Improved Mucosal Wave in Unilateral Autologous Temporal Fascia Graft in Sulcus Vocalis Type 2 and Vocal Scars

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Summary: Objectives/Hypothesis. We analyzed the results of 10 patients treated by unilateral autologous temporal fascia graft, comparing the pre and post surgery results, as well as the appearance of the wave and the intervals until the re-appearance of it.

Study Design. Retrospective, clinical case series.

Methods. Subjective and objective evaluation was preoperatively and postoperatively performed, using laryngovideostroboscopy, the Voice Handicap Index-10, GRBAS (grade, roughness, breathiness, asthenia, and strain), harmonics to noise ratio, Jitter, Shimmer, phonatory range, maximum phonation time, and S/Z ratio in all patients. Postoperative visits were scheduled after 1 week, 1 month, at 3 months, and at 6 months after the surgery.

Results. After surgery, we found significant differences in the maximum phonation time and the S/Z ratio ($P < 0.05$). Most parameters of GRBAS also improved significantly, both in general and in the subscales, except for Breathiness and Asthenia ($P < 0.05$). There was an average decrease in Voice Handicap Index-10 of 11.2 ($P < 0.05$). At laryngovideostroboscopy, the mucous wave reappeared in all patients treated 1 month after surgery, and increased in amplitude until 6 months postoperative.

Key Words: Dysphonia−laryngology−otolaryngology−vocal fold−benign vocal fold lesions−miscellaneous−temporalis fascia graft−sulcus vocalis−vocal fold scar−autologous transplantation of temporalis fascia into the vocal fold.

INTRODUCTION

Vocal fold scarring and sulcus vocalis type 2 produce a significant dysphonia.[1] These two entities are characterized by the deficient or disorganized mucosa and a significant mucosa stiffness, thus inhibiting normal vocal fold vibration and phonation.[2–7]

The option of conservative treatments, such as voice therapy and vocal fold injection augmentation, has been used in a generalized manner, since they are the least risky options with practically no complications; nevertheless, these procedures produce inconsistent and generally unsatisfactory results.[6,8]

Many clinical researches have tried to develop a successful therapy for this disorder. Unfortunately, an optimal treatment does not exist. Multiple surgical techniques have been used in the treatment of vocal fold scar.[6,9–14]

The autologous temporal fascia graft (ATFG) into Reinke's space was introduced as a new surgical option by Tsunoda and Niimi.[15] The same group reported good results with minimal complications after long-term follow-up.[16] This technique has presented a limited diffusion, with few subsequent studies that have used it and demonstrated its reproducibility, and the results obtained.[17,18] Some of these studies include patients treated with ATFG in addition to vocal fold augmentation,[17] which is a confounding factor to evaluate the true impact of the ATFG technique.

On the other hand, the realization of this type of techniques in both vocal cords in the same procedure, has resulted in very long recovery time of vocal function,[17,18] close to 12 months. This is why we have proposed in our study the inclusion of patients treated only unilaterally, to evaluate the recovery times, as well as to be able to compare the amplitude of the mucous wave versus the contralateral, being a good control of the obtained result.

Thus, the specific aim of this investigation was to conduct a retrospective study of the efficacy of unilateral ATFG into Reinke's space after 6 months of the surgery for vocal fold scar and sulcus vocalis type 2, using accepted subjective and objective outcome measures of laryngeal function, vocal quality, and voice handicap.

MATERIALS AND METHODS

Type of study: This study is a retrospective review of patients who were treated with unilateral ATFG into Reinke's space for secondary dysphonia to sulcus vocalis type 2 (six patients) or vocal fold scar (four patients), approved by the Research Ethics Board of the Hospital Universitario de Fuenlabrada.

Patients Selection

The patients were visited at the voice office of the Hospital universitario de Fuenlabrada and Hospital La Zarzuela, benign diagnosis by a laryngovideostroboscopy

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(LVS), suggested by a combination of spindle glottal gap, vibratory edge furrows, or impaired mucosal wave. All the patients included in the study lacked mucous wave in the operated vocal fold, and presented marked glottic incompetence.

