Feminization Laryngoplasty: Surgical Therapy

15

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15.1 Phoniatric Evaluation

People looking for an alleged gender identity disorder (GID) must begin a complex path.

The fundamental purpose of the standards of care is to articulate the consensus among different organized professionals to management regarding psychological, medical, and surgical treatment of GID. These standards provide guidance for professional practice, providing the minimum requirements for the treatment procedure. An accurate diagnosis (*diagnostic criteria for GID according to DSM-IV TR, 2000*) is structured in:

- A real life experience, preferably along with psychotherapy
- Hormonal therapy
- Surgical therapy (especially sex reassignment surgery and others including voice modification)

The female speech is very different from the male speech. Markers of female speech are [1] as follows:

- Higher fundamental frequency than in male.
- Intonation range and pitch variability are higher in female.
- Females tend to have more vocal expression, variety of pitch, and emphasis than males.
- Females tend to have rising intonation after sentences containing statements suggesting uncertainty.
- Females tend to have an overall breathy voice quality and some degree of dysphonia can be considered as attractive.
- The use of feminine modalities of phrasing.
- Nonverbal visual markers including maintaining eye contact, use of more hand/arm and upper body gestures, sitting closer, and occasionally touching the listener.

Because of differences in laryngeal size and mass, average fundamental frequency (f0) for females is higher (220 Hz) than for males (110 Hz). The perceived pitch of the laryngeal fundamental has long been accepted as an acoustic cue to speaker's sex. Thus, for male-to-female transsexuals, in order to be perceived as female voice, fundamental frequency must change.

An f0 of 165 Hz represents the borderline frequency above which a voice is perceived as female [2]. In case of androgynoid conversion (MtF), the use of female hormones can determine a smoother, thinner, and glabrous skin; it can cause moderate mammary gland hypertrophy, and overall it can offer a more feminine look.

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Intake of female hormones has *mild effects* on the vocal cords, larynx, and laryngeal skeleton *but has no effect on the vocal tract in general* [3].

So, with the intake of hormonal therapy, the f0 does not undergo a significant increase.

Consequently, these patients maintain a male voice type.

To increase the value of f0 before the MtF conversion, speech therapists pay attention to the following:

- Emphasize the pronunciation of consonants.
- Use a tone more gentle and subdued, even falsetto.
- Reduce the rounding of the mouth opening, contracting the length of the vocal tract by raising the tongue and the larynx.

This reduces the volume of the vocal tract amplifying the higher frequencies of the voice.

15.1.1 Methods to Change the Voice: FtM

The therapy is more simple when we transform a voice from female to male gender: testosterone administration produces an increase in the volume of the vocal cords and a consequent lowering of the voice, which normally follows a speech therapy rehabilitation.

In particular, an alternative method is represented by the injection of silicone or hydroxyapatite microgranules or autologous fat into the vocal cord to obtain the same effect (increase of the vibrating mass).

15.1.2 Methods to Change the Voice: MtF

The therapy is more complex in case of change from man to woman: as already mentioned, the hormones do not modify the laryngeal structure; surgery is needed in order to modify the structural aspects of the vocal cords, *tension, mass, and length*, and consequently the f0.

The fundamental frequency (f0) is a specific characteristic of each person, and it varies with age and gender. f0 at birth is the same in male and female. This value changes dramatically during puberty up to the values that allow to perceive a voice as female or male. The limit of perceptual discrimination between male and female voice is 165 Hz.

The f0 (fundamental frequency) is expressed by the following formula:

$$f0 = (1/2L)\sqrt{T/P}$$

where:

- *L* is the length of the vocal cord.
- *T* is the medium longitudinal tension.
- *P* is the density of tissue.

Then the three variables are as follows:

- Length
- Mass
- Tension

So, the f0 depends on the variation of these three parameters. The pitch (and specifically the f0) is directly proportional to the tension and inversely proportional to vocal cord length and mass.

