 9, and 10). In a protected situation (◘ Fig. 5.7a–c), a structured transition to assisted oral feeding can start, later assistance in the dining room with others can follow. Temporary diet adaptions or long-term diet modifications are considered (iddsi.org (2020).

1.6.3 Chronic Phase and Palliative Phase

The impairments resulting from brain diseases may last for life. Patients carry a further risk of secondary and long-term complications, which need to be addressed on a long-term base.

In the case of progressive, neurogenic diseases such as amyotrophic lateral sclerosis, multiple sclerosis, or Parkinson's disease, therapeutic support and resources need to be adapted to the respective phase of the disease. Therapy should activate the available potential, relieve symptoms, and maintain skills and movements in the interests of maintaining quality of life (review of safety-related factors, ▶ Sect. 5.4.2). The aim is to enable the patient to communicate, verbally and nonverbally, and/or eat and drink safely. Special aids like cups (▶ Sect. 5.7.3) and a modified diet can be used, also in combination with tube feeding.

Note

If a completely oral diet is not possible, a combination of oral and enteral nutrition (via PEG) is sought.

A daily oral intake of food – even a small dietary modified amount – maintains the movement capability of the structures relevant for swallowing and can help to maintain the health of the mucosa in the digestive tract (therapeutic eating, ▶ Sect. 5.5.2).

The necessity of artificial forms of nutrition and communication must be considered early on.

Agreement with the patient can then be reached, for example, PEG systems can be inserted while the patient's general condition still is adequate, and augmentative and alternative communication aids can be tested and used. While therapy is initially seen from a rehabilitative perspective, in many cases the focus later moves to a more preventive or palliative approach (▶ Sect. 4.3.2, ALS patient example).

Adapted dietary modifications can be integrated into nutrition during the palliative phase, if possible. Handling, positioning, and therapeutic measures (moistening of the oral cavity, breathing support, and oral hygiene) are applied to bring relief, particularly in the final phase (Penner et al. 2010, German guideline palliative care for adult patients with incurable cancer).

1.7 F.O.T.T. – Interprofessional 24-Hour Approach

» Assessment is treatment – treatment is assessment (Kay Coombes)

The aim of therapy is to shift limitations, remove restrictions, and create change. Motor learning can only take place if the newly acquired movements during therapy can be practiced and applied in different contexts throughout the day. The interprofessional team is comprised of all those involved in caring for the welfare of a patient during a hospital or rehabilitation stay, during home care, or in a nursing home.

1.7.1 The 24-Hour Day

Daily therapy sessions will not succeed, if the patient sits slumped in a wheelchair during therapy or spends the rest of the day supine in bed. Apart from the risk of pressure sores and abnormal patterns associated with the supine position (e.g., risk of limb contracture), nobody would wish to spend several hours in the same position.

Following the 24-hour approach, therapeutic support is applied, as and when required, by the present team member or relative over the course of the day.

► Example

- Each transfer, positioning of the patient, or other care measures (such as pulling away the duvet, oral hygiene) provide the patient with opportunities to gain movement experience and to learn.
- Each team member, carer, or relative learns how to support the patient in a structured way (e.g., wiping the mouth, after drooling or coughing, and subsequent swallowing).
- Tongue movements can be facilitated repeatedly during the day, for example, nurses can use the pressure of the spoon during feeding to initiate the tongue moving backwards (► Chap. 5).
- The activities of tooth brushing and dressing also can be used to train swallowing saliva. ◄

1.7.2 Clinical Reasoning Processes

> » The team must see, read and interpret the patient! (Daniela Jakobsen)

Team members working with F.O.T.T. continuously use a cycle of assessment, treatment, and reassessment. They are continually involved in a process of identifying problems, attributing causes, and generating hypotheses, which are then tested and discarded if necessary. It is important to identify both the patient's problems and potentials. Continuous evaluation and interpretation of the patient's (motor) responses are necessary. Each team member can contribute to this process from the point of view of their own professional competencies.

The F.O.T.T. algorithm (► Chap. 12) is a tool for clinical reasoning, which recognizes potentials and problems based on a solution-oriented approach. Decision-making processes provide information on the clinical effect and are used to formulate viable therapeutic hypotheses (Klemme and Siegmann 2014). Algorithms and treatment paths are designed to guide the therapist and the team through these processes.

1.7.3 Therapeutic Expertise of the Interprofessional Team

> » Meet the patients on their own terms. And what are your terms in doing so? (Nusser-Müller-Busch)

The multi-professional skills of all team members are required to identify the specific problems of each patient and to influence them through defined interventions. But the topic, which *handling skills* all team members might require to work effectively, has barely been addressed in the individual professional trainings!

Members of the team may note their limited skills when handling patients with fundamental postural problems and find that certain tasks may prove difficult:

- Recognizing a retracted jaw and tongue position may not help a speech therapist further if she is unable to move the patient out of their unfavorable sitting position!
- Performing neuropsychological tests while supine in bed does not improve a patient's understanding of the situation or their competencies for mastering everyday life!
- If the patient sits in an unsupported, unphysiological (slumped) position during a Fiberoptic Endoscopic Evaluation of Swallowing (FEES, Langmore 2001), it can influence the outcome of the assessment. A slumped position influences the structures responsible for swallowing and therefore adds to the patient's motor deficiencies. ◘ Figure 1.2 shows a patient in supported position during the FEES (◘ Fig. 1.2).

Each team member must be able (or learn) to bring the patients into a suitable starting position or to correct their position, if necessary. The combination of theoretical knowledge about postural control and hands-on work-

Fig. 1.2 Supported sitting position for FEES. The patient is sitting at the table with dorsal and ventral support for his trunk. His arms are supported on a height adjustable table. The therapist provides jaw support and assists the patient's right hand to hold the glass while he can take a sip from the glass. (© Jakobsen 2019. All Rights Reserved)

shops enhance skills and therapeutic competence within the team.

Inhouse workshops for the team are essential. Team members can self-experience normal facial-oral functions they usually perform automated on a daily base. They can self-experience and reflect on what it feels like for the patient to sit in a fixed asymmetric position and to be fed, to speak, or to swallow with the neck hyperextended. They can feel the implementation of a structured oral hygiene with stability provided by a jaw support grip or a structured mouth wiping.

The team will then probably react more attentively to the patients' impairments and use the therapeutic handling to their benefit. Practicing together has also the advantage of getting feedback from the colleagues. Neurological patients are often unable to provide this feedback verbally.

F.O.T.T. courses are generally directed at multi-professional participants; 2 days introductory courses are offered as well as 5 days basic courses (with supervised treatment of patients), or advanced courses, for example, for the treatment of patients with tracheostomy (▶ back 14).

Dealing with the patient competently must be a priority for all professional groups involved in neurological rehabilitation. Learning with and from others provides an opportunity to enhance one's own knowledge and therapeutic skills.

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F.O.T.T. Consensus Recommendations

Ricki Nusser-Müller-Busch

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R. Nusser-Müller-Busch, K. Gampp Lehmann (eds.), *Facial-Oral Tract Therapy (F.O.T.T.)*,
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In a consensus process, recommendations summarising the Facial-Oral Tract Therapy (F.O.T.T.) procedures were compiled and passed by experts and users (2006-2007). F.O.T.T. aims to maximize the benefit for patients in the areas such as nutrition (eating, drinking and swallowing); oral hygiene; non-verbal communication; and breathing, voice and speech as well as their best possible participation (according to International Classification of Functioning, Disability and Health – ICF) in society. These recommendations are intended for doctors, nursing and care staff, therapists and trained family members working with patients of all age groups with brain injuries and/or progressive neurological diseases. The consensus recommendations are intended to provide a basis for therapeutic intervention until higher rated, evidence-based studies become available (Nusser-Müller-Busch 2008).

2.1 Consensus Process

Methodology

Based on a systematic review of the research literature in the Cumulative Index to Nursing & Allied Health Literature (CINAHL), Physiotherapy Evidence Database (PEDro), Embase, and PubMed databases, a catalogue of treatment measures was developed over four consensus conferences during 2006–2007.

The planning, conceptual design and implementation of the consensus process were conducted within the context of a master thesis at the Danube University Krems (Professor Dr. Michael Brainin, DUK). The systematic literature review was updated in 2017.

Participating experts

The 17 participants are trained F.O.T.T. therapists, and are working in the fields of nursing, speech & language therapy, occupational therapy and physiotherapy. They are experts and long-term members of the special interest group S.I.G. F.O.T.T. International. The study participants approved the publication of the document and the list of participants (Shaneyfeldt et al. 1999; Shiffman et al. 2003).

Evidence classification

2007, evidence for F.O.T.T. (Gratz et al. Müller 2004; Frank et al. 2007; Fuchs 2001; Hollweg 2003; Seidl et al. 2007; Welter and Meyer-Königsbüscher 1998) have been classified at level III and IV according to Jäckel et al. (2002), and level IV according to the criteria of European Federation of Neurological Societies (EFNS) evidence classification scheme for therapeutic intervention (since 2014 EAN, ► https://www.eaneurology.org).

Consensus building

The formal procedure was a consensus development conference with a five-stage Likert scale evaluation (Ludwig-Mayerhofer et al. 2004; Nagata et al. 1996; Tastle and Wierman 2006) after the last two conferences. An accompanying questionnaire was used to gather information on group behaviour during all four conferences (Bühner 2004; Kirchhoff et al. 2008; Tzschöckel 2007). *The AGREE instrument* was used for the evaluation (Appraisal of Guidelines for Research & Evaluation, AGREE 2015 ► http://www.agreetrust.org/resource-centre/the-original-agree-instrument/).

All 47 items achieved an approval rating of over 80% in the first rating. The remaining 46 items achieved approval ratings of over 90% in the second rating, indicating an increase in consensus over the course of the procedure.

Conflict of Interest

The author of the study and several of the participants are F.O.T.T. instructors, trainers and shareholders of FOrmaTT GmbH, a company founded by the instructors and based in Germany, which offers advanced training for professionals from the field.

None of the costs incurred by the study and consensus conferences were funded by third parties. The author and members of S.I.G. F.O.T.T. International would like to thank the therapy centers at REHAB Basel (Switzerland), Burgau (Germany) and Hvidovre (Denmark) for their assistance in providing venues and media for the conferences.

Outlook

An agreement was reached to update and broaden the recommendations on a regular basis.

2.2 Catalogue: F.O.T.T. Treatment Measures

F.O.T.T. provides a structured approach to the assessment and treatment of facial-oral tract disorders in patients with neurological damage (Coombes 1996).

F.O.T.T. is an interprofessional approach based on the interdisciplinary 24-hour Bobath concept which integrates the patient's needs and surroundings, for example, relatives. The approach takes a patient perspective in line with the ICF.

Treatment is provided in a variety of settings (e.g., inpatient, outpatient, at home), by a single practitioner or a team, at any stage of care, from the intensive phase to long-term and palliative care.

The measures address relevant structures, functions, activities, and forms of participation. They can also be modified to take account of any changes during treatment. The practitioner uses and varies targeted, structured interventions and tools. Possible measures and targets for a therapy unit are listed in ► Overview 2.1.

Overview 2.1 Treatment Measures Catalogue

Treatment Principles: Preparatory and Follow-up

- Developing of postural control, for example for swallowing, food intake, verbal and nonverbal communication, and oral hygiene (Davies 2004; Shumway-Cook and Woollacott 2007)
- Development of functional postural background in an everyday context (► Chaps. 4 and 8)
- Developing the coordination of movement sequences, for example with the patient's hands while eating independently, speaking and walking simultaneously
- Development of dynamic stability of jaw, hyoid and larynx (► Chap. 4)
- Developing the coordination of functions, for example breathing and swallowing (► Chap. 8)
- Positioning before, during and after treatment

Treating the Face

- Involvement of the patient's hands, for example self-touch, also guided
- Reduction of excessive, non-targeted movements
- Developing/maintaining normal sensitivity in the face (► Chap. 7)
- Facilitate normal, functional facial movements, for example for eating and drinking, oral hygiene, verbal and nonverbal communication

Treating the Mouth

- Tactile oral stimulation (► Sect. 6.2.4)
- Facilitation of oral movements, for example for swallowing, eating and drinking, speaking, oral hygiene
- Therapeutic eating (► Chap. 5).

Oral Hygiene

- Facilitation of facial-oral movements for cleaning the mouth, for example tongue, cheeks for spitting out
- Development of a structured, complete oral hygiene, as independently as possible (► Chap. 6)

Coordination of Breathing, Swallowing and Speech

- Use of positions that facilitate swallowing
- Tactile support for exhalation (► Chap. 8)
- Initiation of voice
- Facilitation and support of effective, coordinated protective mechanisms, for example tactile assistance during coughing with subsequent clearing swallow or spitting out, tactile swallowing aid

Facilitation of Swallowing Saliva

- Tactile oral stimulation, facilitation of oral movements, oral collection and transport movements and their coordination
- Direct swallowing support to help patients sense, collect and transport saliva, for example use of the jaw support grip and/or facilitation at the base of the tongue and mouth (▶ Chap. 5)
- Indirect swallowing support to help patients feel saliva residues, for example through movements of the body, head and tongue; tactile support for exhalation and phonation (▶ Chap. 5)
- Developing safe, automated swallowing of saliva in everyday life

Facilitation of Swallowing Different Food Consistencies

- Therapeutic eating for facilitation of bolus formation and transport, for example apple puree, chewing in gauze (Coombes1996)
- Stimulation and facilitation of normal oral and pharyngeal movements through appropriate food consistencies, for example chewing soft-cooked food, and swallowing with a clearing swallow (▶ Chap. 5)
- Developing safe, automated swallowing of different food consistencies (▶ Chap. 5). Goal: from enteral to oral nutrition
- Interdisciplinary support of the patient during the transition to a normal diet, for example from assisted meals to independent eating and drinking, eating food in public

Breathing – Voice – Speech

- Developing dynamic stability in the trunk (Davies 2004) for physiological breathing and speaking
- Facilitating facial-oral and pharyngo-laryngeal movements for speaking
- Initiation of voice, articulation movements, speech and communication (▶ Chap. 8)
- Transfer of individual achievements into a context with everyday relevance, for example coordination of verbal and non-verbal skills in dialogue, speaking when walking

Treatment and Management of Patients with Tracheostomy Tubes

- Preliminary and accompanying cleansing of the naso-oro-pharyngeal tract, including tactile oral stimulation, suctioning, for example therapeutic suctioning (▶ Chap. 10)
- Directing expiratory airflow through the larynx/pharynx (intermittent closure of the cannula/ tracheostoma; use of a speaking valve, or cap to close the cannula, later: temporary decannulation if possible) whilst ensuring the oxygen supply and monitoring vital parameters (Nusser-Müller-Busch 2007, ▶ Chaps. 9 and 10)

2.3 F.O.T.T. Literature Update 2019

The 2019 review of the literature in the PubMed database produced 11 hits. A variety of terms commonly used in F.O.T.T. literature were utilised as search words: *facio-oral tract therapy* (7), *facial-oral tract therapy* (2), *facial oral tract therapy* (1), and *Face and Oral Tract Therapy* (1).

2.3.1 F.O.T.T. Literature: Peer-Reviewed Papers Referencing F.O.T.T.

- **Keyword: Facial-Oral Tract Therapy or Facial Oral Tract Therapy (PubMed 30 December 2019)**

Jakobsen D, Poulsen I, Riberholt C, Hvass Petersen T, Schultheiss C, Curtis DJ, Seidl RO The effect of intensified nonverbal facilitation of swallowing on dysphagia after severe acquired brain injury: a randomized control pilot study. NeuroRehabilitation 2019 18;45(4):525–536. This pilot study investigated the effect of nonverbal, direct

swallowing support in patients with dysphagia after severe acquired brain injury. Kjaersgaard A, Nielsen LH, Sjölund BH (2015) Factors affecting return to oral intake in inpatient rehabilitation after acquired brain injury. Brain Inj 29(9):1094–104

Mortensen J, Jensen D, Kjaersgaard A (2015) A validation study of the Facial-Oral Tract Therapy Swallowing Assessment of Saliva. Clin Rehabil 2016;30(4):410–415

Kjaersgaard A, Nielsen LH, Sjölund BH (2014) Randomized trial of two swallowing assessment approaches in patients with acquired brain injury: Facial-Oral Tract Therapy versus Fibreoptic Endoscopic Evaluation of Swallowing. Clin Rehabil 28(3):243–253. This prospective randomized controlled trial (RCT) by Kjaersgaard et al. looked at the primary outcome of the number of aspiration pneumonias that developed in 119 patients with acquired brain injury, after beginning oral food intake. The results of the study suggest that a structured clinical F.O.T.T. assessment makes it unnecessary to undertake an initial endoscopic investigation of swallowing as a routine (3/62 clinical examined patients suffered from aspiration pneumonia in comparison to 4/57 examined by FEES). Conclusion: The authors showed that a structured clinical F.O.T.T. assessment has similar results to an endoscopic examination of swallowing prior to oral ingestion. However, further studies are needed to investigate this and other issues.

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Hansen Trine S, Jakobsen Daniela (2010) A decision-algorithm defining the rehabilitation approach: 'Facial-oral tract therapy'. Disabil Rehabil 32(17):1447–1460. The authors found a 12% rate in a setting with clinical examination at admission and interprofessional use from day one for dysphagia and associated disorders of the facial-oral tract.

Hansen TS, Engberg AW, Larsen K (2008) The association of functional oral intake and pneumonia in patients with severe traumatic brain injury. Arch Phys Med Rehabil 89(11):2114–2120

Welter FL, Meyer-Königsbüscher J (1998) Fazioorale Therapie (FOTT) bei Schädel-Hirn-Erkrankungen. Rehabilitation 37: 58–63

Keyword: Facio-Oral Tract Therapy (PubMed 11 April 2019)

Konradi J, Lerch A, Cataldo M, Kerz T (2015) Direct effects of Facio-Oral Tract Therapy® on swallowing frequency of non-tracheotomised patients with acute neurogenic dysphagia. SAGE Open Med 3:2050312115578958

Seidl R, Nusser-Müller-Busch R, Hollweg W, Westhofen M, Ernst A (2007) Pilot study of a neurophysiological dysphagia therapy for neurological patients. Clin Rehabil 21(8):686–697

Keyword: Face and Oral Tract Therapy (PubMed 11 April 2019)

Frank U, Mäder M, Sticher H (2007) Dysphagic Patients with tracheotomies: a multidisciplinary approach to treatment and decannulation management. Dysphagia 22 (1):20–9

Further Literature Referencing F.O.T.T. and the Work of Kay Coombes

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Schultheiss C, Nusser-Müller-Busch R, Seidl RO (2011) The bolus swallow test for clinical diagnosis of dysphagia – a prospective randomised study. Eur Arch Otorhinolaryngol 268(12):1837–1844. The Berlin Swallowing Test (BST) investigated a screening with semi-solid consistencies, on the basis of F.O.T.T.

► http://schlucksprechstunde.de/new/wp-content/uploads/2012/06/Berlin_Swallow_Test_e.pdf. Accessed 18 Apr 2018

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More F.O.T.T. literature (e.g. German, Danish) see ► https://www.formatt.org/literatur.html

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Check for updates

F.O.T.T.: Motor Control and Motor Learning

Karin Gampp Lehmann

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3

Current findings on motor control, motor learning and neuroplasticity are important bases for rehabilitative therapy. They enable the design of an appropriate course of treatment, which is adapted to both the patient's potential and environment. What is learned can thus be integrated, and progress can be made. The results of motor learning research in the field of lower extremity functions and sport have received the most attention, to date.

These and other neuroscientific studies increasingly validate the clinical approach taken by F.O.T.T. This will be explained systematically in the following chapter, which does not claim to be exhaustive. Many research findings are based on studies with healthy subjects, and the same conclusions cannot necessarily be extrapolated for neurorehabilitation. As the principles of motor learning cannot be applied to all aspects of facial-oral functions, many questions remain open.

Previous explanations for the functioning of the CNS (i.e. from reflexive to voluntarily controlled motor activity) followed a hierarchical, deterministic model. In contrast, modern concepts emphasise a systemic environmental model. For every action, activity or movement an interaction occurs between individual, task and environment (see International Classification of Functioning, Disability and Health, ICF, ► http://www.who.int/classifications/icf/en/ ► Chap. 6).

The current concept of motor control and motor learning is based on a *task* or *goal-oriented model*. Activities or movements are planned/learned with the objective of achieving the desired goal in its entirety, rather than individual segments of movement or muscle activity. An activity performed with normal movement results from the interaction of diverse physical systems, with each system making its own contribution to control. Various networks in the brain are active during this process, implying that the nervous system evaluates the end product of motor behaviour and the attainment of the objective, rather than the individual movement (Horak 1991; Shumway-Cook and Woollacott 2007).

> » For neurorehabilitation this means that, even with a very systematic approach, solely training muscles and movements, we activate the wrong areas of the brain! Since each specific action produces a specific and unique pattern of brain activity, rehabilitation must be as task-oriented as possible. This is the only way to trigger the desired plastic alterations in the brain (van Cranenburgh 2007).

Different brain areas are involved in a goal-oriented movement, in differing ways. Which specific brain areas are activated is dependent on a number of factors:

- Does a movement/activity have to be newly learned (learning skills), or is it a case of improving known movement patterns (motor adaptation)?
- Is the movement self-initiated (internal motor control = writing, swimming, eating) or a response to events within the environment (external motor control = ball games, moving around in a crowd)?
- Which sensorimotor channels are available for movement control (visual, acoustic, proprioceptive, vestibular and gustatory)?
- How complex is the movement/activity to be learned (tightrope walking, eating shellfish and speaking at the same time or an isolated movement of the tip of the tongue)?
- Is the patient able to plan (rehearse) the movement mentally? How alert is the patient and to what extent is he able to concentrate, before and during the movement?
- What are the associated motor functions?

Practical Tip

The patient's initial perception of the situation during the pre-oral phase plays a major role in preparing for a safe meal: before food has reached the patient's mouth, stimulation of the olfactory, gustatory and visual senses (Coombes 1996) activates the cerebral areas which subsequently play a key role in the control of movement. Imagining the food intake in advance (pre-oral phase) can help making the process of eating safer for the patient; e.g. Will soup need to be eaten using a spoon? Does bread need to be chewed? Is he about to eat a spoonful of mashed potato?

Merely thinking about an action stimulates the same brain areas as the action itself (Doidge 2014; Naito et al. 2002; Yue and Cole 1992).

The *pre-oral phase* has great therapeutic significance for F.O.T.T.

3.1 Prerequisites of Motor Control and Motor Learning

Motor Learning

Note

Motor learning encompasses all learning processes related to acquiring, maintaining and modifying the movements that form part of activities and their coordination.

Neurorehabilitation includes the relearning of activities which can no longer be performed adequately or have been lost, as a result of damage. It also includes motor adaptation, the ability to adapt to movements/skills in response to changing conditions.

It is important to determine whether an intervention results in improved movement following each treatment (*changes in performance*) or whether the improved movement process can be maintained over subsequent days and under modified conditions (*changes in learning*).

Learning is a search for solving problems! In order to effect changes in learning and influence neuroplasticity, the sequence of tasks must be repeated with sufficient frequency and regularity and approach the maximum level of difficulty achievable for the patient. The sequence of tasks should also be randomised, requiring a new solution each time. Initially, patients make more mistakes during randomised exercise sequences, but tests show that the transfer of the learning effect to other contexts is higher (= contextual interference effect) Stein and Bös (2014). According to Wulf (2007) and Gentile (1995), this effect is critical for the influence on central control and therefore on neuroplasticity.

The interprofessional 24-hour approach to patient care has been postulated by F.O.T.T. for a number of years. The collaborative approach of all team members to pursue common, prearranged learning objectives can be compared to a randomised exercise sequence, transferred to daily life!

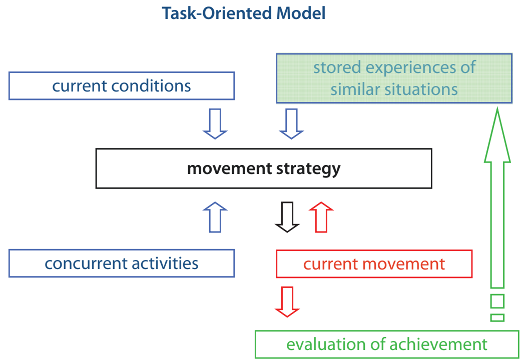


Fig. 3.1 Diagram of motor control. The diagram shows how movement is planned and saved after execution and the components which contribute to movement planning and ongoing motion control. (© Gampp Lehmann 2019. All Rights Reserved)

Motor Control

Note

Motor control is the ability to plan and execute movements and control the results.

A simple diagram (Fig. 3.1) can be used to help clarify the complex neural processes involved in movement and learning.

3.1.1 Schematic Representation of Motor Control

The nervous system creates a *movement strategy*. Previous experiences in analogous situations, similar movements and current conditions are used to plan and execute an activity. During its execution, the movement is adapted to the environmental conditions and concurrent activities and readjusted. Finally, the success of the activity is evaluated (task accomplished/goal achieved?) and the experience stored, making it available for subsequent, similar movement strategies.

The nervous system is organised in a way that the end point of motor behaviour is evaluated, e.g. the achievement of the objective, rather than the individual movements which lead to the goal (Horak 1991; Shumway-Cook and Woollacott 2007; Wulf 2007).

3.1.2 Feedback and Feedforward Mechanisms

▪ Feedback

Note

Feedback is the central monitoring of results after completion of the task, i.e. the activity. It is assessed following execution and the experience is stored.

Feedback refers to the totality of sensory information generated by an individual movement (van Cranenburgh 2007). In the case of movements that have already been acquired, the outcome monitoring will only be taken into account and readjustments will only be made during the next repetition of the movement. The outcome of the current movement is not affected.

When learning new movements or slow, very precise movements (aiming at a target, balancing, eating fish with bones), the feedback mechanism is also used whilst the movement is ongoing. Feedback can be provided by one's own sensorimotor system (also if compensating visually or acoustically) or by the environment (Schewe 1988; Shumway-Cook and Woollacott 2007; Umphred 2000).

▪ Feedforward

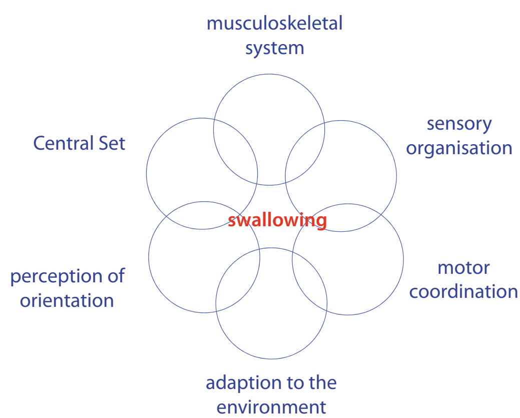
Note

Feedforward is the continuous planning and control of processes, before and during the execution of any movement/action. The system is prepared to act on the movement in progress and to change or adapt it.

As part of the movement strategy, the feedforward mechanism allows the body to take whatever measures are necessary to ensure safe and coordinated movement, before the actual movement begins. The back extensors are activated, and tone levels in the trunk adjusted accordingly, before lifting a tray of glasses, for example. Feedforward control is an anticipatory readjustment, which occurs before a potential error in the current movement can be reported (Edwards 1996, Schewe 2000, Umphred 2000). Feedforward mechanisms make rapid movement possible; visual information and identifying the goal of the action are thereby particularly important.

3.1.3 Influencing Motor Control

Every activity strategy is affected by a number of components (▫ Fig. 3.2). Horak's model of the motor function of gait (Horak1991) will be used here for clarification. The same model is helpful for the observation and diagnosis, the identification of potential and weaknesses in motor learning and motor control of the patients. It can also be referred to during evaluations according to the ICF framework.



▫ **Fig. 3.2** Influencing the motor control of swallowing. The graph illustrates how movement planning and the motor control of swallowing are continuously affected by numerous factors. (© Gampp Lehmann 2019. All Rights Reserved)

Example: Components of the Swallowing Sequence

Musculoskeletal system

Structural preconditions, tone, mobility of the muscles, ligaments, fascia and joints:

- Does the patient have head and trunk control?
- Is the patient able to keep upright, with full thoracic mobility?
- Can the jaw and tongue be moved without restrictions?
- Do the hyoid bone and the larynx move coordinated?
- Is the patient adequately nourished?

Sensory organisation

Flavour, temperature, consistency and viscosity of the bolus and pre-oral and oral awareness/sensibility:

- Is the patient aware of what is in his mouth?
- Does the patient cough efficiently?

Motor coordination

Coordination of the facial-oral and pharyngo-esophageal tract functions and the interplay with posture and breathing:

- Does the patient adopt a posture suited to eating?
- Is there sufficient muscle strength and muscle volume available?
- Is the tongue able to collect and transport the bolus correctly?
- Do breathing and swallowing alternate in coordination?
- Does motor coordination allow safe functioning in everyday life?

Adapting to the environment

What are the circumstances in which the movement patterns take place? What happens simultaneously in the immediate vicinity?

- Do the surroundings motivate/stimulate the patient to carry out the appropriate motor activity, or is he distracted, challenged or handicapped by the environment?
- Is the patient alone in a treatment room, or is he in a dining room where conversations are also taking place?
- Does the patient enjoy the food and the company, or the completion of a planned task (e.g. preparing or eating a meal)?
- Would he organise the circumstances in the same way himself?

Perception of orientation

Local, spatial and temporal orientation:

- Does the patient recognise the time of day, the environment and the actual situation?

Central Set

Note

The *central set* is a neurally stored image of body dynamics and the dynamics of the environment (Horak 1991).

The term *central set* describes the ability of the CNS to prepare the motor system for impending sensory information and the sensory system for upcoming movements (Horak 1991). It enables the feedforward mechanism and links motor experiences with their associated sensory experiences. These are then combined and stored as a central unit, allowing future activities to be planned and executed more smoothly and safely.

► Example

We bite into an apple in a very specific way, because we know from experience that this apple will probably feel hard, sour and juicy. If the juiciness of the apple is then confirmed, the CNS, mouth and oral tract are already prepared and we are able to catch the juice immediately. ◄

The central set is a motion storage device and develops the movement strategy. It is responsible for the following:

- Specifying which muscles participate in the movement
- Determining the order of contraction
- The chronological sequence of muscle activity
- The relative force of the contraction (Keshner 1991)

This requires a certain amount of stored and retrievable experience and a functioning sensorimotor system, in particular.

3

3.2 Therapeutic Consequences to Optimize Motor Learning

» Setting the scene! (Mayston 2002)

Practical Tip

Planning treatment must include the specific components which will be difficult for the patient and how to balance the deficits by adapting the tasks and surroundings.

A therapeutic setting should be created in which the desired behaviour evolves, almost inevitably. Feedforward activity on the part of the therapist is also needed!

▣ Figure 3.2 outlines factors for influencing motor function, which may be used when considering and developing hypotheses during the therapy planning process.

3.2.1 Musculoskeletal System

» In the task-oriented approach, the musculoskeletal system is considered a critical element of control in motor coordination. As a result, major effort must be placed, if possible, on identifying and correcting constraints placed on movements by deficits in the musculoskeletal system. (Horak 1991)

Musculoskeletal limitations can be influenced by the following external factors:

- An alternative starting position of the patient
- Supporting postural weaknesses by means of positioning and stabilisation aids or adapted chairs
- Additional head or jaw stabilisation
- Modified nutrition (different bolus consistencies)
- Special aids (adapted spoon or cup)

It is equally important to define which limitations can be changed by appropriate therapeutic interventions (e.g. improving reciprocal innervation, elongation of anatomical structures or increasing strength).

Warning

Muscles require sufficient nourishment in order to function optimally! Adequate nutrition (including vitamins, minerals, etc.) cannot be assumed for patients who are inadequately or completely unable to feed themselves! The muscles involved in swallowing and breathing atrophy rapidly in cases of inadequate nutrition/vitamin deficiency (Veldee and Peth 1992).

3.2.2 Sensory Organisation

» Movement components which are organised unconsciously should be facilitated proprioceptively, whilst movement components which are executed consciously should be facilitated using visual stimulation, or mental visualisation of the movement. (Horst 2005)

Sensorimotor System

Sensory information is primarily obtained via mechanoreceptors (pressure, touch) and proprioceptors (changes of position, movement) as well as via the neural pathways of taste and smell, vision, hearing and equilibrium.

The sensorimotor system is also referred to as the *sensorimotor control loop*. It is essential to the planning and learning of movement and enables environmental adaptation and responses to changes in the preconditions for movement. The sensorimotor system also recognises and corrects errors, whilst movements are being executed. Not only does one learn whether the movement was successful but also how it feels (Montgomery 1991).

Every movement has a corresponding *sensory structure* (van Cranenburgh 2007). The sensorimotor system does not generate motor activity itself, however (Keshner 1991; Robbins et al. 2008).

Note
An action or movement represents the sum total of all ascending and descending inputs/information processed (Keshner 1991; Shumway-Cook and Woollacott 2007).

Sensory deprivation (or limitations in the absorption or processing of sensory inputs) occurs very rapidly in patients with acquired brain damage, as well as in patients with progressive neurological disorders (van Cranenburgh 2007; Lipp and Schlaegel 1996).

The following assumptions are used as guidance in the F.O.T.T. approach:

- The more inputs/information available for movement/activity planning and readjustment, the more adequately and accurately movements are executed.
- Additional proprioceptive, visual or tactile information, as well as the use of the imagination, can often compensate for a lack of sensory information (Horst 2005).
- To improve motor control, the flow of information in the affected control loop must be increased (van Cranenburgh 2007).
- When learning new motor skills visual control is used primarily.
- Once a skill has been automated, proprioceptive control is used.
- Adults with neurological impairments appear to be more dependent on visual control at the beginning of rehabilitation. It can be assumed that they require extra visual assistance (where is the body positioned in space?) with their postural control.
- Relying upon sensorimotor control is only possible after motor skills and postural control have been regained (Shumway-Cook and Woollacott 2007).

A combination of the functional development of the swallowing sequence and concurrent peripheral input (e.g. taste, smell, bolus consistency) appears to have a positive effect on neuroplasticity. (Robbins et al. 2008).

The control of a movement (including the facial-oral functions and swallowing) is dependent on many different levels of the nervous system. Much remains unclear regarding the specific role and importance of individual possible sensory inputs and the possible stimulation to improved motor control (Hamdy 2003; Hamdy et al. 1998; Power et al. 2004). The effect of food temperature on the swallowing reaction is still unclear. A combination of therapeutic intervention with adequate basal stimuli (i.e. smell or flavour) appears to have a positive influence on motor control; spontaneous, reactive swallowing may be triggered. According to Logemann (1993), different bolus sizes and levels of bolus viscosity affect the motor control of swallowing.

Cortical representation

Every human action activates the brain. Using the hand as an example, Merzenich et al. (1983) demonstrated that missing peripheral inputs reduce the corresponding, cortical somatosensory representation. The goal is therefore to activate the affected motor function using sensory stimuli and the greatest variety of inputs possible. The F.O.T.T. approach has always encompassed the following principles of neuroplasticity, as described by Robbins et al. (2008) in relation to dysphagia.

Principles of Neuroplasticity

Use It or Lose It

Note
Cortical representations change according to incoming inputs.

A skill must be used once it is learned ("use it"), because it may otherwise be lost ("lose it"). This principle of motor activity is not entirely applicable to swallowing, as reflex actions also play a part. Observed in practice, the ability to swallow does not appear to be lost. The following factors can decrease the frequency of swallowing dramatically, however:

- Weakness
- Brain pressure
- Limited vigilance
- Sensory deprivation

Swallowing frequency decreases in the absence of everyday-related sensory inputs in the oral cavity. These include the following:
- Tongue movements
- Tooth brushing
- Speaking
- Eating

This can cause a number of symptoms, including changes in the mucous membrane flora and a white coating on the tongue.

► Example

F.O.T.T. tactile oral stimulation (► Sect. 6.2.4) can be used as a substitute for missing or limited stimuli in the oral cavity, to facilitate motor responses and the swallowing of saliva. During/after intensive care, tactile-oral stimulation routine is the method of choice for normalising facial-oral movements and functions. ◄

Since the brain does not distinguish between physiological and pathological inputs, it is all the more important that patients receive continuous physiological inputs regarding posture and movement. Thus centrally stored patterns of movement and posture can be retained or relearned. The 24-hour therapeutic F.O.T.T. approach must therefore be consistent.

Whilst questioning the effectiveness of compensatory therapeutic actions in terms of the cortical representation, Robbins et al. (2008) critically discuss the use of non-physiological inputs with regard to swallowing and neuroplasticity.

Use It and Improve It

In reference to swallowing as perceived by F.O.T.T. "use it and improve it" refers to the necessity of executing the entire process of swallowing regularly and repetitively, in order to improve accuracy, efficiency and safety. Once they have been practiced, specific tongue activities are then transferred into the swallowing sequence in order to maintain and improve the cortical representation.

► Example

Once the swallowing of saliva is safe and automated, the differentiated chewing, transport and swallowing movements can be developed in a wide variety of sequences. Increasingly challenging consistencies can then be provided during therapeutic meals. The swallowing sequence can be repeated in a variety of ways, and the difficulty of the tasks increased (shaping of motor behaviour). ◄

3.2.3 Motor Coordination: Developing Physiological Sequences

» One learns swallowing by swallowing! (Kay Coombes 1980, personal communication)

Exercises vs. everyday tasks

In order to prepare the patient to cope with everyday life, F.O.T.T. imparts movement experiences and practices physiological movements. They can be experienced and used in the context of daily living. This is consistent with the therapeutic goals and current research referred to previously:
- Everyday activities are task and function oriented.
- The cortical networks used in everyday life are activated.
- Attention is directed towards an external focus, rather than the execution of the movement.

New studies support this approach in the field of sports and also with patients suffering from Parkinson's disease (Wulf 2007). If the patient's attention is focused on achieving the goal, or the effect of the movement (*external focus*), he will usually move and learn more efficiently than if his attention is directed towards the movement itself (*internal focus*).

► Example

"You still have some yoghurt on your lips, lick it off!" (external focus), rather than "Try to move your tongue forward" (internal focus). ◄

Wulf (2007) states that an external focus increases reliance on automatic, centrally guided control processes, making coordination more automatic.

Strengthening vs. coordination

Conventional, strengthening exercises for the tongue are used in many places and can have a positive effect on:
- The volume of the tongue
- Tongue pressure
- Oral transit time
- The pharyngeal phase

This improves preconditions for the swallowing process (Lazarus et al. 2003; Robbins et al. 2005, 2007). However, current perspectives question the value of isolated, monotonic motor exercise sequences, aimed at strengthening individual muscles:
- Is a strong tongue useful if other, contributing structures are not strengthened?
- Is it really necessary to strengthen the tongue, or is it necessary to re-establish coordinated interaction between the tongue and other structures in the swallowing tract, such as the jaw, palate, pharynx and breathing?

In any event, the purpose of a task must be precisely defined, and the possible causes of an apparent weakness identified. It is senseless to strengthen an action such as sticking out the tongue, if an altered position of the hyoid bone, or an unfavourable position of the head and lower jaw, causes the tongue to be held too far retracted (► Chap. 4).

Warning

It is important to observe whether the treatment of isolated parts of the swallowing process, or the use of specifically developed swallowing techniques, adversely affect other components of the swallowing process or make them impossible (Huckabee and Doeltgen 2009).

Individual exercises or so-called random and blocked practice of movement sequences (e.g. to increase skills of the tongue) can improve individual functions and potentially the neural mechanisms of these functions. They have not yet been shown to have a direct effect on the central planning of swallowing or the corresponding neuroplasticity (Robbins et al. 2008).

Attention must be given to improving specific aspects of the movement patterns in the swallowing sequence. However, the movement pattern should be integrated into the motion sequence of swallowing, so that the therapeutic goal of swallowing as a whole is repeated, and coordination of breathing and swallowing takes place and is trained by repetition. If the movement pattern is integrated into meaningful activity, attention can be directed towards an external focus and the entire sequence developed in a coordinated manner, using a variety of versions. This can be equated to a randomised exercise sequence, transferred into practice.

It is also possible to create respiratory sequences which are close to everyday life. This might include blowing at an object whilst simultaneously moving or speaking and performing other physical movements at the same time (Sticher and Gampp Lehmann 2017a, ► Chap. 8).

Note

In addition to functioning muscles a movement action requires normal speed and coordination.

It appears that the central planning of swallowing can primarily be influenced by training swallowing sequence itself (Logemann 1993).

Note

In F.O.T.T. we assume that swallowing is safe and complete, if a finely tuned coordination exists between the facial-oral functions (and therefore their neural control) and the functions of breathing, phonation, articulation and digestion (► Sect. 1.1).

Development of physiological processes vs. compensatory patterns

The body's own compensatory patterns

Every movement strategy is designed to achieve the goal/task as effectively as possible and with the best possible efficiency and safety. An unlimited number of different movement variations can usually be created for this purpose.

If the body no longer has the full range of motor or sensory capabilities at its disposal, it will often use compensatory movements or postures in an attempt to be effective, efficient and safe.

Warning

Compensations are usually achieved at the expense of dynamics and diversity of movement. The patient never has access to the full range of his or her motion variants, which results in stereotypical movement patterns (see hemiplegic gait patterns).

The most vital and difficult task for therapists is to establish whether the patient's current postural and movement strategy can be efficient and effective if maintained over a longer period of time. Alternatively, it may be a compensatory strategy that is limiting in the long term and impedes the acquisition of a complete movement pattern.

> However, the compensatory strategies developed by patients are not always optimal. Thus, a goal in intervention may be to improve the efficiency of compensatory strategies used to perform in functional tasks. (Shumway-Cook and Woollacott 2007)

Pathologic movement pattern, e.g. hypertonia, and hyperreflexia tell us nothing about functional motor capabilities (Craik 1991) or whether the use of compensations is inevitable. A patient may still be able to eat and drink safely, even with these conditions. The genuinely impairing long-term limitations to the motor system are the *secondary*, *structural*, *permanent alterations* (shortening, joint restrictions, postural changes, etc.) caused by the primary disease. These must be prevented as much as possible (Horak 1991, Gampp Lehmann et al. 2020, ► Sect. 4.3.2).

Note

The aim of F.O.T.T. is to avoid reinforcing existing pathologies and to uncover and pave the way for physiological processes. What the healthy body strives for must also be strived for in treatment!

Compensatory techniques

Compensatory swallowing techniques are often used to provide additional protection for the respiratory tract. They do not replace the physiological swallowing sequence, however. They change the conditions for swallowing, but do not directly affect the course of swallowing or the structures involved. According to Robbins et al. (2008), they are not known to have a direct influence on central neuroplasticity with regard to swallowing. Compensatory techniques are a useful therapeutic resource but can never replace the physiological pattern, if this is ever to be learned!

Patients often try to compensate for their postural deficits. Depending on the form and severity of dysphagia some tumour patients realise that they are better able to swallow with the head turned to one side, rather than the other. Compensatory techniques should be used with extreme caution when working with neurological diseases however. The author's experiences show compensatory techniques to have a negative effect on posture and breathing, making the re-learning of the physiological pattern more difficult. Compensatory techniques also require compliance/adherence, which can only be supplied by patients who do not suffer from cognitive impairments.

Note

F.O.T.T. views the rehabilitation process as a journey "back to physiology". The primary concerns are protection of the airways, phonation and the earliest possible facilitation of both swallowing and breathing-swallowing coordination. The approach described in this book is directed at achieving these goals.

3.2.4 Adapting to the Environment

At each stage of treatment, the environment and task are framed in a way that helps the patients to understand the situation and to actively participate. The situation that has been created should enable them to learn and ultimately improve the patients' participation in their own surroundings! (Sticher and Gampp Lehmann 2017a).

In the acute condition and early stages of rehabilitation, when alertness, attention and cognition (prerequisites for motivated collaboration) are severely limited, this is best achieved by creating a very calm or structured environment. Practices from the patient's former daily life should be integrated wherever possible, and the starting position adapted to the patient's tone levels and posture. Familiar activities (preferably involving the patient's guided hands) can be carried out, such as washing the face and brushing the teeth (without toothpaste in patients with high risk of aspiration). Over time, conditions can gradually be configured to include more challenging positions and greater complexity, integrated into the surrounding environment (Sticher and Gampp Lehmann 2017a).

Note

Accompanying patients during activities of daily life would be the therapeutic ideal. Tasks would arise and need to be completed within the limitations of everyday situations, during phases of optimal awareness, motivation and in familiar surroundings. *Context-based learning* of this type offers the optimal conditions for motor learning!

■ Learning from mistakes

In some cases, it may help the patient to seek out and apply a variety of problem-solving strategies, making mistakes during the process. Therapeutic intervention is only applied if the patient is at risk. The patient should fully understand the purpose of the task and the essential criteria which define "correct" and "incorrect". This method may be appropriate for patients with good cognitive function. The method poses a great danger for patients suffering from memory loss or a limited understanding of their condition however, as mistakes can become routine and interfere with effective learning.

3.2.5 Perception of Orientation and Influencing the Central Set

In F.O.T.T. both the therapeutic setting and the task are designed to have relevance to daily life to facilitate the patient's perception of orientation, hence to influence the central set. This means that eating-related actions are practiced at the dining table and oral hygiene at the washbasin, at the appropriate time of day. The task may for example include the tongue to remove residues in the oral cavity, the cleaning of the throat by hawking, spitting out and swallowing.

► Example

Therapeutic assistance with orientation and multimodal stimulation provide optimal support for motor control and motor learning. This equates to a stable (supported) seated position at a table, a plate of appetising food, the visual and olfactory perception of the food, tasting flavours and maybe talking about them/discussing them. ◄

3.3 Additional Factors to Support Learning

Additional factors are important for the central planning and learning of a movement strategy. For example, a movement/activity becomes more controlled and efficient if the patient:

- Understands the situation and objective in advance
- Can visualise the planned activity
- Is motivated (van Cranenburgh 2007; Shumway-Cook and Woollacott 2007)

The significance of motivation must be considered.

3.3.1 Motivation

» Learning depends heavily on factors such as motivation (readiness to learn), attention, and curiosity. [...] Focused attention is the essential prerequisite for conscious learning. [...] As we all know, we learn best

> when the goal is important to us, and has an emotional appeal. [...] The relevance and importance of the information to the individual is vital. [...] If the new information is too unfamiliar, and there is no prior knowledge to which it can be linked, it is perceived as irrelevant, and ignored or rejected […]. (Herschkowitz 2008)

Motivation is an extremely important factor for central control:
- Does the patient want to perform a motor action?
- Can she see any reason to do so?
- Are the surroundings stimulating, yet familiar enough to provide her with motivation for the activity?

The patient must comprehend the situation (cognition). Both therapists and surroundings must provide her with attainable and practical goals, corresponding to her potential: motivation plays an essential role in achieving this. It is more interesting, e.g., to smell a beautiful flower or food, than it is to perform breathing exercises ("deep inhaling and exhaling"). There is no reason to learn to eat independently, if you are going to be fed anyway. It is more motivating to greet a friend, than it is to phonate the sound "ho".

Note
Motivation improves performance and motor control! Learning is stored more effectively when it is associated with positive emotions. Memory and emotions are combined within the limbic system (Kandel 2007).

In terms of treatment, this means:
- Ideally, the patient should determine the goals himself. A suitably structured environment/situation is supplied, in order to motivate him.
- The task must be adapted to the patient's capabilities, yet sufficiently challenging.
- The patient can learn to experiment with ways of achieving the goal.

Fulfilling the objective, and executing a meaningful movement, gives the patient the intrinsic reinforcement which is inherent in the completion of a useful task. For example,
- Lifting a cup of coffee to the mouth independently and enjoying a sip
- Speaking clearly enough for the therapist to understand what is wanted
- To be understood when answering the telephone
- Bringing the toothbrush to the mouth, in order to clean the teeth
- Intrinsic reinforcement is the most important motivating factor in neurorehabilitation. (van Cranenburgh 2007)

3.4 The F.O.T.T. Approach

F.O.T.T. is a problem-oriented approach. The initial assessment provides information about existing dysfunctions and the problems they cause in daily life, as well as the patient's strengths and potential, which can be utilised and built upon during the treatment process.

3.4.1 Example: Patients with Swallowing Disorders

- The patient's current condition determines the therapeutic situation.
- The therapeutic environment and starting position selected must be adapted to the patient's ability and daily life. For this, an appropriate body position and posture must be devised.
- Proprioceptive, visual, acoustic, olfactory and gustatory everyday stimuli for the facial-oral tract are used in a structured manner, to trigger the desired motor responses, e.g. swallowing or phonation.
- Starting F.O.T.T. tactile oral stimulation as early as possible following the onset of damage seems justified, due to the large number of sensory inputs required for a coordinated swallowing sequence, and considering the number of sensory inputs of this type received by a healthy person compared to a patient in the acute phase of a stroke!

- Tactile (touch, tapping), thermal, motor (chewing) and taste information (various teas, salty dishes), stimulation of the face and oral cavity and adapted oral hygiene (with finger or toothbrush, without toothpaste) can form part of early treatment. They can also be used for training and maintenance of the physiological swallowing sequence.
- Tactile and gustatory stimulation of the oral cavity and tongue are used to increase awareness, in preparation for active tongue movements. Targeted motions or partial aspects of movements (e.g. lip/spoon licking, cleaning cheek pouches with the tongue, licking ice) can subsequently be practiced and should always be concluded with a swallow. A systematic sequence of chewing movements can be developed with the aid of apple (or dried meat) pieces wrapped in gauze held in the patient's hand.
- In an optimised starting position, appropriate sequences are used to work on protection of the airway and cleansing of the oral and pharyngo-laryngeal tract (throat clearing or coughing up concluded with swallowing).
- In the context of therapeutically structured oral hygiene, sequences of spitting out, coughing and swallowing when necessary can be developed at the washbasin.
- The so-called therapeutic eating, assisted and supervised meals, also provides opportunities to repeat movement patterns in a variety of ways, with increasing demands (▶ Sect. 5.5.2).

The Daily Life Context in F.O.T.T.

- The daily life context of therapy takes advantage of factors which promote learning, such as implicit body awareness and the patient's understanding of the situation. Emotional/motivational factors which facilitate alertness and attention can be exploited.
- Although the optimal frequency and intensity for stimuli remains unclear, it has been shown that specific inputs via the cranial nerves (trigeminal (V), glossopharyngeal (IX) and vagus (X)) affect the corresponding motor activation of the cerebral cortex (Hamdy 2003). In terms of sensory organisation, this may explain why practical preparatory work using oral stimulation, chewing and tongue movements, and stimulation of the swallowing sequence often lead to improved motor coordination during the following therapeutic meal.
- It is important for the patients to be able to brush their teeth or eat using their own hand (guided), wherever possible. Frequent use of hand-mouth coordination creates additional peripheral inputs. Important synaptic connections to motor control are stimulated, by uncovering known movement patterns. Familiar stimuli such as a toothbrush in the hand often trigger the appropriate opening of the mouth and spontaneous swallowing.

3.4.2 Therapeutic Skills

» Make it possible, make it necessary, let it happen! (B. Bobath and K. Bobath 1977)

Everybody (including patients and therapists) learns through practical experience and observing others. The brain uses feedback-generated hypotheses and tests them through implementation. This enables us to learn to use new tools, such as a PC mouse, even at an advanced age. Patients must relearn movement sequences which have been lost. Therapists also need to learn practical motor skills, in order to help their patients effectively.

Feedforward Advantages

During the F.O.T.T. training course, practical self-awareness exercises for therapists are always conducted, at the beginning of the movement or activity to be taught. This is followed by reflection and often appears "unprofessional". However, it is the method of choice for increasing the awareness of activities which are carried out automatically. This experience can be used explicitly, when instructing patients.

► Example

If the therapist knows from personal experience which responses follow specific facial-oral activities, he/she can apply this feedforward during individual therapeutic tasks; e.g. wait for a spontaneous swallow or be prepared in advance to help with closing of the mouth or swallowing (► Chap. 4). ◄

Feedback via Therapeutic Aids

In F.O.T.T., visual, tactile and verbal aids are used individually or in combination.

> Movement components which are organised unconsciously should be facilitated proprioceptively, whilst movement components which are performed voluntarily should be facilitated using visual stimulation or mental visualisation of the movement. (Horst 2005)

Visual aids

The therapist demonstrates a movement which the patient can then imitate, or he/she performs the movement together with the patient: moistening the lips, for example. It is assumed that a system of mirror neurons is activated in the premotor cortex (area 6) and in Broca's area (area 44), when viewing actions which are meaningful and known. This is the way children learn certain skills from their parents. A central, shortcut connection exists, between the observation of an appropriate action and its execution. Provided that the patient's "imitation system" is intact, this can be extremely useful during the learning process (van Cranenburgh 2007).

Verbal aids

The F.O.T.T. approach alters the therapist's language and verbal requests.

► Example

"Look out of the window! I think it's going to rain soon" (external focus), rather than "turn your head to the left!" (*internal focus*). ◄

The everyday-oriented approach primarily affects the content of therapy for central swallowing and speech disorders.

Positive feedback can be motivating and performance enhancing. There are important differences regarding the timing of therapeutic feedback, once activity/movement patterns have taken place:

- Feedback given at the same time as movement is ineffective.
- The best learning effects are achieved through feedback given by the patient himself after his activity (how successful was the activity?).
- If this is not yet possible, feedback should be delayed for several seconds at least, after the movement has ended. This interval appears to stimulate spontaneous reflection on success (Wulf 2007).

Tactile aids

Much discussion has focused on the question of hands on or hands-off strategies in therapy. This discussion becomes superfluous if the full spectrum of patients is considered. There are patients who cannot perform a movement/activity (e.g. open their mouths) following a verbal request alone (hands off). Personal factors and their general condition make it necessary that the therapist assists them with setting proprioceptive stimuli (hands-on). According to Coombes (2007) however, it is assumed that the CNS registers feedbacks of differing strengths, depending on the level of support (► Overview 3.1).

Overview 3.1 Feedback on Learning Movement

+	Passive: carried out by the therapist.
++	Self-initiated: execution is continued by the therapist.
+++	Active: the patient performs the movement/activity independently.
++++	Repeat: the patient repeats the movement (with variations and increasing difficulty as options).

(Coombes: hand-out materials, F.O.T.T. foundation course 2007)

In order to achieve an upright posture or to move, many patients in acute condition need considerable support from the surroundings or through positioning. If the patient is unable to initiate movement himself, passive movements can be used to encourage motion and facilitate the patient's own search for a movement pattern. The therapist's hands can provide the additional stability required by the patient, allowing the patient to move actively. Ideally this support will be phased out over time, with patients taking over the coordination of both posture and simultaneous motion for themselves. Hands-on techniques supporting trunk stability are also essential to re-establish natural breathing. Stabilisation of the jaw (punctum stabile) by means of a jaw support grip may be necessary, in order for the tongue (punctum mobile) to move selectively and initiate posterior movement. In order for the patient to try movements for himself therapists may physically guide or provide support if the patient is unable to complete the activity or endangers himself (▶ Sect. 4.2.6). Movement control is passed back to the patient as early as possible.

Under the Magnifying Glass

Discussion of hands-on vs. hands-off

Many authors have a similar perspective on the various aspects of hands-on treatment:

- In order to improve postural control in everyday functions, concurrent proprioceptive information is required during the execution of deliberate, functional movements (Horst 2005).
- The therapist can use passive movement to give an idea of the motion required and demonstrate the alignment necessary for the movement/function to be performed (Hüter-Becker and Dölken 2010).
- The passive movement supplies sensory information, which can steer innervation in the required direction (van Cranenburgh 2007).

Hofstetter (2008) transferred the Bobath quote from the beginning of the chapter into a modern approach:

> » Make it possible – hands on, let it happen – hands off, make it necessary – hands off and on. (Hofstetter 2008, p.89)

3.5 Concluding Thoughts

Following the principles of motor control and motor learning in therapeutic work may sound complicated. However, it is no more diverse than the inputs to which we are constantly exposed in daily life and which we induce when dealing with other people. If we become more familiar with the aspects, movements, functions and activities of our daily lives, we may have the chance to orient our treatment towards these goals.

Work becomes evidence based and is more enjoyable and varied, both for our patients and ourselves. The risk of monotony for both parties decreases.

All of our therapeutic interventions are based on the accurate observation of our patients, as well as the observation, interpretation and evaluation of all motor responses, right down to the tips of the toes!

Regardless of all theories, we must rely on our common sense and empathy and ask ourselves: how would I feel in this situation, and what would be helpful to me?

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Posture and Function: What Helps Us Swallow

Karin Gampp Lehmann and Heike Sticher

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This chapter will outline the anatomical, functional, and biomechanical relationships between individual body structures and motor activities. These relationships will be used to explain physiological and non-physiological posture in general and swallowing in greater detail. Profound knowledge of functional relationships and the potential abnormalities resulting from neurogenic damage is highly applicable to the treatment of neurological patients. This enables the specific analysis and treatment of muscular and connective tissue dysfunctions, and the effects of postural changes.

Isolated treatment of the facial-oral tract without reference to the entire body can lead to undesired secondary structural changes which make the patient's relearning of effective and safe movement patterns impossible.

Patients with severe traumatic brain injury, stroke or suffering from a severe neurological disorder are often incapable of changing their position by themselves in a physiological, dynamic, and pain-free way. The reasons are diverse. In addition to lack of strength, insufficient or distorted sensory and sensorimotor information, or difficulty in processing the corresponding information may also play a role. The information cannot be categorised, and an appropriate response cannot be generated. Patients move and change their position only in the way their impaired sensorimotor system allows. Movements become stereotypical and cannot be variably adapted or coordinated. Brain damage affects the whole person, not just specific groups of nerves or muscles. Therefore, a swallowing disorder is often part of an 'overall problem' rather than an isolated issue (Gratz and Müller 2004). Each person must therefore be considered individually, in terms of his or her general functioning and the facial-oral tract treated with reference to the entire body (Gampp Lehmann et al. 2020; Gampp 1994; Gampp and Gattlen 1991; Nusser-Müller-Busch 1997).

The aim is to offer the patient the greatest likelihood of experiencing normal, that is, *pain-free*, *variable, and modifiable movement in the facial-oral tract*. In order to provide a foundation for this, the therapist's preparatory work and guidance emphasise physiological posture and function and the most unrestricted movement possible.

Therapists therefore need the *ability* to recognise and to analyse shortenings of the structures and differences in tension as well as to differentiate between their causes (usually secondary, disease-related, and/or posture-related).

In-depth knowledge of anatomy and physiology, structural and functional relationships, and biomechanics are indispensable. Above all, therapists require observant eyes and hands which are accustomed to touching patients and sensing subtle differences in tension.

4.1 Fundamentals: Physiology and Posture

Note

Body and Brain are designed to perform *all movements* effectively, safely, and economically.

Some movement patterns are laid down before birth, others are learned after birth. They are then used continuously, further refined, and thereby optimised (automated movements). Certain characteristics will develop over time: Particular patterns are reinforced, other movement patterns become less fluid. Detours are made or misalignments arise which must be compensated for. Habits play a role as does 'wear and tear' over time.

4.1.1 Postural Background

> It should be emphasised that posture is the basis of every movement, and that every movement begins with posture and ends in it (Wright 1954).

> Every movement in the shoulder girdle begins in the trunk, pelvis and legs (Rašev 2014).

A large variety of structures (bones, muscles, tendons, nerves, blood vessels, connective tissue) are found in the constrained space of the body. These structures are interrelated, build upon one another, and function together. Since an infinite number of movement possibilities are available, a well-coordinated postural system (the postural background) is essential. At all times this system ensures balance and yet the capacity to perform simple or more complex functions simultaneously and efficiently (Davies 1994; Edwards 2002; Umphred 2000).

Bobath (1980) and Davies (1990) mentioned a flexible postural background or dynamic stability/stable dynamics, whilst Vojta (2007) wrote that 'every movement is accompanied by a balanced, automatically controlled body posture (postural activity)'. Van Cranenburgh (2007) notes that 'the more difficult the skill, the higher the demands placed on the starting position'. The postural background can never be inflexible as it is intended to support movement. It must be stable and yet modifiable or changeable at any time (Shumway-Cook and Woollacott 2007).

Physiological Sitting Posture and Food Intake

An example shows the relationships between the pelvis, the lumbar, thoracic and cervical spine, and the head in the starting position known as *normal sitting posture* (Fig. 4.1).

When sitting at the table unsupported, for example whilst eating, the foundation for the seated position is provided by the pelvis. With the pelvis upright or *anteriorly tilted*, the weight rests on the ischial tuberosity. The feet are placed on the floor and the hips and knees are flexed (±90°). The lumbar, thoracic, and cervical parts of the spine are adjusted accordingly as is the head. The spinal curves form an 'S' shape, with the line of gravity ending between the ischial tuberosity.

From this *optimal postural background* the head can normally be turned or tilted in any direction (Fig. 4.2). It is possible to talk to a neighbour, to use the hands freely, and to chew and swallow. The hyoid bone and the larynx are also free to move in all directions. This position also allows the diaphragm freedom of movement within the thorax, which is important for unrestricted breathing during eating.

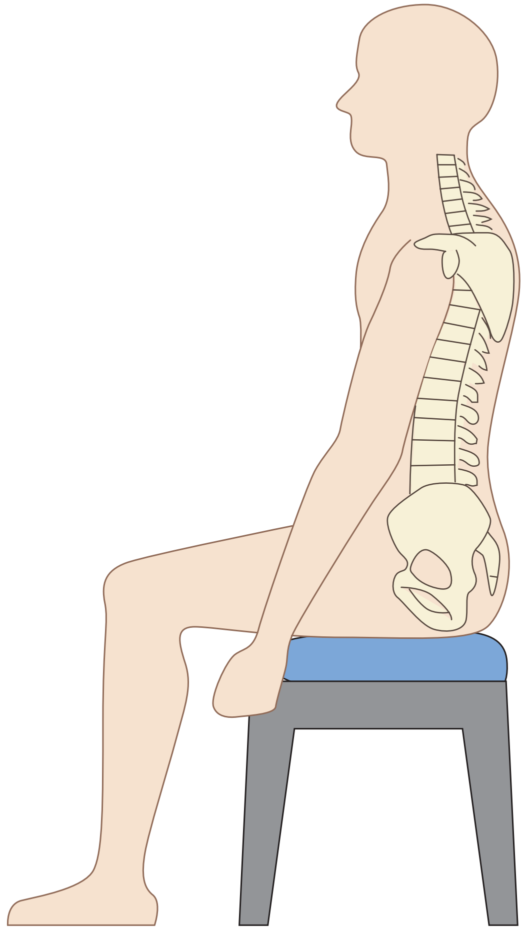


Fig. 4.1 Normal sitting posture. (© Sticher 2019. All Rights Reserved)

Altered Sitting Posture

Postural insufficiencies often cause the patient's *pelvis* to be *tilted posteriorly* rather than anteriorly (Fig. 4.3).

As a *consequence,* the weight no longer rests on the ischial tuberosity, but falls behind them. Moving further up the spine, the resulting *lumbar spine flexion* in turn causes an increase in *thoracic kyphosis*. The *cervical spine* then moves into *flexion*. As everybody needs to see something of the world or the person in front of him, the eyeline does therefore not remain directed towards the ground but is reset horizontally. This results in compensatory *hyperextension of the upper cervical spine* and a very 'short neck'. Anterior translation (displacement) of the head, coupled with posterior displacement of the lower jaw

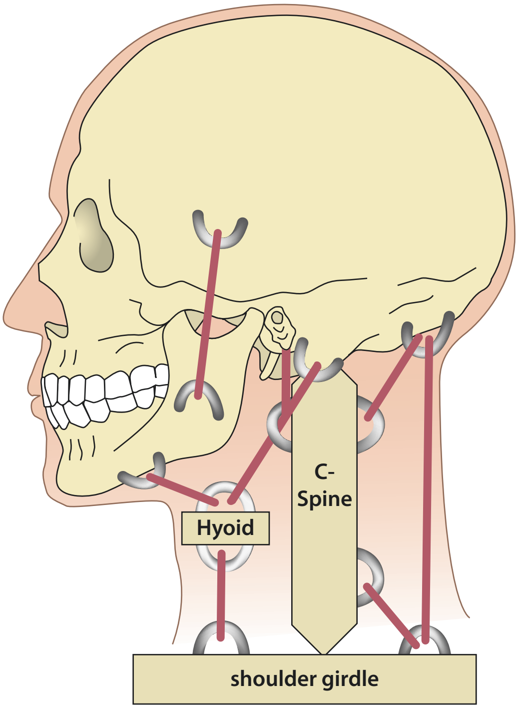


Fig. 4.2 The functional balance of the head (C-S = cervical spine). (© Sticher 2019. All Rights Reserved)

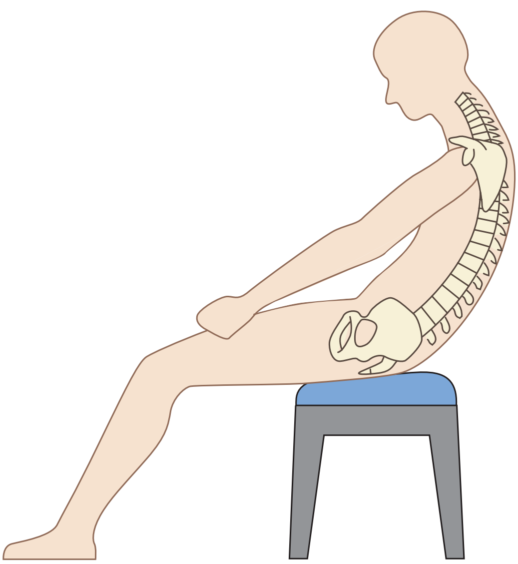


Fig. 4.3 Altered sitting posture. (© Sticher 2019. All Rights Reserved)

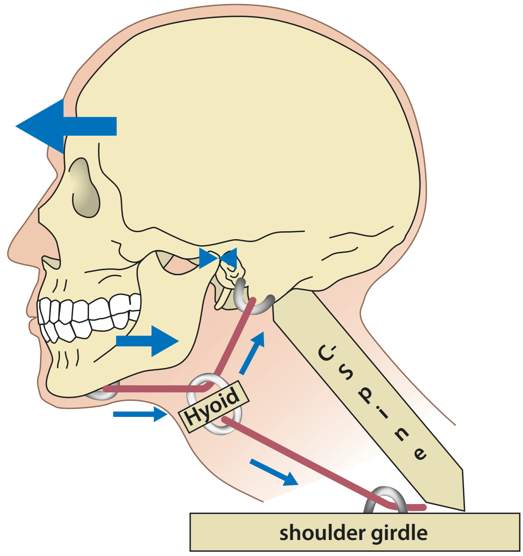


Fig. 4.4 Imbalance of the head (C-S = cervical spine). (© Sticher 2019. All Rights Reserved)

(possibly with jaw joint pain), is also common (Fig. 4.4, Engström 2001).

If only one of the elements (pelvis, parts of the spine) described above changes, the *effect* on the other structures is immediate (Engström 2001; Liem 2013; Orth and Block 1987). The structures which were set up well-adjusted on top of each other become *unbalanced* and biomechanically unable to fulfil their functions correctly. Healthy individuals are able to use muscular strength to compensate for disbalances. As a result of their primary weaknesses, patients usually lack the ability to compensate spontaneously.

According to findings from the fascial research department, led by Robert Schleip et al. (2012) at the University of Ulm, the thoracolumbar fascia has an important function for proprioception and nociception as well as the transmission of forces from the muscular system. During forward bending of more than 20° with a rounded trunk, the erector trunci muscles progressively lose control of the motion and the thoracolumbar fascia takes over their function. Sustained high loading can result in fascial damage with non-specific back pain and signs of inflammation.

Warning
- Even minimal dorsal *shifting of the pelvis* (posterior tilting) causes adjustment of the upper cervical spine towards greater extension.
- A small increase of 8° in the extension of the *upper cervical spine* leads to a 1 mm dorsal shift in the position of the lower jaw (von Piekartz 2009).

Relationship: Head Position and the Swallowing Process

A study by Castell et al. (1993) highlighted *correlations between adjustments to the position of the head and the process of swallowing in healthy individuals*. Manometric measurements were taken in the pharynx and upper esophageal sphincter (UES) during swallowing with the head flexed to 30°, 15°, and 0°. The process was repeated with the head extended to 15°, 30°, and 45°. The results show that cervical flexion had no significant effect on pharyngeal contraction or UES opening. However, the base level of muscle tension of the UES increased markedly with *head extension*. The opening time of the UES decreased and the coordination of pharyngeal contraction and esophageal opening deteriorated progressively, up to a point at which the UES only opened *after* the beginning of pharyngeal contractions. It also closed prematurely, before pharyngeal contractions had come to an end.

Increased extension of the cervical spine has a direct negative influence on all the structures involved in the swallowing process including joints, muscles, fascia, ligaments, nerves, etc. (Liem 2013; Orth and Block 1987; Sasaki 2007; Schewe 1988).

The effects are also observable *below the level of the pelvis*, as Fig. 4.3. illustrates. To counterbalance the posterior displacement of the trunk, the legs extend at the knee and hip (as do the arms, in some cases). The feet are unable to maintain full contact with the ground and slide forwards and the head is translating anteriorly. These responses are normal, common to everybody, and seen in a variety of everyday situations (Edwards 2002; Engström 2001), for example, when sitting in a reclining chair or wheelchair.

Summary

With an *intact sensorimotor system* and physiological structural conditions, body position and postural background can easily be modified or adapted. A broad range of adaptations are available, provided the *prerequisites for normal movement* are present (Panturin 2001; Shumway-Cook and Woollacott 2007; Umphred 2000).

If sensorimotor function is intact, the body has access to innumerable compensatory options and *eating* and *swallowing* are possible from almost any starting position. If the sensorimotor system and scope for compensation are limited, the starting position must be optimised according to physiological and biomechanical principles.

4.1.2 Dynamic Stability

In order to fulfil the almost unlimited range of different functions the body must execute many different, complex, and *highly coordinated movements* both temporally and spatially.

Punctum Stabile/Punctum Mobile

Direction of Muscle Pull

This term is used in Vojta therapy (Vojta 2007) to describe the following process: All muscles have an origin and an insertion. The direction of muscle pull, and therefore the direction of movement, is usually from insertion towards the origin as the origin functions as punctum stabile (the insertion as punctum mobile). This situation can be reversed, however, if the insertion becomes the punctum stabile and the origin moves towards the insertion (► Sect. 4.2).

Depending on the course of the movement, the same structure may perform different and sometimes *opposing tasks*. It may act to stabilise on one occasion yet play an *active* part in movement at another time.

The *alteration in the function of a structure* (as punctum stabile or punctum mobile) results in broader functional capacity. The switching of punctum stabile and punctum mobile can change the direction of muscle pull.

Note

Dynamic stability means that the function determines whether a structure is used as punctum stabile or as punctum mobile. This gives us the ability to switch rapidly back and forth between punctum stabile and punctum mobile as required. It also necessitates a flexible postural background and the ability to modify posture and position.

The *ability to switch* between punctum stabile and punctum mobile contributes greatly to the economy and effectiveness of movements but presupposes great selectivity of movements.

The following section examines the anatomical and functional concepts on which the authors' theories are based. It shows the *functional relationships* between spinal alignment, the osseous (bony) and fascial structures involved in the swallowing sequence, and the relevant musculature. These functional relationships can be used to derive the most physiological starting positions for the patients.

4.2 Fundamentals: Anatomy and Physiology of Swallowing

4.2.1 Os Hyoideum

The os hyoideum (hyoid bone) is a horseshoe-shaped bone located where the floor of the mouth curves into the neck at the level of the third cervical vertebra. The hyoid bone is the only bone in the body which does not have any bony articulating joints. The hyoid is solely connected to other bones by muscles, ligaments, and fascia (◘ Fig. 4.5a, b, Liem 2013; Sobotta 2000; Upledger and Vredevoogd 2003).

These muscular connections link the hyoid bone to the mandible (lower jaw), the tongue, temporal bone, sternum, clavicle, scapula, and the spine (◘ Fig. 4.14). Upledger and Vredevoogd (2003) describe the hyoid bone as a *floating anchor*, connected to the structures below (larynx, sternum, etc.) via muscles, ligaments, and fascia. It also provides attachments for the muscles and connective tissue of the skull including the lower jaw and the tongue (◘ Fig. 4.5c).

- **Specific functions of the hyoid bone**

Note

The hyoid bone functions *alternately* as punctum stabile or punctum mobile, during all movements in the oral and pharyngeal phases of swallowing!

The different functions of the hyoid bone are described in ► Overview 4.1.

Overview 4.1 Functions of the Hyoid Bone

Hyoid bone: Punctum stabile during jaw opening

The hyoid bone is a base of support and stabilisation during movements of the lower jaw. The hyoid bone is then stabilized simultaneously by the infrahyoid and retrohyoid muscles and by the constrictor pharyngis medius (◘ Fig. 4.6a, b, Liem 2013).

Hyoid bone: Punctum mobile during swallowing

When the lower jaw is closed and therefore stabilized, the hyoid bone can move cranially/ventrally during swallowing. As a result, the larynx and connected structures towards the UES are drawn upwards (◘ Fig. 4.6c, d).

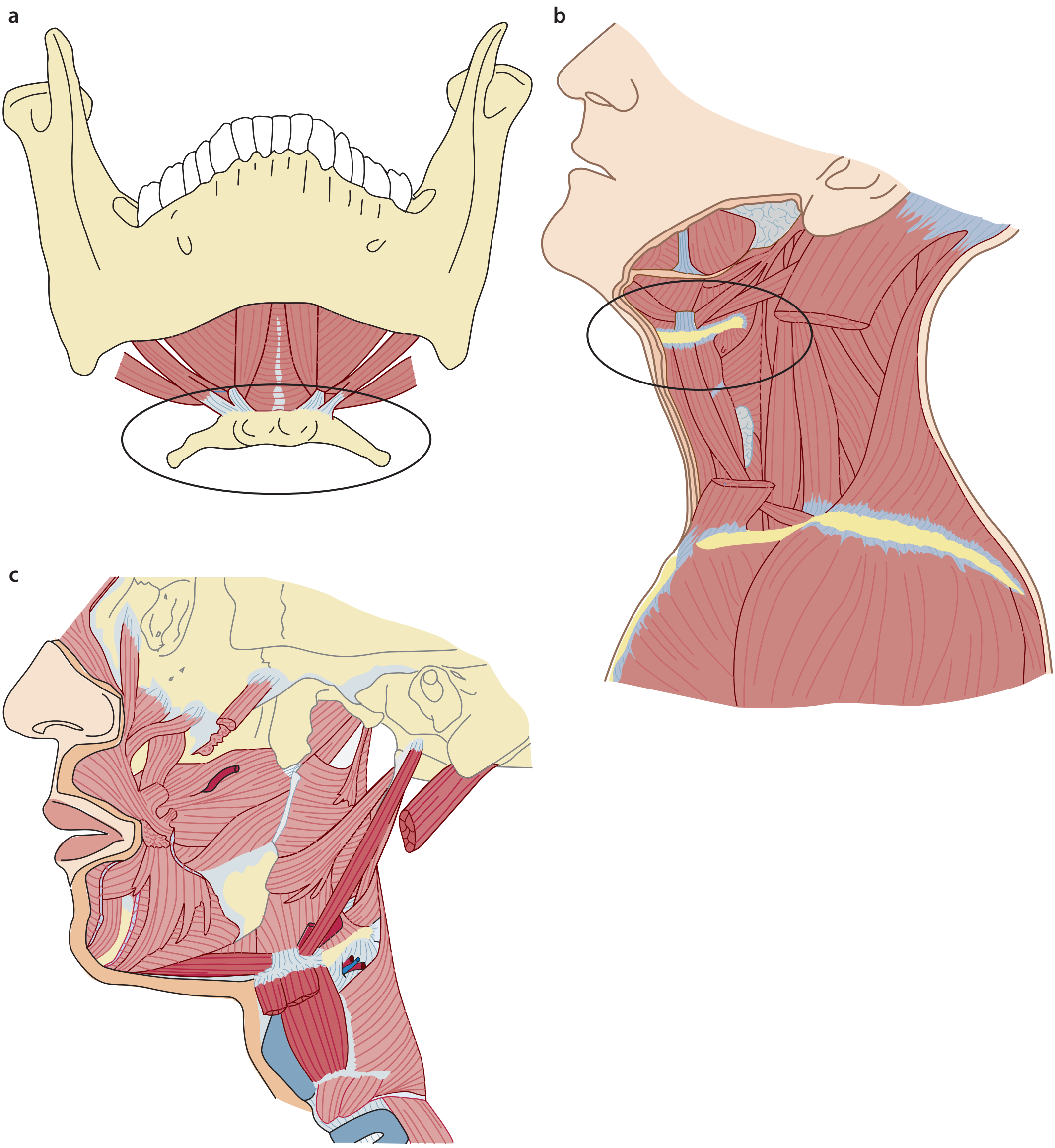


Fig. 4.5 a–c Hyoid bone. (© Gampp Lehmann 2019. All Rights Reserved). **a, b** Location of the hyoid bone. **c** Function of the hyoid bone as a floating anchor

When punctum stabile (formerly: hyoid bone, currently: mandible) and punctum mobile (formerly: mandible, currently: hyoid bone) are reversed, a *change in the direction of muscle pull* occurs. As a result, the muscles that previously functioned to open the lower jaw (for biting and chewing) now allow the hyoid bone and larynx to rise forward/upward during swallowing (Fig. 4.6d).

Warning

Coordinated interaction between the muscles which have an origin or insertion at the hyoid bone is essential to the muscular balance and dynamic stability of the head and neck area.

The inability of any of these muscles to perform its function (contracting or releasing) or

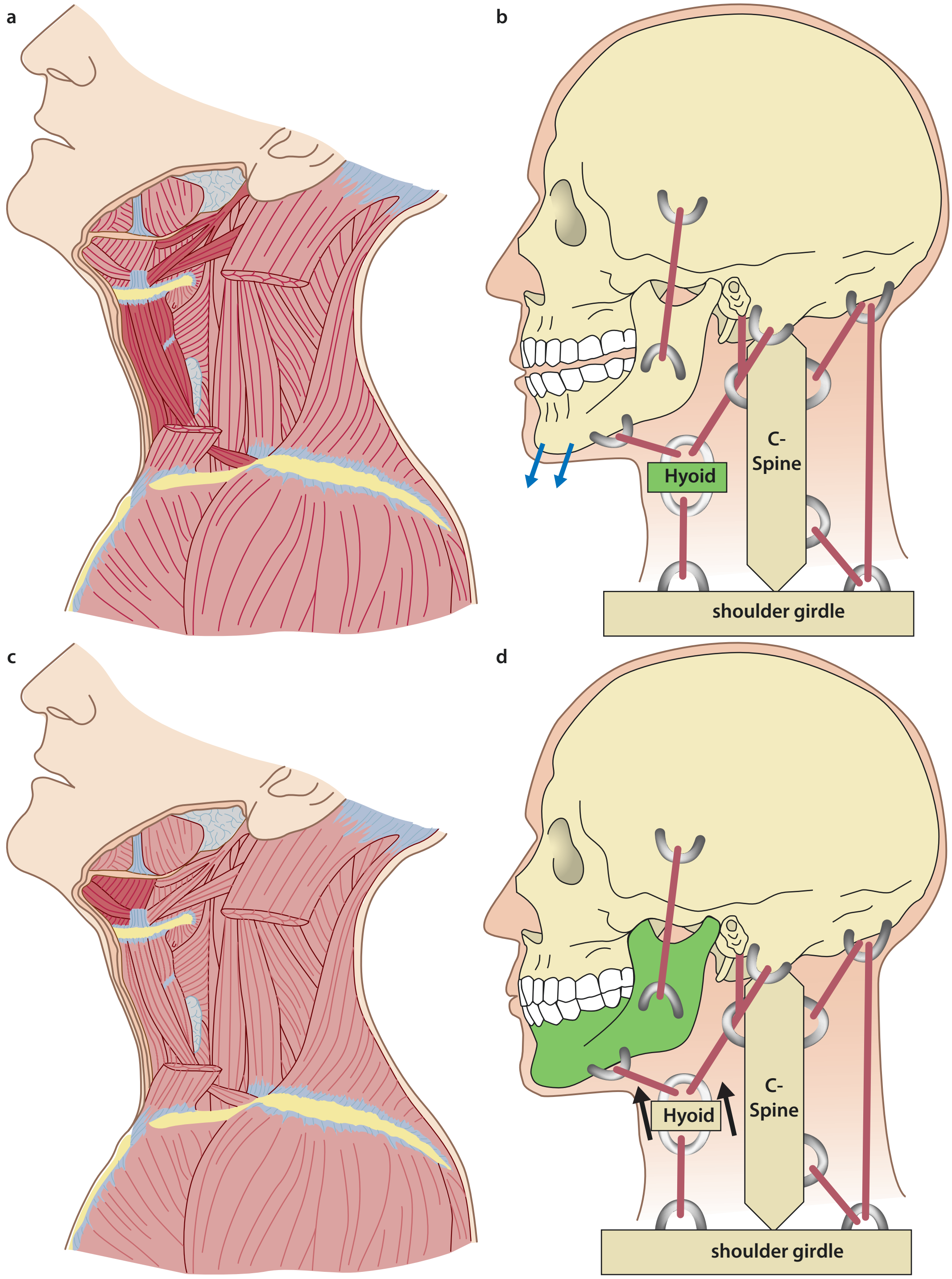


Fig. 4.6 **a–d** The hyoid bone. (© Gampp Lehmann 2019. All Rights Reserved). **a** Hyoid bone as punctum stabile. **b** Function: opening and movement of the lower jaw. **c** Hyoid bone as punctum mobile. (© Gampp Lehmann 2019. All Rights Reserved). **d** Function: elevation of hyoid bone cranially/ventrally during the swallowing process, with stabilized lower jaw (C-S = cervical spine)

fixed conditions in muscle length and connective tissue structures/fascia can cause dysfunction in all of the corresponding structures. The image of the floating anchor effectively illustrates the precariousness of this functional equilibrium.

Although it can be a sensitive marker (Paik et al. 2008), it is possible to swallow *without the hyoid bone*. This is seen in patients with non-neurogenic aetiologies, for example, following a hyoidectomy as part of a laryngectomy (a horizontal partial laryngectomy or throat cyst surgery).

4.2.2 Thoracic Spine – Cervical Spine – Scapula – Hyoid Bone

When sitting, the altered position of the pelvis previously described (posterior tilt, Fig. 4.3) causes an *increase in thoracic kyphosis*. This is coupled with *increased extension of the cervical spine* in order to maintain eye contact. Tension in the shoulder girdle is increased and the shoulder blades are *elevated* (the muscles help bear the weight of the head and cervical spine). The omohyoid muscle affects and is in turn affected by the *position of the shoulder blades* (Figs. 4.5c and 4.7).

By virtue of its location, the *omohyoid muscle* acts indirectly as flexor on the head and neck joints. The cranial part of the muscle is stretched by *hyperextension* of the upper cervical spine, pulling the hyoid bone *caudally* and causing increased tension in the *suprahyoid muscles* as a counterbalance. If the exit points for the nerves (the omohyoid muscle is innervated by the first cervical nerves) become narrowed as a result of this hyperextension, *pressure lesions* can occur and cause impairments – for example, weakness – of the 'insufficiently' innervated musculature (Liem 2013; Upledger and Vredevoogd 2003).

The omohyoid muscle also has an important role as a fascial tensor (specifically of the middle layer of the deep cervical fascia), which directly influences the walls of the jugular and the thyroid veins (Stecco 2015).

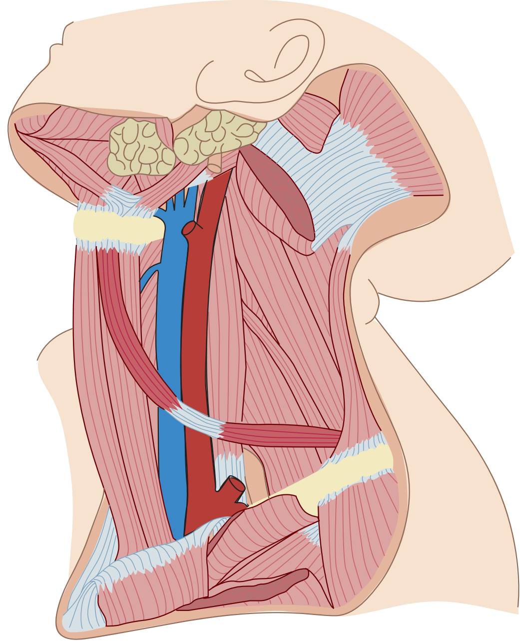


Fig. 4.7 Location of the omohyoid muscle. (© Gampp Lehmann 2019. All Rights Reserved)

Warning
Based on this explanation it makes no sense to simply prescribe strengthening exercises for the suprahyoid musculature or tongue in the event of *weakness*. A precise, functional, and structural evaluation is necessary in order to avoid reinforcing the pathology.

4.2.3 Cervical Spine – Hyoid Bone

Hyperextension of the upper cervical spine causes

- Dorsal *narrowing of the foramina intervertebralia, which are nerve exits.* This can directly affect the hyoid bone, as the geniohyoid muscle is also innervated by the first cervical and by the hypoglossal nerve (Umphred 2000). In addition to the aforementioned omohyoid muscle, the ventral infrahyoid musculature is also innervated by the first cervical nerves (ansa cervicalis profunda).

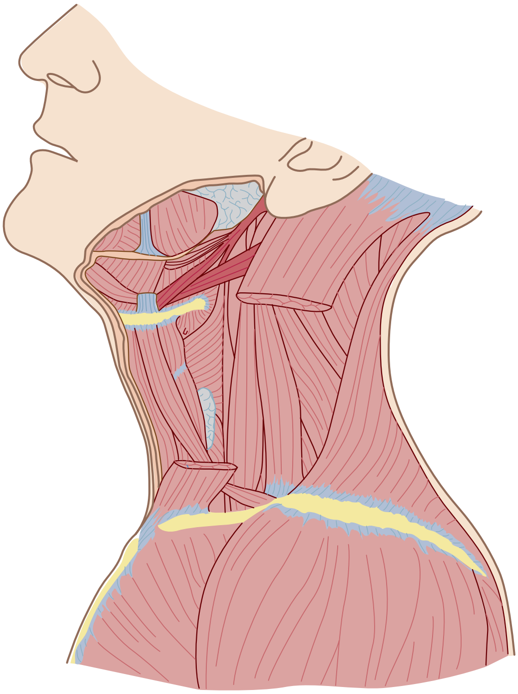


Fig. 4.8 Dorsal-cranial stabilisation of the hyoid bone.

- *A decrease in the distance between the temporal and hyoid bones* (Fig. 4.8). This leads to stretching or tension in the suprahyoid ventral structures, and countertension of the infrahyoid structures. The optimal length of the constrictor pharyngis medius muscle may be lost restricting its function in pharyngeal peristalsis.

The *constrictor pharyngis medius muscle* attaches to the hyoid bone and the pharyngeal raphe. This in turn attaches to the cranial base and is connected to the cervical vertebra by tight, connective tissue. As a result of these connections, *interaction* between the cervical spine and the hyoid bone can occur via the constrictor pharyngis medius (Fig. 4.9a, b, Liem 2013).

The *ventral neck fascias* (e.g. the suprahyoid lamina, which runs from the upper margin of the hyoid bone to either side of the lower jaw) also have a strong influence on the mobility of the hyoid bone (Liem 2013).

a

b

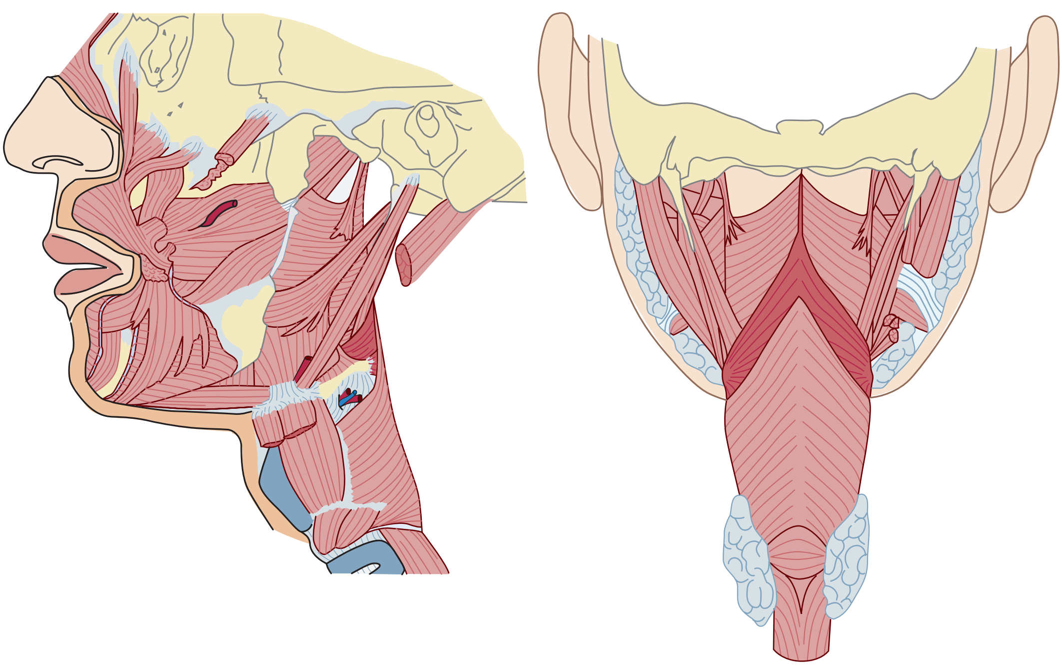


Fig. 4.9 **a, b** Constrictor pharyngis medius muscle. **a** lateral view from left, **b** dorsal view

4.2.4 Temporal Bone – Hyoid Bone

The *stylohyoid muscle* and the ligament of the same name extend from the corpus ossis hyoidei to the processus styloideus connecting the hyoid bone and the temporal bone. The *digastricus muscle* also forms a connection between the two bones (◘ Fig. 4.8). The digastricus venter posterior (posterior belly of the digastric muscle) attaches to the processus mastoideus. The digastricus venter anterior (anterior belly of the same muscle) attaches to the mandible (lower jaw). These muscles establish equilibrium in a dorso-cranial direction and *stabilise* in the same direction *during swallowing* (◘ Fig. 4.8).

