

Autologous grafts for treatment of vocal sulcus and atrophy

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OBJECTIVES: To obtain complete glottal closure, and evaluate improvement of vocal fold vibration amplitude and vocal quality in patients with sulcus vocalis.

METHODS: Autogenous fat and/or fascia augmentation was used in 34 patients with sulcus vocalis. Mean follow-up time was 1 year. The perceptual acoustic and phonatory functions and videolaryngostroboscopic data were evaluated before and after the procedure.

RESULTS: Most of the individuals reported an improvement of vocal quality, a complete glottal closure, an enhancement of mucosal wave excursion, and significant results of acoustic perceptual and phonatory functions after the surgery.

CONCLUSION: Fat and fascia injections are effective autogenous implants and should be considered options in the treatment of patients with sulcus vocalis and vocal fold atrophy.

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Sulcus vocalis represents a longitudinal depression along the membranous portion of the vocal fold. It is usually bilateral, asymmetrical, and of variable extension. It is located in the superficial layer of the lamina propria (LP). In a great number of cases, it is adherent to the vocal ligament owing to inflammatory reactions, resulting in glottic incompetence with alteration of the mucous wave, and presence of fusiform rift and phonatory disorders.

The diagnosis, evaluation, and classification of these lesions are a true challenge. Videolaryngostroboscopy is mandatory for this purpose. However, in many cases, during microlaryngoscopy, it is possible to detect this alteration.

Several techniques and substances have been used for treatment of sulcus vocalis. In this study, autologous graft of total fat and/or fascia has been used in 34 patients since November 1997, with the purpose of obtaining better glottic coaptation and better vibration of the epithelium covering on the vocal ligament, and asserting whether this procedure could improve patients' perception of their voices.

It is hypothesized that surgical treatment of sulcus vocalis

with fat and/or fascia results in improvements of perceptual voice parameters.

MATERIALS AND METHODS

After obtaining approval from the Experimental Surgery Ethics Committee of São Camilo Hospital and Maternity, 34 patients complaining of voice disorders diagnosed with sulcus vocalis and submitted to surgical treatment, from November 1997 to June 2004, were enrolled in the study.

The studied group was divided into two groups, 19 female and 15 male individuals. The mean age was 34.8 years (range, 13-54 years). All the patients were previously diagnosed with bilateral or unilateral sulcus vocalis, 11 and 23, respectively.

All patients were submitted to otolaryngology and speech therapy evaluation. Stroboscopy, perceptual and acoustics analysis of the voice, and patients' completion of a self-evaluation questionnaire were accomplished prior to and after the treatment.

Videolaryngostroboscopy was performed with a 70° rigid endoscope (Storz-Hopkins, Tuttlingen, Germany) and flexible 3.2 mm endoscope (Fujinon, Wayne, NJ) with Toshiba CCD microcamera and stroboscopic 5 source of light model 4914 by Bruel & Kjaer. The recordings were made on videocassettes in the Video Home System (VHS) format.

The preoperative evaluation was performed after the administration of topical anesthesia with lidocaine at 10 percent, the laryngoscope was positioned, and the patient guided to produce the phoneme /e/ sustained. The voice perceptual analysis was carried out in a blinded manner by the same otolaryngologist and speech pathologist with the use of a punctuation scale from 1 to 5 (1 = terrible, 2 = bad, 3 = moderate, 4 = good, 5 = excellent), resulting in an average as shown in Table 1. The vocal acoustic analysis was accomplished through the computer program Doctor Speech (Tiger DRS Inc, Vedbaek,

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Table 1
List of patients, ages, gender, diagnosis, graft, and perceptual analyses