All patients were treated with voice therapy preoperatively for more than 3 months. No patient had been subjected to other previous surgical procedures to improve the vibratory alteration of the vocal cord. Neither management resulted in acceptable vocal improvement, and patients were deemed candidates for ATFG into Reinke's space; then, informed consent was obtained.

The diagnosis was confirmed by adherence of the epithelium to the vocal ligament during direct laryngoscopy. The abnormality was classified as sulcus vocalis, as defined by Ford et al.[2] It was classified as scar, if the cover was sclerotic, had a stiffness mucosa attached to the vocal ligament, and had a previous procedure over the vocal folds as surgeries or possible injuries like a long or aggressive intubation.

All patients who were included in the study, underwent the procedure at the Hospital La Zarzuela or Hospital Universitario de Fuenlabrada, both in Madrid. All surgeries were performed by the senior author (R.G.) between October 2014 and May 2016. They all had at least 6 months of follow-up.

Surgical Technique

The surgeries were performed unilaterally even when the patient had pathology in both vocal cords, in the manner described by Tsunoda et al[16] (1). Undermining under the vocal fold mucosa to make a pocket rising a microflap, (2). Preparation of fascia temporalis, and (3). Autologous transplantation into the vocal fold closing the pocket with a 7/0 vicryl suture (Figure 1).

Six cases had a normal contralateral vocal fold, and four had a minor abnormality in the contralateral vocal fold, less important than the other.

Follow Up

Postoperative visits were held 7 days, 1 month, 3 months, and 6 months following the procedure. Patients underwent 20−40 sessions of postoperative voice therapy.

Voice and Stroboscopic Analysis

LVS were performed at each postoperative visit, and laryngeal function testing, GRBAS rating (grade, roughness, breathiness, asthenia, and strain) and Voice Handicap Index-10 (VHI-10) were performed prior to surgery and after 6 months of surgery.

The 10 patients included in the study had voice samples that were preoperatively collected and 6 months postoperative. The patients were graded using the GRBAS scale by a speech language pathologist in charge of the treatment. Each sample was graded on a scale of 0−3; 0 being normal and 3 indicating severe dysfunction. The individual scores for each category of assessment (grade, roughness, breathiness, asthenia, and strain) were recorded as the five GRBAS subscale values.

VHI-10 questionnaires were collected preoperatively and in 6 months postoperatively. The questionnaires were filled out by the patients during the medical evaluation.

The harmonics to noise ratio (HNR), maximum phonation time (MPT), S/Z ratio, relative Jitter, and Shimmer were evaluated preoperatively, and 6 months after the operation. Recordings of microphones were obtained from a sustained /a/ phonation of at least 3 seconds. The participants used an AKG microphone model C420L (AKG Acoustics GmbH, Vienna, Austria) at a distance of 3 cm