Warning

The stylohyoid muscle and the posterior belly of the digastric muscle are innervated by the *facial nerve*. The anterior belly of the digastric muscle is innervated by the *trigeminal nerve*. These innervations should be borne in mind in the event of corresponding *neural lesions*!

If *hyperextension of the upper cervical spine* persists for an extended period of time, it may result in *contractures* (shortening) of the connections between the temporal and the hyoid bone (◘ Fig. 4.8). As a result, increased effort may be required in order to hold the head in a neutral position. As increased tension in the digastricus and stylohyoid muscles pulls the hyoid bone too far dorso-cranially, this causes a feeling of tightness when trying to hold the head in a neutral or 'long neck' position.

The authors' experience has the following observations:

- Several hours per day of workplace-related, unphysiological sitting posture (e.g. working at a computer screen) can cause contractures of the upper cervical structures and of the connections between the temporal and the hyoid bone (◘ Fig. 4.8) even in *healthy individuals*. Flexion of the upper cervical spine then pulls back the hyoid and leads to a feeling of tension or even of choking.
- Unclear *globus sensations* (the feeling of having a foreign body in the throat) can often be resolved through lengthening the connections of the hyoid bone, and working on the position of the upper cervical spine and the thoracic diaphragm (deep breathing, ► Sect. 4.2.8).

Conclusion

As a consequence of these interrelationships, it is likely that the *imbalance of tension in the hyoid musculature* and in the corresponding connective tissue structures (e.g. as a result of neurogenic damage) contributes to restricted, cranio-ventral movement of the hyoid bone and larynx during swallowing.

It is possible that the *Shaker head lift exercise* (Shaker et al. 2002), which is often considered useful, in fact owes its effectiveness to these relationships. If performed correctly, the exercise will create optimal flexion of the upper cervical spine and support the releasing of the shortened hyoid connections.

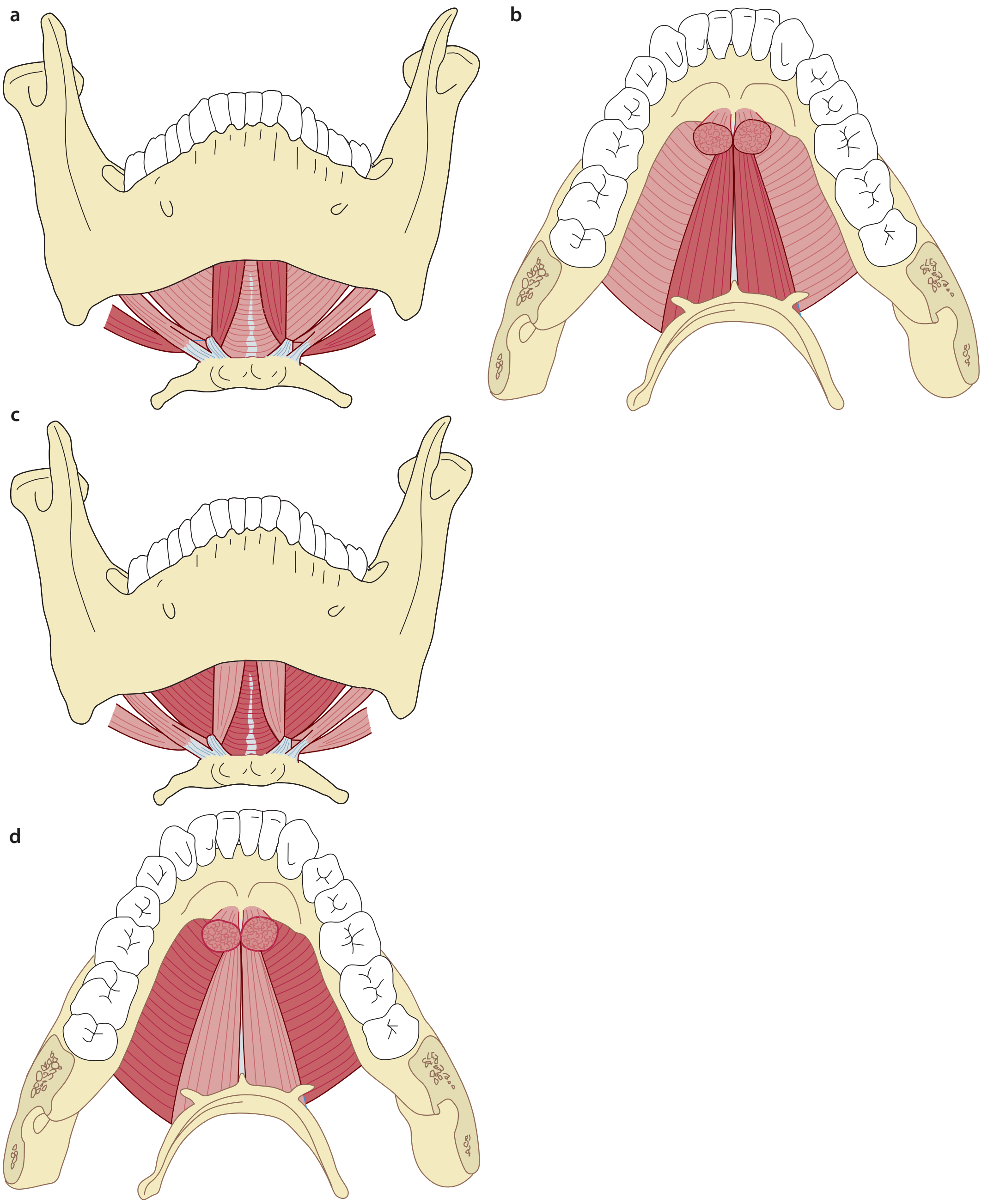
Note

- *Cranial* movements of the hyoid bone and events in the oral cavity are closely linked.
- The opening of the UES is closely related to the *anterior* motion of the hyoid bone (Ishida et al. 2002; Paik et al. 2008).

Practical Tip

Establishing full mobility of all the structures described enables the patient to move and swallow spontaneously, without encountering passive structural resistance. This *vital groundwork* encompasses work on *flexion of the upper cervical spine and on full mobility of the hyoid and larynx* particularly ventrally and laterally. With the patient in a physiological position, treatment takes the form of gentle mobilisation with deepened breathing.

In cases of craniocerebral injury, the forces that have impacted the cervical spine are unknown. But based on the nature of the head injury it can often be assumed that the cervical spine has suffered trauma (whiplash). Attention must be paid to the physiological position of the head, taking into account the biomechanical effects of this type of injury to the cervical spine, and the shear forces to the vertebral artery during head rotation; *head and neck exercises against resistance must be avoided.*



■ **Fig. 4.10** **a–d** Muscular connections between hyoid bone and mandible. (© Gampp Lehmann 2019. All Rights Reserved). **a** Digastricus muscle. **b** Geniohyoid muscle. **c** Mylohyoid muscle from caudal. **d** Mylohyoid muscle from cranial

4.2.5 Mandible – Hyoid Bone

The digastric muscle (■ Fig. 4.10a), geniohyoid muscle (■ Fig. 4.10b), and the mylohyoid muscle (■ Fig. 4.10c) connect the lower jaw to the hyoid bone, forming the *floor of the mouth*.

Warning

If the *hyoid bone* becomes fixed in an overly dorsal or caudal position, thereby losing its function as punctum mobile or punctum stabile, the geniohyoid muscle increasingly depresses the lower jaw. This increases the difficulty of *jaw closure* and normal *tongue function during swallowing* (Upledger and Vredevoogd 2003).

4.2.6 Tongue – Hyoid Bone

Increased dorsal or caudal fixation of the hyoid bone can increase tension on the hyoglossus (Fig. 4.11a) and chondroglossus muscles (Fig. 4.11b) as well as on the genioglossus muscle (Fig. 4.11c). As a result, the tongue and lower jaw may experience increased pull in the same caudal direction, making it more difficult to *lift the tongue* and to move it forward (which may already be neurologically impaired).

The *tension balance of the tongue* can be affected by the hyoid, mandibular, and temporal bones because of the interconnections between muscles and connective tissue (Fig. 4.11d, Ishida et al. 2002; Liem 2010). It is also evident that the *function of the tongue* depends greatly on an *optimal position of the head*, and consequently on *pelvic and thoracic alignment*.

Practical Tip

In F.O.T.T., the *jaw support grip* is primarily used as a *stabilising aid* for the lower jaw, in order to support the punctum stabile adequately. This provides the tongue with a stable point of reference from which to initiate transportation movements and facilitates the oral transport of saliva and food. The jaw support grip therefore assists in the optimisation of muscle function and improves the quality of the movement being performed (Fig. 4.6d). The structures are able to work correctly from a biomechanical perspective.

Stecco (2015) notes that 'all the muscles in chewing and swallowing are interconnected by fasciae.… A perfect fascial tension in this network assures the coordination necessary for chewing and swallowing. The open-mouth position changes the normal tensional relationship in this fascial network resulting in abnormal activity of the muscle spindles connected to the swallowing muscles. This explains why swallowing with the mouth open is almost impossible.'

Stecco (2015) also notes that the buccinator muscle has both a mimetic and a masticatory function and that it connects and modulates the action of the mouth with that of the pharynx. The buccopharyngeal fascia extends on one side into the connective tissue of the lips and on the other side via the superior pharyngeal constrictor into the tunica adventitia of the pharynx and the esophagus. Another explanation for the necessity of a stable/closed jaw while swallowing.

4.2.7 Larynx – Hyoid Bone

During swallowing the thyrohyoid muscle (Fig. 4.12a) pulls the larynx towards the hyoid bone following its cranial–ventral motion. The positions of the epiglottis and arytenoid cartilage are also affected (note that the hyoepiglottic ligament also forms a link between the hyoid and epiglottis, Fig. 4.12b).

Warning

An altered position of the hyoid bone changes the level of tension of the infrahyoid muscles and connective tissue structures (Liem 2013), which can cause *hoarseness* and *swallowing dysfunctions*.

4.2.8 Cricopharyngeus Muscle – Hyoid Bone

The larynx has a direct connection to the UES, via the cricoid cartilage (Fig. 4.13).

Muscular and connective tissue structures connect the hyoid to the cricoid cartilage via the larynx, and finally to the cricopharyngeal muscle as part of the UES (Fig. 4.13). The cricopharyngeal muscle is the caudal part of the constrictor pharyngis inferior.

Figure 4.14 provides an overview of the muscular connections of the hyoid bone.

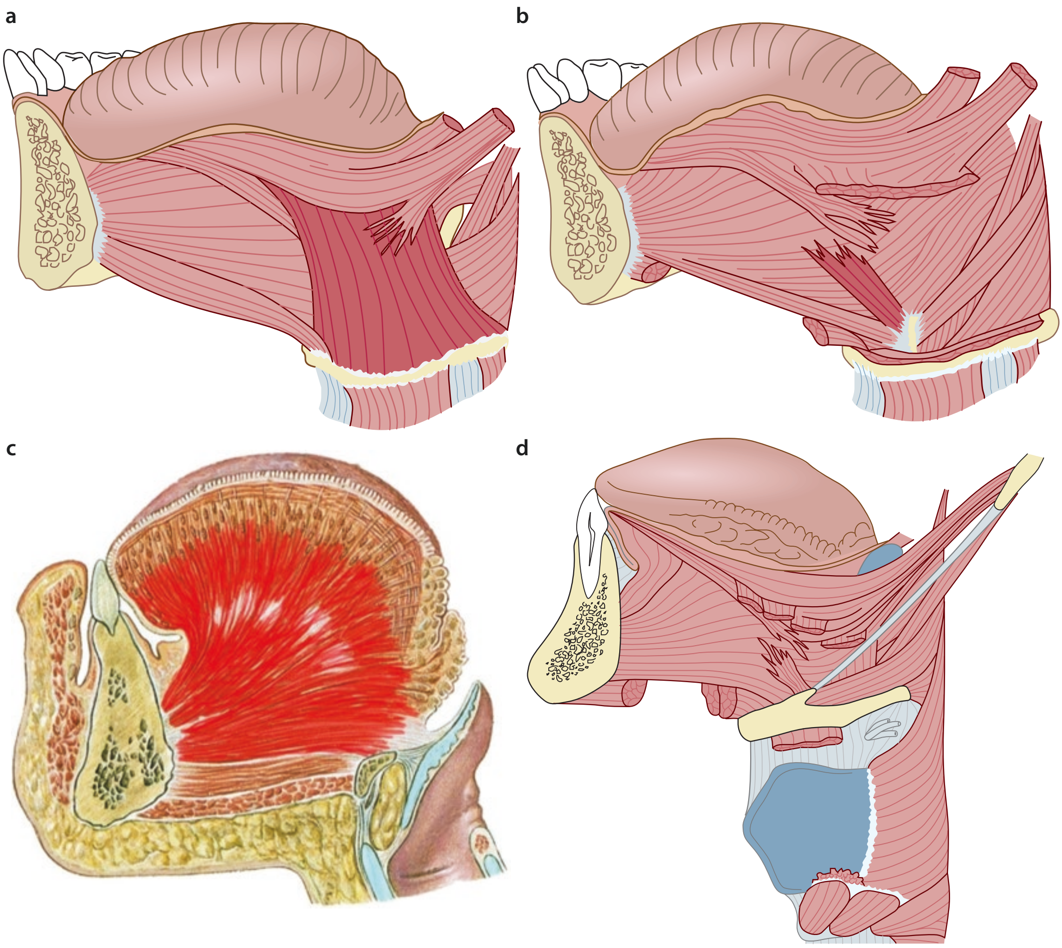


Fig. 4.11 **a–c** Muscular connections between the hyoid bone and tongue. (© Gampp Lehmann 2019. All Rights Reserved). **a** Hyoglossus muscle. **b** Chondroglossus muscle. **c** Genioglossus muscle. **d** Anchoring of the tongue between the mandible, hyoid, and temporal bones

Practical Tip

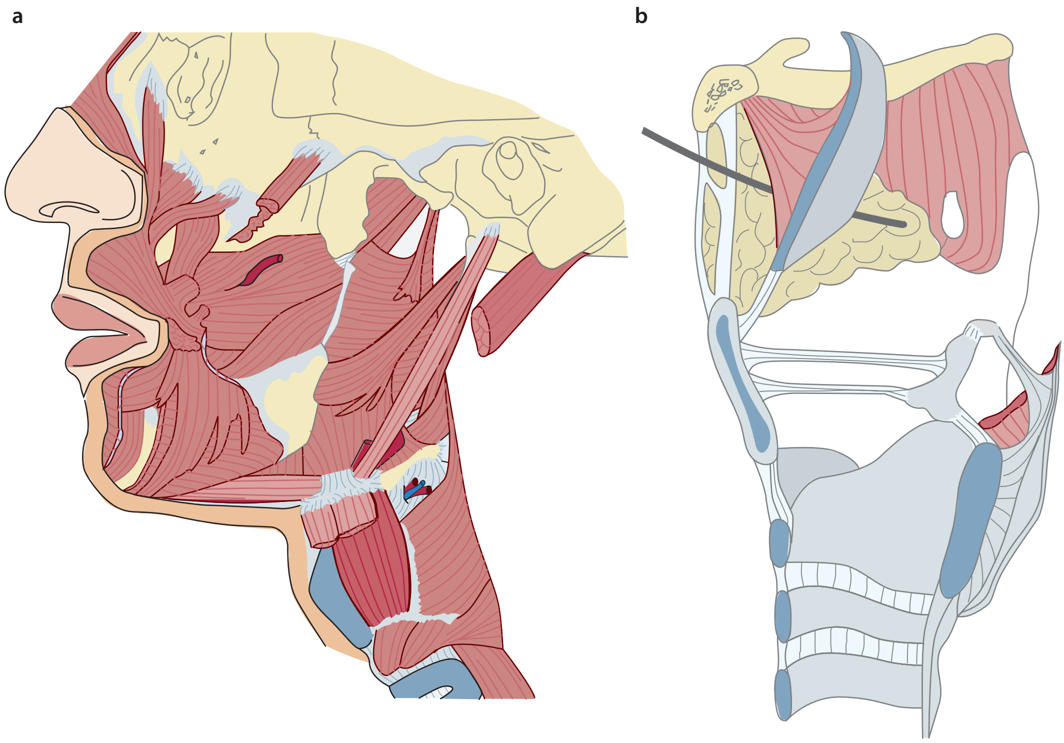
The more freedom of movement the *hyoid bone* and larynx have (particularly the ability to move ventrally/cranially during swallowing), the earlier and faster the UES will open (Garon et al. 2002; Ishida et al. 2002; Paik et al. 2008; Sasaki 2007). When treating *UES opening dysfunctions,* F.O.T.T. places special emphasis on the functional regulation of the structures lying above the UES. Therefore, a functional opening disorder of the UES always begins with *pelvic position*, that is, *upright physiological posture and breathing* are preconditions for treatment.

4.2.9 Thoraco-abdominal Connections

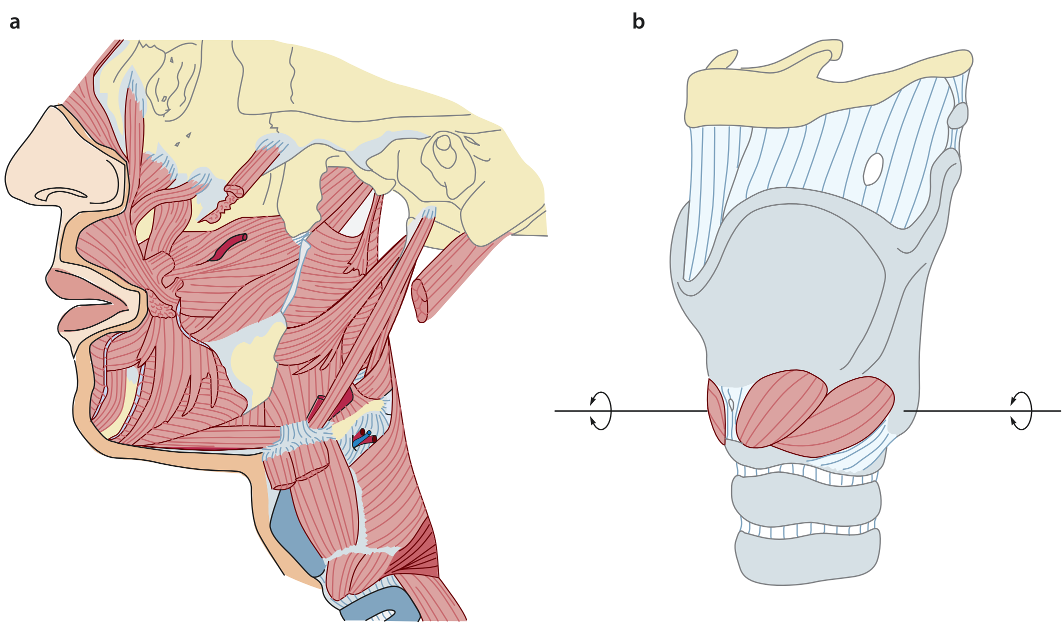
The following section describes the *fascial connections* (beginning from the thoracic diaphragm) which have an influence cranially to the base of the skull. They are therefore able to have a direct effect on the structures relevant to swallowing.

Fascias

As one of the fundamental germ layers from which all body tissues derive (with the exception of the skin and mucous membranes) *mesoderm* is the *developmental origin of fascia*.



■ **Fig. 4.12** **a, b** Larynx (© Gampp Lehmann 2019. All Rights Reserved). **a** Location of the thyrohyoid muscle, which pulls the larynx towards the hyoid bone. **b** Larynx, sagittal section



■ **Fig. 4.13** Muscular connections between the larynx and cricoid cartilage. Cricopharyngeal muscle (caudal part of the constrictor pharyngis inferior) as part of the UES. (© Gampp Lehmann 2019. All Rights Reserved)

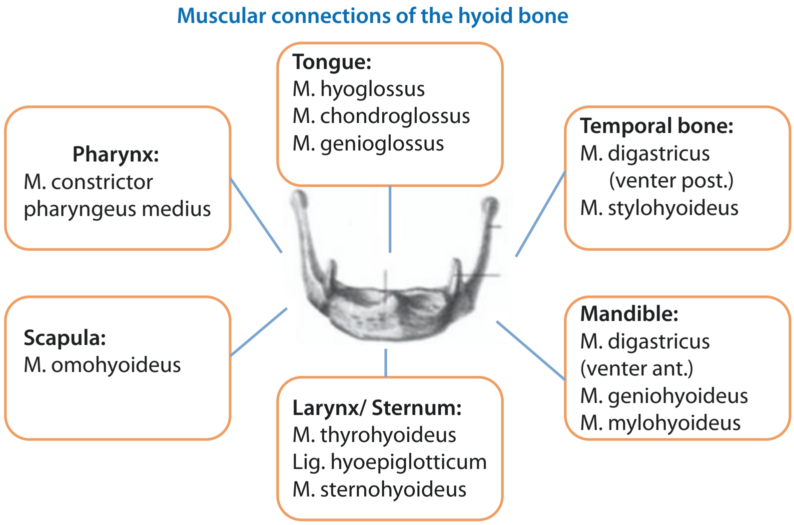


Fig. 4.14 Muscular connections of the hyoid bone. (© Gampp Lehmann 2019. All Rights Reserved)

In osteopathic literature, the term 'fascia' is synonymous with connective tissue. In terms of functionality there are grounds for using the terms interchangeably despite some differences in structure: the fascial–/connective tissue- system has a common function in the regulation of form and movement, ensuring both mobility and binding stability. At the first Fascia Research Congress in 2007 Findley and Schleip (2007) suggested a standard definition, which was expanded in 2009 by Huijing and Langevin (2009). According to this definition fascia is comprised of fibrous, collagenous tissues, which form part of a body-wide tension transmission system. Skin, bone, and cartilage are not part of the fascial network according to this definition as they derive from ectoderm.

Fascias form a *continuous unit of tissue* from head to foot, and from the outside to the inside. There is no break in fascial continuity. In biomechanical terms the attachment points of the fascias to bony structures are transfer points, or pulleys.

In his research and films Guimberteau (2005, 2013, 2015) showed that all tissue cells are connected by fascial connective tissue. He proved that there are no two-dimensional connective tissue layers but that all layers are in fact connected three-dimensionally, that is in all spatial planes (Guimberteau 2005, 2013, 2015).

Fascial tissues vary in their *structure* and may be dense (tendons, ligaments) and resilient (such as the fascia of the postural system) or very loose (glands, areolar tissue). The collagen fibres of fascias become tougher, relative to the amount of stress that they are placed under, and can therefore react to injuries and overuse (Paoletti 2006).

Fascias are present at all levels of the body as the *transmission system* for the forces which initiate and coordinate movement: they encase, support, subdivide, and connect (Paoletti 2006).

The Fascia Research Project (Schleip et al. 2012) determined that fascias are an important sensory organ, by virtue of the presence of innumerable, myelinated sensory receptors and an endless number of free unmyelinated nerve endings in great density. These play an important role in both proprioception and nociception.

Warning

Fascias can become *contracted* in the same way as muscles, for example, if they are not used and moved to their full, original capacity as a result of fixated posture or when being under constant stress.

Scars can create fixations and adhesions which interfere with the freedom and elasticity of fascia.

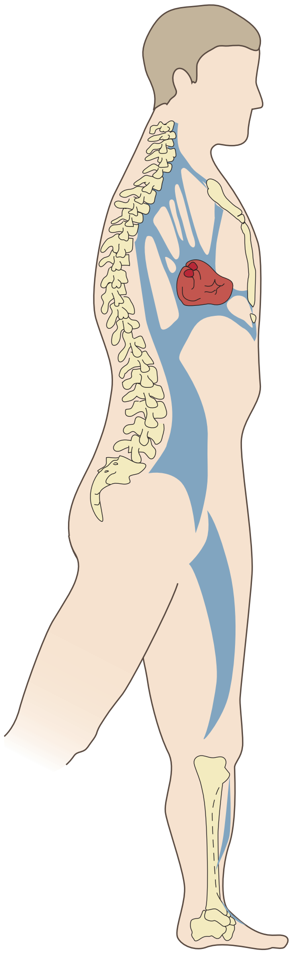


Fig. 4.15 Schematic illustration of the fascial connections which influence posture. Cranially from diaphragm via the pericardium to sternum, thoracic spine, and cervical spine. Caudally via lumbar spine, abdomen, and thighs, to the feet. The fascial lines of the upper cervical spine and skull are not shown. (© Gampp Lehmann 2019. All Rights Reserved)

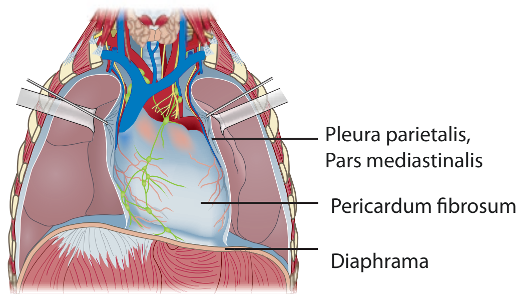


Fig. 4.16 Thoracic fascial connections. Anatomical illustration of the direct fascial connections between the diaphragm, pericardium, and parietal pleura. (© Gampp Lehmann 2019. All Rights Reserved)

Fascial Connections

There are both superficial and deep fascial connections also known as *myo-fascial chains.* In F.O.T.T. the *deep* fascial chains have particular significance because of their interrelations with relevant muscles and their influence on posture.

As part of the deep fascial chain, the *diaphragm* functions as both the interface and a shock absorber between the thorax and the abdomen (Fig. 4.15).

Fascial Lesion Chains

Fascial lesion chains are fascial chains whose physiological function is impaired by trauma, overload, or altered/restricted length ratios. Rather than transferring and distributing movement harmoniously they become *fixation points* from which irritation and movement disruption emanate. Malfunctions can continue along a fascial chain, triggering *dysfunction* in locations far removed from the primary lesion (Paoletti 2006; Schleip et al. 2012; van den Berg 2008).

The most significant fascial connections related to the work in F.O.T.T.

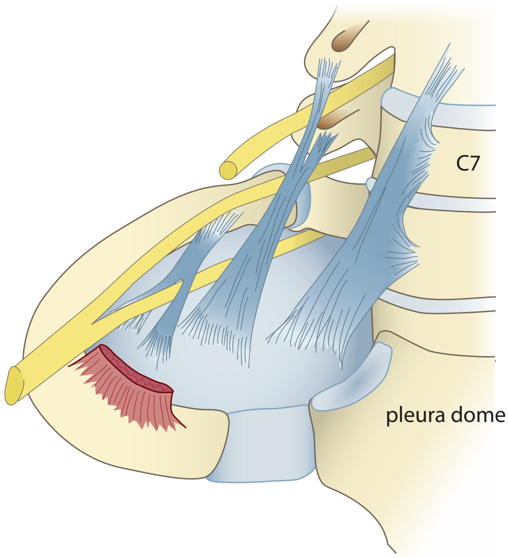
In the work with F.O.T.T., the *deep fascial connections* running cranially from the diaphragm play a significant role.

The fascial connections from the diaphragm run *cranially*, via the pericardium, pleura, and fascia endothoracica. They continue to the shoulder, cervical spine, and base of the skull or to the upper extremities (Fig. 4.16). The *diaphragm has the following* attachments:

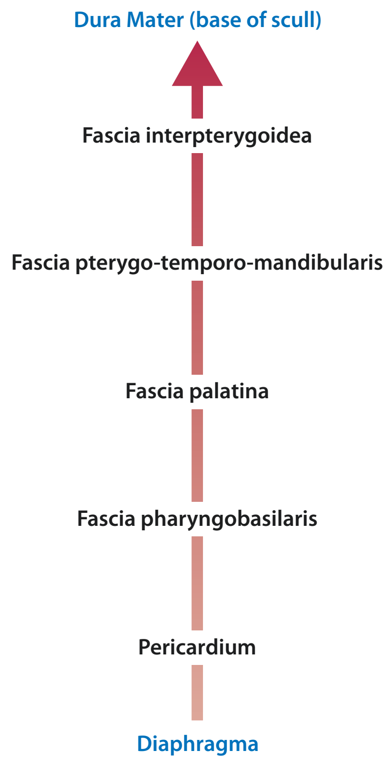
- Via the *pericardium* (which attaches directly to the diaphragm), it is attached by fascias/ligaments to C4-Th4 and the sternum (C6 = level of UES!) (Paoletti 2006; Souchard Ph 1989).

On one side the *parietal pleura* (pulmonary plexus) covers the upper surface and is inseparable from the diaphragm; on the opposite side it separates the pleural cavity from the organs

4



■ **Fig. 4.17** Fascial connections between the pleural cupula and the neck. The thoracic diaphragm arises from the pleural cupula (pleural dome), where the lungs and thoracic pleura interconnect. From this point, fascial connections pass across the pleural borders to the cervical fascia, at the level of the UES. (© Gampp Lehmann 2019. All Rights Reserved)



■ **Fig. 4.18** Description of the direct, deep fascial connections from the diaphragm to the cranial base. (© Gampp Lehmann 2019. All Rights Reserved)

within the mediastinum (corresponding to the inner layer of the endothoracic fascia).

Within the pleural cupula the pleura parietalis attaches firmly to the endothoracic fascia (inner wall of the thoracic cavity) to form the *cervical thoracic diaphragm* (■ Fig. 4.17). It is suspended at C6-Th1 (C6 = level of UES) by *strong ligaments*.

Microscopic and molecular studies by Lennerz et al. (2013) show contractile elements in the apical pleural suspensory system. According to their definition, this system includes 'all structures inserting into the apical parietal pleura that extends above the cranial edge of the first rib'. An examination of 112 pleural apices discovered a level of 66–87% contractile elements (striated contractile elements) in the apical suspensory system.

From the pleural ligaments the connections continue into the cervical fascia via the Fascia pharyngobasilaris (which encases the esophagus as well as the trachea), the Fascia palatina, and the Fascia pterygo-temporo-mandibulare, to the attachments at the cranial base (Paoletti 2006). The suspension of the pharyngeal raphe also forms part of the fascial connection and is described in ► Sect. 4.2.3.

Note

A connective tissue connection extends from the diaphragm to the cranial base (■ Fig. 4.18). *All* of the *structures relevant* for swallowing, speaking, and breathing are located within these connections!

The following *factors* can lead to *tension/ contractures* of the fascial connections:

- *Sitting for several hours* a day with a flexed trunk (ventral shortening).
- The *absence* or insufficiency of *deep breathing*. This can be caused by postural insufficiency, or weakness of the respiratory and accessory breathing muscles (particu-

larly the diaphragm, intercostal muscles, and spinal extensors). As a result, the excursion of the diaphragm is not complete during inspiration, caused by an elevated diaphragm with increased baseline of breathing leading to costal rather than diaphragmatic breathing; ► Fig. 8.5).

- Hence, holding the trunk erect or attempting deep breathing may cause *tension* in those fascias which are already restricted or contracted. The diaphragm then pulls on the cervical fascias, and swallowing and speaking are affected as a consequence.
- Lack of movement and lengthening can cause the structures to lose elasticity resulting in *constant tension*.

Practical Tip

Since the deep fascial connections running cranially from the diaphragm attach directly to the cervical fascias, their tension levels affect *freedom of movement* of the larynx and hyoid bone. They may also lead to *dysfunctional opening of the UES* or swallowing difficulties, for example undefined *globus sensations*. These patterns of shortening are often seen in individuals who spend many hours per day working in front of a screen. They are also found in patients suffering from trunk instability, as described in ► Sects. 4.1.1 and 4.2.4. The author's experience in *practice* has shown that *manual lengthening* of the relevant, deep fascial chains is effective in treating the dysfunctional patterns described above. This in turn reinforces the necessity of paying special attention to a physiological seated posture.

In patients with *neurological deficits,* musculoskeletal restrictions are usually present as *secondary* symptoms, and these can limit normal postural functions significantly (Horak 1991; Shumway-Cook and Woollacott 2007).

Connection: Postural Background and Swallowing Capability

Detoledo et al. (1994) conducted a retrospective study of 36 adults with a history of perinatal brain injury who developed spinal deformities (causes included perinatal hypoxy and meningitis), highlighting the *link between postural background and the ability to swallow*. Oral nutrition was possible during the first and sometimes the second decade of the patients' lives. However, over the course of time, the difficulties with swallowing became so severe that oral nutrition was no longer possible. Patients had to be supplied with a feeding tube. The researchers attributed the increasing difficulties with swallowing to deterioration in the postural backgrounds of the patients (strong kyphoscoliosis, contractures of the extremities were common).

4.3 Therapy

Treatment begins with an assessment of the patient's capabilities and ability to perform particular activities. *Hypotheses* are then formulated (often more than one); these are then tested during *treatment* and modified where appropriate.

Although it can be assumed that every patient has the potential to learn, it is impossible to predict from the outset whether this learning potential can be accessed and whether all or only part of the physiological movements can be relearned. Only the course of therapy will show whether therapists are able to provide the patient with an appropriate learning environment and opportunities for further development or rediscovery.

4.3.1 Physiological Movements and Starting Positions

One of the goals of F.O.T.T is to assist patients in regaining physiological, safe, and economical movements. The *prerequisite* for learning new or complete movements is a musculoskeletal system with as few limitations as possible. Horak (1991) describes this in the following way:

> In the task-oriented approach the musculoskeletal system is considered a critical element of control in motor coordination. As a result major effort must be placed, if possible, on identifying and correcting constraints placed on movements by deficits in the musculoskeletal system.

The *secondary restrictions* resulting from shortened fascias and muscles may interfere more with the learning of a physiological movement than the primary changes to the sensorimotor system. Restrictions in raising or extending the tongue may not necessarily be caused primarily by altered sensorimotor skills or a supposed 'strength issue', for example. They may be a result of secondary shortening of the muscles, ligaments, or fascia. Resolving secondary limitations may therefore make certain physiological movements possible (patient example, ► Sect. 4.3.2).

Integrating the entire postural background and all functionally interrelated structures is therefore one of the principles of F.O.T.T. (Gampp Lehmann et al. 2020).

Practical Tip

The *learning environment* should be designed to favour physiological inputs and prevent secondary restrictions and compensations as much as possible.

An *appropriate starting position* should provide the patient with the opportunity to experience physiological activities mainly without the use of compensation. This is facilitated by the use of 'external' support (e.g. therapist's hands or appropriate pads) for a certain period of time as a replacement for the patient's own lack of stability.

Choosing an appropriate starting position varies with the *objective of the particular therapy session*.

► Example

- If the therapy session is aimed at *increasing the selectivity of the tongue*, the most appropriate starting position for the patient may be *side lying* (◘ Fig. 5.9). This position offers a larger supporting surface, and the jaw support grip can be used to provide additional stabilisation of the lower jaw.
- For the same patient, the goal of *generating a stronger voice* may necessitate a starting position in *standing* (◘ Fig. 5.12) or *walking* (◘ Fig. 5.11).
- If the focus is on the coordinated use of breathing and vocalisation for the *initiation of phonation*, the initial starting position might be *seated* at the table with the upper body resting forward and the arms supported. ◄

Warning

Initially *compensatory aids or techniques are usually avoided* during F.O.T.T. in order to keep all possible paths open for learning economical, physiological movements. Based on the understanding of motor learning, therapists should attempt to stimulate the original, *automated process* first (► Chap. 3).

If compensation is trained from the outset, the extent to which full motor function may be restored cannot be assessed.

The patient should experience *small changes* of the chosen position during the course of therapy. Thereby it can be assessed whether the chosen starting position supports a particular selective function or whether it creates a 'fixated' position.

Practical Tip

- *Starting positions* must be varied during the course of therapy, in order for the patients to experience their influence on movement patterns. The newly acquired knowledge can then be transferred to other situations/positions to support the patient's anatomical structures to function in physiological length and strength ratios.

- Only as much *support* as required for physiological movement should be provided.
- The more *variable* and *varied* the movements and actions are, the greater the probability of restoring a wide range of skills. The patients are better prepared for daily life in which body positions change constantly (Shumway-Cook and Woollacott 2007; van Cranenburgh 2007, ► Chap. 3).

If the appropriate physiological starting positions (as described above) are not provided for the patients, these are forced to compensate. They will make unphysiological/uneconomical movements which result in *secondary problems*. These may include more choking without concurrent safe protective mechanisms, for example, or limited tongue mobility caused by increasingly fixated hyperextension of the upper cervical spine, and an altered position of the hyoid.

Practical Tip

F.O.T.T. *does not offer uniform approaches* but works together with the patients to find *potential solutions and strategies*. It is necessary to understand and *experience personally* the position or level of tension which patients experience when they are being served food or drink.

4.3.2 Patient Examples

The following case studies illustrate the interrelations described in this chapter.

As therapists this approach obliges us to work consistently and to *cooperate* with the patient's relatives and carers. This cooperation is time consuming, but is the *only chance* we have of intervening effectively, efficiently, and cost effectively – and maintaining credibility.

4.4 Mr. A.B., Aged 39

Case History

- Multiple posterior circulation cerebrovascular ischemia. Differential diagnosis: protein c/s deficiency. Acute deep cerebral syndrome at initial Glasgow Coma Scale 7 for 2 more months. Temporary tracheal cannula during the first month. Percutaneous endoscopic gastrostomy (PEG) tube since 10 days after admission. Right-sided incomplete tetra spasticity. Neurogenic bladder dysfunction. Severe neurogenic dysphagia. Severe dysarthrophonia.
- Neurological rehabilitation for 1 year followed by transfer to a nursing home and biweekly physiotherapy. Fourteen months after initial ischemia, the physiotherapist and F.O.T.T. therapist also took over the treatment of the facial–oral tract with the aim to improve and increase the intake of food.

Main Problem

Physical condition

- **A** After admission to the nursing home
- **B** After 2 years of physiotherapy and F.O.T.T.

Trunk

- **A** Noticeable shortening of the left side (pusher syndrome) and hypertonic; right side hypotonic. Sitting straight impossible initially, spine strongly convex to the right. Pelvis posteriorly tilted. Upright trunk position in standing initially prevented by strongly flexed posture, equinus foot position (30–40° on both sides) and limited knee and hip extension. Upper body flexed at 40° ventrally. Walking not possible.
- **B** Reduced over-activity (muscular) in sitting and standing. Patient is able to straighten himself when asked. Walking with an upright trunk and climbing stairs possible if assisted by another person.

4

Arms

- **A** Right arm hypertonic with strong tension in flexors, particularly as an associated reaction.
- **B** Increased basic tone level of the flexors, but improved selectivity and spontaneous use assisting the non-affected limb.

Legs

- **A** Both hips in spontaneous medial rotation. Equinus foot position above 30° on both sides, consequently both hips and knees strongly flexed in standing. Supine, slight flexion contractures below 10°. Special shoes to compensate for equinus feet and to support the ankles.
- **B** Equinus foot position of 20° on the right, 10° on the left. Special shoes. Standing upright and walking with assistance.

Breathing

- **A** Adequate involuntary coughing, but only minimal voluntary deep breathing. End-inspiratory pause not possible, diaphragm can be only minimally activated voluntarily.
- **B** Full deep breathing, breath can be held briefly in all breathing positions.

Head

- **A** Hyperextension of the upper cervical spine (CS) resulting in a backward lean of the head. Actively and passively head and upper CS can only be brought to the neutral position and flexion of the upper CS is not possible. Muscle tension is palpable and visible throughout the neck, face, and mouth area.
- **B** Slight active flexion of the upper CS possible, passive full flexion of upper CS possible.

Facial-oral Tract

- **A** The lower jaw is usually open and pulled dorsally. Constant drooling. Closing the mouth can only be maintained briefly, with full concentration. The tongue, base of the tongue and hyoid bone are pulled posteriorly. Voluntary tongue movements can only be partially executed. The tongue can be moved as far as the lower lip. Lateral movements to the right are limited. The eyes are usually opened widely.
- **B** The mouth is kept closed more often. If tired, the mouth opens spontaneously, but can be kept closed if asked. The tongue, base of the tongue, and hyoid bone are positioned normally, but with slightly increased dorsal muscle tension. Full selective tongue movement. Tongue movements to the right require more concentration. The face is more relaxed, eyes opened normally.

Swallowing

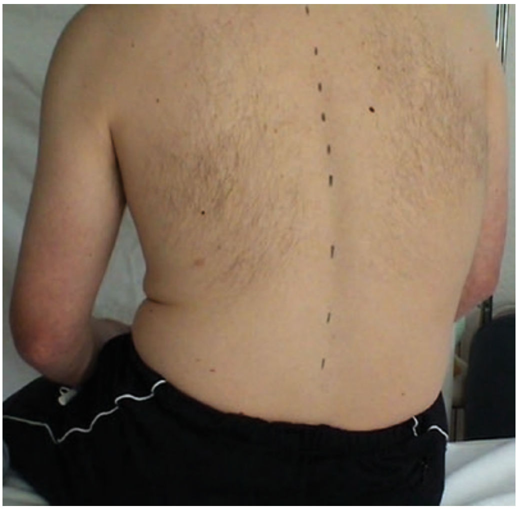
- **A** Some random, partly uncoordinated, and insufficient tongue movements occur in the oral phase. Laryngeal and hyoid movements during swallowing are restricted, with concomitant slight extension of the upper cervical spine each time. Frequent strong coughing when chewing food in gauze.
- **B** Still difficulty with swallowing, depending on the food bolus. The tongue and floor of the mouth perform several pumping movements before swallowing is triggered. Hyoid and laryngeal movements are complete, with slight hypertension of the corresponding dorsal musculature.

Eating

- **A** Via PEG tube. Gradual transition to a normal diet, in consultation with family physician and with regular pulmonary control. In coordination with physiotherapy/F.O.T.T., from selective pureed food to soft cooked food.
- **B** Has progressed to a completely oral diet (soft cooked food such as vegetables, pasta, meat, lettuce, and soft fruits). Chewing is possible. Liquids continue to be provided via PEG tube but are also taken orally under supervision.

Working Hypotheses

- Many of the issues described above resulted from *secondary contractures*, supplementary to the primary neurological deficits.
- These contractures inhibit the available motor system activities. They can



■ **Fig. 4.19** Prior to therapy: Fixed waist folds on the left side caused by secondary internal shortening, resulting from postural deficits. (© Gampp Lehmann 2019. All Rights Reserved)

be influenced by treating the thoraco-abdominal connections (tissues, fascias, muscles), head position, and connections of the hyoid bone. In order to connect to and build upon existing motor skills, the secondary tone disbalance must be resolved. The posterior pelvic tilt is a consequence of hip flexor contractures, an insufficiently erect trunk, pusher symptoms, and internal thoraco-abdominal shortenings.

- The same applies to the sitting posture which is strongly shifted to the right, and the fixated waist folds on the left side (■ Fig. 4.19). These are a consequence of secondary internal shortenings which can only be compensated with effort. The reduction in deep breathing is secondary to a posture-related, elevated diaphragm and has therefore not improved.
- The tongue is insufficiently mobile ventrally/anteriorly due to hyperextension of the upper CS, shortening of the hyoid muscles dorsally, and shortening of the deep caudal connections of the tongue (■ Fig. 4.20).
- The same applies to decreased laryngeal and hyoid movements. The tension in the entire facial area and widely opened eyes are both signs of tone disbalance in the upper CS region, as well as an insufficiently erect trunk.

■ **Fig. 4.20** Prior to therapy: Restricted tongue mobility. The tongue cannot be extended further or selectively moved to the right due to secondary shortening. The resulting strain increases overall postural asymmetry. (© Gampp Lehmann 2019. All Rights Reserved)

Therapeutic Approach

The patient has attended two 45 min F.O.T.T. and physiotherapy sessions weekly. Occupational and speech therapy were added later on. Treatment takes place in close cooperation with carers from the nursing home. They also assume the responsibility for additional, supporting activities. The *treatment sessions* are initially divided as follows:

- *One physiotherapy session per week* for the extremities, trunk, and general motor function. The treatment focuses on the contractures in the legs, the deep inner fascial connections, upright posture, breathing, and standing. Later sessions focus on walking and the initiation of normal motor functions in general. The patient regularly stands in a standing frame in the nursing home.
- *One weekly F.O.T.T. session* centers on the facial–oral tract, and the controlled dietary transition. The upper CS and hyoid

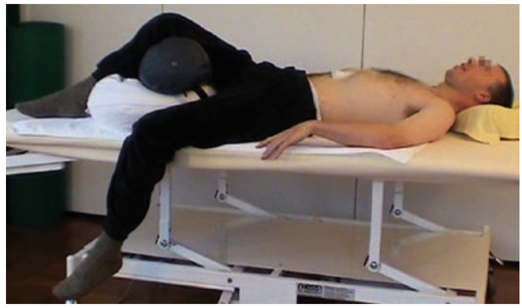
connections are brought into functional balance, in a variety of starting positions. The motor functions of the face, tongue, and swallowing are developed. Chewing exercises begin and are later followed by the transition to normal nutrition. This work is progressed and integrated into the everyday routine by carers at the nursing home.

Staff at the nursing home is eventually able to take over both the dietary transition and regular walking. As a result of this, and organisational and financial reasons, treatment frequency is reduced to once a week after a period of 2 years.

The weekly *speech and occupational therapy* sessions have continued over 1 year. Work has continued to focus on breathing, speech, functional use of the hands, and the use of communication tools. Speech is still dysarthric and difficult to understand but continues to improve.

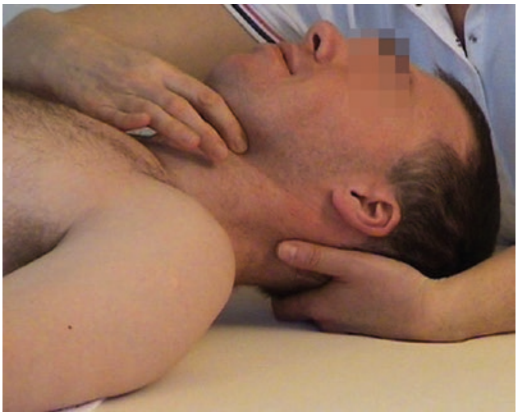
Sample Treatment Structure: Establishing Physiological Length Ratios and Uncovering Existing Motor Skills

- The aim of the treatment is to *reduce secondary shortening* (▶ Sect. 4.3.1). The already weakened motor system does not have the strength and endurance to cope with these restrictions, which ultimately impede its functioning.
- The following *manual techniques for lengthening and release* are carried out in the supine position, allowing the relevant structures to be placed in a symmetrical position.
- Mr. A.B. is placed in a position which allows tone to be released. Depending on the specific contractures and spasms, the extremities may require a tone-regulating preparatory treatment and may be supported by pillows.
- The patient's *position* is modified, allowing the lower part of the left leg to hang over the edge of the bed without pain. This increases the intensity of the stretch for the contractures in the muscles of the left hip. The leg is not abducted. Pillows are used to raise the patient's right leg, allowing the lumbar spine to maintain a comfortable middle position. The knee is slightly flexed (◘ Fig. 4.21).
- The position selected facilitates *deep breathing* into the shortened left side (upper thoracic breathing is limited by gentle pressure applied to the sternum (◘ Fig. 4.22). The dorsal upper CS can be extended in flexion, and the connections of the hyoid bone can be worked on (◘ Fig. 4.23).
- The *waist folds* and the already described restricted ventral tongue movement could be noticeably affected during one session.

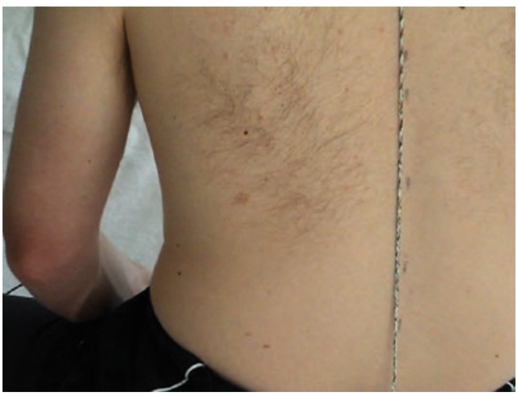


◘ **Fig. 4.21** Therapy: Individually adapted tone-regulating position for lengthening. The shortening on the left side of the thorax and hip flexors are lengthened, with the spine in a neutral position. This position pre-stretches the fascial connections optimally. (© Gampp Lehmann 2019. All Rights Reserved)

◘ **Fig. 4.22** Therapy: Assisted deep breathing. Adapted starting position encourages lengthening. The upper cervical spine remains slightly flexed, upper thoracic breathing is inhibited to promote diaphragmatic breathing. The thoracic fascial connections from the diaphragm to the base of the skull are stretched. (© Gampp Lehmann 2019. All Rights Reserved)



◼ **Fig. 4.23** Therapy: Lengthening the upper cervical spine and hyoid connections. The upper cervical spine remains slightly flexed whilst the hyoid connections are carefully elongated in all possible directions. (© Gampp Lehmann 2019. All Rights Reserved)



◼ **Fig. 4.24** After one therapy session: The waist fold could be released after one treatment. Balanced sitting is no longer structurally impeded (see ◼ Fig. 4.19). (© Gampp Lehmann 2019. All Rights Reserved)

Approximately five further sessions were required to fully resolve these issues. After each session, the progress achieved must be integrated into everyday life and used immediately (◼ Fig. 4.24).

Results

Within half a year of biweekly therapy, this approach yielded the following results:

- It is possible for the patient to actively hold the pelvis, trunk, cervical spine, and head erect and in alignment. *Upright posture* therefore requires much less of the patient's (muscle) energy, which is now available for selective activities and participation in everyday life. Sitting posture in the wheelchair can be adapted accordingly, walking is promoted, and food intake is safer and more controlled.
- *Deep breathing* is expanded and can now be improved further.
- The cervical spine can be held in a physiological position.
- The *mouth* and *lower jaw* can be kept closed without strain.
- The *hyoid muscles* exhibit normal length ratios. As an immediate result the patient is able to move the tongue further and with more precision (◼ Fig. 4.25).

◼ **Fig. 4.25** After one therapy session: Increased range of motion of the tongue. The available motor activity of the tongue is no longer structurally impaired, improving motor function available (see ◼ Fig. 4.20). (© Gampp Lehmann 2019. All Rights Reserved)

The success of this treatment depends on integrating the newly acquired mobility into everyday activities immediately, and on continued support for the development of motor skills, for example, during breathing, eating, drinking, and speaking. The results could be sustained and even improved in further therapy sessions.

Follow-up 10 years after: The patient is able to walk independently with a rollator and nutrition is fully oral and safe. His speech is more fluent and intelligible than after the described therapy.

4.5 Mrs C. D., Aged 60

Diagnosis

- Amyotrophic lateral sclerosis (ALS). Predominantly bulbar symptoms.
- Swallowing difficulties, beginning 6 months prior to onset of physiotherapy.

Disease Progression

- Initially Mrs C. D. received outpatient physiotherapy for *respiratory problems* but *swallowing difficulties* and *unsteady gait* came into focus shortly thereafter.
- Spontaneous speech is already difficult to understand. Dysarthrophonia and dysphagia are increasing, Mrs. C. D. communicates by handwriting as long as possible. The unsteadiness of gait increases steadily; a walking stick is required, progressing to a walking frame.
- Mrs C. D. receives physiotherapy including F.O.T.T. up to two times weekly. At home she is cared for by family members, friends, and an external nursing service.
- In addition, she receives intensive inpatient treatment at a specialist hospital for 3 weeks, approximately once a year.
- The patient becomes dependent on a wheelchair 3 months after onset of physiotherapy. Six months later, a PEG tube is placed to ensure an adequate supply of liquids. She then communicates exclusively by means of a communication device. Up until 1 year after onset of physiotherapy/F.O.T.T. she consumes soft food (yoghurt, muesli, fish, diced and soft cooked poultry, pasta, potatoes, vegetables etc.). Enteral nutrition is used only when necessary, for weight control.
- Six months later, oral food intake became impossible and the primary objective of F.O.T.T. changed to maintenance of the spontaneous and safe swallowing of saliva.
- Mrs C. D. was relieved from her suffering, and she passed away 4 years after diagnosis.

F.O.T.T. Treatment Focus

- Due to the rapid progress of the disease, particular attention was paid to the *preservation of available activity*. Special emphasis was placed on the prevention of tone-induced tension and secondary contractures caused by paralysis, to ensure the functioning of available motor skills. Mrs C. D. had very good body awareness and was highly motivated. The optimal therapeutic approach could therefore be developed in consultation with the patient: This experience was very rewarding and instructive for the therapists involved in her treatment. The increasing weakness and eventual *loss of independent trunk and head control* became a severe problem leading to associated difficulties with oral food intake.
- The patient suffered from a retracted and sometimes *painfully tense tongue* from very early on. It was often impossible for her to move the tongue towards the lips actively, making eating more difficult.
- Weakness of breathing and tension in the tongue also meant that *speech* became incomprehensible relatively rapidly. Unfortunately, it was not possible to influence this positively.
- Treatment focused on the preservation of trunk and head mobility, at least passively, and the deepest possible respiration. The structures of the cervical spine, the tongue, and the hyoid complex were treated, to enable *the tongue to actively move to the lips* and to trigger *several swallows*. The patient reported that this loosening of structures and the subsequent improvement in tongue and hyoid mobility could be maintained for 2–3 days after each therapy session. In the long term, this allowed oral food intake to continue for as long as possible. This objective was met, until 4 months before her passing away.

Therapeutic Approach

Each 45 min *therapy session* began with the support of *mobility of the extremities*. It was achieved by the regulation of tone levels, in a supine position (or an upright position, for as long as possible). This was followed by passive (stretching of the thoraco-abdominal and hyoid connections) and active (breathing techniques) facilitation of *erected trunk posture* and *breathing*, also in a supine position. The last 15 min were dedicated to the *motor function of the facial-oral tract*, beginning with passive lengthening of the tongue. The patient was seated, with a physiological position of the head with slight upper cervical flexion. Motor sequences were performed such as tongue movements and swallowing small amounts of liquid or saliva.

Preparatory work on the trunk and *breathing* created a foundation for all subsequent work on the hyoid complex and other facial-oral structures and functions.

Practical Tip

- Regulation of tone of the cervical spine and hyoid complex as well as the thoraco-abdominal connections are achieved in *relaxed, supine position*.
- The (preferably physiological) conditions established can then be combined with other activities such as swallowing and, if possible, vocalisation, coordinated with respiration. This takes place in sitting or standing with an *upright posture* and appropriate support.
- Progress must be transferred immediately into other therapies and particularly into *everyday life* to maintain the status quo and improve motor skills.

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Eating and Drinking – Involves More Than Swallowing

Doris Müller and Jürgen Meyer-Königsbüscher

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Trailer

Regaining and maintaining functional physiological movements is a main concern for patients who are unable to eat, drink, and swallow. They are also missing out on the pleasure and the social involvement in shared mealtimes (participation).

This chapter describes routes to safe eating and drinking, based on the Facial-Oral Tract Therapy (F.O.T.T.) approach. First, different aspects of normal food intake will be examined, enabling a broader perspective on the swallowing sequence. Then the structural, functional, and activity-related issues will be reviewed, in an everyday context. Finally, this chapter describes therapeutic work around the theme of nutrition (such as therapeutic eating and assisted meals) and discusses the safety aspects relating to oral nutrition. It will be illustrated why communal eating is a very demanding goal for many patients.

5.1 Normal Food Intake

> Eating and drinking is an important part of daily life. Apart from nourishment and pleasure, it provides a basis for daily interaction with our fellow human beings, and the nurturing of social connections. (Müller 2004, personal communication)

When analysing a function in the context of F.O.T.T., the initial attention is focused on its *physiological pattern of movements*. Then deviations from the norm are assessed. This enables to recognise and describe *functional disorders*, and generate *hypotheses*, based on the underlying causes. A *treatment plan* can then be formulated, and therapy initiated.

The process of food intake is multilayered and complex. However, no healthy person wonders about this process. Eating and drinking accompany social interaction. When we meet with other people, it is often combined with eating together. Consuming food can be the central theme in some social situations, in others it is secondary. ► Overview 5.1 lists the characteristics of normal food intake.

Overview 5.1 Characteristics of Normal Food Intake

Normal food consumption is
- Complex
- Safe and automatically controlled
- Central or secondary in social situations
- Integrated into daily life with enjoyment

► Example

Imagine: At a daughter's wedding, the family and relatives are seated at a large, festively decorated and fully laid table. The waiter has already served the main course to all the guests and wished them 'bon appétit'. Most people have experienced a similar situation. The guests pay attention to the food. They sit on the chairs, turn to the neighbours, and ask for the spices. They cut off a piece of meat, raise it with the fork to the mouth. They turn their heads to look for the children, chewing the meat, and adjusting their sitting position at the same time. They straighten up, change the position of their legs and feet, and raise their glasses to the newlywed couple.

In a situation of celebratory togetherness, food intake plays a central role. It is a complex, multilayered and yet automated process. ◄

Looking at ◘ Fig. 5.1, it is clear that food consumption is not the main focus. It is an aspect of the liveliness and communication at the table, and *food intake is integrated into the situation*. The complexity of this is particularly reflected in the *variations of the pre-oral phase*: the slicing of a pizza, the holding of cutlery or a glass, and the forward-leaning of the upper body. People communicate, and take part in the conversation at the table, to varying degrees. The image also highlights the fact that a healthy individual is able to adjust its posture according to the circumstances; to sit asymmetrically, cope with distractions, and involve the hands when speaking, or to touch the face and body.

❯ In some situations, food intake is a central issue, in others secondary, it happens casually.

Fig. 5.1 Merry society, eating together at a long table. (© Müller 2019. All Rights Reserved)

Whilst associating with others, healthy individuals are able to handle different functions and activities of everyday events almost simultaneously. During common meals, eating and drinking are automated; despite the complexity of the situation, and regardless of whether the consumption of food is of central importance or secondary. Healthy individuals adapt to the situation, engage in social interaction, eat and drink, and talk and laugh.

5.2 Eating and Drinking in Neurological Patients

In patients with neurological disorders, the fundamental conditions for everyday activities such as eating and drinking are altered:

- Amongst other things, they have problems with the awareness, sensibility, and coordination of posture and movement.
- They are often unable to alter their posture without effort and strain.
- They have movement limitations, which make it impossible for them to turn their head, move their trunk, or change the position of their legs and feet, for example. They are unable to grasp objects and raise food towards their mouths.

► Example

Hemiplegia may force a patient into an asymmetric posture that he cannot resolve. He has coordination problems during movements, which affect everyday activities. These problems are also reflected in the facial-oral tract, and manifest as impaired or asymmetrical movements. ◄

> Sensorimotor problems impair movement and the coordination of motion sequences. They affect the entire body, including the trunk and the position of the head, and continue in the facial-oral tract.

For details on the psychosocial importance of eating and drinking, note Elferich (2001). The author focuses on the technical and ethical aspects of dysphagia rehabilitation and examines the psychodynamic processes involved in normal food intake, and their alteration in disturbed oral food intake. Elferich describes common patterns of behaviour seen amongst patients, team members, and relatives; during nihil per os (NPO), and also during the transition to a normal diet. In a quantitative case series, Kjaersgaard (2013) summarises the impact of dysphagia from the patient's perspective. Tube feeding, the impact of dysphagia in the social context of meals, and the neuro-rehabilitative therapeutic approach are emphasised as topics of particular importance.

5.2.1 Typical Problems During Eating and Drinking

The problems which typically arise during eating and drinking are summarised in ▶ Overview 5.2.

Overview 5.2 Typical Problems During Eating and Drinking

- Complex activities deteriorate.
- The quality of movement changes.
- Eating becomes 'hard work'.
- Eating and drinking become unsafe.

Many patients with neurogenic lesions are unable to talk and walk at the same time; other patients drool, because they cannot sense their saliva whilst listening or engaged in activity. Complex activities represent a major challenge for these patients. They are often unable to listen whilst eating, or to join in the conversation at the table, by storing food in the cheek in order to talk.

Poor coordination of posture and movement during everyday activities can lead to the deterioration of complex activities, which require doing things simultaneously. The quality of movement may alter dramatically. Movements become inefficient, seem to be ineffective, and are no longer harmonious but rather unphysiological. This leads to increased muscular tone and fixation in certain positions, which may also cause pain. Every movement requires particular effort, and meals become 'hard work'.

5.2.2 Eating and Drinking Become Unsafe

Despite these problems, many patients feed themselves orally or are fed orally. Patients are fully focused on the intake of food, without further capacity for a conversation.

Some patients begin to talk during a meal and are not able to control the bolus adequately. There are a number of consequences:

- Food falls out of the mouth.
- Penetration/aspiration of food into the larynx, at best 'answered' with a strong cough, followed by a clearing swallow.
- Certain consistencies, for example solid or liquid, can no longer be ingested easily.

The food supply is therefore modified, for example food is provided in a pureed form. Many patients require external assistance to cope with the challenge of eating. Participation in social interactions involving food is often impossible to manage or even avoided.

> If the activities necessary for food intake are too complex for the patient, food intake becomes unsafe. Protection of the lower respiratory tract is no longer granted. This is an alarm signal, as aspiration can cause life-threatening complications.

Different stages must therefore be included in the rehabilitation of eating and drinking disorders (▶ Overview 5.3).

Overview 5.3 Treatment Stages for Eating and Drinking Disorders

- Establish a sufficiently safe swallowing sequence, and competent secretion management (▶ Sect. 5.6.2).
- Work with therapeutic food intake, mobilising the patient's personal resources of dealing with food in order to facilitate the best possible movement sequences for common daily activities.
- Specific food consistencies are used to elicit selected movements relevant to everyday life (▶ Sect. 5.5.2).
- Consider all context factors in a patient's specific situation, in order to determine the best time to begin, and the optimal type of food to offer.
- Begin the transition to an oral diet.
- Expand the food quantity and the variety of consistencies offered.

- Guide oral ingestion, following the approach of assisted food intake (► Sect. 5.7).
- Integrate food intake into the daily context (initially with therapeutic support).
- Involve relatives and team members.

During all stages take into account that the body functions are limited affecting activity and sensory context.

The long-term goal is to achieve safe eating and drinking, with enjoyment and possibly in company enabling participation.

5

5.3 When Is Eating and Drinking Safe Enough?

The following *questions* must first be considered:

- Which conditions must be met, in order for ingestion to be safe?
- What capabilities must neurological patients have, in order to be guided back to safe, oral nutrition?

5.3.1 Food Intake Encompasses More Than the Pharyngeal Phase

5.3.1.1 The Pharyngeal Phase – A Crucial Consideration

Physiological processes in the pharyngeal phase are described in detail and uniformly in literature (Logemann 1983; Neumann 1999, etc.). With the propulsive force of the tongue – in particular, the base of the tongue – the bolus of food blended with saliva is transported into the pharynx. Via pharyngeal peristalsis the bolus is then moved onward towards the esophagus. The hyoid bone and closing larynx move upwards/forwards, and the upper esophageal sphincter opens. The nasopharyngeal space and lower airways are closed during this process, and therefore protected from the entry/penetration of misdirected material.

The pharyngeal phase is important…

The word swallowing is often used as a synonym for the pharyngeal phase.

This phase is important, as the respiratory and digestive tracts intersect in the pharynx. If food is not effectively transported and the airway adequately protected, the entry of food into the larynx and the vocal folds – *penetration* – or even beyond the vocal folds – *aspiration* – is the dreaded consequence. In the pharyngeal phase, it is decided whether the food or the saliva ‘takes the right path’. Therefore, it is important to assess competencies, problems, and, consequently, the safety of the patient by means of functionally focused clinical diagnostics, which at best is underpinned by diagnostic imaging.

! Aspirating food or saliva into the lungs can cause severe complications, including life-threatening aspiration pneumonia.

… but that’s not all!

However, therapy focusing solely on the pharyngeal phase may also cause problems:

- The pharyngeal phase is only one part of the swallowing sequence.
- The patient and therapist cannot directly influence this phase.
- Relevant therapeutic resources are not fully utilised.
- Therapeutic potential of the patient is underestimated.

Influencing the swallowing process indirectly

It is not possible to support the structures and movements used in the pharyngeal stage of swallowing directly. But tactile input in the mouth can be used to influence the oral phase. The oral part of the tongue can be touched and moved and this has a sensorimotor effect on the tongue’s pharyngeal performance during swallowing.

Tip

The pharyngeal part of the tongue can indirectly be affected by
- Passive movement of the tongue
- Facilitation by stimulating the oral part of the tongue and/or
- Stimulation at the base of the mouth, and movement and positioning of the head (► Sect. 5.3.3)

Involuntary swallowing

During the pharyngeal phase, neither the patient nor the therapist can directly influence the reflexive parts of the swallowing sequence. The term swallowing *reflex*, which is frequently used as a synonym for the pharyngeal stage of swallowing, highlights the feeling of ineffectiveness which therapists and doctors have with regard to influencing the pharyngeal phase of swallowing (► Sect. 1.1.1, reflex vs. reaction).

Tip

If a stimulus (in this case, to the area of pharyngeal mucosa) is not answered by the appropriate, involuntary process (coordinated excitation of the pharyngeal, laryngeal, and esophageal muscles), how can a useful, therapeutic intervention be achieved?

To answer this question, food intake needs to be examined from a broader perspective, which looks beyond the pharyngeal phase.

Food intake from the perspective of the Bobath concept

> "People generally perform these activities in the same basic economic way. If a patient cannot perform one of the activities in this way, the therapist must discover why he cannot do so. The answer to the "why" will later become the basis of the treatment. She will try to enable the patient to carry out the movement normally and economically again." (Davies 2000)

Observation and evaluation of the normal food intake and the swallowing of saliva shows that swallowing is characterised by predictable processes and movement patterns. The typical qualities of normal movement during food intake are described in ► Overview 5.4.

Overview 5.4 Typical Qualities of Normal Movement

- It is efficient, flowing, and coordinated harmoniously.
- It is directed towards a goal and is task oriented.
- The sequence is adapted to requirements.
- The movement sequences and patterns are similar for different food/drink consistencies, but not uniform.
  - A number of studies suggest that swallowing, specifically the pharyngeal stage (► Sect. 5.3.2), is adapted to specific circumstances (e.g., characteristics of the bolus, Kahrilas et al. 1993; Robbins 1996; Sawczuk and Mosier 2001; Yao et al. 2002; Leopold and Daniels 2010).
  - Several studies support the view that swallowing is not a stereotypical reflex, but is controlled in a similar way to other sensorimotor functions (Yao et al. 2002; Gross et al. 2003; Leopold and Daniels 2010). In F.O.T.T. the term *reaction* instead of *reflex* is used, for example swallowing reaction, gag reaction, and coughing reaction.

► Example

When a person eats a piece of apple or a spoonful of apple puree, the process is similar but not the same. Eating apple puree does not require biting and chewing. Using imaging techniques such as videoendoscopy and videofluoroscopy it is also apparent that the two food consistencies are not transported through the pharynx in the same way. Amongst other things, this is reflected in a differing pharyngeal transit time for the bolus (Bisch et al. 1994). ◄

5

F.O.T.T. – the broader perspective

According to Coombes (1996) the process of swallowing is very variable – and open to influence. Not only different types of food or consistency play a role. It is important to look at the intake of food as a whole, not just the most critical, that is, the pharyngeal phase. Kay Coombes used her knowledge as a Bobath tutor to analyse the normal movement patterns of swallowing and food intake, and came to the following conclusions:

> Preceding processes such as posture, body movements, the involvement of the senses (feel, see, smell, taste) as well as movements within the mouth are crucial for an effective pharyngeal phase.

The complexity of the food consumption is familiar from everyday life. Everyone's experience is used intuitively, to make drinking safe.

► Example

Drinking from a bottle (or even a spouted feeding cup) could be done with extreme caution, if lying supine. To avoid drinking too much at once and to control the flow of liquid into the mouth one would have to use hand and arm movements, and control the position of head, lips, and tongue. Would one prefer to turn onto the side and support oneself, or sit upright?

The supine position – with its typical, accelerated force of gravity on the liquid – would force everyone to cough, and make swallowing unsafe.

Think about a neurological patient in the intensive care unit, who cannot be moved into a sitting position: How can the patient possibly eat a meal in a so-called 'upright' position – actually, lying in bed just with a raised headboard? ◄

This point of view also encompasses additional fields, which influence food intake:

- Posture/tone
- Breathing
- Articulation movements
- Facial movements
- The coordination of these movements

Some components of facial and articulation movements are also used in food intake, for example, the lips and tongue. The lip -and tongue movements with relevance to daily life can be facilitated, whilst the abnormal movement components which are typical of neurological patients are simultaneously inhibited. Unhelpful movements of the lips include:

- Hyperactivity of the less affected side, in cases of hemiparesis
- Evasive movements
- Associated reactions
- Change of muscle tone (*spasticity* or *hypotonicity*, so-called plus or minus symptoms)

The patient's path to more normal, efficient movements can be supported and facilitated.

► Overview 5.5 illustrates the therapeutic approach.

Overview 5.5 Therapeutic Approach

- Developing a safe swallowing sequence.
- Developing efficient protective mechanisms.

The goal is for both functions to be performed automatically as and when necessary, in different position, during all daily activities, and in variable contexts.

At the same time:

- Taking other areas of influence into account: posture/tone, breathing, articulation and facial movements, and their coordination.
- Facilitating physiological movements with everyday relevance (e.g. bolus formation).
- Limiting/inhibiting abnormal movement components that interfere with save functions.
- Avoiding movements which are purely 'exercises', not adapted to the functional competence of the patient, and which do not involve variation or have a connection to daily life.

This treatment approach has proved successful for severely affected neurological patients in early rehabilitation. Detailed analysis of existing movement components is also necessary for mildly affected patients, with circumscribed dysfunctions affecting swallowing and food intake. When combined with hands on techniques for guiding the sensorimotor processes, a foundation for safe swallowing can be established.

F.O.T.T. is more than just 'swallowing therapy' for neurological patients. It also addresses the factors and conditions which affect the daily intake of food, in order to develop normal movement patterns, and allow the patient to relearn and access these whilst eating and drinking, and in daily life.

5.3.2 The Swallowing Sequence

» Swallowing is a daily activity characterised by quickness, high levels of coordination, variability and automation. Economical movements based on sensory information and normal movement patterns, are essential for effective, involuntary swallowing. (Müller in Gratz and Müller 2004)

F.O.T.T.'s broader approach to the swallowing process views food intake as a *sequence of processes*, which build on each other. Each phase influences the next phase of the sequence.

The swallowing sequence according to Coombes

The swallowing sequence is comprised of four phases, outlined in ► Overview 5.6.

Overview 5.6 Phases of the Swallowing Process

Pre-oral phase

- Postural background:
  Upright pelvis; relaxed, symmetrical shoulder girdle; head in a central position; long neck (slight flexion of the upper cervical spine).
- Goal-oriented movements, which involve the sensory channels and perception:
  - The hands prepare the food.
  - The hand and arm transport food to the mouth.
  - The movement and the position of the body and limbs are perceived.
  - Eyes (nose and ears) – the senses – gather information about the preparation of the food.

Oral phase

- *Bolus formation:* Reducing the food to small pieces and mixing it with saliva.
- *Bolus transportation:* The tongue transports the bolus horizontally through the oral cavity into the pharynx.

Pharyngeal phase

- Vertical bolus transport towards the esophagus with coordinated airway closure.

Esophageal phase

- Vertical transport from the upper esophageal sphincter towards the stomach.

Inadequate: an isolated view…

… on the individual phases or movement components!

When the entire process is taken into account, and food intake is seen as a *swallowing sequence*, this is the logical conclusion. It is not sufficient to evaluate the individual nerves, muscles, or movement components in terms of their function and effectivity. *Coordinated movement patterns* and their functional interrelationships – such as breathing and swallowing – must be assessed, and influenced by therapy (► Chaps. 4 and 8).

Tip

The postural background – and therefore the pre-oral phase – affects movement ability in the oral and pharyngeal phases, and thus also affects safety. It is important to note, and make use of the fact, that each phase influences the phase that follows.

Developing the pre-oral phase in patients with disturbed perception is particularly important. Sensory information about the ongoing process, in the activities of daily living (ADL) must be conveyed (Affolter and Bischofberger 1996; Hofer 2009). Only then can the patient 'comprehend' the situation and execute appropriate movements during the oral phase. Without sufficient sensory information, the patient might bite the glass he is supposed to be drinking from, for example. In this context, Gratz (2002) developed the approach of an expanded pre-oral phase. In addition to the preparation of food, the term may also include collecting the ingredients, or even shopping and cooking together with the patient.

The effectiveness of work which is activity-based and centered around the patient's everyday life, has been well documented by research. Motor learning takes place during activities related to daily living, particularly if they reproduce the domestic situation of the patient (Mulder and Hochstenbach 2001). Neural plasticity is experience-specific (Kleim and Jones 2008; Robbins et al. 2008; Martin 2009).

Tip

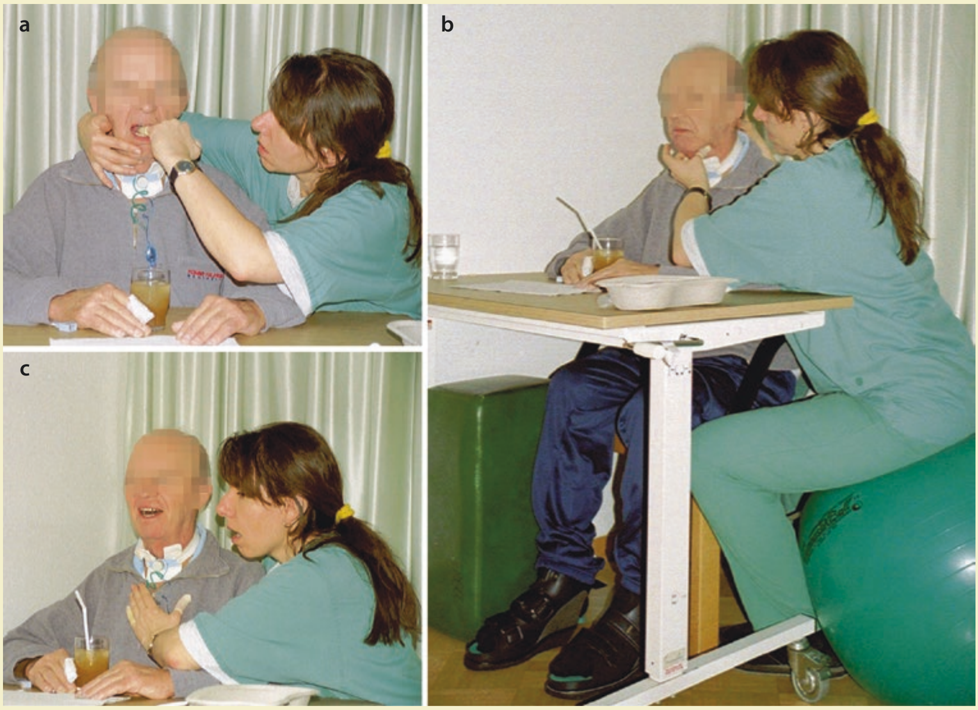
When considering safety
- The pre-oral phase is often underestimated.
- The oral phase is also frequently underestimated.
- The pharyngeal phase is mistakenly considered in isolation.

Therapeutic consequences

Considering food intake as a swallowing sequence provides the therapeutic team, the patient, and their relatives with an opportunity to modify the process of swallowing, eating, and drinking to make it more effective and therefore safer. The pharyngeal phase can be positively influenced by:
- Involving the hands, bringing them in contact with relevant objects, e.g. the food
- Assisting the postural background, position of the head, coordinated jaw and tongue activity
- 'Preparing the mouth' by means of stimulation through movement, and increased tactile input

Tip

General considerations and examples:
- The *'before and after'* of the pharyngeal phase can be influenced by the methods of therapeutic eating and drinking, the assisted meal, and oral hygiene. Fundamental interrelationships, such as posture and breathing, must be taken into account. For many patients, tooth brushing in a supported position will trigger more frequent swallowing.
- The work focuses on the enhancement and development of sensorimotor skills, in order to achieve functional goals: Managing postural background and touching the tongue often helps with the swallowing of saliva.
- The monitoring of whether the approach has created a change, for example, is the voice no longer 'wet' after swallowing? This means that the patient was able to remove, and then swallow, residues from the vocal folds.
- Paying attention to movement quality and use techniques, such as the jaw support grip, to influence it.
- Adjusting the position of the head.
- Assisting dynamic stability of the lower jaw, by using the jaw support grip, adjusted to the capabilities of the patient. Stabilising the jaw from the beginning of oral bolus transportation, until the end of the pharyngeal phase.
- Providing swallowing assistance to the base of the mouth, thus
  - Stabilising the jaw
  - Initiating or supporting transportation movements of the tongue
  - Making residues perceptible, for example in the epiglottic vallecula (■ Figs. 5.2b, 5.4b, and 5.8b.)



■ **Fig. 5.2** **a**–**c** Developing an adequately safe swallowing sequence with Mr. B. (© Müller 2019. All Rights Reserved). **a** The therapist touches Mr. B's tongue. **b** Swallowing stimulation, or an aid to swallowing, follows. **c** Voice control: was swallowing effective?

► Developing an Adequately Safe Swallowing Sequence

Mr. B. normally moves around in a wheelchair. Now he is seated on a chair at the table, in an adjusted posture. A foam block has been placed between the wall and his right leg, so that the patient experiences the wall as a stable surface. After preparing the patient's postural background in this way, the oral cavity is cleaned in a structured way and the cuff of the tracheostomy tube (TT) is deflated. The TT is closed with a speaking valve for short periods. Mr. B. can still exhale easily and fluidly – now via the larynx and pharynx (► Chaps. 9 and 10 for information on TTs).

Mr. B. holds a glass of cold apple juice in his hand (■ Fig. 5.2a). He has already tasted the juice with his finger and swallowed promptly. The therapist now touches the patient's tongue in a targeted way, applying light pressure. Her gloved finger has been moistened with some apple juice, in order to stimulate increased movement and saliva production via the taste stimulus. By means of the jaw support grip applied from the side, the patient's head position is supported using the therapist's right arm.

After touching the tongue, the therapist facilitates swallowing (■ Fig. 5.2b). Her right hand is placed on the occiput, supporting the long neck position of the head. The thumb and middle finger of the left hand stabilise the lower jaw bilaterally, and lift the posterior, oral part of the tongue through the base of the mouth. Mr. B. swallows.

The voice is evaluated after swallowing (■ Fig. 5.2c). The therapist feels Mr. B.'s breathing rhythm, helping him with exhalation and coordinated use of the voice. At the correct moment she uses her voice together with his, rather than prompting him. Whilst exhaling, Mr. B. is able to articulate a strong, clear 'a' sound for 5 seconds. No saliva has collected on the vocal folds, and no rattle can be felt in the sternal area. These are clinical signs of a safe, 'successful' swallow. ◄

There is no 'magic grip', which works for all patients. Care givers need to become familiar with the complexities of everyday actions, such as food intake. Everyone must become a detective, in order to discover what helps an individual patient to perform effective and normal, everyday movements. This allows the patient to perform these procedures later without external help.

> Give the patient their body back! (Coombes 1992, personal communication)

5.3.3 Facilitation of Swallowing

> Efficient movement is dependent upon the ability to limit and combine movements selectively into the desired functional activity under a wide range of environmental conditions. (Graham et al. 2009, page 60)

Basics for facilitation of swallowing (swallowing support), according to F.O.T.T.

When treating patients with neurological swallowing disorders, the goal is the efficient and effective swallowing of saliva, food, and drink. In F.O.T.T., the key strategy is to enable patients to swallow whenever it is necessary. The patient is helped to sense 'the reason for swallowing' (saliva or food) and then efficient swallowing is facilitated. Efficient swallowing means with fewer pumping movements of the lower jaw, effective transport movements of the tongue, complete laryngeal elevation, etc.

The swallowing is facilitated, and tactile support given, to initiate swallowing movements. Hands-on support is used to ensure that movement patterns follow the normal, physiological pathways as far as possible. Both the dynamically stable and the mobile parts of the sequence need to be developed. A specific context must be created by the therapist. This is achieved through positioning of the patient, and supporting surfaces, for example, as well as bimanual work (e.g. stabilisation of the head and jaw, and mobilisation of the tongue for efficient swallowing, ◘ Fig. 5.4b). External, tactile support is decreased as early as possible, and treatment becomes increasingly hands off. The intervention selected for the patient is dependent on the clinical diagnosis, and the hypothesis which has been developed, with regard to the patient's main issue:

What helps *this* patient, in *this* position and situation, to swallow?

Listed below are swallowing aids, which clinical practice has shown to be useful. These interventions must be adapted to the capabilities and needs of the individual patient, using clinical reasoning. Two pilot studies on the efficacy of F.O.T.T. swallowing support have been presented (Müller 2012 and Jakobsen et al. 2019). Jakobsen et al. (2019) published a pilot randomized controlled study investigating the effect of nonverbal facilitation on swallowing in patients with dysphagia after severe acquired brain injury.

5.3.3.1 Direct and Indirect Swallowing Support

F.O.T.T. differentiates between *direct* and *indirect* swallowing support.

- *Direct swallowing support* for the jaw and tongue assists the patient to perform coordinated swallowing movements.
- *Indirect swallowing support* helps patients to sense residue, which makes swallowing necessary. This kind of support helps to initiate the swallowing sequence.

Direct swallowing support

Direct support can be used to facilitate movements in the swallowing sequence. This includes dynamic stabilisation of the lower jaw, and selective tongue movements during the oral and pharyngeal stages of the swallowing sequence, based on an optimised postural control.

Stabilisation of the lower jaw

> In human movement, selective movement of even a single joint is accompanied by activity that balances the unwanted forces at other joints. (Graham et al. 2009)

Many patients with neurological disorders of swallowing, eating, and drinking are unable to stabilise their lower jaw at the start of oral bolus transportation, as seen in clinical practice. Pumping movements of the jaw or even the corner of the mouth can be observed, although the lower jaw should provide a stable point of reference for selective tongue, hyoid – and laryngeal movement at this stage of the swallowing sequence (▶ Chap. 4).

The *jaw support grip* can be used to stabilise the lower jaw and assist mouth closure (▶ Sect. 4.2.6). The implementation of this technique can be adapted, from patient to patient. With this in mind, this tactile method of support should be used in such a way, that a stable reference point is achieved. The therapist himself-/herself must be in a very stable position, and the facilitatory grip must feel safe for the patient; that is, the grip must genuinely provide stability.

Tip

Suitable means of providing *stability*:
- The therapist creates a stable reference point for himself, by placing the weight of his arm on a supporting surface (◘ Fig. 5.3).
- The therapist provides a broad jaw support grip, adapted to the contours of the patient's jaw.

◘ **Fig. 5.3** Jaw support grip from the front. The therapist's hand is supported by the table, providing a stable reference point for the patient's sternum, and stabilising the jaw. In order for the patient to benefit from the jaw support grip, the second hand on the forehead optimises the position of the head towards the long neck position. Goal: The stable jaw permits selective movement of the tongue in the oral and pharyngeal phase (by reducing pumping motion of the lower jaw), and prompt onset of laryngeal movements, with a greater range of motion. (© Müller 2019. All Rights Reserved)

The therapist has all of the necessary utensils (toothbrush, cup of water, towels, food, etc.) prepared and within reach, in order to not have to abandon the hold temporarily.

▪ Indications of Successful Stabilisation of the Lower Jaw

- The intervention has proved helpful if the patient is able to accept the support offered, and there is a change in motor behaviour. For example, the patient releases some of the weight of his head into the therapist's hand during the jaw support grip, and the *patient's neck 'becomes longer'* as the hyperextension of the upper cervical spine is released. This generates a more appropriate alignment between the trunk, shoulder girdle, and head for the swallowing function (posture, ▶ Chap. 4).
- Swallowing alters
  - *Qualitatively*, for example pumping motion of the lower jaw prior to larynx elevation is reduced in frequency and/or range of motion, and the range of larynx elevation during the pharyngeal phase increases; coughing does not follow swallowing; the voice remains clear.
  - *Quantitatively*, that is, the patient swallows more frequently.

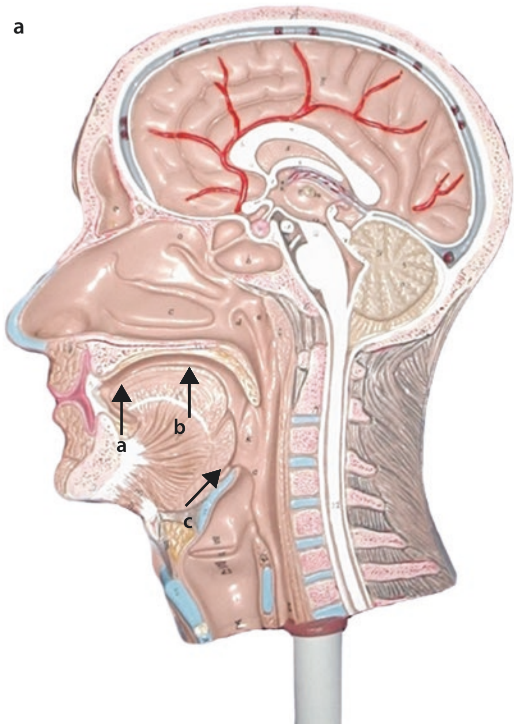
▪▪ Facilitation of tongue movements

The tongue is the main actor in horizontal bolus transportation during the oral phase, making contact with the hard palate in a wave-like motion, from ventral to dorsal. Thus, the bolus is transported into the throat. During the pharyngeal phase, the bolus is transported towards the esophagus via contraction between the back of the throat, pharyngeal constrictors and the tongue (from the dorsum to the base of the tongue).

▪▪ It is possible to facilitate parts of this tongue movement!

◘ Figure 5.4a shows a sagittal section, using vectors (a–c) to illustrate the direction of tactile input for various facilitatory options.

Depending on the functional status of the patient, the *goals of facilitation* will be as follows:



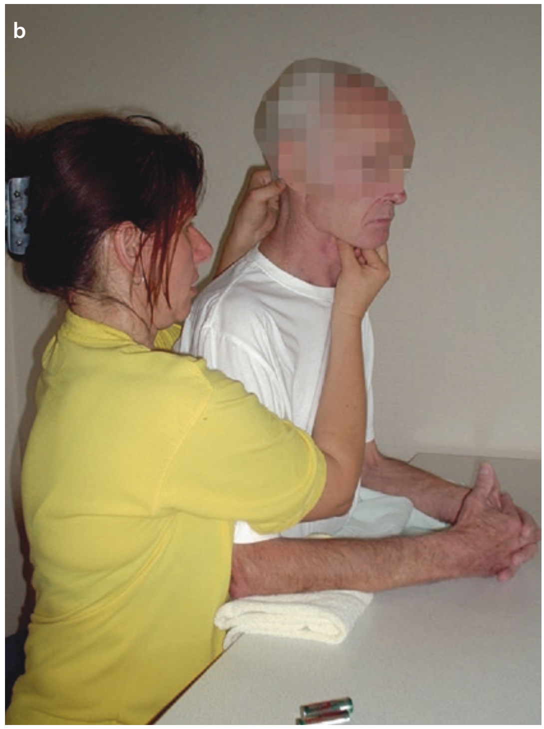


Fig. 5.4 **a** Sagittal model of swallowing support: Vectors a–c illustrate the movement directions in which the tongue can be facilitated. Bilateral positioning of the fingers is necessary for swallowing assistance in the vectors b and c. Please note: In the sagittal section, the spine is always shown verticalised – with shortened neck. The optimised starting position for swallowing is always a 'long neck'. **b** Facilitation for the elevation of the posterior, oral part of the tongue (vector b in Fig. 5.4a) Therapy sequence in assisted standing. (© Müller 2019. All Rights Reserved)

- To bring the front portion of the oral tongue into contact with the hard palate, thereby initiating or coordinating transport movement. The basic support for this facilitation is usually a classic jaw support grip, from the front (Fig. 5.3) or from the side (Figs. 5.6 and 5.2a). Swallowing can be facilitated using the middle finger, centrally and upwards, through the base of the mouth behind the chin.
- To help the back of the tongue with coordinated, onward transportation of the bolus (Fig. 5.4b). Recurring, uncoordinated movements often occur in neurological patients, and can be felt through the floor of the mouth. Clinically it can be observed that after facilitation of the contact between the back of the tongue and the hard palate there is often a clearer elevation of the hyoid and larynx.
- Dorsocranial movement of the pharyngeal part of the tongue. This mobilises residues in the area of the valleculae. Thus, residues are sensed more easily by the created contrast, which may elicit swallowing. Furthermore, the pharyngeal transport movement of the tongue is facilitated (Figs. 5.2b and 5.8b).

The characteristics of these aids to swallowing are summarised and listed in ▶ Overview 5.7.