Patient	Age	Gender	Diagnostic	Autologous grafts	Perceptual analysis		Patient's evaluation	
					Preop	Postop	Preop	Postop
C.N.	18	Female	Sulcus, right	Fat	1.0	5.0	1	5
J.C.B.	34	Male	Sulcus, bilat	Fat	1.5	4.5	1	4
F.T.	19	Male	Sulcus, bilat	Fat	1.5	4.25	2	5
E.S.	38	Male	Sulcus, bilat	Fat	1.0	4.5	1	4
D.A.	42	Female	Sulcus, left	Fat	1.0	3.75	1	4
A. S.	41	Male	Sulcus, right	Fat	1.25	5.0	2	5
M.I.A.	24	Female	Sulcus, left	Fat	1.0	4.0	1	4
G.M.	29	Male	Sulcus, right	Fat	1.5	4.25	1	5
M.P.S.	33	Female	Sulcus, left	Fat	1.25	4.25	2	5
C.S.J.C.	22	Female	Sulcus, right	Fat	1.0	4.5	1	5
R.R.A.	31	Female	Sulcus, left	Fat	1.25	4.25	1	4
V.S.F.	24	Female	Sulcus, bilat	Fat	1.0	4.5	1	4
C.P.R.	19	Female	Sulcus, left	Fat	1.5	4.25	2	5
F.G.F.	29	Male	Sulcus, right	Fat	1.0	4.0	1	4
L.M.S.	21	Female	Sulcus, bilat	Fat	1.5	4.25	1	4
S.M.	34	Female	Sulcus, left	Fat	1.25	3.75	1	5
M.A.C.	31	Female	Sulcus, bilat	Temporal fascia	1.0	4.0	1	4
F.C.M.	42	Male	Sulcus, right	Temporal fascia	2.0	4.0	1	4
L.A.	51	Female	Sulcus, bilat	Temporal fascia	1.5	3.75	1	3
M.E.G.F.	37	Female	Sulcus, right	Temporal fascia	1.0	4.0	2	4
L.C.J.	19	Male	Sulcus, left	Temporal fascia	2.0	4.0	2	3
S.C.	39	Female	Sulcus	Temporal fascia	1.25	4.0	1	4
A.B.F.	54	Female	Sulcus	Temporal fascia	1.5	4.0	1	4
P.C.C.	33	Male	Sulcus, left	Temporal fascia	1.25	4.5	1	5
R.S.	35	Female	Sulcus, right	Temporal fascia	1.0	4.25	1	4
J.M.G.	44	Male	Sulcus, bilat	Temporal fascia	1.0	4.0	1	5
G.C.	43	Male	Sulcus, left	Temporal fascia	1.0	4.25	1	4
L.S.F.J.	41	Male	Sulcus, right	Temporal fascia	1.25	3.75	1	5
C.M.A.	38	Male	Sulcus, right	Temporal fascia	1.5	3	1	3
R.S.R.	44	Fem	Sulcus, bilat	Fat	1.25	3.75	1	4
J.A.S.	25	Male	Sulcus, right	Fat	1.25	4.0	1	4
A.A.L.F.	40	Fem	Sulcus, bilat	Temporal fascia, bilateral	1.5	4.5	1	4
A.S.A.	13	Male	Sulcus, right	Fat	1.25	4.0	2	4
R.O.R.	44	Fem	Sulcus, bilat	Temporal fascia, bilateral	1.0	4.25	1	5
Mean	34.8				1.24	4.13	1.24	4.25

Preop, Preoperative; *postop*, postoperative; *bilat*, bilateral.

Denmark), with a focus on the fundamental frequency, jitter, and shimmer using the phonemes /e/ and /a/. The patient's self-evaluation was accomplished and classified according to the punctuation from 1 to 5 (1 = terrible, 2 = bad, 3 = moderate, 4 = good, 5 = excellent).

The postoperative evaluation was performed 7 days, 1, 3, and 6 months, and 1 year after surgery in a blinded manner by two otolaryngologists and two speech pathologists skilled in voice training.

The speech therapy began after the second postoperative week. The patients were instructed to do vibration exercises with the intention of reducing the adherence of the superficial sheet, which enables the return of the mucosal wave.

