

Effects of Therapy in Oropharyngeal Dysphagia by Speech and Language Therapists: A Systematic Review

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Abstract Medical and paramedical treatments should be evaluated according to current standards of evidence-based medicine. Evaluation of therapy in oropharyngeal dysphagia fits into this growing interest. A systematic review is given of the literature on the effects of therapy in oropharyngeal dysphagia carried out by speech therapists. Thus, the review excludes reports of surgical or pharmacological treatments. The literature search was performed using the electronic databases PubMed and Embase. All available inclusion dates up to November 2008 were used. The search was limited to English, German, French, Spanish, and Dutch publications. MESH terms were supplemented by using free-text words (for the period after January 2005). Fifty-nine studies were included. In general, statistically significant positive therapy effects were found. However, the number of papers was rather small. Moreover, diverse methodological problems were found in many of these studies. For most studies, the conclusions could not be generalized; comparison was hindered by the range of diagnoses, types of therapies, and evaluation techniques. Many questions remain about the effects of therapy in oropharyngeal dysphagia as performed by speech and language therapists. Although some positive significant outcome studies have been published, further research based on randomized controlled trials is needed.

Keywords Systematic review · Dysphagia · Swallowing · Deglutition · Therapy effect · Therapy outcome · Rehabilitation · Deglutition disorders

It is now widely accepted that medical treatments should be evaluated by scientific methods. By extension, paramedical therapies would also need objective evaluation according to current standards of evidence-based medicine. Evaluation of therapy in oropharyngeal dysphagia fits into this growing interest. This article presents a systematic review of the literature on the effects of swallowing therapy carried out by speech and language therapists. Accordingly, the review excludes reports on surgical or pharmacological treatments.

Therapy effects can be determined by performing the same measurements before and after therapy. To obtain objective data, certain issues must be taken into account. When using perceptual or visuoperceptual evaluation (e.g., visuoperceptive evaluation of videofluoroscopy or fiber-optic endoscopy of swallowing), the raters must have no information on the pre- or post-therapy status or on the moment of data collection to ensure blinded scoring. Furthermore, if a placebo or control group cannot participate for ethical or practical reasons, another therapy group may be included instead. Especially in nonhomogeneous subject populations, group analyses of therapy outcome can result in effects that are hardly statistically significant. When focusing on specific patient populations, however, the therapy outcome may be highly diverse. Therefore, besides group analyses, attention must be paid to individual results as well.

In the literature, fiber-optic endoscopy and/or videofluoroscopy of swallowing are taken as the gold standard.

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Either one is used to assess the success or failure of swallowing therapy, frequently along with a variety of clinical evaluations such as dysphagia severity ratings or dietary status. More recently, quality-of-life measurements (e.g., the SWAL-QOL [1] or MDADI [2]) have become part of the assessment protocol for swallowing disorders. A patient's well-being might be taken into consideration when judging the beneficial effects of any therapy. Besides these common methods, there are some less frequently applied evaluation techniques, notably surface electromyography. Assessment tools are administered in many different ways. The literature reveals great variability in the amount or type of boluses and the viscosity of liquids offered to the patients during assessment. The number of trials and the chosen cutoff points for aspiration or penetration may also differ significantly. Recent advances have been made in the digital processing of fiber-optic endoscopic or videofluoroscopic recordings. Thus, new methods to derive objective measurements [3] have been introduced to complement the usual visuoperceptive techniques. It may be useful to include several evaluation techniques in a study of swallowing problems since patients will not necessarily show abnormality in all aspects of swallowing nor improvement in all of these aspects after treatment. For example, objectified findings on videofluoroscopic recordings of swallowing may not be consistent with the patient's own judgment of therapy outcome. However, when applying diverse assessment parameters and tools, the researcher must grapple with the increasing probability of significance.

Three earlier reviews on swallowing therapy should be mentioned. These were restricted to post-stroke patient populations [4–6] and/or (quasi-) randomized controlled trials [5, 6]. The present review, in contrast, covers all studies on oropharyngeal dysphagia without placing any restrictions on subject populations or study designs (except for consensus or expert opinions). It comprises a systematic review of the literature on the effects of swallowing therapy as applied by speech and language therapists.

Methods

A literature search was performed independently by two reviewers. They selected the electronic databases PubMed and Embase and used all available inclusion dates up to November 2008. The search was limited to publications in English, German, French, Spanish, and Dutch. In PubMed, the MESH terms *deglutition* or *deglutition disorders* were combined with *treatment outcome*, *fluoroscopy*, or *pneumonia*. The search was restricted using the MESH terms *humans* and *adult*. In Embase, the MESH terms *dysphagia* and *swallowing* were linked to *behavior-therapy*, *diet-*

therapy, *electrostimulation-therapy*, *movement-therapy*, *muscle-training*, or *thermal-stimulation*. To identify the most recent publications, the search terms were supplemented with free-text words in PubMed and Embase (for the period after January 2005). Specifically, the words *dysphagia*, *deglutition*, and *swallow** were combined with *treatment*, *rehabilitation*, and *therapy*. In PubMed, the search was limited by using a filter (adults 19 + years). In Embase, it was limited by excluding certain free-text words (*not infant*, *not child*, *not baby*, *not babies*, *not adolescent*, *not drug**, *not operat**, and *not surg**).

The included articles were classified according to their level of evidence using the ABC rating scale developed by Siwek et al. [7]. Level A refers to high-quality randomized controlled trials; level B refers to well-designed non-randomized clinical trials. Articles assigned to level C, consensus or expert opinions, were excluded. The methodological quality of the articles was assessed in light of summarized information regarding the random allocation of subjects to an intervention or control group, the blinding of outcome assessors, and patient attrition [8, 9].

Results

Using MESH terms, 2844 articles were found in PubMed and 268 in Embase. Using free-text words resulted in another 1609 articles in PubMed and 501 in Embase. However, the combined searches of MESH terms plus free text yielded 4040 articles in PubMed and 748 in Embase. An overlap of 142 articles occurred when the searches were merged. Thus, the systematic literature search resulted in a total of 4646 articles, 59 of which met the inclusion criteria (see Methods section).

Tables 1, 2, 3, 4, and 5 present an overview of all included articles. The studies are divided into five groups based on the type of intervention: bolus modifications and management (Table 1), facilitation techniques (Table 2), swallow postures and swallow maneuvers (Table 3), other interventions (residual category) (Table 4), and combination of interventions (Table 5). The first group covers what is considered to be compensatory techniques, whereas the residual category includes rehabilitative techniques. All other interventions are classified as compensatory and/or rehabilitative techniques [10, 11]. The first column of each table gives the level of evidence using the ABC rating scale according to Siwek et al. [7]. The second column indicates how the data were handled, i.e., using statistical analyses or descriptive statistics to compare pre- versus post-therapy data. If subgroups were compared using statistical analysis but differences between post- and pre-therapy status were described using descriptive statistics, the study was assigned to the latter method. Authors are listed in

Table 1 Bolus modification and management (compensatory techniques)

Level of evidence	Data analysis	Reference (Literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
A (randomized controlled trial)	Statistical analysis	Groher [12]	46 Chronic dysphagia Excluding: <i>N</i> = 5 (dead), <i>N</i> = 5 (PEG), <i>N</i> = 10 (?)	Clinical evaluation, Other (chest X-ray) Blinding?	Viscosity modulation G1 pureed foods and nonaltered liquids (<i>N</i> = 23) G2 soft mechanical diet with altered/thickened liquids (<i>N</i> = 23)	Prior to inclusion, all subjects were on pureed diet plus fluids and had experienced at least one period of aspiration pneumonia. During the 6-month period of intervention, significantly more episodes of pneumonia were experienced in G1 (28 incidences) compared to G2 (five incidences).
B (non-randomized controlled trial)	Statistical analysis	Bhattacharyya et al. [14]	31 Unilateral vocal fold paralysis with aspiration and/or penetration ^c	Videofluoroscopy Blinding	Viscosity modulation: liquid versus paste (single session)	25% (6/24) aspirated thin liquids, whereas none of these subjects aspirated paste boluses. Liquid versus paste boluses penetrated in, respectively, 79% (19/24) and 50% (12/24). The results indicate that thicker food consistencies are likely to be safer for oral intake in patients with unilateral vocal fold paralysis due to decreases in the risk of laryngeal penetration and aspiration despite a higher prevalence of pharyngeal residue.
		Bisch et al. [16]	18 acute stroke	Videofluoroscopy Blinding?	Bolus temperature, volume, and viscosity modulation (single session) G1 Mild dysphagia, first-time stroke (<i>N</i> = 10) G2 Moderate to severe dysphagia, neurologically impaired (<i>N</i> = 8)	Both patient groups exhibited very few significant effects of temperature on swallowing disorders or swallow measures. Increases in bolus volume and viscosity decreased pharyngeal delay times in both groups.
		Clavé et al. [15]	92	Videofluoroscopy	Viscosity and volume modulation (single session) G1 Nonprogressive brain diseases (<i>N</i> = 46) G2 Neurodegenerative diseases (<i>N</i> = 46)	Increasing bolus viscosity from liquid to nectar and pudding significantly improved efficacy of swallowing and safety by reducing aspiration and penetration during swallowing in G1 and G2. Increasing the bolus viscosity did not affect the timing of swallow response or bolus kinetic energy, whereas increasing bolus volume significantly impaired efficacy and safety of swallowing in both groups.

Table 1 continued

Level of evidence	Data analysis	Reference (Literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
		Hamdy et al. [18]	12 acute stroke	Clinical evaluation (timed water swallow test) Blinding?	Thermal (cold) and/or chemical (citrus) application (single session)	Combined thermal and chemical modification of water substantially alters swallowing behavior in dysphagic stroke resulting in slowed swallowing and reduced swallow capacity.
		Logemann et al. [17]	27	Videofluoroscopy Blinding?	Sour and volume modulation (single session) G1 Stroke (N = 19) G2 Other neurological etiologies (N = 8)	Both groups of subjects revealed significantly improved onset of the oral swallow in response to sour boluses compared to nonsour boluses; G1 also exhibited reduced pharyngeal delay time, oral transit time, and improved swallow efficiency, whereas G2 exhibited reduced aspiration. Increasing bolus volume significantly increased oral residue and number of swallows and decreased the oral transit time, pharyngeal delay time, and pharyngeal transit time in both groups.
	Descriptive statistics	Groher and McKaig [13]	212 Chronic dysphagia	Clinical evaluation (dietary level classification) No blinding	Evaluation/change of dietary level (single session)	31% (212) of the 685 residents were on a consistency-modified diet, 87% (184/212) were on either pursed or tube feeding. After the therapists' evaluation, 91% (192/212) were able to tolerate diets above the level of alimentation received before evaluation, and they continued on these diets at a 30-day follow-up evaluation. 4% were at dietary levels higher than they could tolerate, and 5% were considered to be at the appropriate diet level.

