



Contents lists available at ScienceDirect

JPRAS Open

journal homepage: www.elsevier.com/locate/jpra



Original Article

Assessment of outcomes and complications of posterior pharyngeal wall augmentation with dermal fat graft in patients with Velopharyngeal Insufficiency (VPI) after primary cleft palate repair: A pilot study

Hossein Abdali^{a,1}, Mohammad Yaribakht^{b,1,*}

^a Associate professor of plastic surgery - Craniofacial & cleft research center - Isfahan University of Medical Sciences - Isfahan- Iran

^b Craniofacial & cleft research center - Isfahan University of Medical Sciences- Isfahan- Iran

ARTICLE INFO

Article history:

Received 20 June 2018

Revised 25 September 2018

Accepted 11 October 2018

Available online 26 October 2018

Keywords:

Velopharyngeal dysfunction

Velopharyngeal insufficiency

Dermal fat graft

Cleft palate

Resonance

Hypernasality

ABSTRACT

Introduction: Materials used for posterior pharyngeal wall augmentation have been associated with important complications (exogenous materials) or variable and unpredictable durability (exogenous and endogenous materials); therefore, introducing a different material for augmenting the posterior pharyngeal wall seems necessary for reviving this relatively forgotten technique.

The purpose of this study was to emphasize on the use of a material associated with minimal complications and maximum recovery and durability in correcting VPI and the use of evaluative adjuncts such as nasoendoscopy and videofluoroscopy to assess surgical outcomes.

Methods: In a pilot study, 24 patients underwent posterior pharyngeal wall augmentation with dermal fat graft harvested from the low crease abdominal region. Early and late complications, autologous graft durability in posterior pharynx, and speech improvement were assessed.

Results: There was a significant improvement in hypernasality, nasal emission, and nasal grimace after posterior pharyngeal wall

* Corresponding author: Alzahra Hospital- Isfahan University of Medical sciences- Isfahan- Iran

E-mail address: mohammad.yaribakht.arps@gmail.com (M. Yaribakht).

¹ This author has no financial disclosure.

augmentation with dermal fat graft ($p < 0.0001$). The authors observed no significant life-threatening complication. The most evident short-term complication was snoring, which occurred in five patients, and all relieved uneventfully.

Conclusion: The authors believe that augmenting the posterior pharyngeal wall with dermal fat graft is effective in improving hypernasality in patients with moderate velopharyngeal gap size and relatively adequate velar motion. This method has minimal complication profile because of autologous tissue application.

© 2018 The Authors. Published by Elsevier Ltd on behalf of British Association of Plastic, Reconstructive and Aesthetic Surgeons. This is an open access article under the CC BY-NC-ND license. (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Introduction

Normal speech is dependent on the functional and structural integrity of the velopharynx. Velopharynx is a complex and dynamic structure that acts as a separator of oral and nasal cavities during sound production. Anatomical abnormalities of the velopharyngeal valve (Velopharyngeal insufficiency = VPI) lead to hypernasality, nasal escape, and compensatory errors, all of which will reduce the quality of sound perception.

Anatomy

Velopharynx is defined anteriorly by the soft palate, in lateral areas by the lateral walls of the pharynx, and posteriorly by the posterior wall of the pharynx. Soft palate muscles include levator veli palatini, tensor veli palatini, palatoglossus, palatopharyngeus, and uvula. The contraction of the muscular arc achieved by the paired levator muscles is the primary mechanism for lifting the palate and closing the velopharynx.

Physiology

The theory that the levator muscle is the main muscle responsible for the movement of the soft palate has been widely accepted, and thus, it plays a key role in the closure of the velopharynx.

In the normal velum, the palate moves superior and posterior during speech.

The normal point of contact with the posterior pharynx is at most three-quarters of the posterior part of the length of the pharynx from the posterior nasal spine (PNS). The location of the closure of the velum is usually just below the plane of the palate. However, the height of the palate and the degree of contact with the pharynx are different according to the structure.¹⁻³ Maximum displacement of the lateral wall of the pharynx usually occurs at the time of contact with the pharynx and velopharyngeal closure. Coronal pattern of the closure of velopharynx is seen in most normal individuals and also in patients with VPI.⁴

Any condition resulting in velopharyngeal misclosure or malfunction is called velopharyngeal dysfunction (=VPD). There are four types of VPD: VPI, velopharyngeal incompetence, velopharyngeal mislearning, and combined types. The largest group of VPD is the valve deficiency (VPI) due to anatomical or structural problems in the closure of the velopharynx.