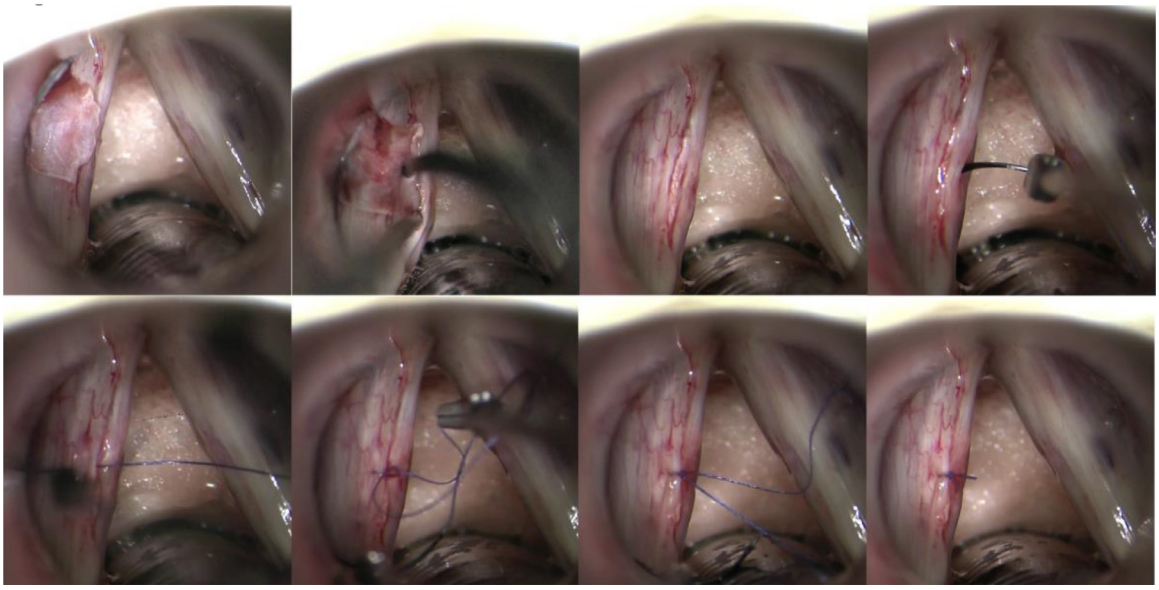

FIGURE 1. Sequence of images showing the placement of the fascia graft in the pocket, and how to proceed with the closure using a 7/0 vicryl suture.

from the corners of the lips during all tasks. The data segments chosen for the analysis were 2 seconds, discarding the initial and final 0.5 second of the recorded sample. The data was collected using the PRAAT Voice Lab.

The videos of LVS performed preoperatively and in each visit were reviewed by the second and third authors in a blind way, without knowing the time of evolution. They graded the amplitude of the mucous wave and compared it to the contralateral cord. The presence of a mucosal wave was evaluated and scored: 0% absent, 25% of the normal amplitude (presence of mucosal wave without overcoming the free edge of the vocal cord), 50% of the normal amplitude (presence of mucous wave that exceeds the free edge of the vocal cord, but of clear amplitude lower than normal), 75% of the normal amplitude (presence of mucous wave that exceeds the free edge of the vocal cord, slightly lower than the normal amplitude), and 100% of the normal amplitude. They were then compared to the contralateral vocal fold wave, and scored as: W worse than contralateral, S similar than contralateral, and B better than contralateral. The glottal gap was characterized using the following nomenclature: irregular, posterior gap, anterior gap, spindle, touch closure, and full closure.

Statistical Analysis

The preoperative and 6 months values for each quantitative variable were compared using a paired *t* test. Due to the small sample size, prior to using the *t* test, Kolmogorov-Smirnov of normality was performed to confirm that none of the variables departed significantly from normality. This evolution of the amplitude of the mucosal and other categorical variables were analyzed by Chi-square test. All the statistical study was performed by IBM SPSS Statistics 23.0. No reliability statistical test were done.

RESULTS

Subjective professional voice assessment using the GRBAS scale evidenced a mean decrease of 4.1 after the five GRBAS values were grouped ($P = 0.006$). A significant decrease was noted in the individual subscales of grade, roughness and strain ($P < 0.05$), decreasing near one point in each of these subscales. Breathiness decreased too, but not under significance with a P value of 0.051 (Table 1), (Figure 2).

There was a significant decrease in average VHI-10 of 11.2 ($P = 0.002$) (Table 1), (Figure 3) which implied a decrease in the value by 45% of the initial score. A closer evaluation of the change in VHI-10 per patient revealed an improvement in eight out of ten patients, with a decrease in this score of at least 25% from preoperative to 6 months.

In this study, was observed a statistically significant improvement in MPT and S/Z ratio (Table 2). Although HNR improved, it was only close to the significance with a P value of 0.062. Jitter and shimmer values were 52% and 17% better postoperatively, but their changes were not statistically significant due to a huge standard deviation of the data (Table 3).

All patients had unilateral grafting performed. After six months, eight vocals folds demonstrated normal amplitude of the mucosal wave, and in two cases the mucosal wave were of the 75% of a normal amplitude after 6 months of follow up. This evolution of the amplitude of the mucosal wave has been analyzed by Chi-square test, showing statistically differences between the groups with a $P < 0.01$ (Figure 4).

Glottal closure improved in eight of 10 patients to full closure, and in the other two cases obtaining a smaller postoperatively gap. We observed a reappearance of the mucous wave in all the patients one month after surgery, improving the amplitude of the wave in the following visits, this recovery being maximum at 6 months postoperatively (Figure 5).