^a Adult men and women, unless otherwise stated

^b Groups based on etiology, treatment, or study design

^c Twenty-four of 55 subjects showed no aspiration nor penetration

Table 2 Facilitation techniques (compensatory techniques and/or rehabilitative techniques)

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions / key findings
A (randomized controlled trial)	Statistical analysis	Bülow et al. [19]	25 Chronic dysphagia	Quality-of-life measure, videofluoroscopy, clinical evaluation (dietary level classification, oral motor function test) Blinding	G1 traditional swallowing therapy (N = 13)	Statistically significant positive therapy effects were found for both NMES and traditional swallowing therapy combined but there was no statistically significant difference in therapy effect between the groups. The correlations between measurements were low.
					G2 Neuromuscular electrical stimulation: NMES (N = 12)	
					Surface electrical stimulation at anterior faucial pillars (single session)	
		Power et al. [20]	16 Acute stroke	Videofluoroscopy Blinding?	G1 Electrical stimulation (N = 8)	Compared with baseline, no significant differences were observed in oral transit time, swallow response time, pharyngeal transit time, laryngeal closure duration, cricopharyngeal opening duration, or aspiration severity within subjects or between G1 and G2.
					G2 Sham stimulation (N = 8)	
					Thermal application at anterior faucial pillars	
		Rosenbek et al. [21]	7 (male) Multiple stroke	Videofluoroscopy Blinding?	A 1 week no therapy	2/3 judges did report a treatment-related decrease in duration of stage transition for 2/7 patients, without any changes in the occurrence of aspiration or penetration. Overall, no strong evidence was found that dysphagia improved after 2 weeks of thermal application alternating with 2 weeks of no thermal application.
					B 1 week thermal application	
					G1 ABAB sequence (N = 1)	
		Rosenbek et al. [22]	22 ≥ 1 stroke Excluding: N = 1 (unable to complete protocol)	Videofluoroscopy Blinding	G2 BABA sequence (N = 6)	Thermal application significantly reduced duration of stage transition and total swallow duration compared to no treatment.
					Thermal application at anterior faucial pillars	
					A 10 swallows without therapy	
B (non-randomized clinical trial)	Statistical analysis	Blumenfeld et al. [23] (retrospective design)	80 Acute care patients Patient attrition?	Clinical evaluation (swallow severity scale) No blinding	B 10 swallows with thermal application (30-min rest period between conditions)	After therapy, both G1 and G2 showed significant improvement in severity score. Significantly more improvement was found in G1 compared to G2; G1 required fewer treatment sessions and displayed a trend toward a shorter length of hospitalization than G2.
					G1 ABAB sequence (N = 9)	
					G2 BABA sequence (N = 13)	
					G1 Surface electrical stimulation: pharyngeal/laryngeal musculature (N = 40)	
					G2 Traditional therapy: exercises, compensatory maneuvers and diet-texture modifications (N = 40)	

Table 2 continued

Level of evidence	Data analysis	Reference (literature)	Subjects/etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions / key findings
		Ludlow et al. [24]	11 Diverse neurological pathologies with chronic dysphagia	Videofluoroscopy Blinding	Surface electrical stimulation Different conditions: G1 Stimulation at sensory threshold level during swallow (N = 8) G2 Stimulation at motor threshold level during swallow (N = 10) G3 Stimulation at motor threshold level at rest (N = 10) G4 No therapy/no stimulation (N = 28 trials by N = 11?)	Only significant hyoid depression occurred during stimulation at rest. Aspiration and pooling were significantly reduced only with low sensory threshold levels of stimulation and not during maximum levels of surface electrical stimulation. Those patients who had reduced aspiration and penetration during swallowing with stimulation had greater hyoid depression during stimulation at rest. Stimulation may have acted to resist patients' hyoid elevation during swallowing.
		Shaw et al. [25] (retrospective design)	18 Diverse neurological pathologies, post laryngeal radiotherapy	Quality-of-life measure (N = 11), videofluoroscopy (N = 16), FEES (N = 2), clinical evaluation (dietary status) Blinding?	Surface electrical stimulation: anterior neck G1 Near-functional swallow (N = 2) G2 Limited swallowing requiring compensatory maneuvers (N = 4) G3 Enteral feedings, ability to swallow small amounts of certain consistencies (N = 7) G4 Tube feeding (N = 5)	Most patients improved with therapy. G2 improved significantly and G1 improved to normal. In G3 most patients (6/7) discontinued tube feeding, whereas in G4 no patient could stop tube feeding. In G4 only 2 patients out of 5 showed any improvement.
	Descriptive statistics	Lazzara et al. [27]	25 Diverse neurological pathologies	Videofluoroscopy	Thermal stimulation at anterior faucial pillars (single session)	Thermal stimulation improved triggering of the swallowing reflex in 23/25 patients on swallows of at least one consistency (liquids or paste). Total transit time improved in 9/10 patients for liquids and 14/14 patients for paste.
		Leelamanit et al. [26]	22 Diverse neurological pathologies Excluding: N = 1 (broken device), N = 2 (failed treatment)	Videofluoroscopy, clinical evaluation, other (weight gain) Blinding?	Synchronous electrical stimulator treatment (SES treatment): thyrohyoid muscle	SES treatment was ended in 2 subjects because of failure to improve and indication for gastrostomy. The remaining 20 subjects showed improved swallowing function after SES. 6 patients relapsed after a first SES treatment but were successfully treated with an additional SES treatment. Stimulating synchronous contraction of the thyrohyoid muscle by synchronous electrical stimulation during swallowing improves dysphagia resulting from reduced laryngeal elevation.

^a Adult men and women, unless otherwise stated

^b Groups based on etiology, treatment, or study design

Table 3 Swallow postures and swallow maneuvers (compensatory techniques and/or rehabilitative techniques)

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
A (randomized controlled trial)	Statistical analysis	Shaker et al. [28]	27 Diverse neurological pathologies, post pharyngeal radiotherapy, diverse cardiovascular diseases	Videofluoroscopy, clinical evaluation (FOAMS: Functional Outcome Assessment of Swallowing Score) Blinding	G1 Sham exercise (N = 7) G2 Head-raising exercise program (N = 27 ^c)	Pretreatment, all subjects suffered from abnormal UES opening. After treatment, G1 showed no significant changes in the measured biomechanical parameters. Following real exercise, both G2 and G1 (when crossed over to the real exercise group) exhibited a significant improvement in the anteroposterior diameter of the UES opening, in the anterior laryngeal excursion, and in the FOAMS scores. A significant decrease was found for postdeglutitive residue and resolution of aspiration.
B (non-randomized clinical trial)	Statistical analysis	Bilow et al. [31]	8 CVA, head and neck cancer	Videofluoroscopy, other (videomanometry) Blinding?	Supraglottic swallow, chin tuck, and effortful swallow (single session)	None of the techniques reduced the number of misdirected swallows, but effortful swallow and chin tuck significantly reduced the depth of contrast penetration into the larynx and pharyngeal retention. The swallowing techniques did not improve weak pharyngeal constriction.
		Logemann et al. [29]	5 Acute brainstem stroke (unilateral dysphagia)	Videofluoroscopy	Head rotation (single session)	The fraction of the bolus swallowed and the UES opening diameter increased significantly with the head turned toward the parietic side.
		Logemann et al. [30]	9 Head and neck cancer	Videofluoroscopy	Super-supraglottic swallow (single session)	With use of the super-supraglottic maneuver, fewer swallowing motility disorders were observed than without use of the maneuver. The maneuver contributed to the elimination or reduction of aspiration in three subjects.
	Descriptive statistics	Bogaert et al. [34]	30 Diverse neurological pathologies	Videofluoroscopy	Chin tuck versus supraglottic swallow (single session)	Both head flexion and supraglottic swallow could improve the pharyngeal phase of swallowing (e.g., reduction of premature spilling, elimination or reduction of aspiration, or penetration), but a consistent effect could not be proven.
		Lewin et al. [33]	21 Esophagectomy with aspiration	Videofluoroscopy	Chin tuck (single session)	Aspiration was eliminated in 81% (17/21) of aspirators using the chin-tuck maneuver.
		Logemann et al. [36]	32 Supraglottic laryngectomy, oral cancer resection, other resections	Videofluoroscopy	Postural techniques with or without supraglottic swallow (single session)	Postural techniques were effective in at least 60% of the patients with 1- and 3-ml volumes. If the patient first aspirated at 3-ml volumes, the posture was effective with 5-ml boluses in 80% of the patients. All patients who were able to swallow 10-ml boluses without aspiration using the posture were also able to swallow from a cup using the posture, an important step toward more normal eating.
		Logemann et al. [37]	9 Post supraglottic laryngectomy	Videofluoroscopy Blinding?	Supraglottic swallow	3/9 of the patients were able to eat orally at 2 weeks postoperatively, whereas 7/9 of the patients were successful oral feeders by 3 months.
		Shanahan et al. [32]	30 Diverse neurological pathologies	Videofluoroscopy	Chin tuck (single session)	All subjects showed presswallow aspiration because of delayed pharyngeal swallow triggering. Use of chin tuck eliminated aspiration in 15 out of 30 subjects.

Table 3 continued

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
		Zaydam et al. [35]	13? Tongue-base resection Patient attrition?	Videofluoroscopy Blinding?	Chin tuck; combination of chin tuck and supraglottic swallow G1 Tongue-base resection less than 1/4 (N = 6?) G2 Tongue-base resection 1/4 or more (N = 7?)	Compensatory procedures and therapy techniques were successful in a third of cases in the larger resection group and in all cases in the smaller resection group.