These defects may be congenital (such as a cleft palate or incongruent congenital velopharyngeal dimension due to shortness of the palate to the depth of the pharynx) or it may be secondary to an operation that disrupts the anatomy of the velopharynx (such as palatoplasty, tumor resection, or adenoidectomy). The most common congenital structural defect associated with VPD is the cleft palate and submucosal cleft palate. This study focuses on VPI.

Table 1
Treatment options for VPD.

Surgical treatment options:
Furlow double-opposing Z-palatoplasty
Posterior pharyngeal flap
Sphincter pharyngoplasty
Posterior pharyngeal wall augmentation
Palate re-repair (intravelar veloplasty)
Buccinator myomucosal flap
Nonsurgical treatment options:
Prosthetic treatment
Behavioral speech therapy approaches

The occurrence of persistent VPI following the repair of the cleft palate is very variable and also subjected to many variables. In the absence of oronasal fistula, the incidence of VPI following palatoplasty is often due to palatal movement abnormalities, velopharyngeal disproportion, or a combination of these two causes. Because the adequacy of the closure of the velopharynx is dependent on the length of the palate, patients with a short palate or deep pharynx may develop incomplete velopharyngeal closure. Each of these conditions may be due to congenital or iatrogenic problems in the velopharyngeal structure. For example, cicatricial changes following palatoplasty may lead to insufficiency of the velopharynx secondary to a shortened palate.

VPI can also be caused by postsurgical changes in the velopharyngeal anatomy. In small children, the closure of the velopharynx is often volar-adenoidal. Removing large adenoids to treat nasopharyngeal airway obstruction or chronic otitis media leads to an acute increase in the depth of the pharynx. In most patients without a cleft palate, the tensile capacity of the palate allows to adapt to this problem. In most cases, VPI following adenoidectomy is transient, and resonance will be normal within 6 to 12 months.⁴ However, VPI in a small percentage of patients remains persistent, some of which may have predisposing factors for the VPI (such as submucosal cleft, short palate, deep pharynx, or neuromuscular disorders). For patients with these conditions, adenoids play a vital role in closing the velopharynx, and their normal degeneration may also lead to VPI. Treatment options for VPD are listed in Table 1.

Actually, the current study is pointed toward correcting hypernasality and VPI in patients who have been operated for cleft palate and after a period of time present with hypernasality. The purpose of the surgery is to establish the structural integrity of the velopharynx along with reducing the upper airway complications.⁴

Material and Method

In a prospective pilot study, we included 24 patients aged between 13 and 41 years old, who were referred to the Cleft Lip and Palate Clinic of Isfahan University of Medical Sciences, between April and September 2016, and had undergone previous primary palatoplasty and already suffered from VPI. Surgery of these patients was performed in the operating room of Alzahra Hospital, Isfahan, Iran, and preoperative and postoperative examinations were conducted in Cleft Lip and Palate Clinic located at the Craniofacial and Cleft Research Center, Isfahan University of Medical Sciences, Isfahan, Iran. This study was approved by the Research Council of Isfahan University of Medical Sciences (project number: 396652). Informed consent was obtained from all patients at the time of explaining the stages of the study.

The study team included one plastic surgeon (Dr. Hossein Abdali) and a fellow resident of plastic surgery (Dr. Mohammad Yaribakht). Two speech therapists collaborated with the treatment team. Graft harvest was carried out by Dr. Yaribakht, the preparation of the pocket and graft insertions in the posterior wall of the pharynx was done by Dr. Abdali, and speech analysis before and after the operation was performed by the speech therapy team.

Patients eligible for this study should have had a maximum of 5 mm velopharyngeal gap (based on accurate measures obtained from fluoroscopy) and a fairly normal palatal movement based on preoperative evaluations (including fluoroscopy and nasoendoscopy).