Using the cord contralateral to the graft as control, we observed an improvement in the mucosal wave of the operated cord, being worse than the contralateral wave in the 10 cases at the beginning, becoming similar to the contralateral wave in eight cases, and better than it in two, this difference was also statistically significant $P < 0.01$ (Figure 6).

TABLE 1.
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	GRABS		G		R		B		A		S		VHI10		
CASE	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	% EMP
I	2	2	0	0	0	1	0	0	0	0	1	1	11	6	45.5%
II	4	1	1	1	1	0	1	0	1	1	1	0	19	18	5.3%
III	8	4	2	2	2	1	2	1	0	0	2	1	20	15	25.0%
IV	12	5	3	2	2	1	2	1	2	1	2	1	18	18	0.0%
V	8	0	1	2	2	0	2	0	2	0	2	0	28	7	75.0%
VI	7	5	2	1	1	1	1	1	1	1	1	1	21	11	47.6%
VII	10	4	2	2	2	0	2	1	1	1	3	1	24	12	50.0%
VIII	5	8	1	1	1	2	1	2	1	0	1	2	29	9	69.0%
IX	11	3	3	2	2	1	2	1	0	0	3	0	29	8	72.4%
X	10	4	3	1	1	1	1	1	0	0	3	1	26	9	65.4%
P value	**0.006**		**0.008**		**0.015**		0.051		**0.104**		**0.017**		**0.002**		

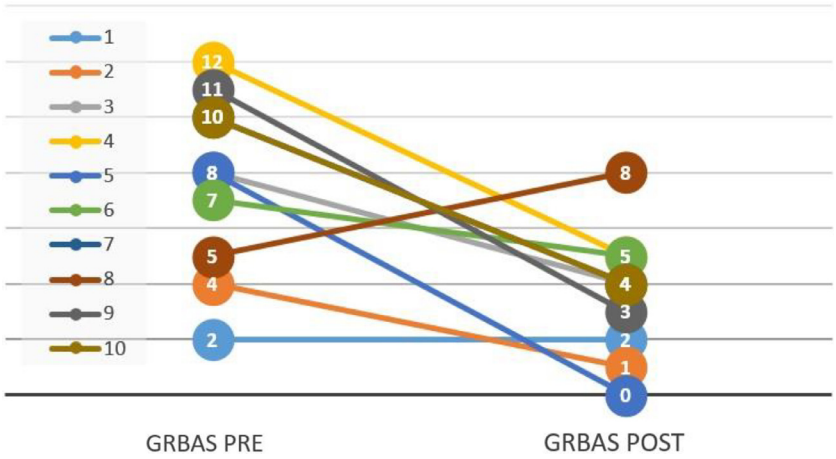

FIGURE 2. Graph showing the change in the total value of GRBAS VHI10 in each patient.

FIGURE 3. Graph showing the change in the value of VHI10 in each patient.

TABLE 2.
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	MFT		S/Z Ratio		Jitter		Shimmer		HNR	
CASE	PRE	POST	POST	PRE	PRE	POST	PRE	POST	PRE	POST
I	11	10	1.55	1.50	0.777	0.461	5.814	6.089	13.913	17.014
II	17	21	1.71	1.10	0.537	0.275	4.95	2.733	15.355	19.156
III	11	14	1.68	1.41	1.033	0.517	6.337	5.149	13.834	17.164
IV	9	15	1.56	1.27	3.529	0.279	8.88	5.98	3.154	18.688
V	10	17	2.30	1.24	0.347	0.138	5.387	2.287	18.138	22.178
VI	7	10	1.14	1.20	0.398	0.575	7.571	4.834	16.798	15.259
VII	11	15	1.69	1.25	1.103	0.374	4.734	4.511	13.532	18.243
VIII	13	12	1.85	2.17	0.608	1.374	5.422	8.974	15.645	10.689
IX	11	14	1.71	1.35	1.042	0.499	6.136	5.069	13.796	17.299
X	10	14	1.75	1.39	1.171	0.540	6.355	5.275	13.511	17.059
P value	**0.003**		**0.030**		0.130		0.123		0.062	