^a Adult men and women, unless otherwise stated

^b Groups based on etiology, treatment, or study design

^c Including crossover of G1 (N = 7) to G2

alphabetical order. For each study, the following data are summarized: number of patients, evaluation techniques, kind of therapy used in addition to (if applicable) diagnostic or therapy subgroup(s), and authors' key findings. The number of subjects refers to the group of subjects on which the study results are based. If studies contain subject groups that fall outside the scope of the present review article, these groups are not mentioned in the tables. Sometimes the primary purpose of a study is not to objectify the effects of swallowing therapy. However, if pre- and post-treatment data are present, the study is included.

Information on qualitative assessment has been given in the tables as well. For any of the randomized controlled trials (level A) no (redundant) information on randomization has been given. However, for trials using different treatment groups and an unclear or no random allocation of subjects, information has been added regarding the questionable randomization. Blinding of outcome assessors is considered essential. Assessors should be blinded for the treatment group as well as for pre- versus post-therapy status. When using swallowing maneuvers (such as chin tuck) or different viscosities (such as paste versus liquid) during videofluoroscopy, blinding is not applicable and is therefore not mentioned in the table. As far as patient attrition is concerned, the table gives the number of individuals who died, were lost to follow-up, or otherwise did not complete the intervention (if mentioned in the article). However, in the case of single-session interventions, such information is not applicable.

Ultimately, 59 studies were included. The results showed 10 high-quality randomized controlled trials (level A) and 49 well-designed nonrandomized clinical trials (level B). The authors of nine of the 10 A studies and 25 of the 49 B studies performed statistical analyses to evaluate the therapy effects. All other studies used descriptive analyses. The 59 included studies are described briefly below.

Bolus Modification and Management (Compensatory Techniques)

Bolus modification means adjusting the viscosity, volume, temperature, and/or acidity of the bolus. Seven studies describe the effects of bolus modification (Table 1). The Groher study [12] is the earliest to focus on viscosity modulation. It is also the only randomized controlled trial in this group of studies. Prior to therapy, all patients (N = 46) suffering from pseudobulbar dysphagia were on a pureed diet plus fluids and had experienced at least one period of aspiration pneumonia. Subjects were randomly assigned to two groups: One received pureed foods and nonaltered liquids and the other had a soft mechanical diet

Table 4 Other interventions (rehabilitative techniques)

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions / key findings
B (nonrandomized clinical trial)	Statistical analysis	El Sharkawi et al. [38]	8 Idiopathic Parkinson's disease	Videofluoroscopy Blinding	Lee Silverman Voice Treatment (LSVT)	LSVT improved neuromuscular control of the entire upper aerodigestive tract, improving oral tongue and tongue-base function during the oral and pharyngeal phases of swallowing: an overall 51% reduction in the number of swallowing motility disorders. For all swallow volumes and consistencies, oral transit time and oral residue were reduced and the oropharyngeal swallow efficiency was improved.
		Robbins et al. [39]	10 Acute and chronic stroke	Quality-of-life measure, videofluoroscopy, clinical evaluation (dietary questionnaire), other (oral pressure measurements; MRI; N = 3) Blinding?	Isometric lingual exercise program (compressing air-filled bulb between tongue and hard palate)	Patients showed positive changes in lingual strength after 8 weeks of progressive resistance lingual exercises. Improved isometric strength corresponded with spontaneous increased pressure generation during swallowing. Patients showed significant improvement in swallowing function and dysphagia-specific quality-of-life measures, with reported changes in social life and dietary intake.

^a Adult men and women, unless otherwise stated

^b Groups based on etiology, treatment, or study design

Table 5 Combination of interventions (compensatory techniques and/or rehabilitative techniques)

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
A randomized controlled trial	Statistical analysis	Hwang et al. [40]	33 Diverse etiologies (IC unit: ≥ 2 days intubation)	Videofluoroscopy Blinding	G1 Preemptive swallowing stimulation: thermal-tactile stimulation, oral stimulation and massage, digital manipulation, and cervical range of motion exercise ($N = 15$)	Preemptive swallowing stimulation during intubation assists in the recovery of swallowing function in long-term intubated patients. Oral transit time, oral pharyngeal transit time, and oropharyngeal swallowing efficiency were significantly faster in G1. Differences between both groups in terms of percentage of aspiration and swallowed volume were not statistically significant.
					G2 No therapy ($N = 18$)	
	Statistical analysis	Robbins et al. [41]	515 Dementia ($N = 260$), Parkinson disease ($N = 154$), Parkinson disease with dementia ($N = 101$) Patient attrition?	Other (chest X-ray, respiratory indicators: sustained fever, rhonchi, sputum gram stain, or sputum culture) Blinding?	Viscosity modulation & chin tuck	No definitive conclusions about the superiority of chin-down posture, nectar- or honey-thickened liquids on the 3-month cumulative incidence of pneumonia in patients with dementia and/or Parkinson's disease can be made.
					G1 Chin tuck ($N = 259$)	
G2 Nectar-thickened liquids ($N = 133$)						
B (non-randomized clinical trial)	Descriptive statistics	Carnaby et al. [43]	303 Acute stroke (including 60 patients who died) Including: $N = 60$ (dead); Excluding: $N = 3$ (lost to follow-up)	Clinical evaluation (dietary status) Blinding	Tactile-thermal application and effortful swallowing maneuver (during 2 weeks)	No single treatment intensity emerged as superior. Overall, improved severity of aspiration and/or penetration and decreased duration of stage transition did not reach clinical or statistical significance.
					G1 150 trials per week ($N = 12$)	
	G2 300 trials per week ($N = 10$)					
	G3 450 trials per week ($N = 10$)					
Statistical analysis	Carnaby-Mann et al. [50]	6 Chronic dysphagia Including $N = 1$ (unrelated adverse advent)	Videofluoroscopy, clinical evaluation (Functional Oral Intake Scale, Mann Assessment of Swallowing Ability), other (weight gain) Blinding	G4 600 trials per week ($N = 13$)	After 6 months, 70% of the patients in G3, 64% in G2, and 56% in G1 returned to a normal diet. A functional swallow without swallowing complications was achieved by 32% of the patients in G1, 43% in G2, and 48% in G3. In patients with standard therapy (G2 and G3), medical complications, chest infections, and death or institutionalization were significantly decreased.	
				G1 Usual care: if treatment, mainly supervision of feeding, precautions for safe swallowing (e.g., positioning, slowed rate of feeding) ($N = 102$)		
Statistical analysis	Carnaby-Mann et al. [50]	6 Chronic dysphagia Including $N = 1$ (unrelated adverse advent)	Videofluoroscopy, clinical evaluation (Functional Oral Intake Scale, Mann Assessment of Swallowing Ability), other (weight gain) Blinding	G2 Standard low-intensity intervention (3x per week up to a month); compensation strategies, safe-swallowing advice, dietary modification ($N = 101$)	Significant change was demonstrated for clinical swallowing ability, functional oral intake, weight gain, and patient perception of swallowing ability. Hyoid and laryngeal elevation during swallowing demonstrated bolus-specific patterns of change.	
				G3 Standard high-intensity intervention (daily/ every working day up to a month); direct swallowing exercises, dietary modification ($N = 100$)		
Statistical analysis	Carnaby-Mann et al. [50]	6 Chronic dysphagia Including $N = 1$ (unrelated adverse advent)	Videofluoroscopy, clinical evaluation (Functional Oral Intake Scale, Mann Assessment of Swallowing Ability), other (weight gain) Blinding	Neuromuscular Electrical Stimulation (NMES) and swallowing maneuver (fast, effortful swallow)		

Table 5 continued

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
		Crary et al. [49] (retrospective design)	45 Patient attrition?	Clinical evaluation (Functional Oral Intake Scale) Blinding?	Swallowing instruction and surface electromyographic biofeedback (sEMG); anterior neck G1 Stroke (N = 25) G2 Head/neck cancer: postirradiation and/or surgery (N = 20)	87% of the patients increased their functional oral intake of food/liquid by at least one scale score subsequent to therapy, including 92% of stroke and 80% of head/neck cancer patients. Average change in functional oral intake scores reflected a trend toward statistical significance. The average number of therapy sessions per patient was significantly higher in G1 than in G2.
		Denk and Kaider [47]	33 Oncology (post head and neck surgery)	Videofluoroscopy, FEES Blinding?	Videoscopic biofeedback in conventional therapy (thermal stimulation, oral motor exercises, compensatory techniques, and dietary measures) G1 Conventional therapy (N = 14) G2 Conventional therapy and videoendoscopic biofeedback (N = 19) Randomization?	Before therapy all patients suffered from aspiration. After therapy restoration of exclusively oral nutrition with food of all consistencies without moderate or severe aspiration was found in G1 for 71% (11/14) and in G2 for 73% (14/19) of the patients. In the first 40 days of therapy, G2 had a significantly better chance of therapeutic success, shortening the period of functional rehabilitation compared to G1. After this first period, no more significant difference in chance existed between G1 and G2.
		Elmståhl et al. [51]	38 Acute stroke	Quality-of-life measure, videofluoroscopy, other (plasma protein levels, body composition) Blinding	Oral motor exercises, swallowing strategies (supraglottic swallowing, effortful swallowing, Mendelsohn maneuver, thermal stimulation), head and neck positioning, and diet modification	About 60% of all patients responded with better swallowing function and improved nutritional status at follow-up, thereby reducing the risk of developing a condition of malnutrition. Changes of subjective complaints did not correlate with swallowing function or nutritional improvements.
		Huckabee and Cannito [49] (retrospective design plus follow-up patient questionnaire)	10 Brainstem injury (stroke, tumor) with chronic dysphagia Patient attrition?	Videofluoroscopy, clinical evaluation (nutritional intake scale, dichotomized respiratory symptomatology) Blinding?	Outpatient accelerated swallowing treatment programme surface electromyography biofeedback and cervical auscultation biofeedback in combination with effortful swallow, Mendelsohn maneuver, vocal adduction exercises, oral motor exercises, head-lifting maneuver, and compensatory mechanisms	After therapy significant improvements were observed in swallowing physiology as measured by severity ratings of videofluoroscopic swallowing studies, diet level, and pulmonary status.

