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Augmentation of Scarred Vocal Folds With Centrifuged and Emulsified Autologous Fat Grafts

Enrique Salmerón-González, MD, PhD[1], Elena García-Vilariño, MD[1], Ignacio Llópez-Carratalá[1], Diego Collado-Martin, MD[1], José María Perolada-Valmaña, MD[1], and Miguel Armengot-Carceller, MD, PhD[1]

Abstract

Objective. To review the results of a series of patients with glottic insufficiency caused by scarred vocal folds who underwent injection laryngoplasty with centrifuged and emulsified autologous fat.

Study Design. Prospective cohort.

Setting. Single center, tertiary institution.

Subjects and Methods. Examination of the medical records of 21 patients operated on through injection laryngoplasty with fat grafts for the treatment of dysphonia was performed. All patients were operated on between January of 2015 and September of 2019. The voice variables measured were the GRABS (Grade, Roughness, Breathiness, Asthenia, Strain) scale, the Voice Handicap Index–10 (VHI-10), maximum phonation time, jitter, shimmer, and harmonic/noise ratio before surgery and 8 months later.

Results. Twenty-six injection laryngoplasties were performed in 21 patients during the reviewed period. Seventeen were men, and 4 were women. Mean age was 57.2 (range, 18-80) years. Mean (SD) follow-up time was 20.7 (9.3) months. Etiology of dysphonia was scarring after tumor resection in 17 patients and sulcus vocalis in 4. Five patients received an additional injection laryngoplasty. Statistically significant improvements were observed in all the parameters evaluated ($P < .05$).

Conclusions. Injection laryngoplasty with fat grafts processed through centrifugation and emulsification is an effective technique for the treatment of dysphonia caused by glottic insufficiency related to scarred vocal folds, with minimal complication rates.

Keywords

voice, injection laryngoplasty, fat graft, vocal fold augmentation

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Injection laryngoplasty is a procedure aimed to medialize a nonfunctioning, scarred, or atrophic vocal fold in order to achieve complete glottic closure. This way, it improves phonation and helps to protect the airway, reducing aspiration-related complications.[1]

This was the first surgical technique described for the treatment of unilateral vocal fold paralysis. It was originally described by Bruning,[2] who used paraffin for injections. Since then, many other injectable products have been used, like Teflon, collagen, hydroxyapatite, and, more recently, autologous fat. However, most of them have been abandoned because of their complication rates and, in the case of biologic substances, because of their short-lasting effect.[3]

The use of autologous fat for injection laryngoplasty was first described by Zielins et al[4] in 1983, who reported fat injection of a scarred vocal fold through an open translaryngeal approach. Nowadays, fat grafting is an extensively used resource in the field of plastic surgery in order to achieve permanent tissue volume augmentation.[4]

To date, many case series of injection laryngoplasty with fat grafts have been reported, but only 2 studies included specifically the treatment of scarred folds after tumor resection, and only 5 reported treatment of sulcus vocalis. Furthermore, no other study has reported the use of lipoaspirate processed through centrifugation and emulsification, and until 2016, none had reported the use of centrifuged fat grafts.[5-26] Centrifugation of the fat graft allows one to obtain a more concentrated tissue, and the process of emulsification reduces the size of fat particles in the graft.[27] This combination of fat-processing techniques has never been reported before for vocal fold augmentation.

The aim of our study was to evaluate the results obtained in a series of 26 injection laryngoplasties with fat grafts obtained through liposuction and processed through centrifugation and emulsification in 21 patients with glottic insufficiency.

[1]University and Polytechnic Hospital La Fe, Valencia, Comunidad Valenciana, Spain

Corresponding Author:
Enrique Salmerón-González, MD, PhD, University and Polytechnic Hospital La Fe, Avenida de Fernando Abril Martorell 106, Torre E, Planta 5, Secretaría de Cirugía Plástica, Valencia, Comunidad Valenciana 46026, Spain.
Email: Enrikes900@gmail.com

Materials and Methods

A prospective review of the clinical records of 21 patients who underwent injection laryngoplasty with fat grafts at the University and Polytechnic Hospital La Fe between January 2015 and September 2019 was performed. This study was approved by the Ethics Committee of the Medical Research Institute Hospital La Fe.