TABLE 3.
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	1 week			1 month			3 month			6 month		
	Wave amp	Defect	Comp	Wave Amp	Defect	Comp	Wave amp	Defect	Comp	Wave Amp	Defect	Comp
I	25	Spindle	W	75	Full	S	100	Full	S	100	Full	S
II	0	Irregular	W	25	Touch closure	S	75	Touch closure	S	100	Touch closure	S
III	25	Spindle	W	25	Spindle	W	50	Full	S	100	Full	S
IV	0	Spindle	W	25	Spindle	W	75	Touch closure	B	100	Anterior gap	B
V	25	Irregular	W	50	Full	S	75	Full	S	75	Full	S
VI	25	Spindle	W	50	Full	S	75	Full	S	100	Full	S
VII	25	Spindle	W	50	Spindle	W	75	Touch closure	S	75	Full	S
VIII	50	Spindle	W	75	Full	B	75	Full	B	100	Full	B
IX	25	Posterior gap	W	50	Posterior gap	S	75	Posterior gap	S	100	Full	S
X	0	Spindle	W	25	Spindle	W	50	Full	S	100	Full	S

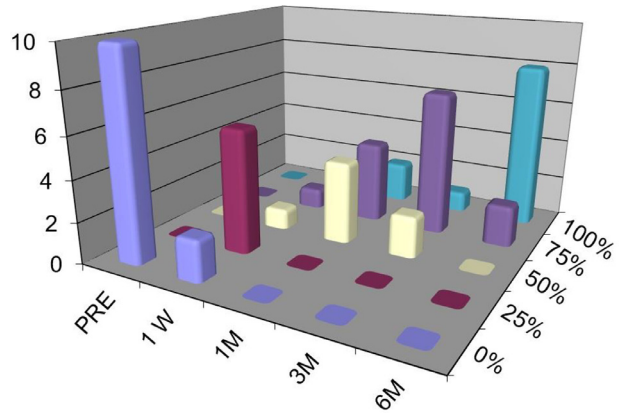

FIGURE 4. Evolution of the amplitude of the mucosal wave compared to the contralateral vocal fold. After six months, eight vocals folds demonstrated normal amplitude of the mucosal wave, and in two cases the mucosal wave were of the 75% of a normal amplitude after 6 months of follow up.

All procedures were performed without intraoperative complication. No granuloma was found during de follow up. As postoperative complications, one patient had a partial postoperative extrusion of the graft, that was observed at the first week visit, and needed to be reoperated, removing the herniated fascia. Even with this complication we decided to maintain the surgical procedure, without placement of fibrin glue over the incision in addition to suturing the incision closed as Pitman et al did.[18]

DISCUSSION

Vocal fold scar and sulcus vocalis type 2 are characterized by a great voice disability and fibrosis and disorganization of the mucosa affecting mainly the mucosal wave.[3–5] The resultant voice is characterized as hoarse, asthenic, with vocal strain, fatigue, and with low projection.[7]

Many treatments options have emerged, but most of them do not restore the architecture of the vocal cords, focusing on correcting glottal insufficiency.[19]

Voice therapy is the most frequent treatment offered,[19] but it is generally unsuccessful, since it does not address the anatomical abnormalities of the vocal cords, its primary objective is an improvement in phonatory mechanisms and avoiding vocal tension and fatigue.

Surgical treatments of these disorders have variable results and are not easy procedures.[19] The main objective of surgical approach is to address either the glottal insufficiency or the stiff vocal fold cover.

To improve the poor vocal fold vibration, many different procedures have been used: excision of the sulcus or scar, mucosal slicing techniques, undermining and releasing of scar, injection of steroids, photoangiolytic laser treatment, or fat implantation into Reinke's space.[9,11–14,19–23] The most common way to address the glottal insufficiency is the vocal fold medialization via type-1 laryngoplasty or injection augmentation.