Speech evaluation (cleft audit protocol for speech augmented [CAPS-A])

1. Evaluation of Nasality and Articulation:
2. Nasality grading based on the 5-degree CAPS-A test (Appendix 4): Normal, borderline, Mild, Moderate, and Severe for Hypernasality and three grades of hyponasality including Normal, Mild, and Significant
3. Audible Nasal Emission (NE) Evaluation
4. Fluoroscopy (lateral view): to assess soft palate motion and estimate the size of the velopharyngeal gap
5. Video nasopharyngoscopy: For direct observation of the velopharyngeal sphincter during speech and also viewing the height of the palate, lateral wall movements, velopharyngeal closure pattern, and total velopharyngeal function during speech.

Patients were assigned for speech evaluation before and 6 months after surgery. To standardize and prevent the bias of the results, the speech samples were coded blindly, and consensus recordings were scored by random speech analyzers.

Exclusion criteria:

1. Patients unwilling to participate in the study
2. Patients with stress VPI
3. History of nasopharyngeal radiotherapy
4. Any problem interfering with surgery (such as coagulopathy)
5. If, at the beginning of the operation, carotid artery pulse was close to the midline of the pharynx
6. The neck circumference-to-height (NC/H) ratio of more than 25
(Explanation: NC/H ratio (cm/m) is related to BMI and metabolic syndrome⁵. As obese patients may also have obstructive apnea, to remove this interfering effect, patients with an NC/H ratio of more than 20 were not included in the study)

Using the checklist prepared for each patient, the following information was recorded, and ultimately, all the patient information was recorded in a final assessment sheet.

- * Patient identification number – Age – Height – Weight – BMI – NC/H ratio – Speech analyzer code
- * Resonance intensity – NE in the mirror test – gap size in fluoroscopy – Nasoendoscopy (gap size – palatal height – lateral wall movements)
- * Short-term complications (7th day)
- * Long-term complications (6th month)
- * Dermal component Height – fat component height – graft volume

Operative technique

The operation of the posterior wall augmentation of the pharynx is performed with general anesthesia in all patients. After induction of anesthesia, the patient is placed in the supine position with neck extension. After skin preparation, the mouth and tongue ecartor is inserted. The first step is observation and examination of the pharynx in search of the presence of palpable or visible carotid artery pulse (which is more common in patients with a cleft palate). Then, the condition of the levator muscle ring and the position of the muscle placement are re-examined by the surgeon. In the next step, with intraoperative design and injection of lidocaine 0.5% + epinephrine 1/200,000 in the posterior pharynx, and after dividing the soft palate from uvula to half way to the hard palate and stitching stay sutures for exposing pharyngeal wall, a 2.5 cm transverse incision at the contact site of the soft palate with the posterior wall of the pharynx (inferior to the natural site of adenoid and the atlas bone) is applied, and the submucosal dissection on four boundaries of incision as large as

0.5 cm on each side is done. This pocket is not allowed to be very wide because it would lead to graft displacement, and it cannot be very small, as it could result in possible graft extrusion. Then, hemostasis is controlled and dermal fat harvesting is started by the second surgeon.

After preparation of the abdominal skin with chlorhexidine solution, with an incision in the lower abdominal crease (3.5 cm in diameter and 1.5 cm in height), the epidermis is removed from the dermis using a surgical blade no. 15. The incision is then deepened, and the entire thickness of the dermis and subcutaneous fat is harvested. Then, hemostasis is checked, and the lower abdomen incision is closed in three layers with 3-0 and 4-0 Monocryl sutures. Then, using a scaled container, filled with 30 cc of normal saline, the volume of the dermal fat graft is measured.

The next step is graft preparation. The maximum height of the block is considered to be 2 cm. Before placement of the graft in the posterior pharyngeal pocket, the heights of the dermal component and the fat component are measured with accurate instruments.

The prepared graft is then inserted in the posterior pharyngeal pocket, and the mucus on it will be closed with interrupted 4-0 absorbable monofilament Monocryl sutures. All patients will be discharged the day after surgery.