Table 5 continued

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
		Kasprisin et al. [46] (retrospective design)	69 Chronic dysphagia Patient attrition?	Pre-treatment: Videofluoroscopy (N = 63) or clinical evaluation (N = 6); Post-treatment: other (radiographic and/or cytological analyses) Blinding?	Bolus modification and/or facilitation and/or compensatory techniques. G1 Therapy, no history of aspiration pneumonia (N = 48) G2 Therapy, history of aspiration pneumonia (N = 13) G3 No therapy (N = 8)	Within 1 year after treatment, 6% (3/48) of G1, 15% (2/13) of G2, and 100% (8/8) of G3 experienced aspiration pneumonia. No significant difference existed in the occurrence of aspiration between G1 and G2, but differences between G1 and G3 as well as between G2 and G3 did reach significance.
		Lin et al. [44]	49 Stroke Excluding: N = 12 (moved, hospitalized, discharged, or withdrawn)	Clinical evaluation, other (e.g., timed swallowing test) Blinding?	Swallowing training protocol: (1) direct therapy: compensatory strategies like diet modification, environment arrangement, positioning, swallowing maneuvers; (2) indirect therapy: thermal stimulation, physical maneuvers like lip and lingual exercises. G1 Swallowing training protocol (N = 35) G2 No therapy (N = 14) Randomization?	After swallowing training, mean differences in volume per second, volume per swallow, mid-arm circumference, and body weight between pre- and post-training of the experimental group were significantly higher than for the control group, while mean differences in neurological examination and choking frequency during meals for the experimental group were significantly lower than for the control group.
		Martens et al. [45]	31 Diverse neurological disorders	Clinical evaluation (e.g., Dysphagia Severity Rating Scale), other (chest X-rays) No blinding	Multidisciplinary management program: counseling and education, modification of diet, nonoral feeding, supervised trial feeds, oral motor exercises, supraglottic swallow, or thermal stimulation G1 Multidisciplinary dysphagia program (N = 16) G2 No therapy (N = 15) Randomization?	A significant improvement in weight gain and caloric intake was found when comparing G1 with G2. No incidence of aspiration was reported in either group.
		Nagaya et al. [53]	10 Parkinson's disease	Other (electromyography) Blinding?	Tongue motion and resistance exercises, exercises to increase the adduction of vocal folds, Mendelsohn maneuver, neck/shoulders/trunk motion exercises (single session)	After therapy, the premotor time was reduced significantly. No significant change in the duration of EMG burst was found.
		Prosiegel et al. [54]	208 Diverse neurological pathologies	Videofluoroscopy and/or FEES (N = 204), clinical evaluation (functional feeding status) Blinding?	Functional swallowing therapy: restitution (89%: 186/208), compensation (89%: 186/208), adaptation (85%: 177/208)	55% of all patients, initially dependent on tube feeding, were full oral feeders after therapy; functional feeding status showed significant improvement.
		Prosiegel et al. [55]	43 Diverse neurological pathologies	Clinical evaluation (functional feeding status) No blinding	Functional swallowing therapy: adaptation, compensation, and restitution G1 Posterior fossa tumors and cerebellar hemorrhage (N = 8) G2 Wallenberg's syndrome (N = 27) G3 Avellis' syndrome and unilateral paresis of vagal nerve (N = 8) Randomization?	After therapy functional feeding status showed significant improvement in G1, G2, and G3. G3 had a significantly better functional outcome compared to G2, and G2 had a significantly better outcome compared to G1. More than 50% (5/8) of the patients in G1 and 30% of the patients in G2 were dependent on tube feeding, while no patients were dependent on tube feeding in G3.
		Seidl et al. [52]	10 Head injury or cerebral hemorrhage (acute phase) Patient attrition?	FEES, clinical evaluation (swallowing frequency) Blinding?	Facio-oral tract therapy by Coombes (based on Bobath concepts)	The increase in swallowing frequency over the entire therapy period of 15 days (1 h per day) was statistically significant. Positive changes in swallowing ability and protection of the lower respiratory tract were statistically significant.

Table 5 continued

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
Descriptive statistics	Barbiera et al. [66]	36	Diverse neurological pathologies	Clinical evaluation (dietary status) Blinding?	Speech therapy and postural techniques G1 Normal swallowing: tracheostomy ($N = 1$), PEG tube ($N = 1$) G2 Minimal and mild dysphagia ($N = 13$) G3a Mild-moderate and moderate dysphagia ($n = 11$) G3b Moderate-severe and severe dysphagia ($n = 10$) (according to Dysphagia Severity Rating Scale)	G2: 10/13 patients returned to a free diet and 3/13 remained on a diet with some restrictions; G3a: 2/10 returned to a free diet and 1/10 was placed on tube feeding and died. The others remained on a diet with restrictions; G3b: 3/10 died and 1/10 went from tube feeding to a diet with restrictions. The others remained on tube feeding.
	Bartolome and Neumann [60]	28	Diverse neurological disorders causing cricopharyngeal dysfunction (including 5 subjects post surgery)	Clinical evaluation (dietary status), other (cineradiography) Blinding?	G1 Direct therapy: strategies to normalize impaired motor and sensory functions ($N = 2$) G2 Indirect therapy: Mendelsohn maneuver, supraglottic swallowing, dietary adjustments, and/or changes of head positioning ($N = 3$) G3 Direct and indirect therapy ($N = 23$, including 5 patients postsurgery) Randomization?	Overall, 90% of the patients improved after swallowing therapy, 65% by objective (type and/or safety of feeding) and 25% by subjective (ease of feeding and range of diet) criteria. Direct and indirect swallow methods are associated with improvement.
	Crary [70]	6	Brainstem stroke (including 2 surgical myotomies) with chronic dysphagia	Clinical evaluation, other (sEMG assessment) Blinding?	Swallowing instruction (focused on bolus control and airway protection) and surface electromyographic biofeedback (sEMG): anterior neck	After 3 weeks of therapy, 3/6 patients were able to resume oral intake. Following completion of therapy, 5/6 patients returned to total oral feeding and maintained feeding tube removal. After therapy, sEMG evaluation demonstrated improved swallowing coordination, longer swallow durations, and increased effort. Functional benefit is long-lasting without related health complications.
	Denk et al. [64]	32	Oncology (post head and neck surgery)	Videofluoroscopy, FEES	Conventional therapy (thermal stimulation, oral motor exercises, compensatory techniques, and dietary measures) Blinding?	Before therapy, all patients suffered from aspiration. After therapy, 75% (24/32) of all patients regained full oral intake diet.
	Hägg and Larsson [67]	7	Chronic dysphagia Stroke	Quality-of-life measure, videofluoroscopy, clinical evaluation Blinding	Orofacial regulation therapy by Morales: Motor and sensory stimulation	Therapy according to Morales can improve long-lasting oropharyngeal dysphagia in stroke patients.
	Horner et al. [57]	22	Brainstem stroke Excluding: $N = 1$ (dead)	Videofluoroscopy, ^c clinical evaluation (dietary status) Blinding?	Diet modifications and chin tuck or lateral head postures (single session; mean period of follow-up = 97 days)	Before treatment 68% (15/22) of the patients took nothing by mouth. After treatment plus follow-up period, 9% (2/22) had oral plus gastrostomy feedings, while 86% (19/22) resumed full oral nutrition. No instances of pulmonary or nutritional compromise were found in any of the 19 successful subjects.
	Kiger et al. [69]	22	Diverse neurological pathologies, respiratory failure/pneumonia, deconditioning, tongue tumor	Videofluoroscopy or FEES, clinical evaluation (dietary status) Blinding?	G1 VitalStim TM therapy ($N = 11$) G2 Traditional swallowing therapy, e.g., oral motor exercises, compensatory strategies, thermal stimulation via deep pharyngeal neuromuscular stimulation ($N = 11$) Randomization?	Raw positive change scores for oral and pharyngeal phases appeared stable in both groups (Run Chart analysis). Differences between G1 and G2 for changes in oral and pharyngeal phase dysphagia severity, dietary consistency restrictions, and progression from nonoral to oral intake were not statistically significant.

Table 5 continued

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
		Logemann et al. [56]	711 Parkinson's disease and/or dementia with aspiration Excluding: $N = 2$ (?), $N = 29$ (no or nonevaluable swallow)	Videofluoroscopy	Viscosity modulation (nectar- and honey-thickened liquid) and chin tuck (single session) G1 Parkinson's disease ($N = 228$) G2 Dementia ($N = 351$) G3 Parkinson's disease & dementia ($N = 132$)	Significantly more patients aspirated on thin liquids despite using chin-down posturing than when using nectar-thickened liquids (68% vs. 63%) or honey-thickened liquids (68% vs. 53%). About half of the patients received no benefit from any intervention. A significantly higher rate of benefit was observed in patients with Parkinson's disease only compared with patients with dementia with or without Parkinson's disease. Patients with the most severe dementia exhibited the least effectiveness on all interventions.
		Masiero et al. [63]	16 Post carotid endarterectomy (acute phase) Excluding: $N = 3$ (?)	FEES, clinical evaluation (dietary level) Blinding?	Oral motor exercises, sensory stimulation, postural and compensatory techniques, dietary modifications, oral hygiene education, and family training	10 and 6 patients recovered completely and returned to their preoperative diet within 1 and 6 months, respectively.
		Nagaya et al. [58]	48	Videofluoroscopy	Compensatory techniques (chin tuck, supraglottic swallow) and/or bolus modification (liquid, jelly); (single session) G1 Parkinson's disease ($N = 25$) G2 Cerebellar ataxia ($N = 23$)	52% (13/25) of G1 and 30% (7/23) of G2 aspirated on thin liquid. When using jelly boluses, aspiration was absent in all subjects, except for 2 subjects of G2. Subjects with aspiration (6 subjects of each group) were instructed to use chin tuck and supraglottic swallow. In 5/6 of G1 and 2/6 of G2 these techniques were not effective.
		Neumann [61]	66 Diverse neurological pathologies	Clinical evaluation (dietary status), other (cineradiography) No blinding	Direct therapy: thermal stimulation, tapping, stretching, and exercises of the tongue, lips, jaw, palate, and larynx Indirect therapy (compensatory strategies): supraglottic swallowing, head and neck positioning, Mendelsohn maneuver, and modification of dietary consistencies G1 Indirect therapy ($N = 8$) G2 Direct therapy ($N = 21$) G3 Direct and indirect therapy ($N = 37$) Randomization?	After therapy, 84% of all patients improved as determined by type of feeding, ease of feeding, safety of feeding, and range of diet. Both direct and indirect methods were potentially useful.