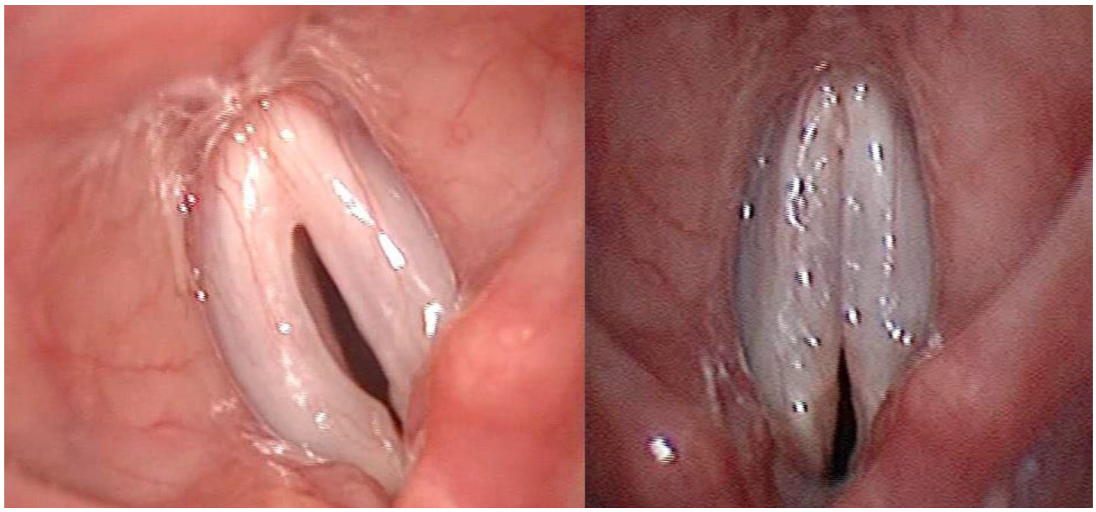

FIGURE 5. Photograph obtained from the stroboscopic exploration of the presurgery closure defect and after 6 months postsurgery.

One of the most successful methods to treat this problem was proposed by Tsunoda and Niimi in 2000. They used an ATFG into Reinke's space as an alternative surgical procedure and with long lasting results.[15] Later, in 2005, Tsunoda et al reported a follow-up of at least 3 years on 10 patients with this technique.[16] After 2 years of follow-up, all patients revealed a restoration of the mucosal wave. They used the MPT as an indirect measure of glottal competency, showing a slow increase in all patients by 6 months. The behavior of this parameter is identical to that obtained in our patients. After 3 years, the improvement was maintained on all patients and it was statistically significant compared to the preoperative measures. Nevertheless, in these studies by Tsunoda et al[15,16], there is no intermedium control until 6 months after surgery; thus, the moment of appearance of the mucosal wave could not be evaluated. In a similar way, Pitman et al[18] evaluated the mucosal wave 12 months after surgery, also not knowing when the mucosal wave did come back. Instead, our study establishes intermediate moments, at 1 week, 1 month, and 3 months in the evaluation of the mucous wave, being able to be more precise at the moment of the restauration of the vibration, which occurs 1 month after surgery.

Pinto et al[17], found in subsequent examinations a progressive gap closure and emergence of mucosal wave around the third and fourth month of follow-up. The appearance of the mucosal wave was much earlier in our study. It appeared in all patients only a month after surgery, although it was of a very limited extent.

Concerning complications, Pitman et al[18] reported one extrusion of the graft within 1 week postoperatively, the same complication as in this study. They decided to add to the suture closure a cover of fibrin glue. We preferred not to modify our technique, thinking that the learning curve was the reason, as happens when a new procedure is established. Our way of acting was the same one adopted by Tsunoda et al, resecting the part of herniated fascia, as soon as possible, to avoid the appearance of granulation tissue.

The histologic specimen excised 7 days postoperatively by Tsunoda et al[16], displayed an increase in cellular components and Ki-67 antigen that is present in proliferating cells but absent of resting cells, confirming proliferative activity.