At the first evaluation, demographic and medical data of each patient, as well as the etiology of the dysphonia, were recorded. Either at first evaluation and in a review 8 months after surgery, 2 voice recordings were performed: one pronouncing continuously the sound /e/ and another reading the 2 first paragraphs of the book *Platero y yo* from the writer Juan Ramón Jiménez. Recordings were performed with a microphone placed 15 cm from the voice source in order to prevent interferences from emitted air. The software and device used for acoustic analysis was the voice laboratory model 4500 of KayPentax (Pentax Medical). All the patients had performed supervised phoniatric rehabilitation for at least 1 year without achieving significant improvement in voice quality. All patients signed the surgical consent and the consent to participate in this study.

The Voice Handicap Index–10 (VHI-10) was used for subjective voice evaluation by the patient.[28] The GRABS (Grade, Roughness, Breathiness, Asthenia, Strain) scale was applied by 2 otolaryngologists from the voice department of our hospital.[29] The records used for determination of the GRABS scale score were the ones in which the book text was read, and they were blindly assessed regarding the moment of the recording (the evaluator ignored whether the recordings were preoperative or postoperative) by each of the laryngologists. The objective measures for voice evaluation were maximum phonation time (MPT), shimmer, jitter, and harmonic-to-noise ratio (HNR). These measures were evaluated in the recordings with the continuous phonation of the sound /e/. During preoperative evaluation, a stroboscopic study was performed by an otolaryngologist from the voice section of the Department of Otorhinolaryngology. Also, the VHI-10 survey, the GRABS scale, MPT, jitter, shimmer, and HNR were evaluated. Eight months after surgery, a new evaluation was performed registering the postoperative values of the same parameters.

Regarding statistical study, the mean values, standard deviation, and the standard error of the mean were calculated. Preoperative and postoperative values were evaluated using the nonparametric Wilcoxon test. $P < .05$ was considered statistically significant. The software used for statistical analysis was SPSS Statistics (SPSS, Inc).

Surgical Technique

The procedure was performed under general anesthesia and orotracheal intubation. In total, 100 mL of a solution containing physiologic saline with epinephrine at a concentration of 1:1,000,000 was infiltered in the abdomen, above the umbilicus, through 2 lateral incisions. Under sterile conditions and after waiting 15 minutes for the vasoconstriction effect of the epinephrine to take place, liposuction started, using a standard canula of 3 mm. Negative pressure was performed manually through a 20-mL Luer-lock syringe. The fat was first processed through centrifugation (Duografter-II, Proteal; Biorregenerative Solutions) at 300 *g* during 3 minutes. Then, the fat was emulsified by performing 10 passes between 5-mL syringes. Afterward, the processed fat was passed to a 1-mL syringe. Under direct suspension laryngoscopy and through endolaryngeal microsurgery, direct injection of fat grafts through a 23-gauge laryngeal needle was performed. Volume was slightly overcorrected (achieving 20%-40% more volume of the desired vocal fold size). A gauze was then used to softly massage the vocal fold, in order to spread the graft. An abdominal compressive dressing was placed on the abdomen, which was later replaced by a compressive abdominal band that was worn 15 days. Patients were placed on partial voice rest for a week, being allowed to speak in a soft voice tone, for small periods of time (shorter than 10 minutes).

Results

Twenty-six injection laryngoplasties with fat grafts processed through centrifugation and emulsification were performed in 21 patients between July 2015 and September 2019. All the procedures were performed in conjunction between the Department of Plastic Surgery and Burns and the Department of Laryngeal Surgery of the Service of Otorhinolaryngology.

From the 21 patients, 17 were men, and 4 were women. Mean age was 57.2 (range, 18-80) years. Nineteen patients attended to the revision visit at 8 months, while 2 were lost to follow-up. The mean (SD) follow-up time was 20.7 (9.3) months. Twenty-one patients had scarred vocal folds, 17 of them after tumor resection, and 4 had sulcus vocalis. Sixteen patients had unilateral affection, and in 5 cases, affection was bilateral. Five patients received an additional injection laryngoplasty for showing unsatisfactory results 12 months after the first intervention (**Table 1** and **Table 2**).

Regarding complications, one of the patients who received a second injection laryngoplasty reported mild dyspnea during the first 2 months after the second intervention, which improved spontaneously. No case of abdominal hematoma requiring drainage was observed, while most of the patients showed diffuse and mild abdominal ecchymosis, which also disappeared spontaneously. None of the patients who showed good results at 8 months reported regression or worsening of their dysphonia.