Table 5 continued

Level of evidence	Data analysis	Reference (literature)	Subjects ^a /etiology	Evaluation techniques	Treatment(s)/groups (G) ^b	Authors' conclusions /key findings
		Neumann et al. [62]	58 Diverse neurological pathologies Patient attrition?	Clinical evaluation (dietary status) No blinding	Direct therapy (compensatory strategies): head and neck positioning, supraglottic swallowing, and Mendelsohn maneuver Indirect therapy: stimulation, assisted isotonic or isometric exercises, and independent exercises G1 Indirect therapy (N = 29) G2 Direct therapy (N = 1) G3 Direct and indirect therapy (N = 28) Randomization?	Before therapy no patients exclusively achieved oral feeding, while after therapy 67% of the patients achieved oral feeding.
		Nguyen et al. [68] (retrospective design)	41 Head and neck cancer Patient attrition?	Videofluoroscopy Blinding?	Individualized combination: diet modification, range of (oro)facial motion exercises, postural training, swallowing maneuvers, electrostimulation G1 Postoperative radiation (N = 17) G2 Postchemoradiation (N = 24)	Before therapy, 39% (16/41) and 61% (25/41) of all subjects showed, respectively, trace and severe aspiration. After therapy, 32% (13/41) of both groups combined had resolution of aspiration: 6 subjects of G1 and 7 subjects of G2. About 30% (7/25) of the severe aspirators improved to trace or no aspiration, allowing discontinuation of gastrostomy tube: 50% (5/10) of G1 and 13% (2/15) of G2.
		Rasley et al. [59]	165 Diverse neurological pathologies, head and neck cancer, Zenker's diverticulum, generalized weakness, unknown (N = 2), Age 3-95 years	Videofluoroscopy	Bolus volume modulation (1, 3, 5, or 10 ml) and drinking from a cup combined with postural changes: head rotation, chin tuck, or side-lying (single session)	Changes in head or body position eliminated aspiration of at least 1 bolus of barium in 77% (127/165) of the subjects, and of all four boluses plus drinking barium from a cup in 25% (41/165). Chin tuck and head rotation resulted in elimination of aspiration for all volumes in 25% (21/84) and 26% (20/71) of the subjects, respectively. Using side-lying, 2 of 4 subjects showed elimination of aspiration for smaller swallows (1 or 3 ml).
		Schurr et al. [65] (retrospective design)	24? Brain injury Patient attrition?	Clinical evaluation (dietary status) No blinding	Postural, dietary, and behavioral modifications	After therapy, 83% (20/24) of the patients returned to oral dietary intake. 4 patients remained on long-term gastrostomy tube feeding.

^a Adult men and women, unless otherwise stated

^b Groups based on etiology, treatment, or study design

^c Pretherapy: videofluoroscopy; post-therapy: clinical examination or videofluoroscopy

with altered or thickened liquids. After 6 months of intervention, the author concluded that the latter group had experienced significantly more episodes of pneumonia than the group with an unaltered diet. In a later study of a group of residents ($N = 212$) who were on a mechanically modified diet, Groher and McKaig [13] described the changes in dietary level after a single evaluation by a speech and language pathologist. Dietary levels were classified as mechanical, mechanical soft, pureed, or enteral. Using descriptive statistics, the authors found that 91% of all subjects were able to tolerate diets at a level above that of alimentation received before the evaluation. They continued on these diets during a 30-day follow-up evaluation. Four percent of the subjects were found to be at dietary levels higher than they could tolerate, whereas only 5% were considered to be at the appropriate level.

Five more nonrandomized clinical trials that performed statistical analyses were found in the literature. All studied the effects of bolus modification using single sessions. Bhattacharyya et al. [14] compared the effects of liquid versus paste boluses in a group of subjects with unilateral vocal fold paralysis. Among all subjects showing aspiration and/or penetration (31 of 55 subjects), 25% aspirated on thin liquids but not on paste boluses. Penetration occurred in 79% of the subjects when using liquid and 50% when using paste. The authors concluded that thicker food consistencies were likely to be safer for oral intake in patients with unilateral vocal fold paralysis due to decreased risk of laryngeal penetration and aspiration.

Clavé et al. [15] confirmed that increasing the bolus viscosity from liquids to nectar and pudding for patients with either nonprogressive brain diseases ($N = 46$) or neurodegenerative diseases ($N = 46$) significantly improved both the efficacy and the safety of swallowing by reducing aspiration and penetration during swallowing. Increasing the bolus viscosity did not affect the timing of swallow response or the bolus kinetic energy, whereas increasing the bolus volume significantly impaired the efficacy and safety of swallowing. However, Bisch et al. [16] demonstrated that increasing the bolus volume and the viscosity decreased pharyngeal delay times in two smaller populations, namely, subjects with either mild dysphagia ($N = 10$) or moderate to severe dysphagia ($N = 8$). The effects of bolus temperature on swallowing disorders or swallow measures proved to be negligible.

Logemann et al. [17] studied the effects of changed bolus acidity and volume in stroke patients ($N = 19$) and a group of patients with other mixed neurological etiologies ($N = 8$). Sour boluses compared to nonsour boluses significantly improved the timing of the onset of the oral swallow. Stroke patients also exhibited reduced pharyngeal delay time, oral transit time, and improved swallow efficiency, whereas the other group exhibited reduced

aspiration. Increasing the bolus volume significantly increased oral residue and number of swallows but decreased the oral transit time, pharyngeal delay time, and pharyngeal transit time in both groups.

Using timed water-swallow testing in acute stroke patients ($N = 12$), Hamdy et al. [18] concluded that the combined thermal (cold) and chemical (sour) modification of water substantially altered swallowing behavior in dysphagic stroke, resulting in slowed swallowing and reduced swallow capacity. Such results were not found when using either thermally or chemically modified boluses.

Facilitation Techniques (Compensatory Techniques and/or Rehabilitative Techniques)

Facilitation techniques include a variety of interventions such as surface electrical stimulation or thermal application at the anterior faucial pillars (Table 2). Four randomized controlled trials were found that deal with facilitation techniques. Bülow et al. [19] compared the outcome of neuromuscular electrical stimulation ($N = 13$) with that of traditional swallowing therapy ($N = 12$) in stroke patients using videofluoroscopy, dietary level, oral motor function testing, and a patient's self-evaluation. Although statistically significant positive therapy effects were found for both groups combined, no statistically significant difference in therapy effect between the groups was present.

Power et al. [20] applied surface electrical stimulation at the anterior faucial pillars during a single 10-min session in acute hemispheric stroke patients. Patients were randomized to either electrical stimulation ($N = 8$) or sham stimulation ($N = 8$). The authors concluded that when compared to baseline data, neither of the interventions resulted in significant differences in oral transit time, swallow response time, pharyngeal transit time, laryngeal closure duration, cricopharyngeal opening duration, or aspiration severity. No differences were observed between the two groups.

Two other randomized controlled trials conducted by Rosenbek et al. [21, 22] were related to thermal application at the anterior faucial pillars. The earlier study [21] used a single-subject withdrawal or ABAB design. The total subject population included seven multiple-stroke patients. Subjects were randomly assigned to a week-long period of thermal application ($N = 6$) or to a week of no therapy ($N = 1$). Thermal application consisted of on average 18 trials per session five times per day. Each trial consisted of repeated strokes on the pillars using a chilled laryngeal mirror followed by a swallow (water or ice chips). Overall, no strong evidence was found that dysphagia improved after 2 weeks of thermal application alternating with 2 weeks of no thermal application. The second study [22] used a cross-over design to determine the short-term effects

of thermal application. A group of stroke subjects ($N = 22$) swallowed ten times in untreated and treated conditions. It was found that swallowing durations were highly variable within and across subjects. Furthermore, thermal stimulation significantly reduced the duration of stage transition and total swallow duration compared to no treatment.

Three nonrandomized clinical trials [23–25] applied statistical analyses to measure the effects of surface electrical stimulation. Using a retrospective design in a group of acute-care patients, Blumenfeld et al. [23] compared the outcome of surface electrical stimulation of the pharyngeal and laryngeal musculature ($N = 40$) with that of traditional therapy ($N = 40$). The latter included therapeutic exercises, compensatory maneuvers, and diet-texture modifications. Treatment success was determined by comparing the swallow scores measured upon admission and prior to discharge on a seven-point swallow-severity scale (nothing safe / aspiration of saliva up to toleration of all consistencies). After therapy, both groups showed significant improvement in severity score. The group that received electrical stimulation showed more improvement, required fewer sessions, and displayed a trend toward shorter length of hospitalization than the group receiving traditional therapy. However, part of the improvement might have been the result of spontaneous recovery.

Ludlow et al. [24] studied the effects of surface electrical stimulation under four different conditions in a group of patients with diverse neurological pathologies ($N = 11$): no stimulation ($N = 11$?), stimulation at sensory threshold level during swallowing ($N = 8$), stimulation at motor threshold level during swallowing ($N = 10$), and stimulation at rest ($N = 10$). Only significant hyoid depression occurred during stimulation at rest. Aspiration and pooling were significantly reduced during low sensory threshold levels of stimulation but not during maximum levels of stimulation. Patients who had reduced aspiration and penetration during swallowing with stimulation showed greater hyoid depression during stimulation at rest. Stimulation may have acted to resist patients' hyoid elevation during swallowing.

Shaw et al. [25] performed a retrospective study on surface electrical stimulation in 18 patients suffering from diverse neurological pathologies or post-laryngeal radiotherapy. Patients were divided into four groups according to their pretherapy overall dysphagia: near-functional swallow ($N = 2$), limited swallowing requiring compensatory maneuvers ($N = 4$), enteral feedings with ability to swallow certain consistencies ($N = 7$), or tube feeding ($N = 5$). Based on varying evaluation techniques per patient, the overall conclusion was that transcutaneous neuromuscular electrical stimulation may help patients with mild to moderate dysphagia. However, patients with the most severe dysphagia did not gain independence from tube feeding.