Overview 5.7 Characteristics of Direct Swallowing Support for the Tongue Area

- *Stable lower jaw*, facilitated where necessary, by use of the jaw support grip (as above).
- *Selective guidance* of the *tongue* into a functional position. The tongue is grad-

ually guided into the desired movement, using a grip adjusted to the structures of the individual patient. The therapist must observe the patient's response carefully, noting whether the direction and input of the change are assisting the desired function of 'swallowing'.
- *Physiological and functional alignment* of the shoulders–neck–head region, lower jaw, lips, and a functional position of the tongue. Otherwise the floor of the mouth is changed in alignment and muscle tone. It may for example be so tight, that it is not possible to reach the tongue musculature with external tactile support.

Allow the patient time to respond to swallowing support. It is usually necessary to maintain tactile input for several seconds before the patient responds.

Warning

The following is not helpful in terms of assisted swallowing:
- Superficial, stroking movements across the floor of the mouth and neck. These are not appropriate for the facilitation of those structures involved in 'swallowing'.
- Quick, 'stirring' movements. These movements do not lead to the desired structural and functional changes in swallowing. They do not contribute to the spatiotemporal organisation of the motion sequence.

Indirect swallowing support

» One cannot feel, without moving. (Hofer 2009)

Indirect swallowing support helps patients to sense saliva and food residue. Automatic collecting and transportation movements are the normal responses to the perception of oral, and particularly pharyngeal, residue, as well as automatic swallowing.

To make *residues more easily perceptible*, movements or functions to mobilise them can be used. Awareness of the contrast is thus increased as described below.

Changing the position of the whole body, or sections of the body, for example shoulder girdle and position of the head

When changing position or moving sections of the body (e.g. correction of the head position, movement of the shoulder girdle and head) the change in structural alignment and gravity affects the position of residue in the oropharyngeal tract. This alteration creates a stimulus that is often easy to perceive for the patient and elicits swallowing (or coughing). Depending on the way in which the change of position is accomplished, the quality of alignment and adaptation of tone, the relevant structures can be moved in a more coordinated way for swallowing, leading to more effective swallowing.

Mobilisation of the tongue

Collecting and cleaning movements in a functional context (Fig. 5.10f), or by the therapist touching and moving the tongue (Fig. 5.10e) can elicit swallowing.

Tactile support of expiration, possibly with vocalisation

To mobilize residue spontaneously, transport movements (e.g. swallowing, throat clearing, coughing, or spitting) can be assisted, to help the patient towards an effective and coordinated swallowing function.

Conclusion

Sensory input (indirect swallowing support) is used to elicit motor responses and guide them using *facilitation (direct swallowing support)*. Both the method and focus of the intervention are dependent on the patient's functional resources and underlying problem.

In practice, jaw stability, activation and guidance of tongue movements, and swallowing aids are used in combination. It is important that structures are clearly and specifically assisted in terms of their function. In other words, grips and tactile support must have a clear, functional, orientation. They cannot be used diffusely, superficially, or in a stroking manner.

This approach presupposes function and activity-based knowledge of the normal movement patterns during swallowing, as well as close monitoring of the patient, and feed-forward activity on the part of the therapist. The patient should be helped to swallow when it is necessary; for example during transfers from bed to wheelchair, after coughing or clearing the throat, or in pauses during speaking (Sticher and Gampp Lehmann 2017).

Tip

All team members, as well as the family, should be familiar with the swallowing support that helps the patient most effectively. Professionals and helpers need to practice how to support the patient.

With this approach in mind, research findings on neural plasticity are implemented in everyday life. The brain manifests the best adaptive and learning changes, when a skill is guided, relearned, or practised intensively and repetitively, using variations which have daily relevance (Robbins et al. 2008; Martin 2009). This provides the patient with the best possible opportunity to relearn safe, efficient swallowing, which is automated and apt for daily life (▶ Chap. 3).

> » Without information (sensory input) there is no control, no learning, no change, no improvement. Afferent information is important for enabling accurate feed forward commands for movements. (Graham et al. 2009)

5.3.4 Recognising Functional Relationships

- **Normal coordination of breathing and swallowing**

Breathing and swallowing normally coordinate with one another, in a predictable way. Residues from the lower pharynx, or even the entrance of the larynx, can be moved by the exhalation which follows swallowing. As a result, the residue can be sensed more easily, the lower respiratory tract is protected, and residue can be transported into the upper pharynx and then swallowed. Even in healthy individuals, an exhalation is sometimes audible after swallowing.

The pharyngeal phase of the swallowing sequence is usually preceded by a slight exhalation; swallowing then takes place (breathing stops – swallowing apnoea), after which the exhalation continues (▶ Chap. 8). A number of studies have documented this process of exhalation–swallowing–exhalation.

Study Results

According to a study by Klahn and Perlman (1999), exhalation preceded swallowing in 93% of cases, and followed swallowing in 100%. Subjects in the study were fed.

In an analysis of 900 swallowing sequences, analysed for breathing-swallowing coordination, Hiss et al. (2001) reported that exhalation preceded swallowing 75% of the time, and succeeded swallowing at a rate of 86%. The authors found that normal test subjects use this safe swallowing–breathing pattern when they are unable to transport food to their mouths themselves, due to the design of the experiment.

Being fed food, a person has to ‘switch to more safety’, which means exhaling before and after swallowing. Residues are thus removed from the area.

Notes

People with normal sensorimotor function protect themselves by adjusting breathing-swallowing coordination, if they are unable to transport food to the mouth themselves.

Swallow and protection mechanisms are based on efficient breathing:

- Coughing and clearing the throat are made possible by coordinated, forced expiration.
- The pause in breathing required for swallowing is only possible if the body is supplied with sufficient oxygen. Otherwise continuous respiration – without a break – has priority.

A patient with noticeable difficulty in breathing has extremely poor preconditions for effective swallowing with adequate protective mechanisms.

In clinical practice, dysphagia is increasing in patients during ventilation or after weaning. Neurological findings are unable to account for this. According to the guidelines for neurogenic dysphagia of the German Society for Neurology (DGN 2008), the incidence of critical illness polyneuropathy (CIP) and myopathy (CIM) after long-term ventilation is 80%.

In an endoscopic examination of 16 CIP patients, Ponfick et al. (2013) found microaspiration of saliva and fluids in all subjects. That speaks on one hand for the importance of efficient and effective breathing for swallowing, and on the other hand for the fact that the two functions of swallowing and breathing should not be treated separately (► Chap. 10).

▪ Typical issues relating to posture, breathing, and swallowing

When being fed food and drink during self-experience workshops, (conducted as part of F.O.T.T. course), the participants (physiotherapists, speech therapists, occupational therapists, nurses) attempt to control the situation with the (pre-oral) movements and protective reactions available to them. Several observations can be made, and can be applied generally:

When food is fed, one compensates with an increased search for information, using additional eye movements, and inclining the head, upper body, or entire trunk forward. The aim of this controlled (re)action to the altered situation is to prepare for safety during the various stages of the swallowing sequence. Safe oral and pharyngeal transport, particularly of fluids, must be made possible and pre-oral 'accidents', for example spilling liquid from the glass that someone is offering, should be avoided.

Food quantity is controlled first and foremost, during the transition from the pre-oral to the oral phase. A 'central position with a long neck' is rapidly taken up which is more convenient for swallowing, in order to handle the pharyngeal phase safely.

Patients who need to be fed may have lost control over this process. Due to their impaired coordination, severely affected patients in particular have limited ability or are unable to use the aforementioned strategies for making food intake safe. They are therefore exposed to an increased risk.

► Example

A fixed body position or trunk instability can often prevent patients from moving themselves into a normal swallowing position and adapting their breathing economically in response to the demand. This is particularly the case as demands become more complex and must be combined with other functions, for example breathing and swallowing, but also breathing and phonation.

It is generally an effort for neurological patients to adapt their posture and movement efficiently to the circumstances:

Selectively holding the trunk upright and moving forward with the upper body is particularly difficult for the patient. In this position, and depending on the tone level of the trunk, the head may be unable to move freely (► Chap. 4). The body cannot move forward to assume some of the control to meet food. Differentiated adjustment of the head position is also a prerequisite for visual control of the process. The problems increase, when the food is presented from the side. ◄

▪ A comprehensive treatment approach is required!

The therapeutic consequence of these observations is obvious. When seeking to avoid aspiration, life-threatening pneumonia, and ensure safety, the dysphagia therapist must consider parameters beyond the assessment of the pharyngeal phase.

The importance of oral hygiene must be emphasised. This is a key area for F.O.T.T. therapists when using techniques such as tactile oral stimulation according to Coombes (► Sect. 6.2.4), initiating tongue and swallowing movements, and during the implementation of structured oral hygiene. These treatments are all closely linked to the themes of safety and pneumonia prevention.

Notes

- Treatment in the pre-oral and oral phase also affects the pharyngeal phase.
- Thinking in terms of functional relationships makes the analysis and handling of everyday problems easier. The therapist should be familiar with the coordination of breathing and swallowing, for example.
- The safe intake of food presupposes that the patient is able to manage his daily life largely in an automated way. If this is impossible, therapeutic interventions directed at daily live activities will be necessary.

Study on the Risk of Pneumonia

A study by Langmore et al. (1998) supports these observations. The authors examined the factors which make the occurrence of pneumonia more likely. One of the most significant predictor of pneumonia was that the patient needed to be fed.

Other relevant prognostic factors were found to be as follows:

- Confinement to bed
- Dependence on others for oral care
- The number of bad teeth
- Tube feeding
- More than one medical diagnosis
- Last but not least – smoking.

Dysphagia or swallowing dysfunction was not amongst the most relevant prognostic factors for pneumonia.

5.4 Safe Food Intake Is More Than Just Swallowing

» In order to prevent pneumonia, we need to look beyond any single factor, such as dysphagia, and focus treatment on all relevant factors. (Langmore et al. 1998)

A comprehensive interprofessional approach to dysphagia therapy is required.

5.4.1 Safety Aspects

"When can we start with oral intake, eating and drinking?" is an important issue for therapists and nursing staff in their daily work and during F.O.T.T. courses. This question is, of course, also a major concern for the patients themselves, and for their relatives. Unfortunately, there is no simple, universal answer to it. The F.O.T.T. approach aims to answer the following questions during clinical examination, often supported by instrumental imaging techniques:

- Is the postural background of the patient in a sitting position dynamically stable, or can it be supported well enough by the therapist?
- What is the position of the neck/shoulders?

Tip

- As a rule, patients should be capable of actively sitting for eating and drinking.
- Can the patients swallow their saliva? Are oral transport movements and pharyngeal movements sufficient?
- Patients who have a cuffed TT due to aspiration of saliva will also aspirate food.
- Can the patients cough effectively, whenever it is necessary?
- Coughing, when asked to do so, is not a criterion with everyday relevance.
- The patient needs to be able to cough when there is a risk of aspiration, and be able for a complete, protective mechanism. This means strong, spontaneous coughing, followed by swallowing (or coughing with subsequent spitting).

Warning

Consider the specific situation of tracheostomised patients!

Patients with a TT are functionally impaired, in terms of both coughing and swallowing (▶ Chap. 10).

If patients meet these criteria, *therapeutic eating and drinking* in a controlled situation can begin, as described below. If patients do not meet these criteria over an extended period of time, the therapist must look at additional factors, when assessing whether therapeutic eating and drinking carries too much risk. The positive effects of the early, controlled use of taste and food stimuli are well known in clinical practice. It has frequently been observed that patients swallow more effectively after preparation of the postural background, oral preparation, and subsequent flavour stimulation or feeding, rather than if there is only saliva to swallow. This is caused by the increased sensory input, the contrasts in flavour and sensory information of foods, and the focus on activities familiar to the patient.

❗ Notwithstanding the positive and stimulating aspects of providing food, any element of trial and error in terms of method is strongly discouraged. The patients should be prepared as well as possible for therapeutic eating and drinking and given optimal support. Therapeutic intervention must focus on evaluating and supporting all aspects of the swallowing sequence and protective functions.

5.4.2 Evaluating Factors Relating to Safety

Discussion between members of the treatment team, patients, and relatives, often centers on the assessment of the patient's situation in terms of safe food intake. Eating is one of the most important daily activities and has multiple levels of significance. A celebratory dinner is a special event for guests and for oneself. Being excluded from eating or drinking for a period of time, such as before and after an operation, for example, affects the well-being significantly. Not being allowed to drink, in particular, is a highly significant impairment for many patients, even if the supply of liquid and nutrients is assured via feeding tube. The inside of the mouth feels unpleasant during fasting or abstaining from liquids. And how can one recover one's strength without having solid food in one's stomach?

It is therefore unsurprising that controversy often surrounds the issue of food intake. Quality of life must be considered, which can lead to emotionally charged debates within the treatment team, or with relatives. Intellectual models which include clear but not one-dimensional criteria can help with decision-making.

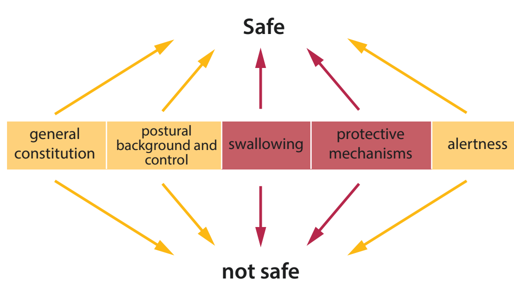
5.4.2.1 Safety-Related Criteria and Decision-Making

The following model was originally used in the decision-making process for weaning from TTs (◘ Fig. 5.5). However, the factors outlined can also be used as decision-making tools when considering the safety of oral food intake. Core factors and contributing factors are identified. If the core factors of 'swallowing and protective mechanisms' exist, but are insufficiently safe at that time, additional factors have to contribute to an appropriate level of security.

❯ Adequate safety: decision-making is individual for each patient, based on differing core and contributing factors.

■ The core factors

The most important aspects to be considered when assessing the safety of food intake are effective swallowing and effective protective mechanisms. These are referred to as core factors.



◘ **Fig. 5.5** Core factors (underlined in red): swallowing and protective mechanisms; contributing factors: alertness, handling and postural background and overall condition (Model: Lehmann & Müller, Clinic Bavaria, Kreischa, Germany). (© Müller 2019. All Rights Reserved)

Swallowing

Normal, safe swallowing (pharyngeal phase) and the swallowing sequence should provide the basis for any evaluation of swallowing. But when is the safety of swallowing sufficient? The decision is made more difficult by the fact that studies have shown that even healthy people do not swallow 'perfectly'. The study by Robbins et al. (1999) illustrates this vividly.

> Although none of the normal healthy subjects aspirated, the Penetration–Aspiration Scale did show that material does enter the airway in normal subjects during swallowing. However, it remains above the level of the vocal folds, a phenomenon we refer to as 'high penetration' and, in most instances (97% of swallows) is ejected from the airway before the completion of the swallow. (Robbins et al. 1999, page 231)

The same conclusion was reached during endoscopic examination of healthy volunteers with no swallowing dysfunction. In one case the examination results corresponded so poorly to the expected norm that the use of a TT might have been considered for a patient with the same results (W. Schlaegel, personal communication). Logemann also doubts the common criteria. She asks:

> Do we know what is normal and abnormal airway protection? (Logemann 1999)

This statement underlines the importance of evaluating normal functions, a fundamental principle of F.O.T.T.. Normal functions are both the basis and the primary goal of treatment. Protection of the airway is not guaranteed solely by effective closure of the airways and regular food transportation during the swallowing sequence.

Material which begins to penetrate into the larynx, that is 'high penetration', is expelled from the respiratory tract by a short exhalation. Therefore, safe breathing-swallowing coordination constitutes an essential aspect of protection.

Sufficiently safe swallowing can also be assumed if the patient demonstrates effective protection, in the event of penetration or aspiration. If there are residues in the throat, or above the vocal folds, the following must be assessed:

- Is the patient able to sense the residue which remains during therapeutic eating and drinking; remove it from the pharynx or laryngeal entrance by clearing the throat or rinsing the mouth; and spit it out or swallow it?
- How do variable factors such as a nasal tube, for example, affect swallowing mechanically?

Huggins et al. (1999) state:

- A nasogastric tube slowed swallowing in young healthy adults; however they were able to compensate adequately and still swallow safely with a nasogastric tube.
- A nasogastric tube may impair the recovery and rehabilitation of patients with dysphagia.

In recent years, the use of percutaneous endoscopic gastrostomy (PEG) has increased. Early tube insertion often establishes the conditions for a successful rehabilitation process, as it has frequently been seen that patients swallow their saliva much more effectively following removal of a nasogastric tube. For patients with a long-term need for artificial feeding, the German guidelines for neurogenic dysphagia of the German Society of Neurology (DGN 2012) recommend the use of a PEG 2 weeks after onset at the earliest for patients suffering from acute strokes.

Tip

If medical considerations delay the placement of a PEG, a therapy session without a nasogastric tube is recommended, during changing of the tube.

► Example

Using an endoscope it can be observed repeatedly that saliva runs downwards along the nasogastric tube, which acts as a type of rail, and penetrates in the larynx at the posterior junction. When this phenomenon is observed, patients constantly aspirate their saliva and often require a cuffed TT. They begin to swallow the saliva once the tube is removed, and safe therapeutic eating and drinking or the consumption of small meals is a viable option from this point onwards. ◀

Even in healthy individuals, the swallowing sequence tends to slow with age (Schaupp 2000). Delayed initiation of pharyngeal swallowing is also a characteristic *symptom* in neurological patients (Bisch et al. 1994, also referencing other studies with similar results). It is therefore understandable that a nasogastric tube can be the proverbial last drop that makes the cup run over for some patients. Bearing in mind the effects described above, the nasogastric tube can be the deciding factor, which makes swallowing too slow and therefore insufficiently safe.

Protective Mechanisms

Effective protective mechanisms are characterised by the following criteria:

- *Effective protective mechanisms are initiated automatically, at the appropriate moment and with appropriate force.*

▶ Example

The patients cough or clear their throat when they feel material entering the airway. This must be observed in daily life. Effective protective mechanisms need to be verified in daily-life situations. They cannot be reliably tested by asking patients to cough on demand. ◀

- *Effective protective mechanisms are productive.*

▶ Example

Material which has penetrated into the airway is transported back into the pharyngeal or oral area by coughing or clearing the throat. ◀

- *Cleansing actions are part of effective, protective mechanisms.*

▶ Example

Material which has been transported upwards into the pharynx must then be swallowed or spat out. There is a danger of it re-entering the respiratory tract if this does not occur. ◀

Functional prerequisites for effective, precisely coordinated coughing are as follows:

- Adequate movement patterns of the whole body: Coughing is primarily coordinated with flexion and forwards motion of the trunk.
- Sufficient potential for the build-up of pressure: Forced expiration requires coordination of the diaphragm, abdominal muscles, and accessory breathing muscles; the vocal folds must remain closed initially and then open explosively (▶ Chap. 8).

❯ A cuffed TT impairs the effective build-up of pressure when coughing, swallowing, and pressing (e.g. during a bowel movement).

Coordination of the core factors

For patients for whom pharyngeal residue, penetration and/or aspiration are an issue, it is particularly important to assess what occurs at critical moments. Key aspects for evaluation are as follows:

- The individual effectiveness of swallowing
- Protective mechanisms
- Their coordination

In addition to clinical assessment, imaging techniques (such as endoscopies) can help to shed light on an extended range of issues (▶ Overview 5.8).

Overview 5.8 Questions to Ask When Assessing Core Factors

- Under what circumstances does this patient swallow effectively and safely? (For example, pre-oral: How must the postural background be supported?)
- Does the patient swallow after coughing?
- How effective and spontaneous are the patient's protective mechanisms?
- How must the patient be assisted, in order to swallow and cough effectively?
- What preparation and follow-up is required in order for this patient to eat therapeutically or have an assisted meal safely?

Contributing factors

It is important to consider whether swallowing and coughing are sufficiently safe in themselves, or when the list of contributing factors is taken into account.

Alertness

Conscious patients who do not have significantly impaired perception and cognitive performance can contribute to the safety of food intake themselves. They can become experts on their own food ingestion capabilities.

► Example

These patients can check for themselves whether the meal they are served has been pureed sufficiently. They can lay the well-meant and decorative, but dangerous, parsley garnish aside, without eating it. ◄

Independent oral care following the meal is relevant to safety. Patients who are not cognitively or speech impaired can call if they have problems or require support or assistance.

All these positive aspects contribute to security, provided the patient is aware of the implications of the problem and not reckless.

Warning

Laypeople often assume that the ability to eat can be concluded from a patient's level of alertness and cognitive abilities.

Relatives and caregivers in particular tend to overlook the fact that the patients cannot solve their swallowing difficulties cognitively.

Postural background and control

Patients who are able to bring themselves into a dynamically stable sitting position when eating and swallowing are contributing to their own safety during food consumption. Food intake is generally safer for patients who are able to change the position of their trunk and head themselves (selective recruitment of the components of flexion), for example when preparing to cough. Patients who are unable to do this adequately are dependent on assistance from staff or relatives and therefore less safe. They must rely on the level of training and the attentiveness of their caregivers at home or in a nursing home and on the amount of time made available to them. If the patient is unable to correct his posture and requires assistance in critical situations, these external factors have to be secured in the context of the patient's everyday life.

Instructions for relatives and the provision of clear information for caregivers are essential. They are just as important as a critical reflection about the (often-limited) specific activating support the patients might experience in their context at home.

General constitution

If swallowing and protective mechanisms cannot be considered safe,

- It is necessary to assess the level of vulnerability and previous damage of the patient's lower respiratory tract and the lungs.

► Example

It is a warning sign if the patient has suffered from pneumonia at some point following the onset of illness or has pre-damaged lungs due to an additional medical condition, for example chronic obstructive pulmonary disease, etc. ◄

- Prognostic factors must be considered.

► Example

In some progressive diseases such as amyotrophic lateral sclerosis (ALS), marked deterioration to the point of a complete loss of the swallowing function and protective mechanisms are to be expected over the course of time. Since so far it has not been possible to halt this process, safety issues take on a different significance.

The patient, his family, and the team must clarify the definition of quality of life for the individual concerned. The needs of the person affected as well as the medical situation itself are at the forefront (► Sect. 4.3.2). ◄

Tip

Typical issues with progressive diseases:
- Would an early PEG placement ease pressure on the patient and his family, because otherwise they would have to pay constant attention to proper hydration – if even thickened drinks can only be sipped slowly?
- The insertion of a PEG system should take place if patients with ALS are suffering from dysphagia and have lost 5–10% of their normal bodyweight. It should also take place before forced vital capacity has fallen to less than 50% (Greenwood 2013).
- Would the patient prefer to continue eating food even if it is time-consuming and unsafe? Does he/she consider this one of the defining elements of his quality of life? Is he aware of the risks?

Conflicts can be avoided if
- Medical problems are clarified.
- Patients and relatives express their needs, these are taken seriously, and
- common goals and objectives are formulated.
- All parties involved agree on how to proceed.

Here too the therapist or team must weigh up the possibility of compromising safety to a certain extend to increase the patient's defined quality of life.

Notes on teamwork

Clear rules, for example regarding no food or drink or dietary restrictions during oral food intake, should be made known to all team members, relatives, and visitors. This particularly applies to patients who make functional progress but are still not permitted to eat food for safety reasons.

► Example

A patient with traumatic brain injury slowly awakes from a coma. He begins to move his non-paralysed side, grabbing things, and letting go. Gradually he tries to look at his visitors. The situation becomes closer to normal for the visitors. Small gifts such as fruit or favourite sweets are brought and offered to the patient to encourage recovery or give pleasure. ◄

Tip

Written information attached to the patient's bed or the intervention of nursing staff on duty can avert dangerous situations.

It may seem easier at first sight not to deal with the issue if a patient is eating or drinking when they should not for safety reasons. But the problem should clearly be looked at. Therapy should take everyday-life into account. It is most helpful if patient and therapist share a therapeutic goal and the desire to eat a particular thing can be integrated into the therapeutic process, whenever possible.

► Example

Mr. B.'s wife brings him an apple from the garden, which is then used during therapeutic eating.

If Mrs. G.'s relatives come to visit, she would also like to drink a little coffee with them, even if it is 'only a few spoonful'. After establishing this goal, therapy sessions focus on swallowing a small amount of warm liquid safely. ◄

Notes

Factors relevant to safety can only be controlled effectively through team management:

- Positioning and handling
- Help with coughing and swallowing
- Adequate support, preparation, and evaluation of food intake
- Effective and structured oral hygiene

A 24-hour interprofessional treatment approach – with the additional involvement of family members – is required to ensure the patient's safety.

5

5.5 Prerequisites for Oral Food Intake

» Remember that mealtimes in their complexity are often the most difficult times to practice movement sequences needed for eating and drinking (Coombes, personal communication).

5.5.1 F.O.T.T. Begins Early

! Therapists and carers should not wait with therapy until the patient begins to swallow.

Intensive therapy is particularly necessary for patients who cannot eat or drink (and are also unable to speak). Due to the lack of sensory information and decreased movement capacity, these patients suffer from sensory deprivation in an area which is usually extremely sensitive and highly selectively mobile. *Use it or lose it* and *use it and improve it* are recognised principles of use-dependent neural plasticity (Kleim and Jones 2008). The importance of tactile oral stimulation (tactile stimulation of gums, tongue, and palate) should be mentioned at this point as well as structured oral hygiene which incorporates the postural background and hands (▶ Sect.6.2.4).

The necessary skills, that is, the functions of the pre-oral, oral, and pharyngeal phases, must be reinitiated before food is offered to the patient. This work clears a path for normal movement and the processing of sensory information. It also prevents secondary complications such as biting and a general increase in tone whenever the mouth is touched. Nusser-Müller-Busch (1997) views these complications as a consequence of the sensory oral deprivation. As with therapeutic eating and drinking, this work initially takes place independently of mealtimes and it is best viewed as a preparatory step, which precedes the initiation of oral food intake. F.O.T.T. treatment approaches are described by Davies (1995, 2000), Nusser-Müller-Busch (1997), Woite (1997), Gratz and Müller (2004) and Tittmann (2001).

▶ Overview 5.9 summarises the ways in which F.O.T.T. approaches the process of reinitiating movements.

Overview 5.9 Fundamental Considerations According to F.O.T.T.

- Develop an active postural background and control of the head.
- Facilitate hand–mouth connection.
- Initiate breathing and protective mechanisms/speaking/weaning from TT.
- Facilitate facial and oral movements as well as oral stimulation.
- Oral hygiene (also to avoid secondary problems such as biting or pneumonia).

Tongue and jaw movements

In order to eat normally, selective tongue movements are required. The tongue is vitally important for the oral and pharyngeal phases of the swallowing sequence. Therapeutic activities in the course of F.O.T.T. aim to facilitate the normal movements of this organ and are outlined below.

Tip

Tongue and jaw movements must be highly coordinated.

Self-experience situations can help us to become aware of the many coordinated movements which occur; for example, as the jaw moves selectively when biting. We can feel the coordinated movements the tongue makes to avoid the jaw as it closes during chewing. If this coordination did not happen, we would bite our own tongue. We affect the pharyngeal phase indirectly through active or passive movements of the tongue.

Patients are often unable to sense residue adequately or *unable to perform adequate cleaning movements*. This makes it difficult for them to remove a piece of meat with the tongue, for example. When trying to remove it with a finger, movements of the whole body may occur. The goal is to get the patient to clean the teeth with the tongue, thereby removing any remains.

Tip

- Patients who cannot initiate an automatic, clearing swallow can often actively learn and automate it by means of targeted tongue movements.
- There are a number of ways to improve limited, lateral, tongue mobility, and some examples are as follows:
  - The patient is asked to lick something from the corner of the mouth (Fig. 5.6).
  - A piece of wetted gauze is placed between the cheek and the teeth. The patient then moves it to the other cheek, or out of the mouth, using coordinated cheek, jaw, and tongue movements.
  - Lateral biting or chewing on a piece of solid food that is secured by gauze.

Fig. 5.6 The patient is asked to lick a drop of liquid from the corner of the mouth. The jaw support grip from the side stabilises the lower jaw, enabling the tongue to optimise selective, lateral movements. The head is centered. Foam blocks are placed at the side of the left leg to provide a stable reference point and improve the postural background. (© Müller 2019. All Rights Reserved)

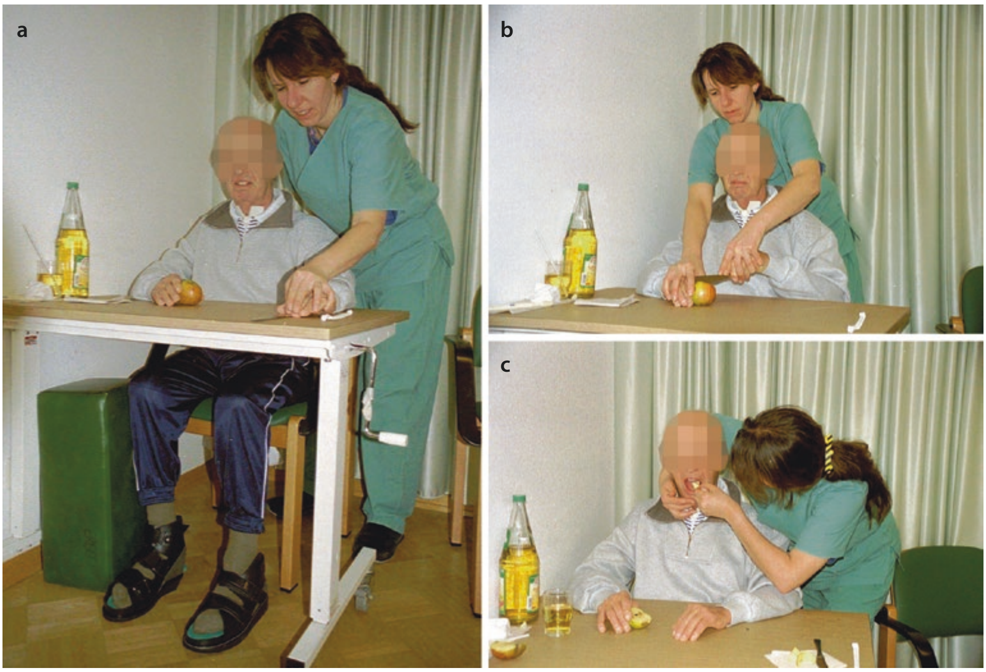
5.5.2 Therapeutic Eating

During therapeutic eating and drinking, the patient is offered small quantities of food. The goal is for either the individual elements, or the whole course of the swallowing sequence, to become part of the automatic movement repertoire. Food often elicits more effective and economical movements in the patient's mouth and throat than swallowing saliva. This is due to the increased sensory input, the functional goal, and the familiarity of the food.

Problems can easily develop if the swallowing sequence or the situation is insufficiently safe. These problems are then reflected by the altered tone and movement behaviour of the patient. The therapeutic meal must therefore be well prepared, closely supervised, and supported by patient-centered facilitation. Therapeutic eating is initially often only a short but intensive sequence of a treatment session.

► **Mr B.**

Therapy begins by generating an adequate postural background and providing tactile oral stimulation. The patient is then given assistance to cut the apple (◘ Fig. 5.7a,b). After this is done, a piece of apple wrapped in damp gauze is guided to the mouth and placed between the chewing surfaces (◘ Fig. 5.7c). Mr. B. chews several times and swallows the juice, sucks briefly, and swallows once more, after facilitation. The piece of apple is removed from the mouth. When the therapist asks if the apple tastes good, Mr. B. answers "yes" in a clear, audible voice. Apple juice and saliva have not reached the level of the vocal cords. Breathing is quiet, with no palpable or audible rattling. However, juice could still remain in the throat, e.g. resting in the vallecular region. The therapist helps Mr. B. to move the tongue repeatedly into the cheeks to collect rest of the apple. In the pauses between the movements, she assists swallowing once again. ◄



◘ **Fig. 5.7** **a–c** Mr. B.: Chewing apple in gauze. Therapeutic emphasis: pre-oral, oral, and pharyngeal phase. **a** Guided sequence: hold the knife. **b** Cut the apple. **c** Chew the apple: the apple is secured in moistened gauze and placed between the chewing surfaces. (© Müller 2019. All Rights Reserved)

The benefits and goals of therapeutic meals can be found in ► Overview 5.10

Overview 5.10 Therapeutic Eating and Drinking

- Food is used to facilitate normal movement and sensation.
- Therapeutic eating allows for a helpful sensorymotor experience in a safe and controlled environment.
- Therapeutic eating and drinking eases further assessment and goal- and activity-directed functional therapy. The situation is less complex than a meal.

» What happens when **that** food meets **that** mouth? (Coombes)

The challenges the patient meets during therapeutic eating should not be underestimated.

Therapists must familiarise themselves with the selective movements and coordination skills involved in the swallowing sequence, depending on differing foodstuffs. They must examine and evaluate the sensorimotor capabilities of the patient. Only then can the approach of therapeutic eating and drinking be specifically tailored and customised to the individual patient.

Table 5.1 shows a sample analysis of the objectives of therapeutic eating, and the demands placed on the patient.

Table 5.1 Chewing in gauze: Examples of the demands placed on the patient and the objectives of therapeutic eating

Phase	Demand	Therapeutic goal
Pre-oral		
Perception Affolter Model(Affolter and Bischofberger 1996, Affolter et al. 2009, Hofer 2009))	Interaction person ↔ environment: to be in contact, move, adapt body tone Event: understand → participate → continue action Using modality-specific skills (feel, see, smell, hear, taste) Using intermodal skills: indirect/unfamiliar: gauze	Change of source during interaction between person and environment in the everyday problem-solving event 'eating apple' From understanding to output
Postural background	Dynamically stable trunk Long neck	Establish basis for coordinated dynamics of the oropharyngeal structures
Oral		
Bolus formation	Well-coordinated: Cheek tone and closed lips Lower jaw rotation Lateral tongue movements	Controlled tone ↑ Cheeks, chewing musculature, tongue Lateral activity: ↑ Feel sides → move sideways Bite → chew Limit sucking Saliva production ↑ Contrast (taste, sensation) ↑ Movement ↑
Bolus transportation	Stable lower jaw Closed lips Tongue trough holds bolus Wavelike pressure of tongue against the hard palate	Spatially and temporally coordinated movements ↑
Pharyngeal		
	Active coordinated bolus transport: Tongue (pharyngeal part) Pharynx Protection of airway: Soft palate rises↑ Larynx lifts ↑ Vocal folds and vestibular folds close → ← Epiglottis tilts ↓ Upper esophageal sphincter opens ← →	Effective transport of food, swallow and clearing–swallow Effective protection through coordination, breathing and swallowing: Breathing pauses → swallowing Inhale/exhale → swallow → exhale ! Sensation ↑ Clear voice/cough → swallow
Esophageal		
	Active transport	Avoid reflux and vomiting → upright sitting position

5

Characteristics of food consistencies

A similar analysis can be compiled for other consistencies. Some of the characteristics of specific food consistencies are familiar to us from daily life, working with patients, and the relevant literature:

Thin liquids must be swallowed quickly. When swallowing thin liquids even in healthy individuals 20% of the swallows showed penetration into the entrance of the larynx, according to a study by Robbins et al. (1999). This did not cause residue, however, because the penetrated material was ejected from the airway.

> **!** In patients with significantly delayed swallowing, drinking liquid usually leads to penetration or aspiration.

A pureed consistency flows more slowly and is already close to bolus form. It, therefore, requires less oral preparatory work and can be placed directly on the center of the tongue. Patients are generally able to control puree more easily in the oral area than liquid. It also requires less selective, preparatory work on the part of the oral structures during bolus formation in comparison to solid food.

> **!** Puree residue is often harder to remove than liquid residues. These can be set into motion again by body movements (tongue, head, change of starting position, coughing).

Solid food must be chewed. Normal chewing motion demands the functional interaction and high selectivity of the jaw, tongue, cheeks and lips. Solid consistencies therefore represent a greater challenge, particularly for patients whose coordination is compromised. Depending on the constituent ingredients, further challenges to coordination may arise, as the food is crushed by chewing. This might be an intervening swallow of liquid, in the case of apples, for example, or the removal of meat fibres using the tongue.

> **Tip**
>
> Chewing and biting are activities well suited
> - to the development of selective, lateral movements of the tongue and jaw,
> - to developing tonus in the cheek and jaw muscles (e.g., in the absence of mouth closure) and
> - to the preparation of a more coordinated, safer pharyngeal phase.

Using cold stimuli

Ice and other cold stimuli are considered significant triggers for swallowing, both in the literature and in therapeutic practice. According to Bisch et al. (1994), the viscosity and size of the bolus affect swallowing more significantly than cold stimuli despite them being popular.

Coldness was only proved beneficial for a significant number of mildly affected neurological patients in the case of small amounts of liquid. The 1 ml bolus used corresponds approximately to the amount of saliva which must be swallowed continually. This was the most challenging constancy for patients with mild dysphagia. The use of cold stimuli therefore appears best indicated for these patients as well as those for whom cold stimuli lead to qualitatively better and more effective movements (e.g., swallowing).

> **!** Cold should not be viewed as a panacea or as the sole means for triggering the swallowing response.

> **Tip**
>
> Bolus size, texture, and temperature must be examined closely, in order to establish the optimal type of bolus for each patient (Bisch et al. 1994).

> There is no fixed formula for the correct consistency to use when initiating therapeutic eating and drinking or transitioning to oral food intake. Targeted analysis of the patient's capabilities is necessary.

- **Choice of situations and consistencies: examples**

Severely perceptually impaired patients
Work in the pre-oral phase has priority with severely perceptually impaired patients. Key aspects for shaping the therapeutic eating environment, using principles drawn from the Affolter model, (Gratz 1996; Schütz 2000; Hofer 2009; Affolter et al. 2009) include:
- The use of familiar food and a familiar situation, for example, a shared meal in the dining room to help the 'event of eating' to be understood.
- The choice of foods which allow the patient to be involved in their preparation. This creates a tactile connection to the event. The patient begins to understand what is happening. The use of objects which provide clear resistance is recommended for this as they are easier to perceive.

► Example

Small medical or transparent plastic beakers are difficult for the patient to perceive and are easily crushed. A solid glass or stable cup is better: The object is easier to perceive due to the clear, tactile input. This provides the patient with an opportunity to comprehend the event and to participate more appropriately in the therapy. ◄
- The creation of a perceptible, stable environment enables many patients to exploit their capacities more fully during the eating experience.

► Seating and Organisation:
- Patients should sit near a *wall* rather than in an open space. (Sitting in a niche at a restaurant is also more popular than sitting at the tables in the middle of a large room.)
- If required solid foam blocks can be used to create perceptible resistance (Figs. 5.6, 5.7, and 5.12). ◄

Non-essential sequences of the event (= parts of the activity which are not absolutely necessary), such as eating with cutlery, are often challenging for patients. Eating with the fingers is easier and may initially be more appropriate for perceptually impaired patients.

In general, the therapist should plan the situation well, and prepare the treatment space and materials before beginning to work with the patient. Interruptions create awkward situations, for example if therapy must be halted because a glass is missing. The overall structure of the activity (Peschke 1996) can easily break down, unless it is possible to solve the problem together with the patient. In a situation that involves guiding (based on the Affolter model), one could go and collect the glass with the patient, for example.

5.6 Pharyngeal Swallowing Disorders

In clinical practice, F.O.T.T. has the advantage of being based on accurate, clinical analysis of the structural, coordinative, functional, and activity-relevant symptoms and skills of the patient. The goal-directed treatment of what appears to be a local neurogenic problem of the facial-oral tract is also based on this clinical analysis. The treatment of patients with primarily pharyngeal dysphagia is outlined below.

- **F.O.T.T. – a systemic approach to pharyngeal dysphagia**

The core working hypotheses are as follows:

Within the swallowing sequence, one phase influences the next.

Attention should therefore be given to the following:
- Postural background
  - Optimise
  - Move/change, make residue perceptible (► Sect. 5.3.3)
- Bolus formation and collection, stimulation to prepare for bolus transport
- At the moment of 'swallowing'
  - Dynamically stable lower jaw, closed lips

  – Selective and coordinated tongue movement (▶ Sect. 5.3.3)
- Coordination of breathing, swallowing, and protective mechanisms

5.6.1 Structure Specific – Free the Hyoid Bone

Posture and movement are highly relevant to swallowing, even in patients who have good physical capabilities overall. There are neurological patients who are largely mobile and independent in their everyday activities and still suffer from severe swallowing disorders.

Bearing in mind the highly complex, fast-paced musculoskeletal coordination that safe swallowing requires, it is vital to provide the patient with the best possible conditions for swallowing and breathing through optimal alignment of the different parts of the body. This is particularly relevant for positioning of the head and neck. Analogous to a 'weighty crown', the head is of particular importance, as it houses the sensory organs. Balanced on the vertebral column of the body, it is also absolutely dependent on the structures below (pelvis, spine, legs), which must work with gravity and provide a stable base for the structures above. The anatomical structure and interaction of the facial-oral structures are also remarkable. Only one of the oropharyngeal structures involved in food intake is predominantly held in place by a joint articulation with the cranium. This structure is the lower jaw. All the other structures are dependent for their position, and consequently their functional capacity, on the surrounding tissue, muscle tension, and traction. In this context, it is also worth noting that the hyoid is the only bone in the human body which does not articulate with another bone (▶ Sect. 4.2).

As therapeutic consequence it is not enough to 'sit the patient as upright as possible'. The structures must be mobilised as far as possible:

- A starting position with an adjusted, supporting surface must be established, which allows the patient optimal movement capacity in the facial-oral tract. Whether the position selected is one in which the patient is largely relieved of the force of gravity, or one in which he must support himself against it (as in sitting, standing, walking), is function- and activity-dependent. A more upright position – such as sitting – should not be too static, as active alignment will be lost over time. Continuous, small adjustments, or transfer to another position, are necessary, so that the optimal alignment for functional activity can be re-established. Specific neurodynamic techniques for mobilisation of the structures relevant to swallowing are also useful. These include the mobilisation of neural structures according to the principle of neurodynamics (Rolf 2007) or the mobilisation of muscles, joints, and/or connective tissue/fascias (Von Piekartz 2005, Chap. 4).

5.6.2 Function Specific – From Spitting to Swallowing

■ Saliva management

For a majority of patients with severe pharyngeal disorders, the safe transport of their saliva is a challenge. The way in which the patient 'manages' his saliva must be assessed concerning functional performance and concerning ADL. This always involves protection of the respiratory tract and swallowing or spitting if necessary.

■ ■ Protection of the respiratory tract

In terms of protecting the airway, it is essential to clinically evaluate whether, when, and how the patient reacts spontaneously to the threat of saliva penetrating into the lower respiratory tract. For example, if he always clears his throat spontaneously as soon as the voice sounds wet, then swallows promptly, and the voice sounds free, he is likely able to protect the airway sufficiently.

Notes

It is important to note the *timing* and *efficiency* of spontaneous protective mechanisms in response to material such as saliva and evaluate their relevance to daily living. These coordinative–functional aspects must also be taken into account when using imaging techniques. The Penetration/Aspiration Scale according to Rosenbek et al. (1996) can be useful here, even if it only examines the timing and efficiency of the expulsion of material from the respiratory tract.

Further evaluation of what happens to the ejected material is indispensable:

- Is it swallowed?
- Is it spat out?
- Does it initially come to rest and then reach the lower airway due to gravity or respiratory flow (▶ Chap. 10)?

From spitting to swallowing

For many patients with pharyngeal problems, the powerful and effective cleansing of the throat and mouth achieved through spitting represents a first step towards protecting the airway independently. A large number of patients who are not cognitively impaired begin to protect themselves spontaneously in this way. It is important to encourage them to spit (out), even if this is not accepted behaviour in a social context. The utensils required for this (cups, kidney dishes, paper towels) must of course be provided. The different elements of spitting (pressure build-up via breathing, throat cleansing, adjustment of the oral structures, adopting a flexed body position, holding the towel, etc.) must often be be facilitated and learned during therapy. An adequate oral care procedure (◘ Fig. 5.9a) must also be developed to ensure regular, aspiration-free cleaning and the removal of residue, if necessary, in the intervening period. Of course, patients with severe swallowing disorders require additional protection of the lungs from aspirate. These patients are provided with a cuffed TT (▶ Chaps. 9 and 10) and/or must be positioned in such a way that saliva is able to flow out of the mouth with gravity and secretions can be coughed up easily.

The primary goal of therapy is to work with the patient to develop increasingly frequent, efficient, and effective swallowing of saliva. Finding the swallowing support (▶ Sect. 5.3.3) best suited to the patient can be a turning point in the transition from spitting to swallowing. It can then be implemented in a variety of ways, during treatment and in daily life, until the patient automatically and effectively swallows as and when necessary.

◘ **Table 5.2** Protection from aspiration-one way of functional recovery: from spitting to swallowing

0	Aspiration (without effective reaction)
+	Spitting out of the saliva
++	Swallowing, spitting out if necessary, followed by a subsequent clearing–swallowing
+++	Automatic swallowing
Quality *Timing + efficiency = safety*	

The process can be represented schematically, as in ◘ Table 5.2.

5.6.3 Activity: Beginning to Eat. Participation: Enjoying a Meal

It is particularly important to establish exactly where the main, functional problem lies with patients for whom the pharyngeal phase is affected. The therapist must identify the initial consistency, that is, the consistency which the patient is able to swallow most safely following preparation and facilitation. For many patients, the use of this specific consistency during therapeutic eating and drinking is the key to the automated (physiological) swallowing sequence. This automation is the first step towards effective swallowing. Thereafter, it is possible to work on varying the consistency and increasing the quantity of food (Nusser-Müller-Busch 2001).

Repetition of the normal processes, independently or with assistance from the family and by means of an individualised home programme, should reinforce automation of the swallowing sequence as much as possible. In F.O.T.T., a variety of short, supervised exercise sequences are applied throughout the day, and are vital for the relearning of the swallowing sequence (▶ Chap. 3). This is one of the reasons why F.O.T.T. is considered a 24-hour approach.

> The therapist must ensure that the home programme is sufficiently safe, however, and follows physiological movement pathways.

▶ Mrs G.

In the daily hospital routine, Mrs. G. is independent. She walks slowly, but without assistance. She cannot eat and drink.

Initial: Swallowing saliva is very difficult. There is continual pooling (accumulation of saliva in the pharynx, sometimes entering the larynx, resulting in a wet voice). The secretion is then spat out.

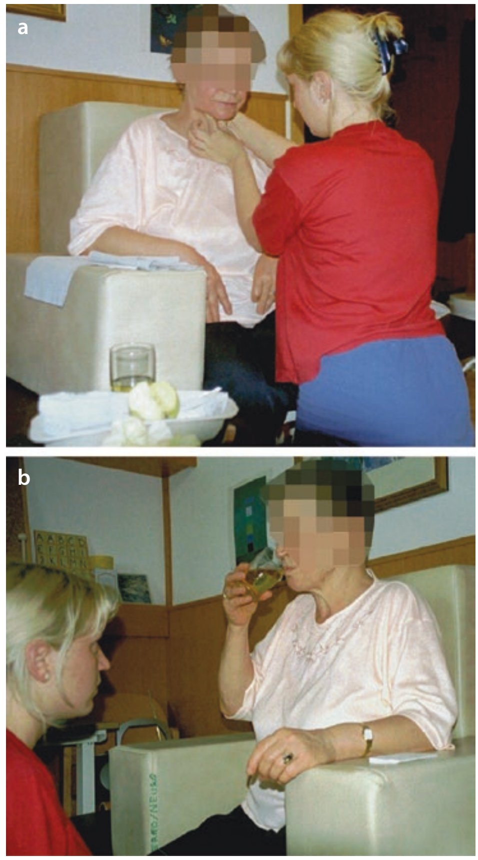
First Treatment Phase: Development of sensorimotor skills, with the goal of safely swallowing saliva.

Approach: 4 weeks of F.O.T.T., without food, but with minimal flavour stimuli. Tactile oral stimulation takes place in side-lying position due to a tendency to raise the shoulders and move the head into a short neck position when attempting to swallow in a sitting position. After this period of treatment Mrs. G. seldom spits out her saliva. She also swallows when she is concentrating on something else, for example whilst climbing the stairs in physiotherapy. The swallowing of saliva follows automatically.

Second Treatment Phase: The goal is a normal swallowing sequence and the safe swallowing of small quantities of food.

Approach: Preparation including tactile stimulation in side-lying position, as in phase 1; followed by therapeutic eating and drinking in a supported (foam blocks) sitting position on the therapy plinth. The first consistency chosen is cold water (◘ Fig. 5.8a, b) because the primary issue identified is pooling in the vallecular region. Residues remain in the area between tongue and epiglottis. Mrs. G. can remove thin, liquid residue from the vallecular space by using the tongue to mobilise the residue, and then swallowing. Thicker, more pulpy residues are retained in the structure, however; this causes overflow if feeding continues without initiating swallowing in time. Coughing follows.

- The patient has good oral control (can gurgle during mouth care, without aspiration).
- By now, initiation is no longer delayed when swallowing cold water (no pumping movements of the lower jaw or tongue and no associated movement of the shoulder girdle).
- Good breathing-swallowing coordination can be observed (exhalation follows, and usually also precedes, swallowing).
- Effective protective mechanisms are present (timely and productive throat clearing and coughing, with a clearing swallow).



◘ **Fig. 5.8** **a**, **b** Mrs. G.: Therapeutic eating and drinking. The patient moves the glass to her mouth independently, and swallows. **b** The first swallow occurs promptly and automatically. Mrs. G. receives tactile assistance with the clearing swallow. (© Müller 2019. All Rights Reserved)

◘ **Fig. 5.9** **a**, **b** Independent home programme (autonomous practice under supervision): **a** Mrs. G. first rinses her mouth. Saliva residues are thus removed from the mouth and throat. **b** Afterwards, Mrs. G. sits at the table and slowly drinks half a glass of cold water, sip by sip. (© Müller 2019. All Rights Reserved)

All other foods collect mainly in the throat, and must be spat out again. After a few days of drinking three to four sips of water, without aspiration, a home programme is worked out: With adequate preparation, Mrs. G. takes a drink independently in her room (◘ Fig. 5.9a, b).

Twice a day Mrs. G. rinses her mouth and spits out any remaining, foamy saliva residue. She then drinks several sips of water autonomously. Following similar therapy using jelly (yoghurt and apple sauce caused more pooling, whereas jelly liquefies in the oral phase), therapeutic eating and drinking now consists of chewing apple in gauze and partly without gauze.

After a further 3 weeks of daily therapy, Mrs. G. is able to eat small meals with a pureed or very soft consistency. With these consistencies she is able to form a very homogeneous bolus. The phase of assisted meals begins. ◄

The number of patients who are tube fed in an outpatient setting is increasing in Germany due to the reduced length of stay in neurological rehabilitation facilities and the increasing number of severely affected patients. Nowadays, treatment which is begun in a hospital environment must often be continued in an outpatient setting. In the case study by Gratz and Müller (2004), both patients received inpatient rehabilitation for a period of more than a year in the mid-1990s. Fifteen years later this length of treatment would be inconceivable.

In the following example, photos are used to illustrate a patient's outpatient F.O.T.T. treatment (◘ Fig. 5.10).

► **Mrs F.**

Mrs. F. has a severe, primarily pharyngeal, swallowing disorder. She is 68 years old and suffered a medulla oblongata infarction on the left side. Inpatient rehabilitation took place between February and August 2008, Mrs. F. was subsequently treated at home (◘ Fig. 5.10a–i). She lives in a small apartment; there is no space to sit in the kitchen, and she does not own a chair. Mrs. F. always sits on the sofa in front of a coffee table. She learned to swallow her saliva safely during her rehabilitation stay and no longer needs to spit it out. Nutrition is received entirely via PEG. ◄

Fig. 5.10 **a**–**l** F.O.T.T. in an outpatient setting. Sequences **a**–**g** Pre-oral and oral preparation (August 2008) (© Müller 2019. All Rights Reserved): **a** optimal positioning in the armchair with blanket and pillows in the specific everyday context. **b** Tactile oral stimulation with ice. **c** Therapeutic eating and drinking, hands off if possible: Mrs. F. lifts a spoonful of frozen apple puree to her mouth. **d** After two spontaneous swallowing movements, she uses a direct tactile aid to facilitate further cleansing swallows

e Hands-on sequence with passive stretching of the tongue (indirect swallowing aid) to complete the work with apple puree. With this support, Mrs. F. is able to swallow the last remaining residues. **f** Drinking cold, thickened juice, Mrs. F. moves the tongue in her mouth in order to facilitate a clearing swallow. **g** Including variations: drinking with a straw in assisted standing. **Sequence h–j** (November 2008): Hands-off sequence in Mrs. F.'s everyday context at the coffee table; mealtimes with adapted textures. **h** Mrs. F. pays attention to whether her mouth is emptied of bread residue, and then drinks a small amount. She is now able to alternate between different consistencies when eating. **i** She coughs occasionally if she is too hasty. **j** The coughing is strong and prompt. After coughing, Mrs. F. uses strategies such as turning the head to the side as an indirect aid to swallowing. She is thus able to mobilise residues, perceives them, and concludes with a clearing swallow. Sequence **k & l** (January 2009) Lunch (normal diet, all consistencies), status after completion of F.O.T.T.:

k Although Mrs. F. takes a position with a very short neck when raising food to her mouth, **l** she forms a bolus, swallows it safely, and prepares the next bite at the same time. Eating and drinking in all variations are safe and take place automatically

5.7 Assisted Meals

In assisted mealtime settings, the patient who is unable to eat independently receives help and support before, during, and/or after meals.

> Assisted eating encompasses a complete meal and ensures nourishment but is dependent eating.

The prerequisites for assisted eating are listed in ► Overview 5.11.

Overview 5.11 Prerequisites for Assisted Meals

- Appropriate postural background
- Eye-hand-mouth coordination
- In the case of solid food: jaw mobility for biting and chewing
- Enough tongue movement for bolus formation and transport
- Sufficient tone in the cheeks to move the food
- Adequate transport movements to move the bolus into to the throat and be able to swallow
- Adequate protective mechanisms

The skills listed in ► Overview 5.11 are initiated during therapy. They are consolidated further and automated in the therapeutic eating context. The sensorimotor processes of the individual phases of the swallowing sequence are supported during the meal.

> Close observation and accurate evaluation of the patient's skills are necessary in order to provide the patient with *assistance* whenever he needs it.

5.7.1 Considerations When Adapting to the Setting

In clinical situations in which a few team members have a lot of work to do, it is often difficult to assist the patient by providing a quiet, stress-free environment for eating. As soon as the telephone rings, for example, or a colleague comes into the room and asks a question, it becomes difficult for the patient to concentrate on the most important thing – the intake of food.

Tip

Patients learn by actively doing, and through new experiences. They can concentrate on safe food intake more easily when the environment is quiet, and free of distractions. Guided meals should take place outside the nursing rush hour.

A quiet and stress-free environment is a prerequisite for as long as the automation level of sequences is too poor to allow normal movement sequences (physiology) to be relearned or consolidated within the framework of assisted eating.

► **Mr N.**

Mr. N. still requires intensive preparation and tactile assistance during the meal. It is necessary to change or correct his postural background continually. Exploration of the table is limited due to his neglect. Mr. N. does not perceive one side. His hands must be guided in order to bring the spoon to his mouth. Because he does not initiate a clearing swallow, Mr. N. requires swallowing assistance (◘ Fig. 5.12). Food remains are left in the mouth. During oral hygiene which follows the meal, he needs help to spit the water out after rinsing his mouth. ◄

Eating in company or a group is still too great a challenge for this patient, but he can eat his meal safely, assisted in a quiet environment.

5.7.2 Preparing the Assisted Meal

▪ Preparing the postural background

The patient needs an adequate postural background for the treatment sequence. Firstly, the sitting position is optimised (◘ Fig. 5.11); foam blocks provide supporting surfaces, and act as stable reference points (◘ Figs. 5.6, 5.7a, and 5.12). The sitting position must be checked constantly during the meal and corrected when necessary.

▪ Preparing the mouth and oropharyngeal movement sequences

Tactile oral stimulation

Tactile oral stimulation is often used at the beginning of therapy (► Sect. 6.2.4). The aim is to increase intraoral perception and promote oral movements and subsequent swallowing before food intake begins (Erzer Lüscher and Sticher 2009). Various liquids can be used, for example apple or orange juice or coffee. The patient's likes and dislikes are taken into account. The intensive flavour provides the patient with specific, gustatory input, which he is able to sense more easily than water.

◘ **Fig. 5.11** Before the meal: facilitation of an upright pelvic position. The arms are already resting on the table. (© Müller 2019. All Rights Reserved)

◘ **Fig. 5.12** The swallowing assistance provided, enables the patient to swallow effectively. (© Müller 2019. All Rights Reserved)

▪▪ Stimulating the lateral mobility of the tongue

► Section 5.5.1 describes how lateral mobility of the tongue can be improved.

If the patient demonstrates an adequate, oropharyngeal movement sequence, the meal can begin.

5.7.3 Therapeutic Support During Meals

The food is placed on the table, in front of the patient. If the patient is unable to participate actively, he receives appropriate assistance.

5

■ Options for assistance

■■ Guiding during preparation

► Example

The therapist guides the patient to fetch the soup dish. They remove the warming cover together. The spoon is taken in the hand. ◄

■■ Guiding food to the mouth

Even with a lot of support some patients are not yet able to eat using a knife and fork. In these patients, the influence of the pre-oral phase on the oral phase is particularly noticeable. Use of adapted cutlery may help the patient to raise the spoon to the mouth. It also reduces the risk of injury, for example, if the patient additionally suffers from ataxia. If this is unsuccessful, the therapist must pass the food.

► Example

The patient draws the soup dish towards himself. He does not yet have sufficient coordination to take the spoon in his hand himself. The therapist guides the patient's hand with the spoon towards the mouth and places it on the tongue. If necessary, she helps the patient to close his mouth and transport the bolus through the oral cavity (► Sect. 5.3.3 direct swallowing support). ◄

■■ Drinking

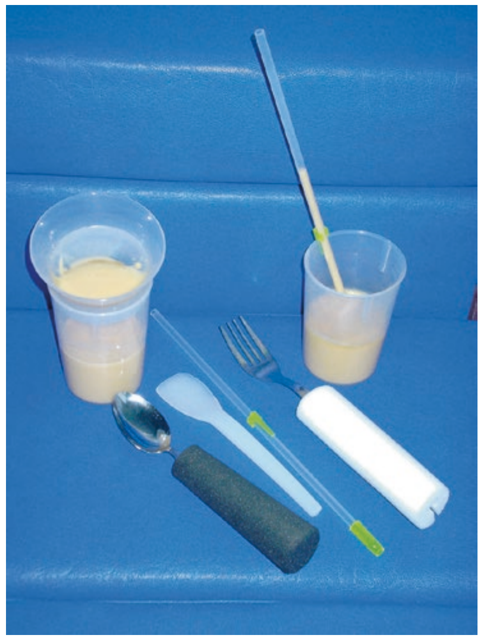
Patients sometimes spill the contents of the cup whilst attempting to drink. Holding themselves stable in an upright position and doing something else at the same time (drinking) is a demanding task.

! For many patients, drinking is more problematic than eating. This is due to the thin consistency of liquids, which pass through the oral cavity more quickly.

It is important to consider what assistance is required to enable the patient to drink.

► Example

Assisting by guiding the arm provides the patient with an opportunity to raise the cup to the mouth and be able to drink. The special cup developed by Coombes (■ Fig. 5.13) is an additional option for providing assistance. ◄



■ **Fig. 5.13** Tools: Front: cutlery with thicker handles, Cheyne spoon. Back: cup with and without lid, Pat Saunders straw. (© Müller 2019. All Rights Reserved)

Tip

- In case of delayed swallowing or reduced oral control, it is advisable to thicken drinks to avoid the liquid leaking prematurely. Thickening allows the consistency of the drink to be adapted to the capabilities of the patient.

- Some thickening agents do not dissolve well; clumps form, or they require more time to reach the desired consistency.
- Attention should be given to the ingredients of the thickener. Vitamins are often added, which may already have been given to patients. An excess of vitamins is unnecessary.

Facilitation of swallowing

If swallowing is not initiated spontaneously or swallowing begins but is not completed, the therapist uses swallowing support combined with the optimal head position (long neck) and a jaw support grip if necessary (Fig. 5.12) to facilitate swallowing (▶ Sect. 5.3.3).

In the event of choking and coughing, the therapist promotes the effectiveness of the cough by assisting controlled trunk flexion and providing tactile support to the exhalation (e.g. to the lateral ribcage). He ensures that swallowing follows immediately after coughing. If this is not the case, the therapist facilitates swallowing.

Aids

Cheyne spoon

Made of stable plastic this spoon is more suitable for patients who tend to bite than a metal spoon. Metal reinforces biting due to its 'coldness'. Taking food into the oral cavity can be more easily facilitated therapeutically using the flattened and widened surface of the spoon. The lips are able to take the food in more easily, and the food can be placed on the tongue with clear input (Fig. 5.13).

Cup with special lid

The cup and its lid are made of plastic. The lid developed by Coombes has *small openings*, which allow a controlled amount of liquid to be held inside, and then offered to the patient. The patient is able to place his lips securely on the broad rim, encompassing it. Delivering the liquid in an 'adult' manner (via an adapted oral transport phase, rather than by sucking) increases the safety of swallowing (Fig. 5.13).

Drinking straw

The Pat Saunders straw has a valve at its lower end, which prevents the backflow of the liquid sucked inside as much as possible. The fluid already sucked into the drinking straw will remain there when the patient stops sucking. This means less work for the patient when he continues drinking from the straw (Fig. 5.13). The drinking straw has been developed for patients who have well-coordinated oral and pharyngeal movements but have difficulty transporting food to the mouth securely.

Cutlery

Spoons, knives, and forks with thicker handles make it easier for the patient to grasp cutlery and guide them to the mouth independently. Individually formed cutlery can help compensate for the patient's movement restrictions (Fig. 5.13).

Verbal requests?

It is often suggested that patients might be prompted to swallow, using verbal requests. But what happens if the therapist or nurse is not standing next to the patient asking him to swallow?

> » We swallow because we sense the saliva or food, and not because we have a little voice in our ear, telling us once or twice a minute to swallow! (Nusser-Müller-Busch 1997)

! Verbal instructions to swallow can cause associated movements and increased tone, even in normal individuals, and this must be particularly avoided in patients. As an alternative, tactile aid may be provided to support the sensorimotor cycle in relearning the function (▶ Sect. 5.3.3).

5.7.4 Follow-up to the Meal

There is a risk of aspiration if patients are laid down immediately after eating due to residues remaining in the swallowing tract. To ensure that no remains are left in the oral cavity, the patient is asked to clean his teeth using the tongue and is assisted in swallowing afterwards. If necessary, the oral cavity is examined for the presence of food remains during the oral hygiene which follows.

Tip

Every patient with a tendency towards pharyngeal residues should remain in an upright or forward-leaning therapeutic position for approximately 20–45 minutes after eating.

This position promotes the swallowing of residue and supports the transport of food through the esophagus and into the stomach by means of gravity.

The patient is therefore positioned forward, for example at the table, with his abdomen and lower arms in contact with the table, head turned to the side, and slightly flexed. The upright alignment of the trunk and upper body can be supported using pillows or foam blocks in front of the upper body. The arms are placed on the table alongside the foam blocks, creating a wide supporting surface. The feet are in contact with the floor (▶ Sect. 13.6.5).

▶ Overview 5.12 summarises the options for providing support before, during, and after the meal.

Overview 5.12 Assisted Meals (= dependent eating, Coombes 1992)

- Preparation
  - Create the starting position
  - Tactile oral stimulation
  - Initiate specific oral and pharyngeal movement patterns
- Support during the meal
  - Guide (e.g. the arm)
  - Jaw support grip
  - Swallowing aid, swallowing
  - Modified consistencies
  - Tools/aids
- Follow-up
  - Position/sitting position
  - Oral hygiene

5.7.5 Assisted Meals and Enteral Nutrition

The assisted meal provides the patient with a more or less complete meal. The proportion of the total calorie balance supplied via tube feeding can therefore be reduced. Nutritionists and dieticians work with doctors and nurses wherever possible to safeguard the balance of calories, fluids, and important nutrients.

As long as hydration cannot be fully assured orally, care must be taken to supply the patient with sufficient fluids via the tube. This is particularly relevant for patients in nursing homes and home care. For many patients, an intake of 2 litres of liquid per day can be very demanding. The supply of fluids via the PEG tube provides relief.

The PEG tube should not be removed too early. Safe swallowing cannot be guaranteed for some patients due to the deterioration of their general condition. It is possible to revert back to the tube immediately during these phases. Criteria for the continuation of PEG tubing are summarised in ▶ Overview 5.13.

Overview 5.13 Criteria for Retaining the PEG Tube

- Oral fluid volume is less than 1.5 l per day
- Risk of dehydration (Martino 2002)
- Increase in inflammation parameters (e.g. CRP)
- Medication is not always safely swallowed or has to be ground
- Body temperature variations (subfebrile mornings and evenings)
- Food quantity is not assured (half portions), protein deficiency
- If the amount of calories is still insufficient, the patient must be given extra calories
- Fluctuating general condition (e.g., epileptic seizures, frequent infections)
- Progressive disease development (ALS, Parkinson's disease, multiple sclerosis, etc.)

> A combination of oral and tube feeding can be a realistic goal for severely affected patients.

5.7.6 Summary

The type and intensity of assistance during the meal is adapted to the needs of the patient and will be different for each patient. This support makes nutritional intake safer and less strenuous, allowing the patient to enjoy eating and drinking to a certain extent. The aim should be to scale back support as soon as movement sequences and quality are sufficient.

From the assisted meal to normal eating, the route to independence encompasses the following aspects:

- Safety, in everyday eating and drinking situations
- Safe swallowing of all consistencies
- The possibility of eating in company

Patients often struggle for months to achieve these goals. As improvements in oral food intake increase, they are able again to take their meals with others – another step towards independence and participation.

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Oral Hygiene: An Interprofessional Concern

Daniela Jakobsen

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This chapter outlines the principles, methods and techniques underlying the F.O.T.T. area for oral hygiene. It explores the implications of oral hygiene for overall health and as a daily activity providing input for swallowing, cleaning and protection of the lower airway. It focuses on patients suffering from severe brain damage, like stroke or acquired brain injury in the acute and subacute phase. Common problems are described, including concrete approaches for problem-solving. Solutions are dependent of the patient's age and disorder, the specific environment, and the conditions for care and treatment. Oral hygiene is set in an interprofessional context, where the different professions, such as nurses, therapists, medical doctors and carers, work together towards the patient's goals and contribute with their core competences. The principles and methods might also be used in patients suffering from neurodegenerative disorders or geriatric diseases, and in children and youth with cerebral palsy.

6.1 Importance of Oral Hygiene

6.1.1 Importance for Food Intake and Social Interaction

A healthy oral cavity is an important precondition for facial-oral functions, including optimal food intake and mastication. The natural self-cleaning mechanism is set in motion when food residues remain in the mouth. Chewing and targeted movements of the lips, tongue and jaw are initiated, and saliva flows. Furthermore, tooth brushing and the use of dental floss or even chewing gum are common remedies to keep the oral cavity clean. A well-cared mouth also plays an important role in social interaction. De Jongh et al. (2014) identified bad breath and body odour as the most off-putting factors when interacting with others. Halitosis often creates a social barrage; sufferers strive to maintain a distance during interpersonal relations with colleagues and peers (De Jongh et al. 2013, 2014; McKeown 2003). A healthy oral cavity can also prevent other organs within the body from becoming diseased.

6.1.2 Correlations Between Dental Health and Disease

During the last decades, various links between oral hygiene and general health have been explored in research projects and provoked controversy and debate.

- **Dental Health and Cardiovascular Disease**

The relationship between periodontitis and cardiovascular disease has long been a subject of contention. Explanatory models of causality vary widely and range from genetically determined factors to the capacity of bacterial infections to cause inflammation in larger vessels through the bloodstream (Schaefer et al. 2009). Gewitz et al. (2012) concluded that the evidence available is insufficient to establish a causal link. Both diseases have similar risk factors, including smoking, overweight and diabetes. There are indications that the treatment of periodontal disease leads to a decrease in inflammatory parameters. Craig and Cramer (2016) describe periodontitis as a 'polymicrobial, complex disease that shares several characteristics with other complex diseases including atherosclerosis, diabetes mellitus, and Alzheimer's disease'. Genetic factors are assumed to play an important role too.

- **Dental Health and Diabetes Mellitus**

A number of links have been shown between diabetes and oral health, xerostomia (dry mouth), increased susceptibility to (fungal) infections, changes in the consistency and quality of saliva, dental caries, periodontitis and slow-healing wounds (Mohamed et al. 2014). A Cochrane Review (Simpson et al. 2010) found the treatment of periodontal disease in individuals with type 2 diabetes to have a positive effect on the stabilisation of blood glucose levels. Interventions included treatment of the periodontal disease and guidance from dental hygiene specialists. These findings are relevant not only for dentists and diabetologists. The implications extend to other professional groups working with individuals who suffer from both brain damage and diabetes and are unable to perform independent oral hygiene. There appear to be correlations between periodontal disease and other systemic diseases, which have yet to be fully explored (Shangase et al. 2013).

The Relation Between Dental Health, Oral Hygiene and Pneumonia

Pneumonia is a multifactorial complication, affecting patients in different environments, with diverse diagnoses and functional limitations. Current studies do not support an unequivocal assertion that inadequate oral hygiene is a factor in the occurrence of pneumonia. It is still unclear to what extent and for whom it may be an issue, or which preventative steps should be taken. Langmore et al. (1998) identified a number of significant risk factors for pneumonia for patients in inpatient and outpatient settings as well as residential homes. Surprisingly, dependence on others for help with eating and oral hygiene and the number of teeth with caries were amongst the most significant risk factors.

'Aspirated bacteria, either normal inhabitants of the oral cavity that serve as opportunistic pathogens in susceptible patients or exogenous pathogens that are not normal members of the oral flora and that transiently colonise the oral cavity, can cause lung infections. In addition, biological mediators, such as cytokines and hydrolytic enzymes, released from the periodontium as the result of periodontal inflammation are aspirated into the airway and may stimulate inflammation and increase susceptibility to infection' (Scannapieco and Harris 2016).

The findings indicate that a multilevel and interprofessional approach is vital for preventing pneumonia. Dai et al. (2015) showed that patients after stroke have a greater tooth loss, more dental caries and poorer periodontal health status than healthy controls. Seen in the light of the study from Langmore et al. (1998), this population definitely is at risk for developing aspiration pneumonia. Furthermore, Kothari et al. (2017) found in their review of oral health status in patients with brain injury that patients with dysphagia after stroke have a higher colonisation of *candida albicans* in saliva than those without dysphagia. In general, the oral health status in patients with brain injury was reported as poor. There is evidence that there are significant improvements when undertaking interventions towards systematic oral care in rehabilitation settings. But what is sufficient oral care?

In addition to the patient's socio-economic environment, the previous experience and expertise of the individual practitioners and team are decisive. These factors shape the decisions made in clinical practice. Sackett et al. (1996) described the nature of this process:

> 'External clinical evidence can inform, but can never replace, individual clinical expertise, and it is this expertise that decides whether the external evidence applies to the individual patient at all and, if so, how it should be integrated into a clinical decision. Similarly, any external guideline must be integrated with individual clinical expertise in deciding whether and how it matches the patient's clinical state, predicament, and preferences, and thus whether it should be applied' (Sackett et al. 1996).

6.1.3 Changes in Saliva Function and Consequences

Saliva plays an important role in the health of the oral structures. It has several important functions, to protect the teeth:

- It helps to protect the enamel.
- It has rinsing function, since it helps to remove food, drinks, food debris and microorganisms from the mouth when swallowing.
- It moistens the mucous membranes and protects against dehydration. Thereby it helps to heal wounds in the oral cavity.
- Saliva is important for bacterial defense, drawing a protective film over the mucous membranes (Dawes 2015).
- Saliva is an acid buffer and has a re-mineralising effect on the hard tooth substance.
- Saliva has an antibacterial, antiviral and antifungal effect.

The natural cleaning and protective function of saliva is impaired or absent if patients lack adequate oral collection and transport movements for swallowing saliva and/or cannot breathe through the nose or close their mouth sufficiently. Mouth breathing, open mouth and lack of salivation are predisposing factors for gum disease (gingivitis), particularly around the front teeth. Low saliva production can also be observed when psychopharmaceuticals are administered, in Sjogren's syndrome or following radiation therapy (Dawes 2015).

Clinical experience shows that large quantities of saliva in patients after acquired brain injury are rarely caused by genuine overproduction (hypersalivation). The most common causes are reduced swallowing frequency and/or an altered, abnormal swallowing pattern.

6.2 F.O.T.T. Oral Hygiene Routine

> 'I am convinced that it is not the lesion alone that dictates the final result, but also the treatment that the patient receives in the early phase. … What is the "right" treatment? The one which avoids preventable secondary complications, encourages and assists the return of functional activity' (Davies 2001, translated by Daniela Jakobsen).

In F.O.T.T., oral hygiene aims not only to brush the teeth. It is also used to analyse and treat problems in the facial-oral tract. Normal functional activities, for example swallowing of saliva, tongue movements for cleaning, or rinsing and spitting out with subsequent swallowing, can be developed and complications avoided. Structured, therapeutic oral hygiene must often substitute for absent or restricted oral movements which the patient is unable to perform. These include the tongue movements used to remove food from the cheek pouches, for example. The specific measures are undertaken within the context of the 24-hour day. They are then implemented inter professionally throughout the rehabilitation process. The principles of oral hygiene are listed in ► Overview 6.1.

Overview 6.1 Principles of Oral Hygiene According to F.O.T.T.

- Client-focused work, within an everyday life context using the best available evidence
- Activity-oriented, problem-solving approach
- Interprofessional treatment, involvement of relatives
- Individualised use of aids
- Assessment and treatment are interconnected

6.2.1 Process of Diagnosis and Treatment

Clinical reasoning is used in a cycle of findings, treatment and evaluation to determine and treat problems concerning oral hygiene. These problems may be the result of perceptual, cognitive, sensorimotor or structural restrictions. The patient's main problems in terms of postural control and facial-oral tract competence are identified during the clinical examination. At the same time, the patient's reactions to the interventions are recorded (► Chaps. 12 and 13):

- What is the patient able to do independently, and how is the effectiveness of movements or of the activity?
- What prevents functional movement?
- Which therapeutic interventions may help the patient to achieve improved movement/function?
- Achievable, evaluable goals are then formulated, if possible, together with the patient and/or the relatives. A treatment plan is devised and implemented, by the patient's interprofessional team (patient example Mr. K, below).

Note

Oral hygiene by means of F.O.T.T. offers an approach to problem analysis, formulation of relevant goals, a treatment plan and evaluation of the patient's response.

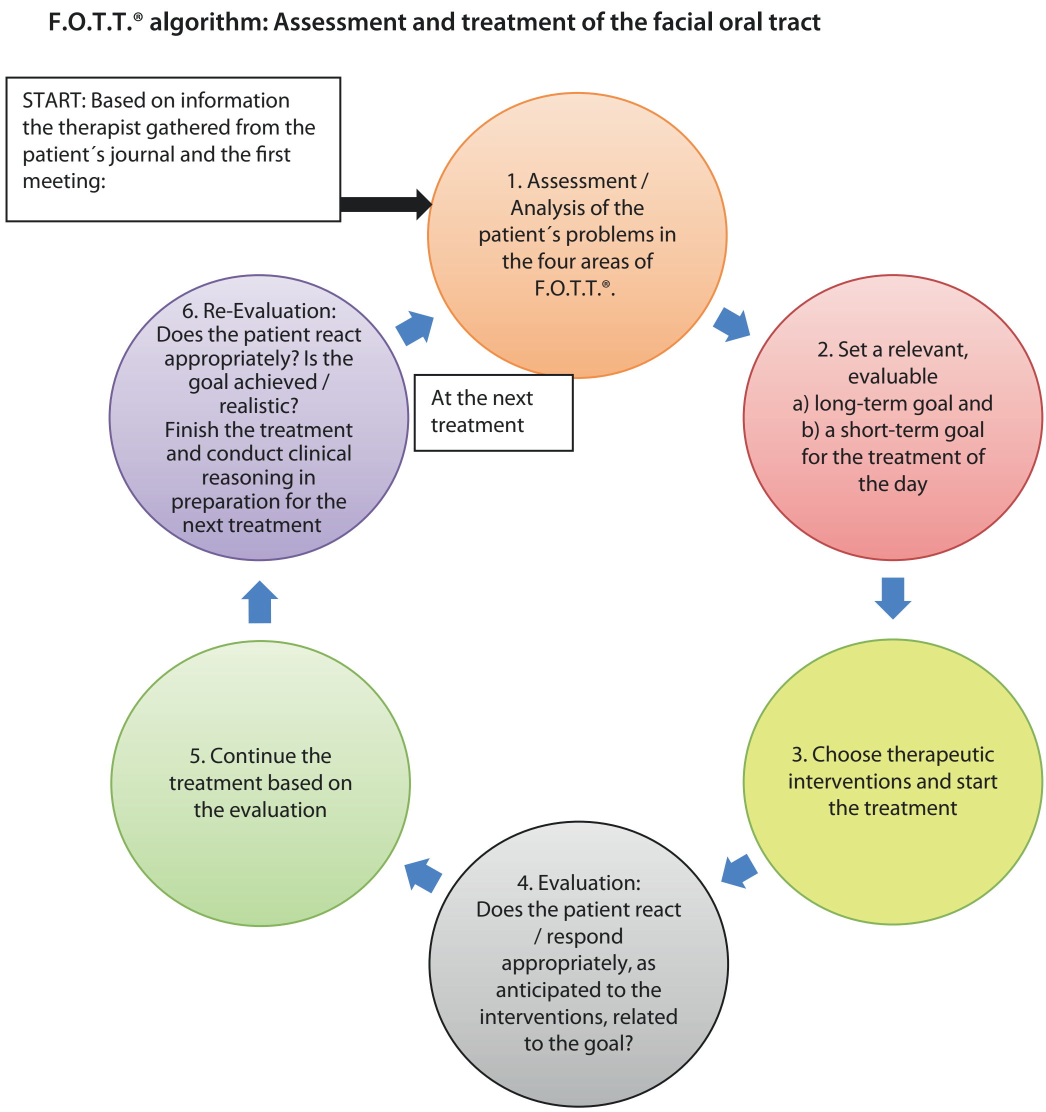


Fig. 6.1 F.O.T.T.® algorithm: Assessment and treatment of the facial oral tract (▶ Chap. 12, © Jakobsen 2019. All Rights Reserved)

Continuous evaluation of the results achieved during therapy is essential for the process of problem analysis and treatment (Fig. 6.1):

- Has the goal been achieved? A functional and evaluable goal could be: With the aid of a padded spatula, the therapist is able to clean the inner and chewing surfaces of the teeth when the patient is positioned in side lying (Figs. 6.26b and 13.15)
- What should be the next goal?
- How and when should it be achieved?

▶ **Example**

Mr. K., Age 21, Condition Following Traumatic Brain Injury and Hypoxia

Problem Analyses during oral hygiene

Mr. K. has poor postural and head control. His arms demonstrate flexion pattern in sitting. His legs show extension pattern. He jerks and groans if his hands, face or mouth are touched and bites his teeth together firmly. He is unable to hold a toothbrush himself or lift it to his mouth. He does not open his mouth when the toothbrush moves towards his lips and he reacts even if the toothbrush is inserted gently into his mouth with increasing body tension. It is impossible to clean the occlusal surfaces of the teeth. Oral hygiene would be necessary at least three times a day, because there are many saliva residues in the oral cavity, which Mr. K. is unable to spit out or swallow safely. Oral hygiene takes about 60 minutes, including positioning. Tactile oral stimulation and cleaning of the outer surfaces of the teeth must be carried out very slowly.

Objective

Functional goals (achievable within 1-2 weeks):

- The patient can tolerate the toothbrush touching the inside of his mouth without biting reactions when he is in side-lying position. Slow brushing of the outer surfaces of the teeth is possible without causing extreme increases in tension throughout the body.
- Swallowing can be facilitated after each quadrant has been cleaned.
- Positioned in side lying, the patient can perform on the outer surfaces of the teeth, with the help of the therapist without the overall tone level increasing.

Prevention/Prophylaxis

Prevention of

- Aspiration pneumonia, caused by the aspiration of contaminated saliva (Kwang-Hwa Chang et al. 2013)
- Gingivitis
- Tooth and lip damage caused by biting reactions
- Contractures in the wrists and fingers: counteracted by involving the hands in the activity *cleaning the teeth*

Treatment Plan

The nursing staff performs oral hygiene twice a day. It is also performed once a day during therapy or more frequently if required. The patient's mother has been taught to clean his mouth systematically using gauze to remove saliva residues. She does this whenever she visits Mr. K.

The oral hygiene process:

The patient is positioned. The stable surroundings provide support, for example wall, niche, table, chair. Mr. K. is brought into contact with the utensils required for oral hygiene in order to develop hand–mouth–eye coordination. The toothbrush is placed in his hand or he is given a cloth to wipe his mouth with. Preparatory tactile oral stimulation is performed (► Sect. 6.2.4).

To clean all of the tooth surfaces, a padded spatula is used to stabilise the lower jaw and thereby to avoid biting reactions (◘ Fig. 6.13).

Swallowing of saliva is facilitated whenever Mr. K. initiates the process. If he does not swallow, movements of the trunk, shoulders or head are used to elicit attempts to swallow.

Start of Treatment (Treatment Process)

- The patient is positioned in side lying. Pillows and blankets support the body for functional alignment, as normal as possible.
- The patient's hands are brought to his face, in a variety of situations: for example washing and drying the face, resting the head on the hands occasionally whilst sitting, dabbing the mouth with a soft cloth. Diffuse wiping movements on the face are avoided.
- If the patient makes any attempts to swallow, the therapist facilitates swallowing (► Chap. 5).
- After cleaning of each quadrant, Mr. K. is given the opportunity to close his mouth and swallow (► Sect. 6.2.4). In order to clean the occlusal and inner surfaces of the teeth, a spatula padded with gauze is placed between the molars on one side of the mouth to stabilise the jaw. A child's toothbrush is used to clean the occlusal surfaces. The spatula is removed after each quadrant has been cleaned, allowing closure of the mouth and swallow.

Evaluating the Patient's Reactions

- The patient's reactions soon become apparent. His tone levels and rate of breathing increase rapidly as the washcloth is moved lightly over his hand. Overall body tension remains relatively high when his left cheek is touched. As the washcloth is moved towards the right cheek, Mr. K. turns his head slightly in this direction. Head and hand movements are coordinated in this short sequence. His level of tone and the breathing frequency decrease and he opens his eyes. For a short moment, Mr K. and his therapist do have eye contact. Pumping jaw and tongue movements can be interrupted, allowing a swallow to be facilitated.

- Whilst jaw opening is generally possible, the tension in the body increases when the spatula is inserted. Consequently, the mobility of the temporomandibular joint is limited, making it difficult to open the jaw. Extension of the cervical spine is accompanied by retraction of the jaw (► Chap. 4). This issue requires further therapy and the process of analysis begins again. ◄

Note
The cycle of evaluation and treatment helps to analyse the patient's problems. Concrete, realistic and functional goals can then be set. It is vital that therapists and nursing staff continue to analyse and evaluate the patient's response, in order to create or discard working hypotheses.

6.2.2 Applying the International Classification of Functioning, Disability and Health (ICF) to Oral Hygiene

The F.O.T.T. approach is open to new research findings and alternative approaches to assessment and problem analysis. The biopsychosocial model ICF (WHO 2018) provides a multi-level conceptual framework for the definition and measurement of health and disability. This framework has many advantages. It allows individualised problem analysis, goal setting and treatment plans to be developed and adapted to the specific needs of the patient. It provides a common reference frame and terms that facilitate teamwork in the interprofessional team. Last but not least it shows that it is important to assess and intervene on the several levels of ICF, since they influence each other.

ICF has recently been used more and more in clinical and research context. Health systems in many countries call for using this framework in rehabilitation. ► https://www.dimdi.de/dynamic/de/klassifikationen/icf/anwendung/ (accessed 28 November 2018) ► http://www.marselisborgcentret.dk/siteassets/icf/notat-om-icf-maj-2016-forskning-og-udvikling-marselisborgcentret.pdf (accessed 28 November 2018)

The Interactions of ICF Components

Figure 6.2 shows a modified ICF model (WHO 2018) applied in an example with oral hygiene. It is important to consider that this example might not cover all aspects. It includes working hypotheses for the underlying causes of the problems on the level of activity and participation (Fig. 6.3).

Body Functions and Structures Body functions are the physiological functions of body systems, for example saliva production, swallowing, including psychological functions. Body structures are anatomical parts of the body, such as organs, limbs and their components, for example tongue, jaw, lips, etc.

The Level of Activity

This refers to an individual's ability to execute a task or action. Activity impairments are difficulties a person may have when participating in, or carrying out, an activity, for example oral hygiene or eating a meal. The ICF model includes a list of components within the domain of activities and participation for the purposes of classification.

Level of Participation

The component of participation assesses the amount of involvement in life situations.

Contextual factors include the complete life experience and background of the individual. They also affect oral hygiene and must be considered. The contextual factors are divided into two components:

- Environmental factors
- Personal factors

Environmental Factors These include the physical, social and attitudinal surroundings in which people live and conduct their lives, for example the patient has a very supportive family. He lives in an area with a good infrastructure.

Fig. 6.2 **a**–**d** Evaluation process during oral hygiene. **a** The lateral incisors and canines were neglected when the patient cleaned his teeth independently. This resulted in plaque formation and redness between the teeth and gums. The patient uses horizontal scrubbing motions **b** The therapist provides instructions for handling the toothbrush and teaches the patient techniques for cleaning. The therapist's hand supports the 'long neck'. The wooden block under the left foot facilitates control of the hip on the right, standing leg. The lower, ventral trunk muscles are simultaneously activated. **c** The standing aid supports the patient's trunk stabilisation. A powered toothbrush can be used to compensate for the limited finger and hand movements available. This makes it possible for the patient to clean his teeth efficiently and independently. **d** Large areas of the plaque were removed once the patient was shown how to brush using the powered toothbrush

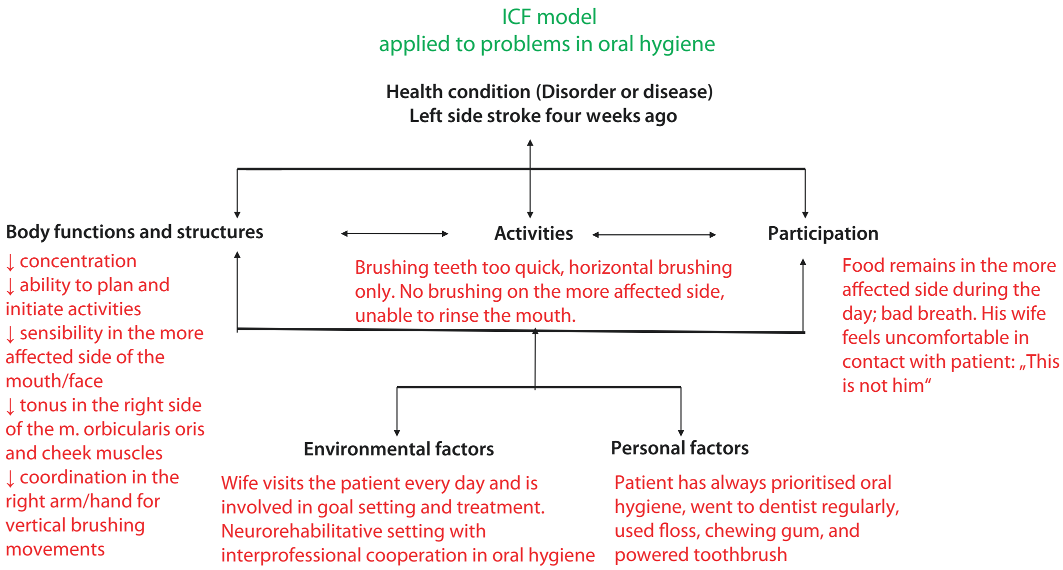


Fig. 6.3 ICF model applied to problems in oral hygiene. (© Jakobsen 2019. All Rights Reserved)

Personal Factors Personal factors may include gender, age, race, lifestyles, habits, education and profession. They represent influences on functioning particular to the individual, which are not represented elsewhere in ICF, for example the patient very much cared for a clean and fresh body and mouth odour.

► Example

Robert, 45 years old, married, father of two children at ages 9 and 11. He is in the subacute phase after a stroke.

The goals, and interventions to reach those goals, have been agreed to by the patient's interprofessional team together with his wife.

Goals (should be realistic to be reached within 2 weeks):

- Robert is able to perform oral hygiene sufficiently (no remains of food in the mouth after tooth brushing) and brushing his teeth vertically (red–white technique) for at least 2 minutes, sitting in front of the sink. All remedies for tooth brushing are in his visual field.
- Robert can rinse his mouth sufficiently.

Interventions to reach the goal:

- *Handling/Strategies:* Structuring Robert's day, where staff initiate oral hygiene after each mealtime and before going to sleep.
- Ask Robert's wife to bring his power toothbrush from home and help him to use it properly
- Evaluate whether he can use the powered toothbrush by himself after instruction.
- Help Robert to use dental floss each day – choose small holders instead of one long piece.
- During oral hygiene: The therapist guides Robert to perform vertical (red–white technique) brushing movements.
- Facilitate rinsing of the mouth.