It means that it is possible to elevate the fundamental frequency of glottal vibration (f0) by increasing the tension and/or reducing the mass and/or the length of vocal cords. It can be achieved by three different surgical procedures:

1. Mass reduction of the vocal folds
2. Tension increase of the vocal folds
3. Shortening the length of the vibrating portion of the vocal folds

15.1.3 Surgical Techniques to Increase the f0

15.1.3.1 Injection into the Vocal Muscle of Triamcinolone Acetate Depot

The procedure consists in the injection with triamcinolone into the vocal muscle, which can be performed under local anesthesia in fiberendoscopy or in direct microlaryngoscopy.

Triamcinolone is a long-lasting corticosteroid which has a side effect of the atrophy of soft tissues at the point of intramuscular injection. This side effect is used to reduce the mass of the vocal folds. This technique produces a temporary muscle hypotrophy and the f0 raising of approximately 25–40 Hz. It is an easy technique to perform but with conflicting and sometimes unpredictable results.

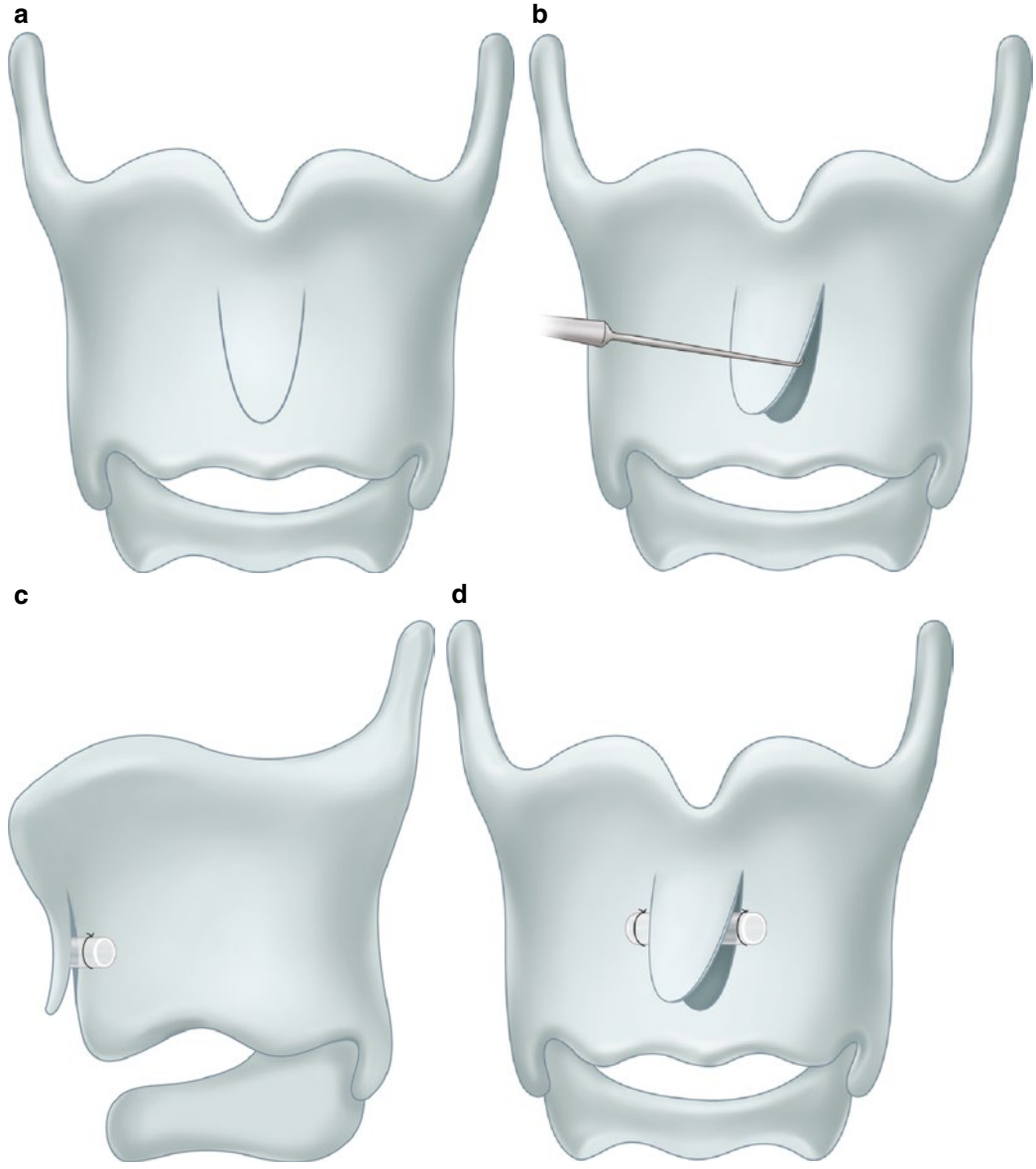

Fig. 15.1

15.1.3.2 Advancement of the Anterior Glottic Commissure

This surgery, proposed by Tucker in 1985, is difficult to achieve.

It requires the incision in the thyroid cartilage at the level of the anterior glottic commissure and the insertion of a silicone thickness to keep it advanced. In these cases, So the vocal cords, as well as increase their tension, become longer and thinner and the tension increases. It produces an action on the vocal cord length.

Despite the good results on the speech signal, this surgical technique is not acceptable to the patient because it creates a second Adam's apple and is not aesthetically acceptable (Fig. 15.1a–d).