A statistically significant improvement in all the parameters of the GRABS scale was observed compared to preoperative values (**Table 3**). Also, a significant improvement in the subjective evaluation was observed in the VHI-10 ($P < .003$). MPT improved from a mean (SD) value of 7.15 (3.59) to 10.16 (4.8), with the differences statistically significant ($P < .003$). Jitter value decreased from a mean (SD) of 5.47 (2.39) to 4.51 (2.4) ($P < .005$). Shimmer decreased from a mean (SD) value of 12.27 (6.39) to 11.07 (6.62) ($P <$

Table 1. Demographic Data of Patients.

Variables	Value
Sex, No.	
Female	4
Male	17
Age, mean (SD), y	57.2 (16.7)
Follow-up time, mean (SD), mo	20.7 (9.3)
Etiology, No.	
Sulcus	4
Scarred	17
Infiltered volume mL	0.1-0.6
Number of interventions	
1	16
2	5
Side, No.	
Left	11
Right	5
Bilateral	5

.05). Harmonic-to-noise ratio increased from a mean (SD) value of 0.24 (0.1) to 0.3 (0.14) ($P < .01$) (**Table 4**).

Three of the 5 patients who received a second lipoinjection had an improvement in the parameters evaluated, while the other 2 achieved slight improvement in objective parameters but reported a subjective worsening on the VHI-10 survey. The etiology of 4 of those 5 cases was scarred vocal fold after tumor resection, while the other one was a grade III sulcus vocalis.

Discussion

Autologous fat offers an important number of advantages with respect to other substances, which has made it become the elective infiltration substance in injection laryngoplasty. Being an autologous material, inflammatory reactions to foreign bodies, extrusion, or rejection are avoided. Furthermore, although there has been some controversy in the past 2 decades regarding the permanence of infiltered fat grafts, recent studies have confirmed the long-term stability of the infiltered volume that persists after initial partial resorption.[30] The stability of fat grafts as a permanent filler is a well-known fact, and it has been reported with its use in breast reconstruction, facial rejuvenation, scar treatment, and correction of body contour deformities.[31]

A statistically significant improvement was observed in all the parameters of voice quality tests performed on the patients in our study 8 months after surgery, with respect to preoperative evaluation. These good results coincide with reports published in the most recent studies (since 2016) in which fat grafts obtained through liposuction were used.[9-15,17,23,30,32] However, our series is the second largest in the literature in the number of patients with glottic insufficiency caused by scarred vocal folds, as most of the studies performed on autologous fat injection laryngoplasty are focused on the treatment of unilateral vocal fold paralysis.[32] Also, ours is the third largest study in sample size, among those published since 2016, in which liposuction fat grafts were used.[5-26,30,32]

Furthermore, our series is the first one in which fat grafts processed through centrifugation and emulsification have been used. The advantage of adding emulsification to fat processing is the production of a graft composed of smaller particles, which improves integration and homogeneity of the grafted tissue, reducing the chances of introducing large adipose tissue fragments that could form globules or cysts.[27] Thus, the graft has a more homogeneous distribution, which might improve softness and pliability of the vocal fold, improving the quality of vibration. In fact, this hypothesis is one of the reasons that justifies the fact that during the past 4 years, no more studies reporting the use of fat grafts obtained through biopsy and fragmentation have been published.[12-15,33] Fragments of adipose tissue are small conglomerates that, when injected, form a tissue composed of multiple fat globules, which could alter pliability and the surface homogeneity of the vocal fold, which are necessary to achieve an optimal vibration.[9-15,17,23,30,32] In a study published by Park et al,[33] in which qualities of fat grafts obtained through liposuction and biopsy were compared, a higher proliferation rate and improved long-term viability were observed in grafts obtained through liposuction.

The stability of voice improvement obtained through injection laryngoplasty with fat grafts has been reported in many studies, with follow-up periods of more than 10 years.[9,11,30] In our study, with an average follow-up time of 20.7 months (range, 9-55 months), no patient reported worsening of their symptoms compared to their postoperative result at 8 months.

The volume of fat graft injected in our series ranged from 0.1 to 0.6 mL, while most of the studies reported a higher volume of graft injected (range, 0.3-6 mL). This might be attributed to the improved control and precision of the injection associated with the use of a fat graft with smaller size particles and its better distribution among the scarred vocal fold tissue.