Surgical technique

Surgery was performed under general anesthesia with the use of endotracheal intubation with wire frame probes number 5.0,

5.5, and 6.0. A surgical microscope was used at a 400-mm focal distance and an increase variable from 10 to 25. The exhibition of the glottis was made with the largest possible caliber laryngoscope for best visualization. For the accomplished procedures, autologous grafts were placed unilaterally in 23 cases and bilaterally in only 11 cases. Nineteen fat grafts and 15 temporal fascia grafts were used on the basis of the characteristics of the sulcus. Fascia grafts were used when there was a decrease in the mucosal wave, and fat grafts were used with the purpose of vocal fold medialization.

Surgical steps

First, chordotomy was performed with the scalpel placed at about 1 mm of the upper border of the sulcus. The incision was made superficially, so as to reach only the superficial layer of the LP. Accordingly, a scythe-form probe was used

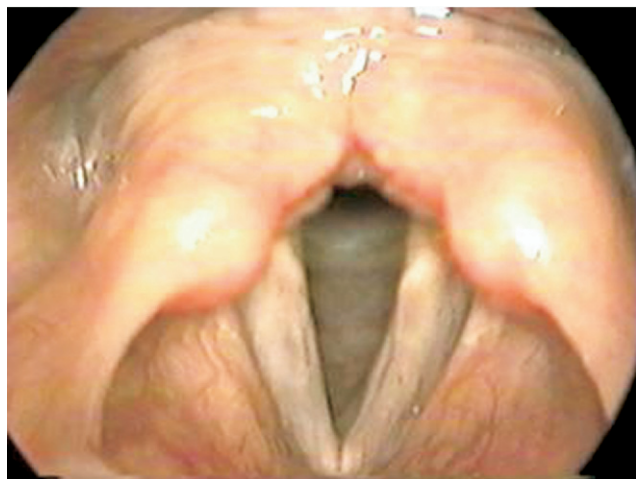


Figure 1 Preoperative aspect.

to allow suspension and incision of the epithelium (Figs 1 and 2).

In the second step, the epithelium was dissected carefully to make a scrap and a pouch for the whole extension of the sulcus. We touched all adherence and fibrosis without causing epithelial injury. The deepest sulci were difficult to dissect owing to the adherences of the superficial layer to the musculature (vocal ligament) (Figs 3 and 4).

Next, fat retreat of the earlobe was performed. A small amount of fat was removed from the posterior face of the ear. The fat was washed only and maintained in saline solution until its use. When fascia was chosen to be used, it was retreated from the temporary muscle.

The surgical field was then prepared and the scrap was placed on the surface of the pleat to be measured (Fig 5).

In the final step, the graft was placed in a subepithelial way to fill in the whole extension of the pouch made previously. To fill in the sulcus, an amount of fat in excess was always used because about 40 to 50 percent of it would be absorbed in a period of 6 to 12 months (Figs 6 and 7).

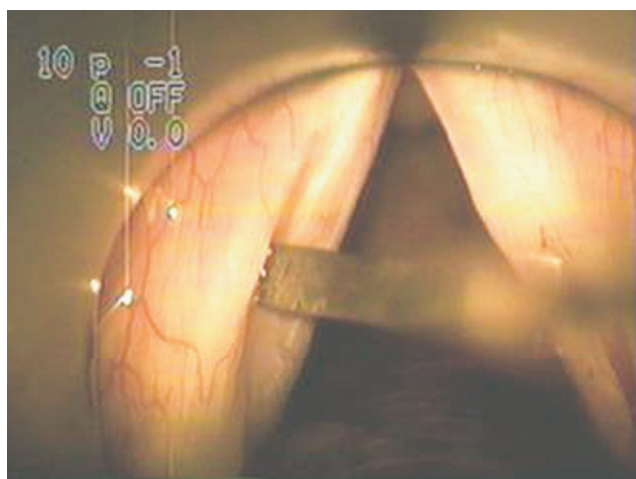


Figure 2 Chordotomy.