15.1.3.3 Endoscopic Anterior Commissure Backward

This procedure, proposed by Wendler, is performed in direct microlaryngoscopy under general anesthesia, and it involves the laser

decortication of the anterior third (or often the front half) of the vocal cords.

The purpose of this intervention is to reduce the length of the vibrating portion of the vocal cord and to simulate the dimension of a female glottis. This action creates an anterior synechia, peeling the anterior third of the vocal cords with the laser and then approaching them with a surgical suture; the synechia is also closed using biological glue to avoid any opening. Sometimes, especially if the surgery is not properly performed, synechia can be opened with the use and give a bad voice (Fig. 15.2a–c).

This is the procedure that can lead to the best results in f0 elevation, but it is also the one that is associated with the greatest surgical and postsurgical complications.

15.1.3.4 Cricothyroid Approximation or Thyroplasty Type IV

The procedure is based on an external laryngoplasty with cricothyroid approximation (laryngoplasty type IV). This procedure, proposed by Isshiki in 1980, is the most widespread approach, and it is associated, in most cases, with a surgical remodeling of the Adam's apple.

This is the surgical technique used by the authors and described in the Sect. 15.2.

It consists in lengthening of the vocal cords (action on the length) performed by attaching the cricoid cartilage to the thyroid cartilage through non-resorbable sutures, simulating a continued spasm of the cricothyroid muscle with a consequent increase of the tension and of the length of the vocal folds (Fig. 15.3a, b).