In treatment:

- Facilitating active symmetrical lip – and cheek movements.
- Tactile oral stimulation and therapeutic eating (chewing in gauze) to regulate tone and sensibility in the mouth.
- Work on selective arm and hand movements (more affected side) for coordinated brushing movements and handling the toothbrush.
- Work on proper initiating, planning and finishing activities of daily life (ADL). ◄

6.2.3 Procedure of Therapeutic Oral Hygiene

> Input forms a sine qua non for change and learning. (Mulder and Hochstenbach 2001)

The approach is determined by assessing, treating and evaluating the patient's response to therapeutic interventions. When performed in a structured way to target the patient's problems, oral hygiene is therapy. Functional movements are facilitated. The patient gets opportunities to perceive his oral structures and use them in a daily life context.

Note

Only if we use the framework of assessment and treatment to identify the type of interventions required by the patient, we can help in a targeted way. This implies structuring the environment, providing feedback, using assistive devices or facilitation. (▶ Chaps. 12 and 13)

- The preparation for oral hygiene can be adapted to the patient in several ways:
- By devising a realistic environment in a daily life context, thereby promoting situational understanding
- Through facilitating postural control
- By using appropriate positions and supporting the position with materials for optimal alignment
- By involving the patient according to his abilities and problems
- By using tactile oral stimulation to prepare the facial-oral tract (▶ Sect. 6.2.4).

Preparation

The more severely impaired the patient's situational understanding or the sensorimotor function, for example hand–eye–mouth coordination, the more important the preparation and the pre-oral phase for oral hygiene.

The situation must be arranged for the patient to understand that 'the teeth are being cleaned now'. Experience has shown that the principles of the Affolter Model® (▶ http://www.apwschweiz.ch/ assessed 18 November 2018) can be combined effectively with the F.O.T.T. approach. The patient is guided during the preparation for oral hygiene (◘ Fig. 6.4).

> We cannot take the patient's eyes, move them and be sure that the patient sees, nor can we move his ears and know that he hears. But when we guide his hands and his body and bring them in contact with surfaces and objects, significant tactile input and interaction is guaranteed. (Affolter 2001, translated by Daniela Jakobsen)

The daily activity of oral hygiene is intentionally structured in a context that provides enough information for the patient to build up comprehension for the activity.

The patient is positioned with optimal alignment. Involving the patient as much as possible creates a sensory *readiness* for the following intraoral input and the cleaning of the mouth. It might be easier for the patient to follow the daily routine if the situation is clearly structured. Familiar and unambiguous situations often provide a basis for the first functional movements. Using familiar items relating to oral hygiene is one way of improving the coordinated movements of the eyes, the hands and the mouth. This increases the chance that the patient might be able to perform the first brief, active sequence of movements.

During preparation and activation, various aspects might help the patient to recognise the situation of oral hygiene, for example once the patient's hands have been touched, they can be placed around the tooth mug. The therapist can then help the patient to hold the mug. Involving the hands not only helps to provide comprehension, it might also be an essential step in patients with hypersensitive reactions, for example turning the head away, biting and grimacing.

Patients with an acquired hypersensitivity to oral hygiene could be treated initially with the tactile oral stimulation described in the next section.

6.2.4 F.O.T.T. Tactile Oral Stimulation: Examination and Oral Routine

The tactile oral stimulation can be used to assess and treat problems with tone, reaction on touch and movement in the facial-oral

Fig. 6.4 **a**–**c** The patient is included in the preparation for oral hygiene. (© Jakobsen and Elferich 2019. All Rights Reserved) **a** Turning on the tap to fill the tooth mug. **b** The patient understands the situation and actively opens his mouth to allow the toothbrush inside. The position of the head and opening of the mouth are both facilitated using the jaw support grip. **c** Dabbing the mouth with a towel is guided

tract and with swallowing of saliva. This stimulation can be applied as a daily routine, preparation for therapeutic eating or oral hygiene.

Note

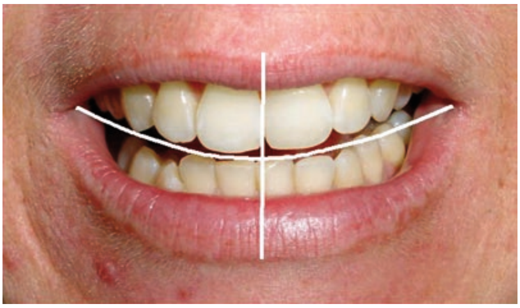
The face and the mouth in particular are amongst the most intimate areas of the human body with a high density of receptors. We therefore have an even greater responsibility to treat these areas with respect and carefulness when working with patients who depend on us.

■ Procedure

The patient is in an appropriate position for tactile oral stimulation, for example sitting or side lying.

Throughout the whole procedure, the therapist offers support to the patient by moving/adapting the position, if necessary, and stabilising the head and the jaw.

The so-called *tactile hello* prepares the patient for subsequent contact inside the mouth. The patient's hands are guided to his own face and mouth by the therapist in a structured way an in an appropriate tempo.



■ **Fig. 6.5** Conceptual division of the mouth into four quadrants. (© Jakobsen and Elferich 2019. All Rights Reserved)

Then the therapist touches the patient's hand and face structured and firmly with her hands. Thereby, the therapist carefully evaluates the patient's reactions to touch. This procedure ensures that the privacy of the person concerned is respected.

The mouth is conceptually divided into four sections or quadrants (■ Fig. 6.5).

Stimulation begins on the more- or the less-affected side, depending on the patient's problems. The therapist touches the mouth from outside (upper lip and lower lip) and observes the response. Contact is targeted and unambiguous, avoiding wiping movements. Then, the therapist moistens her finger with water and touches the gum under the upper lip. The therapist evaluates whether the patient is able to tolerate the touch. The therapist's finger then moves forwards and backwards along the upper gum from the front to the back of each quadrant (usually three times). The finger then moves along the inside of the cheek, enabling the therapist to feel and influence the tone. There is a pause after every quadrant, when the therapist removes the finger and helps the patient to close the mouth. A swallowing reaction would normally be expected at this point if responsiveness and saliva production are intact.

The therapist facilitates swallowing if it does not occur spontaneously (▶ Sect. 5.3.3).

This procedure is repeated on the lower gum on the same side of the mouth, and then on the opposite quadrants (top and bottom). During the whole procedure, the patient's reactions are carefully analysed, and the therapist might modify the procedure depending on the patient's reactions (▶ Chap. 12).

If biting reactions can be excluded, the therapist's finger touches the anterior third of the tongue. The finger is moved from ventral to dorsal in three steps (from the tip to the middle of the tongue). The therapist's finger is then removed so the patient can close his mouth.

When biting might occur, a spatula wrapped with gauze can be used to touch the tongue.

The hard palate is touched once, behind the upper incisors, with the therapist's finger or a wrapped spatula. The patient's reaction might be to move the tongue spontaneously or on request towards the palate. Then the patient gets the opportunity to close the mouth. Each time the mouth is closed, the therapist observes whether there are spontaneous tongue movements (e.g. to collect saliva) or spontaneous swallowing. Swallowing is facilitated, if necessary. The patient's position is monitored during tactile oral stimulation and modified if necessary.

Tip

Using the patient's own finger for stimulation might have therapeutic benefits, but care must be taken; biting reactions are not under the patients' control, even with their own fingers.

Analysis and treatment are in close relation in the F.O.T.T. approach. Tactile oral stimulation can also be used with the focus on the tactile examination of the mouth (▶ Sect. 11.3.4). Oral stimulation, for example the pace, the way of touching and the involvement of the hands, is modified to the patient's specific problems and responses. The objectives of tactile oral stimulation are summarised in ▶ Overview 6.2.

Overview 6.2 F.O.T.T. Tactile Oral Stimulation

Objectives:

- Tactile preparation before oral hygiene or therapeutic eating by providing structured input to the hands, face and mouth (► Chap. 5)
- Regulation of gingival blood circulation
- Increase of saliva production
- Activation of oral structures by structured input goals, for example motor response from the tongue or swallowing of saliva
- Increase of arousal in patients with disorders of consciousness

6.2.5 Cleaning the Oral Cavity

It is essential to clean the oral cavity even if the patient is kept on nihil per os (NPO). This is particularly important if the patient is unable to follow an oral hygiene routine independently. Dental specialists agree that preventive measures for caries and periodontal prophylaxis are not limited to optimal oral hygiene. Regular fluoridation of the teeth (especially in children and adolescents) and a balanced diet play a significant role. Despite the lack of strong evidence of high quality, it is assumed that infrequent tooth brushing is a risk factor for periodontitis (Zimmermann et al. 2014).

Infrequent tongue movements, an open mouth or oral abstinence can cause a usually grey-white colour coating on the tongue. This type of tongue coating creates a breeding ground for fungi and bacteria and should be removed regularly (◘ Fig. 6.6)

Oral hygiene in neurological patients confronts us with a number of complex tasks. In addition to food residues, any coating on the tongue, crusts or secretions must be removed from the oral cavity. At the same time, patients with facial-oral issues may have difficulty rinsing their mouth, transporting saliva and protecting their airway. They cannot sense and/or are unable to remove residues in the mouth or throat. In giving guidance for oral hygiene, a range of potential problems must be considered, such as the risk of aspiration, cognitive issues, problems with postural control, the quality of oral nutrition and problems related to tube feeding.

◘ **Fig. 6.6** Tongue coating proliferated for several weeks, seen after therapeutic jaw opening. (© Nusser-Müller-Busch 2019. All Rights Reserved)

In healthy subjects, sensory input is usually created by swallowing of saliva, eating, drinking, breathing and speaking. Patients who lack this input need alternatives. The longer the patient lacks physiological input, the more important it is to apply tactile oral stimulation. This is especially problematic for patients with cuffed tracheostomy tubes (TT) who do not use the larynx and upper airway for breathing. The lack of the stimulation by the in- and outgoing air might lead to learned non-use (► Sect. 10.3.1).

Practical Tip

A multidimensional approach for oral health is usually successful:

- Regular mechanical removal of the coating, using antibacterial solutions if necessary
- Facilitation of lip closure to avoid oral dryness
- Facilitation of tongue and jaw movements enables mechanical friction, stimulating the natural hydration of the mucous membranes
- Regular hydration of the mucous membranes (for example by oral hygiene, oral stimulation, and eventually combined with application of artificial saliva)
- Therapeutic eating if the patient has the prerequisites (► Sect. 5.5.2)

Warning
The process of removing tongue coatings may trigger a gag reaction. Working slowly and involving the patient's hands can help to prevent this. It may be helpful to moisturise the spatula or gauze thoroughly before they are placed in the oral cavity. Extending the neck encourages the gag reaction, therefore holding the patient's head in slight flexion is recommended.

Pace and McCullough (2010) showed in a geriatric population in nursing homes a combination of mechanical cleaning and the use of chemical aids seem to be effective. However, long-term use of chemicals is not recommended as side effects, for example of chlorhexidine, include dehydration of the mucosa. Non-foaming toothpastes may alleviate mouth dryness and are recommended for patients who are unable to rinse their mouth. It remains unclear which mechanical methods (dental floss, brushing, rinsing) should be used during oral hygiene, as well as the frequency, duration and concentration of use of chemical agents. Ready-to-use mouthwash products are no substitute for brushing. Also, they seem often unsuitable for patients with problems in the oral phase of swallowing who are at risk of aspiration, as they must be moved back and forth in the mouth, before being spat out.

6.2.6 The Tooth Brushing: Principles, Methods and Technique

Recommendations for the best and most sufficient brushing technique for adults and children provided by the dental profession vary. The optimal frequency, method and amount of time to spend cleaning the teeth are still unclear (Wainwright and Sheiham 2014).

The primary cleaning method used in F.O.T.T. (◘ Fig. 6.7a–k) is the red-white technique, where the toothbrush is moved vertically from the gums towards the tooth. Combined with a clear approach and guided movement of the toothbrush, it allows the cleaning process to be adapted to the individual.

The following principles must be observed:

- The conceptual division of the oral cavity into four quadrants (◘ Fig. 6.5) allows for a structured approach, so that reactions to the cleaning can easily be observed. Depending on the patient's problems, brushing begins in the upper quadrant on either the more or the less affected side, followed by brushing of the lower quadrant on the same side.
- The *Red to white method* (◘ Fig. 6.7b, c)
- The toothbrush is guided from the gingival margin to the tooth before being moved to the next tooth. This prevents the spreading of secretions or food.
- From back to front (◘ Fig. 6.7d, e)
- The brush is moved intraorally on the tooth surfaces from dorsal (the molars) to ventral (the incisors). This prevents food or saliva residues being spread. Residues are removed directly. This is particularly important for patients who are unable to rinse their mouth.
- The outer surfaces are cleaned first. A break is taken after each quadrant, so that the patient can close the mouth. This allows the patient to swallow and avoids discomfort by having the mouth open for too long.
- Then, the inner surfaces are cleaned in the upper and lower quadrant (◘ Fig. 6.7e, f)
- Finally the occlusal surfaces are brushed.
- Spitting out of saliva can be facilitated too but might not be necessary when no toothpaste is used. In healthy persons, a swallow reaction often follows after spitting out.
- The toothbrush is rinsed after each cleaning cycle. Excess water should be removed from the toothbrush by dabbing on a clean cloth. It is important to avoid introducing too much liquid into the mouth if patients are at risk for aspiration.

▪ Dealing with Dental Prosthesis

Note
An exactly fitting dental prosthesis plays an important part in the functional unit of the tongue, cheek, palate and jaw. It influences the quality of non-verbal communication, articulation and the oral transport of saliva (Slaughter et al. 1999).

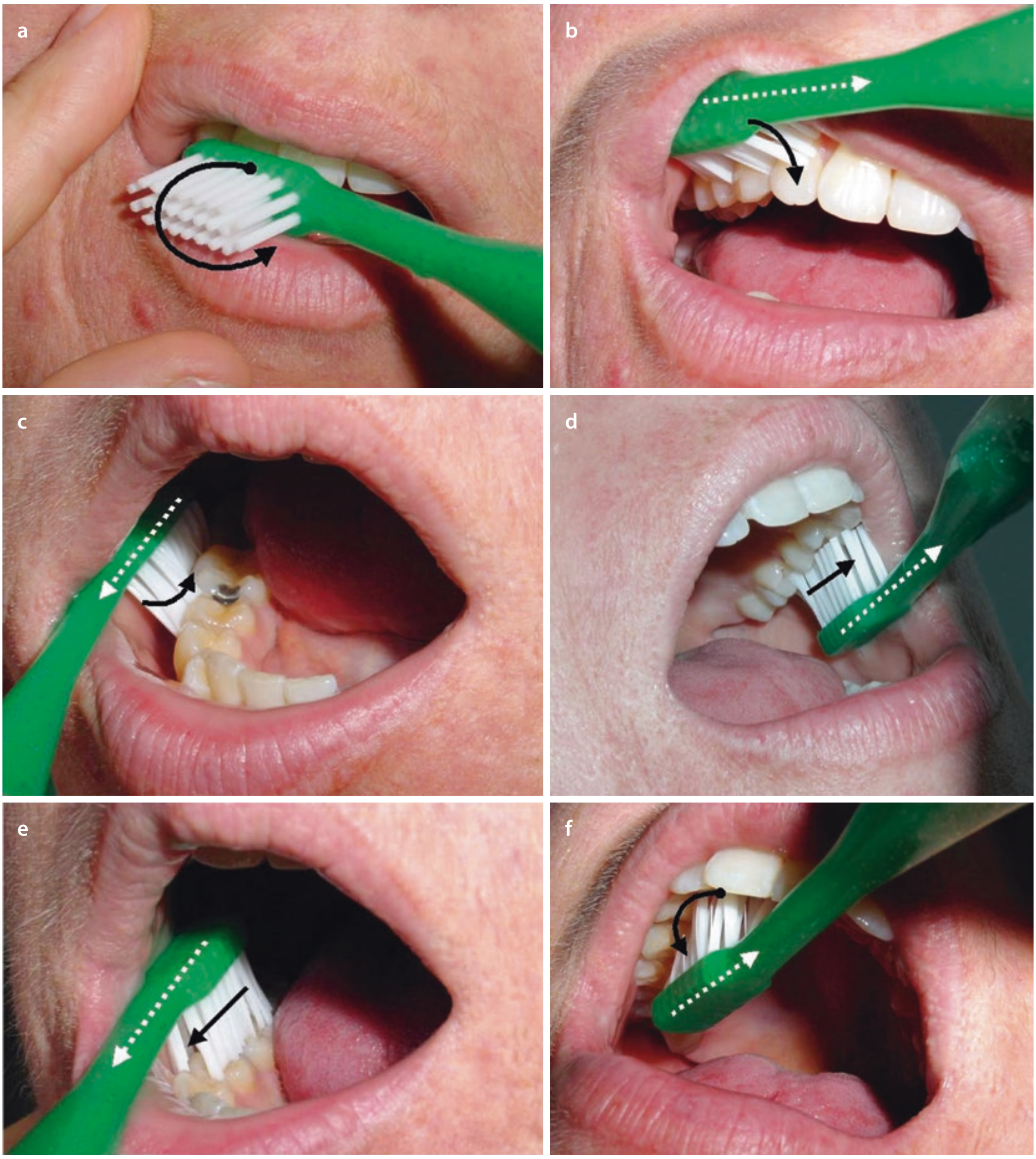
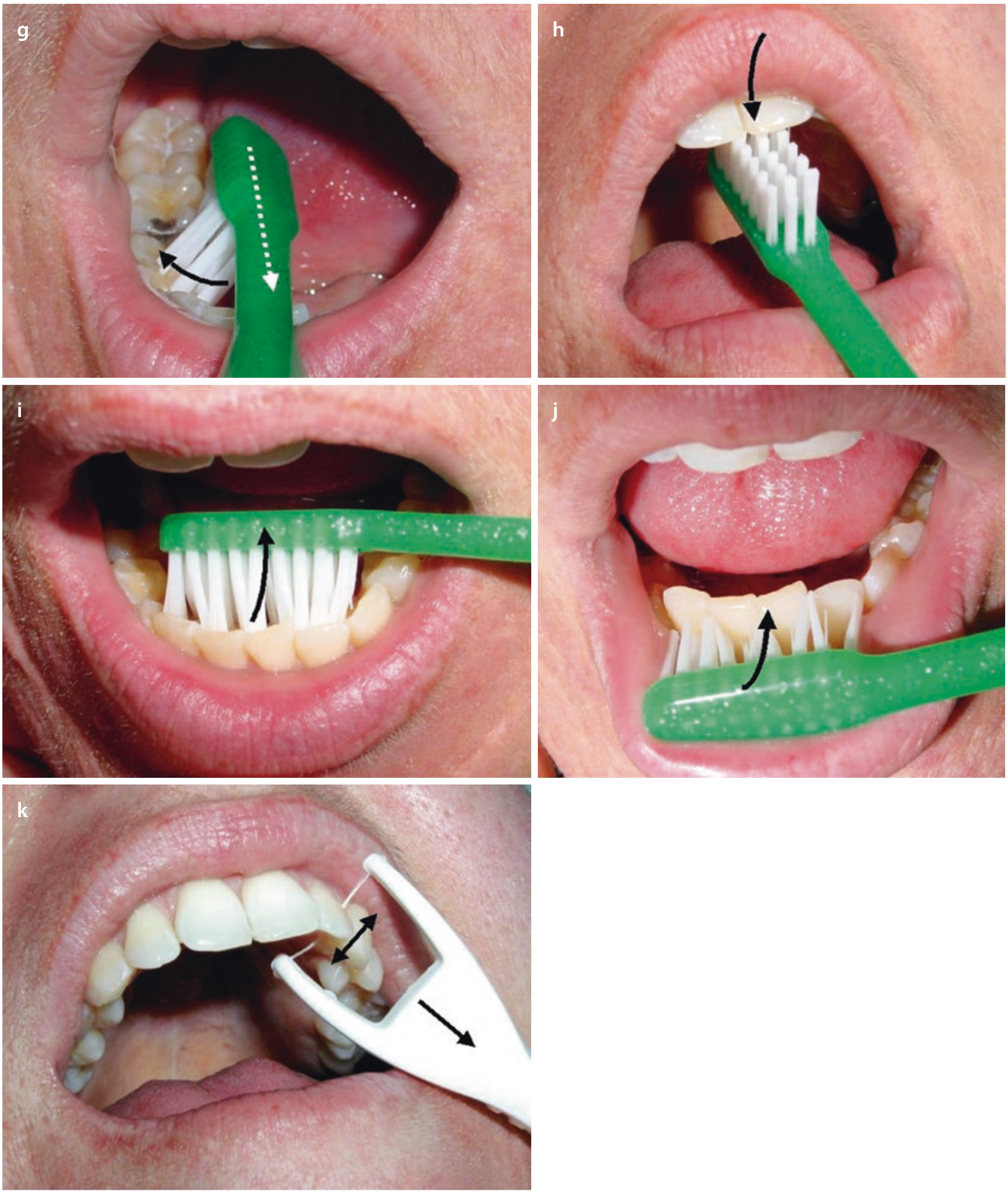


Fig. 6.7 **a**–**k** Teeth cleaning. (© Jakobsen and Elferich 2019. All Rights Reserved). **a** Inserting the toothbrush: The upper lip is slightly lifted and held. The smooth side of the brush head is placed against the tooth. It is turned to the tooth once the brush is inside the cheek. This avoids diffuse cleaning movements of the bristles against the inside of the cheek. **b**, **c** Upper and lower quadrant: The outer surface is cleaned – from gum to tooth ('red to white') and molar to incisor (from 'back to front'). **d** Upper quadrant: The occlusal surfaces are cleaned. From back to front. **e** Lower quadrant: The occlusal surfaces are cleaned. From back to front. **f**, **g** Upper and lower quadrant: The inner surfaces are cleaned. From red to white – from back to front. **h**, **i** Upper and lower quadrant: The inner surface at the front is cleaned. From the gums towards the tooth. **j** The bristles also clean the interdental spaces. **k** Additional interdental care, using floss in a holder



6

Fig. 6.7 (continued)

Altered cheek and lip tone, for example in facial palsy, and reduced tongue mobility can create instability and thereby affect the fit of a dental prosthesis (Klobucar et al. 2012). Changes in the periodontal alveolar ridge can occur rapidly if medical interventions (e.g. ventilation, surgery) deprive the patient of their dental prosthesis for a prolonged period of time. Atrophies (e.g. of the pars alveolaris of the lower jaw) may create additional difficulties when the prosthesis is readjusted.

Inaccurate fitting of a full denture causes the alveolar ridge to atrophy, encouraging the development of stomatitis. This might complicate oral hygiene.

The oral mucosa may react sensitively, particularly when the denture is reintroduced and worn for the first time.

Practical Tip

The dental prosthesis should be worn as long as possible each day.

The prosthesis should be cleaned after every meal. The palate and alveolar ridge must also be cleaned using a soft toothbrush and any coating removed.

A special denture brush should be used to clean the prosthesis, without the use of abrasive toothpaste (Faigenblum 2015). The prosthesis should be stored dry overnight in a special container and rinsed before being inserted in the morning (Manfredi et al. 2013).

Patients who clean their dental prosthesis independently should be carefully supervised. Visual impairments and fine motor disorders often lead to hygiene deficits.

Tactile oral stimulation is initially conducted without the prosthesis (to identify wounds, give clear sensory information, and assess the level of tone in the cheeks). It is then performed with the prosthesis in place. The teeth provide the tongue with a natural boundary and provide stability for the lower jaw. Both are important for swallowing and articulation.

A dentist may need to reline the prosthesis if it is no longer stable (even with the use of adhesive).

Warning

Denture adhesives require a correct mode of application. They cannot compensate for an ill-fitting dental prosthesis. Used in a correct way, they support comfort, retention and stability for the prosthesis.

In patients with neuromuscular disorders, the adhesives might help to achieve stability (Kumar et al. 2015).

In patients who are at risk to aspirate, remains of the adhesive always must be removed from the prosthesis and the oral cavity.

6.2.7 Oral Hygiene Aids

The use of aids during oral hygiene must be individually adapted. Whenever possible familiar objects from everyday life should be used in order to be recognised.

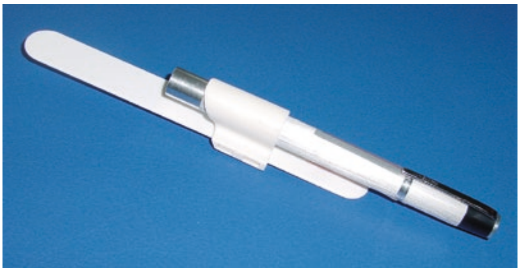
Aids used for oral hygiene should support functional movement and provide helpful input.

The required oral hygiene utensils include (Fig. 6.8):

- Two tooth mugs
- A (child's) toothbrush
- Gauze pads
- Spatula
- Finger stalls (or gloves)
- Dental floss
- A lamp, optimally with a spatula holder, for the visual examination of the mouth (Fig. 6.9)
- Toothpaste (to be resolved in water if the patient cannot rinse his mouth yet)
- Soft tissues or clothes to dab the toothbrush and the mouth

Two tooth mugs are required. One is used to clean the toothbrush after each quadrant is

Fig. 6.8 Standard equipment for F.O.T.T. oral hygiene 2 tooth mugs, 1 child's toothbrush, gauze, plastic spatula, dental floss holder, finger stalls or gloves. (© Jakobsen and Elferich 2019. All Rights Reserved)



■ **Fig. 6.9** Examination lamp with spatula and holder. (© Jakobsen and Elferich 2019. All Rights Reserved)

brushed. The other is used for immersing the toothbrush in fresh water or rinsing the mouth if necessary. The short, narrow brush head of a child's toothbrush is well suited for cleaning the occlusal and inner surfaces of the teeth in patients with limited jaw opening. It is usually sufficient to clean the teeth with a soft toothbrush. This ensures gentle cleaning and prevents enamel loss and damage to the gums. A thicker, individually adapted handle can facilitate handling of the toothbrush as well as increase quality of the cleaning movements. A small toothbrush also makes it easier for the therapist to move it inside the patient's mouth.

The spatula is used to examine the oral cavity, and the examination lamp is attached to the handle (■ Fig. 6.9). The spatula can also be wrapped in gauze to clean the tongue in case of biting reactions. Cleaning the mouth with gauze before tooth brushing helps to remove saliva in a structured way. To do so, the therapist puts on gloves and wraps gauze around the index or little finger (■ Fig. 6.10). She cleans all the four quadrants (■ Fig. 6.5) in a structured way. Subsequently, the tooth brushing follows. Residues can be removed from the oral cavity in this way and ointment or antibacterial gels can be applied.

Note

Only finger stalls or gloves which fit exactly provide clear tactile information for both the patient and the therapist.

Cleaning the interdental spaces with dental floss is an essential part of completing oral hygiene. Flossing is recommended to avoid gingivitis, a risk factor for periodontal diseases (Sambunjak et al. 2012).

■ **Fig. 6.10** A gloved finger wrapped in gauze can be used to clean the oral cavity. (© Jakobsen and Elferich 2019. All Rights Reserved)

If the jaw can be opened widely and safely enough, the interdental spaces can be cleaned with dental floss in a holder (■ Fig. 6.7k). This type of holder is useful for the patient who is independent and able to clean with one hand. It is also useful when assisting with the cleaning process as it leaves the carer with a hand free to facilitate mouth opening. An interdental brush is recommended for larger interdental spaces (■ Fig. 6.11).

A powered toothbrush can be an alternative for individuals who have difficulties to make precise brushing movements due to sensorimotor problems, as most of the fine rotating and vibrating movements are made automatically. The thicker handle also facilitates closing the hand around the toothbrush (■ Fig. 6.12). A powered toothbrush might be contraindicated for hypersensitive patients with phasic biting patterns or severe pumping and smacking movements in response to oral touch. The vibration and noise from the

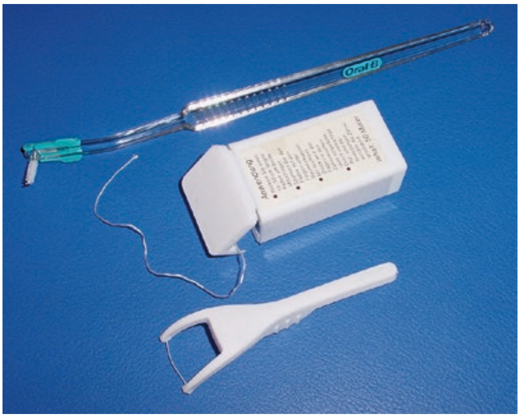


Fig. 6.11 Interdental care from top to bottom: 1 interdental brush, 2 dental floss, 3 dental floss with a holder. (© Jakobsen and Elferich 2019. All Rights Reserved)

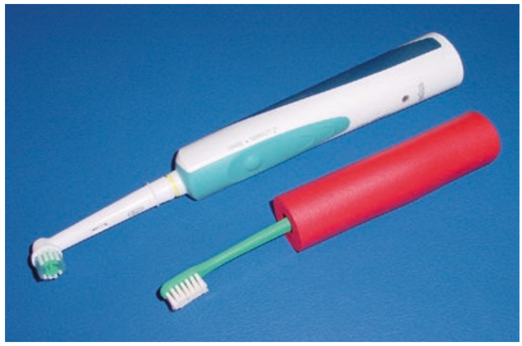


Fig. 6.12 Electric toothbrush and manual toothbrush with a thicker handle. (© Jakobsen and Elferich 2019. All Rights Reserved)

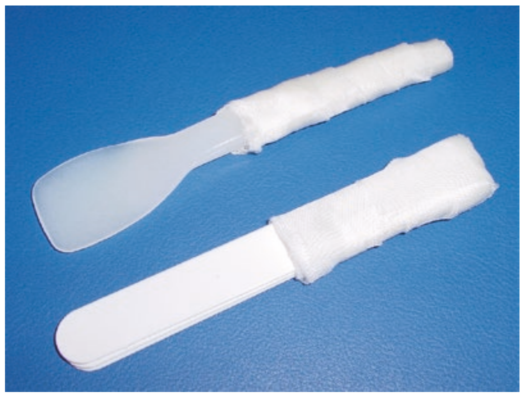


Fig. 6.13 Aids to stabilise the lower jaw in biting reactions. Bottom: plastic spatula, padded with gauze and tape, top: Cheyne spoon, wrapped with gauze and tape. (© Jakobsen and Elferich 2019. All Rights Reserved)

motor may increase the level of tone in the body and provoke biting reactions. The replaceable brush head may become dislodged or break off in the oral cavity if the patient bites the toothbrush. If the electric toothbrush is meant to be used in severely affected patients, it should be tested on the patient's hand first. If the vibration of the toothbrush can be tolerated, the toothbrush can then be placed in the mouth. The vibration should only be switched on after the brush is in contact with the teeth. It should be switched off before the brush is removed to avoid diffuse vibrations against the cheeks and lips.

▪ Built-up Toothbrush Handles

It can be difficult for the patient's paretic hand to grasp and hold a manual toothbrush. A built-up handle (Fig. 6.12) may be an option once the patient's hand and fingers begin to move. The handle makes the first, independent cleaning movements easier and can also be used to facilitate closing the hand during guided cleaning.

▪ ▪ Use of Padded Spatula to stabilise the Lower Jaw during Cleaning of the Inner and Occlusal Surfaces

The padded mouth spatula and the handle of a Cheyne spoon have both proven effective for stabilising the jaw (Fig. 6.13) in patients with phasic biting patterns, sudden biting reactions, or reduced, active jaw opening. After working on gradual opening of the jaw, the padded spatula is introduced from a lateral direction and placed between the molars. The occlusal and inner surfaces of the tooth row on the opposite side can then be cleaned. Afterwards the spatula can be removed carefully to allow a break for the patient to close the mouth. Swallowing is facilitated, if necessary. The padded spatula is then reintroduced on the opposite side of the mouth, and cleaning continues on the second side. The padded spatula is not used to 'pry open the mouth'. It is placed between the rows of teeth after the jaw has been opened. By using the jaw support grip at the same time, the spatula serves to stabilise the lower jaw and inhibit biting reactions.

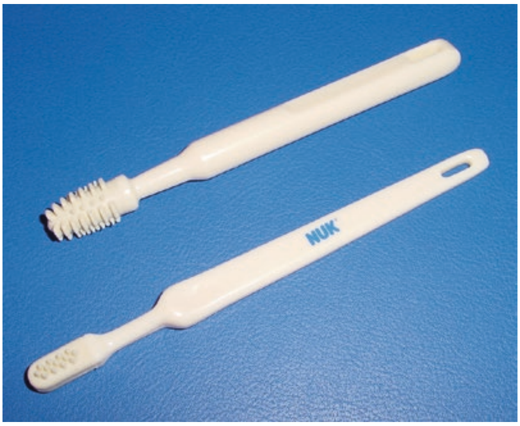


Fig. 6.14 Training toothbrush for babies with rubber nubs. (© Jakobsen and Elferich 2019. All Rights Reserved)

Nubbed Cleaning Stick

A small training toothbrush for babies with rubber nubs is ideal for increasing blood supply to the gums and removing coating from the tongue (Figs. 6.13 and 6.14).

6.2.8 Contraindicated Oral Care Utensils

Warning
Metal objects, dental mirrors and other fragile oral hygiene items (e.g. dental floss holders) should not be used with patients who have biting reactions (Fig. 6.16).

Disposable Toothbrushes

Disposable toothbrushes (e.g. with dried toothpaste) are contraindicated for the regular oral care of those affected by neurogenic disorders for various reasons (Fig. 6.16). If the toothpaste crumbles during cleaning, it can be aspirated. The bristles on the brush in the illustration are not rounded and are very hard. This can injure the gums and cause bleeding even if the gums are healthy.

Practical Tip

The use of sterile water or still mineral water is often recommended for the oral care of patients suffering from immunodeficiency.

Cotton buds and mouth swabs

The smooth surface structure of cotton buds makes them an unsuitable alternative to a toothbrush. They might be useful for wiping away saliva in the oral cavity but have no massaging effect on the gums and cannot remove plaque effectively. The quick, light wiping movements with the buds may elicit increasing tone. If biting reactions occur, the head of the cotton bud might be bitten off. The use of fats or oils cannot be recommended either. Cotton buds with added lemon flavouring (lemon glycerine mouth swabs) are unsuitable for removing coatings too. The citric acid in the swabs attacks tooth enamel (Meurman et al. 1996) and can irritate broken mucosa (Warner 1986). The sour taste also stimulates saliva production. This might increase the risk of aspiration. Glycerine is suspected to dehydrate the mucosa and to form a film on the mucosa beneath which germs continue to multiply. In patients with inadequate mouth closure or oral intubation, this film can dry and form crusts in the oral cavity that are difficult to remove.

Swabs in Metal Clamps

Swabs and clamps are not amongst the daily oral hygiene articles that patients used to clean their teeth prior to suffering brain damage. Therefore, patients might not recognise them as belonging to oral hygiene. Most people associate metal clamps with unpleasant experiences, such as uncomfortable visits at the dentist. They are, therefore, more likely to keep their mouths closed if they do not know what to expect. In many respects, using swabs on clamps (Fig. 6.15) to clean the teeth involves diffuse tactile information within the oral cavity. It is not an effective method of removing plaque. There is a risk of injury to the patient in the event of a sudden biting reaction, which could result in the breaking of teeth. There is also a high risk of injury to the palatal mucosa if the metal is not completely covered by the swab. A toothbrush or the therapist's finger wrapped in gauze might be more helpful for removing secretions from the palate. By positioning the patient forward, either in side-lying or in sitting position, gravity can be used to help move secretions from

Fig. 6.15 Contraindicated oral hygiene products, from left to right: clamp with compress, toothbrush with detachable head, disposable toothbrush with dried toothpaste, cotton bud, bite block. (© Jakobsen and Elferich 2019. All Rights Reserved)

the pharynx. A Yankauer suction device can be used for suctioning big amounts of saliva that remain in the cheeks.

Bite Block

Bite blocks (Fig. 6.15) are not used in F.O.T.T., as they result in an uneven distribution of occlusal forces during mouth closure. More biting and pain can be forced by 'prying' the jaw open. Alternatively, a more even distribution of biting pressure can be achieved with the aid of a soft, flat and padded spatula as well as proper preparation of the patient, as described in Sect. 6.2.3, and the use of the jaw support grip (Figs. 5.3, 5.6, and 6.26b–f).

Change Toothbrushes Regularly

It is important to regularly check the hygienic condition and functional integrity of the patient's toothbrush (Fig. 6.16). If the bristles are bent, it is impossible to remove plaque adequately, especially from the interdental spaces and gingival margin. It is helpful to change the toothbrush regularly especially in patients with oral infections, mycosis or biting reactions.

Toothpaste

The active ingredients such as surfactants (foaming agents) and fluorides in toothpaste

Fig. 6.16 Worn toothbrush with bent bristles. (© Jakobsen and Elferich 2019. All Rights Reserved)

are intended to increase the cleaning effect. From a purely dental perspective, however, it is the cleaning particles which are significant for the removal of plaque. This has been confirmed by comparative clinical and experimental studies on the effects of seven toothpastes, on the hard tooth substance and on gingiva (Albers et al. 1982). It has also been shown that caries can be prevented by brushing with high fluoride toothpaste versus standard fluoride toothpastes.

The desire for a fresh taste in the mouth is a motivating factor in the choice of toothpaste. However, caution is advisable when using toothpaste with patients suffering from neurogenic disorders. In many cases it is difficult or impossible for the patient to spit out foaming material. Using toothpaste therefore increases the risk of aspiration. According to clinical experience, cleaning the teeth with water in which a little toothpaste has been dissolved is also effective. Current evidence is insufficient to confirm the efficacy of various herbal teas during oral hygiene in terms of plaque removal or anti-inflammatory effects. Individual preferences are also important. A Taiwanese study conducted in an intensive care unit found boiled water to be superior to green tea in fighting plaque and in the effect on the quantity and consistence of saliva (Hsu et al. 2010). However, the results must be viewed with caution. A number of intervening variables and systematic errors (bias) could not be excluded.

Controversial statements have been made regarding the effects of herbal teas and antibacterial mouthwash solutions. These statements are dependent on the patient group investigated, the clinical setting, and the aspects selected for examination (plaque, caries, bacterial colonisation, gum disease, complications such as pneumonia, etc.). A more detailed study of the literature is therefore recommended, including the substances of interest and their effects on different patient groups.

Warning

The use of toothpaste is contraindicated for patients with the following problems:

- A high risk of aspiration, especially with a (cuffed) TT
- Lack of understanding of the situation and lack of sensorimotor abilities of rinsing and spitting out toothpaste

As an alternative, a small amount of toothpaste can be dissolved in water. However, the cleaning agents in the toothpaste might not have their full effect.

6.3 Typical Problems and Suggested Solutions in the Early Rehabilitation Phase

The term *problems* refer to dysfunctions or limitations which are a direct consequence of brain damage. Patients with severe acquired brain injury may suffer from vital, perceptive, cognitive, emotional and sensorimotor problems, making it difficult to keep up a sufficient oral hygiene (Zasler et al. 1993). The complications associated with these dysfunctions may include aspiration pneumonia, hypersensitivity to physical contact (touching, moving) in the face and mouth, and gum disease. Oral hygiene is potentially compromised if these challenges are not addressed and resolved. Normal sensation and movement may also be impaired, for example during chewing, swallowing or speaking.

A diverse and complex range of issues may complicate daily oral care, making it more time consuming. Dealing with the patient's sensorimotor, perceptive and cognitive impairments requires specialised knowledge and handling. Structural changes such as infections or jaw fractures must also be considered.

6.3.1 Perceptive/Cognitive Impairments

Problem: Lack of abilities for planning, initiating and executing activities of daily life

A patient after traumatic brain injury (TBI) wanders up and down the corridor. He has problems with orientation, planning and executing activities and memory problems. Repeated verbal requests cannot persuade him to go to his room and clean his teeth. Neither does he seem to understand gestures for brushing teeth.

Suggested Solution

The patient is helped to initiate the activity of oral hygiene. Here guiding by means of the Affolter Model® is used (Affolter and Bischofberger 2000). By guiding the patient's hands and body, the therapist aims to provide relevant tactual information to the patient about the activity and his position in the environment. This is assumed to reorganise perceptual and cognitive processes (Affolter and Bischofberger 2000). In this example, the patient, wandering on the corridor, gets the utensils for tooth brushing in his hands. Then the therapist can follow him to the patient's bathroom. Here, the patient is guided to fill water in the glass and apply toothpaste onto the toothbrush (Affolter 1991). By receiving tactile information about the environment and the activity, the patient begins to understand the activity and takes over with brushing the teeth. In a patient with this kind of symptoms, as part of the interprofessional commitment, oral hygiene should be done with the patient using this non-verbal approach of guiding and when fitting into the daily routine (for example in relation to washing and dressing in the morning or after mealtimes) to ensure a proper context for the understanding of the activity.

In general, if patients have difficulties comprehending activities, personal belongings and familiar utensils should be used whenever possible in an environment that is as realistic as possible and – in this example – where oral hygiene usually is supposed to take place (in a bathroom, at the washbasin). This might increase the chance for the patient to understand the activity that is going on. A normal toothbrush and a stable tooth mug are preferable to disposable plastic cups, paper towels, kidney bowls or foam pads. Besides that, there is evidence that toothbrushes are more effective than foam swabs for removing dental plaque (Kelly 2010).

Problem: Memory problems

A patient after TBI in the state of confusion forgets the daily routine of oral hygiene and is unable to find his room or the necessary utensils.

Suggested Solution

Oral hygiene is established as a regular part of the patient's daily routine in combination with personal hygiene or immediately after meals. The patient gets help to initiate tooth brushing using guidance (Affolter and Bischofberger 2000). Furthermore, he is supported to write down and get oriented in a memory book what he has done during the day and which activities are planned. The staff ensures regularity by recording when oral hygiene has taken place. In general, concerning patients with memory problems, relatives can also be instructed to assist the patient, as long as it is realistic and useful for those involved.

6.3.2 Sensorimotor Issues

Problem: Inadequate/Insufficient postural control

Because of a severe intracerebral haemorrhage, a patient has poor trunk control (insufficient trunk muscles) and poor balance reactions. When sitting, he must brace himself using the upper extremities to avoid falling sideways. This leaves him unable to move his arm away from the edge of the washbasin or raise it in order to brush his teeth. The patient puts the toothbrush in his mouth and moves his head back and forth. This is unhelpful because it feels unsafe for the patient and the kind of brushing movements does not remove plaque sufficiently. A study of horizontal versus vertical cleaning techniques in young adults found the vertical cleaning method to be more effective, removing more plaque from the interdental spaces (Mastroberardino et al. 2014).

Suggested Solution

It is important to evaluate whether the sitting position at the washbasin is helpful for tooth brushing. In sitting, it will be necessary to support not only the patient's arm and hand during brushing but also stabilise the trunk. Alternative positions, which offer a larger base of support, include reclined sitting and side lying on a treatment table or in bed. Moving the toothbrush along the rows of teeth requires a high level of coordination. If this coordination is absent, the therapist may choose to clean the patient's teeth, ensuring gentle but thorough cleaning. Still, the patient should be included in the activity, for example filling the tooth mug with water. In general, the therapist would work on the patient's regaining postural control in sitting in order to be able to use the arms in activities.

Problem: Impaired Hand–Hand–Eye Coordination

A patient with left-sided hemiplegia is not able to handle the utensils required for oral hygiene because selective finger movements and stability of the shoulder and elbow are lacking.

Suggested Solution

In a coordinated interplay, both hands should be involved.

Brief sequences of the activity can be guided, for example filling the tooth mug with water. Here, the less affected right hand is guided to act as the *manipulating hand* (opening the faucet), the more affected left hand is guided to hold the tooth mug (*holding hand*). This integration ensures tactile input despite the hand/arm impairments. The therapist will concentrate carefully on what kind of sequences are meaningful and comfortable for the patient to be guided. Furthermore, the therapist will facilitate coordinated arm and hand function, whenever possible, both during the activity and in treatment sequences outside the activity.

Problem: Impaired hand–eye–mouth coordination

A patient who has suffered a cerebral haemorrhage brushes the outside of her cheek with the toothbrush instead of her teeth. She does not notice the difference as she is unable to perceive where the toothbrush is. She does not even realise it when looking in the mirror during brushing.

Suggested Solution

The patient must be helped to perceive her mouth and face again. Tactile oral stimulation is assumed to be helpful for this purpose and can serve as a preparation to tooth brushing (▶ Sect. 6.2.4).The therapist involves the patient's hands and brings them in contact with the face and mouth in a meaningful context to provide sensory information. Through guiding the patient's hand, the therapist ensures that the toothbrush is placed inside the mouth. The jaw support grip is used to stabilise the lower jaw. In general, the therapy should offer plenty and meaningful sensory input to the face and mouth. This might include facilitation of intraoral, functional tongue movements, therapeutic eating and therapeutic oral hygiene.

Problem: Tight closure of the mouth

A patient who has suffered hypoxic brain damage does not open his mouth when the toothbrush approaches although his eyes are open. He is unable to follow verbal instructions.

Suggested Solution

The starting position selected by the therapist is side lying, providing a large base of support. Blankets and cushions support the whole body and ensure optimal alignment of the body (Pickenbrock et al. 2015).The position of the lower jaw is then assessed. The therapist observes that the lower jaw is retracted and therefore uses an adapted version of the jaw support grip to position the jaw optimally. This is a prerequisite for adequate mouth opening. The therapist then places the toothbrush in the patient's hand. Together they dip the brush into the cup, which the therapist helps the patient to hold in his other hand. He is then guided through the process of cleaning the outside of his teeth. This might help the patient to understand the situation. Clinical experience suggests that patients open their mouths more readily if they are holding the toothbrush themselves rather than if it is placed in the mouth by the therapist. The tooth brushing process includes a *pre-oral phase*, encompassing all of the preparations made before the toothbrush enters the mouth. This includes the suitability of the postural background (see pre-oral phase, ▶ Sect. 5.3.2). The therapist maintains the stability of the patient's jaw. By modifying the jaw support grip and using the thumb to gently separate the lower lip from the upper lip, the therapist also facilitates mouth opening.

Problem: Phasic biting reactions

After severe acquired brain injury, a patient exhibits biting reactions during oral hygiene. They appear as soon as the toothbrush meets the lips or teeth. A healthy adult would not respond to cleaning of the occlusal surfaces with phasic biting. The term phasic biting is used to describe the stereotypical, repeated up-and-down movements of the lower jaw. This reaction is normal during early childhood, but disappears by the age of 9–12 months (▶ Chap. 13). Phasic biting impedes adequate cleaning of the occlusal surfaces. The patient bites the toothbrush frequently and with force, which increases his overall level of tension. Furthermore, the biting reactions might avoid proper sensory feedback and selective tongue and jaw movements for cleaning and/or swallowing (▶ Chaps. 3 and 5).

Suggested Solution

Treatment takes place in side-lying position, providing a large base of support. The involvement of the patient's hands encourages comprehension for the activity and provides tactile preparation for the oral input to come. The biting reaction is inhibited by sliding a padded spatula between the molars if they are slightly apart, allowing the occlusal surfaces on the opposite side to be cleaned. Simultaneously, the jaw support grip stabilizes the lower jaw. Despite being time consuming and possibly requiring assistance by another person, this procedure offers two benefits: First, to ensure cleaning the occlusal and inner surfaces of the teeth and of the tongue. Second, over time, the patient might learn not to respond with biting reactions to oral hygiene.

■ Problem: Oral hypersensitivity

A patient in minimally conscious state after severe traumatic brain damage responds by turning his head to the side if his face or mouth is touched and the tone in his whole body is increasing.

■ Suggested Solution

The goal is to normalise the patient's responsiveness to touch in the face and mouth. This can be achieved by conducting therapeutic oral hygiene regularly and in adequate, rather slow tempo with structured input. A realistic treatment context must be devised. Side-lying position in bed or on a plinth offers a large base of support. The water used for brushing is neither too cold nor too hot. Actions which the patient might perceive as 'attacks' are avoided, such as forcing the mouth to open or rapid brushing movements. The patient's hands are involved and brought in contact with the face and the mouth, but also with the objects for tooth brushing. Tactile oral stimulation is carried out as a preparation (▶ Sect. 6.2.4). Neural mobilisation of the trigeminal and facial nerves is used too to normalise responsiveness (▶ Sect. 7.3.2).

In general, it is essential for patients suffering from hypersensitivity to get used to touch and rediscover their face and mouth with their own hands (▶ Sect. 6.2). The procedure must be adapted to the individual, however. Hypersensitive patients can only tolerate contact in the face or mouth if the duration of that contact is in a meaningful context and also foreseeable, regardless of whether the contact comes from the therapist's hand or their own. It may help to signal contact in advance. A verbal announcement can be made, for example 'I am going to touch your cheek now'. Contact is maintained for a slow count of three; the hand is then removed, and a pause follows. Counting provides the patient with a rhythm and predictability, which might help him to tolerate the contact better. It is important to maintain contact if the patient's tension increases in spite of the slow approach and to avoid removing the hand hastily. This gives the patient an opportunity to become accustomed to the contact. This approach, used consequently, might help to decrease or even avoid defensive reactions on touch.

Example: A patient in minimally conscious state uses to react with massive defensive reactions on tooth brushing. His tone increases dramatically in response, and he turns his head away from the toothbrush. Simultaneously, he moans and grimaces. He grasps at the therapist's hand and pushes it away with his left hand. The therapist works on a strategy for tooth brushing to reduce or even avoid those defensive reactions. She involves the patient in the preparation for tooth brushing in a structured way. As a preparation, she uses tactile oral stimulation: She helps the patient to hold a glass of water. She dips his finger into it and slowly guides his finger on the upper gum. During the following tactile oral stimulation, the therapist first touches the patient's gums for a few seconds with her finger without moving it immediately. Then, she slowly begins to move her finger along his gum. This is accompanied by a verbal count of up to three, allowing the patient to foresee the duration of the contact. A pause follows after each quadrant to facilitate swallowing. The therapist then guides the patient through the process of removing a toothbrush from his toiletry bag and guides him to brush the first quadrant of the teeth by himself. Then she takes over and brushes his teeth structured and carefully.

Hypersensitivity or hyperresponsiveness

The clinical manifestation of hypersensitivity includes increased tension levels throughout the whole body and defensive reactions to the face or mouth being touched (also during oral hygiene). Staff and relatives often misinterpret these reactions as lack of cooperation, disinterest, or negative emotions. Many patients with these issues also have a limited ability or are unable to communicate verbally.

Mindfulness and objectivity are therefore essential during the process of diagnosis and treatment.

Biting reactions (tonic or phasic biting) often unsettle the nursing staff, who may be reminded of previous bad experiences, for example difficulty in removing objects from the mouths of patients who bite or injuries which they may have sustained in the past. These kinds of experiences may cause staff to hesitate or treat patients with unnecessary roughness. This can also lead to oral hygiene being neglected significantly.

Hypersensitivity or hyperresponsiveness may be due to impaired sensorimotor feedback, caused by either the brain injury or because of a lack of sensory stimulation in the facial-oral tract. The patient's stimulus threshold for touch and movement in the oral and facial regions has become lower (Achilles et al. 1990). Being touched on the hands, in the face or mouth might feel painful or uncomfortable. This might be caused by missing or insufficient movements for speaking, swallowing saliva, eating and drinking, or the absence of respiratory airflow in the upper airway in patients with a cuffed TT (▶ Chap. 10). A decrease of input might lead to underrepresentation in the sensorimotor cortex.

Mulder and Hochstenbach (2001) point out that input in general is necessary for the maintenance of normal somatotopic cortical organisation. The sensorimotor cortical representation of the face, mouth and hands is relatively large in comparison to that of the trunk (McNaught and Callander 1983). Avivi Arber et al. (2011) found evidence that the so-called face sensorimotor cortex can undergo neuroplastic changes by stimulation, training and learning of motor skills. For the clinical work with patients, this knowledge underlines the importance of helpful, structured and functional input to the patient's hands, face and mouth for remapping cortical presentation of this area.

6

Note

It is important:
- To be aware of the phenomena of hypersensitivity and biting reactions (often combined)
- To be competent at dealing with this pattern of response, as well as emergency situations, for example biting down on the lower lip, a toothbrush or a helper's finger

Sensory deprivation in the facial-oral region and biting reactions must be prevented from the early phase of rehabilitation onwards (Davies 1998). Adequate and structured sensorimotor input is essential if an individualised oral hygiene routine is to be maintained for the patient in the long term. If hyperresponsiveness does arise, it must be made a focal point during the rehabilitation process. A long-term approach may be required.

▪ Problem: Altered tone in the facial muscles affects function and activity

A patient has right-sided central facial palsy due to a stroke. The left (less affected) side tends to have light to moderate hyperactivity, with the angle of the mouth pulled upwards and backwards. There is nearly no activity in the facial muscles required for functional movement during oral hygiene. Both, the hypotonia in the right perioral and the buccinator muscle and the hyperactivity in the left cheek and lip cause difficulties in lifting the upper and lower lip when inserting the toothbrush or closing the lips for rinsing the mouth. The subsequent active spitting out is not possible; the water just runs out of the mouth.

▪ Suggested Solution

The therapeutic interventions during oral hygiene aim to regulate tone in the facial muscles and inhibit hyperactivity on the left side of the face. Symmetrical facial movements are then facilitated, for example closing or puckering the lips. During the subsequent tooth brushing, specific techniques are used to facilitate rinsing the mouth and spitting out, with a subsequent swallowing (◘ Fig. 6.17). In this patient, standing position is modified and

■ **Fig. 6.17** Oral hygiene is performed standing at a washbasin. The therapist guides the patient's paretic hand through the motions of applying toothpaste to the brush. (© Jakobsen and Elferich 2019. All Rights Reserved)

■ **Fig. 6.18** After brushing the teeth, the therapist facilitates symmetrical pursing of the lips to make spitting possible. (© Jakobsen and Elferich 2019. All Rights Reserved)

supported to create a realistic context and to integrate work on postural control with bilateral activity of the arms (■ Fig. 6.18).

Problem: Aspiration of saliva during oral hygiene

A stroke patient has difficulties in the coordination of the oral and pharyngeal phase of swallowing. He is not able to feel saliva in the oral cavity. Swallowing frequency is decreased, and before swallowing one can observe up to 10 pumping movements of the lower jaw, especially in sitting position. During oral hygiene, the saliva production increases, and the patient coughs. This may indicate aspiration.

Suggested Solution

Oral hygiene takes place in side-lying position or sitting and leaning forward. These positions prevent saliva from running down the pharynx towards the lower airway due to the effect of gravity. No matter in which of these two positions the patient is, particular attention is paid to the optimal alignment of the pelvis, trunk, shoulder girdle, neck and jaw. As a preparation for oral hygiene, gauze is used to remove saliva from the oral cavity. Swallowing is facilitated as often as possible to avoid pumping jaw movements and to clean the pharynx from rests of saliva before tooth brushing (▶ Chap. 5).

Problem: Bruxism

The aetiology of bruxism (Greek: 'brygmos', biting or gnashing of teeth) includes both central and periphere explanatory models (Behr 2012). Bruxism is defined as clenching or teeth grinding and/or bracing or thrusting the lower jaw (Lobbezoo et al. 2013). A distinction is made between awake bruxism and sleeping bruxism (SB). SB is related to sleeping disorders. Sleep studies conducted in healthy individuals show that bruxism occurs during the transition from deep sleep to light sleep, and can be triggered by sounds, touch or light (Satoh and Haradaya 1971). Bruxism is described in psychiatric and neurodegenerative disorders and genetic syndromes, for example Down syndrome (Jankovic 2017), but also in patients with severe acquired brain injury (Kesikburun et al. 2014; Tan et al. 2004; Ivanhoe et al. 1997; El Maaytah et al. 2006).

Clinical experience leads to the supposition that bruxism might be an expression of the search for sensory information, for example if an individual is unable to sense his face or mouth post-injury or experiences it very differently. Maximising pressure on the rows of teeth may be an attempt to recreate the sense of having a mouth or a face. Experience has shown tooth grinding to be common in patients following a subjectively unpleasant experience, for example taking a necessary blood sample. It is worth noting that grinding often ceases, if the mouth and/or hands are given an alternative source of input, for example during tactile oral stimulation or therapeutic meals. Persistent teeth grinding prevents cleaning of the occlusal and inner surfaces of the teeth. This causes further complications in the long run:

- Damage to the temporomandibular joint
- Facial-oral pain
- Tooth mobility and migration
- Abrasion facets in the masticating surfaces
- Hypertrophy of the chewing muscles

Suggested Solution

The therapist has excluded factors as pain and infection and assumes that the primary cause is disturbed oral responsiveness or an attempt to use jaw muscle activity to get stability due to the lack of postural control. Therefore, a side-lying position is used during treatment. Structured input for the hands, the face and the mouth by tactile oral stimulation is provided. Mobilisation of the trigeminal and facial nerves aims to improve the neural impulse transport (▶ Sect. 7.3.2). Since the patient has the prerequisites for therapeutic eating, this is used to offer alternative sensorimotor input (▶ Sect. 5.5.2). A piece of dried fruit wrapped in moist gauze is placed between the molars and removed after a few chewing motions. Swallowing is then facilitated (▶ Sect. 5.3.3). Oral hygiene follows therapeutic eating with stability for the head and jaw and involving the patient's hands. The therapist observes which interventions are most successful in terms of reducing frequency and intensity of teeth grinding. These will be used to give the patient the most helpful support and input.

Use of botulinum toxin in bruxism management

Botulinum toxin is sometimes used as a treatment for individuals affected by bruxism. To date, evidence on the effects of botulinum toxin, mostly in treating sleeping bruxism, is based on case reports, case series and smaller randomised trials (Jankovic 2017; De la Torre Canales 2017). Long et al. (2012) found that the effects of treatment with the toxin were similar to the effects of treatment using a dental guard. The evidence for treating bruxism in patients with acquired brain injury with botulinum toxins consists primarily of case studies (Kesikburun et al. 2014; Tan et al. 2004; Ivanhoe et al. 1997; El Maaytah et al. 2006).

The use of botulinum toxin injections into the masseter and temporalis muscles is employed as a last resort or when there has been significant injury. It is essential to establish the causes of grinding and treat them consistently. An injection may be necessary if the grinding is severe, but it is still essential to address its underlying cause. After the injection, the now hypotonic jaw closure muscles facilitate 'access' to the inside of the mouth for several weeks. The patient must become accustomed to daily oral hygiene and active opening and closing of the mouth during this period. Helpful input to the inside of the patient's oral cavity can be provided. The effect of the botulinum toxin subsides after 2–3 months. At best, there is a normalisation of tone and responsiveness, which makes further injections unnecessary.

An injection can be considered, if:

- It is not possible to clean the inner surfaces of the teeth and there is a presence or threat of infections.
- There is the possibility for therapeutic interventions after the injection to obtain and keep mouth opening once the effect of the botulinum toxin subsides.
- There is persistent grinding of the teeth, with pain, a risk of significant tooth damage and potential tooth loss.

6.4 Typical Complications and Suggested Solutions

Complications are delayed effects of the primary issues caused by acquired brain damage. They can arise because unhelpful compensation strategies might aggravate abnormal non-functional movement patterns, for example biting. Patients tend to develop complications if therapeutic interventions are not made at a sufficiently early phase. This can happen if problems are not recognised as they arise or are misinterpreted by the interprofessional team. The lack or absence of tactile input in the facial-oral tract prevents normal sensorimotor feedback. This counteracts motor learning, physiological movement and sensitivity.

Complication: Infections in the oral cavity

A patient with facial palsy and sensory disturbances on the right side of the oral cavity cleans his teeth independently but neglects the more affected side. This leads to the formation of plaque and a gingival infection on the right side (Fig. 6.19). Infections are caused by dental plaque or bacterial colonisation of the mucosa.

Fig. 6.19 Patient with facial palsy on the right side and gum disease. (© Jakobsen and Elferich 2019. All Rights Reserved)

Note

A fungal infection of the mouth is often caused by a weakening of the mucosal barrier, for example due to dehydration. These fungal infections include thrush, which creates a whitish layer difficult to remove (Hebecker et al. 2014). Thrush is mainly caused by *candida albicans*, a common commensal of the oral mucosa that belongs to the group of yeast fungi. It can overgrow the entire oral cavity when the balance between host, normal candida colonisation and the oral microbiota is disturbed (Roulet et al. 2012). It can cause severe inflammation of the oral mucosa, and aspiration can lead to candida pneumonia (Langmore et al. 1998).

Suggested Solution

The regular therapeutic oral hygiene is supplemented by the use of specially selected anti-inflammatory gel. A dental consultation may be indicated. If the patient can eat and drink, dentists may recommend waiting for approximately 30 minutes after meals before brushing the teeth. This prevents acid from attacking the tooth enamel. It is important that the patient is provided with guidance and support for oral hygiene. For example, he might brush his teeth himself with guidance and the carer might then give the teeth a 'final cleaning', if necessary. The oral cavity is inspected at least once a week (visual examination of the mouth). This enables changes in the oral mucosa and dental status to be identified and treated early on.

Infections of the oral cavity and erosion of tooth enamel can also be caused by regurgitation of gastro-esophageal reflux into the oral cavity. This is common in neurological patients due to motility disturbances of the esophageal sphincters and digestive tract. Reflux can be treated in several ways: medication, altering the rate and amount of enteral feeding, adjusting the angle of the patient's bed to 30° during and after enteral feeding, or inserting a gastrojejunal feeding tube. Oral hygiene should be performed regularly and as often as necessary to ensure that the respiratory tract is protected from regurgitated material. Anti-inflammatory and tooth hardening medication can also be used.

Complication: Airway infection

Pneumonia can be caused by aspiration (Morgan and Mackay 1999; Dziewas et al. 2017). A constantly open mouth and irregular oral hygiene can lead to bacterial colonisation of the saliva. Changes in salivary consistency make it difficult to swallow, and residues may remain in the pharynx or larynx. Swallowing and breathing become more difficult, which can lead to pneumonia. Chao et al. (2008) showed that in intensive care patients the incidence of ventilator-associated pneumonia (VAP) was reduced simply by removing saliva from the oral cavity prior to moving the patient.

Suggested Solutions

An interprofessional approach to the management of secretions is essential:

- The supine position should be consistently avoided to minimise the risk of aspiration by saliva running towards the pharynx and larynx.
- A cough assist device for respiration therapy can help to clear secretions from the airway (Frank and Frank 2011).
- Swallowing, throat clearing and coughing should be facilitated, whenever necessary.
- Oral hygiene must be performed as often as necessary and should include cleaning of the tongue and the palate.
- For patients with a cuffed tracheostomy tube, careful removal of saliva in the mouth, pharynx and larynx prior to cuff deflation is recommended (▶ Chap. 10).

Complication: Deformities of the hard palate and jaw

The changes in tone levels associated with cerebral movement disorders often lead to hyperextension of the upper cervical spine, accompanied by retraction of the lower jaw and by hypertonicity of the jaw and perioral muscles (▶ Chaps. 3 and 4). Altered tone levels in the cheek muscles and forward displacement of the tongue, for example tongue protrusion, can result in tooth displacement towards an open bite (◘ Fig. 6.20a). Excessive tone of the orbicularis oris muscle and inversion of the lower lip can push the teeth dorsally towards the tongue (◘ Fig. 6.20b, c). Other complications may include deformation of the upper palate. These complications are seen after months or years and must be prevented.

◘ **Fig. 6.20** **a**–**c** Jaw/tooth displacement deformity. (© Jakobsen and Elferich 2019. All Rights Reserved). **a** Open bite, **b** inverted lower lip, **c** dorsally tilted lower incisors

Suggested Solution

Regular treatment emphasising the regulation of overall tone, by means of altered positioning, targeted mobilisation and work within the oral cavity. The goal is to achieve a functional alignment and tone for the neck, the jaw muscles and the tongue.

Complication: Dentine abrasions and gingival defects

Rough, horizontal scrubbing movements and too much pressure used when brushing the teeth, due to disturbed hand–mouth coordination causes wedge-shaped defects in the gingiva and dentine (tooth tissue, Wiegand et al. 2013).

Suggested Solution

The patient is supervised to use the red-white brushing technique. Excessive pressure is avoided. If necessary, the teeth can be cleaned again by the therapist or carer afterwards.

Complication: Ulcers caused by an ill-fitting prosthesis

Many patients in the acute or subacute phase after brain injury find that their prosthesis no longer fit correctly after a few days. This is caused by rapid atrophy of the alveolar crests due to facial-oral functional alterations in the cheeks, lips and tongue. The oral mucosa may also react sensitively when the prosthesis is worn again for the first time. This can cause reddening, pressure points and ulcers.

Suggested Solution

The prosthesis should be used again as soon as possible and examined for accuracy of fit. It can be stabilised using denture adhesives. The palate and tooth wall must be cleaned thoroughly of adhesive material after each wearing and examined for redness. Daily removal of the prosthesis for cleaning is important even with a non-oral diet. It may be necessary for a dentist to reline the prosthesis (Kelly 2010). An exactly fitting prosthesis allows redness and even ulcers to heal quickly, but prostheses should be avoided if pressure sores or ulcers are already present (Lindenmüller and Lambrecht 2011).

Complication: Bite wounds

Sudden, forceful biting reactions are seen as a tight and long-lasting closure of the jaw, which can be difficult to release. Patients with severe traumatic brain injury often severely lack postural control, accompanied by hyperextension in the neck and retraction of the lower jaw. When yawning, making sounds, coughing or by unpleasant experiences, for example suctioning in the lower airway, the lower jaw closes rapidly afterwards (◻ Fig. 6.20a–c). This can cause injuries to the lower lip, tongue or the inside of the cheeks. Oral hygiene is often severely limited due to the pain, swelling, and scarring (Millwood and Fiske 2001). This can create a vicious cycle for the patient, particularly when using force or contraindicated tools (◻ Fig. 6.16) during oral care. Hypersensitivity and tone level in the jaw muscles increase, preventing active mouth opening. Careful therapeutic intervention is required to break the cycle.

Suggested Solution

To avoid hyperextension of the neck, patients are positioned in a side-lying position, with flexed hips and knees, or seated and reclining backwards or forwards. As the patients often have no head control, pillows are used to provide support and keep the head and neck stable in a neutral position, with rather light flexion in the upper cervical spine.

The treatment aims to facilitate postural control and selective jaw movements in an optimal alignment of pelvis, trunk, shoulder girdle, neck and the lower jaw, in supported positions. Furthermore, hypersensitive reactions should be addressed to enable a more normal response on touching and movement. Existing bite wounds are treated with anti-inflammatory cream. Oral hygiene is conducted slowly and carefully, avoiding unhelpful increase of the body tone and more biting. All team members should be instructed in this specific handling (◻ Fig. 6.21).

! Warning

Pain and fear cause the patient's overall tone levels to increase, reinforcing sensorimotor dysfunction (Davies 1998).

Fig. 6.21 **a**–**c** Example of a bite wound on the lower lip. (© Jakobsen and Elferich 2019. All Rights Reserved)

6.5 Oral Hygiene – An Interprofessional Issue

Patients with serious brain injury receive only minimal sensory input if the movements associated with eating, drinking, swallowing or speaking are missing. This massive impact on sensory feedback might affect the representation of the facial-oral structures in the brain and the composition of the saliva and oral flora. While this process is not yet fully understood, the consequences of sensory deprivation can be seen daily in clinical practice. Oral hygiene plays an important role in addressing this issue and in maintaining the health of the patient's oral cavity. The goal is to recover and optimise the facial-oral activities and maximise participation by means of a systematic and continuous approach.

Oral hygiene must therefore be addressed by collaboration of different professional groups. Important tasks include the joint analysis of existing problems, the consultation with specialists, and the implementation of specific oral hygiene measures.

In hospitals and nursing homes, conducting oral hygiene with patients who are unable to do this independently is primarily a nursing activity. A number of studies have focused on the behaviour and attitudes of nursing staff as well as the implementation of oral hygiene in different settings. Pace and McCullough (2010) point out that oral care is an interdisciplinary task, encompassing the specialised expertise of nursing staff, dental hygienists and dentists. The review also noted that nursing staff often receive insufficient training in oral hygiene. The time and resources available for carrying out oral care are often limited.

Forsell and Sjögren (2011) looked at the attitudes and behaviour of nurses towards oral hygiene provided to dementia patients in a residential care setting. While most of the respondents stated that they had enough time to perform mouth care, less than a third was satisfied with the outcome, however. Over 80% found it unpleasant to carry out oral hygiene, partly because residents refused oral care or were unable to cooperate due to cognitive issues. Anxiety about damaging teeth or prostheses was also a factor.

The importance of oral hygiene is also highlighted by a Japanese study on neurological patients. In addition to the daily oral hygiene routine, the oral cavity was cleaned professionally twice a week, for 3 weeks. The condition of the oral cavity improved in terms of plaque, gingival bleeding and periodontal disease. The number of patients colonised by multi-resistant bacteria (MRSA) was also lower than in the control group. As a point of interest, the intervention group also experienced a higher level of food intake at the end of the test period (Mori et al. 2012). The authors interpret this as an effect of the increased stimulation in the oral cavity as a result of professional oral care.

Treloar and Stechmiller (1995) suggested that oral hygiene might even be lifesaving. They identified 26 instances of oropharyngeal lesions in a group of 16 intensive care patients on ventilation. Many of the patients with oropharyngeal lesions also suffered from nosocomial pneumonia. One explanation might be that the lesions provided entry sites for bacteria. These findings call for regular, sound oral hygiene procedures. In many countries, oral hygiene is not the exclusive responsibility of nursing staff. For example, in Germany, Denmark and Switzerland, physiotherapists, occupational therapists, speech therapists and other professionals are involved in oral hygiene. This places high demands on the cooperation and communication skills of the team, for example when allocating responsibilities and tasks. It also challenges the ability of individual team members to learn from each other and with each other. Experience with interprofessional learning and cooperation (Brown Bonwell et al. 2014; CAIPE 2012) has shown that many participants of interprofessional courses in oral hygiene for the elderly have changed their previous methods. They have also reported benefits in terms of knowledge and competence (Brown Bonwell et al. 2014).

The following figures (◘ Figs. 6.22, 6.23, and 6.24) show practical examples of interprofessional teamwork in oral hygiene from a rehabilitation center in Burgau, Germany.

Dental examinations and treatment should be available for patients with neurogenic damage. Oral and periodontal problems can then be identified and treated early. A Cochrane Review by Brady et al. (2006) states that even an hour-long training session can change healthcare staff's knowledge of and attitude towards administering oral care and improve dental health as measured by the cleanliness of dentures in stroke patients. The researchers suggested that oral hygiene should be given higher priority in post-stroke care, and that more emphasis should be placed on oral care as a rehabilitative and multidisciplinary issue.

◘ Figure 6.25 shows examples for the integration of several interventions within the interprofessional team.

6.5.1 Ensuring Continuity by Formal Carers

Keeping up the good practice of oral hygiene after discharge of the patient is regularly a matter of concern. From the subacute phase of rehabilitation onwards the question arises of how best to document and transmit important observations and information regarding the handling of the patient.

This is even more difficult as economic and human healthcare resources are constantly under pressure. As a result, the average length of stay in hospitals is decreasing. In the acute care setting, there is little time available for the treatment of severely affected patients who often will be dealing with the consequences of their disorders for the rest of their lives. Ensuring continuity of care in the transition from the rehabilitation facility to outpatient care, nursing homes, special schools or day care centers will therefore become increasingly important.

6

Fig. 6.22 **a**–**c** Maximum support for oral hygiene. (© Jakobsen and Elferich 2019. All Rights Reserved). **a** The nurse stabilises the jaw with the jaw support grip during tactile oral stimulation. The occupational therapist stabilises the trunk and helps the patient's paretic hand to hold the tooth mug. **b** The nurse guides the paretic hand with the toothbrush to help the patient to brush the occlusal surfaces. The occupational therapist stabilises the head, trying to avoid ventral translation of the cervical spine. **c** The nurse guides the patient to dab the mouth

Fig. 6.23 **a–c** **a** Light support for oral hygiene. (© Jakobsen and Elferich 2019. All Rights Reserved). **a** Moving to the washbasin for tooth brushing, with a walking frame: The physiotherapist facilitates weight-bearing on the patient's paretic leg and helps him place the tooth mug on the edge of the basin. **b** The patient cleans his teeth, whilst the physiotherapist facilitates hip and knee extension with the help of supportive positioning elements. The paretic hand is placed on the edge of the washbasin for stability. **c** Facilitating gripping and holding the tooth mug with the paretic hand

Fig. 6.24 **a**–**c** Speech therapist approach: After tooth brushing. (© Jakobsen and Elferich 2019. All Rights Reserved). **a**, **b** The speech therapist works with the aphasic patient, naming the oral hygiene utensils. **c** The paretic hand is involved while the sentences are being read

Fig. 6.25 Interventions by different professions during the day. (© Jakobsen and Elferich 2019. All Rights Reserved)

As part of a professional discharge management, vital contents regarding oral care must be conveyed, including:

- Transfers, for example from bed to wheelchair
- Positions which are helpful for the patient for oral hygiene and eating
- Aids and techniques which ensure thorough oral hygiene and encourage functional movements and motion sequences according to activities of daily living

The interprofessional team must involve the professional carers responsible for continuing treatment to avoid readmissions or other poor outcomes. The transfer of information, knowledge and skills must be assured to guarantee the patient a smooth transition to community-based facilities or treatment at home. As a part of the F.O.T.T. approach, close relatives and friends should also be trained in oral hygiene, if possible and relevant. The available resources of each patient should be fully utilised in order to avoid complications and enable maximum activity and participation.

6.5.2 The Involvement of Informal Carers

It is not uncommon for relatives (informal carers) to accompany the patients on their path through rehabilitation from the acute hospital to care at home. Providing guidance for informal carers, such as relatives and friends, is an essential aspect of rehabilitation. This opens up a number of possibilities and opportunities but there are also risks. Close relatives and partners are fundamentally affected. Their responses to the crisis can resemble those of bereavement. During this coping process, they may also need psychosocial support by members of the rehabilitation team (Norup et al. 2013). The potential and the limitations of relatives must be carefully assessed by the team. Training for informal carers should be based on a person-centered, structured approach (▶ Chap. 12), enabling the carer to take individual responsibility for defined tasks and treatment objectives. These co-therapeutic competences can be developed in preparation of an independent takeover of specific care measures in the long term if this is needed and desired. ▶ Overview 6.4 outlines some aspects of process support for relatives, within the F.O.T.T. concept. The objective is to allow each relative to follow an individual path.

Overview 6.4 Guidance for Relatives, Informal Carers

1. *Presence:* Being present during treatment lets informal carers experience patient's progress as well as the limitations. Observing how professionals handle oral hygiene provides a good basis for the next steps.
2. *Information:* Understanding the treatment goals and the related interventions can be facilitated by discussion with the professionals, for instance in team meetings. Additional media can be used individually to facilitate comprehension, for example pictures, models and videos.
3. *Self-experience:* Self-experience is an important part of the learning process, helping relatives in handling and rehabilitative interventions.
4. *Practical instructions*: Following self-experience, newly acquired skills are practiced on the therapist before being performed on the patient under supervision.
5. *Dealing with emergency procedures*: Informal carers must be capable of dealing with emergency situations, for example before the patient's first weekend stay at home. This includes recognising and understanding the nature of possible emergencies (e.g., aspiration, vomiting, biting). The appropriate assistive measures should be practiced beforehand.
6. *Establishing a home programme*: The strengths, resources and challenges of both the patient and his relative or the informal carers must be considered when a home programme is devised. Helpful handling as positioning and support for oral hygiene can be formulated (▶ Chap. 12). Illustrations, photographs and short, precise descriptions are helpful. The home programme should be revised as soon as necessary. The informal carers should be offered supervision regularly to avoid mistakes and unhelpful handling.

Process support will ideally continue during ongoing outpatient treatment. The rehabilitation team is also tasked with providing contacts to outpatient therapists, psychosocial services or self-help groups.

◘ Figure 6.26a–g shows an example of a patient's wife receiving instruction during a visit to the hospital.

Informal carers are highly affected by the patient's situation and must always be guided through the phases of the rehabilitation process. The professional transfer of information is not enough. Equal consideration must be given to the provision of process support. A constant exchange of information is required, and new insights into the objectives and measures must be discussed. The entire interprofessional team is responsible for providing guidance. The technical, social and ethical factors must also be taken into account if the patients are to be reintegrated into their home successfully.

Fig. 6.26 **a**–**g** Instructing relatives. (© Jakobsen and Elferich 2019. All Rights Reserved). **a** The patient's wife shows how she performs oral hygiene with her husband at home. The head remains in a position which is unhelpful for oral and pharyngeal movements and is not corrected. **b** The occupational therapist demonstrates the process and shows the facilitation of mouth opening. **c** Learning through personal experience: The patient's wife experiences the jaw support grip and correction of neck position given by the therapist. **d** Practicing on the therapist then provides an opportunity to receive helpful feedback on newly learned skills. **e** What has been learned is applied when the teeth are next cleaned. The therapist continues to provide assistance. **f** The newly learned skills are applied under the therapist's supervision (not illustrated). The head and neck are now positioned optimally. **g** The patient's relatives had been using a toothbrush with interchangeable heads to clean the patient's teeth. The dangers of this type of toothbrush are pointed out

6

Fig. 6.26 (continued)

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Treating the Face as a Functional Entity: More Than Practicing Facial Muscles

Daniela Jakobsen and Heike Sticher

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In neurorehabilitation, the treatment of the face is often neglected in favour of the swallowing problems or reduced to a minimum in the form of a home programme in front of the mirror. The face is a part of the body which cannot be easily concealed. Communication and social interactions are influenced by the absence or exaggeration of facial movements of one's counterpart as well as by movements, which differ from the norm (Leppänen and Nelson 2009). In addition to the relevant anatomy and physiology, this chapter illustrates the examination and treatment of the face, based on the F.O.T.T. approach. The focus will be on functional, everyday-oriented work with patients suffering from central or peripheral lesions of the facial nerves, referring to the relevant literature for surgical options and drug treatment.

7.1 Normal Facial Movements

Whether during speech, food consumption or non-verbal communication, facial movements must be rapid and to some extend automatic. In many cases the movements should be brief, and the muscles used should be capable of relaxing immediately afterwards.

7.1.1 Central Control of Facial Movements

Voluntary and emotional facial movements are controlled by different areas of the brain. The motor areas of the brain control the voluntary action of raising the forehead, for example when instructed to do so. However, the prefrontal limbic structures and subcortical nuclei are responsible for raising the forehead involuntarily in the event of fright or astonishment. The motor system for the control of facial movements consists of multiple, parallel systems, which are responsible for voluntary or affective movements (Birbaumer and Schmidt 2010; Cattaneo and Pavesi 2014).

A distinction is made between central and peripheral facial palsy. The clinical hallmark of the central facial palsy is that frowning and eye closure can be performed on the affected side. This is possible because the upper nucleus of the facial nerve (which innervates m. orbicularis oculi and m. occipitofrontalis) is supplied by both hemispheres Therefore, a supranuclear infarct in one hemisphere or in the relevant corticobulbar pathways typically causes the picture of a central facial palsy. The lower nucleus – innervating the other branches of the facial nerve (muscles around the nose, cheek and mouth) – is only supplied by the contralateral, precentral region and therefore causes the picture of a peripheral facial palsy. However, a nuclear or peripheral lesion causes complete facial palsy on the ipsilateral side (Mazhar 2008).

It is interesting to note that the facial motor nuclei not only are innervated by the precentral region, but also by the diencephalon, mainly for emotionally caused movements. As a result, there may be a difference between voluntary and emotional motor activity. Central facial paralysis may disappear during spontaneous laughter, although the neurological status indicates a focal motor deficit of the mouth branch. This occurs primarily with lesions of the frontal brain or semioval center or the basal ganglia contralateral to the clinical manifestation (Mazhar 2008).

Anastomoses with other cerebral nerves have been demonstrated along the path of the facial nerve from the pons to the various end organs. Bischoff (1977) identified interconnections of branches of the facial nerve with the following nerves:

- Trigeminus nerve
- Intermedius nerve
- Vestibularis nerve
- Glossopharyngeus nerve
- Vagus nerve
- Accessorius nerve
- Hypoglossal nerve
- The upper cervical nerves
- The sympathetic and parasympathetic nerves

Note
Due to the presence of anastomoses between the facial nerve and other cranial nerves, the lesion of a particular nerve may also affect other nerves and innervation areas (Baumel 1974; Bischoff 1977; Cattaneo and Pavesi 2014; Lacombe 2009; Tohma et al. 2004).

7.1.2 Anatomy and Physiology

Knowledge of the anatomical and functional characteristics of the facial muscles is essential to the examination and treatment of the face.

Note

Analysis of the problems and resources of the patient, combined with knowledge of normal facial movement, allows us to identify underlying causes and develop approaches to treatment.

A number of criteria are used to assess facial movements. These include:
- The way in which the movements are performed during the specific functions and activities, for example rapidly, slowly, selectively.
- Whether the objective of the movement is achieved, for example complete closure of the eyelid or reactive blinking in response to a sudden light.
- Whether the movements are/become hyperactive.
- How often and with what level of quality movements can be repeated.

In order to identify the patient's problem precisely, it is necessary to examine the face at rest, during spontaneous movements, for example in a social context or during movements which have been prompted. Movement must also be observed during daily activities, such as brushing the teeth. The following issues must be considered:
- Which structures move too much or too little to the detriment of others?
- Do compensatory movements help by allowing a function to take place as normally as possible or do they encourage dysfunctions?

Comparing the patient's movement with the normal movement behaviour of healthy individuals can assist in the formulation of individual objectives and the development of a personalised treatment plan.

Structure

This chapter refers to the relevant anatomical literature, but does not include pictures of the facial muscles. The facial muscles belong to the skeletal muscles and are comprised of striated muscle tissue, which enables voluntary movement. The muscles are composed of type I and type II (a + b) fibres, both of which are responsible for muscle contractions:
- *Type I fibres* react more slowly and have endurance.
- *Type II fibres* react quickly and tire rapidly.

The ratio of fibre types or predominance of type I or type II fibres in a particular muscle is dependent on the particular function or use of that muscle (Burkhead et al. 2007; Cattaneo and Pavesi 2014; Freilinger et al. 1990; Kent 2004; Lieber and Fridén 2000, 2001; Stål 1994).

▶ Example

- *The buccinator muscle* must be capable of contracting strongly in order to fulfil its function during sucking, blowing, chewing and swallowing. It must also be capable of sustaining that contraction. This necessitates a higher proportion of tonic fibres; therefore type I fibres predominate (up to 67%) in this muscle.
- *The orbicularis oculi muscle* is responsible for blinking and must be able to contract briefly and rapidly. The eyes close approximately 12–13 times per minute, that is 750 times per hour. This muscle therefore consists mainly of type II fibres, with a smaller percentage of type I fibres (15%). ◀

Research findings in general indicate that the facial muscles are mainly comprised of fast-twitch or phasic fibres. However, the distribution of fibres becomes altered if function changes, for example if the muscle is placed under constant tension. It is most common for phasic fibres to be converted into tonic fibres (Pette 2002; Pette and Staron 2001). This modification impairs muscle function and should be prevented if at all possible by avoiding hyperactivity. A permanent grin may seem amusing in a film, but it is uncomfortable and painful if constantly maintained. Similarly, it might be painful for patients who are forced to hold the same facial expression for hours, because they cannot change their facial expressions due to a lack of sensory feedback and/or motor skills.

Practical Tip

Normal muscle function should be the guide when selecting appropriate tasks or sequences of functional movement. Tasks should also be carried out with an appropriate (i.e. limited) number of repetitions and/or level of resistance.

Location, origin and insertion of the facial muscles

The 23 paired facial muscles are located in layers, one above the other (Freilinger et al. 1987):

- Some of these muscles have a widening function, such as the risorius muscle and the zygomaticus major and minor muscles. These lift the corners of the mouth or pull the mouth wide.
- Others have a narrowing function. These include the orbicularis oris muscle, which is responsible for mouth closure and pursing the lips.

The muscles are closely interwoven and therefore difficult to distinguish from each other. They are partially attached to one another, showing a great individual variability (Cattaneo and Pavesi 2014).

The function of the facial muscles is to move skin rather than joints. For this reason, they originate from the bones or fascia of the skull, and insert into the skin of the face, or other muscles.

▶ Example

- The *zygomaticus major muscle* attaches to the modiolus at the angle of the mouth (Pélissier et al. 2000).
- The *levator labii superioris muscle* inserts into the skin of the upper lip, and the orbicularis oris muscle.
- The origin of the *buccinator muscle* is also found on the orbicularis oris muscle.

During the bolus formation, for example chewing in the oral stage of the swallowing sequence, the hyoid bone serves as punctum stabile for the mobile lower jaw. At the onset of the pharyngeal stage, the muscle's direction of pull is reversed. The lower jaw becomes the punctum stabile for the mobile hyoid, which moves forwards and upwards (▶ Chap. 4). ◀

In contrast to the skeletal muscle function elsewhere in the body, in the face the direction of muscle pull cannot be reversed to ensure dynamic stability. Dynamic stability must be achieved by lengthening muscles eccentrically rather than by moving concentrically in the opposing direction. The zygomaticus muscle (origin: arcus zygomatic, insertion: angle of the mouth) lifts the corners of the mouth during laughter (concentric activity). If the lips are pursed, that is during activity of the orbicularis oris muscle, the zygomaticus must be able to lengthen eccentrically and remain lengthened to allow the orbicularis oris access to its entire movement repertoire.

Innervation

The pattern of innervation of the facial muscles noticeably resembles a tree, whose trunk splits into two principal branches. These are further divided into a variable number of smaller branches, which communicate with each other. This type of innervation is referred to as polyneural. Although different for each individual, some typical patterns of distribution can be identified (May and Schaitkin 2000).

It has been suggested that this type of innervation ensures that a muscle continues to be supplied in the event of an isolated lesion, as impulses are still provided by other nerve branches.

▶ Example

The *depressor anguli oris* muscle (function: lowering the angle of the mouth) is innervated by both the rami buccalis and the ramus marginalis mandibularis of the facial nerve (◘ Fig. 7.1). ◀

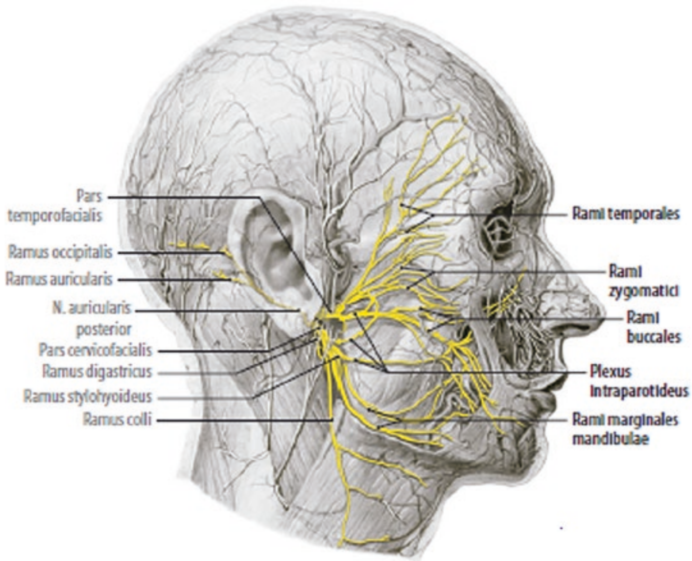

Fig. 7.1 Facial nerve. (© Tillmann BN (2016) Atlas der Anatomie des Menschen, Springer)

Another interesting feature of facial muscle innervation is the number and arrangement of the motor end plates. Each of the 7000 myelinated motor axons from the pontine facial nucleus innervates only 25 muscle fibres (May and Schaitkin 2000). This can be contrasted with the 1500–2000 muscle fibres of the gracilis thigh adductor muscle, which are innervated by 1 motor axon. Arranged in a bunch, up to five motor end plates can be found in one fibre of a facial muscle. This type of innervation is known as multifocal. Happak et al. (1997) demonstrated that these polyneural and multifocal innervations enable a multitude of nuances of individual facial movements (Monti et al. 2001). Such a complex neural system is highly susceptible to interference, however. This may be the reason why following a lesion of the facial nerve the complete regeneration of spontaneous facial expression is often impossible, and unwanted co-movements are common. Intact neural innervation is a prerequisite for fine-tuned muscular coordination and allows the face to exhibit its normal repertoire of expression.

Facial muscles do not have muscle spindles (Goodmurphy and Ovalle 1999; May and Schaitkin 2000; Stål et al. 1987, 1990). However, they do contain spindle-like structures, the precise function of which has yet to be clarified. Several authors believe that mechanoreceptors in the facial skin register the skin movements caused by contractions (Dubner et al. 1978). These sensory impulses are then transmitted to the brain stem via the trigeminal nerve. The search for an explanation regarding the missing muscle spindles (Cattaneo and Pavesi 2014) has provoked some controversy. One working hypothesis suggests that stretch receptors in the facial muscles are unnecessary, as there is no risk of sudden overstretching in the facial area. In contrast to the rest of the skeletal muscles, contraction of the facial muscles moves the skin and tissue of the face rather than joints.