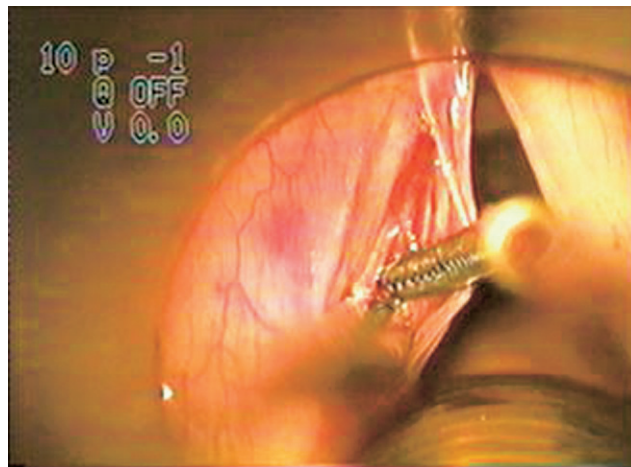


Figure 3 Epithelial dissection.

RESULTS

Statistical analysis of the data revealed impressive results. In the original protocol used, a follow-up time of 1 year was determined. In former evaluations, until the first postoperative month, all patients' vocal quality worsened. Owing to the need for overcorrection in seven cases, an extra amount of fat was used, which resulted in a breathy voice. Part of the grafted fat was absorbed in a variable period from 3 to 8 months, and the graft was viable after this period. Patients' careful orientation on the evolution after surgery was of extreme importance because the improvement of vocal quality is slow and progressive. The improvement of the vocal quality was clearer after 3 to 4 months postoperatively and then was progressive.

In the initial postoperative videolaryngoscopic evaluations, we noticed a large amount of granulation tissue on the vocal folds, mainly after the use of fibrin glue. In cases that sutures of the epithelium were performed, there was a smaller amount of granulation. However, the containment of the graft inside the pouch became more difficult, in addition to the high hazard of epithelium laceration. Great camber was noticed in the free border from the vocal fold

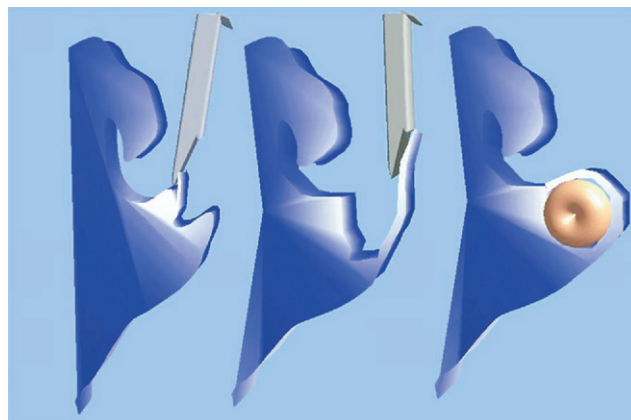


Figure 4 Scrap-making scheme.

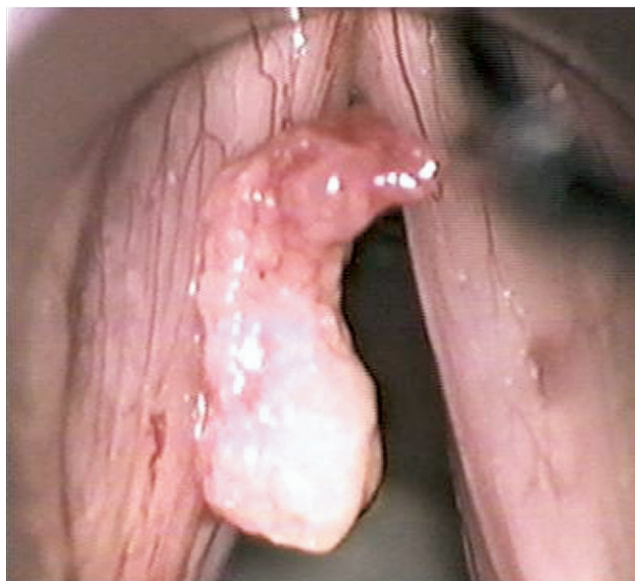


Figure 5 Fat graft measurement.

and gap formation. The stroboscopic assessment revealed rigidity, and in some cases there was no pitch for the appropriate evaluation.