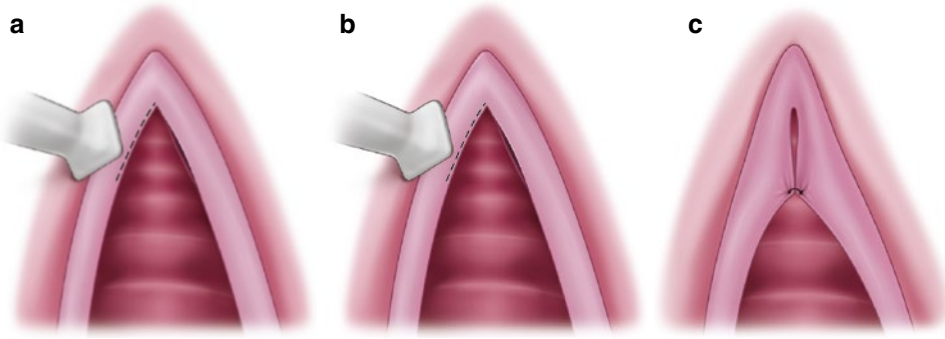

Fig. 15.2

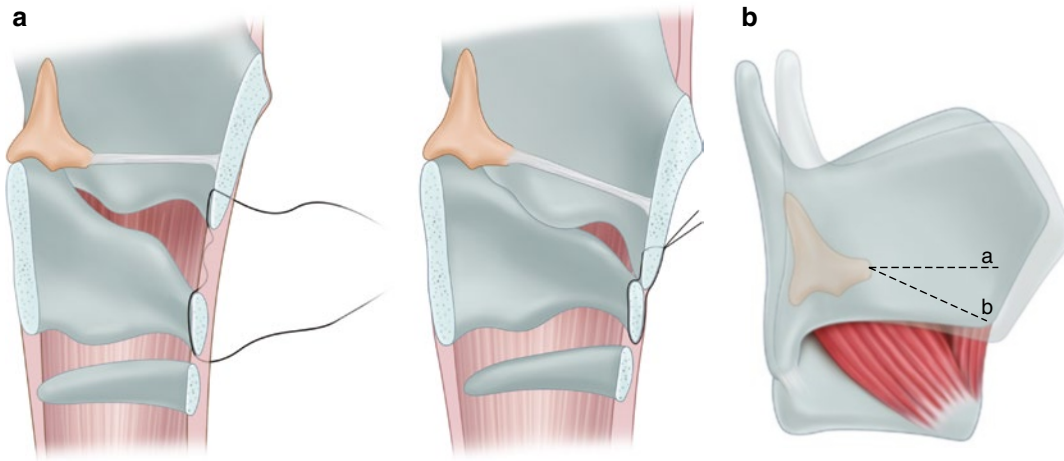

Fig. 15.3

Radiologic studies confirm that by reducing the distance between the thyroid and cricoid cartilage, the pitch increases (about 18 Hz for each mm of approaching).

15.1.4 The Preoperative Phoniatric Evaluation

- Counseling
- Laryngostroboscopy
- Functional examination
- Acoustic spectrum of the speech
- Manual approximation test

15.1.4.1 Counseling

Counseling in the MtF patient candidate for thyroplasty type IV is the most important and delicate moment in phoniatric presurgical evaluation.

In addition to assessing the substantial appearance of the female candidate (somatic and vocal), the phoniatrician has to objectively assess the quality and the manner of speech (through the use of instruments such as GIRBAS and CAPE-V).

The phoniatrician should inform the patient about the surgical approach, should illustrate where the incision will be made, and should inform about the various steps of surgery and postsurgical phases, including the treatment of the postsurgical scar.

The phoniatrician invites later the candidate to explain the reasons that have led him to the surgical choice, their doubts, and their expectations about the surgery, trying to establish a constructive and honest relationship with the patient.

So he should remind the patient that surgery can only act on one of the voice-generating factors, the vocal cords, and remember that the ventilatory function and the cavity of resonance will remain unchanged (i.e., male). After surgery, patients will have to readjust all their body-voice patterns to find the best coupling between vibrator and resonator, also through a modification of Psub.

And this is why speech therapist is essential before and after surgery. It is very important during counseling to suggest the use of speech therapy to the transgender patient.

The aims of speech therapy are as follows:

- Removal of mostly incorrect spontaneous forms of compensation
- Maintenance of postsurgical results.
- Modification of the acoustic parameters of the spoken voice:
  Fundamental frequency (f0)
  First and second formant (F1, F2)
- Modification of suprasegmental features of speech:
  Pitch (prosodic contour), intonation, and duration
- Pragmatic skills and communicative behavior

In addition, speech therapy, by changing the attitude of the supraglottic structures and tongue, helps to elevate f2. This increase is as important as the elevation of the f0 because vocal tract resonance characteristics may be the second most important acoustic cue to speaker identification.

Later modified test TSEQ of Davies et al. [4] (Italian version to 14 items by the writer) and the VHI-10 are administered.

The use of both these tests is due to the fact that the VHI has been shown to be a valid tool used to assess psychosocial handicap of voice disorders representing the breadth of pathology seen in most clinical settings and a moderately strong relationship was found between the patient's self-perceived severity and VHI scores.

Individuals seeking vocal feminization may or may not have vocal pathology and often have concerns not addressed on the VHI (e.g., my laughing, coughing, and sneezing sound like a man). The Transgender Self-Evaluation Questionnaire (TSEQ) is a subjective measure of voice handicap tailored to the transgender population.