Two more nonrandomized clinical trials used descriptive statistics to describe therapy outcome using facilitation techniques. First, Leelamanit et al. [26] described the effects of stimulating synchronous contraction of the thyrohyoid muscle during swallowing with a synchronous electrical stimulator (SES treatment) in 22 patients with diverse neurological pathologies plus dysphagia resulting from reduced laryngeal elevation. Based on videofluoroscopic findings, clinical evaluation, and weight gain, the authors concluded that SES treatment improved dysphagia resulting from reduced hyolaryngeal elevation. Second, one of the earliest studies on facilitation in dysphagia was performed by Lazzara et al. [27]. Using thermal stimulation at the anterior faucial pillars during a single session in patients with diverse neurological pathologies ($N = 25$), the results indicated an improved triggering of the swallowing reflex for at least one consistency (liquids or paste). The total transit time for liquids and paste improved in 90% ($N = 10$) and 100% ($N = 14$) of the patients, respectively.

Swallow Postures and Swallow Maneuvers (Compensatory Techniques and/or Rehabilitative Techniques)

Ten studies on swallow postures and swallow maneuvers in dysphagia, such as chin tuck and supraglottic or effortful swallow, were found in the literature (Table 3). Most studies described single-session interventions using videofluoroscopy of the swallowing act as an evaluation tool. The only clinical randomized trial was performed by Shaker et al. [28]. Twenty-seven patients with diverse etiology (neurological pathology, post-pharyngeal radiotherapy, cardiovascular disease) and abnormal upper esophageal sphincter opening underwent a head-raising exercise program. Prior to this program seven patients had been randomly assigned to a period of sham exercises. Whereas sham exercises resulted in no significant changes in biomechanical parameters, real exercises showed significant therapy effects. These include improvement in the anteroposterior diameter of the sphincter opening and the anterior laryngeal excursion, decrease of postdeglutitive residue, and resolution of aspiration. Scores on a seven-point swallowing competency scale (Functional Outcome Assessment of Swallowing Score) showed positive changes as well.

Three of nine nonrandomized clinical trials performed statistical analyses to check on therapy outcome. All three studies used subject populations smaller than ten patients in single sessions. Logemann et al. [29] studied the effects of head rotation in acute brainstem stroke patients with unilateral oropharyngeal dysphagia ($N = 5$). The fraction of the bolus swallowed and the upper esophageal sphincter diameter increased significantly with the head turned

toward the paretic side. In a later study by Logemann et al. [30], the effects of a super-supraglottic swallow in a group of head and neck cancer patients ($N = 9$) were observed. The maneuver resulted in fewer swallowing motility disorders and in some cases the elimination or reduction of aspiration. Bülow et al. [31] described the effects of supraglottic swallow, chin tuck, and effortful swallow. None of these techniques reduced the number of misdirected swallows. However, effortful swallow or chin tuck resulted in significantly less deep contrast penetration into the larynx and reduction of pharyngeal retention. Swallowing techniques did not improve a weak pharyngeal constriction.

Six nonrandomized trials used descriptive statistics to study videofluoroscopic outcome parameters. Shanahan et al. [32] and Lewin et al. [33] studied the effects of chin tuck during a single session in a group of patients suffering from aspiration as a result of, respectively, diverse neurological pathologies ($N = 30$) and esophagectomy ($N = 21$). Both studies indicated elimination of aspiration: 50% (Shanahan et al.) and 81% (Lewin et al.) of all subjects. Bogaert et al. [34] confirmed that chin tuck as well as supraglottic swallow in a group of patients with diverse neurological pathologies ($N = 30$) during a single session could improve the pharyngeal phase of swallowing, e.g., reduction of premature spilling and elimination or reduction of aspiration or penetration. However, no consistent effect was found. Zuydam et al. [35] included a group of patients ($N = 13$) following surgical resection of the oropharynx, including the base of tongue. All patients used chin tuck. If aspiration was still present, chin tuck was combined with a supraglottic swallow. At subsequent follow-up, compensatory procedures and therapy techniques proved to be successful in a third of the cases with larger tongue resections ($N = 7$) and in all cases with smaller resections ($N = 6$). Finally, two studies by Logemann [36, 37] should be mentioned. Using supraglottic swallow in a rather small group of nine patients after supraglottic laryngectomy, three of the nine were able to take in food orally at 2 weeks postoperatively, whereas seven of the nine were successful oral feeders by 3 months [36]. In a second larger study in a similar subject population combined with subjects who had undergone diverse resections, including oral cancer resections ($N = 32$), postural techniques were studied with or without supraglottic swallow (single session). Postural techniques were effective in at least 60% of the patients at 1- and 3-ml volumes. If the patient first aspirated at a 3-ml volume, the posture was effective in 80% of the patients for 5-ml boluses. All patients who were able to swallow 10-ml boluses without aspiration using the posture were also able to swallow from a cup using the posture.

Other Interventions (Rehabilitative Techniques)

Two nonrandomized clinical trials were considered as a residual category (Table 4). Both studies used statistical analyses to determine therapy outcome. In a group of eight patients with idiopathic Parkinson's disease, El Sharkawi et al. [38] found an improved neuromuscular control of the entire upper aerodigestive tract as a result of the Lee Silverman Voice Treatment. Because this intensive voice treatment requires high phonatory effort tasks, it stimulates increased vocal fold adduction and respiratory support. Oral tongue and tongue base function during oral and pharyngeal phases of swallowing showed positive changes after therapy, i.e., an overall reduction of 51% in the number of swallowing motility disorders. For all swallow volumes and consistencies, oral transit time and oral residue were reduced and the oropharyngeal swallow efficiency was improved. In a combined group of acute ($N = 6$) and chronic ($N = 4$) stroke patients, Robbins et al. [39] studied the effects of an isometric lingual exercise program by compressing an air-filled bulb between the tongue and the hard palate. After 8 weeks of progressive resistance lingual exercises, all patients had significantly increased isometric and swallowing pressures. Patients showed significant improvement in swallowing function and dysphagia-specific quality-of-life measures, with reported changes in their social life and dietary intake. However, the therapy outcome could not be distinguished from possible spontaneous recovery.

Combination of Interventions (Compensatory Techniques and/or Rehabilitative Techniques)

A set of 31 studies used a combination of different types of interventions (Table 5). Four of these studies were randomized controlled trials.

Hwang et al. [40] evaluated the effect of preemptive swallowing stimulation on the recovery of swallowing function in patients who had been intubated for at least 48 h in the intensive care unit ($N = 33$). Patients were randomly assigned to either an experimental group receiving stimulation ($N = 15$) or a control group receiving no stimulation ($N = 18$). The preemptive stimulation therapy consisted of thermal-tactile stimulation, oral stimulation, oral massage, digital manipulation, and a cervical range-of-motion exercise. A single therapist performed therapy for 15 min twice a day for 6 days per week. Using videofluoroscopy, it was concluded that stimulation during intubation assisted in the recovery of swallowing function. Oral transit time, oral pharyngeal transit time, and oropharyngeal swallowing efficiency were significantly faster in the experimental group than in the control group. Differences between both groups with respect to percentage of

aspiration and swallowed volume were not statistically significant.

Robbins et al. [41] studied the effects of chin tuck ($N = 259$) and of nectar- ($N = 133$) and honey-thickened liquids ($N = 123$) on a 3-month cumulative incidence of pneumonia in patients with dementia and/or Parkinson's disease. Using the criterion of pneumonia, as diagnosed by chest radiography or by the presence of three respiratory indicators (sustained fever, rhonchi, sputum gram stain, or a sputum culture), no definitive conclusions could be drawn about the superiority of any of the tested interventions.

Rosenbek et al. [42] investigated the effects of four intensities of tactile-thermal application combined with effortful swallowing in acute stroke patients ($N = 45$). Patients were randomly assigned to receive 150 ($N = 12$), 300 ($N = 10$), 450 ($N = 10$), or 600 ($N = 13$) trials of tactile-thermal application per week for 2 weeks. No single treatment intensity emerged as superior. Overall, positive changes on an eight-point aspiration-penetration scale and decreased duration of stage transition did not reach clinical or statistical significance, possibly because the samples were too small. The study was initially designed to distinguish between the most efficacious treatment intensities. The authors recognized that the actual changes may be the result of physiological recovery as well.

Finally, Carnaby et al. [43] performed statistical analyses to compare differences between therapy conditions but used descriptive statistics to describe post- versus pretherapy status. The authors compared the change in dietary status in a large group of acute stroke patients ($N = 303$) after usual care ($N = 102$), standard low-intensity intervention ($N = 101$), and standard high-intensity intervention ($N = 100$). Usual care consisted of patient management by the attending physicians as per usual practice. Treatment, if offered, consisted mainly of supervising feeding and taking precautions for safe swallowing (e.g., positioning, slower pace of eating). Standard low-intensity intervention was based on compensation strategies, mainly environmental modifications (e.g., positioning), safe swallowing advice, and dietary modification. These interventions were carried out under the direction of a speech pathologist three times per week for up to 1 month. High-intensity intervention referred to direct swallowing exercises (e.g., effortful swallowing, supraglottic swallow technique) and appropriate dietary modification. These exercises were done every working day for a month or daily during the hospital stay (if less than 1 month). After 6 months the percentage of patients returning to a normal diet and receiving usual care, standard low-intensity, or high-intensity intervention was 56, 64, and 70%, respectively. A functional swallow without swallowing complications was achieved by 32% of the patients who received usual care, 43% who received standard low-intensity intervention, and 48% who received

high-intensity intervention. In patients who received standard therapy, medical complications, chest infections, and death or institutionalization decreased significantly.

Twenty-seven nonrandomized clinical trials used combinations of interventions. Twelve studies performed statistical analyses while estimating therapy effects.

Lin et al. [44] studied the outcome of a swallowing training protocol in a group of stroke patients ($N = 49$). The protocol included direct therapy (compensatory strategies like diet modification, environment arrangement, positioning, swallowing maneuvers) and indirect therapy (thermal stimulation, physical maneuvers like lip and lingual exercises). Patients were divided into an experimental group ($N = 35$) that received the swallowing training protocol over a period of 8 weeks (30 min per day, 6 days per week) and a control group ($N = 14$) that received no therapy. After the training, mean differences for the experimental group with respect to volume per second, volume per swallow, midarm circumference, and body weight between pre- and post-training were significantly higher than for the control group. However, the mean differences in neurological examination and choking frequency during meals for the experimental group were significantly lower than for the control group.