In subsequent examinations, we noticed progressive gap closure and emergence of mucosal wave around the third and fourth month of follow-up. In one case after 1 year of attendance, a significant reduction of the mucous wave was observed.

Vocal acoustic analysis did not reveal significant changes. The jitter and shimmer values remained similar to those of the initial examination. Noise decrease and breathy voice were verified. There was a significant frequency reduction with close to normal values.

The postoperative perceptual voice evaluation demonstrated considerable improvement compared with the pre-

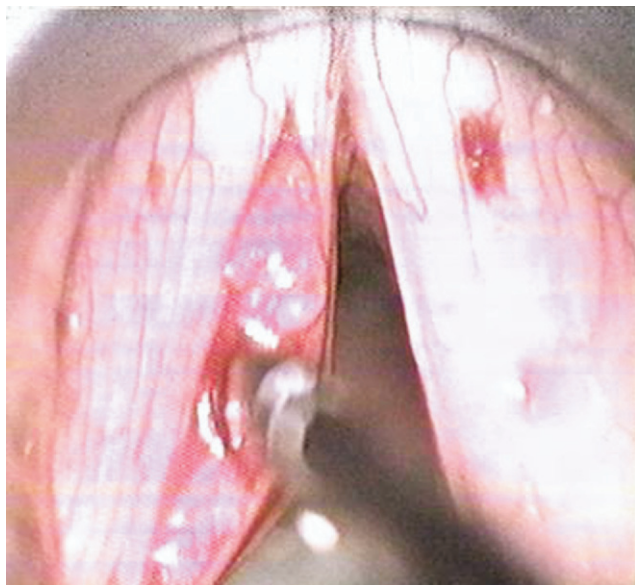


Figure 6 Graft positioning.

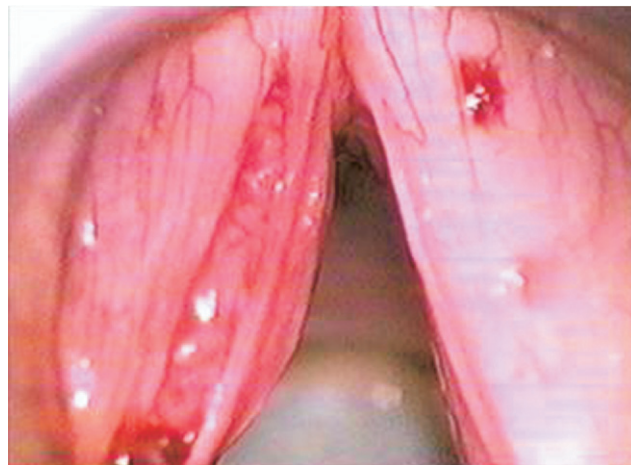


Figure 7 Placed graft.

operative values (Table 1). The initial average punctuation of 1.24 increased to 4.13, and it was statistically significant ($P < 0.001$). Following the same trend, the results of initial patients' vocal analysis demonstrated averages of 1.24 rising to 4.25 postoperatively, which was a statistically significant difference ($P < 0.001$). However, neither assessment demonstrated any statistically significant difference ($P > 0.05$) between the postoperative results comparing fat with fascia graft implantation.

Two ENT practitioners and two speech pathologists skilled in voice training conducted the analysis in a blinded manner. All the patients reported great improvement in the vocal quality after the surgical implant.

There was postoperative improvement of appraised objective parameters, as well as subjective ones and, consequently, an evident enhancement in patients' quality of life.

All patients had a good postoperative recovery with extremely low indexes of complications. Four patients presented the formation of scar granuloma in the superior portion of the vocal fold after use of fibrin glue during surgery, one improved with inhaled corticosteroid therapy for 21 days, and the three others were submitted to surgical resection. One patient presented partial graft extrusion, also after surgical use of fibrin glue, which did not compromise the result. Another patient submitted to fat graft was later submitted to type I thyroplasty and graft of temporal fascia, with good results.