Hancock et al. [5] demonstrated a significant relationship ($r = 0.89$) between VHI and TSEQ scores when administered to male-to-female transgender individuals presenting as females 100 % of the time, indicating criterion validity of the TSEQ.

Additionally, a strong correlation ($r = 0.97$) indicated test-retest reliability of the TSEQ. Although the VHI and TSEQ may be correlated, they are not identical; therefore, using a measure with greater content validity will provide the clinician with a richer picture of the

client's feelings and may be helpful in directing treatment.

Already in the 1950s, Peterson and Barney [6] and Ladefoged and Broadbent [7] found that females have higher average vowel formant frequencies than males.

The importance of vocal tract resonances as a cue to speaker sex identification was shown by Coleman [8].

He reported that listeners correctly identified speaker's sex in 88 % when listening to the sound produced by an artificial laryngeal source with a fundamental of 85 Hz of both sexes. In 1976, Coleman further investigated the importance of vocal tract resonance and fundamental frequency related to gender identification.

In one experiment, male and female speakers produced speech samples using normal voice, and in another they used an artificial larynx.

When speakers used normal voice, vocal tract resonance and fundamental frequency were both important to male vs. female identification.

When they used artificial voice and when vocal tract resonance characteristics of one sex were combined with f0 characteristics of the opposite sex, listeners generally identified the speaker as male. This was true both when a male f0 was combined with female vocal tract resonance and when a female f0 was combined with male vocal tract resonance.

These cumulative findings lead to the hypotheses that in MtF transsexuals, raising the f0 alone will likely result in perception of male voice and simultaneously raising the f0 and the vocal tract resonance will likely result in the perception of female voice. So, we use a speech therapy focused on changing both the laryngeal tone and its resonance.

During the speech therapy, the patient's natural abilities were used to produce voluntarily a higher laryngeal f0 and to enhance it by forward carriage of the tongue, thereby raising f2 vowel frequency.

So, key elements of success are as follows:

- Adjustment of vocal parameters (f0, f1, f2)
- Use of correct verbal communicative signals (linguistic code)
- Use of correct nonverbal communicative signals (tone, duration, intensity, pitch)
- Use of correct nonlinguistic communicative signals (facial expressions, gestures)

15.1.4.2 Laryngostroboscopy

We use this technique to investigate the following:

- General morphology
- Pathological findings (cysts, nodules, polyps, tumors, inflammation, edema)
- Involuntary muscle activity (fasciculations, myoclonus, tremor)
- Vocal cord motility
- Glottic closure
- Attitude of the supraglottic structures

15.1.4.3 Acoustic Spectrum of the Speech (Yang)

We use this technique to evaluate the following:

- f0 of vowel /a/ sustained for at least 4 s (CSL 4500)
- f0 on a standardized test of reading (VRP)
- Vocal range in semitones (VRP)
- Evaluation of voice signal
- Perturbation indexes (jitter-shimmer)

15.1.4.4 Manual Approximation Test

During phonation, the cricoid and the thyroid cartilages are manually approached: the right index finger lifts the bottom edge of the cricoid while the left index finger pushes down the thyroid cartilage (Fig. 15.4). In this way, we can check the approximation length between the cricoid and thyroid cartilages and simultaneously listen to a "preview" of the postoperative voice result. A modest result is usually due to excessive mass.

A low pitch (due to vocal cord hypertrophy) is not significantly raised with cricothyroid approximation only.

In this case, after the surgical approximation, one or more injections of triamcinolone inside the vocal muscle can be performed, in order to decrease its mass.

Fig. 15.4

15.2 Surgical Procedure

15.2.1 Thyroplasty Type IV: Surgical Technique

The surgery begins with a careful choice of the surgical incision site, trying to match the surgical wound with a preexisting skinfold.

For this purpose, the neck is mobilized with extension and flexion to identify the most suitable fold, possibly coinciding with the cricothyroid membrane.

A dermographic pencil is used to mark the incising line. Later a subcutaneous infiltration is done with 10 cc of Carbocaine 2 % with epinephrine (Fig. 15.5).