Note

Which parts of the face are able to move selectively, and which parts are not able to isolate? The fact that some of the facial muscles are attached to each other means that most people make some *associated movements*. These movements are nevertheless physiological:

- It is normal for a fold to be created between the eyebrows at the bridge of the nose when sniffing.
- It is also normal for the upper lip to be pulled upwards.
- However, it is not normal for the nose to scrunch up in response to the verbal instruction 'raise your forehead'.
- It is also not normal if the eye closes when asked to 'purse your lips'.

7.1.3 Functions of the Facial Muscles

It is common to refer to the 'mimetic muscles' more accurately as facial muscles, because they perform many additional tasks apart from generating specific facial expressions. The term mimic refers purely to facial expression and is generally associated with emotions or communication. ◘ Table 7.1 illustrates the variety of functions performed by the facial muscles. The goal is to facilitate a better understanding of the diverse contexts in which these muscles are activated.

◘ **Table 7.1** Tasks of the facial muscles with functional examples from everyday life

Function	Example
Non-verbal communication	Frowning, smiling, winking
Protective	Reflex closing of an eye (e.g. if a mosquito flies towards your face whilst you are riding a bike) Blinking if a foreign object enters the eye
Oral hygiene	Lifting the upper lip to place a toothbrush in the mouth Tensing the cheeks when rinsing the mouth
Articulation	Moving the lips forward to form vowels such as "o" or "u"
Intake of food and liquids	Taking food from a spoon Pursing the lips to suck liquid into the mouth Tensing the cheeks to hold a bolus between the molars when chewing
General personal hygiene	Tensing the platysma whilst shaving or applying cream

7.2 Central Causes of Impaired Facial Movements

7.2.1 Central Facial Palsy and Its Clinical Presentation

As a result of the contralateral nerve innervation, the temporal branch of the facial nerve continues to receive information in cases of central facial nerve palsy. Symmetrical eye closure and movements of the forehead and eyebrows are also possible. The exception to this is a nuclear lesion in the brainstem, which is similar to peripheral paralysis in its clinical presentation.

Research findings suggest that in addition to the forehead, parts of the middle and lower face are also contralaterally innervated (Fischer et al. 2005). A study by May and Schaitkin (2000) is recommended for further details.

7.2.2 Diffuse Facial Movement Disorders

Patients affected by traumatic brain injury, cerebral haemorrhage/infarction or hypoxia do not show signs of typical facial palsy, but the quality and quantity of their facial movements are limited by the effects of brain damage.

Both sides of the face often appear to be affected, but closer observation may still reveal differences between the right and left side. In most cases, there are general limitations to the range of movement and movement selectivity. Altered tone levels may also range from flaccid to hypo- or hypertonic. In some cases, the patient's forehead is constantly raised. This may form part of a general pattern of extension encompassing the whole body or indicate an effort (compensation) to remain upright against the force of gravity.

It is not always clear whether the behaviour is part of an overall pattern or caused by activity of the frontalis muscle. In either case, the patient has difficulty relaxing the forehead or executing opposing movements, such as drawing the eyebrows together.

Clinical examination often shows significantly altered sensitivity as well as altered levels of tone, allodynia, hyper- or hypoesthesia. As a result, patients respond to facial contact in one of two ways:

- An exaggerated response (allodynia, dysesthesia and hyperaesthesia)
- No response at all (hypoesthesia)

Both extremes inhibit normal sensory feedback and a normal motor response. The next chapter examines how these clinical symptoms can be addressed and suggests specific adaptations for treatment.

Note
In clinical practice, the term hypersensitive often is applied to patients who show extreme reactions to touch and/or movement in the facial-oral tract. In this chapter, the term hypersensitive is used for reactions like withdrawal of the head, defensive reactions or increasing tone in parts of or in the whole body on being touched and/or moved.

7.3 Principle of Assessment and Treatment

7.3.1 Examining the Face

An examination aims to create a snapshot of the patient's sensory feedback and movement capabilities in a social context (spontaneous) and in response to verbal instructions. It is important to identify the types of aids (e.g. tactile, visual, auditory, a combination thereof) which are most helpful in performing movements more functionally, more frequently, with greater selectivity or in a more targeted manner. This assessment can also consider the facilitation of postural control and the effects of the supporting surfaces offered in different positions. The information gathered is essential for the generation of hypotheses regarding the underlying causes of the patient's issues. It also allows evaluable goals to be formulated. A treatment plan can then be created with or for the patient.

7.3.2 Developing Normal Movement Within a Functional Context

Developing postural control

Trunk stability is a part of postural control. Postural control is the ability to control the position of the body against the force of gravity, during all activities.

Almost every movement a person performs is the result of two components:

- One, which stabilises the body
- A second, which is the driving force and is related to a specific movement goal (Massion 1994; Woollacott 2004)

Postural control is assumed to be a prerequisite for selective movements of the extremities and also in the face and oral tract. Patients with neurological damage often have a limited capacity to establish and maintain trunk stability.

Postural control is essential for the performance of selective movements within an activity, such as applying lip balm. Stability therefore must be established:

- By positioning or supporting the patient in an alignment favourable to the activity
- Through activation of the postural system via mobilisation, movement or facilitation

Position for assessment and treatment

The choice of a helpful position for the treatment plays an important role:

- A position which provides too much support may be preferred by the patient but is likely to increase passivity.
- A position which provides inadequate support will result in insufficient postural control and the quality and/or quantity of movement during an activity will suffer (► Chap. 12).

The principle of evaluation can be applied to the patient's response: Does he react as expected or intended? If not, the environment, task, or therapeutic intervention must be adjusted qualitatively or quantitatively.

► Example

A typical dilemma in clinical practice: Lack of postural control requires that the patient is positioned in side lying for treatment – and he then falls asleep. Therefore, the therapist involves the hands of the patient or moves the patient into sitting position at the edge of the bed. The intention is to increase vigilance by changing the position of the body and activating the postural system. The patient opens his eyes and holds up his head and supports himself with his right hand. The new sitting position offers comparatively limited support. The challenge now is to modify the patient's seated position at the unstable edge of the bed. The position should be activating but should not require all his capacity to remain upright. This will then allow him to produce selective facial movements, if at all possible.

Appropriate steps may include:

- Using blocks and/or pillows to support the patient from behind
- Using the surface of a table to provide stability from the front
- Applying the jaw support grip
- Transferring the patient to a chair, and providing a stable environment by means of a wall from the side and a table in front
- If it is necessary to maintain a horizontal position, the therapist moves the patient frequently and involves his hands in the activity, to encourage attention and alertness ◄

The following situation will be familiar to many healthy people: We become tired if we sit or lie motionless for a long period. We will often instinctively begin to stretch or get up and move around if the opportunity arises.

Patients often present therapists with a dilemma. They may be unable to stay awake if placed in a 'low' position such as side lying, which offers a lot of support. However, they do not have sufficient postural control for a more raised position, such as sitting. If sitting can only be achieved through misalignment, the individual parts of the body will tend to arrange themselves awkwardly and cause the position to become relatively passive.

It is important to remember two things:

- Posture is suspended motion. In order for raised positions to remain dynamically stable and active, the patient must be moved regularly.
- It must be ensured that the patient has sufficient support, particularly in higher positions (with little support) such as sitting or standing. This can be achieved by using props (e.g. blankets or pillows), the natural surroundings (table, wall, etc.), and/or by using hands (tactile facilitation) in providing postural control.

▪ Maintaining/re-establishing symmetry

Facial palsy results in hypertonia and hyperactivity on the unaffected side of the face, which may become the less-affected side over time. Any additional increase in asymmetry represents a barrier to all normal movement. It is therefore important to establish a degree of rest in the face, as a starting point or basis for treatment. This can be achieved in several ways:

- Create of a helpful position to start the treatment
- Providing as much postural control as possible
- Providing support for the head and the lower jaw
- Using the therapist's or patient's hands or props to establish a clear contact with the overactive muscles

It is not always possible to reduce hyperactivity and establish this degree of rest. It may then be necessary to mobilise any facial and cervical nerves which are restricted in mobility and sliding capacity, and/or muscles and tissue which may already be shortened (◘ Fig. 7.2).

▪ Mobilisation of neural structures and muscles

» A muscle is only as good as the nerve that supplies it! (Rolf 2007)

Mobilisation of the nervous system (Butler 2004; Elvey 1997) is originally a manual therapy approach to the diagnosis and treatment

Fig. 7.2 Treatment situation during an F.O.T.T. course: During training: Half sitting position on a treatment table, with elevated backrest for hip flexion. The knees are supported in flexion with positioning material. The course participants use the patient's own hand to facilitate reduction of hyperactivity in the forehead (m. occipitofrontalis). The neck is flexed to offset a predominant pattern of extension. (© Jakobsen & Sticher 2019. All Rights Reserved)

of neural tissue. Many physiotherapists are aware that it is possible to influence nerve tissue affected by a lesion, either directly (using neurodynamic tests and palpation techniques on the nerve itself) or indirectly (by mobilisation, activation of muscles, or correcting a position). Obviously, increased tension and decreased mobility due to a lesion of the nervous system will have severe consequences for tone, sensitive feedback and selective movement. This is because the nervous system innervates all target tissues, such as muscles, connective tissue, organs, intervertebral discs, bones, and joints, including the dense, connective tissue of the nerve itself.

As a neurophysiological approach, F.O.T.T. has its roots in empirical work with patients. It remains open to the influence of other approaches, which view and treat the patient comprehensively.

Lately, the neurodynamic approach has been the subject of particular attention. It includes specific ways of the mobilisation of the nervous system (Rolf 2007), with applications for selective movement and normal function within the facial-oral tract. The aspect of influencing neural structures has become an important part of the examination and treatment of patients with F.O.T.T.

Mobilisation of the nervous system can take place during the treatment process, and can also be integrated into the execution of normal body functions and participation in activities of daily living.

The facial and trigeminal nerves and the cervical plexus play an important role in normal facial movements and sensation. Clinical experience has shown that it is possible to affect tone levels, active movements, sensibility and responsiveness. The facial nerve also innervates the salivary glands, making it possible to influence the secretion of saliva. Different palpation techniques can be used, such as transverse shifting or rolling of the nerves within the nerve bed, or mobilising them within the surrounding tissue (Monkhouse 1990).

Cranial neurodynamics offer another new approach to the mobilisation of the nervous system, topographically specific to the head, neck, and face region (von Piekartz and Aufdemkampe 2001). Changes in the surrounding tissue (neural container, mechanical interface) can expose the nerve tissue to mechanical stress, for example as a result of oedema, scarring, or muscle hypertonus. This may result in neuronal degeneration and fibrosis (von Piekartz 2005). It may be helpful to mobilise either the facial nerve tissue (surrounding structures include the temporal and petrosal bones and the facial muscles), or the tissue surrounding the occipitofrontalis muscle (the galea aponeurotica and the tendinous sheet which covers the skull).

If they are already chronically shortened or contracted (neuropathic contracture) as a result of hyperactivity, it may also help to mobilise individual facial muscles or groups, such as the cheek muscles. Movement restrictions caused by contractures make normal movements difficult or impossible. This may lead to dysfunctional movements in the form of overuse of other structures due to compensation.

Note

Neural and/or muscular or tissue mobilisation ideally leads to improvements in movement quality. This includes:

- Increased range of motion
- More active and selective movement and/or
- Increased repeatability of movements

This is a result of improved sensory feedback and/or changes in the alignment, length and elasticity of muscles and tissue. These improvements in quality are often temporary during the early stages of treatment. They must then be turned into sustained functional movements in order to facilitate carry-over into everyday life and enable motor learning.

This approach leads to the question of how to facilitate and evoke functional movements in daily life.

Facilitation/elicitation of normal movement in a functional context

F.O.T.T. treatment focuses on *facilitating* or *eliciting* functional movement in the context of activities of daily life. The objective is to avoid unhelpful compensations, support the initiation or development of movement and avoid patients becoming frustrated by their inability to master a task.

Warning

Stress levels might increase if a patient with facial palsy is just given a leaflet with exercises or verbal instructions for movements to practice in front of the mirror, and he fails to see progress. Furthermore, the risk of overactivity in the less-affected side of the face or even of synkinesis increases and might prevent or impede activity in the more-affected side.

Based on the assumption that human motor behaviour depends on constant interaction between people, their surroundings and the task (Shumway-Cook and Woollacott 1995), the practitioners must ensure that the surrounding, the task and the support given to the patient are shaped to promote normal movement and allow the movement objectives to be achieved. When treating the face, this can be accomplished by inhibiting unwanted movements, or facilitating and eliciting the movements, which are desired.

Note

Providing the patient with manual support enables the facilitation, guidance and promotion of functional muscular activity. Tactile assistance may take the form of the following:

- Stabilising the patient or relevant structures, for example the mandible, so that selective movements can be performed.
- Using specific manual techniques to activate those muscles or muscle groups which the patient is unable to activate himself.

Inhibiting unwanted muscle activity or movement can make it easier to facilitate and/or elicit helpful movements. It can be achieved by using the patient's or therapist's hands to make contact with the relevant muscle groups or by working in a position which provides a large base of support (e.g. side lying or lateral recumbent, Fig. 7.5). In this context, inhibition means to invite the muscles to relax and rest by creating a situation which enables them to do so rather than to suppress unwanted movement.

Elicitation is using position, support and/or situation to draw out a functional response or reaction from the patient (Sect. 1.5.2).

Generating a motor response from brain-damaged patients by means of verbal commands can be difficult and often produces the 'wrong' response. Coombes (2008, personal conversation) explains this by suggesting that these patients are only able to fall back on abnormal movement patterns that are available to him.

Practical Tip

In clinical practice, it appears easier for many patients to perform functional movements or movement patterns if they are facilitated or elicited, or if both methods are combined and the task is given a meaningful context.

The transfer or carryover of learning into daily living is also more likely if that learning takes place and the task is chosen within an everyday context (▶ Chap. 3).

▶ **Example**

The verbal instruction 'bring your lips together' produces unsuccessful attempts at movement. However, the patient often performs the required movement spontaneously and symmetrically when asked to open and apply a lip balm. If the focus is on the task 'rub the balm on your lips' (external focus) rather than on the instruction to 'bring the lips towards one another' (internal focus), the patient is often able to bring the lips towards each other automatically (▶ Chap. 3). The appropriate task design elicits the desired motor response. ◀

7.3.3 Preventing Complications

In facial palsy, complications which hinder regeneration may arise and these should be avoided where possible. Potential complications and suggested solutions are listed in ◘ Table 7.2.

7.3.4 Different Techniques and Their Applications

The use of stimulation (cold) and vibration (e.g. using an electric toothbrush) has been the subject of much debate.

Thermal-tactile stimulation with cold – applied briefly – generally increases tonus, provided there is a difference in temperature between the stimulus and the tissue. The effect does not last longer than the application itself (Miglietta 1973). It is therefore important to use the temporary elevation of tonus to achieve improved function, giving the patient

◘ **Table 7.2** Potential complications of facial palsy, and suggestions for minimising or avoiding them

Complication	Suggested solution
Hyperactivity of the less-affected side	Neural mobilisation of the facial nerve, oral stimulation with mobilisation of the hyperactive cheek muscles Facilitation of movement in the opposing direction to the hyperactivity
Muscle contractures on the hyperactive, less-affected side	Mobilisation of the hyperactive muscles, optimisation of the patient's position to prevent/limit hyperactivity Use of the patient's or therapist's hands to inhibit hyperactivity and supply relaxing tactile inputs (contact) Adaptation of muscle tone and facilitation on the more-affected side rather than indiscriminate performance of movements in an uncorrected position General avoidance of movements/activities at the patient's sensorimotor limit, with insufficient support (e.g. climbing stairs, standing or personal hygiene in an open space)
In cases of peripheral or nuclear central paralysis which includes the eyelids: Infections and dehydration of the eyes	Assisting the patient to close the eye regularly, when performing everyday tasks during treatment/care (◘ Fig. 7.5) Eyedrops/ointment without preservatives Sunglasses, protection from draughts and foreign bodies (e.g. dust) Assisting/bringing about complete eye closure at night
Bite wounds in the cheek pouch, with either absent or excessive tension in the cheek (buccinator muscle)	Adaptation of muscle tone/activation of the more-affected side Tactile input (e.g. tactile oral stimulation)
Inflammation, aphthae as a result of food residue left in the cheek caused by lack of activity/sensitivity	Regular oral hygiene after every meal Making the patient aware of residue in the cheek Tactile oral stimulation, therapeutic meals (▶ Chap. 5)
Muscle contractures	Maintaining mobility of the structures and expanding ranges of movement which are already limited

an opportunity to experience stronger sensorimotor feedback.

This general approach can also be applied to the treatment of the face. The patient is assisted in a movement/functional activity immediately after stimulation of the lips and cheeks with cold, for example

- Sucking liquid out of a straw
- Blowing on a whistle
- Holding a spatula between the lips
- Pursing the lips

The authors are not aware of any specific research into the application of ice to the face in conservative therapy.

There is no absolute consensus on the effectiveness of vibration in the literature: Beyond the field of training for high-performance athletes, the subject is comparatively poorly researched. A frequency of between 30 and 50 Hz is required in order to activate muscles optimally (Luo et al. 2005). The electric toothbrushes which are commonly used have frequencies between 80 and 250 Hz.

Clinical experience has shown that people respond differently to vibration. It is therefore necessary to decide on an individual basis whether the technique may be effective. The goal of the vibration would either be to give a sensory input or to regulate muscle tone.

The literature also contains varying and inconclusive data on the subjects of electrotherapy and acupuncture (He et al. 2007; Gittins et al. 1999; Targan et al. 2000; Teixeira et al. 2008; Zhou et al. 2009; Wang et al. 2009).

7.3.5 Support in Daily Life

The increasing scarcity of economic and human resources must be taken into account when considering how to implement the following aspects of a 24-hour approach.

- Instruct the patient or family/caregiver in the mobilisation and/or relaxation of the patient's face.
- Support the patient whilst he is talking, eating, brushing teeth and swallowing saliva; help him to avoid facial hyperactivity and asymmetry, and experience more normal sensory feedback.
- Consider the ways in which to position/lay the patient when he is resting, watching television or otherwise occupied.
- Deliberately position yourself slightly below eye level when communicating with the patient. This helps to avoid unwanted rotation or extension of the patient's neck when making eye contact, which may cause unhelpful hyperactivity in the patient's face.
- Document important measures and make them accessible to each team member. This might include personalised programmes, eye drops, dressings and observation of staff or carers in the patient's team.

Examples are shown in Figs. 7.3, 7.4, 7.5, 7.6 and 7.7.

7.3.6 Home Therapy Programme: When? How? With Whom?

When is a home therapy programme appropriate?

In order to increase the intensity of treatment, a home programme should be created whilst the patient is still receiving in-patient care. A programme for the post-discharge period must be prepared in good time, ensuring that the patient understands the instructions and has sufficient aware-

Fig. 7.3 Patient with left side facial palsy. The lower eyelid sags and is additionally pulled downwards by the weight of the hypotonic cheek. There is an increased risk of infection in the eye, and closing the eye is difficult. (© Jakobsen & Sticher 2019. All Rights Reserved)

Fig. 7.4 Two steri-strips can be attached crosswise as an alternative to the watch glass bandage. They can be used to move the eyelid towards its normal position and protect it. The duration of application is customised to the patient. (© Jakobsen & Sticher 2019. All Rights Reserved)

Fig. 7.5 Participants in an F.O.T.T. training course working with a patient – with peripheral facial palsy affecting the right side – in supine position: An appropriate starting position is selected; the therapist's hands support the face and allow the right eye to almost fully close. The colleague's hand is placed on the jaw and cheek, helping to bring facial muscles and tissue into a normal position. Cushions are used to support the alignment of the patient's neck as much as possible. (© Jakobsen & Sticher 2019. All Rights Reserved)

ness to perform the exercises correctly. The therapist has to find helpful positions and activities and supervising the patient effectively before he performs the programme independently. Illustrations or photographs should be provided, accompanied by concise descriptions.

Fig. 7.6 Patient with left side peripheral facial palsy (course teaching situation): The therapist inhibits the hyperactive right side and facilitates the left side, to encourage symmetrical pursing of the lips. (© Jakobsen & Sticher 2019. All Rights Reserved)

Fig. 7.7 The patient is supported in a sitting position whilst drinking. A pillow is placed in the lumbar region to maintain an upright position of the pelvis, and the table provides support from the front. The therapist facilitates sucking of the liquid from the drinking cup. The left side of the lower lip must be stabilized to achieve symmetrical movement to prevent drooling. The cup and attachment also provide more sensory input to the left side, which is more affected. (© Jakobsen & Sticher 2019. All Rights Reserved)

Warning

A pre-prepared sheet of generalised exercises is not a substitute for a personalised home programme and is often unsuited to the patient's specific needs nor does it consider the patient's divergent muscle tone levels.

The patient can complete the programme with the assistance of relatives if his injuries prevent him from carrying it out independently.

Who should be given a home programme?

A home programme is indicated if the patient possesses the perceptive, sensorimotor and cognitive capabilities to carry it out without triggering associated reactions and hyperactivity on the less-affected side.

Patients with central lesions often suffer from impaired memory, spatial cognition and vision, as well as general changes in tone and sensitivity. These factors can prevent a home-based programme from being carried out correctly, and it may be necessary to examine additional factors relating to the patient's environment or resources, for example whether there are relatives or other caregivers who are able to assist.

What does a home programme look like?

The following elements might be included in a home-based programme:

- Helpful position for exercising: The patient is positioned in a chair at the table, with his pelvis in an upright position. His elbows rest on the table and the less-affected hand is placed on the less-affected right cheek and supports his head. This inhibits existing hyperactivity and helps to bring the face into symmetry
- The patient performs tactile oral stimulation (▶ Sect. 6.2.4) himself/independently. By using two specific grips he learned from the therapist, he relaxes the hyperactive cheek muscles on the less-affected side. The inside of the more-affected cheek is mobilised and stimulated in a specific way. Subsequently, the patient performs various lip and cheek movements for a maximum of five repetitions. Performing movements in the opposing direction to the hyperactivity is recommended, for the hyperactive cheek and lip muscles on the less-affected side. This might include closing the mouth and pursing the lips, sliding the upper lip over the lower lip, and vice versa (▶ Sect. 7.3.2).

7.4 Peripheral Facial Palsy

7.4.1 Typical Clinical Presentation

The entire contralateral side of the face is paralysed in the event of a peripheral or infranuclear lesion. In contrast to a supranuclear lesion, the patient is unable to frown or close the eye. The eye is vulnerable as it cannot be closed, and the patient cannot blink. The cornea may become dehydrated as the continuous moistening and cleansing of the eye, which occurs during blinking, is absent. The eye is also unable to protect itself from wind, dust, other foreign objects or bright light, and often becomes reddened or inflamed. Body posture is also adapted, in order to provide more protection for the eye: the head is tilted and the body slightly twisted. The hand moves towards the eye constantly in order to close it or wipe away the tears. Eating, drinking and oral hygiene become much more difficult, and this often causes the patients to withdraw from their social environment.

7.4.2 Differences in Peripheral and Central Palsy

Investigating the cause

The type of facial palsy is determined during clinical examination. Central lesions are typically caused by brain injury or stroke. Peripheral lesions may appear acute with known or unknown origin. They might be caused by one of the following reasons:

- Viral or bacterial infection (e.g. herpes simplex, herpes zoster, borrelia, syphilis, HIV)
- Brain tumour or brain surgery because of a brain tumour
- Nerve inflammation
- Fracture (e.g. petrous bone fracture) or surgical procedure (e.g. operation on acoustic neuroma).

In around 50% of cases the cause remains unclear; this is referred to as idiopathic facial paralysis.

Diagnosis

Additional *diagnostic procedures* may be required to formulate a prognosis throughout the cause of the disease, including magnetic resonance imaging (MRI) or electroneurography.

A traumatic lesion should be classified according to the type of injury (Table 7.3) and an assessment used to document progress. A simple, easy-to-use scale is preferable and can also be used to document unwanted co-movements (known as synkinesis). In 1985,

Table 7.3 Classification of injury and recovery for facial nerve palsy

Degree of damage	Pathology	SFEMG-Result as a percentage of normal	Neural recovery	Clinical signs of recovery	Spontaneous recovery 1 year post-injury
1	Compression, axonal plasma injury, no morphological changes (neurapraxia)	100	No observable morphological changes	1–3 weeks	*Group I:* Complete recovery (no occurrence of misinnervation)
2	Compression persists. Increased intraneural pressure Loss of axons, but endoneurial tube remains (axonotmesis)	25	Axons grow within the intact endoneurial tube at a rate of 1 mm/day; recovery time for degree of injury 2 is therefore longer, than for degree 1; if the degree of injury is 3, incomplete healing of some fibres is a possibility	3 weeks to 2 months	*Group II:* Good recovery (some differences noticeable during voluntary or spontaneous movements, minimal occurrence of misinnervation)
3	Increase in intraneural pressure, loss of endoneurial tube (neurotmesis)	0–10	Loss of the endoneurial tube allows the axons to increase and split. This can cause mouth motions with eye closure (referred to as synkinesis) and mass movements	2–4 Monate	*Group III–IV:* Satisfactory to little recovery (clearly incomplete recovery, with paralysing deformities and marked synkinesis, spasms, mass movements)
4	As above, plus rupture of the perineurium (incompletely severed)	0	In addition to the problems of degree of injury 2 and 3, the axons are also blocked by scars and recovery is hindered	4–18 months	*Group V:* Severe weakness (synkinesis and mass movements rare/ barely observable or not present)
5	As above, plus rupture of the epineurium (completely severed)	0	Complete rupture with a scar-filled gap, forming an insurmountable barrier to the regrowth and innervation of the muscles	None	*Group VI:* No recovery (loss of muscle tone, slack/ flaccid face)

VI modified according to house

SFEMG single-fibre electromyography (testing of muscle activity) the American Academy of Otolaryngology – Head and Neck Surgery determined the House–Brackmann Scale as the universal standard. Since then different grading systems have been developed depending on the nature of the injury and type of treatment (Coulson et al. 2005; De Ru et al. 2006; Fattah et al. 2015).

In a systematic review Fattah et al. (2014) compared different grading systems concerning

- Applicability in clinical practice
- Assessment of relevant areas of the face
- Judgement at rest and during movement
- Assessment of secondary effects like synkinesis
- Interobserver and intraobserver variability
- Sensitivity to changes over time

Only the Sunnybrook Facial Grading System (Ross, Fradet and Nedzelski 1996) meets all criteria above and therefore should be used for therapeutic use even though doctors prefer the House–Brackman Scale.

The literature varies with regard to medication during the acute phase (Allen and Dunn 2009). Post-operative recovery and progress should also be documented in the event of surgery.

Therapeutic approach

Information must first be given to the patient in both verbal and written form. He needs to know how long it takes for movements to become possible once again. The nerve grows at a rate of 1 mm per day and the time frame and degree of restitution can vary, depending on the location and cause of the lesion. After diagnosis, it may be helpful to collaborate with an ophthalmologist, to determine the most appropriate methods for protecting the eye, during the daytime and at night.

Practical Tip

It is not only important to protect the eye as much as possible but also to restore function. A watch glass bandage creates a 'damp chamber' but prevents the hand from being used to assist in closing the eye.

Aids for eating and drinking are discussed:

- Which aids are helpful?
- How can the patient support himself, to avoid hyperactivity on the unaffected side (◘ Fig. 7.2)?

A special exercise programme is created to maintain the brain–nerve–muscle connection:

- For as long as active movements are impossible, the therapist maintains passive mobility by mobilizing the relevant facial tissue. The individual layers of skin and tissue must be able to slide across one another, so that normal movements are possible once active movement has been restored (Vanswearingen 2008).
- Mental imagination is practiced; the movements are mentally rehearsed but not carried out. An activity, such as moving the lips correctly for playing a flute, is stored in a more complex and multifaceted movement pattern compared to the isolated movement pattern of just pursing the lips (▶ Chap. 3).
- The exercise programme is modified when active movement is regained. The patient should practice two to three times a day but exercise sequences should be of short duration (about 10 minutes) to avoid overstraining of muscles which are still weak. This prevents unwanted co-movements (overflow, ▶ http://www.bellspalsy.ws/) and furthers the goal of developing fine, flowing motion without mass movements.

Warning

Quality of movement is more important than quantity. Patients must be made aware that strenuous and excessive exercise is contraindicated. They often have difficulty understanding this initially.

- Part of every treatment session is dedicated to maintaining the mobility of the tissue (muscles, skin, connective tissue) and mobilising the nerves. Neural mobilisation should be performed on both the affected and unaffected sides, following the course

of all the branches of the facial nerve and extending to the neck and cranial regions (Butler 2004; Rolf 2007)
- The exercise programme must be adapted when reinnervations are discernible. Developing symmetry at rest is the preferred means for developing symmetrical movements.
- Practicing in front of a mirror – to find the center again – should be tried during therapy beforehand. It can be counterproductive, because not everybody can cope with viewing the reverse image of the mirror when performing movements.
- Emphasis should be placed on eliciting selective movements if there are signs of synkinesis. Envisaging a functional movement without executing the motion is the best method of achieving this (Husseman and Mehta 2008).
- Alternatively, the patient can be asked to perform movements that are neither common nor routine, such as moving the upper lip forward and simultaneously lifting it off the teeth. To do so, the patient must identify the new movement in the movement memory/repertoire and initiate it. Then the patient may experiment with performing it in different ways, thereby optimising sensory feedback (▶ Chap. 3).
- Other therapeutic approaches can be used to assist in the normalisation of facial movements, including EMG biofeedback, botulinum toxin, and acupuncture (Zheng et al. 2009). These and other methods are the subject of ongoing discussion. The approaches that are selected depend on the patients' symptoms and their response to the intervention.

Surgical options

A surgical option may be appropriate if the nerve is definitively non-functional (◘ Table 7.3), for example following the excision of an acoustic neuroma, which necessitates the removal of a long section of the nerve. A number of surgical interventions are available, including:
- Microvascular nerve decompression
- Selective myotomy
- Nerve anastomosis
- Transplant of the temporalis, masseter or digastricus muscle

Cross-facial nerve grafting may be carried out to provide a substitute for the non-functional nerve. The hypoglossal nerve, or a nerve from the contralateral side, can be used for the procedure. Gold or titanium implants can be used to support closure of the upper eyelid. May and Schaitkin's (2000) book *The Facial Nerve* is recommended for more detailed illustrations and explanations.

7.5 Outlook

Doctors, therapists and nursing staff must take a farsighted approach to the manifold problems and solutions in facial rehabilitation. Empathy for the patient and precise knowledge of anatomy and physiology are essential. The symptoms and their significance for the patients must be accurately assessed, and their willingness and ability to remain open to input from other specialist areas are invaluable.

Sadiq et al. (2011) evaluated an interprofessional practice approach for patients with facial palsy, which involved joint clinics of ophthalmologists, psychologists, physiotherapists, plastic surgeons and ENT specialists. The benefits included shorter travel and waiting times for patients and carers when consulting several specialists. Patients felt involved and could participate in team meetings and ask questions. The multidisciplinary cooperation also provided learning opportunities for the professionals who could communicate directly with each other.

At present, there are many ways of measurement and documentation of facial palsy, including grading scales, clinometric evaluation scales, photography, videography, 3D imaging techniques and instruments assessing the quality of life and psychological impact (Fattah et al. 2015). Finding more accurate methods of clinical assessment that become an accepted standard is a matter for current research. Fattah et al. (2014), for example, investigated a range of nerve-grading instruments and made suggestions for a greater uniformity of the assessment. Santosa and coworkers (2017) suggested standards for photography and videography. Nevertheless, the question remains, how to improve the assessment of the individual limitations in activities and participation experienced by patients in their daily life.

This chapter aims to encourage a more detailed consideration of the themes which characterise the assessment and treatment of the face. It is essential to view the facial nerve within the context of the surrounding tissues and structures, and equally important to acknowledge the personality of the patient in addition to the symptoms. This enables us to treat the individual person with facial palsy instead of treating a diagnosis of 'facial palsy' (Lindsay et al. 2010).

There is insufficient research and data available regarding facial therapy, for patients who have suffered traumatic brain injury or stroke (Pereira et al. 2011). Nevertheless, it is important to reflect on the way how to examine and treat those affected.

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Breathing and Voice: Speaking Again

Margaret Walker

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The ability to speak is unique to humans. Communication takes place through the use of body language, facial expression, breathing, voice, articulation and cognition. We are able to communicate desires, needs and fears, express thoughts and exchange ideas on different topics.

8.1 Breathing

The lungs of a baby unfold following birth. The first breath and cry occur when the child's skin comes into contact with the air and the breathing mechanism is triggered. The three most important functions of breathing are specified in ▶ Overview 8.1.

Overview 8.1 Functions of Breathing

- Vital exchange of gases
- Protection of the lower respiratory passages
- Phonation

The coordination of breathing and voice production is not fully developed in infancy. Infants produce sounds – cries – which are partly created on inhalation. They are not able to hold their breath voluntarily. Typical breathing when crying is characterised by a short, deep inhalation through the mouth and a sustained exhalation phase (Wendler et al. 1987). Control over breathing and voice, and the ability to express and communicate needs, evolves with increasing maturity and the development of selective movement. The personal breathing rhythm and respiratory support required for speech and singing change and develop alongside the physiological development of language and speech. The volume of the lungs (respiratory capacity) increases as a result of growth, as does the duration of the inhalation and exhalation phases. The lung capacity of women is generally smaller than that of men.

8.1.1 Central Control of Breathing

Breathing is controlled by the respiratory center in the pons and medulla oblongata. Stretch receptors relay information from the lungs to the brain and mechanoreceptors refer information from the respiratory muscles. Chemoreceptors record pH levels, carbon dioxide and partial pressure of oxygen in the blood. The respiratory center processes the range of afferent stimuli received from the organism and transmits efferent impulses to all of the muscles involved in respiration to coordinate their movements (Siemon and Ehrenberg 1996). During inspiration the inspiratory neurons transmit impulses and the expiratory neurons are inhibited (reciprocal innervation). Expiratory neurons only innervate the exhalation muscles during forced (active) exhalation (coughing, speaking, etc.).

The basic autonomic rhythm can be changed by a number of factors, including influences of the limbic system, e.g. fear, grief. This occurs unconsciously. There is a change in breathing if one is emotionally aroused or if the body is placed under physical stress (e.g. climbing stairs). Breathing changes to meet the increased requirement for oxygen. The respiratory system automatically reacts to the emotional and physical demands on the individual.

Note
Breathing is an *automatic process* which takes place unconsciously. However, it can be consciously influenced and altered.

Breathing can be influenced voluntarily and made conscious. Neural pathways extend from the higher brain regions, including the cortex, to the respiratory center, meaning that automatic breathing can be suspended voluntarily at any time (Schultz-Coulon 2000).

8.1.2 Anatomical and Physiological Factors

During *inhalation*, air passes through the nose or mouth into the pharynx, through the larynx into the trachea, into the bronchi and into the pulmonary alveoli of the lungs. Gaseous exchange takes place in the alveoli, with oxygen entering the bloodstream and carbon dioxide (CO_2) passing from the blood into the air which is then exhaled.

Tidal breathing or breathing at rest (inhalation and exhalation through the nose, without phonation) is made up of three phases:

- Inhalation
- Exhalation
- Breathing pause

The ratio of inhalation to exhalation is approximately 1:1. A pause in breathing follows exhalation, a brief cessation of respiratory movement, before the impulse for inhalation is repeated (controlled by the concentration of CO_2 in the blood).

Note
The respiratory rate of a newborn is approximately 50 breaths per minute. The rate of respiration slowly decreases as the child grows: The respiratory rate in adolescents and adults is approximately 15 breaths per minute. Each individual has his own characteristic breathing pattern.

Different types of breathing can be identified (▶ Overview 8.2).

Overview 8.2 Types of Breathing

- *Thoracic* or *costal breathing*: The volume of the thoracic cavity is primarily increased by the changing position of the ribs (lateral breathing is included in this breathing type).
- *Diaphragmatic breathing* (abdominal breathing): The volume of the thoracic cavity is primarily increased due to the lowering of the diaphragm
- *Mixed breathing* (costo-abdominal breathing): A combination of costal and diaphragmatic breathing is the most physiologically advantageous.

When speaking most exhaled air passes through the mouth with a smaller proportion through the nose, producing a nasal sound. The flow of air during exhalation must be controlled and modulated. Control means that breathing can be paused voluntarily and recommence afterwards. When speaking the ratio of inhalation to exhalation is approximately 1:10 or more.

Note
For a healthy adult, phonation time (the duration of a sound or of speech) during exhalation is approximately 15–20 seconds.

Speaking and singing require a longer and slower release of air; therefore the muscles of inspiration are also activated eccentrically during exhalation. As a result, the thoracic cavity initially remains expanded during exhalation, enabling the air to flow out more slowly (Fiukowski 2010). This controlled release of air is known as breath support.

8.1.2.1 Inhalation

The most important inspiratory muscle is the diaphragm (■ Fig. 8.1).

The functions of the diaphragm are summarised in ▶ Overview 8.3.

Overview 8.3 Functions of the Diaphragm

- Separates the abdominal cavity from the thoracic cavity
- Breathing (including specific forms of exhalation)
- Mobilisation of the thoracic region
- Pressure gradient: the most important venous and lymphatic pump
- Interaction with the vagus and phrenic nerves
- Supports the process of vomiting and coughing

The following physiological movements can be observed during *costo-diaphragmatic breathing:*

The diaphragm originates from the sternum and the inferior border of the lower ribs as well as L1-L4. It inserts into the central tendon. Via fascial connections (pericardium, pleura parietalis) it has connections to the upper spine up to T4-C4 (▶ Fig. 4.16). The diaphragm relaxes following exhalation. At the beginning of the next inhalation it contracts and descends. The volume of thoracic

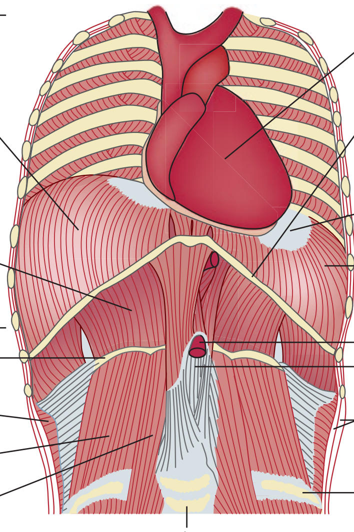

Fig. 8.1 Diaphragm

cavity increases downwards, creating a vacuum in the lungs which allows air to enter. The abdominal wall bulges slightly as the diaphragm lowers the position of the abdominal organs.

Note

The position of the ribs and muscle tone of the trunk muscles and inner tissue connections play an important role in diaphragm function (▶ Sect. 8.4 and 4.2.9).

The *external intercostal muscles* are essential for inhalation (Ehrenberg 1997; Spiecker-Henke 2014). The lungs follow the movement of the thoracic wall increasing both the transverse diameter and thoracic volume. The function of the external intercostal muscles has been debated in the literature. Some authors do not view these muscles as being involved in resting inspiration (Dayme 2009).

In certain circumstances (oxygen deficiency and during physical exertion) *auxiliary breathing muscles* (Fig. 8.2) are required. These include pectoralis major and minor, sternocleidomastoid, serratus and scalene muscles. These muscles increase the vertical diameter of the thoracic cavity by elevating the ribcage (Schultz-Coulon 2000).

8.1.2.2 Exhalation

During breathing at rest, the diaphragm relaxes and elevates. The elastic recoil of the lungs and ribs together with the weight of the ribcage increases pressure within the lungs. The used air is exhaled, and the volume of the thoracic cavity is decreased (Ehrenberg 1997). This process is assisted by the weight of the thorax.

Expiration at rest is a passive process; no muscles are concentrically active; i.e. there is no active shortening of the muscles against gravity. However, the muscles of inspiration must release eccentrically and actively lengthen with gravity.

The internal intercostal muscles are activated for forced expiration during speech (an active process) and during intense physical effort (note this is also controversial in the literature; see Dayme 2009). They decrease the diameter of the thoracic cavity by lowering the ribs and sternum.

The auxiliary expiration muscles include the external and internal obliques and rectus abdominis muscles. When these muscles contract, the abdominal organs are forced backwards and the diaphragm is displaced upwards (Schultz-Coulon 2000). This causes the chest cavity to become smaller.

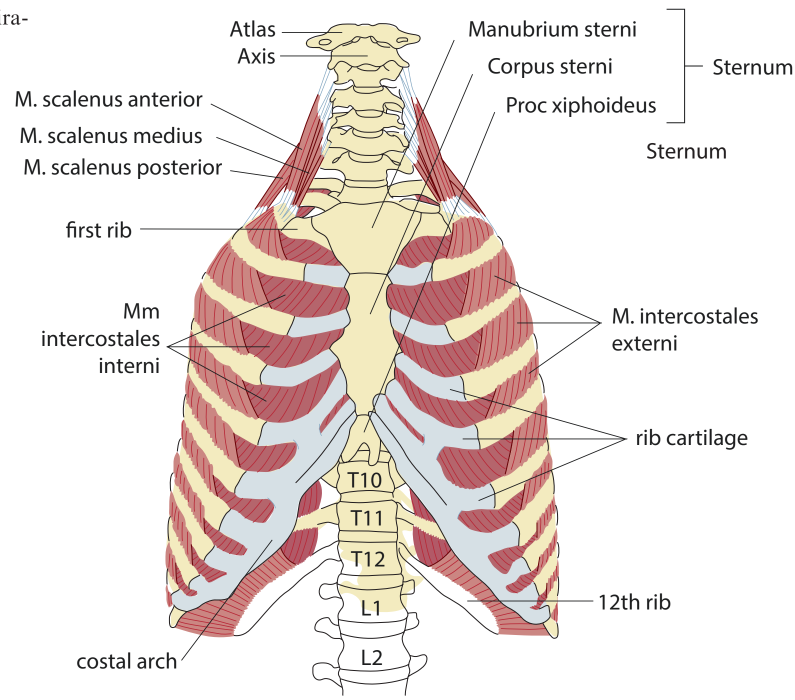

Fig. 8.2 Muscles of respiration and auxiliary breathing muscles

> **Note**
> Specific forms of forced expiration include coughing, sneezing, throat clearing, laughing, crying, shouting and sighing.

Abdominal muscles are particularly important during coughing (clearing secretions or irritants from the airway) and require synchronised interaction of the abdominal muscles (*abdominal press*).

8.2 Breathing-Swallowing Coordination

The swallowing process affects the respiratory rhythm. At the start of the pharyngeal phase of swallowing the hyoid bone and laryngeal structures are pulled upwards and forwards beneath the floor of the mouth. Simultaneously, the vocal and vestibular folds draw towards each other and close the glottis and the epiglottis tilts over the entrance to the larynx. Breathing stops and the lower airway is protected. The base of the tongue and pharyngeal peristalsis propel the bolus towards the esophagus.

Under the Microscope

Coordination Pattern

Several authors have described the coordination pattern between breathing and swallowing (Selley et al. 1989; Smith et al. 1989). However, studies differ in their descriptions of the phase preceding the respiratory pause. A physiological rhythm of *inhalation – breathing pause/swallowing – exhalation* was observed in some test subjects (Selley et al. 1989). However, other studies (Klahn and Perlman 1999; Martin et al. 1994) noted that in most test subjects the expiratory phase had already begun prior to the breathing pause and exhalation resumed after swallowing. Martin et al. (1994) found that the breathing pause occurs prior to laryngeal elevation.

In normal healthy adults the swallowing phase usually begins in the expiratory phase of breathing and resumes in the expiratory phase after swallowing. Expiration following swallowing is regarded as being part of effective airway protection.

Practical Tip

If saliva or food penetrates (above the level of the vocal folds) or is aspirated (below the level of the vocal folds), the airway is cleared by throat clearing or coughing (on exhalation). A clearing swallow prevents the dislodged material from re-entering the trachea.

The respiratory pause is slightly longer in older adults than in younger people (Selley et al. 1989). Hiss et al. (2001) found that women have a longer respiratory pause than men. Bolus size has an impact on the duration of the respiratory pause; i.e. the greater the bolus volume, the longer the respiratory pause.

8.3 Voice

The development of the voice begins at birth with the baby's first cry. The literature states that this cry is approximately 440 Hz (concert pitch a, Schultz-Coulon 2000).

Several different crying periods can be distinguished during the course of the infant's development. The first crying period is characterised by non-specific cries with low pitched contented sound and vocal range increases.

In the second crying period, cries of pleasure (cooing) can be distinguished from unhappy cries (harsher voice), (Nawka and Wirth 2007). These cries express, through changes in the sound of the voice, desires or reactions to hunger, thirst, being alone, cold, etc. Similarly, initial spontaneous facial expressions (facial movements which do not have a known cause) evolve into responsive facial expressions (Herzka 1979). This provides the first opportunities to interact non-verbally with the environment or support the vocal expression of needs. Speech organs (articulators) develop further during the first motor extension phase, as neck extension increases (► Sect. 13.5.1). The babbling stage follows, during which the speech organs are used for the first time (precursor to speech). Vowels, consonants and even phonation sequences are produced and known as canonical babbling. All children initially babble non-specific sounds. As development progresses children only imitate sounds and elements of sounds heard in their environment (linguistic region), and voice becomes more melodic and rhythmic (Wendler et al. 1987).

Note
As the individual grows, so does the larynx and its associated structures. The larynx descends and the vocal folds become longer and stronger. The voice register lowers increasingly and the vocal range becomes larger.

Voice mutation or voice change (voice break) is a specific change from a child's to an adult voice, which takes place at the onset of sexual maturity. Voice mutation begins at approximately 11–12 years of age and is much more noticeable in boys than in girls. It is a result of changes in hormonal balance causing the larynx to grow and the vocal folds to alter (widen, lengthen and increase in mass). The larynx descends and the vocal register lowers by approximately one octave.

Note
The vocal range in adults is slightly under two octaves (Biesalski and Frank 1994).

Singers have the largest (trained) vocal range. Vocal hygiene is particularly important for those who work in speaking or singing professions. Specialised vocal training in the physiological use of the voice (attention to posture and use of breath support, etc.) is important.

Every person has their own individual vocal timbre, which forms part of their personal identity. Breathing and voice can be used to change the tone of words and give statements a calm or a threatening character. Prosodic elements such as pitch, loudness and emphasis are controlled through breathing and voice and play an important role in a person's speech.

Change of body tissue occurs as the body ages, affecting the larynx and timbre of the voice. Hormonal changes play an important role in this process (Wendler et al. 1987). There may be increasing ossification of the larynx, resulting in a loss of joint elasticity (this process begins at approximately 15 years of age). The vocal folds can become atrophied and changes occur in the mucous membrane. Muscle laxity causes the larynx to lower and the intra-articular spaces to become larger. These restructuring processes can result in a lowering of vocal timbre in women, as well as changes in the tone of the voice. Vocal range decreases and the voice may tire more rapidly when speaking (Wendler et al. 1987).

Note
Physiological changes associated with ageing can also affect the swallowing sequence.

8.3.1 Central Control of Voice

The entire laryngeal musculature is innervated by the tenth cranial nerve: the vagus nerve. Motor innervation of the intrinsic (inner) laryngeal musculature is by the inferior laryngeal nerve (branching from the recurrent laryngeal nerve). The superior laryngeal nerve provides sensory innervation for the upper laryngeal mucosa, extending to the vocal folds and motor innervation to the cricothyroid muscle. The inferior laryngeal nerve provides sensory innervation of the mucosa in the subglottal region (Nawka and Wirth 2007).

8.3.2 Anatomical and Physiological Aspects

The larynx is located at the upper end of the trachea (Fig. 8.3). The basic structure is comprised of the thyroid, cricoid and arytenoid cartilages, all of which are connected by ligaments, muscles and membranes. The thyroid and cricoid cartilages can be tilted against each other: This action is effected by the cricothyroid muscle, which connects the two cartilages. The two arytenoid cartilages are shaped like small pyramids and articulate with the cricoid cartilage plate, opposite the thyroid cartilage (Nawka and Wirth 2007).

The vocal folds are predominately responsible for voice production. They attach posteriorly to the arytenoid cartilages (processus vocalis) and anteriorly to the middle of the thyroid cartilage, opposite. The vocal folds are comprised of the thyroarytenoid muscles (the vocalis muscle and the thyromuscularis) and the vocal ligament (vocal cord). The space between the vocal folds and the arytenoid cartilages is called the rima glottidis.

These muscles are positioned in pairs. They must coordinate and work together with equivalent levels of muscle tone, for effective breathing, swallowing and efficient voice production.

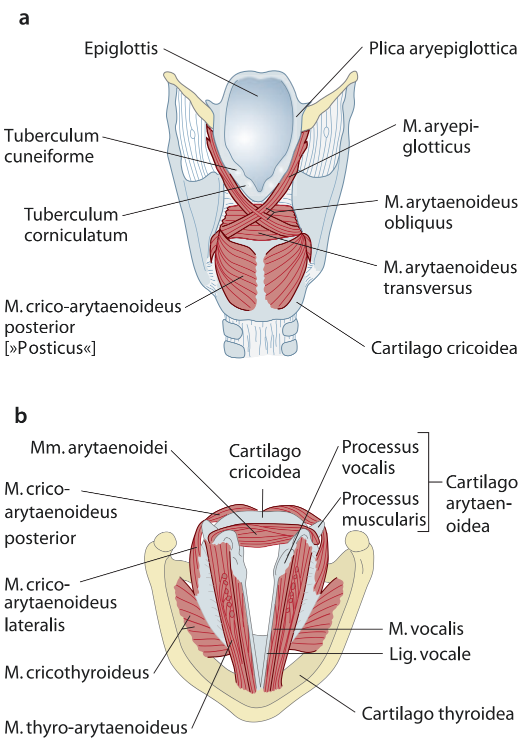

Fig. 8.3 **a, b**. View of the larynx **a** Dorsal view, **b** Cranial view

8.3.2.1 Voice Production

Voice is produced by the vibration of the vocal folds, as a result of myoelastic and aerodynamic forces. In order to make the vocal folds vibrate, subglottic pressure must be built up by the respiratory muscles whilst the glottis is closed.

The tension of the vocal cords is crucial during phonation: the expelled air pushes the vocal folds upwards and outwards and the glottis opens to allow the air to escape (Spiecker-Henke 2014). This reduces the subglottic pressure and the vocal folds then close (a vibration). The subglottic pressure then builds up again and the process is repeated. In this way, the exhalation of air can be regulated and controlled during phonation. The vocal cord (mucous membrane) is only loosely connected to the muscles of the vocal folds and has its own motion during the oscillation process, referred to as the mucosal wave (Spiecker-Henke 2014).

8

Note

Pitch is generated by the tension of the vocal folds.

If the vocal folds vibrate at their full length and are relaxed, a low tone is produced. The higher the tension in the vocal folds, the higher the sound produced.

The various mechanisms required for this include tipping the thyroid cartilage, resulting in lengthening and passive tension on the vocal folds. The isometric contraction of the vocalis muscle causes the vocal folds to become narrower (decrease in mass). The number of vibrations increases as pitch rises (Nawka and Wirth 2007). Only the mucous membrane (ligamentum vocale) vibrates when a very high tone is produced.

Each individual has its own unique physiological vocal register (neutral pitch). This is the vocal range which can be produced using the least amount of laryngeal force combined with the least amount of air pressure. This unique vocal register is in the lower two-thirds of the individual's vocal range (Fiukowski 2010).

The loudness of the sound is dependent on the amplitude of vocal fold vibration. The greater the subglottic pressure, the higher the vibration amplitude and therefore the volume.

Note

Loudness is determined by the force of air through the vocal folds, i.e. the amount of subglottal pressure.

There are different forms of physiological vocal register, which are explained in more detail in ► Overview 8.4.

Overview 8.4 Physiological Vocal Registers

The shape of the glottis can vary at the vocal onset and this variation affects the vocal register. Three physiological vocal registers are distinguished:

- *Aspirated/breathy vocal onset:* The vocal folds are approximated but do not touch each other. Exhaled air is already flowing when the vocal folds begin to vibrate (words beginning with "h").
- *Soft/modal vocal onset:* The vocal folds overlap slightly and begin to vibrate.
- *Hard vocal onset*: Slight tension of the vocal folds, which are adjacent to each other and separate when phonation begins (with initial vowels).

When speaking, the respiratory rhythm is influenced by the meaning of the sentences spoken and the individual's own respiratory rhythm (Breath Timed Phonation (BTP), Coblenzer and Muhar 2006, ► http://coblenzer.net/breath_timed_phonation.pdf).

Note

Voice, primarily generated by the vocal folds, can be modified by the pharyngeal, oral and nasal cavities and articulation. The quality of the voice is similarly affected, for example:

- Narrowing of the resonance chambers results in a strained tonal sound.
- Opening of the resonance chambers produces a clear vocal sound.
- A nasal sound is produced when the soft palate is lowered and some air escapes through the nose, as in "m", "n" and "ng". If the soft pal-

ate is taut, the air escapes through the mouth, e.g. "ah". Different languages have different degrees of nasality.

8.4 The Influence of Posture and Muscle Tone

In addition to posture, facial expression and gesture (body language), voice plays an important role in shaping the first impression of others. For example, if one's posture is "hunched" and the voice quiet and weak, it may give the impression that one is either tired or sick. An upright posture and a firm voice may suggest a strong personality.

» Speak, that I may see thee! (Socrates)

Posture and muscle tone are particularly important factors for efficient breathing and voice production (phonation). Upright body posture and appropriate muscle tone are essential for full expansion of the respiratory spaces. The body must be physiologically aligned above an upright pelvis. The head and neck must be tilted slightly forward (chin towards chest) and a "long back of the neck" maintained.

When breathing, a finely tuned reciprocal innervation produces an effortless transition from inhalation to exhalation.

Note

Inhalation is associated with the pattern of extension/lengthening and *exhalation* with the pattern of flexion/bending.

It is important that the body's muscle tone (residual muscle tension) is neither too high (hypertone) nor too low (hypotone). There must be dynamic stability (► Sect. 4.1.2). Stability of the thorax is achieved through reciprocal innervation of the abdominal muscles working together with the autochthonous back musculature (spinal extensors). This anchors and aligns the ribcage against gravity, creating the basis for dynamic stability.

Note

The coordinated interaction of physiological posture, movement and appropriate muscle tone is required for the efficient and economical performance of the swallowing sequence, quiet breathing, breathing for voice production and speech.

8.5 F.O.T.T. Principles

The importance of posture and its effect on breathing and voice has long been recognised in training professional singers (Dayme 2009) and has increasingly been adopted for the treatment of functional voice disorders (Saatweber 2007; Spiecker-Henke 2014). Unfortunately this knowledge has not routinely been incorporated into the treatment of patients with brain damage. A possible explanation could be that the various health professions have developed their own areas of expertise but a holistic view on the complex functioning of breathing, swallowing and voice remained limited.

Note

Treating breathing and voice requires understanding of how body structures function, coordinate together and influence each other.

If voice (or absence thereof, i.e. aphonia) is treated in isolation without consideration of abnormal posture, reduced mobility or impaired balance, any improvements will be short-lived or nonexistent.

If the underlying issues are not addressed, it can lead in the long term to *secondary problems*.

► Example

If too much effort is used to produce a voice, it causes increased muscle tone and associated reactions. Effort disrupts the efficient use of air flow essential for phonation, impairing voice production or making it impossible. ◄

The influence of an individual's postural background on breathing and swallowing is described in a study of healthy subjects by Smith et al. (1989).

Based on the understanding and knowledge of normal posture, movement and function, the F.O.T.T. therapist must be able to analyse any deviation from the norm, form a hypothesis as to the cause, develop a treatment plan and implement it during treatment. The patient's response to intervention must be monitored and evaluated and treatment modified as appropriate.

! The problems facing patients with acquired brain damage may be lifelong. They can lead to secondary complications which worsen the patient's condition over time. Prevention of these complications is essential. It is important to identify secondary problems which may have developed and differentiate these from primary symptoms (Horak 1991).

► Example

Impaired coordination of breathing and swallowing (a primary problem following brain damage) can result in saliva and/or food being aspirated, which may cause aspiration pneumonia (secondary problem). ◄

It is important that the knowledge from medicine, occupational-, speech- and physiotherapy is combined and integrated therapeutically to improve the outcome for the patients. The F.O.T.T. approach is a hands-on approach. Therapeutic handling and facilitation are crucial (Coombes 1991). Observation and the therapist's hands are used to assess and treat muscle tone and movement. Targeted tactile facilitation enables the patients to feel the most physiological movements possible. Without such input they would be unable to achieve these movements, e.g. due to movement impairment, perceptual disturbances or lack of sensation. The importance of using the patient's own body to normalise or improve sensation (termed self-stimulation) is emphasised by Coombes (2001b).

Practical Tip

- *Self-stimulation* (= feeling one's own active movement) provides the strongest feedback for sensorimotor learning. This is facilitated using tactile assistance/support.
- *Hands-on* is an important principle of the F.O.T.T. approach. The starting position is chosen to influence the key points of control and achieve the therapeutic goal.
- *Verbal instructions are kept to a minimum.*
- *Verbal prompts* should be: brief, concise and relevant to the situation.

It is extremely valuable to use functional activities during treatment. Appropriate functional activities may include blowing out candles, playing a harmonica or blowing soap bubbles. Everyday activities have the advantage of allowing patients to feel, see or hear the results directly and receive concrete feedback without requiring an understanding of auditory verbal (spoken) language. The selection of an appropriate starting position and base of support (◘ Fig. 8.4) can affect the success of the activity.

Therapy-free times are important. Nursing staff and relatives play a crucial role during these periods, e.g. positioning the patient during the day and night (► Sect. 8.6.3). Consistent implementation of F.O.T.T. principles over 24 hours can reduce or prevent secondary complications and help to reduce costs incurred as a result of these complications.

The general principles of F.O.T.T. are summarised in ► Overview 8.5.

Overview 8.5 General F.O.T.T. Principles

- Knowledge and understanding of normal posture, movement and function.
- Identify and differentiate between primary and secondary problems.
- During treatment and when handling the patient:
  - Facilitate and support the most normal function possible, i.e. provide tactile and proprioceptive input – verbal instructions are kept to a minimum.
  - Use real and targeted functional activities.

Fig. 8.4 The support provided by a (crescent-shaped) pack in front of the patient enables her to purse her lips selectively and blow soap bubbles. (© Walker and Jakobsen 2019. All Rights Reserved)

8.6 Typical Problems Experienced by Patients with Brain Damage and Potential Solutions

This section addresses a range of problems typically experienced by patients with acquired brain damage affecting breathing, swallowing, voice and their coordination.

8.6.1 Central Respiratory Disorders

Some of the pathological breathing types associated with central damage to the respiratory center include:

- Cheyne-Stokes breathing
- Biot breathing
- Agonal breathing with short, snapping, irregularly inserted breaths (Kasper and Kraut 2000)

There are changes in the rhythm, depth of inhalation and exhalation as well as prolonged pauses in breathing. Breathing sounds may also be altered.

Thoracic instability resulting from brain damage and injuries to the spinal cord can cause paradoxical respiration, in patients with quadriplegia and paresis. The movements of physiological breathing become reversed. Phonation and speech change, due to the altered breathing pattern.

A study by Hadjikoutis et al. (2000) identified the following abnormal breathing-swallowing patterns: inhalation after swallowing in 91% (20 of 22 cases) of patients with central, spinal or peripheral lesions and in 44% (14 of 32 cases) of patients with motor neurone disease. The deviation from the norm in the control group of healthy individuals was just 9% (2 of 22 subjects).

Potential approaches to resolving the altered breathing pattern can be found in Sect. 8.6.4, together with tactile breathing guidance to help increase ventilation of the lungs or initiate physiological respiratory patterns.

8.6.2 Postural and Movement Issues

Respiratory problems are frequently associated with difficulties in trunk control; therefore, postural background and movement play a central role in treatment (Broich 1992; Davies 2013; Paeth Rohlfs 2010). Dynamic stabilisation of the thorax is dependent on trunk muscles (including the vertical, horizontal, internal and external oblique abdominal muscles). These muscles are often unable to perform this function adequately following acquired brain damage.

8.6.2.1 Abdominal Muscles

Note

The *stabilizing function* of the abdominal muscles is often weakened following brain injury.

Patients have difficulty maintaining an upright position and simultaneously performing other functions like swallowing and/or speaking in a physiologically normal way. Insufficient active and passive tension on the ribcage caused by weakness of the abdominal muscles results in limited mobility of the ribcage, especially in the direction of exhalation. Breathing becomes shallow and the expiratory phase shortens. The vocal tone of the voice is affected and may become aphonic (toneless), whispered or hard and forced due to a compensatory increase in muscle tone. Phonation time may be reduced. Physical activities rapidly cause shortness of breath and symptoms of fatigue in these patients (Davies 2013; Panturin 2001).

8.6.2.2 Trunk Muscles

Note

Ineffective trunk musculature restricts the movement and functional use of the upper extremities.

The shoulder girdle is primarily connected by muscles to the thorax and the dynamic stability is dependent on the intact function of the trunk musculature. If trunk muscles are hypotonic, distal muscle groups (i.e. muscles of the arms and hands) are often used in an intuitive attempt to stabilise and hold the body upright against gravity. This results in increased distal muscle tone (Davies 2013, Panturin 2001).

8.6.2.3 Head and Neck Muscles

Note

This compensation principle also applies to the head and neck, which are connected to the thorax.

Without the *antagonistic effect* of the abdominal muscles on the thorax, the increased muscle tone in the neck and shoulder muscles pulls the ribs upwards. This results in shallow respiratory movements and restricts head and neck movement.

The dynamic stability of the hyoid bone is dependent on its muscular connections to the lower jaw, tongue, head, scapulae, sternum and clavicles. As a result, patients who lack of trunk control may experience disorders in the jaw and tongue and swallowing (▶ Sect. 4.2, Panturin 2001).

8.6.2.4 Rotation of the Trunk

Patients with the difficulties described above often have reduced trunk rotation.

It is impossible to use the muscles on one side of the body effectively without stability being provided by the trunk muscles on the opposing side (Davies 2013). It is difficult to move if the ribs are fixed in one position as they block movements of the trunk.

Note
If the muscle tone in the *pectoralis major muscle* is excessive, the shoulders become fixed in flexion, with the punctum fixum proximal (on the ribcage). This makes expansion of the respiratory spaces difficult (Paeth-Rohlfs 1999).

Figure 8.5 shows the elevated ribcage of a patient with a hypotonic trunk.

8.6.2.5 Problem-Solving Approach: Use of Movement

A study by Falkenbach (2001) confirmed the effectiveness of movement in the treatment of breathing disorders. Patients diagnosed with a rigid thorax showed more effective abdominal breathing after minimal movement and activity in the lumbar area. A correlation between activity and swallowing frequency was observed in infants (Wilson et al. 1981). The combination of stability and movement can improve the movement capacity of the trunk and make breathing more effective.

- This combination enables the patient to perform more selective movements, thus reducing mass movements (Davies 2013; Edwards 2002).
- Inhalation is physiologically associated with the pattern of extension, and exhalation tends to be associated with the pattern of flexion. It therefore makes sense to integrate these patterns of movement into treatment.

These movement patterns must be combined with rotational components. Flexion and extension alone are not sufficient to ensure complete freedom of movement for the trunk and extremities. Rotation is the coordinated result of flexion and extension in all movement planes (Edwards 2002). It is important to use rotation combining flexion and extension of the key points of control, in different starting positions (► Sect. 8.7). Figure 8.6 illustrates development of the exhalation in conjunction with rotational movements of the upper trunk.

Note
The muscle tone of the *abdominal and trunk musculature* should not be too low, as a hypotonic trunk is often flexed by gravitational pull and can result in a hyperextended or translocated forward (short back of the neck) position of the head and neck. This position increases tension in the laryngeal muscles (► Sect. 4.2).

If the abdominal muscles are hypotonic, the ribs remain fixed in the inhalation position, making exhalation difficult. The diaphragm is also affected by an elevated ribcage and can no longer function effectively.

Fig. 8.5 Patient with an elevated ribcage. (© Walker and Jakobsen 2019. All Rights Reserved)

Fig. 8.6 Exhalation in conjunction with rotational movement of the upper trunk. A towel is placed under the ischial tuberosities, sitting bones, to support the upright position of the pelvis. (© Walker and Jakobsen 2019. All Rights Reserved)

8.6.3 Additional Factors Affecting Breathing

8.6.3.1 Unhelpful Positioning Increases the Patient's Overall Muscle Tone

Often, severely affected patients can only tolerate being positioned for a short period of time.

They sweat profusely and their rate of respiration increases.

Practical Tip

During this stage of rehabilitation the entire team is challenged to find a position which enables the patient to let go of the increased muscle tone and regulate the overall muscle tone. The patient requires frequent repositioning.

8.6.3.2 Stridor

Stridor refers to high pitched, wheezing sound during inhalation and/or exhalation.

Inspiratory stridor

Some causes of inspiratory stridor include:

- Secretions obstructing the upper respiratory tract or tension from the pharyngeal and tongue musculature. It can also be caused by dorsal tilting of the epiglottis (e.g. in a supine position).
- Granulations must be considered in the case of tracheal intubation (► Sect. 9.4).
- Constriction at laryngeal level, e.g. bilateral vocal cord palsy.
- Subglottal narrowing, e.g. tracheal stenosis.

Practical Tip

- Remove secretions from the upper respiratory tract through mobilisation and positioning (e.g. prone) of the patient. Support coughing and use a secretolytic agent (nebuliser) if required.
- Mobilise and normalise the muscle tone in the shoulder girdle and neck.
- Supine positioning should be avoided due to the adverse effect of gravity on the

patient's overall muscle tone and position of the ribcage due to the lack of stabilising abdominal musculature making breathing more difficult (► Sect. 8.7).

Note
A tracheostomy and tracheostomy tube may be required in the event of apnoea or dyspnoea due to constriction in the larynx and/or trachea.

- **Expiratory stridor**

Expiratory stridor occurs in obstructive diseases of the airway, e.g. bronchitis, asthma or chronic obstructive pulmonary disease (COPD).

Practical Tip

It is essential to treat the primary disease and use preventive measures through positioning and mobilisation in sitting and standing.

8.6.3.3 The Effects of Tracheostomy Tubes on Breathing, Swallowing and Phonation

Many severely affected neurological patients have a tracheostomy and a tracheostomy tube (TT) in the acute phase, as they require long-term ventilation and/or have a swallowing disorder.

Note
Patients with tracheostomy tubes do not have the respiratory resistance of the naso-, oro- and hypopharynx. Breathing is shallower and more rapid.

The type of TT affects the physiological respiration and therefore the functions of breathing, phonation and swallowing (► Chap. 9).

- **Cuffed (blocked) tracheostomy tubes**

A TT with inflated cuff stops the flow of air to the entire nasal, oral, pharyngeal and laryngeal area including the trachea above the level of the tracheostoma. The following changes in breathing, voice and swallowing result:

- Breathing through the nose or mouth is impossible.
- Sensation and therefore control over the area is reduced. Secretions in these areas can no longer be moved with the assistance of expiratory airflow and can no longer be sufficiently felt. Throat clearing or coughing is no longer initiated or occurs less frequently, with reduced efficacy. As a result, secretions are swallowed less frequently or not at all (see ► Figs. 9.4c and 10.10b).
- It is not possible to produce voice.
- The ability to smell and taste is reduced.

Practical Tip

Deflating the cuff of a TT – initially only during therapy following consultation with the treating physician (see ► Sect. 10.3.3 for the exact procedure for cuff deflation). If the patient is able to breathe past the deflated cuff of the cannula when a speaking valve or a cap is inserted, the air flowing through the upper respiratory tract has a stimulating effect on the sensation of the oro-naso-hypopharynx.

- **Uncuffed tracheostomy tubes**

An uncuffed tracheostomy tube with a speaking valve enables air to be inhaled via the tube and exhaled through the larynx, vocal folds, throat, mouth or nose.

As a result:

- Sensation and therefore control over this area is improved.
- Patients with sufficient coordination of breathing and phonation are able to produce voice or speak.

All TTs occupy space within the trachea. Exhaled air can only flow past a cuffless TT or a TT with deflated cuff.

Warning
If the tube occupies too much space within the trachea and insufficient air can be exhaled around it, exhalation is blocked. The same applies if granulations obstruct the passage of air. There is an acute risk of suffocation!

If this occurs, immediate exhalation via the tracheostomy tube must be ensured. Any speaking valve or sealing cap must be removed straight away!

Practical Tip

In this case a TT with a smaller diameter is required to allow more exhaled air to move through the trachea. Voice quality is usually improved.

TTs and their management are described in more detail in ► Chaps. 9 and 10.

8.6.3.4 Restricted Jaw Opening

8

Patients who have difficulty opening their jaw may experience altered sensory feedback in the oropharyngeal tract. The jaw is often fixed in an abnormal position and the patient cannot alter this pattern to move their tongue, initiate swallowing or breathe through their mouth.

► Example

A swallow or attempted swallow is frequently observed in these patients after spontaneous yawning. A hypothesis is that the airflow through the mouth provides an input of stimulus into an understimulated area. The airflow increases sensation resulting in a swallow due to the increased sensory feedback. ◄

Note

A reaction cannot be expected without stimulation in an understimulated area.

Practical Tip

It is important to influence the patient's postural background and integrate the pre-oral phase when facilitating mouth opening using targeted tactile input to the face and mouth.

8.6.3.5 Inadequate Mouth Closure

Some patients have difficulty closing their mouth. It is difficult or impossible to alternate between resting breathing through the nose and forced exhalation through the mouth. Inadequate jaw closure alters the position of the lower jaw, tongue and soft palate, affecting breathing and swallowing.

Note

Nasal breathing is largely precluded when the mouth is open and the perception of olfactory and gustatory stimuli is reduced. The oral mucosa becomes dehydrated and saliva viscous.

Altered body and head posture influence jaw closure (► Sect. 4.3.2).

An open mouth posture does not provide the tongue with a stable foundation to initiate selective oral movements for bolus formation and transportation in the direction of the pharynx.

This leads to an increase in effort and often results in pumping jaw and tongue movements, when attempting to transport the bolus to the back of the oral cavity. Transportation of saliva is slower and:

- Either prolongs the duration of the respiratory pause during swallowing
- Or leads to an intrusive breath, so-called intermediate breathing; i.e. the patient must inhale during the swallowing process

Several swallowing attempts are required before patients with these difficulties are eventually able to swallow. In many cases the swallowing process is incomplete. Subsequent pharyngeal movements are inefficient and inadequate in transporting saliva into the esophagus. There is an increased risk of aspirating saliva and food (Selley et al. 1989; Smith et al. 1989).

Practical Tip

- An appropriate position to commence therapy must be identified (note alignment of the pelvis, trunk and neck as this will affect the mobility of the larynx).
- Jaw support is used to facilitate mouth closure and provide tactile support of the tongue through the floor of the mouth to facilitate swallowing.

Reducing the pumping movements of the jaw and tongue leads to a shorter respiratory pause while swallowing and reduces the risk of an intermediate breath, which may be associated with aspiration.

8.6.3.6 Coordination of Breathing and Swallowing

Swallowing interrupts the breathing process. As mentioned previously in ► Sect. 8.2, studies of healthy subjects suggest that most individuals exhale reflexively after swallowing, regardless of the presence of a bolus (Hiss et al. 2001; Preiksaitis et al. 1992; Smith et al. 1989). The coordination of breathing and swallowing pattern changes in both healthy individuals and neurological patients when food is offered (Selley et al. 1989). In healthy subjects, breathing at rest altered when they were fed but they always exhaled after swallowing. In contrast, many neurological patients inhaled directly after swallowing, rather than exhaling.

Warning

There is a risk of aspirating debris and secretions when inhaling directly after swallowing.

Exhaling after swallowing is a protective function. Any debris or secretions remaining in the pharynx and respiratory tract after swallowing can be detected and removed from the airway by coughing if necessary. The residue can then be swallowed or spat out again.

► Overview 8.6 provides a summary of factors that increase the risk of aspiration.

Overview 8.6 Increased Risk of Aspiration

The risk of aspiration increases:

- If the periods of apnoea are too short.
- If reflexive exhalation does not follow swallowing.
- If the swallowing process is too long due to prolonged bolus transit time through oral cavity and pharynx, the patient will have to inhale during bolus transport and material within the pharynx may enter the lower respiratory tract.

Practical Tip

F.O.T.T. places particular emphasis on the pre-oral phase including when assisting at mealtimes. The patient is involved in the preparation as much as possible.

Therapy begins here: setting up the environment (therapy packs, wall, etc.) and optimising the patient's postural background making it possible to guide the patient's hands to take an appropriate amount of food to his/her mouth, at an appropriate speed (see algorithms ► Chap. 12).

Special attention is paid to the *clearing swallow*. This plays a vital role in removing residues from the valleculae and piriform sinuses. The patient may be insufficiently able to feel these residues and is at risk of aspirating them during the next inhalation or when they move (► Chap. 5).

8.6.3.7 Coordination of Breathing and Swallowing When Drinking Through a Straw

Patients are often advised to drink through a straw, e.g. to compensate for insufficient mouth closure or impaired tongue movements.

A study of healthy subjects conducted by Martin et al. (1994) examined the act of drinking through a straw. They described repeated consecutive swallows without intermediate breathing; i.e. a prolonged respiratory pause was required.

Warning

Martin et al. (1994) concluded there was an increased risk of aspiration for neurological patients especially when drinking through a straw due to the increased time taken for the swallowing sequence and the disrupted coordination of breathing and swallowing.

Practical Tip

It is important to accurately assess and evaluate whether it is helpful or not for a particular patient to drink using a straw.

It may be safer to take the liquid from a cup or glass using lip seal (closure of the lips around the rim of the cup), as liquid does not immediately flow to the back of the oral cavity.

Patients with the above difficulties may benefit from having their background posture, head and jaw supported when drinking.

8.6.4 Impact of Pathological Breathing on Voice and Speech

Breathing and phonation are normally performed unconsciously, without effort and simultaneously with other activities.

Many of the structures used during speech have a role in the swallowing process, which is why dysphagia, dysarthria and dysphonia can occur following acquired neurological damage (Coombes 1991; Logemann 1999; Perkins and Kent 1986). Dysarthria and dysphonia, centrally caused disorders of posture and muscle tone, breathing (for speech), phonation and articulation, affect the intelligibility and naturalness of speech.

The fundamental problems have been addressed previously, for example, altered body posture, muscle tone, movement (► Sects. 8.4 and 8.6.2) and respiratory patterns (► Sect. 8.6.1). However, they also affect voice production or phonation (which may also be a primary impairment), articulation and the prosodic elements of speech, as well as their coordination.

Practical Tip

Hands-on – tactile support of breathing: A first step in treatment might be to lengthen the expiratory phase of breathing, which as a direct consequence deepens the following inspiratory breath.

- **Tactile breathing support**

The patient is in a modified supine position (◘ Fig. 8.7) or in one of the starting positions described in ► Sect. 8.7; the therapist uses his/her hands to direct respiratory movement towards the lateral ribcage and influences the breathing pattern.

The hands are placed on the left and right sides of the thorax (ventral–lateral) at the approximate level of the fifth to tenth ribs. The therapist follows the patient's breathing movements with her hands and begins to emphasise and lengthen the exhalation phase using steady, gentle but constant downwards (dorsal and caudal) pressure with the thorax and hands as a unit. The therapist's hands remain in contact with the patient's thorax during the respiratory pause and inhalation, maintaining a gentle pressure, but at the same time allowing the ribcage to move upwards during inspiration. Depending on the patient's breathing rate, exhalation can be lengthened by emphasising every third breath.

The therapist records and evaluates tactile, visual and auditory changes in respiratory

Fig. 8.7 The thorax is supported to counteract the spontaneous elevated position of the ribs. Stable and mouldable pillows are used to support the neck and head and ensure a "long back of the neck". The arms are supported alongside the body. (© Walker and Jakobsen 2019. All Rights Reserved)

movements and their frequency, e.g. the physiological respiratory pause, lateral motion of the ribcage and breathing sounds.

Tactile breathing support can be combined with the voice and/or vibration on the ribcage or sternum.

► Example

A therapy ball is used in the patient example (Fig. 8.7). The patient uses his legs to pull the ball towards his body during the exhalation and pushes the ball away during the inhalation. This exercise supports the function of the abdominal muscles. ◄

Goals for therapy include the following:

- Improved airway protection by increasing laryngeal and pharyngeal sensation
- Improved coordination of breathing, swallowing and voice production

Warning

Verbal instructions should be kept to a minimum as the breathing changes when one thinks about it. When neurological patients try hard, their muscle tone increases and their breathing becomes more effortful and strained.

Practical Tip

The more forceful expiratory airflow (with or without phonation) causes secretions in the pharynx, e.g. the valleculae, to vibrate or move. The stimulus provided by the airflow temporarily increases sensation. This can trigger a swallowing response, which might require manual support for swallowing (► Chap. 5).

8.6.4.1 Voice Initiation

Many patients with central innervation disorders affecting the vocal apparatus cannot produce a voice initially. These patients are often only able to whisper or generate sound on inspiration. This can be due to insufficient subglottal pressure resulting from limited trunk activity including the abdominal muscles or constriction in the larynx (e.g. ventricular folds). It is a sign of impaired coordination of breathing and voice.

Adequate subglottic pressure from expiratory airflow makes the vocal folds vibrate and produces the voice (Perkins and Kent 1986). Phonation is impossible without an appropriately controlled flow of air suitable for the required volume and pitch.

Practical Tip

- Work to lengthen exhalation is vital from the outset. This can take place in various positions. Being able to sustain a breath is the foundation for voice production.
- If the patient can stand, a good starting position is standing (with support) at a high table or bench (Fig. 8.8). In this position, the base of support is smaller and a patient with hypotonic trunk muscles often has more control on exhalation, because the muscle tone is higher to maintain the upright position against gravity. The patient shown in Fig. 8.8 is able to control his exhalation, thereby producing larger soap bubbles.
- At the beginning of treatment the phonation of a sigh may be the first indication of voice. Supported voicing of syllables with rounded vowel sounds on exhalation such as “ho”, “ha” or “he” and short words such as “hello” can be used.
- The patient should not be requested to take a deep breath or consciously focus on the breathing during phonation. A large amount of air is not necessary to generate voice; rather the air is released in a controlled manner (Coombes 1991).

Warning

The patient shown in Fig. 8.9 can only spontaneously produce voice in short sharp bursts with strong associated reactions. A side lying position with a large base of support is selected which enables the patient to phonate the sound “ho” without associated reactions. The therapist assists by providing vibration to the sternum and pressure on the lateral ribcage.

Fig. 8.8 Standing at a table is a position which automatically increases muscle tone, due to the small base of support. This position enables a patient who normally has hypotonic trunk muscles to control expiratory airflow, allowing large soap bubbles to be formed. (© Walker and Jakobsen 2019. All Rights Reserved)

Practical Tip

A starting position with a larger base of support should be selected when the patient has associated reactions or unhelpful movements, e.g. increased muscle tone or too much movement in the shoulder girdle.

8.6.4.2 Vocal Timbre

Nasal timbre

Paralysis of the soft palate as well as limited mobility of the head, neck and trunk can affect the sound of the voice, resulting in a nasal tone/quality.

Fig. 8.9 The patient phonates the sound "ho" in a side lying position. The therapist assists with vibration to the sternum and pressure on the lateral ribcage. (© Walker and Jakobsen 2019. All Rights Reserved)

Note

An abnormal head position alters the position and mobility of the larynx and affects vocal tone (Coombes 1991).

Practical Tip

It is important to normalise posture, including alignment of the pelvis and muscle tone of the trunk, head and neck and facial-oral tract using jaw support, tactile input and facilitated movements. Indication for a palatal lift should be assessed!

Wet-gurgly sounding voice

A wet voice is a sign of secretions or fluid on the vocal cords.

Warning

A voice that sounds moist, gurgly and/or congested is always a sign of penetration or aspiration of secretions, liquid or food!

Practical Tip

Throat clearing or *coughing* must be facilitated immediately in order to reduce the risk of aspiration. Pressure and/or vibration on the thorax and sternum can help make throat clearing or coughing more effective and swallowing support should be provided afterwards.

Hoarse voice

Recurrent paralysis or incorrect use of the voice can cause the voice to sound hoarse.

Practical Tip

The goal is to generate a smooth onset of voice on exhalation using the resonance chambers of the head and trunk, in a position that enables the patient to have the most physiological muscle tone possible.

Promoting voice production for airway protection is an important goal for the entire team.

Specific targeted work on speech should be continued using the principles of F.O.T.T.

8.6.4.3 Sustainability of the Voice and Duration of Sound

Many patients have difficulty controlling expiratory airflow due to impaired coordination of their diaphragm, intercostal and abdomi-

Fig. 8.10 Controlling the expiratory airflow and voicing the syllable "ho". (© Walker and Jakobsen 2019. All Rights Reserved)

nal muscles. However, coordination is essential for efficient voice production. "Pushing or pressing" as a means of compensation produces a forced, hard voice. Phonation is often limited to 1or 2 seconds. Forced expiration requires a great deal of air and is inefficient. Initially, severely affected neurological patients can only produce voice for only one or two syllables per exhalation and it may sound very monotonous.

Practical Tip

Coordination is necessary in order to vocalise, maintain voice and start and stop voice on exhalation. Movement stimulus comes from the diaphragm. The effect of diaphragmatic movement can be felt in the abdomen as the abdominal organs are pushed downwards and forwards.

The abdomen is a good place to assess diaphragmatic movement.

Note

Producing voice for 4 seconds may be an initial goal for patients with acquired brain damage.

To learn how to start and stop phonation voluntarily, the patient (Fig. 8.10) is instructed to pronounce a syllable several times during one exhalation, e.g. "ho, ho, ho". Note the therapist behind the patient models the sound with her own voice. The second therapist helps the patient move his arms closer to his body with each syllable, whilst the first therapist supports exhalation through contact with the lateral ribcage. As the patient progresses, two syllables with contrasting movements, e.g. "hu" and "he", can be used.

Note

The more controlled the flow of exhalation, the longer the tone duration.

Practical Tip

Voiced consonants, e.g. "m", "n" and "l", are produced with vocal cord vibration. They should be combined with vowels, e.g. "mum", "Anna", to improve the coordination of breathing and phonation and increase phonation time.

It is important to maintain a balance between vowels and consonants when working to extend tone duration and develop variations in emphasis (Coombes 2001a; Smith 2000).

Note
A combination of sounds is useful as speech is not comprised of isolated movements.

8.6.4.4 Articulation

When the tongue is unable to perform the precise movements of articulation, prosody and intonation change. Articulation is imprecise and pronunciation is slurred or indistinct.

If the neck is hyperextended (short back of the neck) as a result of a compensatory postural pattern to stabilise the head and jaw in an upright position, the tongue can be retracted into the oral cavity and throat and the tension of the soft palate changes. A rigid or "fixed" tongue can barely move and cannot produce accurate movements for speech (▶ Chap. 4).

Paralysis of the tongue also affects the range of movement and articulation.

Practical Tip

A prerequisite for intelligible normal speech is coordination and the ability to adapt breathing to produce and modulate phonation and articulatory movements.

When voicing, the stabilising function of the lower jaw is often lost. Jaw support provides a stable basis for the tongue and lips to move selectively and purposefully during swallowing and speaking.

When working on the initiation of consonants, tactile and visual models (a visual model provided by the therapist) are used in addition to an auditory model.

A simple question determines both the approach and choice of assistance provided by the therapist when working on articulatory movements:

» What must go where? (Coombes 2001a, b)

▶ Example

For an "L" sound, *the what*' – in this case the tip of the tongue – receives input from either the therapist's finger or the tip of a long handled cotton bud.

The reaction is monitored:

- Was the input provided sufficient?
- Does the tongue move to the point of articulation?
- Is the input inadequate?

If the required movement is not achieved, more help must be provided. *The where* or point of articulation must also receive input, (e.g. "L": the therapist's finger touches the point of articulation, the incisive papilla at the midline of the palate, posterior to the palatal surface of the incisors). ◀

Practical Tip

Tactile oral stimulation is very effective for the organs of articulation, e.g. the tongue, to feel and find the point of articulation. The motor response indicates whether the therapeutic input is effective.

It is important not to just practice individual sounds, rather the connected sounds that form words and speech; e.g. "I owe you" is produced using the vowel sounds "I", "o" and "u".

Speech respiration often effectively mobilises saliva residue in the larynx and pharynx and enables it to be felt. The disturbance of this residue can initiate throat clearing or coughing. If required, swallowing assistance can be given after spontaneous or supported (on the lateral ribcage) coughing, to facilitate a clearing swallow.

8.6.4.5 Prosody

The prosodic aspects of speech also play an essential role in intelligibility alongside articulation. A significant number of patients have

Fig. 8.11 The therapist supports the patient's trunk as he walks alongside the treatment table. The patient combines phonation of the sound "o" with each step. (© Walker and Jakobsen 2019. All Rights Reserved)

altered prosody as a consequence of central speech disorders; i.e. they are unable to exploit prosodic variables in order to make their speech interesting for the listener. These variables include the ability to change the emphasis or rhythm of speech, vary the pitch and volume of their voice, increase the number of syllables or in later stages use a diverse range of words to make their speech interesting. Variations in "airway resistance" and small, differentiated changes in intraoral pressure are also essential for natural prosody.

Practical Tip

- It is important to include the prosodic elements in treatment whenever possible, rather than focusing solely on improving articulation (Coombes 1991).
- It can be helpful to use rhythmic elements to improve voice quality and increase the number of syllables or words per breath.
- A combination of phonation and movement can be attempted in the advanced

stages of therapy, e.g. walking alongside a treatment table (Sticher and Gampp Lehmann 2017) (■ Fig. 8.11).

8.7 Starting Positions for Treatment

Positioning of the patient during treatment and rest periods is vital. The result of the consistent use of the different positions can be seen in the optimisation of muscle tone, improvements in sensory feedback and deepening of respiration. There are also reductions in secondary complications (Lange et al. 1999; Schenker 2000).

The term key areas was developed in the Bobath concept (Bassoe Gjelsvik 2012) to refer to specific areas of the body that influence movement, posture, balance, function, selectivity and muscle tone (Bassoe Gjelsvik 2012; Edwards 2002; Paeth Rohlfs 2010). Some authors use the term key points of control (Edwards 2002, Paeth Rohlfs 2010). The therapeutic implications for both terms are the same.

When gravity acts on the key areas, healthy individuals can adapt appropriately, but neurological patients are often unable to adapt to its effects on the body. For example, in a supine position, gravity pulls the shoulder girdle backwards in the direction of the bed or supporting surface (retraction). Without assistance the patient often remains fixed in this position. The patient requires assistance to make the necessary adjustments and corrections.

- The aim is to find a position suited to the therapeutic goal and provide support by influencing the key areas.
- Special attention must be paid to the positioning and support of the shoulder girdle, pelvis, head and neck.

Positioning the head is often challenging, as the neck requires more support than the head. In order to maintain space between the shoulder girdle and head whilst following the lordotic form of the neck, care must be taken to support the cervical spine by placing thinner material under the head than under the neck (Pickenbrock 2002).

Practical Tip

The patient should not remain static, i.e. in one position for the duration of treatment, regardless of the position selected. Opportunities for movement and activity should be included in all treating positions.

The amount of positioning equipment required varies from patient to patient. However, the materials used should be sufficiently supportive and comfortable. They should have a stable form, i.e. not yield too much over time, thereby reducing the amount of support they provide.

Practical Tip

It is important to find a starting position appropriate for each individual patient and evaluate their response during treatment. If the position chosen does not have the desired effect, changes (small or large) must be made or a different position selected.

8.7.1 Side Lying

Side lying offers a large supporting surface. This allows the patient to focus on the specific task, e.g. phonation, without having to maintain their posture against gravity at the same time. A side lying position can be varied and is suitable for patients with either low or increased muscle tone.

Warning

There is a risk of shoulder girdle compression in a side lying position. This can reduce breathing efficiency.

Supportive materials should be used to position the trunk and head and avoid pressure on the lower shoulder, including a risk of shoulder compression. The abdomen must also be supported as the weight of the stomach may pull the abdomen away from the midline and adversely affecting breathing.

The following two starting positions are particularly helpful for patients who have significant associated reactions when attempting to swallow or talk in sitting or standing.

- **Asymmetrical position**

The therapist may opt for an asymmetrical side lying position (Fig. 8.9). In this position the patient's lower leg is extended, lengthening the lower side of the trunk. The upper side of the body is shortened and the top leg is placed in flexion. Extension and flexion patterns are combined as a result of the asymmetry.

- **Symmetrical position**

In a symmetrical side lying position both legs are flexed. The advantages of this position include ease of coughing up and a symmetrical position of the thorax.

8.7.2 Sitting Position

Warning

A sitting position requires the patient to work harder against gravity than when in a lying position. Support is required for both hypertone and hypotone patients.

Practical Tip

There are a variety of ways to adapt a sitting position in order to provide support:

- *Hypotone* patients usually require more posterior support, as they do not have enough active extension to resist the force of gravity. If these patients are only supported anteriorly the pelvis tilts backwards and causes the chest to sink, creating a rounded (hunched) back. This in turn results in hyperextension of the neck.
- *Hypertone* patients generally require more anterior support when sitting, as they frequently have too much extension. They have difficulty adopting a flexed position and anterior support provides them with a stable point of reference. This allows them to move forwards and reduce the extensor tone.

8.7.3 Standing Position

Warning

Standing requires the body to work harder against gravity to maintain an upright position as the base of support is comparatively small (the feet on the floor). Maintaining this position demands a higher level of muscle tone and can be more strenuous than side lying or sitting.