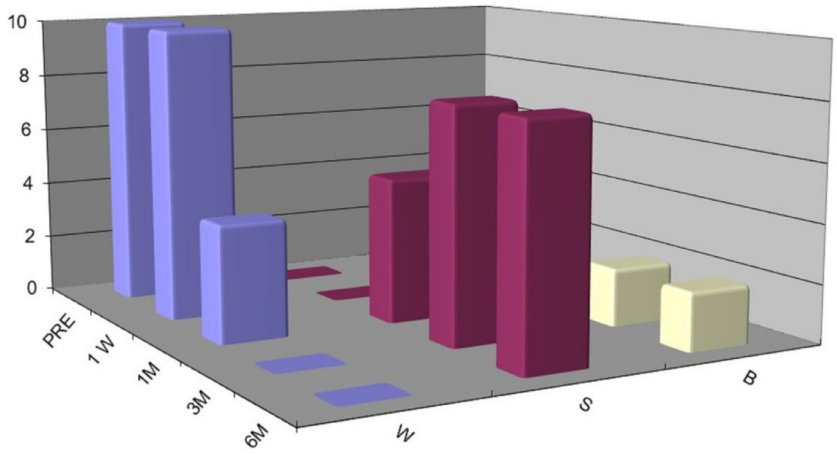

FIGURE 6. Evolution of the amplitude of the mucosal wave compared to the contralateral vocal fold (W-worse than contralateral S-Similar to contralateral B-better than contralateral).

This activity suggests that such improvement in vocal fold function after ATFG into Reinke's space may be due to metaplasia stimulated by the proliferating fibroblasts and possibly stem cells of the temporalis fascia graft, explaining the phenomena of remodeling and the restoration of the mucous wave.

The formation of granuloma can cause a poor result and a prolonged recovery.[17,18] We have not had this complication, and it is very possible that the shorter recovery time and the good functional results of our series can be related to it.

There are few publications that have treated sulcus vocalis type 2 and the scar using ATFG into Reinke's space. Most do not use appropriate tools that can give us information about the quality of glottal vibration and the quality of the voice, such as the perceptual evaluation of voice using the GRBAS scale, the use of scales that measure the vocal handicap as the case of VHI10[24] or objective measures such as acoustic analysis of parameters such as Jitter, Shimmer, or HNR.[18]

In other studies, as well as in this, improvement in acoustic parameters was not shown.[18] No statistically significant differences were found in Jitter, Shimmer, or HNR, this last parameter being the closest to finding differences with a $P = 0.062$. Perceptual voice analysis using the GRBAS scale showed significant improvement and in all subscales except in Asthenic and Breathiness. Pitman et al found similar results with a P value for breathiness near significance.[18]

For us, the main parameter to measure the improvement of the patients is the self-assessment of vocal handicap using the VHI-10.[24] The VHI-10 scores had a mean decrease of 11.2 ($P = 0.002$) (Table 1) between the preoperative and 6-month postoperative visits, being a similar value as founded by Karle.[25] It showed a significant improvement 6 months after surgery ($P = 0.002$). None of the patients had an increase in their VHI-10. The worst result obtained was a score equal to the initial score, this being 18 points. The S/Z Ratio improvement was found in nine out of 10 patients with statistical significance. This supports the idea of improving the closing function in the vocal cycle.

With this study, we can affirm that the majority of vocal improvement after unilateral ATFG into Reinke's space occurs 1–3 months after the operation, these times being clearly shorter than those suggested by other authors[17,18], who estimated them between 2 and 6 months. In the first postoperative weeks, the patients were severely dysphonic, showing objective improvement at the 1-month visit. This faster recovery than that described by other authors is attributed to the particularity of our series: unilateral grafts and absence of postoperative complications, except for the case of fascial extrusion which was solved without complications.

A possible bias that we may have committed in the study is the inclusion of cases of limited severity, as it is our first approach to this technique. We have observed over time, that currently we are dealing with patients with a greater vocal handicap produced by their pathology animated by the good results obtained so far. We believe that this bias, has been produced in other similar studies, blaming an attitude of prudence at the beginning of the application of a new technique.

In view of the significant vocal improvement in all our patients, and being a technique already used with similar success by other authors, we consider the ATFV a very good option for treatment. Probably, in the future, biological engineering will allow us to have other grafts which will improve these results even more with the use of grow factor or other options that will be offered to us soon.[26–28]

CONCLUSION

In the great majority of patients, the unilateral ATFG into Reinke's space produces an improvement in the VHI10 and restores the mucosal wave and the glottic closure, without significant complications. For us, the unilateral ATFG into Reinke's space is the main treatment to offer in patients with type 2 sulcus or scars with a severe voice handicap.

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