The incision of the skin and subcutaneous tissue is done, removing the excess fat until reaching the level of the prelaryngeal muscles.

Here you can see large-caliber venous vessels, consisting of the anterior jugular and its collateral branches.

If the caliber is greater than 3 mm, they must be tied and cut.

The cervical "linea alba" is identified, and the muscles are lateralized, carefully avoiding to dissect them, to identify the membrane between the

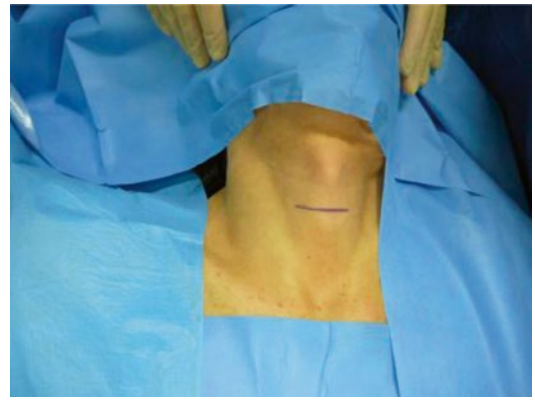

Fig. 15.5

Fig. 15.6

cricoid and thyroid, to the upper edge of the cricoid cartilage and the lower edge of the thyroid (Fig. 15.6).

In this phase, after careful hemostasis, we must carefully avoid to cut the membrane between the cricoid and thyroid, avoiding even its damage, which would expose the patient to bleeding and subcutaneous emphysema.

Later we proceed carefully to subperiosteal dissection of the internal side of the lower edge of the thyroid cartilage and the upper one of the cricoid cartilage by the use of a surgical instrument used in septoplasty.

This allows the sliding of the cricothyroid membrane that is folded into the internal side, favoring a good healing (Fig. 15.7).

Fig. 15.7

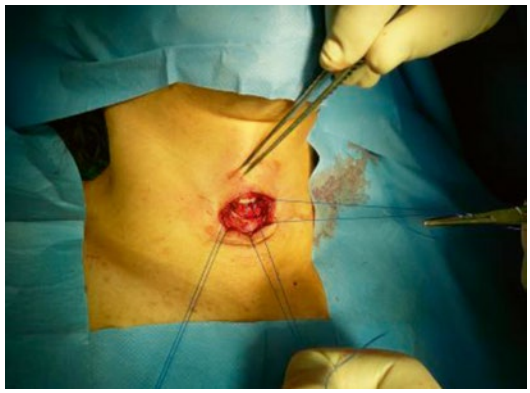

Fig. 15.8

After checking again the correct hemostasis and after measuring the space between the two cartilaginous edges to have a prediction on frequency increase, we proceed to surgical fastening between the two cartilages.

We usually use three large-size (0/1) Prolene wire and we suture starting from the central point (Fig. 15.8).

The lower suture does not pass through the cricoid cartilage to prevent its rupture, but below it. Regarding the thyroid cartilage, the needle must enter 4–5 mm from the bottom edge. When the cartilage is not yet ossified, as occurs in young patients, drilling is quite easy. When this is not possible due to cartilage ossification is necessary to prepare three holes by using the drill. Once the Prolene wires are positioned, these are tightened starting from the central wire (Fig. 15.9).

Fig. 15.9

It may happen that, due to the hormonal action, cartilages become particularly fragile. In this case, the risk to tear the cartilage at time of traction of the sutures is very high.

In this case, it may be helpful to use wires with little "wings" on the side (e.g., Quill). In this way, there is no need to tie knots.

In this case, the "hoist" effect is used. Of course, we will have to increase the number of steps with respect to sutures with Prolene.

After, the muscles are joined in the midline, and subcutaneous and intradermal suture is executed.

No drains are placed, and the wound is treated with a flat plaster.

The reduction of the Adam's apple, if requested, will be made only after finishing the thyroplasty.

This is particularly important because the approximation between the cartilages tilts down and forwards the front angle of the thyroid cartilage which is precisely the Adam's apple.

We must therefore remove the perichondrium to expose the cartilage.