In standing, the thorax and diaphragm are in a more physiologically advantageous position which can be helpful when treating or supporting breathing and phonation. This position is more demanding on patients with ineffectively functioning trunk muscles (Davies 2013; Edwards 2002). Standing has multiple variations.

Practical Tip

Supported standing:

- A dorsal knee brace if required (preferably custom made from Scotchcast, gypsum, or a similar material)
- Standing frame
- Perched standing (an elevated seat with minimal support for the buttocks), e.g. a raised therapy plinth
- Standing and leaning against the wall or in the corner of a room
- Standing with one foot raised on a step
- Stable anterior support for the forearms

8.7.4 Supine Position

This position can be adapted and used during therapy for breathing and speech; however, careful consideration is required.

Warning
A supine position with inadequate or inappropriate support can reinforce unfavourable alignment!

Patients with insufficient trunk muscles can often be found lying in a supine position with their shoulder girdle in a retracted position! This reinforces elevation of the ribcage and hyperextension of the spine and lower extremities.

This position should be avoided with patients at risk of aspiration, including those with cuffed tracheostomy tubes. Saliva can flow uncontrolled to the back of the mouth and into the pharynx, thereby significantly increasing the risk of aspiration.

Practical Tip

- The trunk and head are placed in a slightly flexed position to reduce the possible disadvantages inherent in a supine position.
- The arms should be placed alongside the body and the legs slightly bent.
- A midway position with support is best suited for the activation of hypotone abdominal muscles; i.e. the legs should not be completely flexed or extended.

8.7.5 Prone Position

A prone position can be particularly useful to mobilise secretions in the bronchi and lungs. Lange et al. (1999) found that pulmonary ventilation, oxygen concentration and circulation improved within the first 30 minutes after prone positioning.

Warning
This position should only be used after consultation with the attending physician. It may be contraindicated, for example, in cases of cardiac insufficiency or elevated intracranial pressure.

In a prone position, observation and/or monitoring (e.g. pulsoximeter) is required for patients with severe neurological brain damage (with or without TTs).

One variation of the prone position is referred, in the literature, to the 30° or 135° prone position (Lange et al. 1999; Lipp et al. 2000). This position is comparable to the recovery position used in the event of an emergency. Ventral support along the length of the trunk and pelvis is essential, in order to prevent the patient from falling forwards and increasing pressure on the shoulder, neck and head or obstruct breathing.

8.7.6 Team Work

All members of the team should have the knowledge, understanding and skill to be able to position the patient appropriately in variations of sitting, standing and lying.

The entire team should understand the significance of the different positions which can be used every day. They should be capable of positioning the patient appropriately.

Note
Positioning should be practiced including by the patient's family and carers.

Relatives who want to support their family member effectively during visits or have decided to care for them at home should participate in training sessions specifically arranged for this purpose.

Figure 8.12 shows the involvement of a relative in a treatment session. The therapist shows the patient's son how to support exhalation to deepen breathing and support more effective coughing and voice production. Note: The TT has been uncuffed and a speak-

Fig. 8.12 Working with relatives: teaching a relative how to assist breathing (picture courtesy of Frau Gratz, Burgau Therapy Center, Dr. Friedl Str. 1, 89331 Burgau). (© Elferich and Megele 2019. All Rights Reserved)

ing valve attached to enable the patient to produce voice. The co-therapist assists the patient by providing vibration on the sternum.

8.7.7 Summary

► Overview 8.7 summarises the most important aspects of treatment.

Overview 8.7 Important Aspects of Treatment

- Treatment is an interactive process involving the therapist and the patient: A treating position is selected. The therapist's hands and the activities chosen actively influence the patient's difficulties.
- F.O.T.T. therapists must have knowledge of physiological movement patterns and abnormalities exhibited by patients with brain damage, as well as the necessary therapeutic skills to promote and facilitate the most normal functions possible.
- F.O.T.T. utilises tactile support and facilitation during this process. A movement can only be relearned if the patient is able to feel the (facilitated) movement. The position used during therapy and the patient's posture are

vital as they allow the patient to access their intrinsic capabilities.

- In severely affected patients, treatment begins with the essential care necessary to preserve life; protection of the airway, e.g. use of a cuffed tracheostomy tube; positioning; involvement of the patient's hands and mouth; tactile oral stimulation; and oral hygiene. Ideally it concludes with the coordination of breathing, voice, swallowing and speech.

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Tracheostomy Tubes: A Blessing and a Curse

Rainer O. Seidl and Ricki Nusser-Müller-Busch

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Early experiences with tracheostomies and tube feeding took place in the fields of laryngology and surgery. The bulk of experience and practice today is found in the ear, nose and throat medicine (ENT), where all physicians and nursing staff are able to change a tracheostomy tube (TT). ENT patients and their relatives are also trained to change a TT, if required. This experience can be utilised in the field of neurological rehabilitation and adapted to the specific characteristics of patients with neurological damage.

At times, the structured tracheostomy tube management (TTM) in neurological patients with dysphagia necessitates frequent TT changes, e.g. transitioning to a speech cannula during therapy. With this premise in mind, the chapter emphasises frequent cleaning of the TT and complete cleaning of the larynx and trachea, both of which are routine in ENT medicine and intensive care medicine.

Warning

In patients with severe swallowing disorders, aspirated saliva accumulates above the cuff and builds up in the larynx, trachea and throat. The TTs also may cause Eustachian tube dysfunction and pain. Severely affected patients may be unable to communicate this pain to us. No matter how good the treatment provided, swallowing movements are impossible if the throat is full of secretions!

Changing TTs regularly must become a routine aspect of neurological rehabilitation! Compare the situation: It would be unthinkable to leave an incontinent patient lying in wet diapers for 10 days or more!

The increasing use of *percutaneous tracheostomies* in intensive care makes changing TTs and treating swallowing disorders considerably more difficult. If a swallowing disorder is suspected, a conventional tracheostomy should always be the first option.

9.1 Indications for Tracheostomy

Note

The term *tracheostomy* refers to an opening in the trachea, below the larynx. *Tracheotomy* is the term for the surgical procedure to create this opening, but the terms are often used interchangeably.

Tracheotomies are performed electively, i.e. under certain surgical conditions. They are also performed in cases of emergency, such as respiratory distress which cannot be controlled by intubation. The indications for a tracheostomy are listed in ► Overview 9.1.

Overview 9.1 Indications for a Tracheostomy

- Long-term ventilation
- Laryngeal stenosis, caused by tumours, swelling (e.g. due to radiation or allergic reaction)
- Bilateral vocal fold paresis
- Subglottal stenosis
- Pulmonary diseases (to facilitate bronchial toilet)
- Swallowing disorders with a permanent risk of aspiration

The majority of tracheotomies are performed on patients on long-term ventilation. Today, most patients in critical condition receive initial treatment in an intensive care unit (ICU). The task of assessing the indications for tracheotomy therefore lies primarily in the hands of intensive care physicians. In Germany indications for a tracheotomy were determined at a consensus conference for intensive care physicians (Graumüller et al. 2002):

- A translaryngeal intubation is sufficient if the expected duration of intubation is less than 10 days.
- If the expected duration of intubation is more than 21 days, a tracheotomy should be performed after 3–5 days. If the

projected period of intubation is unclear, the indications for a tracheotomy should be checked daily. A study of tracheotomy timing by Oeken et al. (2002) reflected these guidelines. But there still is a lack of and a need for European ICU guidelines (Marra et al. 2016). Pan-American and Iberian guidelines for tracheostomy in critically ill patients were published by Raimondi et al. (2017).

9.2 Standard Types of Tracheotomy

It is possible to differentiate between the following:

- Temporary tracheotomy
- Surgical tracheotomy

9.2.1 Temporary Tracheotomy

A temporary tracheotomy is placed if it is anticipated that the tracheostomy will be closed within the next 4–6 weeks.

Note

A *temporary tracheotomy* creates a temporary connection between the skin and the trachea.

Both conventional tracheotomies and a variety of endoscopic techniques are used today.

9.2.1.1 Conventional Temporary Tracheotomy

A longitudinal or transverse incision is made, and the prelaryngeal muscles are pushed apart (Fig. 9.1a):

- *Transverse incisions* follow the direction of the skin; therefore, scarring is usually reduced. However, in many cases they do not close spontaneously following decannulation.
- *Longitudinal incisions* are technically easier to perform. They have a lower rate of complications and close spontaneously in most cases (Denecke 1979).

The isthmus of the thyroid gland is exposed and separated, allowing wider access to the trachea (Fig. 9.1b). Techniques including incisions above, below or through the thyroid gland were previously common, but are no longer used today. The undivided thyroid increases the difficulty of changing the TT and encourages bleeding and complications.

The cricoid cartilage is identified. An incision is made at least one tracheal ring below the cartilage. The incision is made in the interstitial space between the tracheal rings and extends across one third of the anterior tracheal wall.

A flap the length of 2–3 tracheal rings is cut into the anterior tracheal wall (Fig. 9.1c). This flap is then attached to the skin and can be folded back when the tracheostomy is closed.

The tracheal flap can serve as a guide rail when the TT is changed (Fig. 9.1d). A resection of the tracheal front wall should not be required (Denecke 1979). The stitches are removed 10 days after surgery.

If the opening of the trachea extends across more than a third of the anterior tracheal wall, the lateral walls become unstable and fall into the tracheal lumen. Stenosis may form after the tracheostomy has been closed and has a typical, hourglass shape in X-rays.

9.2.1.2 Percutaneous Tracheotomy

In principle, all types of percutaneous tracheo(s)tomy are based on the *Seldinger technique*; i.e. a TT is placed using a guide wire or catheter. Four different methods are used today.

Percutaneous Tracheostomy according to Ciaglia

After the initial puncture of the trachea and insertion of a guide wire, the puncture channel is increasingly expanded from the outside. Dilators (pin-shaped instruments) of differing sizes are used in succession, until it is possible to insert a TT. The puncture is made between the second and third tracheal rings. The exact site is determined through palpation and

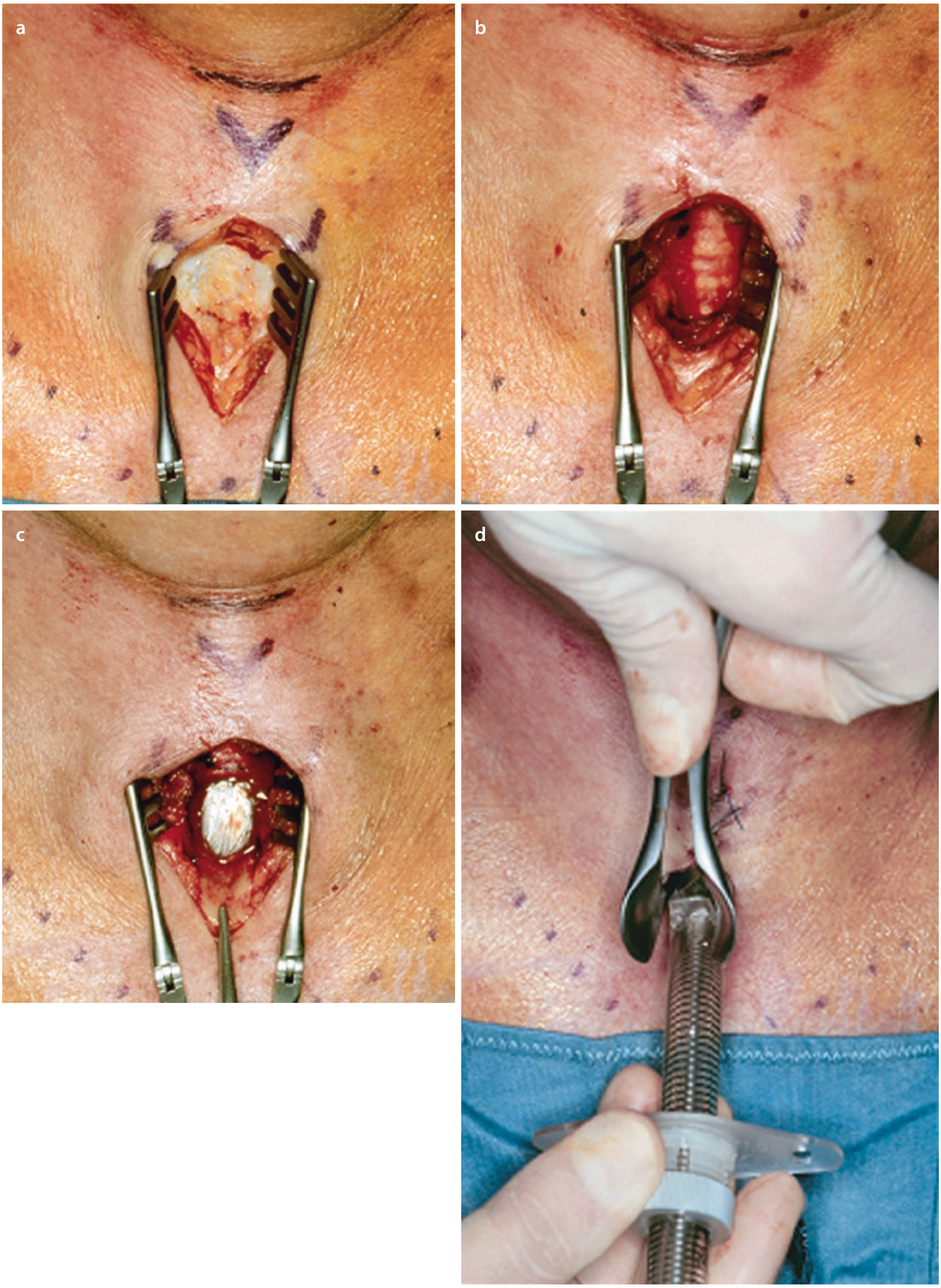


Fig. 9.1 **a**–**d**. Conventional tracheotomy. **a** The thyroid tissue is exposed following the incision in the skin and separation of the prelaryngeal musculature. **b** The trachea and cartilaginous rings are visible once the thyroid gland is divided. **c** View of the ventilation tube, inserted through the mouth after opening of the trachea and retraction of the tracheal flap. **d** Placement of the TT using a speculum, at the end of the operation.

endotracheal bronchoscopy. In recent times, the dilatation has been performed using a single dilator ("blue rhino") (◘ Fig. 9.2; Ciaglia et al. 1985).

▪ Dilatation Tracheotomy according to Griggs

This approach corresponds to the percutaneous tracheotomy technique according to Ciaglia et al. (1985). However the tissue dilatation is performed using dilating forceps, inserted into the trachea (Griggs et al. 1991).

▪ Dilatation Tracheotomy according to Frova

This procedure for percutaneous tracheotomy also corresponds to the Ciaglia procedure. Dilatation is performed using a tapered dilation screw with a self-tapping thread. The dilatation procedure should also be observed endotracheally.

▪ Translaryngeal Tracheotomy according to Fantoni

The puncture of the trachea between the second and third tracheal rings is also performed externally. However, the guide wire is then passed out of the trachea through the mouth. A special TT with a conical tip is then pulled through the larynx, using the guide wire. The dilation of the tracheostoma is endolaryngeal, by means of the TT. At the conclusion, the conical tip is removed from the tube, and the cannula is positioned in the branch of the trachea leading to the lungs (Oeken et al. 2002).

9.2.2 Surgical Tracheotomy

If there are grounds for assuming that a tracheostomy will remain for more than 6–8 weeks or become long term, e.g. in the context of long-term ventilation, a surgical tracheotomy should be performed.

Note

A permanent connection between the skin and the tracheal mucosa is created when a surgical tracheotomy is placed.

Following the incision in the skin, the prelaryngeal muscles are separated and the thyroid isthmus is split. If necessary, any cystic changes found in the thyroid gland are removed, to provide sufficient space to attach the skin to the tracheal wall.

The anterior tracheal wall is then opened over three tracheal rings and resected. Care must be taken to resect no more than one third of the anterior wall. The mobilised skin is subsequently attached to the tracheal mucosa. The skin must be stitched edge-to-edge with the tracheal mucosa, to ensure that healing is unproblematic. The stitches are removed after 10 days.

Long-term or surgical tracheo(s)tomies must be closed surgically.

Practical Tip

The tracheostoma should be sufficiently large. This allows the tube to be changed easily and saliva overflow to be suctioned at the tracheostoma. It must also be narrow enough to prevent excessive loss of expiratory airflow at the tracheostoma and avoid insufficient airflow for potential vocalisation!

9.2.3 Complications of Tracheotomy

Intraoperative bleeding may occur, e.g. from the thyroid gland, and can be closed off immediately by electrocoagulation or stitching. Although rare, more extensive injuries to the trachea or esophagus can occur, e.g. punctures during a percutaneous tracheotomy. The procedure must then be extended, and the issue resolved immediately.

Postoperative bleeding from the tracheostomy is not uncommon during the first hours post-surgery. In most cases, the bleeding is from the skin or the thyroid tissue. In an emergency, a tamponade (moist compress) pressed between the tube and the tracheostoma is sufficient to stop bleeding in most cases. Heavier haemorrhaging must be dealt with surgically. The tracheal cartilages are particularly at risk during percutaneous methods, and in the

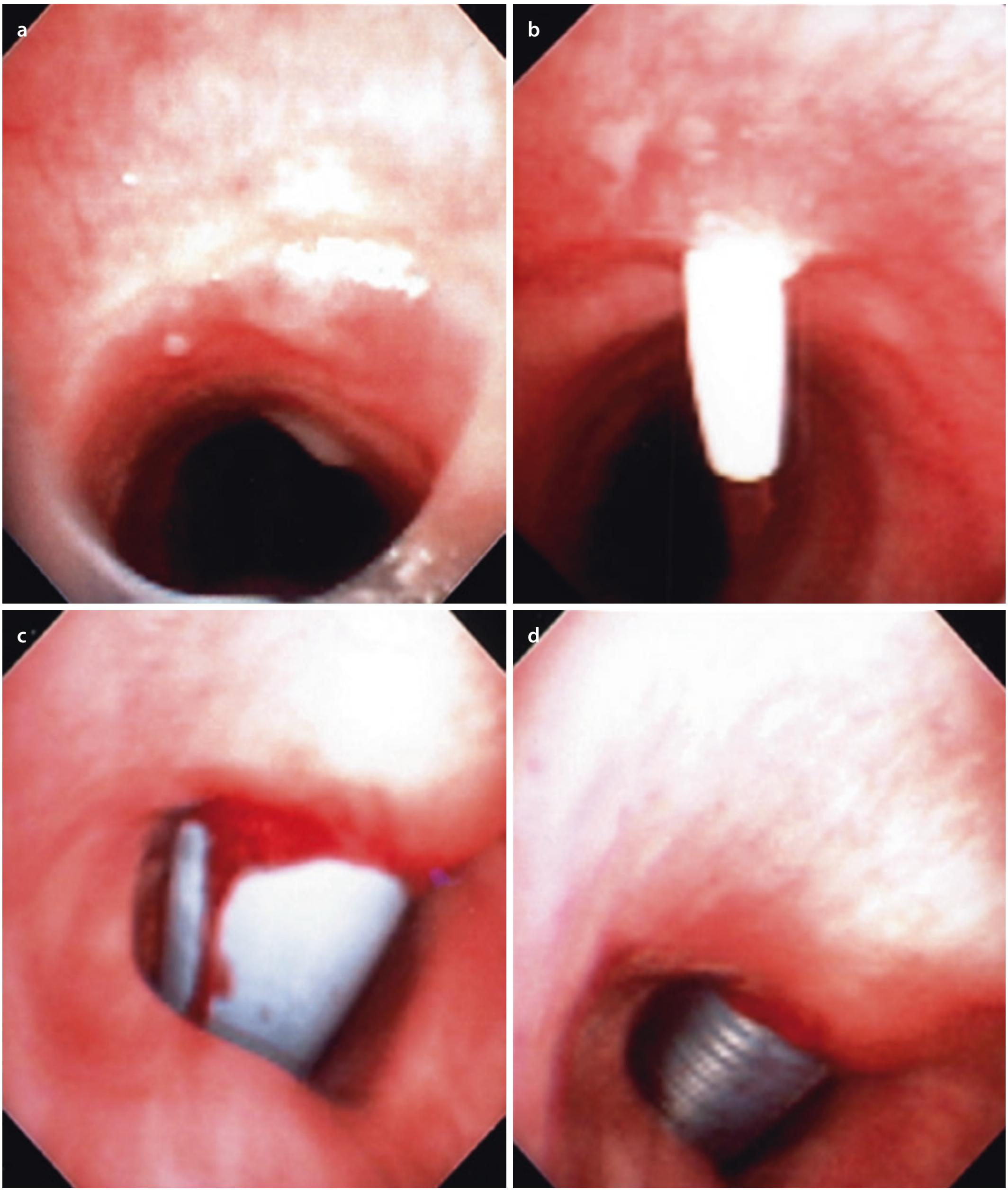


Fig. 9.2 a-d. Percutaneous tracheotomy. **a** View inside the trachea through a bronchoscope. **b** Puncture of the trachea with a visible probe, which is guided through the anterior wall. **c** Widening the puncture canal with a dilator. **d** TT positioned in the trachea. (We would like to thank Dr. Laun of the St. Josefs-Krankenhaus Potsdam-Sanssouci for the images of percutaneous tracheotomy). (© Seidl & Nusser-Müller-Busch 2019. All Rights Reserved)

event of damage an operative revision is necessary.

Subcutaneous emphysema is caused by air from the trachea, which is unable to escape between the TT and the edge of the tracheostoma. The air is then forced under the skin, during expiration. If this occurs, the tube must be repositioned or an alternative type of tube selected. It is essential to check the position of the TT endoscopically.

9.3 General Types of Tracheostomy Tubes

Note
The basic functional principle of a tracheostomy tube is the direction of respiratory air into the trachea or out of the body, bypassing the larynx.

After tracheotomy, the newly created tracheostomy should be kept open by the tube. We can differentiate between the following:
- Cuffable
- Cuffless TTs

Both are available as single or double cannulas (with inner and outer cannulas) that are made of a variety of materials. Flexible TTs may have the advantage of adjusting more easily to the anatomical conditions of the patient.

9.3.1 Cuffable Tracheostomy Tubes

Cuffable TTs have a uniform construction (Fig. 9.3). They consist of a tube which extends into the trachea to allow breathing and a cuff which closes the tube against the walls of the trachea. The cuff is connected to an external valve and/or pilot balloon, by a thin tube. Air is normally used to fill the cuff. However other gases (nitrous oxide, etc.) may be used in specific cases.

Practical Tip

Cuffable TTs are used when complete closure of the trachea is necessary. In most cases, this is in the context of mechanical ventilation. Less commonly, the cause is a swallowing disorder with aspiration.

The cuff functions to close the tube against the tracheal wall. The cuff of a TT must be compressible. Every swallow causes compression of the trachea, which must be compensated in order to avoid damaging the trachea. Modern, *low-pressure* TTs allow the cuff to be balanced by an external pilot balloon, which compensates for pressure fluctuations within the trachea.

Two cuff forms are available: round and cylindrical. Round cuffs have a minimal area of contact with the trachea, compared to the entire outer surface of a cylindrical cuff Fig. 9.3 (Winklmaier 2007). The smaller contact area of a round cuff is usually sufficient for patients on long-term ventilation, as it is only necessary to maintain the air pressure within the trachea.

Practical Tip

- The rounded cuff surface often provides inadequate protection of the lower airway in patients with swallowing disorders, if they are continually aspirating saliva. The much larger contact surface of cylindrical cuffs usually offers better protection against aspiration.
- It is important that the cuff membrane is fully unfolded when filling cylindrical cuffs, to ensure contact with the tracheal wall thereafter. When filled, the cuff should be moderately over-pressurised, so that some pressure can be released.

Note
Liquids are non-compressible and should not be used to fill the cuff!

The pressure in the cuff should not exceed 25 mmHg (the “green area” on the cuff pressure gauge).

The pressure within the capillaries of the tracheal mucosa is 25 mmHg. Blood supply to the tracheal mucosa cannot be ensured if this pressure is exceeded, and the mucous membrane may atrophy and be destroyed.

In some cases, a cuff pressure of 25 mmHg is insufficient for complete closure of the trachea from the flow of saliva. TT with an alternative cuff form should be tested if this is the case (e.g. a cylindrical cuff, which offers more contact area with the tracheal wall). Saliva reduction medication such as scopolamine patches or atropine drops can also be tried,

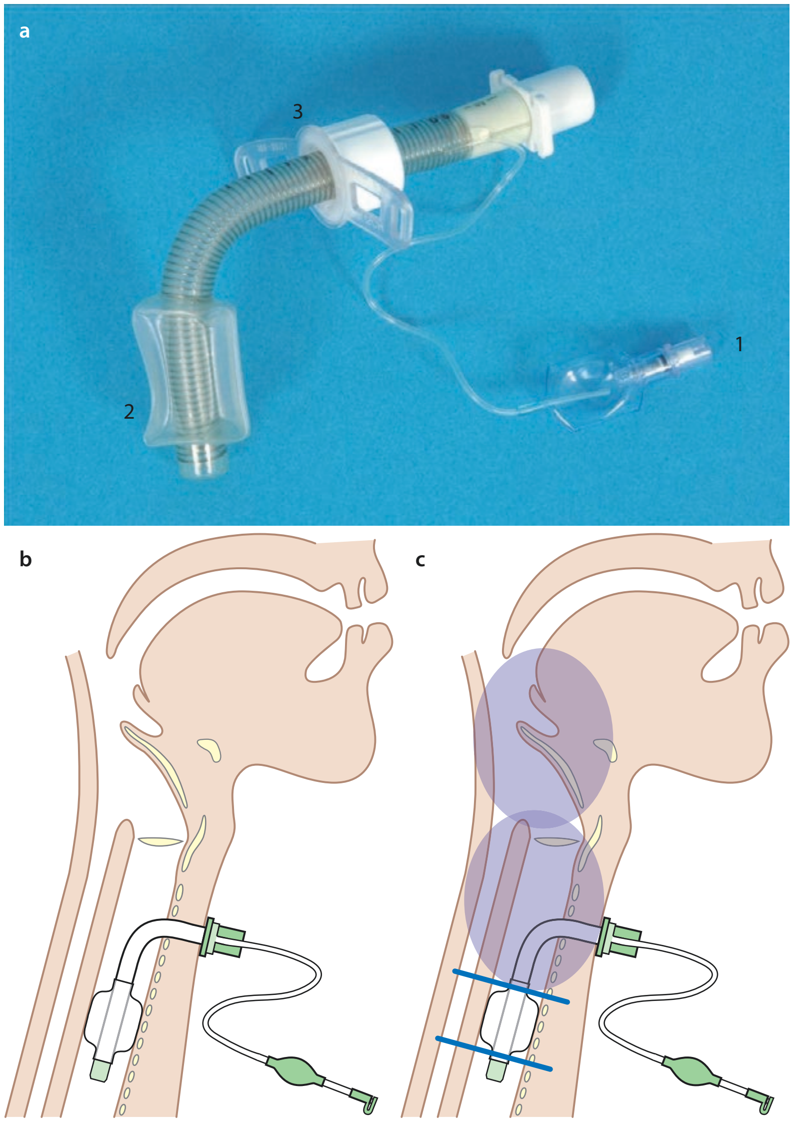


Fig. 9.3 **a–c**. Tracheostomy tube with a cuff. **a** The cuff (2) can be filled with air via a valve (1). The tracheal flange (3) fixes the tracheostomy tube. **b** Diagram of a cuffed tracheostomy tube in the trachea. **c** Diagram of the functioning of a cuffed tracheostomy tube, designed to prevent the overflow of saliva (blue) into the trachea. (© Seidl & Nusser-Müller-Busch 2019. All Rights Reserved)

although these medications may increase visceral mucus, creating additional problems.

Many of the cuffed TTs currently available have an additional channel, directed towards the larynx (▶ Fig. 10.8a, b). This solution appears to be advantageous for nursing facilities: suctioning without requiring a change of the cannula. However, it is impossible to clean the trachea completely without removal of the TT.

Warning

Long-term exposure of a patient to the noise generated by constant suctioning is unacceptable, particularly in the case of severely affected patients!

Accessories, e.g. valves for speaking, are used (▶ Sect. 9.3.4).

9.3.2 Cuffless Tracheostomy Tubes

Cuffless TTs are also available as single or double cannulas. Double cannulas are composed of two parts: an outer cannula and an inner cannula (Fig. 9.4a). The inner cannula can be removed for cleaning, without having to remove the entire TT every time. Most modern tubes are made from synthetic material, e.g. silicone. Although previously common, metal cannulas ("silver cannulas") are now the exception as they do not adapt to the anatomical conditions of the patient.

A cuffless fenestrated TT has holes or a sieve (fenestrations) in the tube ◘ Fig. 9.4a [2], so that the air can be guided through the trachea and the TT into the larynx during exhalation. A speaking valve with a flap is placed on the cannula. The flap opens during inhalation, allowing air to flow through the tube ("short path") when breathing in. It then closes during exhalation, creating a seal which directs the flow of air through the larynx to allow phonation ("long path"; ◘ Fig. 9.4b–d). These TTs are also called *speech cannulas*.

In non-fenestrated TT, ◘ Fig. 9.4a [1], all exhaled air must pass the trachea around the tube in order to enter the larynx. This can increase exhaling significantly for the patient. It can also make speaking more difficult or impossible, e.g. if the tube size is too big.

9.3.3 Other Types of Tubes

■ Combined Tracheostomy Tubes

The use of combined TTs has increased. These tubes are equipped with both a cuff and fenestrations, combining the functional principles of a cuffed tube with those of a fenestrated tube.

Observations of out patients in our consulting hours (► www.schlucksprechstunde.de) indicate that combined TTs (cuffed tubes with fenestration) are often accepted by carers as the "final stage". Although the disposable inner cannula is removed during treatment, it is replaced when therapy is over, maintaining the status quo. The patient does not progress (► Sect. 9.6).

Warning

A fenestrated tube with an inflated cuff can only fulfil the functions of a cuffed tube if a closed, inner cannula is inserted!

Complete closure of the trachea is only possible if the fenestrations are closed, by means of an inner cannula. Otherwise aspiration via the holes in the tube remains possible.

This type of cannula is sometimes equipped with an additional suction channel.

■ Cuffable Tracheostomy Tube with Additional Suction Channel

The functional principle of these tubes is explained in ► Sect. 10.3.3 (► Figs. 10.8, 10.10 and 10.11).

9.3.4 Tracheostomy Tube Accessories

■ Heat and Moister Exchanger (HME Filter, artificial nose)

The normal warming, particle filtering, humidification of respiratory air and the breathing resistance within the nose and oral cavity are missing using a TT. In order to prevent dehydration of tracheal mucosa, the inhaled air must be artificially moistened using a filter. However, the saliva present in the trachea also prevents the mucous membrane from becoming dehydrated. Some filters are also supplied with an adapter, allowing them to be connected to an oxygen tube. Filters provide protection against foreign bodies.

Warning

Life-threatening complication, asphyxia, can be caused by filters contaminated with secretion and no longer permeable, e.g. in patients with dry, viscous mucus.

■ Speaking Valves

Speaking valves are one-way valves which make it possible to inhale via the TT (the valve is open) and exhale via the larynx (the valve is closed). Initially speaking valves were developed to enable speaking. Nowadays it is also used for improving facial-oral functions, e.g. swallowing.

Note

Speaking valves enable inhalation through the cannula (the valve is open) and exhalation through the larynx (the valve is closed).

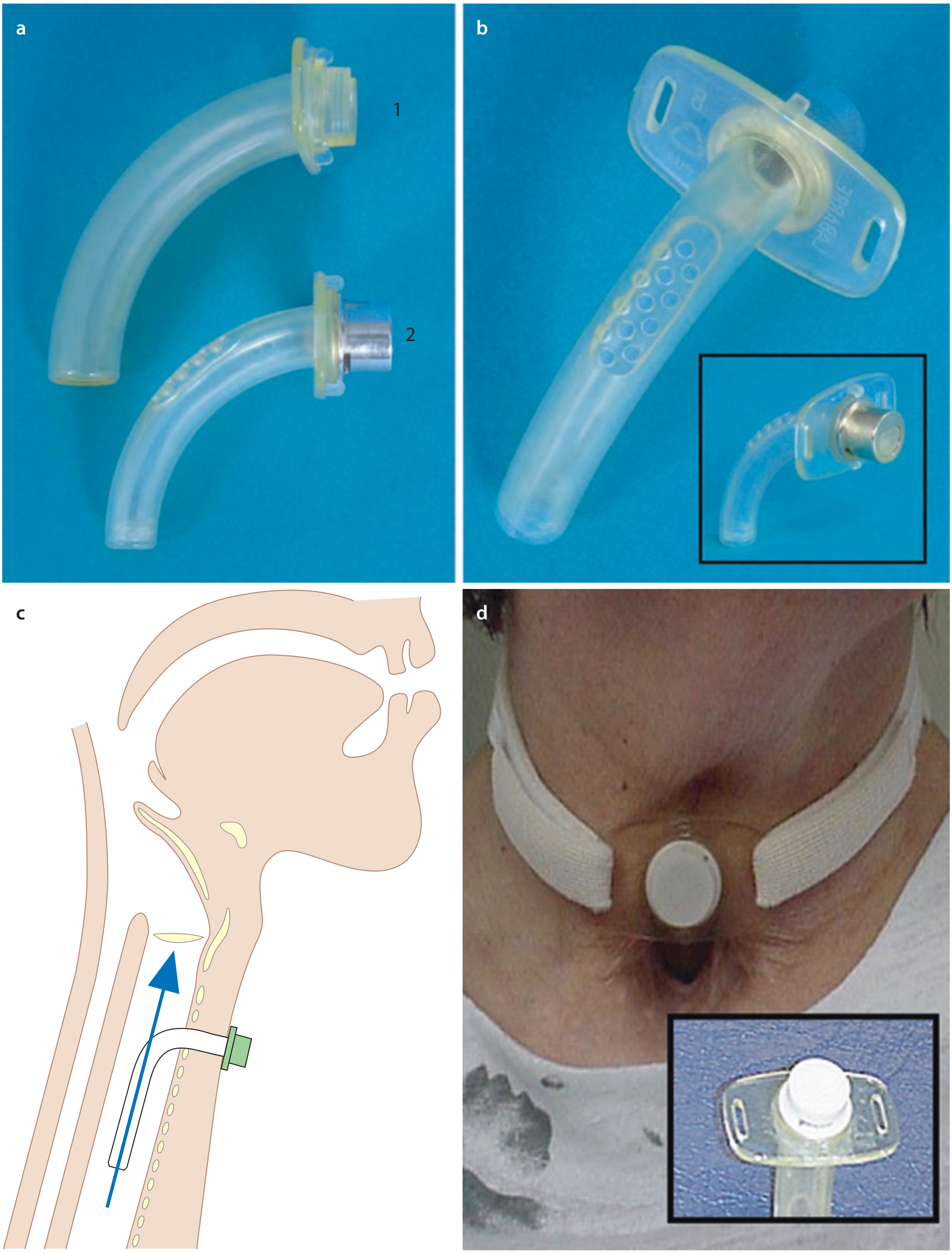


Fig. 9.4 **a**–**d**. **a** Cuffless closed tracheostomy tube (1), with fenestration (2). **b** Speech cannulas: The holes allow the passage of air through the larynx. The valve on the front (small picture) closes during exhalation and opens during inhalation. **c** Diagram of a speech cannula, which directs airflow through the larynx when the valve is closed. **d** Speech cannula closed with a cap, to enable both inhalation and exhalation via the larynx. ()

In contrast to HME Filters, they provide an almost closed system, which enables a physiological pressure build-up during swallowing and coughing and pressing (bowel movement)!

A speaking valve is indicated, when the patient tolerates the deflated cuff of a TT and is able to swallow saliva for a while in an appropriate frequency. The valve is contraindicated for patients with upper respiratory obstructions and sometimes in patients with impaired cognition.

Warning

- It is absolutely mandatory that the cuff is deflated before the speaking valve is added; otherwise, the patient is unable to exhale!
- In many cases, there is only a very small space between the cuff of the tube and the tracheal wall.
- This can make the work of breathing more strenuous or lead to hypoventilation, which can be life-threatening! The problem will not be solved if the patient simply practices breathing with the speaking valve for a sufficient length of time. A smaller TT must be provided, which allows expiratory air to pass the tube and exit through the larynx!

Cap

It is possible to breathe entirely through the larynx, if a speaking valve of the speech cannula is removed and replaced by a cap (e.g. prior to decannulation). The presence of the cannula still increases respiratory resistance, however (Fig. 9.4d).

Tracheostomy Placeholder

A soft silicone placeholder can be used to stabilise the airway after surgery or if decannulation is planned, but the patient will continue to require intermittent suctioning. The external form of the place holder is T-shaped. The long arm is placed in the trachea, and the shorter arm is placed over the tracheostoma.

Warning

It can be difficult to attach a placeholder in many cases, and they are often expelled if the patient coughs violently. If the placeholder is dislodged, there is a danger that the trachea opening inside will close. In an emergency the T-tube must be removed immediately and replaced by a TT. In many cases a speech cannula with a cap is better tolerated by the patient and they are a better solution for the patient and also for the carers.

Stoma Plaster

A stoma plaster can also be used to close a stoma without inserting a tube. Stoma plasters are commonly used with patients who have had their larynx removed. The plaster provides the stoma with a filter, which can be closed temporarily by applying pressure. This allows the patient to speak through a valve. Stoma plasters with a solid cap are also available and can also be used with a stable tracheostomy for stoma closure. This has the advantage of allowing the trachea to be suctioned easily once the cap has been removed, without inserting a tube.

9.4 Tracheostomy Care and Changing the Tube

TTs must be cleaned and tracheostomy care carried out daily, in order to prevent complications.

9.4.1 Placing and Attaching the Tracheostomy Tube

The TT can be coated with a gliding agent if necessary, e.g. cannula oil, xylocaine gel, etc. During insertion the tube is rotated 90° in a clockwise direction from “quarter to half”. Excessive pressure should be avoided to prevent injury. Finally, the position of the new tube should always be checked endoscopically.

Practical Tip

Before insertion, the tracheostomy dressing and neck band for fixing the TT should be attached to one side of the tube. This approach makes it easier to secure the tube, minimises irritation caused by further manipulation in the trachea and protects the patient.

Patient reactions to the insertion of the tube can vary greatly. If the tracheostomy is intact and large enough, it should be possible to insert the tube carefully and avoid complications, other than a few coughs.

Note

Patients with impaired cognition often react strongly to the insertion of the tube. It is important to prepare for the process slowly and provide the patient with appropriate support.

In rare cases, protracted coughing or a severe coughing reaction can cause vomiting. In this situation, an anaesthetic spray, e.g. xylocaine spray, can be used to anaesthetise the trachea prior to insertion of the tube. The TT can also be coated with an anaesthetising gel (e.g. xylocaine gel).

The TT is fixed using ties, neck bands, to provide secure positioning and to minimise movement of the TT. The flange and the neck band must be individually adjusted (◘ Fig. 9.4d). Rubber neck bands that allow too tight fastening should be avoided.

Care must be taken to ensure that the TT is sufficiently mobile.

Practical Tip

As a general rule, a cuffed TT is positioned correctly if the part which extends beyond the skin is at a 90° angle to the posterior tracheal wall. The tube should have minimal or no contact with the skin around the tracheostomy.

Warning

Space for about two fingers should always be kept between the neck band and the skin of the neck!

If the neck band is too tight it will cause pressure damage or may hinder the larynx elevation during swallowing. If the neck band is too loose the TT may fall out.

In order to protect the skin and the TT, patients change the head position in a compensatory manner. Anterior and ventral translation of the neck and/or a rigidly attached TT may pull the cannula cranially and interfere with swallowing. We must help the patient to find an adequate body alignment during the therapy and the 24-hour day!

There are a number of risks associated with long-term tracheostomies. During prolonged exposure, damage to cranial tracheal cartilage or cricoid cartilage, granulation and tracheal stenosis due to compression may occur (► Sect. 9.4.5).

9.4.2 Changing the Tracheostomy Tube

The TT must be removed and cleaned regularly, to clear the tube and larynx in the event of aspiration and avoid further complications, e.g. shortness of breath and inflammation (► Sect. 9.4.4)!

Practical Tip

- In intensive care, new TTs are placed under sterile conditions and used tubes are disposed of.
- In terms of hygiene, TTs are treated similarly to a dental prosthesis in most other areas. They can be reused by the same patient once they have been cleaned.
- The TT must be changed if it cannot be completely cleaned or is no longer fully functional. In cuffed tubes, this means

that the cuff is no longer able to build up sufficient pressure or maintain pressure for an extended period of time.

- Plastic tubes age over time. Plastic becomes porous; thermoplastic materials lose their plasticity and become hard. The length of time varies however, so that the decision to change the tube is dependent on the discretion of the team treating the patient.

Every change of the TT must be prepared in advance, and the necessary instruments laid out in readiness. Changing a TT requires, e.g.:

- A functional suction unit, with an appropriately sized suction catheter (Charriere 12, green, Charriere 14, orange).
- A speculum to keep the tracheostomy open (◘ Fig. 9.1d); the blades of the speculum should be at least 12 cm in length.
- A light for inspecting the tracheostomy.
- An additional TT, which can be inserted in an emergency.

The mouth must be cleared of secretions before the TT is removed. Secretion above the TT sometimes may be suctioned beside or at the edge of the tracheostoma, if the stoma is relatively large. The trachea below the tracheostomy can be suctioned through the cannula. The cuff should only be deflated and removed after this has been done (see ► Sects. 10.3.3 and 10.3.4).

It is important to suction through the tracheostoma again immediately after removal of the tube. This removes any secretions which have gathered above the cuff and can now flow down the trachea. The speculum can be used to keep the tracheostomy open if it is very tight or contracts rapidly. The tracheostomy is then inspected, including the external skin, channel and trachea (endoscopically if necessary).

Practical Tip

A standard insertion aid (mandrin, obturator) should be used when placing flexible cuffable tracheostomy tubes. The obturator stabilises and guides the cannula, particularly in case of difficulties or complications.

Note

"If in doubt, pull it out" Any person (doctor, nurse, therapist, relative) entrusted with caring for a patient who has a TT must be able to change the tube. Clinical experience shows that complications as a result of the tube are common. In this situation, e.g. if the patient suddenly becomes breathless and starts to turn blue, the first person at the scene has responsibility for taking the first measures, i.e. removal or changing of the TT. Waiting for a second person, e.g. a doctor, to arrive could have catastrophic consequences.

9.4.3 Tracheostomy Care

Clogging of the TT is one of the most common problems in tracheostomised patients with viscous secretions. The moistening function fulfilled by the nose during normal breathing is absent. This causes the trachea to dehydrate more rapidly and become clogged.

This complication can be prevented by placing HME Filters on the TT or regularly humidifying the air using a humidifier or inhalation. These measures should be re-evaluated in the presence of a swallowing disorder with aspiration, however. The constant flow of saliva makes dehydration of the trachea unlikely.

Warning

Attachable filters and speaking valves are blessing and curse too. They can be dislodged or clogged if secretions are coughed up, making it impossible to breathe. Checking the filter regularly and cleaning the TT are still the most important safeguards!

In intensive care units TTs must be changed under sterile conditions, in accordance with the regulations in force. The tubes are exchanged and replaced with new ones. The same procedure is followed with all patients who have bacterial colonisation of the tracheal secretions, e.g. MRSA.

Plastic and silver TTs are cleaned using a brush and running water. Extra disinfection is not required in most cases, and the same rules of hygiene apply to TTs and dental prostheses.

In patients with swallowing disorders, the tracheostomy must be checked and attended to regularly. Removing and replacing the moist compresses used for the tracheostomy is particularly important, but complications due to the TT may still arise.

Note

To limit the number of tracheostomal and tracheal complications, it is essential to check the trachea and tube regularly and remove and clean the TT when necessary. This is particularly important in cases of swallowing disorder.

Every patient with aspiration must be suctioned on a regular basis. Care must be taken to avoid causing additional injuries to the tracheal mucous membranes, during suctioning!

Practical Tip

In order to suction the trachea gently, a fingertip should be located between the suction tube and the suction catheter. This prevents suction whilst the catheter is being inserted, and removing the fingertip allows suction to be applied as the catheter is withdrawn.

Aspiration can be anticipated, if a patient with a TT requires suctioning more than 3 or 4 times a day. Lung infections are rarely associated with the heavy production of secretions. If the patient already has a cuffed TT, then the cuff does not adequately prevent the flow of saliva. This means that the TT does not protect the patient sufficiently! The tube and the cuff must be checked, and it may be necessary to replace the tube with a different type or size (larger).

9.4.4 Tracheostoma-Related Complications

Inflammation

The most common complication is inflammation. The cause is often saliva, which accumulates above the cuff of the TT and flows out via the stoma, onto the skin. Saliva attacks tissue aggressively; its main function is the breakdown of “tissue”, usually the food contained in the stomach. The tissue surrounding the tracheostoma is therefore “digested” and damaged, causing inflammation of the stoma canal and the surrounding skin (Fig. 9.5a).

Note

In order to treat inflammation around the stoma, it is essential to minimise the amount of saliva which escapes and/or the length of time it spends in contact with the tissue.

Practical Tip

- Regular tracheal care must be performed; the tracheostomy tube is removed and suction used to clean the larynx and the trachea.
- The oral cavity must be cleansed of secretions regularly. The larynx and trachea must be suctioned via the TT. A small, suction catheter can also be used gently on the tracheostoma next to the tube, if required.
- Compresses applied to the tracheostoma must be changed regularly, if they are moist. It is important to use the most absorbent gauze compresses available. Metallic compresses should not be used if there is leaking saliva. Experience has shown that the plastic materials used intensify inflammation in the area around the tracheostoma.

Saliva-reducing medication can be used in severe cases.

The reddened surface of the skin around the tracheostoma can be treated with zinc ointment, which should be applied generously. Zinc ointment is not dissolved by saliva and therefore protects the skin. A thin tamponade, provided with zinc ointment, can also be wrapped around the TT to care for the tracheostomy canal. Complete healing of the skin around the tracheostoma can only be expected once the swallowing process is free of aspiration.

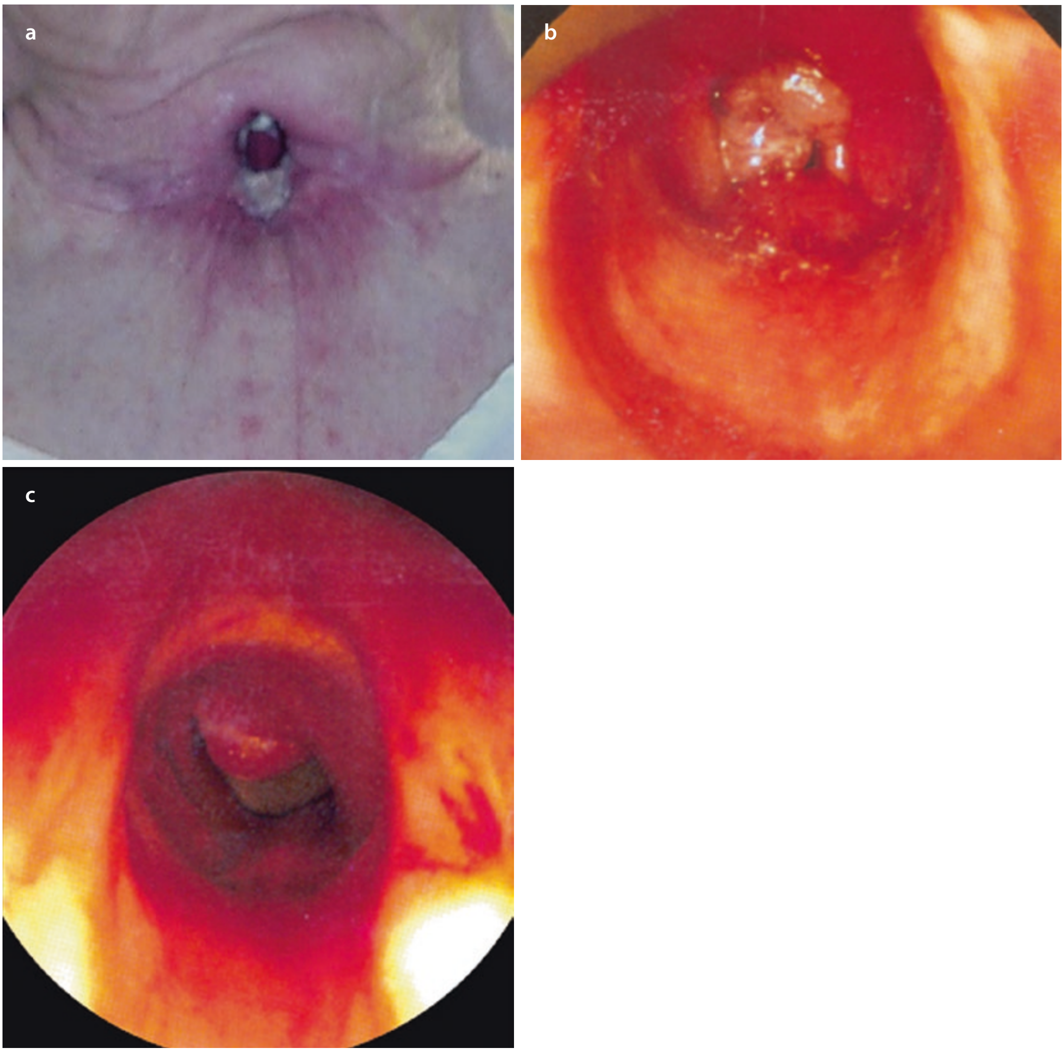


Fig. 9.5 **a–c**. Inflamed tracheostoma. **a** With granulation. **b** View into the trachea. The tracheal wall is completely covered with granulation. **c** View into the trachea, showing collapse of the anterior tracheal wall and resulting tracheal stenosis. (© Seidl & Nusser-Müller-Busch 2019. All Rights Reserved)

Under the Microscope

Studies of Percutaneous Tracheostomies
Many studies of percutaneous tracheostomies have determined that complications related to inflammation are decreased, with this type of surgery (Raimondi et al. 2017). The reason for this is the very narrow puncture channel, which does not allow saliva to flow through the tracheostoma. There is a constant build-up of saliva in the pharynx and larynx. This makes the treatment and rehabilitation of swallowing disorders much more difficult and also may cause tube ventilation disorders.

Percutaneous tracheostomies are therefore contraindicated in manifest cases of swallowing disorders with aspiration!

Granulation Tissue

The irritation of an open wound causes granulation tissue to form (Fig. 9.5b).

Possible causes of granulation tissue on the tracheostoma include the following:
- An overly hard and inflexible TT (metal, hard, non-thermoplastic material)
- Mechanical irritation caused by the TT to the margin of the tracheostoma
- A tracheostoma which is too narrow
- Attaching the TT too tightly
- Persistent salivation

It can be assumed that the likelihood of developing granulation tissue increases with the duration of the TT placement. A noticeable increase in these responses has been observed from 6 weeks onwards (Graumüller et al. 2002).

Granulation tissue can be treated by:
- Altering the position of the TT
- Changing the type of TT
- Removing the tissue through cauterisation. Methods include use of silver nitrate, laser ablation and use of an electrosurgical knife under local anaesthesia
- Operative revision of the tracheostomy, e.g. changing a percutaneous into a surgical tracheostomy

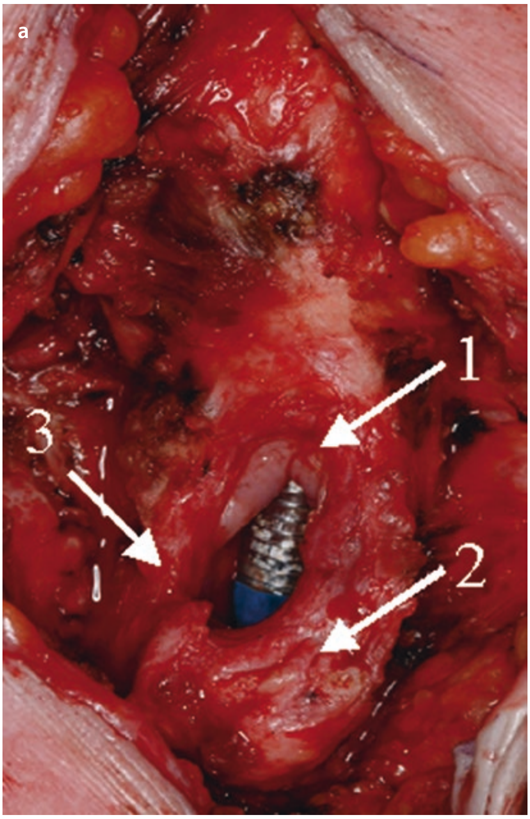
9.4.5 Tracheal Complications

The trachea must be inspected for damage when the TT is changed. Pressure from the tube or cuff may cause injury to the tracheal walls. Damage to the mucous membrane is not uncommon. These injuries usually heal quickly and without complications, if the tube and cuff are not placed on the existing injury when the tube is replaced.

Injuries to the tracheal cartilages are more dangerous and difficult to treat (Sudhoff et al. 2015).

Warning
- Abrasion or incorrect placement can cause the TT to pierce the tracheal wall, damaging or destroying the cartilage. In rare cases this may cause penetrating trauma to the mediastinum and damage to the brachiocephalic trunk, which is located at the level of the cuff.
- Pressure from the TT at the upper margin of the tracheostoma can push the tracheal cartilage and/or the cricoid cartilage inwards. This occurs most frequently just above the opening in the trachea. The tracheal lumen is forced inwards, causing tracheal stenosis (Fig. 9.5c).
- Tracheal stenoses do not necessarily occur immediately after the removal of a TT and the closing of the tracheostomy. In many cases they become clinically relevant after 3-4 months, which is the length of time required for the inflammation remaining in the tracheal rings to lead to stenosis.
- Patients suffering from difficulties in breathing and increasing breathlessness/dyspnoea following a tracheostomy/long-term intubation should therefore be examined immediately to establish the diagnosis of clinically relevant tracheal stenosis or any other cause, such as asthma!

A Montgomery T-tube can be used to splint the airway temporarily, in the event of a minor injury to the tracheal wall. Extensive injuries require operative revision.



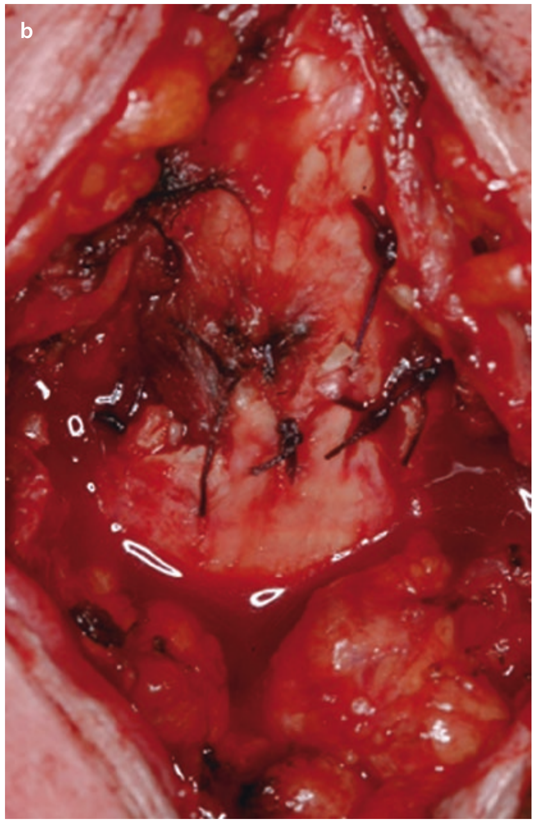


Fig. 9.6 **a**, **b**. Changes to the trachea and treatment. **a** Intraoperative picture of typical changes in the trachea and tracheostoma, 5 years post-tracheostomy. **1** Granulation tissue on the upper margin of the trachea, caused by abrasion from the TT. The tracheal cartilages above, and the cricoid cartilage, are pushed inwards. **2** Massive thickening of the lower part of the tracheostoma and trachea, due to pressure from the TT. **3** The tracheostomy was not performed exactly at the midline, or pressure from the TT has led to loss of tracheal cartilage on the lateral walls of the trachea. The lateral walls will collapse and block the trachea if the tube is removed, causing tracheal stenosis. **b** The ends of the remaining trachea are sewn together after the stenosis has been removed (end-to-end anastomosis); a normal trachea is recreated. (© Seidl & Nusser-Müller-Busch 2019. All Rights Reserved)

A large number of surgical procedures for the treatment of tracheal stenoses are now available (Fig. 9.6). Stenoses of up to approx. 5 cm are treated by resection of the stenosis and rejoining of the trachea. More complex procedures are necessary if the injuries are extensive. The transplantation of tracheal tissue may be necessary.

9.5 Tracheostomy Tubes and Swallowing

The effect of a TT on swallowing frequency was examined by Seidl et al. (2002a). Ten patients were studied; each had been diagnosed with neurogenic oropharyngeal dysphagia due to a stroke or traumatic brain injury. The patients' swallowing frequency per 5 minutes was less than or equal to one (≤1). All patients underwent a tracheostomy due to the swallowing disorder, 14 days (±7 days) prior to the study. The *Early Rehabilitation Barthel Index* (FRBI; Schönle 1995) for all patients was below –200 (± 29) points; further data can be found in Table 9.1.

Early Functional Abilities (EFA, Heck et al. 2000), Coma Recovery Scale (CRS, Schönle and Schwalle 1995)

Swallowing frequency was used as a parameter for assessing the effect of a TT on the swallowing sequence. Swallowing frequency was

Table 9.1 Patient data (Seidl et al. 2002a)

Patient	Value
Gender	♂ 8, 2 ♀
Age	64 ± 7 years
FRBI (−325 to 0)	−200 ± 29
EFA (20 to 100)	22.25 ± 2.6
CRS (0 to 24)	8.25 ± 4.9

Table 9.2 Changes in swallowing frequency after removal of a tracheostomy tube

Swallowing frequency	Tube with inflated cuff	Tube removed
Average	0.4	1.65
Standard deviation	0.82	1.5

$n = 10$, t-test, $p \leq 0.001$

assessed by counting the number of swallowing movements, over a period of 5 minutes.

The first measurement of swallowing frequency was taken prior to any manipulation of the tube, with the TT in place and the cuff inflated.

The patients were sitting upright or placed in a side lying position. The oral cavity was then cleaned according to the F.O.T.T. tactile oral stimulation (▶ Sect. 6.2.4), to exclude the influence of any saliva residue in the oral cavity and pharynx. Suction was used to clean the tracheobronchial tree before deflating the cuff and removing the tube; the tracheostoma was then occluded manually for 5 minutes.

A second measurement of swallowing frequency was then taken. To exclude random results, the examination was repeated for all patients on 5 consecutive days in the same week.

The result of 20 individual examinations shows a significant increase in swallowing frequency, after removal of the TT and occlusion of the tracheostoma (Student's t-test, $p \leq 0.001$; Table 9.2, Fig. 9.7a).

There was no correlation between the increase in swallowing frequency and the status of the patients, as measured using the following scales: FRBI, EFA and CRS.

Note
The increase in swallowing frequency after removal of the TT and closure of the tracheostomy was reproducible.

The way in which a TT affects swallowing behaviour, the swallowing process and the results of swallowing has been discussed controversially.

Under the Microscope

Effect of a tracheostomy tube on swallowing
Studies showed changes in sensitivity in the larynx and trachea, caused by the TT (Murray 1999, Shaker et al. 1995, Wyke 1973). The triggering of swallowing is decreased, as are the protective mechanisms of coughing and throat clearing (Tolep et al. 1996). Consequences are as follows:

- A shortening of laryngeal closure during swallowing
- A discoordination between the triggering of swallowing, closure of the vocal cords and the apnoea phase during swallowing (Tolep et al. 1996)

A number of studies have suggested that a cuffed TT may have a negative effect on swallowing. Muz et al. (1989) reported a decrease in aspiration after occlusion of the TT, in scintigraphic tests on patients after head and neck tumour surgery. Dettelbach et al. (1995) and Stachler et al. (1996) also found a positive effect on aspiration with TT closure.

The exhalation route through the larynx is a direct result of a change in TT status. Eibling and Gross (1996) and Stachler et al. (1996) assumed that positive subglottal pressure resulting from TT removal could be a catalyst for the improved swallowing capacity. Other authors

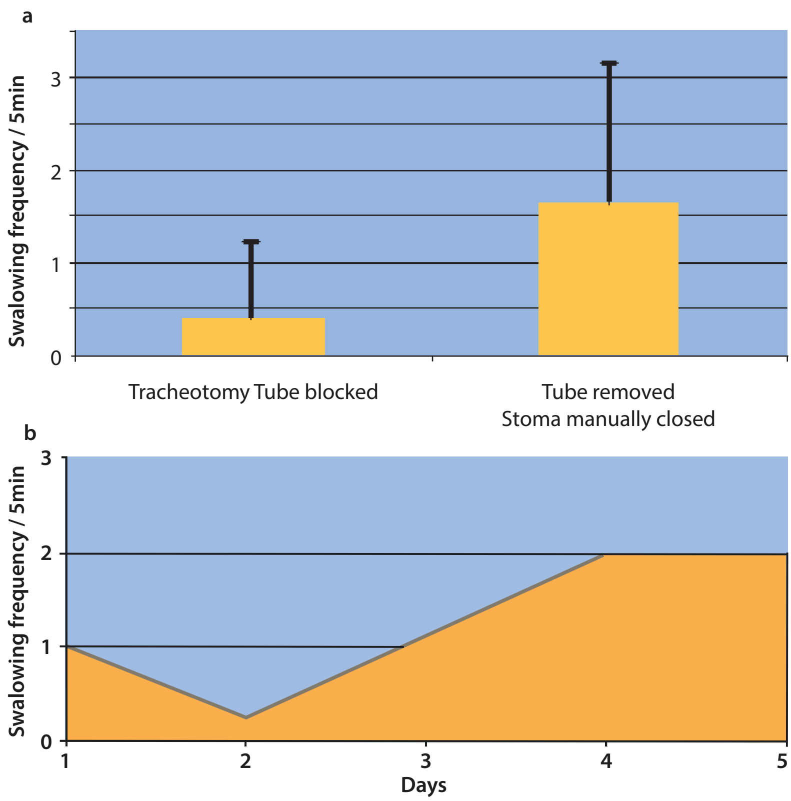


Fig. 9.7 **a**, **b**. Swallowing frequency. **a** Average swallowing frequency by days after TT removal ($n = 10$). **b** Average swallowing frequency and standard deviation, before and after TT removal ($n = 10$). Adapted from Seidl et al. 2002a. (© Seidl & Nusser-Müller-Busch 2019. All Rights Reserved)

have pointed to the restrictions caused by TTs during swallowing. Laryngeal mobility is mechanically restricted by the attachment of the tube to the skin on the neck. Laryngeal elevation is decreased, leading to insufficient opening of the upper esophageal sphincter (Bonanno 1971, Nash 1988). Cuff pressure leads to narrowing of the esophagus. The passage of saliva becomes more difficult, causing a build-up of saliva in the larynx (Feldmann et al. 1966).

In our own studies we found an increase of swallowing frequency in severely affected tracheotomised patients after changing the TT status from cuffed TT to TT with deflated cuff and speaking valves, which alters the breathing route through the larynx and probably the sensitivity in the larynx (Seidl et al. 2002a). Other clinical studies found a TT and its status to have no effect on swallowing and aspiration (Leder 1999, Leder et al. 1996, 1998, 2001). However, these studies focused on patients with head/neck surgery. In these patients, the swallowing disorder is caused by structural and mechanical changes.

Increased stimulus to the larynx and pharynx caused by airflow can increase sensitivity in these regions. Altered sensitivity can have both direct and indirect consequences (▶ Overview 9.2).

Overview 9.2 Impact of Altered Sensitivity

Direct effects

- Residues such as saliva and food can be sensed.
- Swallowing and protective reactions, such as coughing and hawking, increase.
- The control of aspirate is improved, as well as efforts to remove it (spitting out, cleansing swallow).
- A bolus can be controlled more effectively.

Indirect effects

- Hamdy et al. (1997) have shown that an increase in sensory stimuli in the pharynx leads to a change in the motor cortex representation of the corresponding areas.
- Repeatable electrical stimuli in the pharynx lead to an increase in swallowing frequency (Fraser et al. 2002).
- Stimulation in the larynx and pharynx can lead to improved reorganisation and rehabilitation of the swallowing process in the long term, once the TT is removed. This hypothesis was confirmed by our own research (Seidl et al. 2002a, 2005, (◘ Fig. 9.7). However, further studies are needed to clarify these issues.

9

9.6 Tracheostomy Tube Management (TTM) – Therapy and Weaning: Step by Step

After prolonged TT placement, the removal of a TT needs a structured and therapeutic TT management (TTM) approach. TTM is mandatory after long-term mechanical ventilation due to critical illness, cervical spine lesion, chronic obstructive pulmonary disease (COPD) and severe swallowing disorders.

Warning

A spontaneous, unprepared decannulation, i.e. the removal of a TT after prolonged tracheostomy tube placement, may fatigue the untrained respiratory muscles quickly, since both in- and exhalation must now take the long, physiological path through the upper airway. This may quickly lead to failure of respiratory mechanics and a massive aspiration of secretions to the lungs and require intubation to restore adequate oxygenation and protection of the airway from aspiration.

It is often underestimated that the restoration of physiological breathing requires unaccustomed and demanding breathing work and the ability to coordinate breathing and swallowing.

This multifaceted process of weaning may involve days, weeks, or months of treatment. It is not enough just to remove the tube or deflate the cuff and to use a speaking valve regularly (Heidler 2007). The procedures and protocols may vary by institutions. The entire team needs to be trained in therapeutic TTM (► Chap. 10).

9.6.1 Berlin Dysphagia Index (BDI)

As an initial step before starting with TTM the aspiration risk needs to be assessed. Fibreoptic endoscopic evaluation of swallowing (FEES, Langmore 2001) and videofluoroscopy can be used to evaluate the protection of the lower airway. A standardised protocol for fibre-optic examination, the Berlin Dysphagia Index (BDI), makes decision-making easier (Seidl et al. 2002b, free download in English, German and Danish ► http://schlucksprechstunde.de/download/).

The BDI identifies three subcategories for the evaluation of lower airway protection (◘ Fig. 9.8):

- General condition: e.g. breathing, coordination, tone, posture, vigilance

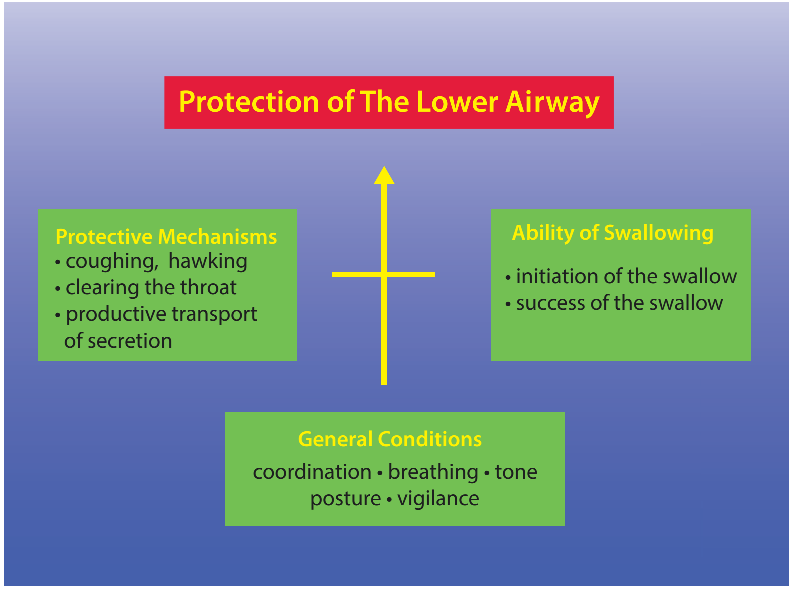


Fig. 9.8 Protection of the lower airway – model according to the Berlin Dysphagia Index (BDI). (© Seidl & Nusser-Müller-Busch 2019. All Rights Reserved)

- Protective mechanisms: Efficient coughing, throat clearing, productive transport of secretion from the lower respiratory tract
- Swallowing ability: Timed initiation of swallowing, success of swallowing (effectiveness)

Note

It is important that all team members involved in TTM evaluate regularly that the patient is sufficiently able:
- To breathe through the larynx – without assistance
- To swallow saliva
- To protect the airway

Step by Step: Advantages of a Speech Cannula in TTM

As a first step in the weaning process the TT cuff is deflated, and a speaking valve used. Often the swallowing frequency starts to increase due to improved sensory input of the exhaled air in the larynx and pharynx. F.O.T.T. tactile oral stimulation may improve the swallowing frequency and the range of motion of the oral or swallowing movements (▶ Chap. 10). In the beginning this requires tight observation and monitoring by oximetry, to evaluate the patient's respiratory status during daily therapies and care. With increased and stable oxygen saturation of at least 95%, time intervals of using the speaking valve are increased, to hours, and then during daytime, for a day or days.

Under stable general conditions a more comfortable speech cannula should be used, in the beginning also only for short time in therapy or care, then for hours, during daytime, for a day, few days or weeks. A speech cannula allows the patient's lungs to become gradually accustomed to the increased work of breathing: When breathing in, inhaled air uses the short path through the tube to the lungs as before with the cuffed TT. With the closed flap of the valve, the exhaled air flows the long path through the larynx. Getting used to the speaking cannula is an important step to train. Later the speaking valve can be changed to a cap.

The swallowing frequency often increases further after changing to a speech cannula, and the need for suctioning decreases. This improves the quality of life, and there are often demonstrable improvements in movement sequences and coordination.

The use of a speech cannula combined with therapy can prevent recannulation or a re-tracheotomy and is also an option for some patients with prolonged TT placement in nursing homes. Outpatients are also examined initially by FEES. After a period of time, up to 3 months, of tolerating a speech cannula with a cap and nearly no suctioning they undergo a

FEES again. If the FEES and the BDI score are satisfying, and no pneumonia has occurred during the last 3 months, the TT can be removed.

The procedures of TTM are an important option for patients with percutaneous tracheostomies, if the tracheostoma shows a tendency to shrink immediately without the TT, making recannulation difficult. All team members need to be trained in observing and assisting the patient and be able to suction the patient if necessary, during this period.

9.6.2 Removal and Surgical Closure of the Tracheostomy

Indications for Removal

TTs can be removed if the indications for a tracheostomy are no longer present. Breathing and swallowing and their coordination must be efficient!

The indication for tracheostomy is no longer present, if a patient after weaning from mechanical ventilation can breathe steadily and sufficiently through the nose and mouth, for an extended period of time. The patient must be able to swallow saliva and clear the airway with an effective cough.

In cases of swallowing dysfunction, the status of the lower airway protective mechanisms (one of the BDI subcategories) must be assessed prior to removing or changing the type of a TT.

Patients should be weaned from the TT gradually, to prevent pulmonary problems. This process involves structured TTM, and often the use of a speech cannula, combined with facial-oral treatment. The lungs require time to adjust to the physiological workload of breathing through the mouth/nose, which requires more strength and a different breathing mechanism.

FEES Evaluation

A FEES is mandatory, to evaluate breathing, swallowing and tracheal patency and to exclude aspiration, vocal cord paralysis, vocal fold motion impairment, tracheal damage and tracheal stenosis.

In our experience decannulation may even be possible in patients with a poor level of consciousness, e.g. a vegetative or minimal conscious state, after a structured TTM, if the three categories of the BDI are fulfilled.

Warning

It should be noted that patients with tetraplegic spine lesions, i.e. paralysis of the thoracic muscles, cannot cough efficiently (▣ Fig. 9.8). It may be necessary to maintain a tracheostomy and a speech cannula, e.g. for occasional suctioning, depending on the level of tetraplegia and functional restrictions (Seidl et al. 2010a, b)!

Removal and Operative Closure

The tracheostoma should be covered with an occlusive dressing for several days following decannulation, to allow the opening to shrink or close spontaneously. The wound should be cleaned and dressed once daily or more frequently if required. It is recommended to keep a TT equipment with two TTs (one of the same size and another one size smaller) at the bedside during the first 24 hours in case reinsertion is required.

If a surgical tracheotomy has been performed, surgery is necessary to close the stoma.

Warning

Surgical intervention to close a tracheostomy should always be conducted on an inpatient basis. Post-surgical bleeding can lead to compression of the trachea, with life-threatening complications.

Wound healing can be delayed once the TT has been removed. The tissue around the tracheostoma can become inflamed due to prolonged saliva leaking. This may lead to purulent discharge or the formation of a fistula. In rare cases, repeated interventions may be necessary before the wound closes successfully.

Practical Tip

Delayed wound healing should initially be treated locally and conservatively, by cleaning and the use of absorbent strips and pressure bandages. If the stoma does not heal and close within 6–8 weeks, a second operation can be attempted.

Swallowing is a vital function! TTs might be essential for the survival of patients with severe swallowing disorders and aspiration. Basic knowledge is essential for everyone involved in the care of TTs, in addition to the practical skills necessary for the care of tracheostomised patients!

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The F.O.T.T. Approach to Tracheostomy Tube Management (TTM): Return to Physiology

Heike Sticher and Claudia Gratz

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The treatment of patients with tracheostomy tubes places rigorous demands on an interprofessional and interdisciplinary team. The successful treatment of tracheostomised patients with brain injury is dependent on more than selection of the right tracheostomy tube. It requires an in-depth knowledge of physiology and a thorough understanding of the changes caused by the brain damage, which often affect the complex system of respiration and swallowing. In this chapter we outline an interprofessional approach of tracheostomy tube management (TTM). The primary responsibility for assessment, goal setting, treatment planning, and evaluation should be allocated to those members of staff who have the most experience and a solid background in F.O.T.T. Continuing education is vital, to establish conceptually sound knowledge and provide background experience in the treatment of this particularly complex problem.

Since the mid-1980s, the therapeutic treatment of neurological patients with tracheostomy tubes (TTs) in Germany has evolved markedly. It has become an area of reponsibility which involves doctors, nurses and other caregivers and occupational, physio- and speech therapists. It is a field which places rigorous demands on the entire treatment team.

10.1 Physiology

The approach to treatment is based on in-depth knowledge of respiration and swallowing and the coordination of these functions (▶ Chaps. 1, 5 and 8). These functions are described in detail below.

10.1.1 Normal Breathing

▪ Anatomy of the airway

The distance from the upper row of teeth to the glottis is approximately 14 cm . The larynx is located at the level of the sixth and seventh cervical vertebral bodies: beneath the larynx, the elastic tube of the trachea extends down and divides into the bronchial tubes. The trachea is 10–12 cm in length and has a diameter of approx.13–20 mm (approximately the size of a 1 to a 5 cent coin). It is composed of 16–20 horseshoe-shaped cartilages, connected by ligaments. This structure ensures that the trachea remains open continuously and is able to withstand tensile and compressive loads during inhalation, exhalation, and movements of the body. Each cartilage is closed dorsally by elastic connective tissue (pars membranacea) and muscle (trachealis muscle), to form a ring (Dikeman and Kazandjian 2002; Ehrenberg 2001; Mang 1992). This creates an elastic separation from the esophagus. The entire trachea is lined with ciliated mucous membrane.

The trachea divides into the right and left primary bronchi at the bifurcation (level of fifth thoracic vertebra). It then divides further into lobar bronchi, into bronchioles and, finally, into alveoli. The entire lung contains approximately 300–400 million alveoli, with diameters ranging from 0.06 to 0.2 mm. The total surface area is between 80 m^2 during inhalation and 40 m^2 during strong exhalation.

> **Note**
> The trachea and bronchi are held open by their construction. A specific (protective) mechanism is required in order to close them. In contrast, the bronchioles are both distensible and compressible.

10.1.1.1 Respiratory Center

The respiratory center is located in the cerebrum (medulla oblongata). The breathing rhythm is established there but can also be modulated, e.g. in response to demands for oxygen exchange, or by focusing attention on the breath. From the respiratory center, respiratory neurons control the movements of inhalation and exhalation via the innervation of the muscles.

The variables controlling breathing include:

- PH value
- Carbon dioxide partial pressure (pCO_2)
- Oxygen partial pressure (pO_2) in the arterial blood

The pCO_2 is the most powerful chemical regulator of breathing.

Factors influencing breathing frequency include:
- Age
- Effort (e.g. high-performance sports) or tension (e.g. anxiety)
- Anatomical conditions (e.g. pronounced kyphoscoliosis)
- Changes in postural background, associated with various neurological disorders

▶ Overview 10.1 summarises the factors which affect breathing.

Overview 10.1 Factors Which Affect Breathing
- Age
- Constitution
- Condition
- Postural background
- Psychological factors

10.1.1.2 Breathing Process

▪ **Respiratory phases**

Breathing is divided at least into the following phases:
- Inhalation
- Exhalation
- Pause

Inhalation

The diaphragm (our most important inspiratory muscle) contracts and moves downwards, thereby increasing volume in the chest/abdomen. The pressure of the air inside the lungs decreases and air rushes into the lungs.

Exhalation

The lungs are returned to their starting position by the relaxation of the diaphragm and restoring force of the lungs and thoracic tissue (stretched during inhalation). The resulting excess pressure causes the air to flow out of the lungs and be expelled. The oblique abdominals and rectus abdominis become active if exhalation is forced.

Pause

There is a brief pause following exhalation, before the renewed impulse for inhalation is given (Dikeman and Kazandjian 2002; Ehrenberg 2001; Mang 1992).

Note

Normal tidal breathing is characterised by a pattern of inhalation-exhalation-pause. The breathing frequency in adults is approximately 15 breaths per minute.

▪ **Breathing process**

Inhaled air is channelled through the upper (nose/mouth/throat) and lower (larynx/trachea/bronchi) airway to the alveoli, where the gaseous exchange takes place. Each section of the airway performs a specific function.

The inhaled air is cleaned, moistened and warmed within the nasal cavity, which is approximately 5–8 cm in length. The moistening process continues as the air continues downwards to the bronchial tubes. The entire pathway from the nose to the bronchial tubes (about 40–50 cm) is referred to as the anatomical dead space; air is transported through this space, but no gaseous exchange takes place.

The functional dead space also includes the volumes of those alveoli, which are ventilated but not perfused (no gaseous exchange can take place). The anatomical and functional dead space is almost equal in healthy individuals (a volume of circa150 ml).

10.1.1.3 Lung Volumes

Specific terms are used to designate the different volumes in respiratory physiology. In general there are both mobilisable and non-mobilisable lung volumes:
- The non-mobilisable volumes always remain in the lungs.
- The mobilisable volumes are utilised according to requirements.

A summary of the most important respiratory volumes is shown in ▪ Table 10.1 (Dikeman and Kazandjian 2002, Ehrenberg 2001, Mang 1992).

10.1.1.4 Gaseous Exchange

During the process of gaseous exchange in the alveoli, oxygen (O2) from the air is diffused into the bloodstream, and carbon dioxide (CO2) passes from the bloodstream into the airway. The used air is then exhaled. The tidal

Table 10.1 Respiratory volumes

Volume	Description
Total lung capacity (TLC)	The volume in the lungs at maximal inflation (=RV + VC)
Vital capacity (VC)	Maximum air volume that can be expelled from the lungs after maximum inhalation (=ERV + TV + IRV), ca. 4.5 l
Expiratory reserve volume (ERV)	The maximum amount of additional air that can be expelled after a normal exhalation, ca. 1.5 l
Inspiratory reserve volume (IRV)	The maximum amount of additional air that can be inhaled after a normal inhalation, ca. 2.5 l
Tidal volume (TV)	The volume of air entering and leaving the lungs during normal breathing (=alveolar + dead space volume), ca. 600 ml in healthy adults
Inspiratory capacity (IC)	Maximum amount of air that can be drawn into the lungs after normal exhalation (IC = TV + IRV)
Dead space volume (VD)	The volume of air remaining in the upper and lower airways (TV), which does not take part in gaseous exchange, ca. 150 ml
Alveolar volume (AV)	The volume of air which is involved in gaseous exchange, ca. 450 ml
Residual volume (RV)	The volume of air remaining in the lungs after a maximal exhalation, ca. 1.5 l
Functional residual volume (FRV)	The volume of air remaining in the lungs after a normal exhalation (= ERV + RV), ca. 3 l
Respiratory minute volume (RMV)	The volume of air inhaled and exhaled per minute, ca. 6–9 l/min

volume (TV) must be large enough to ensure a sufficient supply of oxygen, i.e. must significantly exceed the dead space volume. This depends directly on the respiratory rate: A healthy individual has a TV of ca. 600 ml (at a frequency of 15 breaths per minute).

Note
The required tidal volume can be achieved more efficiently by taking fewer and deeper breaths, rather than multiple shallow ones. Numerous shallow breaths decrease the tidal volume (e.g. to 350 ml), lowering the proportion of oxygen-rich air in the lungs.

During speaking most of the exhalation is directed through the mouth.

During rest, both inhalation and exhalation usually take place through the nose.

A certain level of airway resistance must be overcome during inhalation and exhalation (Ehrenberg 2001; Martin et al. 1994; Sasaki et al. 1977). Assuming a total resistance of 100% for the entire pathway, this is accounted for as follows:

- The nasal segment alone, ca. 50%
- The pharyngeal/laryngeal segment ca. 25%
- The final tracheal/bronchial segment, ca. 25%

This resistance is required in order for the lungs to inflate sufficiently, thereby making the greatest perfused surface area (alveoli) available for gaseous exchange.

The respiratory system is well secured, designed to prevent materials other than air from passing to the lungs. Any penetrating particles are immediately transported upwards and expelled:

- The vocal folds and vestibular folds can be closed, to prevent particles penetrating from the top to the bottom of the system.
- The cilia of the lung and tracheal mucosa can transport dust and secretion particles upwards. The coordinated beating of the cilia (20 times per second) transports mucus cranially, at a rate of 2 cm/min.

Note
Respiratory air must overcome a degree of airway resistance and travel a certain distance, in order to pass from the nose/mouth to the alveoli, or vice versa.

10.1.2 Protective Mechanisms

The protective/cleansing mechanisms of the respiratory tract are linked to forced exhalation:
- Throat clearing
- Sneezing
- Coughing

Throat clearing

Throat clearing (forced expiratory technique with medium lung volume) can transport material from the laryngeal entrance into the throat. Having passed into the throat, misdirected secretions, fluid or food can then be swallowed (Martin et al. 1994).

Sneezing

Sneezing cleans the nose and pharyngeal cavity, e.g. if dust or food has penetrated.

Coughing

Coughing can be triggered in different locations and varies in strength. Involuntary, reflexive coughing is normally initiated at the level of the glottis, in the trachea (particularly at the bifurcation) or in the bronchi (Sasaki et al. 1977).

> **Note**
> Effective, physiological protective mechanisms occur involuntarily and are not controlled consciously.

Protective mechanisms can also be initiated and affected voluntarily, to a degree. Voluntary throat clearing, hawking and/or coughing does not provide adequate protection for the deeper airway if the sensorimotor system is impaired, however. If the individual is unable to sense that he/she is choking, he/she is also unlikely to cough.

10.1.2.1 Reflexive Coughing

Contraction of the thoracic, abdominal and pelvic muscles compresses the volume of air within the lungs; concurrently the vocal folds and vestibular folds close. The contraction of the thoracic, abdominal and pelvic muscles is maintained as the air is released cranially, through explosive opening of the vocal and vestibular folds (Ehrenberg 2001, Kapandji 2006, Mang 1992; Sasaki 2017).

In order to protect the airway it is vital that the compressed air released from the lungs has a clear path upwards. Coughing creates a 42-fold increase in linear flow velocity within the trachea – from 667 cm per second to 28,000 cm per second (De Vita 1990). In paradoxical breathing, the upwards flow of exhalation is no longer assured. The thoracic, abdominal and pelvic muscles are unable to build and sustain compression. As a result the accumulated pressure is very low and released into the uncompressed abdominal cavity, and the cough loses effectiveness (▶ Chap. 8).

In order for the protective mechanism to be successful, the material which has been coughed upwards must be prevented from moving back towards the lower airway once more.

> **Note**
> After being coughed up, particles are either carried into the stomach by swallowing or spat out. An intact sensorimotor system is a prerequisite for this.

If the protective mechanisms are incomplete (coughing without swallowing) or ineffective (coughing is too weak), they cannot protect the lung by removing material which has gone astray. Therapeutic support can be used to facilitate swallowing, which is necessary after coughing (Addington et al. 1999; Davies 1994; Edwards 2002; Gratz and Müller 2004).

The most important aspects of reflexive coughing are outlined in ▶ Overview 10.2.

Overview 10.2 Important Aspects of (Involuntary) Reflexive Coughing

- One of the protective mechanisms
- Takes place with forced exhalation
- Coordinates with swallowing or spitting
- Clears the lower and middle (possibly even upper) airways of material which has penetrated
- Varies in strength according to need

10.1.3 Breathing-Swallowing Coordination

The protection of the airways during swallowing is achieved through:

- Elevation of the soft palate against the pharyngeal wall
- Cranial/ventral elevation of hyoid/larynx and caudal/dorsal tilting of the epiglottis
- Opening of the upper esophageal sphincter
- Adduction or closure of the vocal and vestibular folds
- A final exhalation

An involuntary breathing-swallowing pattern also contributes to the protection of the airway. The following pattern applies for most people:

- Either: Inhalation-breathing pause/swallow-exhalation
- Or: Inhalation-start of exhalation-breathing pause/swallow-the exhalation continues (Leder et al. 1996; Morgan and Mackay 1999; Selley et al. 1989; Smith et al. 1989)

This implies that respiration corresponds with when swallowing occurs. This is only possible if the body has been supplied with sufficient oxygen to allow the vital breathing pause to take place, thereby ensuring safe swallowing. Residues often remain in the oropharynx after swallowing. These particles are "swirled" around by the airflow during in- and exhalation, allowing them to be perceived more easily:

- During inhalation, this residue is drawn in the direction of the trachea/lung.
- During exhalation, a potential cough can force the residue directly upwards.

A further swallow can then take place, without causing a lack of oxygen (Dikeman and Kazandjian 2002; Klahn and Perlman 1999; Martin et al. 1994).

Note

There is a coordinated, involuntary breathing-swallowing pattern whereby exhalation is initiated prior to the breathing pause or immediately after.

The economy, efficiency and safety of swallowing are closely related to the normal postural and movement capabilities of our body and also to intact sensitivity. The ability of oropharyngeal and laryngeal structures to adapt to changes in posture and movement is impressive, as long as the functional balance is not disturbed.

10.2 Pathophysiology

The treatment approach is based on detailed knowledge of the changes to breathing, swallowing and their coordination, as well as the effects of those changes on the individual. These changes are described below.

10.2.1 Alterations in Breathing

Brain damage can impair the functioning of the respiratory or swallowing centers. Abnormal breathing-swallowing patterns are common, particularly the tendency to inhale after swallowing (Hadjikoutis et al. 2002). If the respiratory center is affected directly, this can lead to Cheyne-Stokes, Kussmaul or Biot's respiration, for example (Frost 1977). Neurovegetative dysregulation can result in a high-frequency respiratory rhythm or changes in the composition of saliva/secretion. Paradoxical breathing can be caused by a loss of respiratory muscle function, e.g. in tetraplegia (▶ Chap. 8). Spasticity (increased muscle activity) can lead to an increase in the demand for oxygen. Both respiratory frequency and tidal volume usually increase, in order to meet the greater demand for oxygen:

- The breathing pause is eliminated.
- Both inhalation and exhalation are curtailed, subject to the respiratory rate; i.e. as the respiratory rate increases, inhalation and exhalation become briefer.

For a patient who also has a TT, the reduction in physiological airway resistance (by approx. 70–75%) and (used) anatomical dead space (by approx. 50%) (▶ Sect. 10.1) make it difficult, to increase his or her tidal volume.

Note
If respiratory function is impaired, the options available to the patient are as follows:

- To increase the respiratory rate
- Reduce exhalation to a minimum
- Eliminate the breathing pause

The patient's breathing becomes shallower and more rapid.

This has the effect of increasing dead space volume and reducing the alveolar volume; i.e. the supply of oxygen decreases (Dikeman and Kazandjian 2002; Ehrenberg 2001; Mang 1992).

Note
In the respiratory rhythm of most patients with a tracheostomy tube, no breathing pause can be observed. They breathe in and out continuously, without a break!

The ventilation of the lungs becomes inadequate at a frequency of 24 breaths per minute or more. The breathing capacity of the lungs alone is no longer sufficient to meet demand; therefore, the body attempts to support the effort with movements of the trunk and head (Davies 1991):

- During inhalation, the patient attempts to stretch.
- During exhalation, the patient attempts to flex.

This is physically demanding work for the patient. A pause in movement normally follows physical exertion, providing an opportunity to rest.

Oxygen saturation decreases if patients stop to move in the ways described above, as the lung is not ventilated sufficiently (Frost 1977). The increased work of breathing and forward movements of the head can cause the TT to rub against the tracheal wall and press on the esophagus, causing vomiting. This is clearly undesirable in patients with an increased risk of aspiration due to swallowing disorders. Further complications include stenosis or damage to the tracheal cartilages (▶ Sect. 9.4.5).

10.2.2 Abnormal Posture and Movement

The ability to **hold** and **move** the body normally is dependent on certain preconditions:

- Adequate muscle tone, which is adapted constantly to the requirements of (targeted) activities
- Intact tactile-kinaesthetic perception
- Constant maintenance of equilibrium

This is the foundation which allows highly coordinated and selective movements to take place. It enables the individual to adopt a postural background appropriate to a particular activity.