DISCUSSION

Several techniques, such as speech therapy, phonosurgery, and molecular therapy have been described in the approach of sulcus vocalis. Neuber¹ described the use of fat graft for the correction of anatomical defects in 1893. Lexer² was the first to describe the use of fat graft successfully in 1910. Peer³ has shown that grafts of free fats in small amounts could survive the absorption for osmosis and remain stable

after neovascularization formation. Sataloff⁴ mentions satisfactory results in the use of autologous en bloc fat grafting for the treatment of paralysis of the vocal pleat.

Other substances have been used in the treatment of sulcus and atrophies of vocal folds, such as fascia, calcium hydroxyapatite, Teflon, silicon, gelfoam, and collagen. Tsunoda et al⁵ has used implants of autologous fascia to increase the volume of a vocal fold atrophic area. However, none of those substances was considered ideal; they had limitations, such as durability, effectiveness, and safety.⁶ More recently, experimental studies with hyaluronic acid (HA), replacement therapy of the LP with autologous fibroblasts, and therapy with hepatic growth factor have been given. HA is a component found in the extracellular matrix and plays an important biomechanical role in protection against phonatory traumas. HA and proteoglycans of the LP have been raising considerable attention in research and could be a viable substance to be used in the treatment of the glottic insufficiency.⁷

LP consists of three layers based on the distribution of the collagen and elastic fibers. The superficial layer, or Reinke's space, is composed of a few fibrous components, but it is rich in HA and proteoglycans responsible for maintaining the viscoelastic properties of that layer, whereas the intermediate and deep layers have a great amount of collagen and elastic fibers that grants their rigidity.

The extracellular matrix is composed of fibrous proteins (collagen and elastin), contributing to the flexibility and resistance, and of interstitial constituent, proteoglycans, and glycosaminoglycans (AH), occupying the space among the fibers.

Controversies persist with regard to the terminology, histogenesis, and treatment of sulcus vocalis. Bouchayer and Cornut⁸ consider it a result of an open sulcus, whereas others consider it a congenital or hereditary malformation. Ford⁹ and Hsiung^{10,11} classify the sulcus into three types: type I, *physiologic*, with atrophy of the epithelium, but without lesion of the LP and without vocal complaints; type II, *vergeture*, a linear depression with superficial loss of LP; type III, *true*, a penetration of the sulcus inside the vocal ligament or thyroarytenoid muscle (TA). The sulcus types II and III are associated with the bowing and atrophy of the muscle, and TA could show glottic insufficiency.¹⁰ Pontes et al¹² classifies the sulcus into smaller grooves, larger grooves, pouch-sulcus, and occult.

Sulcus vocalis and atrophies of vocal folds still pose a great challenge for laryngologists. Speech therapy alone allows the development of an appropriate vocal behavior and the prevention of compensatory hyperfunction, which can result in larger vocal deterioration.¹³ The main treatment option is surgical, together with preoperative and postoperative speech therapy.

The use of bioreactive substances, such as paraffin, and relatively inert substances, like Teflon, have not shown effectiveness, presenting a high degree of complications

with unsatisfactory results.¹⁴⁻¹⁶ The material's viscoelastic properties are pertinent. Teflon can cause vocal fold stiffness and granuloma formation.¹⁷ More recently, biocompatible substances, such as collagen and autologous fat grafts, were being widely accepted. The use of collagen and gelfoam, as well as centrifuged fat, presents unsatisfactory results owing to fast tissue reabsorption.¹⁰

Fascia implants have been used with satisfactory results, but with limited indication in a small amount of cases without atrophy of TA. The fascia is effective for regeneration of the flexibility of the mucous wave, but it does not provide an appropriate medialization.¹⁰ Hsiung¹¹ observed that the combination of fascial transplant and fat injection has great benefits,³ such as the possible restoration of vocal fold vibration and the synergic effect of fascia and fat on vocal fold medialization. Of the 22 patients studied (sulcus types II and III), 16 presented excellent results, 3 presented some improvement, and 3 did not present any change in the vocal quality.