At this point, the anterior dihedral angle can be modeled initially with an aggressive bur and further with a diamond bur.

The goal is to modify the anterior angle, from an acute angle to an angle as close as a straight angle, taking great care not to penetrate the larynx and to avoid damaging the anterior tendon (Broyles tendon).

The aesthetic result is usually very satisfactory (Fig. 15.10a, b).

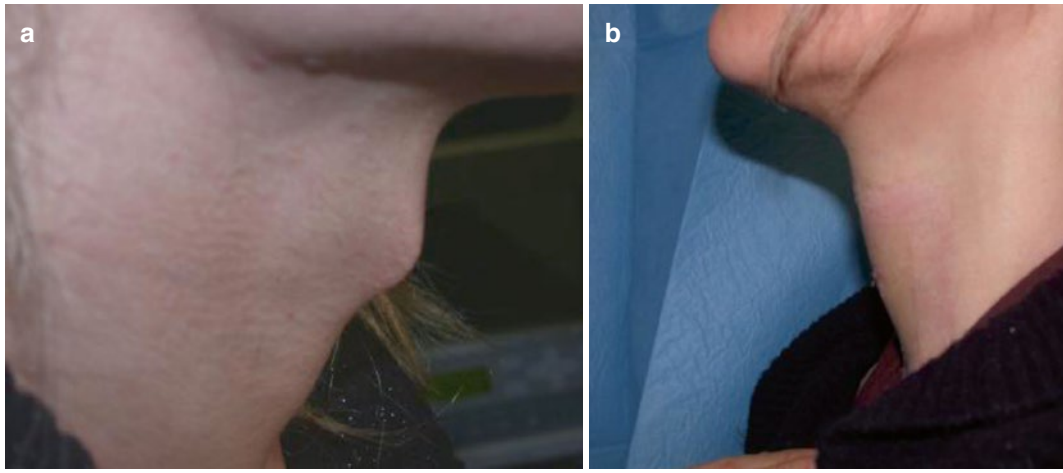

Fig. 15.10

15.3 The Postoperative Phoniatric Evaluation

15.3.1 Postsurgical Process

It is not necessary to place a drain; a bandage which is a little bit compressive, maintained for 24 h, is sufficient to prevent a hematoma.

The patient must be maintained with the head slightly bent forward and is recommended absolute vocal rest for a week.

No complications were reported when the patient maintained absolute silence for a week. Note that in the first week of postsurgery, the patient is almost voiceless and should not strive to speak (use of alternative communication: SMS, e-mail, block notes, etc.).

15.3.2 Postsurgical Evaluations

15.3.2.1 Laryngostroboscopy

Evaluation of the vocal fold anatomy and in particular paying special attention to potential blood spills and the integrity of the anterior commissure and free edge, especially after an Adam's apple reduction.

Analysis of the vocal cord motility for a physiological reduction of breathing space.

Following careful monitoring of the recovery and quality of mucosal wave.

15.3.2.2 Acoustic Spectrum of the Speech

f0 of vowel /a/ sustained for at least 4 s (CSL 4500).

f0 evaluated on a standardized reading test (VRP).

Vocal range in semitones (VRP).

Evaluation of indexes of voice signal perturbation (jitter%).

Voice analysis detects a substantial elevation of the pitch of sustained speech (fundamental frequency) and of reading, immediately after surgery and 6–8 months later.

Finally, are the results stable?

Generally yes. For a stable result some operator binds the cricoid and thyroid cartilage with the classical three stitches and, in addition, peels the perichondrium of the upper border of the cricoid and the lower one of the thyroid to facilitate, through contact, the process of neochondrogenesis and fusion of the two cartilage surfaces.

However, this process is practically not used because *it is not reversible*.

The instability of the result due to loosening or breakage of sutures isn't acceptable.

There is a physiological adaptation of the vocal cord to the new state of tension, with a slight decrease of f0. This value will stabilize over time and always be above the threshold of perception for the female voice.

Although a rehabilitation (speech therapy) it's always preferred after phonosurgery, the

results, even without proper rehabilitation (often patients don't come back to controls!) appeared good, capable of raising a significant and lasting pitch.

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