Neurological patients have mild to severe impairments in these areas. They show abnormal patterns of posture and movement, resulting in major limitations, e.g. of the ability to walk and/or move the arms and hands. Breathing and the coordination of breathing with swallowing and speech are affected. Left untreated, these altered movement patterns result in false/unhelpful sensory feedback. They impair sensorimotor learning and frequently cause secondary complications.

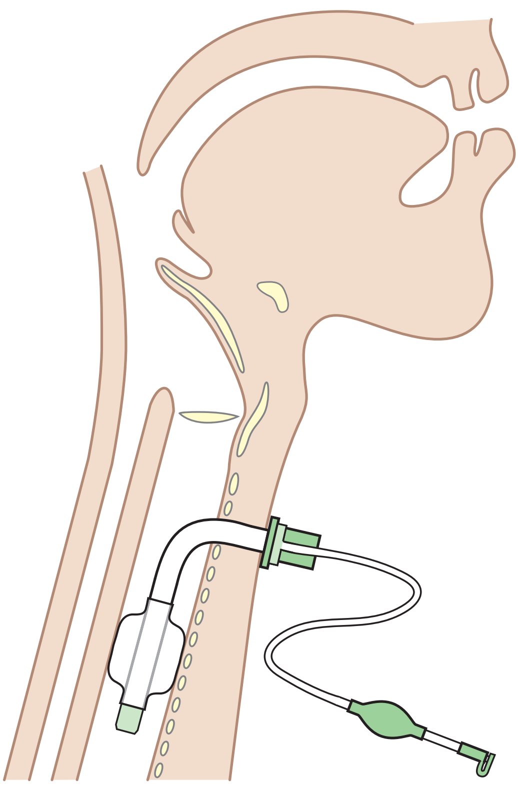
10.2.3 Tracheostomy Tubes and Their Impact

A tracheostomy is a life-saving and life-sustaining intervention, ensuring that the patient receives an adequate supply of air (and oxygen) via a TT. Provided it is used correctly, a cuffed TT (◘ Fig. 10.1) will also protect the deep respiratory tract from aspirated material to a great extent. Despite these clear advantages, there are also considerable disadvantages associated with their use (► Chap. 9).

Many patients with acquired brain damage will require a TT for a prolonged period (weeks, months). The type of tracheostomy must be known because a percutaneous tracheostomy must be treated differently in the rehabilitative process than a surgical one.

■ Impact of a tracheostomy tube

► Overview 10.3 describes the impact a TT has on posture, movement and swallowing.



◘ **Fig. 10.1** Diagram of a cuffed tracheostomy tube.

Overview 10.3 Impact of a Tracheostomy Tube

Effects on posture and movement

- Most patients adopt compensatory posture. The neck contracts and becomes rigid to guard against mechanical irritation, making selective head movements more difficult (Gratz and Müller 2004).

Dramatic changes in the conditions within the external respiratory system

- Moisturisation, warming and purification of respiratory air become more difficult or are no longer assured (Dikeman and Kazandjian 2002; Gratz and Müller 2004; Sasaki et al. 1977).
- It is difficult or impossible to smell and taste (Dikeman and Kazandjian 2002; Gratz and Müller 2004).
- Respiratory resistance and distance changes for both inhalation and exhalation. The patient’s breathing is more rapid and shallow (Dikeman and Kazandjian 2002, Gratz and Müller 2004; Sasaki 2017; Sasaki et al. 1977).
- There is no closed system for physiological and effective swallowing and coughing (Buckwalter and Sasaki 1984; Dikeman and Kazandjian 2002; Gratz and Müller 2004).

Effects on swallowing

- Swallowing movements and elevation of the hyoid and larynx may become more difficult (Bonanno 1971; Butcher 1982; Cameron et al. 1973; Lipp and Schlaegel 1997).
- Breathing-swallowing coordination becomes dysfunctional. Although the glottis closes, air in the lower part of the airway escapes via the TT, limiting the breathing pause (Buckwalter and Sasaki 1984; De Vita 1990; Higgins and Maclean 1997).
- Little or no air enters the laryngeal and pharyngeal space; the normal sensitivity which is a prerequisite for normal

protective mechanisms is reduced (Davies 1994; Leder et al. 1996; Nash 1988; Selley et al. 1989).
- The frequency of swallowing and of further clearing swallowing often decreases (Gratz and Müller 2004, Sasaki et al. 1977).
- There is an increased risk of infection in the lower airway and lungs (Dikeman and Kazandjian 2002; Higgins and Maclean 1997).

The restricted hyoid and laryngeal elevation described in ► Overview 10.3 can impair the functioning of the upper esophageal sphincter. The opening of the sphincter may be delayed and/or inadequate and its closure premature (Butcher 1982; Cameron et al. 1973; De Vita 1990).

10.3 Treatment

The treatment approach is founded on an understanding of normal movements and the factors which influence them. Particular attention must be paid to the physiology of breathing and swallowing and the protective mechanisms and coordination which are vital for these functions. Knowledge and understanding of F.O.T.T. is crucial when treating tracheostomised patients.

Detailed examination findings, documentation and evaluation of the patient's current condition are essential. The therapeutic approach is also determined by a number of other factors:

- Condition of the patient
- Motor skills (Umphred 2000)
- Postural background of the patient
- Effectiveness of airway protection
- Potential positioning in sitting, supine and standing (also outside of treatment)
- Type of tracheostomy (Graumüller et al. 2002)
- Type of TT
- Previous bronchopulmonary infections and (aspiration) pneumonia
- Existing difficulties with reflux
- Results of FEES (Langmore 2001), bronchoscopic and (if required) videofluoroscopic examinations
- Staffing, temporal and professional capacity of the facility
- Cooperation of relatives
- Patient care following discharge from the hospital to the home, residential or day care facility or other facility

10.3.1 Basic Considerations

Patients with severe neurological damage often have significant limitations in terms of posture, movement, coordination and protective mechanisms (► Chaps. 3 and 4).

The dysfunctional swallowing sequence and lack of effective protective mechanisms require the placement of a cuffed TT. The secondary effects of the TT on posture, movement and swallowing have been described already in ► Sect. 10.2. These effects exacerbate the difficulties.

The precondition for the protection of the airway is intact sensitivity in the laryngopharyngeal area. Sensorimotor learning presupposes practical activity.

Note

A stimulus is vital for maintaining (or re-establishing) normal sensitivity in the physiological system. Regarding the larynx and pharynx this means respiratory airflow.

Only a person who is able to sense saliva or food particles in the pharynx will swallow as a result. Only a person who is able to sense food particles moving towards the larynx will cough or clear the throat, before swallowing again.

Clinical observations suggest that mobility of the head and shoulder girdle play a role in the normal sensitivity of this region (Gratz and Müller 2004).

Example

Head movements noticeably increase the frequency of spontaneous swallowing in patients with a wet-sounding voice and without consecutive clearing swallows. The same can be observed during facilitated arm movements.

Both sensitivity and movement capability are compromised in neurological patients with (cuffed) TTs (Butcher 1982, Cameron et al. 1973, De Vita 1990). The tracheostomised patient is caught in a vicious circle:

- On the one hand, a cuffed TT is necessary, because the safety of the swallowing sequence is endangered by inadequate or absent sensitivity.
- On the other hand, patients are cut off by the cuffed TT from the possibilities to feel normal and move, and the swallowing process is additionally mechanically impaired.
- On the one hand, it would be negligent to permanently deflate the cuff or remove the TT too early, if the patients cannot protect their lungs from aspiration adequately.
- On the other hand, the cannulated patient cannot perform swallowing movements under physiological conditions and therefore has no way of developing protective mechanisms.

It is essential that these patients have an opportunity to relearn these functions in a protected/supervised environment. This is only possible if the cuff of the TT is deflated and has a speaking valve or is removed during therapy (► Chap. 9, Gratz and Müller 2004, Leder et al. 1996, Sasaki 2017). Awareness of these interdependencies is required when prioritising objectives for therapy.

Note

There can be no nutritionally relevant intake of food as long as the patient is dependent on a (cuffed) TT. At best, the basic principles of therapeutic meals can be followed (► Sect. 5.5.2). Permanent decannulation usually remains the primary goal, which will allow the emphasis to be placed on oral nutrition.

10.3.2 Treatment Position

In the first stages of therapy, devising and preparing the optimal position for treatment (Fig. 10.2) can be time-consuming. This process is essential, however, and ensures that the entire decannulation process and therapeutic situation remain safe for the patient (Davies 1994; Gratz and Müller 2004).

Fig. 10.2 Severely affected patient standing (standing frame). Tracheostomy tube with deflated cuff, size 7, equipped with a speaking valve. The therapist stands behind the patient and assists exhalation by directing the movement of the ribs forwards/downwards. (© Sticher & Gratz 2019. All Rights Reserved)

Warning

The cuff of a TT should not be deflated without taking into account the starting position of the patient and the amount of saliva which may already have accumulated!

10.3.2.1 Side Lying

The side lying position should always allow secretions and saliva to run out of the mouth. It should be possible to remove secretion which has collected in the bottom cheek if necessary, using wet gauze. This minimises the risk of aspirating the saliva.

10.3.2.2 Sitting

In sitting, the patient's upper body should be tilted forwards with the head in slight flexion ("long neck"), i.e. chin slightly towards the chest. This also allows secretion or saliva to flow out of the mouth or be removed regularly by the therapist.

10.3.2.3 Standing

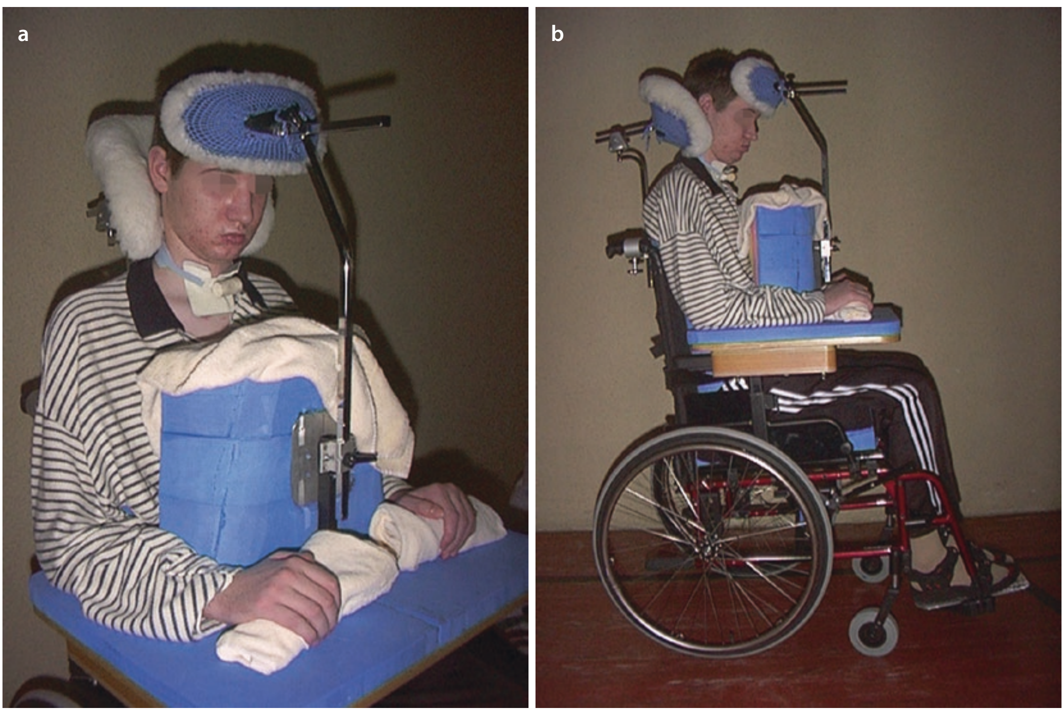
It is particularly important to support the upper torso and cervical spine in slight flexion. This increases the efficiency of coughing and reduces the risk of renewed aspiration. Breathing and coughing can also be supported effectively in standing (◘ Fig. 10.2).

10.3.2.4 Wheelchair Fitting: Example from the Basler Anterior Trunk Support Approach (B.A.T.S.A)

The care which the patient receives outside of therapy sessions is an important aspect of overall management and an integral part of the 24-hour approach. This includes wheelchair fitting for severely affected patients who also have a TT (De Vita 1990; Engström 2001; Mack 2002).

◘ Figure 10.3 illustrates one of the ways in which the basic ideas of patient positioning can be adapted, for patients with a wheelchair. The patient shown does not have active trunk and head control and is sitting in a specially adapted wheelchair. The missing postural background is supplied "from the outside", providing him with enough support to manage more complex activities such as swallowing. The external postural background builds on the foundation of the pelvis to create stability for the whole trunk (B.A.T.S.A.) and provide a solid basis for positioning of the head. Depending on the patient's capabilities, the sitting position can be held for between 30 and a maximum of 90 minutes (Mack 2002).

Warning
The supine position immediately results in passive leakage of saliva from the oral cavity into the lower airway and is therefore contraindicated for deflating the cuff of the TT.



◘ **Fig. 10.3** **a, b**. Patient with no trunk and head control, in a wheelchair (© Sticher & Gratz 2019. All Rights Reserved). **a** Lateral view: with anterior trunk support and adapted headrest (B.A.T.S.A.). **b** Side view: the construction of the wheelchair (B.A.T.S.A.) allows the individual sections of the body to be positioned one above the other, even in patients with decreased body tone

10.3.3 Cleaning the Aerodigestive Tract

The secretions which accumulate above the cuff (saliva, nasal and pharyngeal secretions) form an ideal milieu for the multiplication of bacteria. If these secretions are not removed prior to cuff deflation, the subsequent downward passage of bacteria through the respiratory tract endangers the patient, e.g. increasing the risk of nosocomial pneumonia (Dikeman and Kazandjian 2002; Higgins and Maclean 1997). Cleaning the nasal, oral, (pharyngeal) and laryngotracheal tract is therefore particularly important.

10.3.3.1 Cleaning the Oral Cavity and Nose

The necessary materials are prepared in advance (◘ Fig. 10.4).

First, moist gauze is used to clean the mouth (◘ Fig. 10.5b), and any coating is removed from the tongue. The nose is cleaned and if necessary the teeth.

◘ **Fig. 10.4** Materials and equipment prepared for deflating the cuff of the tracheostomy tube (© Sticher & Gratz 2019. All Rights Reserved). **1** Suction device, **2** suction catheter, **3** sterile gloves, **4** 2 × 20 ml syringes, **5** compresses, **6** finger stalls, **7** “artificial nose” filter, **8** speech valve, **9** masking foil, **10** manometer, **11** mouth mask, **12** F.O.T.T. box, **13** gauze pads

◘ **Fig. 10.5** **a, b**. Preparatory cleaning of the oral cavity before deflating the cuff (© Sticher & Gratz 2019. All Rights Reserved), **a** guided brushing, **b** removal of saliva from the cheek pockets, with the assistance of the jaw support grip

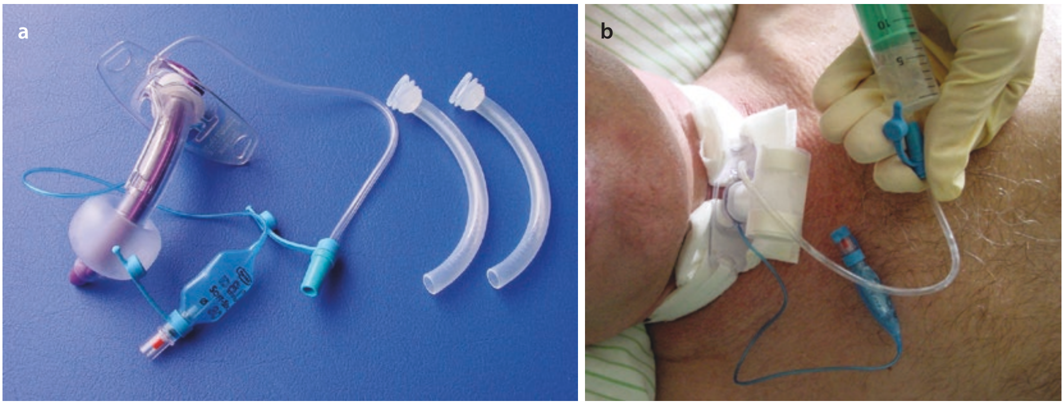


Fig. 10.6 **a, b**. Cuffed tracheostomy tube with subglottic suction capacity (© Sticher & Gratz 2019. All Rights Reserved). **a** With two matching inner cannulas. **b** A syringe is used to remove secretion from above the cuff

(Fig. 10.5a) shows a guided sequence (Affolter 2006). This minimises the amount of secretion entering the trachea during the deflating process.

Cleaning the mouth and nose prior to deflating the cuff is an indispensable part of the management. It should be carried out several times a day as a matter of course, regardless of whether deflating of the cuff is planned.

Note
The mouth and nasal cavity must be cleaned (in an appropriate starting position) before the cuff of the TT will be deflated.

10.3.3.2 Cleaning the Tracheostomy Tube and the Area Above the Cuff

The exact method of cleaning the TT depends on the type of tube:
- An inner cannula can be removed and cleaned.
- If the tracheostoma is relatively large in proportion to the TT, some of the accumulated secretions (above the cuff) can be carefully suctioned beside or at the edge of the tracheostoma.

If the TT allows suctioning of secretions from above the cuff (subglottic), these are removed first using a syringe (Fig. 10.6). This establishes a parameter for documenting the amount of aspirated material during the entire treatment process.

10.3.4 Therapeutic Suctioning

Suctioning of the TT and trachea of tracheostomised patients occurs daily, with varying frequency.

The objective of suctioning is to remove secretions which hamper the patient's breathing and endanger the adequate supply of oxygen. This could be secretions from the mucous membranes or aspirated material.

The process referred to in F.O.T.T. as therapeutic suctioning begins before the actual suctioning takes place. An assisted forced exhalation is used to mobilise the secretion upwards as far as possible, to just below or inside of the TT. It can then be carefully suctioned off during an exhalation phase. The procedure sometimes stimulates coughing, as the increased pressure of airflow through the trachea helps the patient to sense the secretions more effectively.

The patient is unable to generate a build-up of pressure with a cuffed TT. The pressure must be produced by the person who forces the exhalation, by applying the hands to the lateral ribcage. Ideally, the procedure is performed by two members of the therapeutic and nursing staff working as a team: One person assists exhalation and the other suctions the secretions (Fig. 10.7).

Fig. 10.7 Therapeutic suctioning: The suction catheter is inserted to just beneath the tracheostomy tube, with no suction. Assisted forced exhalation is used to mobilise secretion in the trachea upwards to the level of the tracheostomy tube, where it is gently suctioned – preferably during the exhalation phase. (© Sticher & Gratz 2019. All Rights Reserved)

Therapeutic suctioning takes account of the patient's breathing rhythm and supports the exhalation. This reduces the risk of suction damage, bleeding lesions due to mechanical irritation of the tracheal mucous membrane or even the bifurcation through the suction catheter and forceful coughing.

Forceful coughing can:

- Disturb the patient's established position which has often been painstakingly established
- Provoke increased production of secretion

The most important aspects of therapeutic suctioning are summarised in ▶ Overview 10.4.

Overview 10.4 Therapeutic Suctioning

- Perform it by slightly rotating the catheder between the fingers during pulling out
- Only suction 10 to 15 seconds (Ullrich et al. 2017)
- Pay attention to the patient's respiratory rhythm
- Assist forced exhalation
- Only suction within (or just below) the TT

10.3.5 Therapeutic Deflation of the Cuff

If the TT is equipped with a subglottic suction system, secretion on the cuff is removed with a syringe (>20 ml) before the cuff is deflated. The reduction in secretion prevents the aspirate from flowing freely into the trachea and downwards into the bronchi (Fig. 10.8).

Therapeutic deflation of the cuff is immediately followed by therapeutic suctioning. Two people are required for the brief process of deflation of the cuff. The entire process can then be completed without rushing or causing the patient anxiety. One person deflates the cuff and continues to assist the patient with breathing; the second person is ready to provide suction. Clear communication is essential for coordinated implementation. The patient is connected to a pulse oximeter or monitor to control oxygen saturation during the decuffing process and subsequent treatment.

Practical Tip

A syringe is used for the deflating procedure itself. Pressure is first reduced, and the patient's reactions are noted:

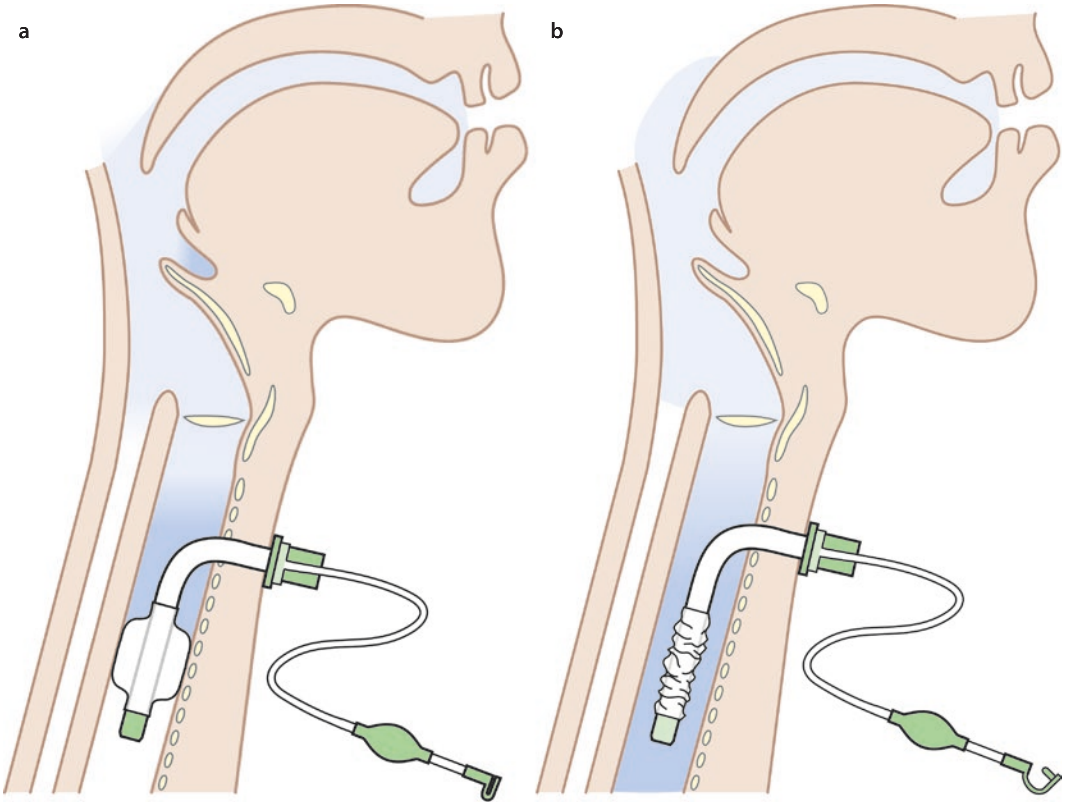


Fig. 10.8 **a, b**. Diagram showing the collection of secretion (© Sticher & Gratz 2019. All Rights Reserved). **a** Above the inflated cuff of the tracheostomy tube. **b** The accumulated secretion moves by gravity, during and after cuff deflation

Coughing spontaneously or throat clearing may provide an indication of the patient's sensitivity. The cuff can then be deflated completely (Fig. 10.9).

Note
The unblocking process provides information about:
- Sensitivity
- Protective mechanisms

The patient's ability to maintain the postural background in the event of coughing

10.3.6 Therapeutic Procedure After Deflating the Cuff

As the patient's cuff of the TT has been deflated, the primary focus shifts to directing airflow through the larynx and into the upper airway.

One person places the hands on the lateral ribcage to guide and assist the patient's breathing. The second person uses the index and middle finger to stabilise the TT during inhalation. The thumb is used to close the TT during the exhalation phase (Fig. 10.10).

Note
The tracheostomy tube must be closed in a way which avoids irritation of the trachea. Blocking the outer end of the TT is sufficient to direct the flow of air. Pushing with force against the TT is unnecessary and may cause irritation.

Following this approach:
- Makes it possible for the patient to inhale through the TT again safely and without fear
- Directs expiratory airflow through the larynx and throat

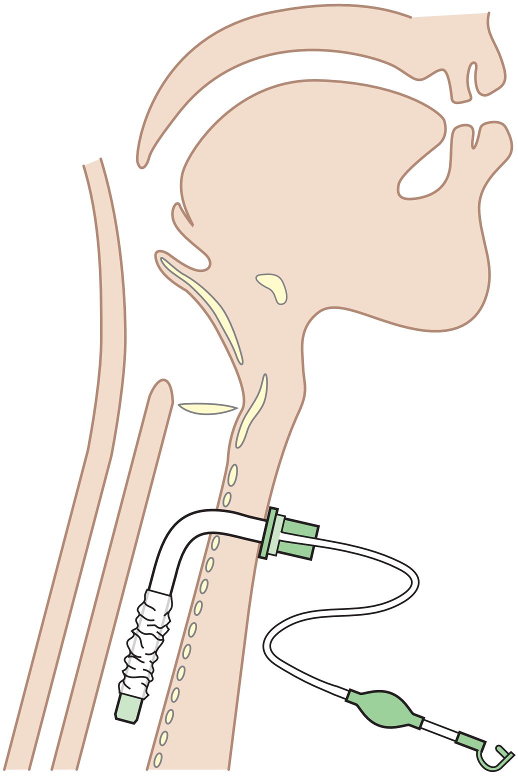


Fig. 10.9 Diagram showing the reduced pressure and volume of the cuff after deflating. ()

Fig. 10.10 Treatment with a tracheostomy tube with deflated cuff: Directing airflow through the upper airway during exhalation. ()

The patient is able to sense residues, which can then be coughed up and/or subsequently swallowed.

The patient may cough during the first attempt to close the TT in an exhalation phase. This reaction can be considered positive, i.e. normal, and indicates that the patient is able to sense and cough up secretions. The response may suggest that secretions in the upper airway caused the irritation which led to coughing.

A finger and a moist compress are used to close the TT again for each exhalation. This allows the expiratory airflow to escape physiologically via the throat and nasal or oral cavity. Asking the patient to phonate "haa" also enhances the ability to sense and react to residue. A combination of assisted exhalation and slight vibration on the ribcage has also proven useful (Gratz and Müller 2004).

If the patient tolerates occlusion of the TT during the exhalation phases, the moistened compress can be replaced with a speaking valve.

Warning

- Deflating the cuff of the TT without concurrent therapeutic intervention (Heidler 2007) exposes the patient to the risk of aspiration! Treatment must be continued during the periods when the cuff of the TT is deflated, until the physiological control of air flow and spontaneous swallowing becomes reliable in terms of quantity and quality. These functions must be performed effectively and efficiently with the TT occluded.
- Coughing often causes patients to change their position. The TT may cause irritation once it is able to move freely within the trachea. Attention must therefore be paid to the postural background ("long neck"). Coughing and swallowing assistance should be provided as and when necessary!

Many patients are still unable to move the lower jaw and tongue selectively when they first attempt to swallow. They have difficulty maintaining stability of the jaw and moving the tongue simultaneously. The jaw support grip (▶ Fig. 5.3) can be used to stabilise the lower jaw whilst swallowing aid (▶ Figs. 5.2b and

5.4b) is offered; e.g. two fingers can be positioned laterally to the posterior third of the tongue for "support" (► Chap. 5). It is important that the position of the fingers does not interfere with movement of the hyoid. This method of assisted swallowing gives the tongue and hyoid a better sense of the anatomical location from which the movement should arise.

The TT can also be occluded during inhalation, if the patient is able to breathe through the nose without effort. If inhalation and exhalation are both possible without strain, a moistened compress, speech valve or cap can be used to close the TT.

If the initial breathing work is successful, the next step is stimulation of the swallowing process or work to improve the quality of swallowing movements. Attention must be paid to the frequency and quality of swallowing in deflated conditions.

Practical Tip

- Saliva accumulates in the cheek pouches of patients who are treated in a side lying position. This must be removed periodically to prevent it overflowing into the throat.
- Evaluating voice quality can help make any penetration into the larynx audible, if the patient is able to speak or make sounds. If the patient's voice sounds moist or bubbly it is essential to clean the glottis by swallowing, throat clearing or coughing, before each subsequent procedure.

► Overview 10.5 provides an overview of therapeutic interventions after deflating the cuff of the TT.

Overview 10.5 Therapeutic Interventions After Deflating the Cuff of the Tracheostomy Tube

- Use a moist compress to close the TT during exhalation.
- If possible, stimulate use of the voice during exhalation.
- Use of a speech valve.
- Close the TT (with a moist, gloved finger) during both inhalation and exhalation.
- Close the TT (with a moist compress/cap) during both inhalation and exhalation.
- Perform tactile oral stimulation.
- Assist coughing.
- Use the jaw support grip and/or assist swallowing if the patient attempts to swallow.

Warning

For different reasons air may not pass by the TT into the upper airway. If so it is essential for survival to open the TT immediately.

The **cause** of the problem must then be identified:

- Size of the TT: A size 10 or 9 may be too large to allow sufficient air to flow past the TT.
- Bilateral vocal fold paresis.
- Granulation tissue in the trachea.
- Tracheal or laryngeal stenosis (► Sect. 9.4.5).

Warning

Endoscopic examination is urgently indicated in the event of an obstruction of the airway.

The TT is initially uncuffed for a brief period (not longer than 3–5 minutes), which can be extended as required.

If the patient's TT is uncuffed outside of the treatment sessions, a speaking valve or fenestrated TT can be supplied. Both have a regulating effect on breathing (Leder et al. 1996).

Warning

The holes in a fenestrated TT must be positioned correctly when the tube is inserted into the trachea. This must be controlled, as the holes are often positioned within the tracheostomy canal where they cannot fulfil the task of directing expiratory air towards the larynx. This can also encourage the development of granulation tissue.

Fig. 10.11 Closing the tracheostoma after decannulation, with a compress and an air-impermeable backing sheet. The patient is in a side lying position. A second person supports the head in an optimal position. (© Sticher & Gratz 2019. All Rights Reserved)

Some clinics perform temporary decannulation, covering the patient's tracheostoma for the duration of a therapy unit. The conditions created by the taped tracheostoma (Fig. 10.11) are advantageous during treatment to deepen respiration and improve the mobility of the head and neck. The reasons for early decannulation cited by Sasaki (2016) also support this approach.

Note

Reasons for early decannulation:
- Prevention of central disorganisation of the laryngeal closure reflex (Sasaki 1977)
- Restoration of physiological functions of the larynx (Sasaki 2016)

The type of tracheostomy is crucial in terms of procedure. Percutaneous dilatational tracheostomy creates particular difficulties. There may be cosmetic advantages for the patient, but the therapeutic process is made more difficult (Graumüller et al. 2002).

Note

The punctured channel of a percutaneous tracheostomy may contract relatively quickly (within minutes) making it difficult to reintroduce a TT of similar size.

Our approach is not always viable with a dilatational tracheostomy. The punctured channel can contract within minutes without the TT to maintain the space, making it difficult or impossible to reintroduce a TT of similar size. The Burgau Therapy Centre has developed a special placeholder which allows immediate, airtight closure of the tracheostoma. The placeholder clicks into a special plaster, which is then attached to the skin of the tracheostoma and prevents the placeholder being pulled out by the neck ties. Mechanical irritation is minimised.

As an alternative, a fenestrated TT or short cannula can be used for the duration of the treatment session (► Sect. 9.3.3).

Warning

A placeholder or TT of sufficient length must be selected. The inner skin of trachea can close without warning if the end of the placeholder does not extend slightly into the trachea.

► Overview 10.6 outlines the F.O.T.T. approach to the deflating of a TT cuff.

Overview 10.6 F.O.T.T. Focus Points for Deflating a Cuff
- Determine the position for treatment.
- Therapeutic cleaning of the mouth and nose.
- Therapeutic suctioning.
- Therapeutic deflating of the cuff.
- Direct airflow through the upper airway.
- Facilitate swallowing.

Once treatment in the decuffed condition is completed
- Inflate the cuff again.
- Clean the entire area (oral, nasal, pharyngeal, tracheal).
- Complete documentation.

10.3.7 Interprofessional Cooperation

The above course of action is based on an interprofessional management approach (Higgins and Maclean 1997). Working with tracheostomised patients demands adequate background knowledge and collaborative skills on the part of everybody who interacts with the patient. The range of professional disciplines involved in the care of patients with TTs varies from facility to facility, but includes:

- Occupational therapy
- Speech therapy
- Physiotherapy
- Nursing
- Nutritional advisors
- Medical staff

Consultation and clear agreement within the team are essential. The implementation of these agreements must also be thoroughly documented, to facilitate informed decision-making or changes in procedure (Frank et al. 2007; Gratz and Müller 2004; Higgins and Maclean 1997). The success of any case of tracheostomy tube management (TTM) rests on its practical implementation. There must be scope for variation based on individual patient needs. Of great advantage are F.O.T.T. supervisors who can play an important advisory role.

An examination with a laryngoscope (through nose and/or TT) gives additional information for the treatment if it is fully integrated into an F.O.T.T.-based approach (Lipp and Schlaegel 1997); e.g. position of the TT can be controlled or management of secretions can be evaluated by this examination.

Facilities vary in their approach to wean a patient from a TT. Studies based on the F.O.T.T. approach have shown that the skills and experience of staff play a part in this process, as does the type of TT system used (► Chap. 9, Frank et al. 2007, Seidl et al. 2007).

Factors that might influence this weaning approach in each individual patient case are summarised in ► Overview 10.7.

Overview 10.7 Factors Which Determine the Weaning Approach

- General condition of the patient
- Postural background of the patient
- Movement capacity of the patient
- Potential positioning in sitting, supine and standing (also outside of treatment)
- Effectiveness of airway protection
- Type of tracheostoma
- Previous bronchopulmonary infections and (aspiration) pneumonia
- Existing difficulties with reflux
- Results of FEES, bronchoscopic and (if required) videofluoroscopic examinations
- Staffing, temporal and professional capacity of the facility
- Cooperation of relatives
- Patient care following discharge from the hospital to the home, residential or day care facility or other facility.

The optimal care and treatment of the tracheotomised patient is guaranteed by effective tracheostomy management and well-trained staff. The goal of permanent decannulation and tracheostomy closure is not always achievable. However, an increase in normal input for the patient is possible through small steps in the right direction, such as regular periods of deflating the cuff and the provision of a speaking valve. This is a prerequisite for the patient's further development and potential for verbal communication.

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F.O.T.T. Assessment: An Ongoing Process

Margaret Walker

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F.O.T.T. is a therapeutic approach, developed specifically for the treatment of patients with neurological disorders. The process of diagnostic assessment encompasses the four main F.O.T.T areas: nutrition/eating, drinking and swallowing; oral hygiene; non-verbal communication; and breathing, voice and speech.

This chapter guides through the process underlying the F.O.T.T. approach to assessment, highlighting the complexity of these interactions. It would not be possible to describe every eventuality within a single chapter. The topics to be assessed are discussed in detail within the individual chapters of the book.

> It is not enough to tick the box, you have got to open it and make use of the contents. (Coombes 2010, personal communication)

Therapists, working with patients who have complex symptoms, make decisions that have significant implications, e.g. the amount of therapy input a patient receives and whether, or in what form, a patient may be allowed to consume food or drink. Those decisions can be potentially life-threatening, or life-altering, e.g. no food or taste for the rest of their life, due to incorrect assessment.

F.O.T.T. emphasises the importance of the *postural background and its influence on the functions of the face and oral tract.* Inadequate posture results in the patient being unable to maintain or adapt their posture dynamically against gravity. Changes in muscle tone affect the movement of the trunk, neck and head. This in turn has a negative effect on airway protection, breathing, swallowing (saliva, food and liquids) and communication.

For this reason, both background posture and muscle tone are observed and analysed throughout the assessment process and treatment. Observations made during the assessment of facial movements also have relevance to the assessment of the oral cavity; for example, many of the muscles responsible for facial expression are involved during swallowing and speaking.

If it is not possible for the patient to actively initiate movement, the initial assessments are integrated into the first treatment session. The therapists must use their hands to feel and manipulate the structures and functions of the body and guide the patients' movements where necessary. This enables the patients to feel and understand the intention of an activity (movement) and, if possible, take over the movement with assistance.

Symptoms are a snapshot of the patient's abilities at a given moment. The therapist is like a detective, investigating the causal relationships which give rise to the patient's symptoms, including muscle tone, posture and movement. For example, hyolaryngeal excursion can be hampered or impaired by a compensatory pattern of shortening and forward translocation of the head and neck (▶ Chap. 4), in a patient with trunk instability.

Throughout the assessment process (and treatment), the therapist formulates hypotheses regarding the underlying cause of the patient's symptoms. These hypotheses are constantly reevaluated and used to determine the therapeutic emphasis and treatment algorithms (▶ Chap. 12). F.O.T.T. applies a differential diagnosis to the underlying cause of a patient's problem. An appropriate working hypothesis can then be formulated. Examples of this can be found in ▶ Chap. 6.

It is important to establish a working relationship between the therapist and patient whilst being mindful that the partnership is unequal.

11.1 Objectives of F.O.T.T. Assessment

> F.OT.T. assessment consists of more than reaching a diagnosis (Fuchs 2010, personal communication)

The F.O.T.T. assessment process seeks to:

- Assess the individual as comprehensively as possible, including abilities and difficulties.
- Assess and describe not only the main problems, e.g. inefficient airway protection or impaired postural background, but also the complex interconnections between the symptoms.

- Identify the underlying causes including perception, sensation, movement, cognition and their influence on observed behaviour.
- Develop hypotheses and formulate both short- and long-term goals:
  - Short-term goals should be reevaluated and reformulated after 2–3 weeks.
  - Long-term goals indicate what should be achieved during the patient's hospitalisation or within the first months.
- Use therapeutic techniques designed to create change through treatment, e.g. changes in the patient's starting position, vocal facilitation, oral stimulation and asymmetrical biting of food wrapped in gauze.
- Identify the patient's strengths, i.e. abilities, which can be utilised during the treatment process. For example, is the patient able to attract attention or turn himself independently in order to reach the buzzer?

Regular assessment helps the therapist to generate, modify and adapt treatment plans.

11.2 F.O.T.T. Assessment Principles

Note
F.O.T.T. principle: Know the normal! The better we understand what is normal, the more able we are to detect deviations from the norm.

F.O.T.T. assessment – treatment – evaluation: a continuum (Coombes and Davis 1987)

Assessment is an ongoing process of information gathering and treatment followed by evaluation (Fig. 11.1). Every treatment session is a source of fresh information. This is the only way to assess the effectiveness of the treatment or decide whether the approach needs to be modified.

The patient's behaviour and responses to therapeutic input are continually evaluated. Whilst treating the patient, the therapist is simultaneously testing to establish whether muscle tone, movement or coordination can be influenced by therapeutic handling to create a change in function. Can muscle tone be influenced by treatment, to the extent that it becomes possible for the patient to perform a function? The assistance provided should not have a negative effect on overall function or promote further compensation or pathology.

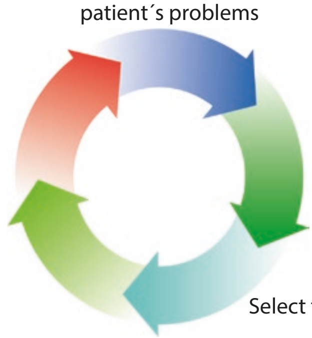

Fig. 11.1. F.O.T.T. model: Each step requires an understanding of the characteristics of normal development and normal movement. (© Coombes and Davis 1987. All Rights Reserved)

> Why are you continuing to do something that clearly does not work? (B. Bobath speaking to her young student Kay Coombes, during the 1970's)

Knowledge and understanding of the normal human system are essential

Not only are physiology, anatomy and the movements of swallowing important but also knowledge of voice production, articulation, non-verbal communication and breathing. Identifying and treating these systems in their complexity rather than as isolated areas is a defining feature of F.O.T.T.

The functions of breathing, swallowing and speech are interdependent and work in coordination with each other

The therapist assesses the interplay of facial oral functions and the occurrence of protective mechanisms (▶ Sect. 1.1.1). Patients with rapid, shallow breathing are unlikely to exhibit a normal swallowing frequency or normal speech production. They may then be limited to short, one word responses.

Structured approach to the formulation of hypotheses, therapeutic goal setting and the evaluation of complex interrelationships

Simply recording symptoms by ticking boxes on a screening sheet does not help the therapist or the patient to move forward. The underlying cause(s) of the patient's behaviour and symptoms can be due to difficulties in perception, sensorimotor skills and cognition. The symptoms themselves may be primary or secondary, e.g. a result of compensation. It is therefore necessary to reflect, formulate and evaluate working hypotheses (▶ Chap. 6). The clarification of algorithms in ▶ Chap. 12 highlights the complex nature of this process.

Record the quality of movement

Evaluating the quality of movement is essential. Any alteration or deterioration in movement, such as reduced selectivity or "freezing" during movement, is noted, e.g.:

- When saying "n", can the patient lift their tongue without movement of their lower jaw or does the jaw also move upwards? The latter is compensation, which affects both speech and swallowing.
- Is an existing movement pattern reinforced every time the patient performs the same, non-selective movement?

11

Test and retest before and after an intervention as this provides information as to whether the treatment is effective.

Assessment is not a test of the patient's language comprehension

Part of the therapist's skill repertoire includes visual and/or tactile assistance, together with concise verbal cues to help the patient carry out the requested movement.

The verbal instructions provided in F.O.T.T. are not explanations of how to do something. In general, they are short and relevant to the required goal or action.

Every patient can be assessed

F.O.T.T. assessment and treatment is not dependent on the patient's level of cognition or capacity to follow verbal instructions. Severely affected patients (e.g. in coma) can be assessed just as individuals who are less affected, e.g. independently mobile.

11.3 Assessment Structure

11.3.1 Data Collection

The process of assessment begins with information gathering. This includes medical history, previous examinations and treatment. The information is compiled from patient records, direct contact with the patient and/or relatives and from other members of the interdisciplinary team. It provides the therapist with an overview of the patient's general condition, capabilities and skills, as well as positions that could potentially be used during the assessment process.

The assessment findings are recorded in writing.

11.3.2 Assessment Equipment

Facilities should be equipped with the following basic items:

- Height adjustable plinth
- Stool
- Bench
- Standing frame
- Positioning material (blankets, cushions, towels)
- Therapy packs (firm foam positioning blocks and wedges)
- F.O.T.T. therapy set:
  - Gloves
  - Gauze, plastic spatula, etc.
- Water
- Selection of food (juice, fruit puree, apple and possibly bread)

Home visits: require some creativity as therapy equipment is not always available:

- Therapy packs can be replaced with height adjustable steps.
- Blankets and towels can be used as positioning materials.

11.3.3 Required Skills

The therapists must utilise all of their skills to observe, recognise, adapt and reflect on what they see, hear and feel. They use their own hands and body to stabilize, feel, facilitate and modify movements. These required clinical skills are not purely theoretical but must be actively acquired under supervision.

11.3.4 Examination

All medical devices are noted, e.g. nasogastric tubes, PEGs, shunts, catheters and tracheostomies, including the type and size of tracheostomy tube (TT).

Throughout the assessment the two sides of the body and face are compared to each other. Any differences in symmetry and movement are noted.

A starting position is selected, which enables the patients to demonstrate their best level of function (▶ Chap. 8). In the early stages this may be a side lying position (which offers a large base of support), sitting or (supported) standing. The position should provide the patients with sufficient support so that they do not have to use compensatory fixing to maintain their position against gravity, allowing the structures of the body to move more freely.

The starting position should not be static or fixed. The patient should move, or be moved, during the assessment!

Warning

From the first moment of contact, spontaneous swallowing frequency and any symptoms which may indicate a swallowing problem are noted:

- Pooling of saliva and/or food debris in the mouth
- Drooling
- Increased and altered breathing frequency, e.g. rapid, noisy breathing
- A gurgly or wet sounding voice
- Coughing

Appropriate measures must be taken immediately if one or more of these symptoms are present, e.g.:

- Removing pooled saliva or food debris from the mouth
- Selecting an alternative starting position to reduce the risk of aspiration
- Facilitating swallowing, throat clearing or coughing, followed by a clearing swallow

11.3.4.1 Assessment of Postural Background

Trunk and head control are assessed in sitting and standing:

- Is the patient able to sit unsupported, to turn the head to each side, to see an object to the right and left?
- Is the patient able to use hands or arms during activities without losing balance?
- Is increased muscle tone a primary problem or a secondary issue caused by insufficient dynamic stability?

The test and retest method is used to assess how a position affects muscle tone, e.g. in the neck and trunk before and after changes in support.

Note

Postural background describes the position of the body in the space. It is dependent on alignment, i.e. the relationship of body parts to one other, dependent on gravity and the supporting surface. Changes in muscle tone (too much or too little) make dynamic alignment difficult. Limited trunk control, impaired balance or reduced mobility of the head and neck affect the protection of the airway. They impact on breathing, physiological swallowing movements (the transport of saliva, food and liquids) and verbal and non-verbal communication (Chaps. 5, 7, and 8).

Tongue and jaw movements are dependent on postural background (Chap. 4). For example, tongue movements are restricted if the head is tilted backwards. A stable jaw provides the tongue with the base of support necessary for movement. An unstable jaw may move with the tongue or remain tightly shut, making tongue movements extremely difficult or impossible.

11.3.4.2 Assessing the Face

The face is first assessed visually, at rest and during spontaneous movement, including visual fixation and visual tracking.

When assessing either the face or the oral tract, the therapist begins by demonstrating the movement (visual model). A brief verbal instruction is given. Additional tactile facilitation is given if the patient struggles to perform the movement. The quality of movement is assessed: Any deviation from the normal, e.g. asymmetries, is recorded.

For the purposes of the tactile assessment the face is divided into an upper third (forehead/eyebrows), middle third (eyes/nose) and lower third (mouth/cheeks/chin). The assessment of facial movement begins at the forehead. This area is less sensitive and has bilateral innervation. It is likely that the patient can feel and perform the requested movements more easily than movements in the lower part of the face (► Chap. 7).

Note

Muscle tone in the face not only affects facial expression, speech and swallowing; it also affects jaw opening, required for oral hygiene and eating. It influences the ability of the lips to remove food and liquid from cutlery and cups. An impaired pre-oral phase can have a negative impact on oral and tongue movements. It is important to remember that certain facial movements elicit mass movements, even in the absence of neurological issues, e.g. screwing up the nose.

Tactile assessment provides an indication of hyper- or hyposensitivity. Any associated reactions are noted; e.g. sweating, increased muscle tone and the patient's reaction to both self-contact (patient's own hands) and the therapist's touch.

The face may reflect levels of muscle tone prevalent in the rest of the body. Raising the eyebrows when lifting the head against gravity can be an indication of compensatory extensor tone. The hypothesis must of course be tested during the tactile assessment.

11.3.4.3 Assessing the Oral Cavity

The initial assessment of the mouth and oral cavity usually takes place with a visual assessment of the oral structures; e.g.:

- The presence of bite wounds
- Changes to the mucous membrane
- Condition of the gums
- Position and status of the teeth
- Saliva and/or food debris

When assessing severely affected patients, the tactile assessment (i.e. tactile oral stimulation routine) often precedes the visual assessment. This may provide the therapist with a brief opportunity to see inside the oral cavity (► Sect. 6.2.4).

The following factors are assessed during tactile oral stimulation:

- Muscle tone in the cheeks, lips and tongue
- The patient's reaction to touch
- Swallowing frequency
- Breath sounds

Practical Tip

Tactile oral stimulation can also be carried out with a patient who has a cuffed tracheostomy tube (TT). Spontaneous swallowing attempts are supported but not facilitated. The use of jaw support can help to reduce pumping (up and down) movements of the lower jaw.

The quality, quantity and range of jaw and tongue movements (including those of the floor of the mouth) are assessed. Guiding the patient's hand to their mouth can be helpful to promote tongue movement or jaw opening.

Warning

- If a *bite reaction* cannot be ruled out, neither the patient's nor the therapist's finger should be placed into the oral cavity, between the teeth!
- Self-made bite aids (Fig. 6.13) have proven helpful for keeping the jaw open, as they are softer than commercially available bite blocks (Fig. 6.15) and provide contact for the entire surface of the jaw.

It is important to remember that the tongue resides inside the mouth and it is not normal for it to be outside of the mouth for any period of time. Assessment of tongue movement often involves the tongue moving outside the mouth, as it is easier for the therapist. However this is not the normal functional movement of the tongue. The tongue only moves outside the mouth briefly, e.g. to lick the lips. For assessment, intraoral movements (poking the tongue into the cheek, running the tongue over the teeth, sweeping movements for clearing) and extraoral movements (poking the tongue out of the mouth, moving the tongue laterally (sideways) to the corner of the lip, licking the lips) are demonstrated. Any abnormalities in movement and symmetry are recorded. It is important to allow time for motor responses or reactions such as spontaneous tongue, jaw and swallowing movements. These responses or the lack of them are recorded.

The following are assessed if possible:

- Repeating the sound "n-ga". These movements are similar to the tongue movements required for swallowing.
- Symmetrical elevation of the soft palate when phonating "ah".

Jaw support should be used to assess the quality and selectivity of tongue and jaw movements or to support swallowing if required (▶ Sect. 5.3.3.1; ◘ Fig. 5.2a; ◘ Fig. 5.3 and ◘ Fig. 5.6).

11.3.4.4 Assessing Breathing, Protective Mechanisms and Voice

Breathing, airway protection and voice are assessed throughout the examination. Different positions are used, i.e. side lying, sitting, standing and walking if possible. Any changes to breathing or voice due to a change in position are documented. Positions to be avoided (initially) are also recorded, e.g. the supine position, as saliva can be aspirated more rapidly in this position and effective coughing is not possible.

Warning

- Breathing and voice are affected by emotion, e.g. levels of insecurity, anxiety or fear and effort. Muscle tension increases if the patient strains to produce a voice and associated reactions may occur.
- Patients with a tracheostomy tube always have disturbed breathing (▶ Chaps. 9 and 10) !

The aspects of breathing are assessed using visual, auditory and tactile (with the hands) information as appropriate:

- Breathing frequency
- Breathing rhythm
- Breath sounds (e.g. stridor)
- Type of breathing (e.g. costo-clavicular breathing movements primarily evident in the shoulder girdle and neck muscles, paradoxical breathing)
- Symmetry of breathing movements
- Nasal and oral breathing
- Requirement for artificial oxygen via a nasal oxygen cannula or tube

If the patient requires a monitor, breathing, heart rate, temperature and blood pressure are recorded in addition to oxygen saturation levels.

Warning

It should be noted that any decrease in oxygen saturation does not immediately appear on a monitor, but is subject to a delay (1–2 minutes)!

During the tactile assessment (contact to the lateral ribcage), changes in breathing are carefully recorded. This can provide a way of beginning treatment and initiate positive changes to breathing.

If structural anomalies prevent mouth breathing, e.g. a tightly clenched jaw or if the upper airway is blocked due to hypotonic oral and/or pharyngeal structures, the possible causes must be determined.

Warning

A patient who is unable to open the mouth risks suffocation if the nose becomes blocked. It is therefore vital to establish whether mouth and nasal breathing are possible before removing a TT. An instrumental evaluation using FEES (fiberoptic endoscopic evaluation of swallowing, Langmore 2001) is urgently required in this case.

Breathing is assessed in relation to airway protection (Fig. 9.8). The following questions elicit important information on the protection of the respiratory tract:

- At which point in the breathing phase does the patient swallow?
- Does the patient exhale after swallowing?
- Does breathing (and voice) change after swallowing?

Note

Breathing-swallowing coordination: The exhaled air disturbs saliva and/or food debris, which touch and irritate the mucous membrane. This can cause various reactions: swallowing, throat clearing, coughing and spitting with or without a clearing swallow.

Hypotonic abdominal muscles make it difficult to cough forcefully enough to clear the lower airway and pharynx. Exhalation after swallowing is an important element in the protection of the airway (▶ Chaps. 5, 8, 9 and 10).

11.3.4.5 Assessment of Voice and Speech

During the entire assessment the therapist collects information as to whether the patient can spontaneously phonate (produce voice), e.g. throat clearing, coughing, groaning or whether he/she is able to speak.

The quality and sound of the voice are evaluated:

- How long can voice be maintained (normal tone duration is 10–15 seconds)?
- Is voice spontaneous or in response to verbal instruction or an auditory model, e.g. pronouncing a surprised “ah”?
- Can the voice be facilitated using an auditory model and tactile support to the lateral ribcage and/or vibration on the sternum?
- What is the quality of the voice: breathy, hoarse, gurgly, wet, nasal, forced, constricted, monotone, slurred, overly loud or quiet, or clear? Are there changes in pitch and intonation (melody)?
- Is the voice produced at the beginning (normal) or end of exhalation or during inspiration (pathological)?
- Can the patient communicate using speech? Are there attempts to form isolated sounds?
- Can the patient join in with automatic speech (counting, greetings)?
- Does the patient use individual words or intelligible, situation-appropriate sentences?

In order to assess the voice of *patients with a cuffed* TT the cuff must be deflated and a gloved finger or speaking valve used to close the TT (▶ Sects. 9.5, 9.6 and 10.3).

Tactile assessment of the larynx

Laryngeal movements are observed and assessed during *vocalisation, speech* and *swallowing*. A tactile assessment of lateral movement is performed, including symmetry. The hand performing the examination is stabilised on the sternum; the range of motion is measured using the thumb.

11.3.4.6 Clinical Assessment of Swallowing

Spontaneous swallowing of saliva

Spontaneous saliva swallowing is assessed as soon as the therapist meets the patient and throughout all activities and movement transitions. The swallowing sequence, quality of the movement, timing and frequency of swallowing (at rest approximate 1 x pro minute) are recorded.

If spontaneous saliva swallowing occurs rarely or not at all, motor responses and swallowing reactions are recorded following *facilitation*, e.g. during tactile oral stimulation (▶ Sect. 6.2.4).

Note

Breathing-swallowing coordination: Swallowing does not occur in isolation. It is part of a complex system and is coordinated with breathing and voice production. It is important to assess not only the motor movements required for swallowing but also the patient’s breathing and the coordination between breathing and swallowing.

Swallowing of saliva, food and liquid

The swallowing sequence is initially examined during the tactile oral stimulation routine, i.e. assessment without food. For the initial examination *water* is used and noted at the start of the assessment.

Water

Pre-oral phase

The anticipatory phase before the liquid or food reaches the mouth is assessed. Are there indications of the patient getting ready for the medium being used?

Potential scenarios for the situation

The patient may be assisted to hold the cup and dip the finger into the water before being guided to take the coated finger to the mouth.

If it is determined that the patient is able to manage small tastes, e.g. a finger coated with juice, he then can hold or he can be assisted to hold an orange in both hands, and stick a finger into the flesh of the fruit to coat it with juice. His finger is guided to his mouth. Alternatively, a bottle of orange juice can be opened together with the patient and poured into a glass. The patient's finger is dipped into the juice and the coated finger or a spoon is guided to his mouth.

What reactions are observed before the water/juice reaches his mouth?

- Does the patient have sufficient postural background?
- Does the patient make oral preparatory movements and/or swallow saliva?
- Does the patient's gaze follow the activity?
- Is there observable hand-eye coordination, hand-hand coordination and hand-mouth coordination?

Oral phase

During the oral phase, jaw opening and closing, jaw and tongue movements, sucking and oral transit are observed in terms of execution, quality, timing and duration:

- What can be seen, felt and heard?
- Are the observable facial movements and oral movements adequate?
- Are there changes in breathing?

Pharyngeal phase

Visible or audible signs of quality, range, speed and timing of movement are assessed during the pharyngeal phase, e.g.:

- Does the patient swallow promptly?
- Is hyolaryngeal excursion (elevation, anterior tilt and descent) complete, prompt and consistent in duration?
- Does exhalation follow swallowing?
- Are the nasopharynx and lower airway closed during swallowing, i.e. saliva does not enter the nose, no sneezing, throat clearing or coughing?
- Does breathing change and is the voice clear after swallowing?
- Are clearing swallows evident?

Swallowing movements can also be detected tactilely, through the floor of the mouth and the larynx.

Esophageal Phase

The esophageal phase can only be clinically assessed by means of indirect symptoms, such as burping, gastro-esophageal reflux disease (GERD) or heart burn, subjectively described as retrosternal.

> **Warning**
>
> An *assessment of swallowing* using food and liquids should not be undertaken if the patient:
>
> - Is unable to sit (supported)
> - Has insufficient head control
> - Has severely reduced swallowing frequency or no swallowing or if the larynx does not move sufficiently
> - Is aphonic (with or without a cannula!)
> - Has inefficient protective mechanisms; i.e. the patient does not cough spontaneously and/or clear the throat when required or if there is no clearing swallow
> - Has fluctuating levels of alertness

Asymmetrical biting

Asymmetrical biting – a precursor for chewing – is carried out if there is uncertainty regarding bolus formation, bolus transport and airway protection. The selected medium should only produce *small amounts of juice* (e.g. apple, dried fruit, salami). The gauze-wrapped food is placed between the molars on one side of the mouth and held securely by the therapist. It is removed after the patient has bitten the sack once or twice. Following swallowing, breath sounds and/or voice are checked and a clearing swallow facilitated before another piece is placed in the opposite side of the mouth (◘ Fig. 5.7c).

Cheek, tongue and jaw movements are assessed during *asymmetric biting*. Swallowing frequency and its effectiveness are measured, e.g. by the amount of saliva remaining in the mouth after swallowing or increasingly wet breath or voice sounds. *Patients with TTs* perform asymmetrical biting only when the TT has been decuffed and a speaking valve attached.

The subsequent assessment with food and liquids is only undertaken if the patient is able to safely manage the examination with water and asymmetrical biting (described above). Following assessment the therapist selects a consistency which the patient can safely swallow, e.g. pureed or soft food.

All phases of the swallowing sequence are assessed when evaluating the appropriateness of *pureed, soft and firm consistencies*.

In addition to the postural background, the following aspects are noted during the *pre-oral phase*:

- Interest shown in food
- Observable hand-hand coordination
- Observable hand-eye coordination or hand-mouth coordination
- Use of cutlery and ability to cut food

The following aspects are observed during the *oral phase*:

- Taking food from a fork or spoon with the lips
- Biting
- Sucking/drawing in liquid
- Bolus formation and bolus transport

Aspects observed during the *pharyngeal phase*, see above (examination with water).

Liquids

The patient's ability to swallow liquid is initially assessed by observing spontaneous saliva swallows, use of the tactile oral stimulation routine and asymmetrical biting in gauze. If the patient is able to safely swallow the excess liquid produced by the bitten material wrapped in gauze, the therapist can place small amounts (drops) of liquid into the patient's mouth, using a straw as a pipette. The ability to move the lips forward, maintain lip closure, form a bolus and bolus transit time are noted, as are breathing and clearing swallows.

Each consistency should be offered at least *three times* before increasing the quantity.

If the swallowing trial has to be halted because it is unsafe or causes coughing, the *reasons* must be determined. Before attempting another swallowing trial the position of the patient and the oral structures are reassessed and the consistency and/or quantity can be changed.

Note

For airway protection it is important that the patient can be brought (leant) *forwards* in case of choking. Factors that hinder this must be identified, e.g. hip contractures or fractures.

The Berlin swallow test, based on the F.O.T.T. approach, uses pureed food first, then water and solid food consistencies for testing (Berlin swallow test, BST, Schultheiss et al. 2011 ► http://schlucksprechstunde.de/new/wp-content/uploads/2012/06/Berlin_Swallow_Test_e.pdf).

11.3.4.7 Aspiration and Risk of Aspiration

The assessment of aspiration or aspiration risk is just as important for patients who have a PEG and do not receive nutrition orally. The assumption that there is no risk of aspiration in these cases is false. The aspiration of (bacterially contaminated) saliva and/or gastroenteral reflux material can lead to pneumonia.

Warning

Silent aspiration can never be ruled out by clinical examination. It requires instrumental evaluation. However, a comprehensive and systematic clinical assessment should alert the therapist to *signs of silent aspiration*. These include the following:

- Delayed swallowing
- Audibly altered or increased rate of breathing
- Wet sounding voice
- Absence of voice

- Eyes occasionally moist, facial grimace before or after swallowing
- Delayed or absent cough
- Subfebrile temperatures of unknown cause

The decision as to whether and how the patient receives nutrition depends on the entire assessment, e.g. whether only small amounts can be given during therapy, or are dependent on the patient's level of alertness and stamina or whether an oral diet three times a day is possible. Some patients may require a combination of an oral and enteral diet.

During the assessment the patients' ability to spontaneously protect their airway and the risk of aspiration in all situations is noted. The presence or absence of spontaneous protective mechanisms and their effectiveness must be evaluated. The level of *alertness, background posture and pathological reactions, e.g. premature gag*, are also important factors. Effective protection of the airway is characterised by a spontaneous swallow, strong throat clear or timely cough, followed by a clearing swallow. In the absence of a clearing swallow, residues remain that could re-enter the airway.

The model by Lehmann and Müller discussed in ► Sect. 5.4.2.1 (◘ Fig. 5.5) is helpful for evaluating the risk of aspiration. If the key factors *swallowing* and *protective mechanisms* are insufficient, the risk is high and the additional factors of *alertness, postural background* and *overall condition* must compensate to ensure safety. The BDI model can also be used for evaluation purposes (◘ Fig. 9.8).

11.3.4.8 Assessing Communication

The *ability to communicate* is an essential part of being human. It allows us to participate in society, exchange information and share our thoughts and opinions with others.

Problems with verbal and non-verbal communication can be neglected in rehabilitation. Therapeutic resources are often limited. As a result, walking/mobility, eating and drinking are often prioritised by the team, family members or by the patients themselves. There is often significantly less time spent on establishing other means of communication, e.g. using pictures to communicate non-verbally. Communication books or devices are often ignored or not all members of the team know how to use them effectively.

The assessment should establish *how the patient communicates*:

- Does the patient communicate by speaking and/or in writing or non-verbally by means of gestures and facial expressions? Does he use an alternative means of communicating (alphabet board, pictures, digital, high-tech devices)?
- Is the patient able to make eye contact with the therapist, track movements in the room visually or use sounds to participate in dialogue ("turn taking")?

The goal is to formulate *hypotheses about the patient's potential to communicate*:

- Can the patient close the eyes independently if instructed or with help?
- What other selective movements are available that might be used for the purposes of communication, e.g. foot, finger or head movements?

Warning

All too often, patients are instructed to hold their thumbs up for "yes" or down for "no", without any real communicative purpose. The patient is told to practice these movements and repeat them when asked, but there is no real context of communication. It is more useful to develop a range of options for communication which the patients can use for themselves.

It is also important that the movements selected for communication do not have an adverse effect on muscle tone and function in the long term. The potential for communication should therefore be assessed in the context of a realistic conversation, rather than in a test situation.

Note

Patients with limited head and neck mobility not only experience swallowing difficulties, but are also likely to find it difficult to communicate using non-verbal gestures such as head nodding or shaking.

11.4 Further Evaluation

- The utensils required by the patient must be checked for suitability, e.g. Pat Saunders straw and feeding cup (Fig. 5.13).
- Dental examination is indicated for patients with gum infections, damaged or loose teeth, toothache, ill-fitting dentures or those requiring a bite guard. Orthodontic consultations are indicated in cases of jaw malformation and for patients who cannot close their jaw due to long-term alterations in muscle tone.
- The indications for further instrumental examination must be considered, e.g. FEES and videofluoroscopy:
  - Not every patient can undergo a videofluoroscopy procedure, e.g. if the patient cannot sit or stand or hold the contrast agent in their mouth and swallow when instructed.
  - A FEES evaluation is possible with severely affected patients. There should be a clinical reason for assessment, formulated by the carers or therapists; e.g.: Why is oral and nasal breathing difficult or impossible?
  - A FEES evaluation is required for patients with a TT, to assess for saliva residue, pressure areas and granulation tissue.
  - A FEES evaluation before removal of the TT (▶ Chap. 9) is essential.
- A gastroenterological examination (e.g. a 24-hour esophageal pH metry test) must be carried out if the patient vomits or complains of nausea when eating or if these symptoms are recorded in the case history. A manometry may be indicated if the patient complains of "food sticking", e.g. at sternum level to measure pressure in the esophagus. Zenker's diverticulum must be ruled out if (undigested) food is regurgitated – sometimes hours after it has been consumed.

11

11.5 Areas Not Assessed

Gag Reaction

The presence of a gag does not guarantee effective swallowing or adequate protection of the airway. Conversely, the absence of a gag in an assessment situation does not necessarily indicate that it might not be present in an emergency.

Water Swallowing Tests

Innumerable water swallowing tests are published. The evidence on their utility for bedside screening is inconclusive (Virvidaki et al. 2018). While these tests are mentioned in stroke guidelines they contradict the author's therapeutic experience.

Note

Neurological patients often have great difficulty swallowing liquids. They have delayed initiation, slowed movement and/or delayed protective reactions:

- For many neurological patients drinking water results in an often foreseeable choking scenario, in which aspiration occurs without any relevant information being gained about the underlying disorder.

  In many cases, puree is the first consistency which can be swallowed.

  The F.O.T.T. approach does not advocate a "one test fits all" before deciding on oral nutrition. The BST (Berlin swallow test, Schultheiss et al. 2011) is an alternative and screens water, puree and solids for testing food consistencies. Following testing, a medium is selected that the patient can safely swallow and another medium may be used to improve movement quality and the coordination of the swallowing sequence (therapeutic eating, ▶ Sect. 5.5.2).

  Rather, the capabilities of the individual patient and the resources available in the setting are considered.

Repeated Assessment Without Treatment

Assessment plays a significant role in the F.O.T.T. approach. If the assessment and resulting hypotheses are incorrect, then the treatment will be ineffective or less effective than it should be.

Assessment alone does not help the patient further. All too often patients are simply tested and retested to see if their condition has changed without any treatment actually being carried out. This is neither helpful nor useful. Without treatment, during which any effect on the patient's symptoms can be observed, repeated clarification is pointless.

11.6 Closing Thoughts

The ICF classification can be used to categorise problems according to the different levels of body structures/functions, activities and participation (WHO 2012). The patient and/or family (and the team) agree on the goals that each discipline will implement. If the expectations or goals formulated are unrealistic, it is the therapist's responsibility to guide the patient and family towards more realistic treatment objectives.

The assessment process guides therapists and/or carers in their approach to treating the patient. However, in severely affected patients, we often need to initiate the treatment process and formulate goals based on the responses of the patient to treatment, rather than waiting for them "to be ready for treatment".

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The F.O.T.T. Algorithm: A Clinical Decision-Making Tool

Daniela Jakobsen

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The lack of evidence-based practice has led to the characterisation of complex interventions in neurorehabilitation as a "black box" which provides little insight into its contents (Whyte and Hart 2003). The contents of a complex treatment approach must be determined, however, to be able to examine the effectiveness and efficiency of the approach. The current F.O.T.T. algorithm was developed in 2010 and updated in 2017. It aims to guide both the experienced and the inexperienced therapist in clinical reasoning processes during the assessment and treatment of people with problems in the facial-oral tract. It visualises and simplifies the process of assessment, supports the analysis of the patient's problems and underlying causes and guides through the process of goal setting, treatment planning and evaluation of the patient's response to the therapeutic interventions. It provides a systematic description of frequently used F.O.T.T. interventions, establishes criteria for their use based on clinical reasoning and provides suggestions how to grade them. The algorithm has been further developed over the last years, inspired by using it for teaching and developing F.O.T.T. in practice. This chapter presents the algorithm and discusses options how to use it for clinical reasoning in clinical practice and for future research.

12.1 The History of the Development of the F.O.T.T. Algorithm

Bovend'Eerdt (2009) describe rehabilitation as an "archetypically" intervention, where patients get many different interventions, given by "different people, frequently in a specific sequence". Considering the definition of complex interventions to improve health by the UK Medical Research Council (2018), F.O.T.T. is such a complex approach in neurorehabilitation. While complex interventions contain several interacting components, they may also exhibit different dimensions of complexity. This may have to do "with the range of possible outcomes, or their variability in the target population, rather than with the number of elements in the intervention package itself" (UK Medical Research Council 2018). Other factors contributing to the complexity may include the "... interactions between components of the intervention, the difficulty of the behaviours required by those delivering or receiving the intervention" or the "number and variability of outcomes", just to name a few examples (UK Medical Research Council 2018). Working with complex interventions to improve health provides several challenges for both clinicians and researchers.

The idea to develop a decision-making model for F.O.T.T. has its origin in a highly specialised department for subacute neurorehabilitation in Copenhagen, Denmark. In this facility, F.O.T.T is used in an interdisciplinary context for patients with severe acquired brain injury (Hansen and Jakobsen 2010). The F.O.T.T. approach is based on the Bobath concept and contains multiple components (i.e. techniques and methods), deriving from the principles and theoretical assumptions about motor learning, childhood development and neural plasticity. Clinical reasoning is used in the process of assessment and analysis, as well as for establishing working hypotheses, goal setting, treatment and evaluation. Barrwos and Pickell (1991) define clinical reasoning as a "…dynamic, cyclic, reiterative process in which observation, analysis, synthesis, deduction, induction, generation and testing of hypotheses, inquiry-strategy design, and the skills of examination are all interrelated". Michielsen et al. (2017) describe similar processes of clinical reasoning as essential parts of the Bobath concept.

- **Background for the development from the clinician's point of view**

The F.O.T.T algorithm has been developed by Hansen and Jakobsen (2010) in a department for patients with severe brain injury in the subacute state. It is based on participant observation of both experienced and unexperienced occupational therapists (OTs) in their clinical work with F.O.T.T. In our setting, F.O.T.T is a core competency of the OTs, but still, the approach is delivered in an interprofessional manner, involving different professions such as physicians, physiotherapists, speech therapists and nurses.

Each staff member in the clinic is introduced to the F.O.T.T. approach, when relevant for their specific profession. There is regular access to education, training and supervision by a certified F.O.T.T. instructor and several experienced OTs during daily work. The permanently employed OTs complete a five-day F.O.T.T. basic course within the first year of their employment to ensure a proper quality of their theoretical understanding and clinical competence working with F.O.T.T.

Before developing the algorithm we observed that the process of assessment, goal setting and evaluation of the patient's response on the treatment differed not only between experienced and less experienced therapists but also within the group of highly experienced therapists. For example, different therapists varied in their opinion, whether the same patient could eat or drink safely by mouth. In other cases, the amount or type of support given to a patient during therapeutic eating differed, e.g. in terms of the appropriate consistency of the food or liquid or the position for eating and drinking or in choosing strategies to facilitate swallowing of saliva. Furthermore, the structure of the assessment and treatment could vary. Also, treatment methods or techniques were selected and combined differently, for instance, to target unhelpful reactions, e.g. biting reactions during oral hygiene.

Research on the process of clinical reasoning has shown that the way reasoning is used varies with the level of experience of the therapist (Kuipers and Grice 2009). These differences refer to the whole process of assessment and treatment, including goal setting, the choice, dose and intensity of treatment interventions, and may thereby affect the patient's outcome.

In our clinic, less experienced therapists seemed to have greater difficulties to get an overview of the range of interventions used in F.O.T.T., when and how to use them, how to interpret the patient's reactions and thereafter to modify the treatment. They seemed to choose "exercises" arbitrarily, without evaluating the quality of the movement, and had difficulties to grade the interventions, e.g. to elicit adequate response in terms of functional selective movements or movement patterns or sequences. Observation and critical evaluation of the patient's reactions or movement behaviour are essential for the process of clinical reasoning in F.O.T.T.

Critical questions to be asked include: How does the patient respond to the therapeutic interventions? What must be changed to get the intended response? In addition, the process of goal setting could be challenging for OTs. For example, goals could be unconcrete, not evaluable, unrealistic or too easy to reach within one treatment session. Bovend'Eerdt (2009) and Wade (2009) highlight goal setting as a central part of rehabilitation and stress the advantages of setting SMART goals, which stands for *specific, measurable, attainable, relevant* and *time-related goals.*

Nevertheless, the goal setting process in an interprofessional setting can be challenging. Plant and Tyson (2018) found some evidence that inpatient stroke rehabilitation involved hurdles such as ensuring the consistency of goals, the integration between goals and actions or the involvement of the patient and the relatives in the process. Only a minority of goals met the SMART criteria and many goals were never reviewed or linked to previous goals. In some instances, goals were unconnected to a treatment or action plan.

Another aspect, which led to the development of the algorithm, was the lack of a tool for visualising and simplifying the processes of assessment, analysis, treatment and evaluation, our OTs and experts could use in teaching and supervising their colleagues. The experienced therapists had difficulties to verbalise their decision-making process during treatment (tacit knowledge) or afterwards in a session for evaluation of the therapy session. This could make it difficult for the supervised therapists to understand the steps of decision-making. They found it difficult to transfer the supervisor's input into their own reasoning. Vaughan-Graham (2016) points out that the role of tacit knowledge in clinical reasoning in neurorehabilitation has not been investigated sufficiently yet.

We concluded that OTs – at least in our clinic – need a suitable introduction to the approach before being able to use the F.O.T.T. approach consistently. Sometimes therapists must wait for a few months until they can attend the F.O.T.T. basic course. During that time, they are introduced to the approach and supervised, to be able to deliver the treatment needed. After the five days basic course, the therapist applies her knowledge from the course in our setting with further options for supervision, education, teaching and training sessions. For clinical reasoning processes, like cognition, meta-cognition, conclusion, etc., therapists need a guiding thread that supports them throughout the process of assessment, treatment, goal setting, planning the treatment and evaluation. Here, we considered that an algorithm could play an important role in embedding the knowledge and enabling the transfer of skills from the basic course into daily work.

■ From a researcher's point of view

Hart (2009) emphasises how difficult it is to conduct valid studies of rehabilitation effectiveness. One challenge is that complex rehabilitation approaches are not well defined. Another challenge is the patient-treater interaction as a component, which is difficult to eliminate or isolate, when searching for the active ingredients of a treatment. Furthermore, multiple components are difficult to assess, since they are specifically adapted to the problems and goals of the patient and in combination may provide benefits that are "more than the sum of the parts" (Hart 2009). Hypothesis-oriented algorithms for clinicians were developed as early as in the 1980s. Rothstein and Echternach (1986, 2003), Kenyon (2013) and Schenkman et al. (2006) have developed similar algorithms for trainees or individuals starting out in the physiotherapy profession. Michielsen et al. (2017) have also pointed out the benefit of a framework, serving as a clinical practice model for the Bobath concept.

Nevertheless, there is still limited evidence of the effectiveness of treatments, which target swallowing disorders and/ or other problems in the facial-oral tract. Evidence-based practice requires integrating clinical experience and patient values with the best available research information, preferably based on controlled studies, which demonstrate the effectiveness of specific procedure or therapy (Masic et al. 2008). The evidence for F.O.T.T. is still weak. A few publications with an evidence class III and IV are available (► Chap. 2). To date, the content of the treatment has been recorded in a consensus document published in German (Nusser Müller Busch 2008), which was a basis for the description of the therapeutic interventions in the F.O.T.T. algorithm (► Chap. 2).

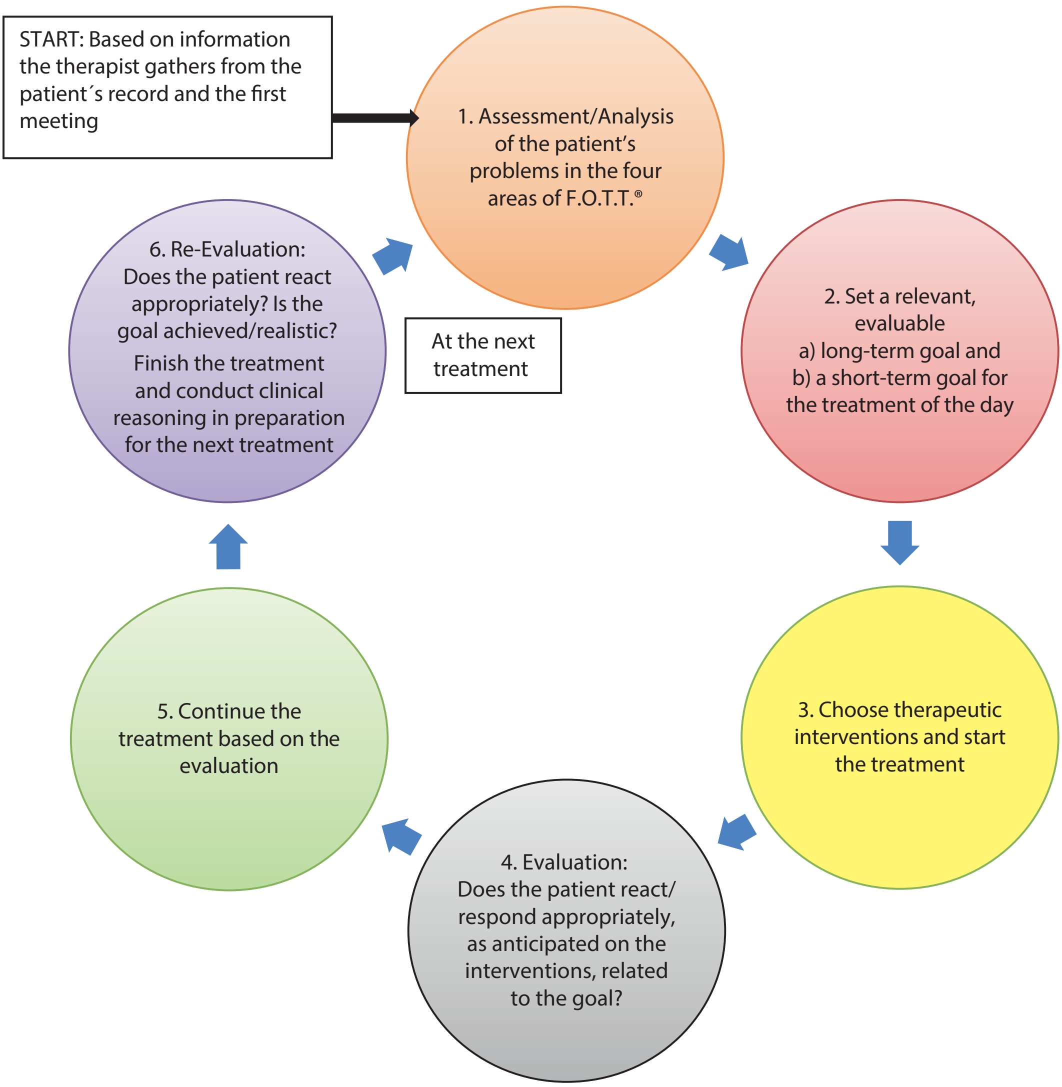
Other treatment approaches targeting dysphagia have similar problems in terms of evidence-based practice. Langmore (2015) concludes in a recent article: "The field of dysphagia lacks sufficient well-designed larger studies to support clinical utility of many swallowing and non-swallowing exercises for dysphagia rehabilitation…" There is insufficient support for a long-term effect for several of the most commonly used swallowing exercises.

McCurtin and Healy (2017) investigated 116 speech therapists in their choice of treatment strategies and found that the most common interventions were texture modification, thickening fluids and change of the patient's position. Another finding was that therapists had practice-based rules instead of evidence-based rules for selecting treatments and that they on average used 6.93 different therapeutic interventions.

Similarly, the F.O.T.T. approach includes many components (described in the manual of the algorithm, contact author) that can be combined and used in different positions, context, intensity and dose, depending on the clinical reasoning processes of the therapist and the patient's individual situation. Conducting research on F.O.T.T. requires a systematic approach based on adherence to agreed guidelines for treatment. This adherence should be observed in all therapists participating in an eventual research project. Achieving this objective can be supported by an algorithm that visualises and guides through the clinical decision-making process. Adherence does not mean to follow a fixed protocol where all therapists should always do the same thing. Rather, they use the thread provided by the algorithm and the accompanying manual which describes the processes in more detail.

12.2 The Structure of the F.O.T.T. Algorithm

The F.O.T.T. algorithm is intended to provide both an overview and a structure for clinical reasoning and for approaching assessment and therapy. The structure of the algorithm is based on the model of assessment and treatment by Coombes and Davies (1987, ◘ Fig. 12.1) and on processes specific to F.O.T.T. (Hansen and Jakobsen 2010). According to the model, the clinical reasoning already starts, when the therapist is gathering information about the patient from the medical chart. The first impression, when the therapist meets the patient for the first time, will contribute to confirm hypotheses about the patient's main problems and underlying causes or to establish new working hypotheses. The therapist focuses on the patient's sensorimotor, perceptual, mental and/or cognitive problems and resources. How does the patient react to tactile, auditive and/or visual information? Is he able to protect the airways? Are there possibilities to communicate? With this in mind and the informations gathered beforehand from the patient's medical record,



◘ **Fig. 12.1** Model of assessment, treatment and evaluation (© Original Coombes & Davies, 1987, modified by Jakobsen et al. 2017. All Rights Reserved) the therapist prioritises one area of F.O.T.T. to start the in-depth going assessment and analysis.

The algorithm is composed of five charts, illustrating the model of assessment and treatment. One chart for assessment and analysis (◘ Fig. 12.2) and four charts for treatment – one for each area of F.O.T.T.: "Eating, drinking and swallowing" (◘ Fig. 12.3); "Breathing/voice, articulation and speech movements" (◘ Fig. 12.4); "Oral hygiene" (◘ Fig. 12.5); and "Facial expression/Facial movement" (◘ Fig. 12.6). In addition, a manual outlines assessment and frequently used therapeutic interventions in F.O.T.T. The criteria for the application of the interventions, their graduations and criteria for evaluation are clarified in detail in the manual.

1. *Assessment/analysis of the patient's problems in the four areas of F.O.T.T.*

In F.O.T.T., it is fundamental to assess whether there are any problems with postural control. How these can influence function and activity in the facial-oral tract has been emphasised by Coombes and is a key point in the approach. Vaughan Graham et al. (2015) also stress the importance of the integration of postural control into the Bobath concept, where F.O.T.T. has its roots. The assessment chart allows the therapist to move flexible between areas of the assessment, depending on the patient's problems and response to therapeutic interventions (◘ Fig. 12.2).

12

The clinical assessment always includes information about how the patient reacts to the treatment. This information has great importance for goal setting and treatment planning.

The interconnection between assessment and treatment is complex and requires detailed observation of symptoms and interpretation of the possible underlying causes, to identify the problem clearly.

► **Example**

Saliva drools out of the patient's mouth (assessment). What are the underlying causes, for example hyposensibility in the face and mouth and a lack of transport movements of the tongue? Does it help to give the patient input on the tongue and facilitate the closure of the mouth (treatment *and* assessment)? Afterwards, the patient's response is evaluated: Is he able to swallow his saliva spontaneously (assessment) or can he be facilitated to do so (treatment *and* assessment)? ◄

In the four boxes for the several areas of F.O.T.T. (◘ Fig. 12.2) are keywords for how and in what context the patient's problems might be assessed, for example, by visual or tactile assessment of the mouth. It is possible and might be necessary to assess the same function or activity (for example selective facial movements) in different positions, like in sitting or side lying.

The methods and techniques to assess and treat patients with problems in the facial-oral tract are taught on F.O.T.T. basic courses. They are described briefly in the algorithm manual. In the analysis, the therapist identifies the patient's resources and the main problems and establishes working hypothesis about the underlying causes for the problems, as a prerequisite for goal setting and treatment planning.

Note

The assessment always includes how postural control and tone influence function and activity in the facial-oral tract!

In F.O.T.T., there is a fluent interrelationship between assessment and treatment.

Assessment ⇔ Treatment

Included in the assessment is the patient's reaction to treatment interventions. The assessment is structured to provide adequate input to the patient (e.g. the tactile oral stimulation) that might lead to an adequate response by the patient. It is part of the assessment to establish what kind of intervention helps the patient to improve movement quality. For the evaluation of the quality of movement, parameters such as *selectivity, required tempo, repeatability, range and clear beginning and end of a movement* as well as *achieving of a functional goal* are used.