In our series, 5 patients required a second procedure as their postoperative result was considered insufficient by both the patients and their otolaryngologist. All of them obtained an improvement in objective voice quality parameters after the second procedure, although one of them reported no perception of subjective improvement. These results are coincident with the ones published in scientific literature, where scarred vocal folds show a higher chance to require a second procedure than nonscarred vocal folds.[9-14,32]

In 2016, Siu et al[34] published a bibliographic review on surgical techniques for the treatment of glottic insufficiency caused by unilateral vocal fold paralysis (medialization thyroplasty, injection laryngoplasty, laryngeal reinnervation, and arytenoid adduction). In this review, the authors found favorable results for all techniques, without observing statistically significant differences among them. Having similar functional results, injection laryngoplasty is a procedure with reduced technical complexity and reduced surgical time.

Table 2. All the Procedures Performed in Patients With Dysphonia Caused by Different Etiologies and Their Voice Quality Results Before Surgery (Left Side) and 8 Months After Injection Laryngoplasty (Right Side).[a]

N	Age	Sex	Etiology	Side	No. of surgeries	VHI-10	G	R	A	B	S	MPT, s	Fo, Hz	Follow-up, mo	Volume, mL	VHI-10	G	R	A	B	S	MPT, s	Follow-up, mo
1	47	M	Sulcus	Left	2	—	—	—	—	—	—	—	—	55	0.3	28	3	3	2	1	3	5.28	183.49
2	68	M	Scarred	Left	2	—	—	—	—	—	—	—	—	35	0.3	21	3	2	2	1	2	4.21	267.19
3	65	M	Scarred	Bilat	1	23	2	2	2	1	2	3.78	281.48	35	0.3	11	2	1	2	1	2	4	292.63
4	39	M	Sulcus	Left	1	25	2	2	2	1	3	4.4	221.91	35	0.3	14	1	2	0	0	1	6.22	190.38
5	59	M	Scarred	Bilat	2	29	3	3	1	2	3	6.3	132.40	34	0.3	13	3	3	1	1	3	8.2	78.94
6	18	F	Sulcus	Bilat	1	17	2	2	1	0	1	7.3	234.79	32	R: 0.1 L: 0.2	12	2	1	0	0	1	12.1	217.70
7	49	M	Scarred	Right	1	23	2	2	1	1	3	5.2	197.39	32	0.3	11	1	1	1	0	2	8.31	183.42
8	63	M	Scarred	Left	1	11	1	1	1	2	1	7.89	224.84	24	0.3	21	1	1	0	0	0	11.95	201.93
9	47	M	Scarred	Right	1	20	2	1	2	1	2	19.34	220.56	24	0.1	24	2	2	0	0	1	24.59	199.79
10	53	F	Scarred	Left	2	27	3	1	3	3	0	6	203.21	24	0.1	27	2	1	3	3	0	12.54	189.51
11	50	M	Sulcus	Left	2	28	3	3	2	1	3	5.28	183.49	23	0.3	12	2	2	2	1	2	9.71	172.33
12	70	M	Scarred	Left	2	21	3	2	2	1	2	4.21	267.19	23	0.3	9	3	1	2	1	2	3.86	258.50
13	60	M	Scarred	Bilat	2	13	3	3	1	1	3	8.2	78.94	21	R: 0.1 L: 0.2	15	2	2	0	0	2	10.86	82.22
14	29	M	Sulcus	Bilat	1	36	3	2	2	2	2	4.6	320.83	21	0.6	32	2	1	2	1	1	12.1	280.88
15	80	F	Scarred	Left	1	25	2	2	1	2	1	3.42	310.92	21	R: 0.3 L: 0.1	13	1	1	1	2	1	3.7	289.86
16	60	F	Scarred	Left	2	26	2	1	1	2	0	8.75	237.23	21	R: 0.4 L: 0.1	13	1	1	1	2	1	6.88	167.40
17	76	M	Scarred	Right	1	22	2	2	1	1	3	6.86	293.15	9	R: 0.2 L: 0.1	10	1	1	0	0	1	15.92	165.75
18	66	M	Scarred	Left	1	9	2	2	2	0	2	7.5	141.71	21	R: 0.1 L: 0.5	13	2	2	1	1	2	7.42	99.15
19	61	M	Scarred	Left	1	21	2	0	3	2	1	3.79	195.48	32	0.2	13	2	0	2	1	1	6.32	174.87
20	67	M	Scarred	Right	1	8	2	2	1	0	1	9.8	205.91	10	0.3	11	1	1	1	0	1	11.85	200.40
21	74	M	Scarred	Right	1	22	2	2	2	1	2	7	232.26	10	0.3	15	1	1	1	1	1	10.71	196.42
22	53	F	Scarred	Left	2	27	2	1	3	3	2	12.54	189.51	10	0.3	33	2	1	2	2	2	17.52	200.54
23	20	M	Scarred	Right	1	27	1	0	1	2	1	4.82	265.80	9	0.8	9	1	0	1	1	0	10	243.42
24	77	M	Scarred	Left	1	26	2	2	1	1	3	5.24	118.40	9	0.3	22	2	2	1	2	1	5.69	144.72
25	60	F	Scarred	Left	2	13	1	1	1	2	1	6.88	167.40	9	R: 0.2 L: 0.3	24	1	1	1	1	1	8.7	171.21
26	78	M	Scarred	Left	1	27	3	2	2	1	2	12.6	172.67	9	0.3	15	2	1	1	1	2	14.2	183.29