Martens et al. [45] described an individualized, multidisciplinary management program for neurologically impaired patients ($N = 31$), including counseling and education, modification of diet, nonoral feeding, supervised trial feeds, oral motor exercises, supraglottic swallow, and thermal stimulation. After therapy, a significant improvement in weight gain and caloric intake was found in the experimental group ($N = 16$) but not in the control group ($N = 15$). No incidence of aspiration was reported in either group. The outcome of a questionnaire on the patients' feeding ability measured by the Dysphagia Severity Rating Scale was disregarded as it was not considered a valid instrument for measuring therapy effects. For instance, the placement of a feeding tube advised by the multidisciplinary dysphagia team led to improved patient safety and weight gain but also to regression in the patient's feeding ability.

Kasprisin et al. [46] studied the effects of bolus modification, facilitation, and compensatory techniques in a group of chronic dysphagic patients ($N = 69$) through retrospective chart review. Two groups of treated patients (48 patients without and 13 patients with a history of aspiration pneumonia) were compared to a control group receiving no therapy ($N = 8$). Pretherapy data included videofluoroscopy ($N = 63$) and/or bedside screening and post-therapy data included radiographic and/or cytologic analyses. Within 1 year after treatment, 15% of the patients without and 6% of the patients with a history of pneumonia did experience aspiration pneumonia compared with 100%

of the patients in the control group. Differences between the treated groups were not significant, but both groups were subject to significantly less aspiration pneumonia when compared to the control group.

Denk and Kaider [47] included a group of 33 oncological patients with prolonged postoperative aspiration. One group ($N = 14$) received conventional therapy, which included thermal stimulation, oral motor exercises, compensatory techniques, and dietary measures. Another group ($N = 19$) received videoendoscopic biofeedback in addition to conventional therapy. After therapy, restoration of exclusively oral nutrition with food of all consistencies without moderate or severe aspiration was found in 71% of the patients in the conventional therapy group and in 73% of the patients receiving biofeedback as well. In the first 40 days of therapy, patients receiving biofeedback had a significantly better chance of therapeutic success. Their period of functional rehabilitation was thereby shorter compared to that of patients without biofeedback. After this first period, no more significant difference was found between the two groups.

In a study of ten patients who suffered from brainstem injury and chronic dysphagia, Huckabee and Cannito [48] used surface electromyography biofeedback and cervical auscultation biofeedback in combination with effortful swallow, the Mendelsohn maneuver, vocal adduction exercises, oral motor exercises, the head-lifting maneuver, and compensatory mechanisms (Outpatient Accelerated Swallowing Treatment Programme). After therapy, significant improvements were observed in swallowing physiology as measured by severity ratings of videofluoroscopic swallowing studies, diet level, and pulmonary status.

In a second study using supplemental surface electromyography biofeedback, Crary et al. [49] presented a systematic therapy program (retrospective study design) to 25 stroke patients and 20 patients following their treatment for head and neck cancer. Therapy outcome was scored on a seven-point functional oral intake scale (FOIS): from nothing by mouth up to total oral diet with no restrictions. Functional oral intake increased in 87% of all patients (92% of the stroke and 80% of the head and neck cancer patients) by at least one scale score subsequent to therapy. The stroke patients received significantly more therapy sessions than the cancer patients. The average change in functional oral intake reflected a trend toward statistical significance.

Carnaby-Mann and Crary [50] described the effects of a protocol of swallowing exercises (fast, effortful swallow) in combination with adjunctive neuromuscular electrical stimulation in a group of six patients with chronic dysphagia. Significant changes were demonstrated for clinical swallowing ability, functional oral intake, weight gain, and patient perception of swallowing ability.

In a study by Elmståhl et al. [51], the effects of therapy on nutritional and anthropometric variables in a group of acute stroke patients ($N = 38$) were described. During a period of about 2 months, therapy focused on oral motor exercises, swallowing strategies (supraglottic swallowing, effortful swallowing, Mendelsohn maneuver, and thermal stimulation), head and neck positioning, and diet modifications. About 60% of all patients responded with better swallowing function and improved nutritional status at follow-up, thereby reducing the risk of developing malnutrition. Treatment reduced the degree of oral dysfunction (dissociation) and pharyngeal dysfunction (penetration and constrictor paresis). Changes in subjective complaints, however, did not correlate with swallowing function or nutritional improvements.

Seidl et al. [52] performed a pilot study to investigate the success of a neurophysiological dysphagia therapy in ten patients with neurogenic swallowing disorders following cerebral hemorrhage or head injury. As early as possible following the onset of illness, patients started facio-oral therapy based on the Bobath concept (15 sessions of 1 h over 3 weeks). Over the entire therapy period the increase in swallowing frequency and the positive changes in swallowing ability and protection of the lower respiratory tract were statistically significant. However, therapy outcome could not be distinguished from possible spontaneous recovery.

Nagaya et al. [53] offered a single therapy session to a group of ten patients with Parkinson's disease. The session included tongue motion and resistance exercises, exercises to increase the adduction of vocal folds, the Mendelsohn maneuver, and motion exercises for the neck, shoulders, and trunk. Therapy outcome was evaluated by electromyography. After therapy, the premotor time was reduced significantly, whereas no significant change in the duration of the EMG burst was found.

Finally, two studies by Prosiegel et al. [54, 55] must be added to the list of nonrandomized trials that described therapy outcome using statistical analyses. The first study [54] included a large patient population of 208 subjects with diverse neurological pathologies. Patients received functional swallowing therapy, including restitution methods, compensation, and adaptation. Each technique was used with more than 80% of the patients. After therapy, functional feeding status showed significant improvement: 55% of all patients, initially dependent on tube feeding, were full oral feeders after therapy. The second study [55], which referred to the earlier one, described therapy effects in three subpopulations consisting of patients with posterior fossa tumors or cerebellar hemorrhage ($N = 8$), Wallenberg's syndrome ($N = 27$), and Avellis' syndrome or unilateral paresis of the vagal nerve ($N = 8$). After therapy, functional feeding status had improved significantly in all

three groups. Patients with Avellis' syndrome or unilateral paresis of the vagal nerve had a significantly better functional outcome than patients with Wallenberg's syndrome. In contrast, patients with Wallenberg's syndrome had a significantly better outcome than patients with posterior fossa tumors or cerebellar hemorrhage. More than 50% of the patients with posterior fossa tumors or cerebellar hemorrhage and 30% of the patients with Wallenberg's syndrome were dependent on tube feeding. Yet none of the patients with Avellis' syndrome or unilateral paresis of the vagal nerve were on tube feeding.

Fifteen nonrandomized studies used descriptive statistics to demonstrate therapy effects in dysphagic subject populations. Logemann et al. [56] included a large subject population ($N = 711$) of patients with Parkinson's disease ($N = 228$), dementia ($N = 351$), and Parkinson's disease combined with dementia ($N = 132$). During a single session, three treatments for aspiration on thin liquids were tested for immediate elimination of aspiration during videofluoroscopy: chin tuck, nectar-thickened liquids, and honey-thickened liquids. Significantly more patients aspirated on thin liquids (68%) using chin-down posturing than when using nectar-thickened liquids (63%) or honey-thickened liquids (53%). About half of the patients received no benefit from any intervention. A significantly higher rate of benefit was observed in patients with Parkinson's disease only compared with patients with dementia with or without Parkinson's disease. Patients with the most severe dementia were least effected by all interventions.

Horner et al. [57] presented a group of brainstem stroke patients ($N = 22$, excluding one deceased individual). After videofluoroscopic swallowing recordings (single session), the patients received diet modifications plus compensatory techniques (chin tuck or lateral head postures) if proven effective by videofluoroscopy. Before treatment, 68% of the patients took nothing by mouth. Eventually, based on recommendations from follow-up clinical or videofluoroscopic examinations, 9% had oral plus gastrostomy feedings, while 86% resumed full oral nutrition. No instance of pulmonary or nutritional compromise was found in any of the 19 successfully treated subjects. The authors acknowledged that the population was rather small and heterogeneous with regard to the length of time after the stroke; the mean interval between stroke and swallowing examination was 46 days (range = 1-575 days).

Nagaya et al. [58] studied a group of patients with Parkinson's disease ($N = 25$) and a group of patients with cerebellar ataxia ($N = 23$) to discern the efficiency of compensatory techniques (chin tuck and supraglottic swallow) and/or bolus modification (liquid and jelly) during a single session. Fifty-two percent of Parkinson's

disease patients and 30% of cerebellar ataxia patients aspirated on thin liquid. When using jelly boluses, aspiration was absent in all subjects except for two in the cerebellar ataxia group. Six patients from each group were instructed to use chin tuck and supraglottic swallow. These techniques were not effective in five patients with Parkinson's disease and two ataxic patients.

In a patient population of 165 subjects with diverse etiologies, including neurological pathologies and head and neck oncology ($N = 165$), Rasley et al. [59] investigated during a single videofluoroscopic examination the effects of bolus volume modulation (1, 3, 5, or 10 ml) and drinking from a cup combined with postural changes (head rotation, chin tuck, or side-lying). Changes in head or body position eliminated aspiration of at least one bolus of barium in 77% of the subjects and of all four boluses plus drinking from a cup in 25%. Chin tuck and head rotation resulted in elimination of aspiration for all volumes in 25 and 26% of the subjects, respectively. Using side-lying, two of four subjects showed elimination of aspiration for smaller swallows (1 or 3 ml). The authors concluded that postural techniques could eliminate aspiration of at least small volumes in most patients. They also concluded that the videofluoroscopic swallowing examination could be expanded to include the effect of various postures with minimal risk of increased aspiration.