2. *Set a relevant, evaluable long-term and a short-term goal for the treatment of the day*

Long-term goals (reachable within weeks to months) and short-term goals (here defined as the goal for the treatment of the day) should be relevant to the patient, related to everyday

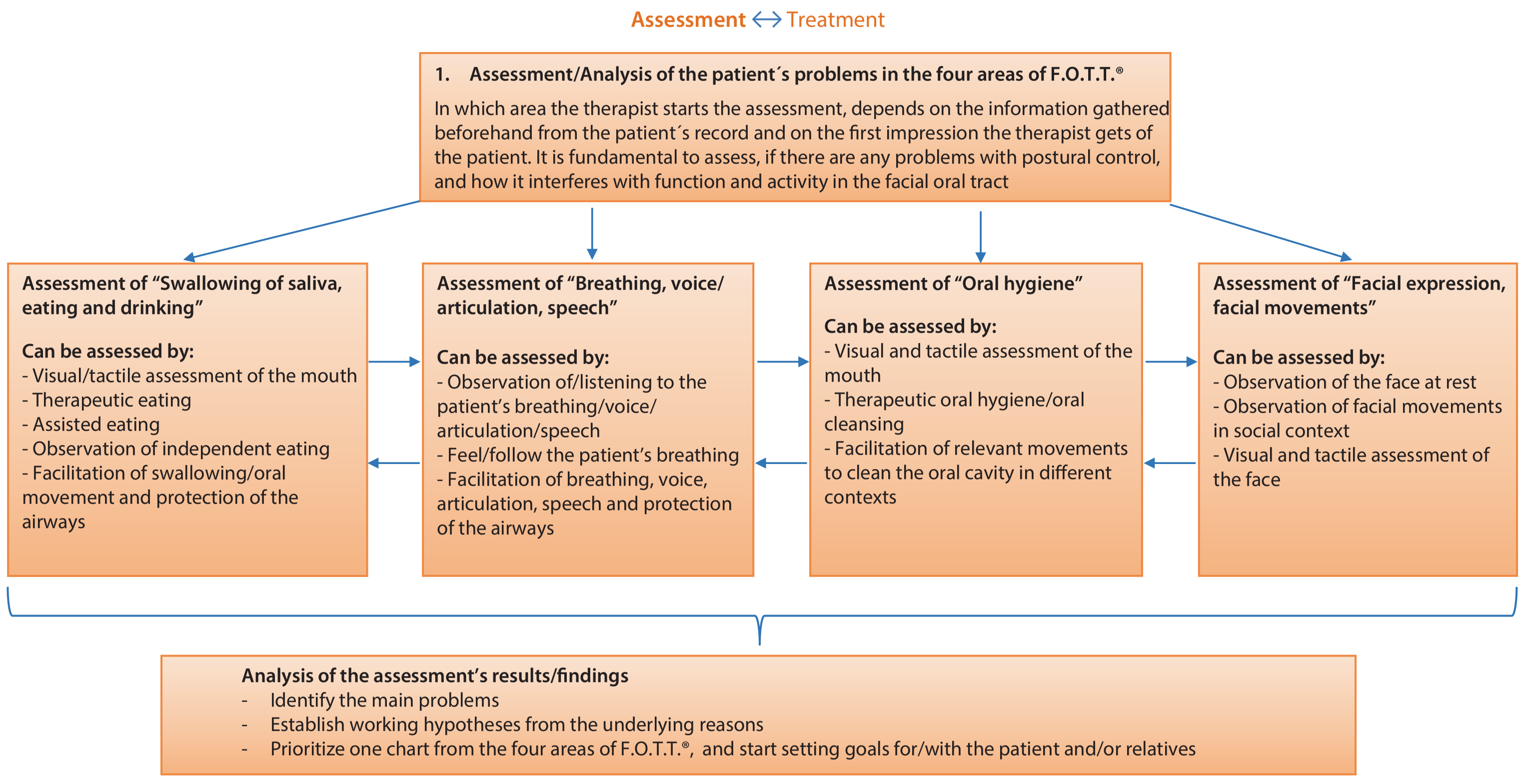


Fig. 12.2 Assessment/analysis of the patient's problems in the four areas of F.O.T.T. (© Hansen and Jakobsen 2010/2017. All Rights Reserved)

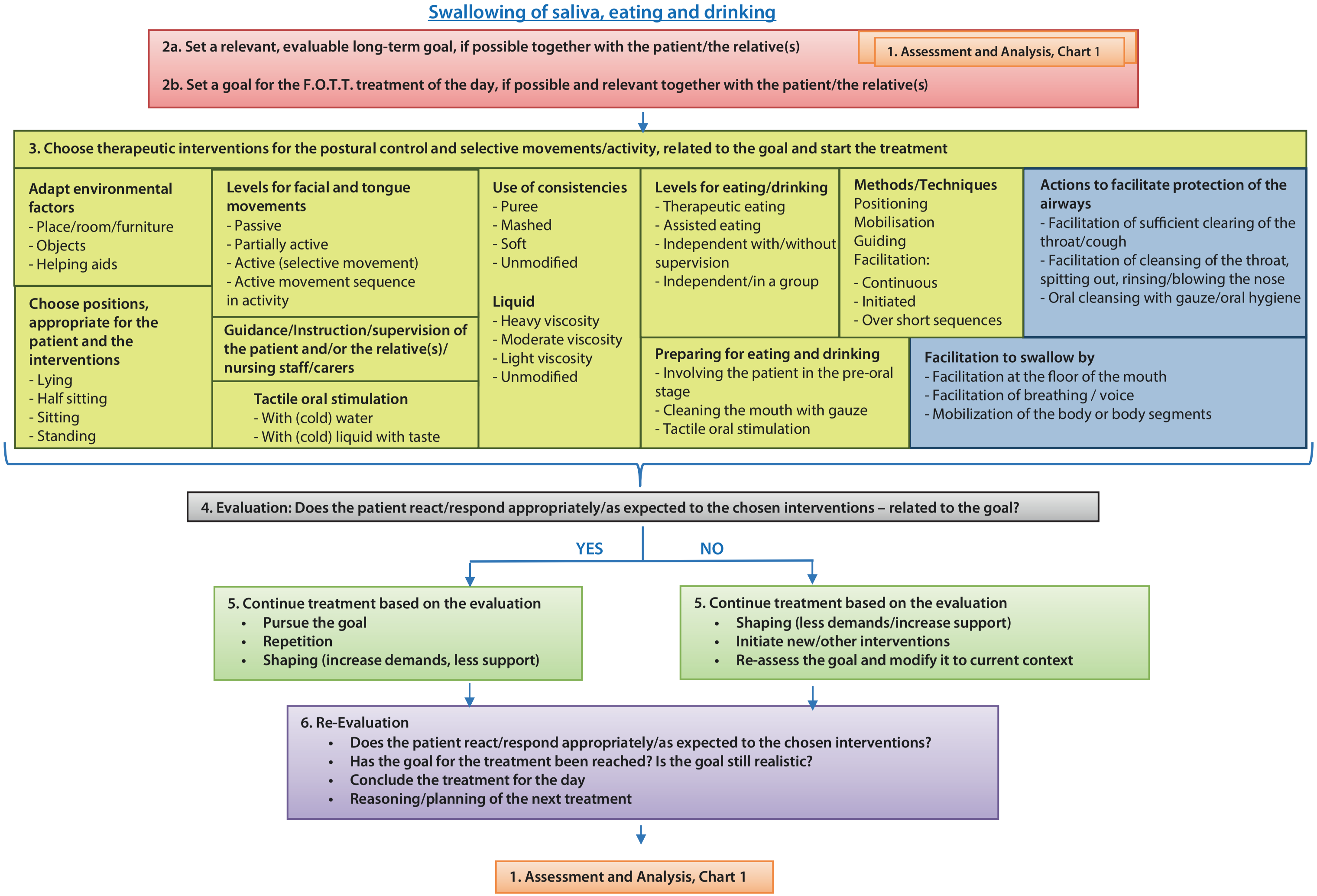


Fig. 12.3 Treatment chart: Swallowing of saliva, eating and drinking. (© Hansen and Jakobsen 2010/2017. All Rights Reserved)

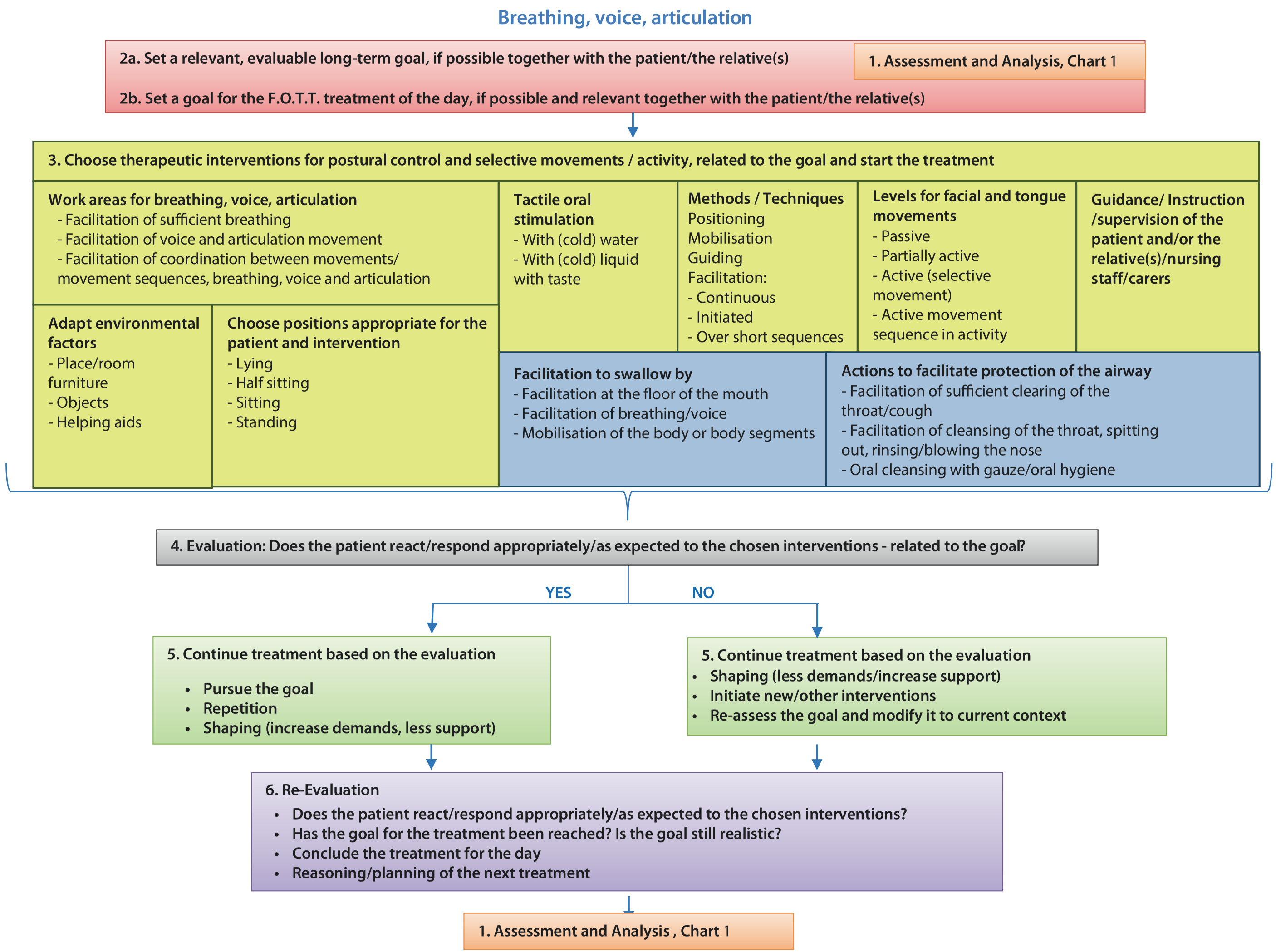


Fig. 12.4 Treatment chart: Breathing, voice and articulation. (© Hansen and Jakobsen 2010/2017. All Rights Reserved)

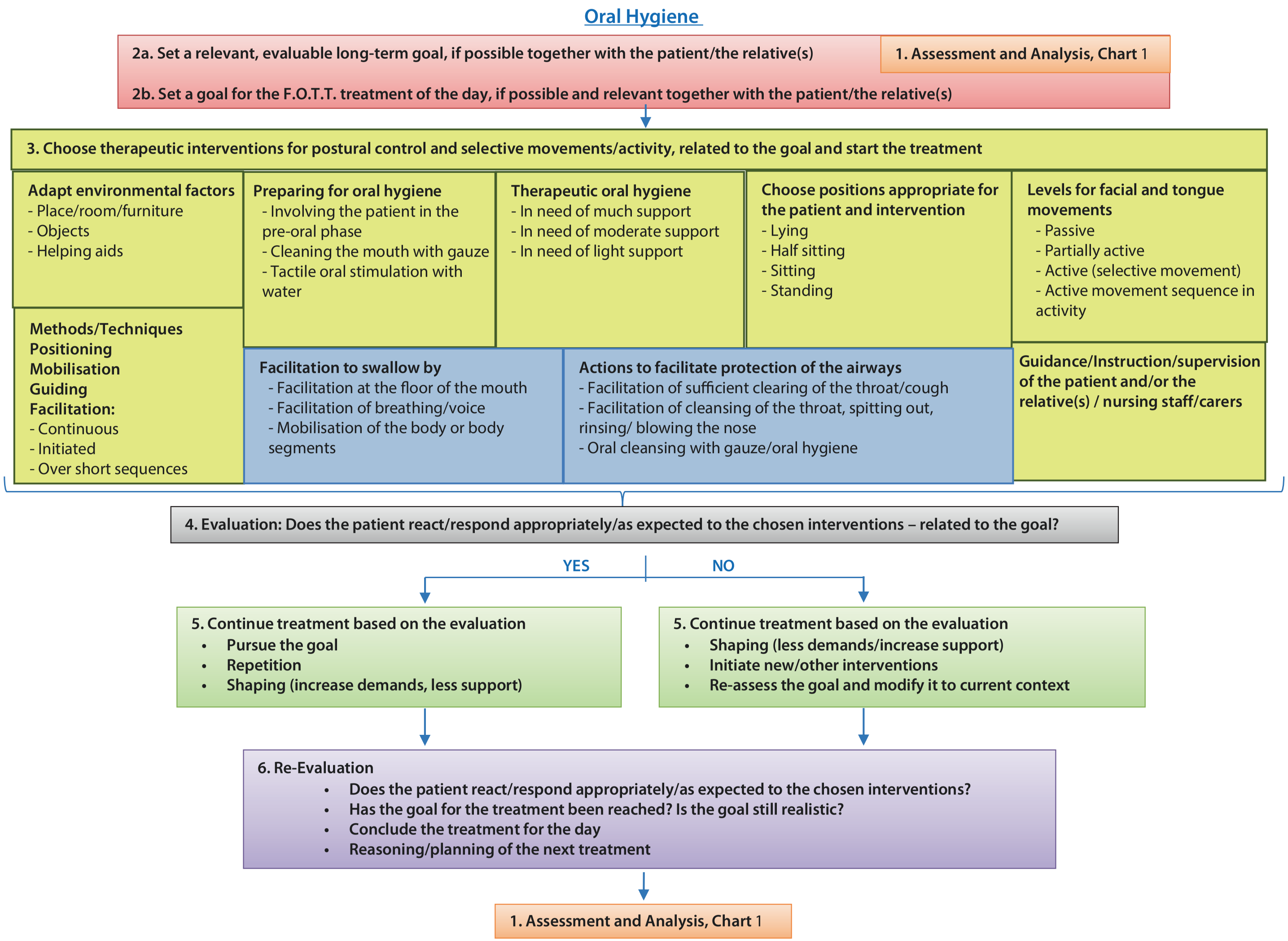


Fig. 12.5 Treatment chart: Oral hygiene. (© Hansen and Jakobsen 2010/2017. All Rights Reserved)

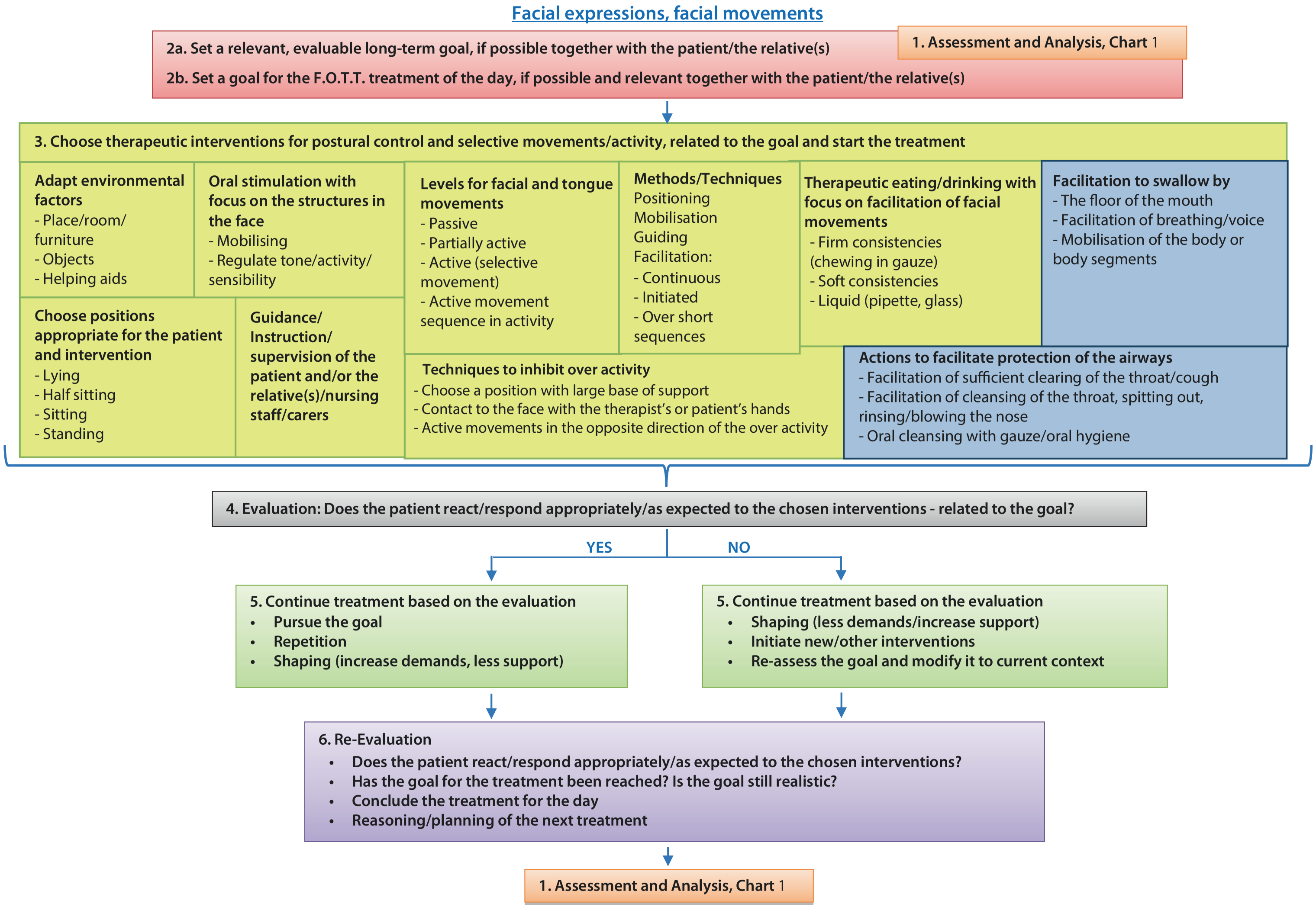


Fig. 12.6 Treatment chart: Facial movements and facial expression. (© Hansen and Jakobsen 2010/2017. All Rights Reserved)

life activities, realistic and evaluable. Depending on the patient's condition and his context, it can be set with or for the patient, for example in patients with severe brain damage. Whenever possible and relevant, the relatives should be included in goal setting, too. When the goal has been set, the therapist plans the treatment.

3. *Choose therapeutic interventions and start the treatment*

For treatment planning, the charts for the four areas give an overview, not only of the whole model but also of the range of therapeutic interventions to choose from (◘ Figs. 12.3, 12.4, 12.5 and 12.6). The manual for each chart contains the description of most frequently used components for each area in F.O.T.T. (eating, drinking and swallowing; oral hygiene; breathing, voice and articulation; facial movements/facial expression). Note that there is mandatory content in each of these charts. The boxes – adapt environmental factors, choice of position, methods and techniques, guidance/instruction/supervision of the patient and/or relatives, nursing staff/helpers and levels for facial movements – are relevant for each area of F.O.T.T. Furthermore, the boxes – facilitation of swallowing and protection of the airway – appear on each chart because they are an essential principle of F.O.T.T. As soon as the patient needs facilitation of swallowing or help to protect the airway, the therapist considers and prioritises this.

12

► Example

The therapist decides on the interventions necessary to reach the goal. First, the environment in which the treatment should take place is taken into account, and one or more adequate positions for the patient and the methods/techniques that will be used to reach the goal are considered. The therapist will then decide on the level of the interventions, e.g. the intensity of facilitation or the requirements regarding the patient's postural control. Motor learning is dependent on sensory input. This input should be variable, meaningful and relevant for everyday life (Mulder and Hochstenbach 2001, Michielsen et al. 2017). When the therapist has started the treatment, the patient's response to each intervention is observed. The change between assessment and treatment is fluent. The therapist tries to influence unexpected and unfunctional reactions of the patient as soon as they appear. If the patient reacts inappropriately, or much differently than anticipated (e.g. with massive biting reactions on tactile oral stimulation), the therapist immediately modifies the technique in order to see if this has influence on the patient's reaction in a helpful way. ◄

4. *Evaluation: Does the patient respond appropriately to the interventions?*

At this stage, the therapist evaluates the observations that have been collected until now: Does the treatment seem appropriate? Is the goal for the treatment of the day still realistic? Has the goal been achieved already? The therapist should answer YES or NO (see charts for the four areas of F.O.T.T.) (◘ Figs. 12.3, 12.4, 12.5 and 12.6).

5. *Continue treatment based on the evaluation*

If the answer is YES (the goal still is realistic), the therapist continues to work towards the goal. If the goal has already been achieved, repetition or shaping is used. Shaping means to work on the patient's individual limit, on a neither too high nor too low level, in order to exceed it (Sect. 1.5.2). This could be achieved by increasing requirements or offering the patient less base of support, e.g. choosing a sitting position instead of lying, or less facilitation. Shaping is a method to encourage motor learning, by asking the patient to perform the same sequence of movement or activity again under more "difficult conditions", but still in the same quality. Repetition might include different aspects of the chosen activity or be encouraged under different conditions, for example in a different context, since motor learning is assumed to be most effective, when repetition is variable.

► Example

The goal for the treatment is that the patient can eat a portion of applesauce safely in sitting position, supported by the therapist. (Safely means with sufficient protection of the airway.) The goal is achieved, and the therapist hypothesises that the patient will also be able to drink thickened liquid safely, supported by the therapist. The therapist establishes this hypothesis based on actual information about the patient's problems and resources within the swallowing sequence. ◄

If the answer is NO (the goal seems unrealistic), the therapist should consider how to increase support for the patient, for example by using a position with more base of support or more intense facilitation. If it is doubtful to reach the goal of the day at all, the therapist should modify the goal to the patient's actual resources and problems.

► Example

The goal for today was that the patient could chew some fresh apple in gauze safely in sitting position (i.e. that the juice from the piece of apple and the saliva produced during chewing can be managed safely). However, already during the preparatory tactile oral stimulation, the patient shows signs of aspiration of saliva and coughs insufficiently. The therapist now lowers the goal to the patient being able to swallow just his saliva safely. The therapist brings the patient into side lying position and facilitates swallowing whenever necessary. As a new intervention, the therapist mobilises the patient's tongue passively. Afterwards, active tongue movements can be facilitated. The patient's reaction to the treatment now needs to be evaluated. ◄

6. *Re-evaluation: Does the patient react appropriately/as anticipated to the interventions? Is the goal still realistic? Has the goal for the treatment been achieved? If yes, finish the treatment and prepare the next treatment based on clinical reasoning.*

As a general rule, at the end of the treatment, the therapist re-evaluates whether the modification of interventions and/or the use of new interventions were successful. These aspects are relevant to consider:

Were the therapeutic interventions appropriate in relation to the patient's resources and problems and the underlying causes?

Did the interventions have an adequate level/intensity?

What kind of interventions was most helpful for the patient to move more selectively and functionally?

If the short-term goal for treatment has not been achieved: is it still realistic/relevant to go for it in the next treatment session?

Is the long-term goal still relevant/realistic?

Which reflections and experiences from the treatment today are relevant to consider before the next treatment session?

Practical Tip

During assessment, it is important to consider the ways in which abnormal tone, sensibility and perception affect the patient's ability to act and how learning of functional movements and movement patterns can be supported.

12.3 F.O.T.T. Algorithm in Clinical Context, for Teaching and Research: Goals and Perspectives

■ **The goals of the F.O.T.T algorithm**

The algorithm pursues several aims. It should help to visualise and simplify processes of clinical reasoning during assessment, analysis, goal setting, treatment and evaluation of the patient's response to the treatment. Both the experienced and the unexperienced therapist can use the charts to reflect on their assessment and treatment and see where they have adhered to the model and where not.

The algorithm supports therapists in enabling patients to learn movements and movement patterns, which can be used and varied in the context of their individual, daily life. There is a box in every chart for involving the patient and/or the relatives into treatment and handling whenever possible and meaningful. It supports the integration of the patient, the relatives and/or relevant staff in goal setting, specific handling and treatment, done by the patient himself, the relatives or staff. Since the algorithm and the manual request goal setting with the SMART method (Bovend'Eerdt 2009), it facilitates the work with F.O.T.T. in a meaningful and functional everyday life context.

The algorithm can also be used as a tool for the supervision of staff/ therapists and might help to facilitate the interprofessional work with F.O.T.T. For instance, each chart has a box: *Guidance/instruction/supervision of the patient and/or the relative(s)/nursing staff/ helpers*. Here, the therapist would share helpful techniques and methods of handling with other professions/carers. The algorithm might also help the therapist in clinical reasoning, for example when and why to involve other professions, e.g. medical specialists or dietitians. A clearly described treatment approach promotes communication within the team involved in the rehabilitation process and with patients and their families.

■ Experience with the algorithm in the clinical context and for teaching

The algorithm has been implemented as a framework for the OTs, since they have the main responsibility for the rehabilitation of the facial-oral tract in our setting. After a first presentation of the algorithm to the OTs, example cases were discussed using the algorithm during weekly staff trainings. Each case presentation was prepared by the author and the patient's primary OT. Specific topics for discussion were outlined, e.g. goal setting or the use of therapeutic interventions. Parallel, whenever the author supervised an OT on the ward, the algorithm was used to reflect on specific issues and the OT was encouraged to read the relevant parts of the manual to support clinical reasoning. Posters of the charts were hung up in the OTs' office so they could be used easily for quick reference and shorter briefings or discussions about specific patients during the day.

The algorithm serves as a guideline for this complex treatment method. For less experienced therapists in particular, it can be challenging or impossible to apply complex procedures in a meaningful way. Without a framework defining the treatment, it would be difficult to guarantee the quality, clarity and authenticity of the approach. The approach would run the risk of being altered or watered down, with the result that the treatment might not be delivered reliably by each therapist (Whyte and Hart 2003, Hart 2009).

Since a couple of years, the algorithm has been used for teaching during F.O.T.T. advanced courses with specific focus on clinical reasoning. During the course, three participants treat a patient supervised by the course instructors. Before and afterwards, they use the algorithm for their assessment, goal setting, treatment planning and evaluation.

■ Further plans with the algorithm

The algorithm should be critically evaluated and updated regularly to consider new insight from clinical practice and research. We plan to add charts for assessment and therapeutic interventions for tracheostomised patients. Other professions should also more commonly use the algorithm, since F.O.T.T. takes place in an interprofessional context. Hereby, the algorithm would function as a reference for developing standardised guidance, e.g. for oral hygiene or treatment and handling of patients with tracheostomy tubes.

■ Perspectives of using the algorithm for research

The F.O.T.T. approach has been developed through practical work and experience with patients. Updating the theoretical background, the principles, methods and techniques according to recent scientific models is an ongoing process.

A number of factors make studies in neurorehabilitation difficult. These include the lack of scientific qualifications amongst those working in clinics and practices, insufficient research funding and ethical limitations (Whyte and Hart 2003; Hart 2009). In addition, the large number and variety of disorders, clinical settings and treatment goals being pursued (from the restoration of muscle and nerve functions to the patient's participation in social life) contribute to a lack of uniform guidelines and consistent study designs. Researchers have shown that despite its numerous advantages, the randomised controlled trial (RCT) also has its limitations as a method (Campbell et al. 2000). These limitations include limited external validity, when using proven interventions with proven efficacy outside the ideal research setting in daily practice (Campbell et al. 2000). The attempt to answer research questions solely by means of controlled studies (mainly used in reviews or meta-analyses) may prevent the application of alternative research methods (for example observational case studies) which could potentially be more appropriate in evaluating the effectiveness of the approach (Black 1996; Hart and Bagielle 2012).

The F.O.T.T. algorithm provides a framework for describing the multiple elements of F.O.T.T. From the point of view of the practical experience, it should include the active ingredients of the treatment and describe its essential components and processes. Still, the active ingredients and their effect have to be defined in research. Both clinicians and researchers would benefit in several ways.

With the description of the essential components and processes of a treatment, researchers can be supported in formulating specific research hypotheses (Whyte and Hart 2003).Treatment manuals make it possible to standardise methods, to differentiate between different approaches and to evaluate treatment discipline (treatment adherence, i.e. whether a therapist follows the guidelines or treatment manual). It would also allow evaluation of the inter-rater reliability and stability of the assessment. The non-standard application of a treatment can be a significant issue affecting the internal and external validity of a study, when measuring and comparing treatment outcomes within a facility or between different institutions. If a treatment procedure is defined and carried out in a standardised manner, it is possible to compare different concepts and relate the chosen treatment to therapeutic goals and treatment success. The term *standardised* in this context does not imply that all therapists should always do the same. It refers instead to an active adherence to the treatment manual, i.e. to analyse problems, establish working hypotheses, set goals, create a treatment plan and evaluate the patient's reactions. This can help in narrowing down the treatment to its core elements and thereby enhance the development of research and clinical practice. Whether the algorithm can contribute to the balance between internal validity (does it support a standardised delivery of the therapy during a clinical study?) and external validity (does it support replication of results in different clinical settings?) has yet to be investigated.

The high level of flexibility of F.O.T.T. may negatively affect internal validity. The clearer and more specific the manual, the higher the probability that the treatment derived from it will reflect the intentions and current working principles of the approach. If the algorithm is too specific, it may not reflect the variations in clinical practice across different settings, thereby causing it to fail in terms of external validity.

The question, which elements of the therapy are decisive for treatment, could also be examined. Whyte and Hart (2003) raise the issue of whether to evaluate a single component (e.g. swallowing facilitation) or aspects of the service delivery system, e.g. the setting, decision-making rules and interprofessional teamwork. While, for example, task-specific training is known to be a key active ingredient in stroke rehabilitation, dosing parameter, such as which amount, frequency, intensity, duration and task difficulty might be most appropriate, is largely unknown (Lang et al. 2015). Likewise, dose and timing are also unknown for specific cognitive interventions, which have been found to be effective in reducing anxiety and improving the patient's self-concept and interpersonal relationships (Carney et al. 1999). There is also some evidence that a positive relationship between therapist and patient has a beneficial effect on treatment outcome (Hall et al. 2010). All this requires an individualised adaptation of the therapeutic approach, while at the same time a high degree of flexibility can make it more difficult to replicate treatment activities in a research design (Hart 2009). Thus, study designs for evaluating effectiveness must consider not only clear definitions of the treatment but also patient variability as well as relevant outcome measures that reflect the health and function changes attributable to the intervention (Carney et al. 1999).

The complexity of F.O T.T. is reflected in the algorithm. The aim is to encourage therapists to reflect on their work and analyse problems continuously, enabling them to evaluate their patients' potential. The algorithm is designed to allow therapists a great deal of flexibility when selecting therapeutic interventions and in terms of environmental factors. The diverse problems faced by patients can be taken into account in their daily clinical routine and the general framework of conditions in which F.O.T.T. takes place, e.g. in hospitals, nursing facilities and the outpatient sector.

Note

In clinical practice, the setting for each treatment is affected and altered by a number of factors. This flexibility is considered essential, in order to guarantee an individually adapted approach.

The limitations of the F.O.T.T. algorithm

Even though the algorithm's manual is quite detailed, it cannot ensure that each therapist is able to deliver proper treatment to the patient, because the skills and competencies needed can only be acquired by guidance and training under supervision. The same is true for clinical reasoning which demands acquisition of practical experience in hypotheses-driven processes.

Despite its flexibility, the algorithm is not intended to be an instruction manual for F.O.T.T. Just following a manual is not sufficient for mastery of the approach.

12.4 Conclusion

The initial idea behind the development of the algorithm was to open one of the "black boxes" of neurorehabilitation and describe and evaluate the defining F.O.T.T. components. It can also be used as a tool for teaching and developing the work.

Although the current algorithm provides a framework outlining these components, many of them still require further investigation. Current F.O.T.T. research projects in Germany and Denmark are investigating the effect of intensive facilitation of swallowing on swallowing function and the risk of aspiration in patients with severe dysphagia.

This algorithm hopefully will serve as a resource for further research activities and provide support for those who treat patients with F.O.T.T. It is one element in the ongoing process of finding out how we can deliver the best treatment to our patients.

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F.O.T.T. in Paediatrics: Eating, Drinking and Swallowing - with Confidence!

Ricki Nusser-Müller-Busch and Barbara Elferich

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Pre-, peri- or postnatal brain lesions affect the development of growing children. This chapter will outline the treatment approach for children with postural and tone disorders caused by cerebral lesions and their implications for facial-oral functions.

Knowledge of the components of normal child development and understanding how they interact is essential and helpful when treating children. Parents, carers and all those involved must work together to provide the child with individualised support for vital functions, nutrition, verbal and nonverbal communication, daily activities and participation.

13.1 Dysfunction in Breathing-Swallowing Coordination, Eating, Drinking and Swallowing in Children

Breathing-swallowing coordination and swallowing disorders in infants and children may have a number of different causes. Syndromes, infections, strokes, hypoxia or premature birth can cause pre-, peri- and postnatal lesions to the developing brain. These include genetic and/or chromosomal changes, e.g. Down's syndrome, Chiari malformation and Pierre-Robin syndrome, and/or deformities such as cleft lip/palate, esophageal or tracheal stenosis and neuroblastomas/tumours. Other causes include metabolic disorders and autoimmune/systemic diseases such as scleroderma.

According to Schwemmle and Arens (2017), feeding problems or swallowing disorders are seen in 1–25% of all children. The prevalence is up to 40% in prematurely born infants and much higher in children with developmental disorders or cerebral palsy.

Note
Coordination and timing of swallowing and breathing are important aspects to be considered.

Premature birth

Preterm infants, e.g. with bronchopulmonary dysplasia (BPD; da Costa et al. 2010), may develop an infant respiratory stress syndrome, and mechanical ventilation may be necessary. There is insufficient surfactant to keep the alveoli open to allow gaseous exchange in the still immature lung. The sucking pattern is absent or weak and accompanied by abnormal, whole body movement responses (Hübl 2012). The temporary insertion of an endotracheal tube may be required. Long-term studies show a link between early dysfunctions of the suck-swallow-breathe sequence and neurological development disorders, at around the age of two years (Wolthuis-Stitger et al. 2015).

So far, there are no objective measuring methods with which the breathing-swallowing coordination of infants can be assessed. Two studies from Berlin have yielded first results on this topic with a bioimpedance-based measurement method in adults (Schultheiss et al. 2013, 2015). A German study group (cooperation of children's department of the university Düsseldorf and Unfallkrankenhaus Berlin) is now investigating the influence of body position on respiratory-swallowing coordination in mature infants and preterm infants. It should be judged objectively whether the children benefit from the increased upright position when drinking.

Feeding disorders

Early childhood feeding and eating disorders can lead to failure to thrive, i.e. insufficient growth. A differentiated classification of early childhood feeding disorders suggested by Chatoor (2012) incorporates aspects of the physical development and behaviour of children and their interactions with and relationship to their parents.

Note
Feeding disorders can add to a primary problem, e.g. in premature child after the experience of nasogastric tubes, ventilation and intubation.

13.2 Problems in Children with Cerebral Palsy

Brain damage alters both the processing of internal and external stimuli to the central nervous system (CNS) and/or the reactive output. The development of postural control, movement capability, muscle tone, coordination, sensory processing and balance in infants can be impaired to a greater or lesser extent.

Fencing Posture

In a supine position with head turned to the side, the extremities on the side to which the face is turned are extended, and on the opposite side they are flexed. This asymmetric position resembles that of a fencer. The prenatally acquired body posture is observed physiologically between the 4th and 8th weeks of life and disappears with continuing motor development.

In affected infants, the prenatal asymmetric fencing posture may persist in the form of an asymmetrical tonic neck reflex (ATNR). This is often accompanied by fist closure on the extended side. Rotating, turning, straightening, hand-mouth coordination and oral exploration, etc., cannot develop.

Note

The infant is not able to orientate to the center. Keeping balance, shifting weight, crossing over the midline of the body and rotating cannot develop. Dysfunctions of eye-hand coordination, hand-hand coordination, visual awareness and a fixed gaze are discernible. Further normal sensorimotor development is severely compromised.

If there is a lack of physiological movements, a chain reaction occurs. The resulting disorders of muscle and joint functions and their biomechanics include locking of thoracic spinal segments (affecting the attachments of the diaphragm), possible malfunctions of the intervertebral joints and altered information to the receptors at the joint. The function of the deep neck flexors (longus colli, capitis and rectus capitis anterior muscles) is also inhibited (Orth and Block 1987). A weak musculature leads to compensatory kyphosis and lordosis, hyperextension of the neck (Bobath 1986; Bobath and Bobath 2005; Morris and Klein 2000), scoliosis and the obstruction of lung segments. Compensatory activity by the respiratory and accessory breathing muscles to create stability has corresponding effects on movements of the head, larynx and hyoid (▶ Chap. 4). This influences the diaphragmatic and facial-oral functions. The compensatory reclination of the head serves to keep the airway open (Limbrock 2011).

In cases of prolonged gross motor disorders, movements of breathing, jaw, tongue, pharynx and larynx are unable to develop normally. Tongue movements, lateralisation of the tongue and jaw, rotatory mastication movements and cleaning and protective mechanisms for the lower airway are made difficult or impossible. Speech and nonverbal communication are also usually affected. Often, only the consumption of pureed food or artificial nutrition is possible. The resulting structural changes include alterations to the facial-oral tract (oral cavity, jaw, palate and teeth), as well as contractures and deformities of the hands, feet, hips, thorax and back muscles (Elferich 2011). Sleep disorders are also common (Simard-Tremblay et al. 2011). Essential medication, e.g. for epilepsy, affects vigilance and behaviour.

The presence of gastro-esophageal reflux disease (GERD) should be investigated in cases of combined symptoms (including excessive crying, spitting, bad breath/halitosis, excessive hiccuping, refusing food and disturbed sleep), coupled with recurring respiratory tract disorders such as bronchitis, lung and middle ear infections, asthma, apnoea or Krupp seizures.

Note

Reflux disease and other gastrointestinal problems, e.g. esophageal dysmobility and delayed gastric emptying, are common in children with cerebral palsy. Persistent GERD can result in inflammation and changes in the mucosa. Extra-esophageal manifestations include laryngeal oedema, bronchitis and microaspiration of food particles into the lung (Riessen 2013). Gastric juice exposure is also associated with middle ear inflammation in children (Miura et al. 2012).

As children grow up, the range of challenges broadens, e.g. malnutrition and problems of gaining weight and of digestion and breathing (Rodriguez et al. 2011). Orthopaedic issues are also common, such as scoliosis, contractures and joint stiffening (Fig. 13.22). In the transition from child care to adult care the search for a new team of doctors and carers is often necessary to ensure continuity.

This entire process takes place within the interpersonal context of the family's concerns, anxiety and worries. The pressure caused by the inability to nourish one's own child is exacerbated by doctor's warnings to avoid the threat of malnutrition and dehydration, recurrent respiratory infections and aspiration pneumonia. Other siblings must also be considered, and all these factors contribute to the difficulty of the situation for the parents.

13.3 Problems in the Facial-Oral Tract

Even in the older literature, prolonged feeding and dependent eating was found in up to 80% of the children with cerebral palsy (CP, Rogers et al. 1994). Those disorders are indicated at a rate of 25–30% in children with hemi- or diparesis, rising to 60–90% (Arvedson and Brodsky 2002) or 100% (Calis et al. 2008) in children with tetraparesis or extrapyramidal movement disorders.

Note
In children with CP, swallowing disorders are closely related to severe gross motor disorders. Early evaluation is necessary in managing feeding problems (Kim et al. 2013).

Limbrock (2011) describes the following developing pattern: Persistent tongue protrusion causes the maxilla and the palate to become narrow and high. The tongue cannot explore the lateral oral cavity. Therefore lateral movements of the jaw are unable to develop. A frontal open bite forms as a result of the tongue protrusion, which causes the upper incisors to shift forwards and often leads to prognathism. The lower incisors are pressed inwards by the overactive mentalis muscle. Later on, only the child's last molars maintain tooth contact.

There are weak facial expressions, lack of mouth closure and drooling of saliva from the mouth. Sucking is affected by fatigue and apnoea, leading to difficulties with eating and drinking. Permanent mouth breathing has consequences for the oral mucosa; with the additional absence of tongue and jaw movements, intraoral perception cannot develop.

According to Limbrock (2011), 75% of affected children show dysarthria or anarthria. The children's speech is often characterised by a hypernasal resonance, which has a forced and jerky sound and tires rapidly. Children with ataxia often have coordination problems when using their voice and their speech has a monotonous rhythm.

13.3.1 Signs of Facial-Oral Problems and Swallowing Disorders

- **Direct signs**
  - "Weak" drinking
  - Apnoea when sucking/drinking
  - Sucking interrupted by hyperextension of the head, neck and trunk
  - Retracted jaw
    Altered jaw position, e.g. retracted jaw, or jaw movements, e.g. restricted jaw opening
  - Retracted tongue, no lateral tongue movements
  - Pathological reactions: persistent tongue thrusting, prolonged phasic biting, bite reactions, etc.
  - Drooling
  - Wet, gurgly voice
  - Breathing-swallowing discoordination
  - Mucus accumulation, mucilage
  - Gagging, coughing with or without food
  - Food residues remaining in the oral cavity

- **Indirect signs**
  - Lack of postural control
  - Asymmetric, restricted or absent head, trunk and jaw control

- Abnormal muscle tone
- Lacking hand-eye – and/or hand-mouth coordination
- Hypersensitivity in the face/mouth area
- High-arched narrow palate
- Continuing dependence for food intake on carers
- Excessively long feeding time, exceeding 30 minutes
- Often only able to consume one consistency
- Frequent bronchitis or pneumonia caused by aspiration
- Constipation
- Lack of understanding of the (feeding) situation
- Refusal of food

13.3.2 Coping with Saliva and Aspiration

13

Drooling (saliva flow outside the mouth) can be a challenge for the child, family, caregivers and therapists, too. It is common in healthy children under two years of age, but it can be obstinate in children with teeth problems, mouth breathing and reduced swallowing frequency and/or impaired swallowing caused by cerebral lesions.

The vital problems caused by aspiration and pneumonia have come to the fore during the last decades. In endoscopic examinations, Bader and Niemann (2010) found penetrations (24%) and aspirations (39%) in over 60% of children with CP. Half of the patients had no protective coughing reactions and silent aspiration. A large proportion of the children were orally fed at the time of the examination – including those who were aspirating! Of those children 40% had no pneumonia in their medical history.

The findings are consistent with our experience and the statement by Diesener (2010) that aspiration in these patients is "generally compatible with life". The lungs of infants and children who are exposed to saliva aspirations from birth adapt surprisingly over the years. But a final drop is often enough to cause the "barrel to overflow" and many children or adolescents struggle with recurrent respiratory infections, often triggered by the (silent) aspiration of saliva or food.

13.3.3 Pulmonary Issues

Central respiratory disorders affect the development of vital functions (breathing-swallowing coordination, protective and cleansing mechanisms), as do subsequent secondary breathing impairments and unhelpful movement patterns.

The reduction in nasopharyngeal muscle tone can cause obstruction of the upper airway and sleep apnoea syndrome (Bosma 1986).

Riessen (2013) describes the risk of bronchial collapse in premature infants, as the diameter of the respiratory tract is still small and the bronchi are not as stiff as in adolescents or adults, who develop collateral pathways for ventilation.

If the elasticity of the muscles is decreased due to disturbed central feedback, stiffness or fatigue, the functions of the stretch receptors in the lungs, the proprioceptors and the chemical processes change and cannot fulfil their tasks. Inhalation is reflexively inhibited and the endurance capacity of the muscles reduced, and their energy consumption exceeds the energy supply (Kasper and Kraut 2000).

If breathing is shallow it must inevitably increase in frequency, to ensure the necessary oxygen saturation in the blood. Respiratory movements and coughing are usually insufficient, the lungs cannot be adequately ventilated and atelectasis can occur. Bronchial secretions cannot be mobilised and coughed up. If the oxygen saturation in the blood is marginal, it must be monitored, and a suction unit kept at hand. Breathing therapy and regular secretion management are essential (► Sect. 13.6.6).

Immobile or artificially ventilated children struggle with mucus and secretion in the upper and lower airways and constant aspiration of bacterial contaminated saliva. Severe complications or death in early adulthood is common, due to the pulmonary issues, obstruction of the lower bronchial lobes resulting from scoliosis and sleep apnoea syndrome (Karatas et al. 2013).

Note

The extent and way in which hypotonia at birth develops, in the direction of spasticity, dyskinesia (athetosis, tremor, rigidity), ataxia or a combination thereof, can only be assessed over the course of the next years of life.

Brain damaged children have limited or no access to previous learning. They cannot have adequate sensorimotor experiences. To support their development and their capabilities of acting and problem-solving, they must be provided with structured treatment and inputs, in a therapeutically designed environment adapted for their developmental age and potential (Ritter and Welling 2008).

13.4 The F.O.T.T. Assessment Process

The F.O.T.T. assessment process is outlined in ► Chap. 11. The approach is ICF compatible and can be applied to children with all types of congenital or acquired impairments (regardless of the genesis).

Note

- The interview and assessment should not revolve primarily around the child's "deficits", but should emphasise the child's individuality and potential.
- Triad: Child - parents - examiner
  The child and the parent-child interaction should be observed in a familiar context, at rest and during feeding if possible.
  The parents' verbal and nonverbal signals should be observed by the examiner to establish whether they feel comfortable with the idea to entrust their child to the therapist. They may need more time to build up trust in the examiner. If this is the case, the parents can be asked to demonstrate how they handle and feed their child. Either way, their decision is not judged, because they may have significant reasons for the option chosen, which may not be apparent during the first encounter.

The assessment process involves child, parents and examiner in a communicative triad. Mothers often find the process of compiling a medical history particularly stressful and inevitably feel "guilty" when questioned about their pregnancy. For this reason, it may be beneficial to study referral letters and findings in advance. Somatic percentile values such as weight, body size or head circumference can be recorded "in passing".

13.4.1 Clinical Assessment

Any external aids should be noted during the assessment, e.g. external oxygen supply, gastric tubes, tracheostomy tubes (TT), catheters, braces and wheel chair. If the child's vital functions are monitored, parameters such as oxygen saturation, breathing and heart rate are documented before and after the assessment. These can be utilised as comparative values for subsequent assessment activities and in a feeding situation. The assessment is age-adjusted, i.e. based on the child's level of development.

Any history or signs of GERD should be noted and investigated further.

In current clinical practice, many clinicians will use informal checklists based on normal swallowing and feeding development instead of formal assessment tools when assessing children with suspected swallowing disorders, e.g. the paediatric dysphagia screening of a temporary German working group (► http://schlucksprechstunde.de/download/ – Kinder Dysphagie Screening/english). The screening includes questions relating to feeding method and diet, number of meals per day, interest in food, breathing, protective mechanisms, vomiting, mucus, etc.

It may be advantageous to provide the parents with a screening form in advance. Parent report measures with informal interviews and key questions are also available, e.g. Drooling Impact Scale (DIS, Reid et al. 2010) and Feeding/Swallowing Impact Survey (FS-IS, Lefton-Greif et al. 2014).

Note

Throughout the session, swallowing frequency and breathing-swallowing coordination, motor and breathing movements, muscle tone, sensitivity and any reactions which arise are observed and recorded. Any compensations for missing movements and recurring movement responses and patterns are also noted (► Overview 13.1; ► Chap. 11).

Overview 13.1 Aspects of Assessment

Assessment Process

Observing the child at rest:

- What is the child's movement behaviour?
- How does the child respond to touch and movement?
- Do the eyes focus on people and activities?
- Is the eye-hand coordination appropriate?
- How does the child use the hands?
- Does the child bring the hands to the face and to/into the mouth?
- Is the facial expression situational and adequately adjusted?
- Does the child breathe through the nose and/or (open) mouth?
- How is the range of motion of the structures, tongue, jaw and larynx?
- How often does spontaneous swallowing occur?
- Is the coordination of breathing and swallowing appropriate?
- What occurs after swallowing: breathing in or breathing out?
- What are frequency, intensity and movement of breathing? Thorax movements during breathing?
- Are breath sounds, such as rattling, nostril breathing, mucus, or stridor, audible?
- How does the voice sound, e.g. hoarse and/or gurgly, wet?
- Are protective reactions efficient?
- Are there attempts to cough, yawn or sneeze with or without swallowing responses?
- Are primary responses age appropriate or persistent, e.g. sucking, phasic biting and hand-mouth coordination?
- Does saliva drool from the child's mouth?
- Does the child have breath or mouth odour?
- How do the child's secretions, sputum look like?
- What is the condition of the oral cavity? Coated tongue, thrush?

Interaction between the parents and child:

- What is the first impression of parent-child interaction?
- Are mealtimes stressful to the child and/or parents?
- Do the parents have to help the child with movement transitions?
- Are handling instructions required?

Feeding situation:

- Age-appropriate nutrition: breast, bottle, spoon, cup, finger feeding?
- Positioning of the child for feeding?
- Appropriate suck-swallow-breath sequence? With adequate rhythm?
- Drinking interrupted due to breathing difficulties or tiredness?
- Drooling – losing liquid, food?
- Does coughing and choking occur? With hyperextension in the body?
- Are protective reactions after choking carried out, e.g. coughing with an efficient, subsequent swallowing response?
- How does voice sound after swallowing, eating?
- Does the child consume enough food at mealtimes?
- How long does a meal take (more than 20 or 30 minutes)?

There are clinical assessment tools available for the evaluation of sucking, drinking and swallowing behaviour in infants, including the Neonatal Oral Motor Assessment Scale

(NOMAS, Palmer et al. 1993), Schedule for Oral Motor Assessment (SOMA, Skuse et al. 1995) and the Early Feeding Skills Assessment (EFS, Thoyre et al. 2005). The Pre-Speech Assessment Scale (PSAS, Morris 1982) was developed for children from birth to two years. The Dysphagia Disorder Survey (DDS, Sheppard et al. 2014) is indicated for children and adults with developmental disabilities from 8 to 82.

Sellers et al. (2014) published an algorithm, Eating and Drinking Ability Classification System, for individuals with CP (EDACS) for classifying eating and drinking performance of people with CP, for use in both clinical and research contexts. A Dutch version (Van Hulst et al. 2018) and a German version (Tschirren et al. 2018) are available.

Note

Depending on the examiner's experience, the first hypotheses can be formed during or after the assessment itself. Why can the desired movements not be performed? What can be done to elicit or facilitate them? If possible, during the first meeting changes in posture and position are provided as well as tactile support to evaluate the effects on tone and behaviour. This requires knowledge of normal child development and handling skills (► Sect. 13.5.1)!

13.4.2 Instrumental Diagnostic Procedures

The saliva in the laryngopharyngeal region can be assessed effectively within the framework of a Fiberoptic Endoscopic Evaluation of Swallowing (FEES, Langmore 2001), even in children (Seidl and Nusser-Müller-Busch 2011). A videofluoroscopy (VFC) allows for an assessment of the passage of food through the pharynx and esophagus (Arvedson 2011; ASHA 2004). In Germany a VFC is not performed in children to be fed, as the parents or therapist offering the bolus or holding the child during the examination must not be exposed to radiation (radiation safety procedures).

Also, gastrointestinal diseases, e.g. GERD, esophageal dysmobility, delayed gastric emptying and constipation, should be excluded. The 24-hour pH-metry test has been the most common method of identifying reflux to date. According to the guidelines of the Association of the Scientific Medical Societies, Germany (AWMF), when used in children, the test should be combined with intraluminal impedance measurement: a pH-independent method of detecting reflux (pH-metry MII; AWMF 2014).

13.5 F.O.T.T. Principles: Therapeutical Considerations

This section will address some F.O.T.T. principles which have proven particularly useful when working with children:

- Treatment should begin as early as possible, to provide the CNS with adequate stimuli for processing.
- The goal is to recognise and utilise the patient's potential.
- It is important to select individual goals and methods which encourage the integration and coordination of the developing systems. This ensures "carry over" into everyday life and prevents secondary complications (Coombes, personal conversation).

13.5.1 Child Development: Know the Normal!

> We must know the normal, in order to treat deviations. (Kay Coombes 2002)

All the internal organs are created within the embryo by the 14th week of pregnancy. Intrauterine images show the thumb pushing against the mouth area in the 7th week of pregnancy, indicating the first intrauterine tactile interactions with the environment (Biber 2012). The drinking of amniotic fluid is observable from the 12th week and suckling from the 24th week. At 28 weeks, the presence of surfactant causes the lungs to begin to expand. Suck-swallow coordination is possible from the 32nd week of pregnancy onwards. Immediately after birth a healthy baby is able to follow its sense of smell and turn its head towards the mother's breast, beginning to suck.

Infancy is characterised by homeostatic regulation (Chatoor 2012), and a rhythm of sleeping-waking periods, feeding, digestion and excretion is established. The newborn child starts to control the body against gravity. The early movements of the newborn look involuntary rather than purposeful and there is an absence of tonic adaptation. Slow motion video analysis has indicated that babies imitate facial expressions and tongue movements in a rudimentary fashion from the first week of life onwards, as soon as visual recognition occurs. It is not possible to hold the head up yet and the tongue is moved forward. Several sphincters within the body still have less tone and are incapable of fulfilling their functions. Flatulence is a familiar phenomenon in infants and is caused by swallowing air into the stomach as the upper esophageal sphincter still does not have sufficient tone in the first months of life (Bosma 1986).

Interacting with gravity – learning from day one

The infant begins to learn how to move with and against gravity with the help of the developing vestibular system. According to Vojta (1984, 1997) the CNS recruites upon an embedded matrix of postural and movement patterns. Orth and Block (1987) describe physiological spinal curves and balanced interrelationships between spinal segments as prerequisites, for the differentiated muscle functions which allow targeted movements.

In terms of gross motor skills, flexion predominates during the first and third trimesters of the first year and extension during the second and fourth trimesters (Pörnbacher 2006). The asymmetrical fencer position (▶ Sect. 13.2), the primary oral and almost all hand-mouth responses gradually disappear during the first year of life (◘ Table 13.1).

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Table 13.1 Primary oral responses (m/o = months old)

Primary oral responses	Stimulus–response	Cranial nerves	Disappearance
Rooting	Touching the cheek or angle of the mouth triggers opening of the lips and rotation of the head towards the stimulus (food source)	V, VII, XI, XII	3–6 m
Suckling	“Milking” the nipple	V, VII, IX, XII	6–12 m
Tongue protrusion	If touched or when drinking: Ttongue moves anteriorly, extraoral	XII	4–6 m
Transverse tongue	The tongue moves to the stimulus after the side border of the tongue is touched	XII	6–10 m
Phasic biting	Pressure on the gums triggers rhythmic up-and-down movements of the lower jaw	V	9–12 m
Gagging	Response to touching the back of the tongue	IX, X	Persists, but triggering is relocated posteriorly

Modified according to Arvedson and Brodsky (2002), Biber (2012)

Primary hand-mouth responses

- Palmar grasp: Between fifth and ninth months of age, pressure applied to the palm causes the fingers to bend and the hand to grasp.
- Palmomental: Reaction of the ipsilateral m. orbicularis oris and m. mentalis following stimulus to the area of the newborn baby's hand.
- Babkin: Flexion and rotation of the head causes opening of the mouth, up to 3 months of age.

Reflex vs. Reaction

In the Bobath and F.O.T.T. context, it has been suggested to replace the term reflex by "reaction" when referring to responses like swallowing, coughing and gagging (▶ Sect. 1.1.1). Ingram used the term neonatal mouth reactions rather than primitive reflexes to describe these activities as early as 1962 (van den Engel-Hoek 2008). The CNS learns to adapt and respond reactively to central, genetically determined brain activities (Orth 2006). The movement responses of a healthy baby begin to develop and change from day one!

The effect of function on form

A number of authors have emphasised the Roux principle: function affects the form (Bosma 1986; Castillo Morales 1998) and form in turn affects function! Both the form and the structures of the body are altered by the development of centering, locomotion, body straightening and breathing. The creation of new preconditions enables further development of the functions.

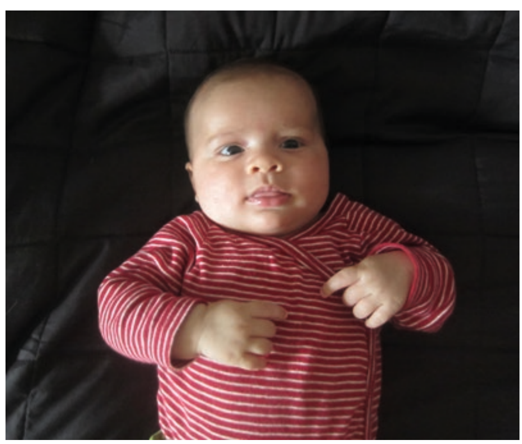
Significance of the pharynx for the head/neck region and upright body posture

By means of X-ray studies on healthy children (which would be impossible nowadays for ethical reasons) Bosma (1986) described the early childhood development of the pharynx into the upper airway and the significance for the development of postural functions in the head and neck region. The cries of a newborn baby tone the pharyngeal upper airway. Bosma identified the first stable position of the head and neck area as the earliest evident form of posture and competence, i.e. the start of postural control. Based on this, controlled and adjusted movements of the head against gravity can develop. The baby's crying strengthens the initially high-frequency breathing (which has no breathing pause), the voice and the pharyngeal musculature. Practice (and variety) makes perfect!

Elevation of the velopharyngeal tract

Pörnbacher (2006) describes the active neck extension as a basic function for all movement initiation. According to current understanding, active eccentric activation rather than passive stretching of the short neck extensors (suboccipital muscles) is considered to be effective (Horst 2011). Developing postural control and muscular (dynamic) stabilisation of the neck and shoulder girdle establishes preconditions for the development of head control and oral motor function (Orth 2011).

With verticalisation, the tongue which is physiological in an anterior position during the first months of life retracts into the oral cavity (◘ Figs. 13.1, 13.2, 13.3, 13.4 and 13.5).



◘ **Fig. 13.1** Two-week-old: physiological anterior tongue position. (© Nusser-Müller-Busch 2019. All Rights Reserved)

Fig. 13.2 Six-month-old: inconsistent anterior tongue position, support point (sternum). (© Nusser-Müller-Busch 2019. All Rights Reserved)

Fig. 13.3 Six-month-old: the tongue is retracted when the body is symmetrically supported in the hands/forearms, with the pelvis as the base, the support point. (© Nusser-Müller-Busch 2019. All Rights Reserved)

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The face is shaped by muscle forces, initially by breathing and suck-swallow movements, and the resulting pressure of the so-called buccinator mechanism (movement synergies of the orbicularis oris, buccinator and upper constrictor pharyngeal muscles, which are essential for the oral transport phase). At the beginning, the lower jaw and tongue move together in a mass pattern, with little variation in the movement sequence (Bosma and Donner 1980).

The early rhythmic feeding pattern known as *suckling* is characterised by "milking" of the breast. The nipple is extended to its full length and compressed against the hard palate by rhythmic, back and forward motions of the tongue and some opening and closing of the lower jaw. The same pattern is evident during bottle feeding, although the forward movement of the tongue is less pronounced (Morris and Klein 2000). In addition, the deep neck flexors are not engaged and strengthened dur-

Fig. 13.4 Twenty-four-month-old: the tongue is extended with intention. (© Nusser-Müller-Busch 2019. All Rights Reserved)

Fig. 13.5 Twenty-four-month-old: after swallowing, the tongue is located in the mouth. (© Nusser-Müller-Busch 2019. All Rights Reserved)

ing "passive" bottle feeding in the same way as during breast feeding (Orth and Block 1987).

From the 3rd/4th month of life onwards, the voluntary control of activities by means of central circuits begins (Hadders-Algra 2000). The body learns to center itself. As a result, the hands can be brought together in the middle and led into the mouth and face. The mouth (phylogenetically a grasping organ) is used for oral exploration. As a result, the balance can be maintained more and more.

The neurological maturation leads to an increasingly voluntary pump-suck-swallow pattern, known as *sucking*, at 4–6 months of age. The tongue is increasingly active with a greater range of motion (up and down movements of the tongue) and the intrinsic tongue muscles are formed. Lip and mouth closure (less vertical jaw movements) improves due to increasing dynamic stability of the neck and the lower jaw. This increases intraoral pressure and sucking becomes more effective. The reciprocal coordination of breathing and swallowing improves continually; i.e. a reflexive respiratory pause occurs during swallowing (▶ Sect. 8.2).

Dynamic stability and the development of motor strategies

The child develops motor strategies to achieve goals. The proprioceptive and vestibular systems are responsible for learning to balance, shift weight and focus.

Moving from supine to the side, supporting the body on the forearms, crawling on all fours, standing upright, walking, running and climbing are all characteristics of normal movement learning during the first two years of life. They lead to the acquisition of dynamic stability and postural control (Table 13.2). More detailed checklists can be found in Morris and Klein (2000) and ▶ https://www.nature.com/gimo/contents/pt1/fig_tab/gimo17_T3.html (assessed 2019, January 06).

Table 13.2 Development of body, hand and oral skills

Months of age	Motor skills	Oral skills and communication
1	Flexed posture Supine: random kicking, head moving to the side Arms/hands: Moro type mass movements Prone: turning head quickly to the side to keep airway open Turning to auditory, olfactory stimuli, visual fixation for 2–3 seconds	Hand to mouth by chance Suckling, rooting can be triggered Suckling liquid food
3	Head control, neck extension First isolated movement: eyes up to 30° from the midline, maintaining eye contact when changing head position Supine: Decrease in flexed posture and fencer position; Kicking: Arms, legs Orientating to the middle: Bringing the arms and hands together Prone: Raising the head briefly, neck flexion, symmetrical support on forearms Weight shifts to abdomen and pelvis (from cranial to caudal)	Mouthing Hand on breast/bottle Suckling thicker food Sustained eye contact, smiling Vocalisation, somewhat differentiated sounds
4–5	Tendency: Extension, head control, head turning Supine, legs in 90° flexion; support area: cranial/neck Bringing hand to hand Passing objects from hand to hand Grasping across the midline, purposeful grasping laterally Prone: "Swimming" – moving all extremities – Turning from supine to prone	Oral exploration, mouthing Spoon feeding Drinking from a cup with assistance Teething Identifying people Developing interaction and nonverbal communication Crowing laughter Modulated vocalisation – alone and in dialogue
6–7	Posture: Using flexion and extension Prone: Symmetrical support on hands and thighs Adjusting the head position when slowly be pulled up to sit, arms bent Side lying: Not stable Coordinated rolling from supine to prone All fours Sitting – for short time Grasping and moving objects from one hand to the other Enjoyment when changing position playfully	Oral exploration, mouthing Reaching for the bottle with both hands Salivation when grasping Sucking thicker and pureed consistencies Lips closing around the spoon Exploring, sucks solid food, asymmetrical biting (precursor for rotational movements of lower jaw/chewing) Phasic biting Following activities in the immediate vicinity Sounds become more varied

Table 13.2 (Continued)

Months of age	Motor skills	Oral skills and communication
8–10	Crawling Coordinated turning from prone to supine, via secure side lying Pulling to standing Hand activities with a stable shoulder girdle Hand-mouth-eye coordination Using the whole hand to grasp a spoon Grasping upwards Holding objects with one hand	Holding a cup Drinking from a cup Different facial expressions, shy, anxiety of strangers Responding to its name Using upper lip to take soft pureed food from a spoon, grabs the spoon Helping to move the spoon Exploration of objects Beginning rotational jaw/tongue movements for solid food Vocalising series of sounds "a"
11–12	Steps sideways, holding onto furniture with both hands, eventually walking Standing without support (wide base) (Long) sitting without support Pincer grasp with opposable thumbs Using one hand whilst standing, carrying	Holding a cup with both hands – drinking from a cup with support Increasingly solid food, also using pincer grasp Pointing at objects of desire Using objects correctly, e.g. pretending to talk on a mobile phone Forming concrete/object-related sounds Syllable coupling ("mama", "dada")
13–14	Further verticalisation (trunk, head and spine, punctum stabile; tongue and mandible, punctum mobile) First steps Sitting upright Walking hand in hand, first independent steps Holding and tilting the cup with both hands Holding a spoon with one hand	Lateral tongue and jaw movements Beginning to grasp the spoon Eat with a spoon Drinking from the cup independently: 4–5 successive swallows Initiation, continuation and ending of social interactions First one or two words
15–24	Maintaining balance confidently Walking, running Hand dexterity Spine extension and stable jaw allow intra- und extraoral tongue movements cranially and in all directions Learned skills are refined and varied Imitation: Two blocks can be placed on top of each other Passing objects with the hand Looking at picture books Rhythmic (finger)games Playing alone	Improving rotatory jaw movements "chewing", Swallowing with closed lips Simple requests, offers and prohibitions are understood Developing language
25–36	Walking confidently, can avoid obstacles Improving dynamic stability: Climbing, swinging, the whole range of activities Role playing, implementing own ideas for games Turning the pages of a book	Unwrapping sweets Eating nearly all kind of solid food Eating and drinking independently, using spoon and fork

According to Arvedson and Brodsky (2002), Arvedson (2006), Fischer (1998), Michaelis and Niemann (2010), Steding-Albrecht (2003), Vojta and Schweizer (2010)

Dynamic Stability

The head and trunk and shoulder girdle provide stability. Stability creates a punctum stabile allowing the extremities, hands, jaw or tongue to act as punctum mobile and adapt to the situation and task, e.g. to grasp a cup, to open the lips and jaw to eat or brush the teeth and eventually to speak. This dynamic stability, or ability of one and the same structure to switch instantaneously from punctum stabile to punctum mobile and vice versa, eventually becomes automated over time. This is essential for all activities including eating, drinking and swallowing (Morris and Klein 2000).

Dynamic Stability during Eating and Drinking

Healthy individuals can eat, drink and swallow in almost any position. There are certain patterns which make these functions easier, however, such as sitting up straight at a table with pelvis anteriorly tilted or standing with the head centered. Adjusting the pelvis, trunk, head and jaw to the task at hand is a prerequisite for the development of normal, age-appropriate food intake. The jaw must be dynamically stable: mobile when talking and chewing and stable when swallowing (Fig. 4.6b, d).

This biomechanical principle also determines the formation of a physiological phonation and of speech movements.

» A good feeding pattern is essential for further speech. (Helen Mueller 1997)

More selective jaw and tongue movements develop with increasing rotation. At 6–8 months of age lateral, asymmetric jaw movements start when biting off pieces of food. "Munching" follows with stereotypical vertical jaw movements, which become increasingly differentiated and controlled (Morris and Klein 2000). In the next phase, jaw movements appear to be more diagonal before merging into the typical rotatory movements. These movements help to adequately grind, chew and transport the food back and forth in the oral cavity and mix it with saliva. The chewing pattern gets mature by around four years of age.

Goal-directed, isolated tongue movements (caudally, laterally and later cranially by sticking the tongue out, punctum mobile) become possible from about 12 months of age, as the spine becomes upright, the neck and the lower jaw increasingly stable (punctum stabile). Between one and two years of age the time is right to bid farewell to bottle feeding and begin drinking from a beaker. The buccal space is increased by the disappearance of the buccal pads, breakthrough of the molars (up to 24 months of age) and the growth of the oral cavity. The face changes shape and loses its baby-like appearance. The larynx lowers from the level of the third cervical vertebra C3 to C7-C8 (in adulthood) due to longitudinal growth and extension of the spine and is located in front of the upper esophageal sphincter segment.

Development of further facial-oral activities

Differentiated facial expressions, phonation and speech movements become possible by the evolving postural control and coordinated breathing.

The head and neck (punctum stabile) must be stable while speaking, so that the lower jaw and tongue (punctum mobile) can move.

Of the total resistance of the airway in infants and toddlers, 70% is generated within the nose (Riessen 2013), making it vital that the nasal passage be kept free. The bronchi have minimal stiffness and the diameter of the airway is smaller. Secretions are primarily transported out of the lungs by the movements of the ciliated epithelium and only secondarily by coughing. From school age onwards, the conditions become increasingly similar to those in adults.

For coughing to be efficient, several components must be synchronised, required in time: inspiration with rapid and sufficient capacity, glottis closure, compression of the expiratory muscles, with trachea-bronchial stability and a strong, expulsive thrust of the secretion upwards and outwards. The prerequisites include functioning receptors and ciliated epithelium and sufficient mobilisation of secretions in the bronchi and lungs.

Blowing the nose, i.e. targeted pressure build-up whilst breathing through the nose, only becomes possible once children have reached preschool age. Professional methods of cleaning the teeth (Sect. 6.5) also require highly coordinated movements of the hand and fingers, which are only possible at school age. Parents should always give their children's teeth a final brush until they are around 7 years of age.

- **Experiential learning – plasticity through experience**

The plasticity of the brain, muscles and structures develops according to experience. The process of gaining experience in and with the environment, of experimentation and imitation within a meaningful context, continues throughout our lives.

Note

Driving forces of learning and the acquisition of competencies:
- Vigilance
- Attention
- Well-being
- Curiosity, interest
- Motivation

In motor learning, the attention is always directed towards solving a problem or completing a task, rather than the cognitively controlled "how-to-do" of the process (Wulf 2009). Repetition and variation enable motor learning to take place (► Sect. 1.3.3). Postural responses and motor movement patterns are repeated and varied until they demand less and less attention and become automated (Bower 2008; Kleim and Jones 2008; Mulder and Hochstenbach 2002). Well-being and slowness (also breaks) are necessary for neuronal development (Orth 2006).

13.5.2 Children with CP: Positioning and Handling

Without the ability to maintain equilibrium and change positions, environmental interactions and food intake are severely impaired. Children with persistent, asymmetric tonic neck reaction (ATNR) must be given opportunities to find symmetry and balance and need help to achieve appropriate positions, often for the rest of their lives. Changes in posture and increasingly shortened musculature lead to hyperextension of the body and head: saliva swallowing and the intake, processing and swallowing of food are all severely impaired. Ekberg (1986) has highlighted the mutual influence between posture and head position (1986).

Note

Fundamental considerations:
- What can we do to minimise pathological motor reactions and to elicit spontaneous swallowing responses?
- How should we touch, hold or position a child, e.g. in cases of defensive behaviour?

Handling refers to holding, positioning of a child and manual support during movement transitions, i.e. performing activities such as changing diapers, dressing (◘ Fig. 13.6) and carrying or everyday assistance, e.g. assisting mouth closure. Hands-on techniques are implemented to support postural control and improve the biomechanical situation if needed.

◘ **Fig. 13.6** Handling: when the trousers are pulled up, the mother lifts the pelvis with hips bent. The center of gravity and support is located in the area of the upper thoracic spine and the neck, whose receptors are those to receive impulses for extension. (© Nusser-Müller-Busch 2019. All Rights Reserved)

Positioning during eating and drinking

There is consensus on the importance of postural control when serving food to children (West and Redstone 2004). Positions have been implemented in paediatric therapy with the goal of ensuring safety. These positions were developed during the 1960s and 1970s, by the protagonists of the Bobath approach (Mueller 1997; Bower 2008).

In older children and adults a symmetrical, upright trunk position with a long neck, with the feet resting on a firm surface and the hips flexed to 90° if possible, improves adequate muscle tone (Nwaobi 1987). This posture is designed to facilitate oral activities and reduce aspiration (Gisel et al. 2000).

Our experience suggests that a solid base of support for the arms (e.g. resting on a table to support upright posture and stabilisation of the shoulder girdle) is a contributing factor when creating a useful position for therapy or eating (▶ Chaps. 5 and 8). The person offering the food can sit opposite (allowing eye contact, ◘ Fig. 13.12) or behind the child to guide her through activities (◘ Fig. 13.8).

Infants can be placed on the thighs of a seated adult to ensure adequate flexion at hips and knees. This position allows the spine and neck to remain long, and most importantly, eye contact can be maintained. Establishing motor rest at the Bobath key points in the neck and sternum has proven effective (calma motora; Castillo Morales 1998, Türk et al. 2012), as it helps with centering and making eye contact and imitation if applicable. Of course, vocalised expressions can be picked up naturally, repeated and offered changed over time.

If an infant is held in the arms for feeding, care should be taken to guide both arms to the midline (avoid trapping an arm behind the mother). Further information on feeding positions (from birth to 18 months of age) can be found in Morris and Klein (2000).

Resting positions

Therapeutic and functional support in a neutral body position is increasingly popular (Pickenbrock 2012). The joints are placed in the most neutral position possible to avoid overstretching and shortening the muscles. The supporting surface adapts to the body rather than vice versa; i.e. supportive materials such as blankets and pillows are used to stabilize body segments by "modelling" and "filling" (▶ http://www.lin-arge.de/, Pickenbrock et al. 2015). The authors list one exception for working with children: For children up to 6 years of age, the hips are placed in a wider position than neutral to avoid adversely affecting the development of the hip socket.

Regular positioning in a prone position or the 135° position should also be aimed for.

Note

To prevent (silent) aspiration, the patient's position should be changed regularly or as often as required. To move or to be moved opens up the possibility of perceiving saliva and residues in the oral cavity and then swallowing it.

The position of side lying supports saliva to flow out of the mouth with the aid of gravity.

An additional 40° inclination/elevation of the supporting surface is necessary for children with GERD. The prone position should be used with caution and under observation, e.g. in children with a PEG/PEJ only during breaks in tube feeding.

Alternative positions, and positions designed to improve active participation in daily activities such as eating and drinking, must be selected on an individual basis. They will need to be adapted constantly (▶ Chap. 8). Regular training and instructions for relatives and carers are essential.

13.5.3 Involving the Hands: From Hand to Mouth!

The hands unconsciously and intuitively touch the face throughout the day and night, e.g. scratching the nose, drying the face, wiping the mouth, resting the face in the hands, etc. A close developmental relationship exists between the hands and the mouth: The interdigital membrane between the fingers of an embryo has the same genetic origin as the tongue. Hand-mouth associations are found in primary responses such as the neonatal mouth reactions, palmar, palmomental and Babkin (Biber 2012; ▶ Sect. 13.5.1). Involving the hands mostly lead to mouth movements and vice versa. If contractures in the hands make it impossible to hold a plate, cup or other object, another way of involving the arms and hands must be found, e.g. in contact with the therapist or positioning the plate so that it touches the patient's arm or hand (◘ Figs. 13.12 and 13.15).

Note
Know the normal! In daily life the hands are involved in almost all activities. They touch or enter the mouth countless times each day. For this reason, they should always be included in the child's (and grown up's) activities and treatment!

13.6 Facilitating Facial-Oral Functions and Activities

To prevent oral sensory deprivation and to enable children to learn functions and activities appropriately, opportunities for oral and manual exploration must be offered consistently, within the different contexts of daily life. Stimulation of the structures in the oral cavity is vitally important, particularly for children who cannot use their tongues voluntarily and stimulate themselves intraorally.

13.6.1 Face - Hand - Mouth: Tactile Hello and F.O.T.T. Stimulation

Children are greeted according to the circumstances and their specific needs. For example, children with reduced vigilance and/or awareness, or in a coma, are greeted in the same way by all members of the team, e.g. by an initial contact on the shoulder. The nature of the greeting is agreed by the team in advance.

A suitable starting position is found, or the current position checked and adjusted if necessary. The initial approach to the face is slow and takes the form of a *tactile hello*. It is preferable to use the child's hands until the touch can be tolerated (◘ Fig. 13.7).

The jaw is stabilised using the jaw support grip as the child's or therapist's finger approaches, and the mouth or oral cavity is touched several times in different ways.

This process can be followed by F.O.T.T. tactile oral stimulation (▶ Sect. 6.2.4, ◘ Fig. 13.8).

◘ **Fig. 13.7** Tactile hello. The therapist uses her body to provide support, creating boundary and supporting surface from behind. She guides the child's hands to the face. The child is positioned forward. The arms are supported. (© Elferich 2019. All Rights Reserved)

◘ **Fig. 13.8** Subsequent tactile oral stimulation with the child's finger while the jaw is stabilized. (© Elferich 2019. All Rights Reserved)

F.O.T.T. Tactile Oral Stimulation

Know the normal! We stimulate our face and mouth throughout the day, in particular when eating, drinking and speaking. Those who are not able to do this for themselves must receive the necessary experience "from outside". Tactile oral stimulation supplies information and stimuli wherever the tongue is not able to move by itself. The goal is to give structured sensory input and to trigger motor or swallowing reactions, which can be developed into actual swallowing.
Tactile oral stimulation takes place after the *tactile hello*.

- During assessment
- To prepare the oral systems
- To trigger oral and swallowing reactions
- To develop structural components
- As part of the routine preceding food intake
- Prior to or as a modified form of oral hygiene (e.g. with moistened gauze)
- To detect injuries and bite wounds in the cheeks
- To prevent hypersensitivity

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The slow approach is designed to ensure that the system is in a state of readiness. This can prevent hypersensitivity, e.g. defensive reactions, which also occur more frequently if the patient is fatigued.

Warning
If there is a danger of bite reactions, the therapist's fingers can be introduced into the buccal cavity but not placed between the teeth. This includes the child's own finger!

Saliva or food which drools out of the mouth should not be removed with diffuse wiping movements, as these may cause evasive movements and extension (Fig. 13.9). If considerable amounts of saliva drool from the mouth throughout the day, everybody dealing with the child should provide the required assistance in an identical way!

Fig. 13.9 The child's hand is guided while the mouth is wiped. The other hand is touching the cup. (© Elferich 2019. All Rights Reserved)

Practical Tip

Cleaning the Mouth: Therapeutically Structured
Drooled saliva or food should be slowly removed with an appropriate amount of pressure, wiping in the direction of the mouth. Moist gauze can be used to clean the mouth intraorally, e.g. during tactile oral stimulation.

13.6.2 Therapeutic Eating and Drinking

If the general preconditions are fulfilled (▶ Overview 13.2), therapeutic eating and drinking (▶ Sect. 5.5.2) can begin once the child is prepared and the oral cavity is prepared, "awake".

Overview 13.2 Preconditions for Therapeutic Eating and Drinking (According to F.O.T.T.)

- Alertness
- Understanding of the situation "eating"
- Positioning (including supporting aids)
- Lip and jaw closure (including assisted)
- Incipient oral and pharyngeal movements
- (Ideally) swallowing of saliva
- Sufficient coughing reaction (including assisted)
- Phonation is possible
- No laryngo-pharyngeal secretion, no mucus
- No pneumonia

The aim is to stimulate the interest in food and allow the child to experience smell, taste and the necessary movements in a safe, controlled situation (◘ Figs. 13.10 and 13.11).

◘ **Fig. 13.10** Pre-oral phase: the child is guided while holding the cup and wetting the finger. (© Elferich 2019. All Rights Reserved)

Drops of liquid or puree are usually offered, to stimulate taste. A finger is used to offer very small quantities at first to set impulses and trigger motor responses. A small spoon or a cup can be used later (◘ Fig. 13.12). Later, solid food wrapped in wet gauze can also be chewed (► Table 5.1). The neck must be kept long, and the jaw support grip can be

◘ **Fig. 13.11** The wet finger is guided to the child's mouth. Movements and taste stimuli can be experienced in a controlled situation (© Elferich 2019. All Rights Reserved)

◘ **Fig. 13.12** Sipping a drink. The arms are involved. The therapist demonstrates pursing the lips and provides acoustic support. (© Elferich 2019. All Rights Reserved) used to stabilise the jaw and provide tactile assistance for jaw closure, if needed. Tactile swallowing support can also be given (▶ Sect. 5.3.3).

Note

Safety comes first! The daily physical state can vary greatly in children, if their condition is unstable.

It may therefore be necessary to deviate from the treatment plan for safety reasons. Factors such as slowness, repetition and variation must be taken into account, and it is essential that the adult remains patient!

A structured approach is vital, offering food in small steps and slowly with pauses, to allow the rhythm of breathing to be reestablished after swallowing again.

If children are prone to vomiting, then small quantities should be offered and often.

Note

Breathing and voice quality – before, during and after eating – are indicators of whether food has taken the correct path.

Practical Tip

Coughing Assistance and Swallowing Support

The coughing person's head and trunk should be kept in forward position (flexion) to avoid hyperextension! The therapist's hands provide lateral stability for the ribcage, allowing the expiratory air to find its way upwards more efficiently (▶ Fig. 10.4). Tactile swallowing support (▶ Sect. 5.3.3) should be offered for the clearing and subsequent swallowing which follows after coughing.

Afterwards the oral cavity (and especially the cheeks) should be carefully inspected for food residues and should be wiped out carefully with wet gauze if necessary.

The developmental age and functional abilities of the child must be taken into account when selecting an appropriate diet. The consistency of the food provided may range from a viscous liquid to soft or solid foods.

Combined oral feeding and tube feeding

Any intake of food orally should be considered a positive achievement that should be maintained, no matter how small the quantity. Additional food or fluids required can be supplemented by tube feeding. Combined feeding has many advantages over nutrition entirely by tube. Structures within the swallowing tract are moved and the health of the mucous membrane is maintained. The dreaded tongue coating and thrush can be minimised or prevented.

13.6.3 Tube Feeding Is a Meal

Artificial nutrition is designed to alleviate phases of malnutrition which may be life-threatening. It mitigates the pressure on parents and caregivers to maintain an adequate supply of calories and liquids, which are essential for growth and energy requirements. In emergency situations, parenteral nutrition is provided intravenously.

Nasogastric tubes are initially supplied. But they can impede swallowing movements mechanically and often the tube is pulled accidentally – either by the child or during handling. If problems persist, then a PEG is supplied or a PEJ in case of reflux.

Note

At least once or twice a day, the child should be placed in the same position used for oral feeding for a period of time. The hands and mouth are involved during this meal, e.g. through tactile oral stimulation or taste stimulation using a finger (◘ Fig. 13.13). The idea is to create an understanding and reference to the feeling of sating hunger. Due to the risk of reflux, tube feeding generally takes place with the upper body raised (◘ Fig. 13.14).

Fig. 13.13 During tube feeding: Wiping milk from the mouth. (© Elferich 2019. All Rights Reserved)

Fig. 13.14 Tube feeding in a side lying position, with the upper body raised. The position of the hips and legs is changed every few minutes. (© Elferich 2019. All Rights Reserved)

Tube Weaning in Children with Feeding Disorders

In recent decades, interdisciplinary tube weaning programs have been developed for children with feeding disorders, who are organically capable of consuming food orally (Dunitz-Scheer et al. 2007; Wilken and Jotzo 2011). The programmes can be carried out in hospital or at home, e.g. via net coaching. Both methods of the Graz model from Austria show success rates of 90% for net coaching and 81% for in-patient treatment (Marinschek et al. 2014). The earlier a weaning program can begin after tube feeding, the lower the risk of undesired behaviour patterns or dependence on tube feeding becoming established (▶ http://www.notube.com/de/).

13.6.4 Oral Hygiene: Stimulation of Swallowing and Pneumonia Prophylaxis

Maintaining the health of the teeth is not the only goal of oral hygiene. It is particularly important for children who are fed artificially and/or (silently) aspirate, as bacteria can enter the lungs from the oral cavity along with saliva, causing pneumonia (▶ Chap. 6).

Note

Special attention must be paid to breathing and to residues in the oral cavity after each meal. It is vital to inspect and clean the oral cavity after eating, before placing the child in a supine position.

Even if nothing has been eaten beforehand, brushing the teeth is one of the best ways to supply structured, tactile input inside the mouth and facilitate swallowing reactions. An infant's toothbrush or nubbed finger stalls can be used for this purpose (Figs. 13.15 and 13.16).

Fig. 13.15 Cleaning the teeth in a side lying position. (© Elferich 2019. All Rights Reserved)

Fig. 13.16 Cleaning the teeth at the washbasin (© Elferich 2019. All Rights Reserved)

Practical Tip

A Cheyne spoon or spatula padded with gauze (Fig. 6.13) can be prepared to keep the mouth open and give stability to the lower jaw. During brushing, these aids must be removed frequently in anticipation of possible swallowing reactions and be repositioned afterwards.

The regular moistening of dry oral mucosa is recommended, e.g. for children in palliative situations (Penner et al. 2010).

13.6.5 Rest Positions after Eating

A safe upright position should be adopted for a period of approximately 20 minutes, after eating and oral hygiene. This can prevent the regurgitation of food into the throat, reflux or vomiting and possible aspiration. Positioning materials can be used to

Fig. 13.17 Upright position after a meal: head resting to the side. (© Elferich 2019. All Rights Reserved)

Fig. 13.18 Upright position after a meal: head resting forwards. (© Elferich 2019. All Rights Reserved)

Fig. 13.19 Standing rest position for several minutes after tube feeding. (© Elferich 2019. All Rights Reserved)

support the child from the front or side. Saliva residues in the mouth are able to drool out by gravity (Figs. 13.17, 13.18 and 13.19). The side lying position is indispensable, with the upper body raised if there is a risk of reflux.

Warning
The flat supine position is contraindicated: Oral residues or stomach contents can flow backwards into the open airway.

13.6.6 Secretion Management and Respiratory Therapy

Secretion residues pool in the bronchial tubes and lungs, due to the dysfunction of ciliated epithelium and the inability to cough efficiently. Therapeutic respiratory measures and secretion management are vital for children who are immobile, supplied with TT and/or ventilated, at home or in intensive care units.

The term *secretolysis* encompasses all methods of dissolving and liquefying viscous (bronchial) secretions, which allows them to be removed from the lower airway and coughed up or suctioned off (Van Gestel and Teschler 2010).

Different methods are often used in combination:

- Medication, inhalation, respiratory stimulating rubs, physiotherapy techniques to mobilise secretions (e.g. heat applications, skin rollers, thoracic mobilisation, percussion and vibration), suctioning and positioning the patient to support respiration and secretion drainage.
- Mechanical airway clearance devices (i.e. “cough assist”, which reinforces the strength of coughing by increasing positive and negative pressure) and vibrating vests (high-frequency chest wall oscillation vests) are increasingly common in the domestic sector (Riessen 2013).

Secretion mobilisation is designed to remove bronchial secretions from the mucous membranes. Various activities are used to loosen secretions, e.g. twisting, rolling on a mat, moving on a gymnastic ball or trampoline or while standing in a standing frame. Manually assisted prolonged exhalation deepens the subsequent inhalation. These measures can easily be integrated into everyday activities (Figs. 13.20 and 13.21).

In the event of congestion, stroking of the intercostal spaces is carried out with the patient in an adapted starting position. The side lying position improves ventilation and respiratory movements in the upper section of the thorax. Placing the legs in a slightly bent position keeps the pelvis upright, improving the mobility of the diaphragm (Figs. 13.22 and 13.23).

Physical activity and movement cause breathing to deepen. Breathing therapy can improve the ventilation of the thorax, increase pulmonary capacity and promote more productive coughing (► Chap. 8).

Fig. 13.20 Before getting dressed: Exhalation is supported manually in sitting. (© Elferich 2019. All Rights Reserved)

Fig. 13.21 Fetching a t-shirt from the shelf together: use of targeted rotational movements to mobilize and deepen breath. (© Elferich 2019. All Rights Reserved)

Fig. 13.22 The function affects the form: thoracolumbar scoliosis in adolescence. (© Elferich 2019. All Rights Reserved)

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Warning

Extreme care must be taken when using techniques involving the fingers, electric massage devices, toothbrushes, etc., with infants. "The musculoskeletal framework is still very fragile" and rib fractures and neurological damage can easily occur (Riessen 2013)!

The efficacy of manual coughing assistance has yet to be fully investigated. Studies by Frank et al. (2015) presented a respiratory intervention technique known as *bagging*, for adult patients in early neurorehabilitation. Air is added to the lungs using a resuscitation bag, and this is followed by manual coughing assistance. The patients investigated showed improvements in oxygen levels, vigilance, bronchial secretions and swallowing. However, no data is currently available regarding the use of bagging in children and adolescents.

Positions which support breathing, such as alternate lengthening or pressure-relieving position, may also benefit respiratory muscle activity and lung ventilation. The

Fig. 13.23 Intercostal spaces: light pressure is applied as the fingers stroke slowly from dorsal to ventral during exhalation. (© Elferich 2019. All Rights Reserved)

temporary side lying position shown in Fig. 13.14 combines several aspects of respiratory therapy: the use of gravity to ease respiration, by relieving the thorax of the weight of the shoulder girdle, and further expansion of the right side due to the bent position of the arm. The top leg is bent, abducted and externally rotated at the hip to prevent sliding.

Drainage positions exploit gravity to increase the flow of secretions out of the bronchial tubes. There are several specific positions designed to use gravity to mobilise secretions in the lobes of the lungs. These include side lying, prone and the head down position (Gerdes 2003). Additional manual techniques for secretion mobilisation can be carried out in these positions.

Warning

Only trained staff should carry out drainage positioning! Contraindications for the head down position include reflux disease, aortic aneurisms and/or aneurisms of the cerebral arteries, cerebral oedema, intercranial pressure, dyspnoea and unstable cardiovascular conditions.

► Chapters 9 and 10 address the handling and therapeutic approach to TT. The use of cuffed TT in children must be carefully weighed up by all parties involved. Clinical recommendations for endotracheal suction in infants and children can be found in Riessen (2013) along with the corresponding evidence level.

13.7 Children in the Focus of Interdisciplinary Efforts

13.7.1 Interdisciplinary Team

Ideally, an interdisciplinary team (comprised of physicians, nurses, physio-, occupational, speech therapists) should support the parents in caring for the child. Other disciplines complement the interprofessional spectrum as required, including dieticians, dentists, orthodontists, orthoptists and specialists in orthotics and prosthetics.

13.7.2 Children in Special Need Facilities

Despite the current debate about inclusive education of healthy children and children with special needs (e.g. in Germany), many children and adolescents with special needs still receive schooling in specialised residential institutions.

The team responsible for the child during the day is under pressure to ensure an adequate intake of calories and fluids. This pressure is felt by carers, relatives and children alike! Frequent or permanent (often silent) aspirations are the cause of recurrent pneumonia and bronchitis, endangering the patient. The unfortunate reality is that many residential institutions may be far away from the nearest specialist physician or the availability of instrumental diagnostic procedures (e.g. FEES or videofluoroscopy). Parents may reject these and other tests, because they fear having to abandon an oral diet, painstakingly built-up over time, in favour of tube feeding.

A cooperative approach in which differing points of view can be exchanged with confidence, maintaining the emphasis on the child's or adolescent's participation, is a goal which must be constantly strived for! Schlichting (2010) advocates approaching nursing as a teaching opportunity rather than an additional form of care provision. Teaching goals include the promotion of perception and movement and the acquisition of both independence and culture. In order to utilise nursing procedures to develop sensorimotor and communication skills, the teachers and professional groups involved must acquire nursing expertise and therapeutic skills (Kuhl and Spies 2013). This includes the basic principles of handling, in order to transfer students during school and play activities, supporting the mobilisation of secretions, and changing diapers.

Note

Special attention must be paid to breathing and to residues in the oral cavity after each meal. It is vital to inspect and clean the oral cavity after eating, before placing the child in a supine position.

Problems with nutrition are almost universal. The range of tasks to learn includes drinking and eating independently, preparing and transporting food, swallowing different consistencies, breathing-swallowing coordination, saliva management and the mobilisation of secretions. It also encompasses the control of dietary progression and weight gain.

The vital situation of the affected person is in the foreground and shapes everyday life. Nevertheless, it is both desirable and necessary that team members work towards developing methods of augmentative and alternative communication (AAC) approaches for children and adolescents with complex communication needs (► https://www.isaac-online.org/english/home/).

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Definitions

Alignment - Adjusting body sections (the head, shoulders, spine, hips, knees and ankles) to each other and the body position with respect to gravity and supporting surface.

Mobilization - The patient moves or can be moved within a postural set or into another postural set, passively or with facilitation/support. Depending on the task, the goal is to achieve adapted postural control to gain more/different sensorimotor input and a higher range of motion (ROM).

Positioning - All body segments (pelvis, thorax, shoulder girdle, head and extremities) are brought in an appropriate position to each other, to the base of support, the gravity and the activity. Each position chosen must be safe, e.g. without risk of falling or aspirating. A position should never be uncomfortable or painful.

Before positioning, the patient should be mobilized and postural control should be facilitated to create optimal alignment. For patients with rather severe problems of perception, *guiding* might be useful to achieve the new position (e.g. from sitting to side lying). Positioning can be passive, assisted or active.

Facilitation - This is a therapeutic method helping the patient to initiate, continue and complete functional tasks. Various types of afferent input (tactile/propreoceptive, visual, vestibular, somatosensory and acoustic information) can be used to stimulate the sensorimotor system, e.g. functional movements in the facial-oral tract. The location, direction and duration of facilitation might vary. Facilitation is an active learning process, helping a person overcome inertia, continue or terminate functional tasks.

Facilitation can be used when the patient has inadequate motor behaviour, decreased/lack of postural control, or problems to perform selective movement.

Elicitation - Evoking of a movement, a function, an activity or behavioural pattern by an appropriate environment design. Elicitation is using position, support and/or situation (‘setting the scene’) to draw out a functional response or reaction from the patient.

Guiding - The therapist guides the patient’s body and hands in problem-solving activities of daily living (ADL), e.g. dressing or dining. Goals are to provide tactile/proprioceptive information to the patient about the position of his/her body in the environment and its activity and to improve the organisation of perceptional processes in the brain (Affolter 1991).

Service

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