Abbreviations: Fo, fundamental frequency; L, left; MPT, maximum phonation time; R, right; VHI, Voice Handicap Index–10; —, unable to record information for this patient.
[a]G, R, A, B, and S indicate the parameters of the GRABS (Grade, Roughness, Breathiness, Asthenia, Strain) scale.

Table 3. Preoperative and Postoperative Results (8 Months After Surgery) in GRABS (Grade, Roughness, Breathiness, Asthenia, Strain) Scale Parameters.

Parameter	Preoperative, mean (SD)	Postoperative (8 mo), mean (SD)	*P* value
Grade	2.17 (0.64)	1.67 (0.64)	<.003
Roughness	1.71 (0.81)	1.25 (0.68)	<.003
Asthenia	1.63 (0.71)	1.08 (0.83)	<.001
Breathiness	1.38 (0.82)	0.92 (0.83)	<.002
Strain	1.83 (0.96)	1.29 (0.75)	<.003

Table 4. Preoperative and Postoperative Results (8 Months After Surgery) in Objective and Subjective Tests.

Parameter	Preoperative, mean (SD)	Postoperative (8 mo), mean (SD)	*P* value
VHI-10	21.92 (6.95)	16.33 (7.06)	<.003
MPT	7.15 (3.59)	10.16 (4.8)	<.001
Jitter	5.47 (2.39)	4.51 (2.4)	<.005
Shimmer	12.27 (6.39)	11.07 (6.62)	<.05
HNR	0.24 (0.1)	0.3 (0.14)	<.01

Abbreviations: HNR, harmonic-to-noise ratio; MPT, maximum phonation time; VHI, Voice Handicap Index–.

Complications are more frequent and severe in medialization thyroplasty (extrusion, displacement, infection, hematoma, with the possibility of causing airway compromise) than with injection laryngoplasty. Extrusion of the prosthesis in thyroplasty has a reported incidence between 1% and 10% of the cases.[35] Also, complications that were traditionally associated with injection laryngoplasty (granuloma formation, extrusion of the injected substance, and fibrosis) are prevented when using an autologous substance.[35] Furthermore, fat graft injections can be repeated if necessary, without having additional risks than a primary procedure.

Regarding limitations of our study, although the sample is high compared to the few studies focused on lipoinjection in scarred vocal folds, in absolute numbers, the sample is small, and increasing its size could improve the quality of the study. Also, although stroboscopy was performed in all patients before and after surgery, no parameter measuring changes in mucosal wave was recorded. As the number of patients was not really high, we were not able to make 2 groups in which fat-processing techniques were different, so we cannot confirm our hypothesis that centrifuged and emulsified fat grafts provide better vibrating quality to the augmented vocal fold.

Conclusions

In our study, the performance of injection laryngoplasty with fat grafts obtained through liposuction and processed with centrifugation and emulsification achieved a statistically significant improvement of voice quality in patients with glottic insufficiency caused by scarred vocal folds, determined by subjective and objective parameters.

Author Contributions

Enrique Salmerón-González, design of the work, analysis of data, drafting the work, critical revision, final approval; **Elena García-Vilariño**, design of the work, analysis of data, critical revision, final approval; **Ignacio Llópez-Carratalá**, acquisition of data for the work, critical revision, final approval; **Diego Collado-Martin**, acquisition of data, critical revision, final approval; **José María Perolada-Valmaña**, acquisition of data, critical revision, final approval; **Miguel Armengot-Carceller**, design of the work, analysis of data, critical revision, final approval.

Disclosures

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