Three similar studies in patients with diverse neurological pathologies compared the outcome of direct therapy, indirect therapy, and direct combined with indirect therapy [60–62]. A study by Bartolome and Neumann [60] reported the results of therapy in 28 patients with neurological disorders that had caused cricopharyngeal dysfunction. Indirect therapy consisted of strategies to normalize impaired motor and sensory functions. Direct therapy included the Mendelsohn maneuver, supraglottic swallowing, dietary adjustments, and/or changes of head positioning. The duration of therapy varied from 2 weeks to 1 year (median = 16 weeks). Ninety percent of the patients improved after undergoing swallowing therapy: 65% by objective criteria (type and/or safety of feeding) and 25% by subjective criteria (ease of feeding and range of diet). The authors associated direct as well as indirect therapy methods with improvement. However, the three groups were rather unequal: only two patients received direct therapy and three patients received indirect therapy, whereas all other patients ($N = 23$) had indirect combined with direct therapy. In another study by Neumann [61], 66 patients received direct ($N = 8$), indirect ($N = 21$), or combined therapy ($N = 37$). The median treatment period was 17 weeks, with a range of 1 week to 1 year. After therapy, 84% of all patients had improved as determined by type of feeding, ease of feeding, safety of feeding, and range of diet. According to the author, both direct and

indirect methods were potentially useful. In a later study by Neumann et al. [62], 67% of the 58 patients who were not exclusively oral feeders before therapy achieved oral feeding after therapy (median = 15 weeks, range = 2–52 weeks), which included indirect therapy ($N = 29$), direct therapy ($N = 1$), and combined therapy ($N = 28$). All three studies showed overall positive therapy effects without distinguishing between intervention groups.

Several studies described the effects of conventional or functional therapy. In a study by Masiero et al. [63], 16 patients underwent early rehabilitation treatment during the acute phase of post-carotid endarterectomy. Therapy consisted of oral motor exercises, sensory stimulation, postural and compensatory techniques, dietary modifications, oral hygiene education, and family training (on average, 12 h-long sessions three times weekly). All patients returned to their preoperative diet, ten patients within 1 month and six patients within 6 months.

Denk et al. [64] studied oncological patients with aspiration after head and neck surgery ($N = 32$). Patients received functional therapy, including thermal stimulation, oral motor exercises, compensatory techniques, and dietary measures. Most patients ($N = 27$) started swallowing therapy after the healing process was completed, i.e., between postoperative days 9 and 49. Four patients started later (4 months to 2 years). Therapy lasted until a full oral intake diet was achieved, except when no further improvement of the swallowing function was expected or new tumor growth appeared. After therapy, 75% of all subjects regained full oral intake.

Using a retrospective study design, Schurr et al. [65] described the effects of postural, dietary, and behavioral modifications in patients with brain injury ($N = 24$). The authors found a slightly higher percentage of patients returning to oral dietary intake (83%) than Denk et al. had found. The other patients remained on long-term gastrostomy tube feeding.

Barbiera et al. [66] studied a group of patients with diverse neurological pathologies and varying degrees of dysphagia ($N = 36$) who underwent speech therapy combined with postural techniques during their stay at a neurorehabilitation ward. Patients who were within the first 6–12 months from onset of dysphagia were included. Fourteen patients (39%) returned to free oral diet, 12 (33%) remained on a diet with some restrictions, six (17%) remained on tube feeding, and four patients (11%) died. The degree of dysphagia at the onset of therapy seemed to correlate with therapy outcome. In the initially less impaired patients, therapy outcome proved to be more positive than in the more severely dysphagic patients.

Hägg and Larsson [67] described the use of orofacial regulation therapy developed by Morales, including motor and sensory stimulation, in a small group of seven stroke

patients with chronic dysphagia. After a 5-week treatment intervention, all subjects showed objectively positive changes based on videofluoroscopic and clinical examination as well as self-assessed swallowing improvement.

Nguyen et al. [68] presented data on a group of patients with head and neck cancer ($N = 41$) who had postoperative radiation ($N = 17$) or chemoradiation ($N = 24$). Subjects underwent individualized therapy consisting of diet modification, range of (orofacial) motion exercises, postural training, swallowing maneuvers, and electrostimulation. Before therapy, 39% of all subjects showed trace aspiration and 61% of all subjects showed severe aspiration. After therapy, 32% of the total subject population had resolution of aspiration: six from the postoperatively radiated group and seven from the chemoradiation group. About 30% of the severe aspirators improved to trace or no aspiration, allowing discontinuation of the gastrostomy tube (50% of the postoperatively radiated group and 13% of the chemoradiation group).

Kiger et al. [69] compared therapy outcome after neuromuscular electrical stimulation or VitalStimTM ($N = 11$) and traditional swallowing therapy ($N = 11$), including oral motor exercises, compensatory strategies, and thermal stimulation via deep pharyngeal neuromuscular stimulation. The VitalStimTM group underwent from 1 to 13 treatment sessions whereas the traditional therapy group had from 1 to 6 sessions. Evaluation techniques consisted of dietary status and endoscopic or videofluoroscopic evaluation of swallowing. Raw positive change scores for oral and pharyngeal phases appeared stable in both groups (run chart analysis). However, regarding changes in oral and pharyngeal phase dysphagia severity, dietary consistency restrictions, and progression from nonoral to oral intake, the differences between the two groups were not statistically significant.

A retrospective study by Cray et al. [70] in a small group of six brainstem stroke patients might be considered a pilot for the study of 2004, as mentioned earlier. Swallowing instruction, focused on bolus control and airway protection, was combined with surface electromyography used as a tool for biofeedback. Evaluation of therapy demonstrated improved swallowing coordination, longer swallow duration, and increased effort. Changes in oral intake indicated long-lasting functional benefits.

Discussion

In total, 59 studies have been included in this systematic review of the effects of therapy in oropharyngeal dysphagia by speech and language therapists. However, considering the major impact of dysphagia on a patient's quality of life [1, 2], this number seems rather small. Furthermore, not all

studies define oropharyngeal dysphagia in the same way. The majority describe it as the presence of problems of swallowing objectified by videofluoroscopy, excluding esophageal dysphagia. However, some authors emphasize issues such as quality of life related to dysphagia (e.g., Elmståhl et al. [51]; Hägg and Larsson [67]; Robbins et al. [39]). The effect of therapy on a patient's quality of life does not necessarily have to be consistent with other findings, such as those based on videofluoroscopy, for example. Nonetheless, these authors see a patient's self-evaluation as a relevant aspect of therapy evaluation. In the field of voice therapy, quality-of-life assessment is already considered an important evaluation technique [71, 72]. But in swallowing therapy this issue is still under discussion and is usually ignored when describing therapy outcome.

This review includes only studies on patients with oropharyngeal dysphagia. In the wider literature, most studies covered patients with diverse neurological pathologies showing high variability in subject characteristics, including differences in anamnesis, age, or prior swallowing therapy. Different inclusion or exclusion criteria were set by various authors. Some included patients with penetration and/or aspiration based on videofluoroscopic protocols using specified quantities of boluses (e.g., Bhattacharyya et al. [14]; Lewin et al. [33]), whereas others included patients with cricopharyngeal dysfunction (e.g., Bartolome and Neumann [60]). The number of subjects in all of these studies ranged from 5 (as studies with fewer subjects were excluded) to 711. Twenty studies included patient populations with fewer than 20 subjects; 28 studies had between 20 and 50 subjects; and 11 studies had more than 50 subjects. The median number of subjects was 27 (25th percentile = 12; 75th percentile = 45).

The evaluation techniques were divided into five categories: quality-of-life measures, videofluoroscopy, fiberoptic endoscopic evaluation of swallowing (FEES), clinical screening (e.g., dietary questionnaire), and a residual category of "other evaluation techniques" (e.g., videomanometry). Among these techniques, the use of videofluoroscopy was the most common (40 studies). However, the choice of outcome parameters, rating procedure, or protocol in videofluoroscopic recording (e.g., number of swallows, type of bolus) differed considerably. FEES and quality-of-life measures were used infrequently (in seven and five studies, respectively). About 60% of the studies restricted the dysphagia assessment to a single evaluation technique, about 30% used two different techniques, and about 10% of all studies included more than two. An association is apparent between the number of subjects and the number of evaluation techniques used: when the study covered a larger number of participants, it applied fewer techniques to evaluate swallowing effects, and vice versa.

The conclusions found in the literature on the effects of swallowing therapy are strongly dependent on the selected evaluation protocol (e.g., number of swallowing trials, bolus volume and consistency) as well as the outcome parameters (e.g., incidence of pneumonia, temporal or spatial videofluoroscopic parameters, dysphagia-related quality of life).

Furthermore, the diversity in type of therapy is impressive. Some interventions are well known, but certain studies describe rather unconventional therapy concepts. Besides this variety of interventions, the literature reveals enormous variation in the duration of therapy. Some studies claim significant (short-term) improvement after a single treatment session, whereas others report a long series of sessions. Although all of these studies provide information on the short-term effects of therapy, hardly any data are available on the long-term effects.

The diverse methodological problems to which many of the included studies attest warrant further attention. For example, many study designs are weakened by the lack of a good alternative for a control group receiving no therapy. Frequently, the authors ignore the possibility of spontaneous recovery during therapy (e.g., Masiero et al. [63]; Seidl et al. [52]). The evaluation of therapy outcome is repeatedly based on small or restricted groups of patients and a small number of speech therapists. Some studies use subjective instruments to evaluate therapy effects without any statistical grounds or test validation. It is often unclear whether the data have been scored in randomized order and without any information on pre- or post-therapy status (blinded rating). In summary, the studies that have been included in this systematic review are not necessarily examples of evidence-based best practice and, therefore, the reader is advised to return to the original studies for further methodological information.

In view of the heterogeneity of the study designs and therapies as well as the evident methodological problems, statistical pooling of the data was not possible for this review. Still, summarizing the literature on the effects of dysphagia therapy as applied by speech and language therapists gives the overall impression that most interventions have a positive therapy outcome. However, the number of evidence-based papers is rather low and many studies have methodological problems. As usual in literature reviews, some publication bias cannot be entirely ruled out.

Conclusion

In general, statistically significant positive therapy effects are found. However, the number of papers is rather small and many of these effect studies have diverse methodological

problems. Furthermore, the conclusions of most studies cannot be generalized easily or compared to one another because of the diversity in subject characteristics, therapies, and assessment instruments. Therefore, when trying to determine whether swallowing therapy in general is effective, one may conclude that no single answer can be given. Many questions about the effects of therapy in oropharyngeal dysphagia as applied by speech and language therapists remain unanswered. Although some positive significant outcome studies have been published, there is a need for further research using randomized controlled trials.

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