Dedo and Rowe,¹⁵ who described the correction of a scar in vocal folds after laryngofissure, initially described the use of fat in vocal folds. Brandenburg¹⁴ has used autologous graft in 12 patients for the treatment of vocal fold paralysis, with a 5-month follow-up and also satisfactory subjective results. Shaw¹⁸ has used fat injection for the correction of glottic insufficiency of several etiologies, including volume deficiency, paralyzes, and scars. During 1-year follow-up, objective and subjective studies were performed, including vocal acoustic analysis with satisfactory results.

According to Hertegard,¹⁷ the degree of fat reabsorption is not predictable. Different authors^{14,16,19} have been using fat injection for sulcus treatment, and disappearance of injected fat occurred in the major part of the cases. The use of total fat graft in monoblock seems more appropriate because the fat viability in that state is larger,^{1,2,14,15} leading to durable results. Of the 11 patients submitted to monoblock fat graft in vocal folds, according to Duprat et al¹⁹, 90.9 percent of patients presented improvement of vocal pattern, 45.45 percent presented normalization, and 90.9 percent reported decrease of vocal fatigue.

Another positive aspect is that fat may be obtained easily and at a low cost compared with other substances (such as collagen).

The *slicing* technique is described in the literature as an alternative to the sulcus treatment, mainly in deep sulcus cases. However, it seems contradictory to the first phonosurgeries because it acts mainly on the epithelium covering of vocal folds.

Fat injection techniques, owing to the centrifugation performed, produce larger greasy cell destruction, and provide faster reabsorption and a less durable graft. For this reason, we opted for the total fat autologous graft, which, being a more solid tissue and having lower absorption, allows recreating the Reinke's space with larger viability. According to Hsiung¹¹, autologous fat graft is an easy and safe method to increase the vocal folds of patients with atrophy and

complete glottic closure. Subjective evaluation and videolaryngoscopy revealed significant statistical results in his study.

The proposed technique is easy to execute and preserves the integrity of the covering mucous membrane. The fat introduction into Reinke's space makes the release of adhesions and epithelium possible, causing the epithelium to slide over the vocal ligament and making the emergence of mucosal wave. We significantly reduced the breathiness and roughness scores according to GRBAS scale due to vocal fold augmentation by fat graft.

Even the worst cases of sulcus vocalis (type III), which present larger adherence to the vocal ligament and larger fibrosis, showed good results with the proposed technique because it preserved the epithelium's integrity. In two patients, owing to accentuated epithelial atrophy, fascia implant was carried out in their vocal ligament.

In the initial cases, we sutured the epithelium covering of the vocal fold for graft contention, which shortened the postoperative time. However, the occurrence of epithelium laceration was more frequent. The use of fibrin glue made the procedure easier, making surgery viable in even some cases with great laceration. The appearance of a large amount of tissue granulation after the use of fibrin glue was commonly found during the first 2 to 3 months of follow-up.

The use of appropriate surgical materials, mainly microdissectors, is essential to ensure that all technical steps are executed with the necessary care and accuracy, to avoid the occurrence of complications and enhance the patient's well-being during the recovery period. The use of carbon dioxide laser brings advantages, mainly in cases of hard sulcus dissection.

The total fat amount to be grafted depends on the surgeon's experience. Exact amounts do not exist, bearing in mind that about 40 to 50 percent of the total fat graft is absorbed, and that the final aspect is of an arched fold with the emergence of a camber in the free border.¹⁵

CONCLUSION

Total fat and temporal fascia grafts present expressive advantages for sulcus vocalis treatment compared with other techniques. Procedure simplicity, low cost, and good results are significant examples.

The improvement in videolaryngoscopic parameters and perceptual analysis, despite subjective data for analysis, is extremely important. The acoustic voice evaluation did not present improvement of parameters. However, improvement of the assessments carried out by the patients in relation to their own voices is a factor of immense satisfaction. All patients have reported larger vocal comfort, decrease of the breathy and vocal fatigue, reduction of phonatory effort, and reaching of voice pattern with significantly improved quality of life.

Despite a need for larger follow-up, total fat and temporal fascia grafts constitute excellent techniques for vocal fold sulcus and atrophy treatment.²⁰

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FINANCIAL DISCLOSURE

None.

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