Follow-up

All patients were visited in the clinic 1 week after surgery. The purpose of this visit, which is performed as a pharyngeal examination, is to evaluate short-term complications associated with surgery (including bleeding, hematoma, infection, graft extrusion due to incisional dehiscence, obstructive sleep apnea during night, severe pain at surgery site, snoring, and otalgia). The pain will be evaluated with VAS score.

The next visit was 6 months after the operation. In this visit, which will be jointly performed by the surgery team and the speech therapy team, the surgeon will examine the patient for graft displacement and graft extrusion (through fluoroscopy and nasoendoscopy). The speech therapy team will repeat and record all speech assessments as performed preoperatively.

Short-term complications (7 days after surgery): Hematoma, bleeding, infection, graft extrusion (incisional dehiscence), obstructive sleep apnea, severe postoperative pain, snoring, and otalgia.

Long-term complications (6 months after surgery): graft displacement, graft resorption, and graft extrusion.

Statistical analysis

Statistical analyses were carried out using SPSS software for Windows (SPSS, Inc., Chicago, IL, USA, version 24). Descriptive data are reported as mean \pm SD, median [IQR], or number (percent) as appropriate. The Wilcoxon signed rank test and McNemar test were used as appropriate. All hypothesis testing were two tailed, and the level of significance was considered to be less than 0.05 in all tests.

Results

For a nearly 1-year period, posterior pharyngeal wall augmentation with dermal fat graft was performed in 25 patients referred to Cleft Palate Research Center of Isfahan University of Medical Sciences. Patients were followed up for 6 months. One patient was excluded from the study because of the lack of compliance for follow-up schedule. Of the remaining 24 patients, 41.7% (10 patients) were male and 58.3% (14 patients) were female. The mean age of studied participants was 23.4 ± 6.3 years (13–41 years). Patients had a mean BMI of 20.63 kg/m^2 ($16.02\text{--}23.43 \text{ kg/m}^2$). None of patients had an NC/H ratio of more than 25; therefore, no patient was excluded from the study due to NC/H ratio of more than 25. The mean preoperative velopharyngeal gap sizes at rest and activity (phonation) were 8.38 ± 1.84 and 4.08 ± 0.93 mm, respectively. Mean postoperative gap size values at rest and activity were 5.79 and 1.67 mm, respectively. By using the Wilcoxon signed rank Test, statistically significant difference was observed between preoperative and postoperative values (Gap size at rest and activity and velopharyngeal closure ratio; $p < 0.0001$). Velopharyngeal gap size characteristics are shown in [Table 2](#).

Table 2
Velopharyngeal gap.

		Median [IQR]	Mean±SD	P-value
Gap size (mm)	Rest – Preop.	8.0 [7.0-9.8]	8.38±1.84	<0.0001
	Rest – Postop.	6.0 [5.0-6.0]	5.79±1.74	
	Activity – Preop.	4.0 [3.0-5.0]	4.08±0.93	
	Activity – Postop.	1.5 [1.0-2.0]	1.67±1.04	
Velopharyngeal Closure Ratio (%)	Preop.	50.0 [44.4-58.0]	50.64±9.51	<0.0001
	Postop.	70.8 [62.8-82.5]	71.92±15.30	

P-values calculated by the Wilcoxon signed rank test.

Table 3
Speech evaluation data.

Characteristics	Values		P-value
Hypernasality – Preop.	5 [4-5]	4.58±0.50	<0.0001 [#]
Hypernasality – Postop.	3 [3-4]	3.33±0.82	
Nasal emission – Preop.	2 [2-3]	2.29±0.46	0.002 [#]
Nasal emission – Postop.	2 [2-2]	1.87±0.54	
Nasal grimace – Preop.	20 (83.3)	0.83±0.38	0.001 ^{##}
Nasal grimace – Postop.	9 (37.5)	0.38±0.46	

The data are presented as median [IQR], Mean±SD, and Number (%).

P-values calculated by [#]Wilcoxon signed rank test and ^{##}McNemar test.

Speech evaluation data were categorized as nasality, nasal emission, and nasal grimace. No case of hyponasality was observed among patients before or after surgery. Hypernasality severity was scored from 2 to 5 (2=no hypernasality, 3=mild, 4=moderate, 5=severe). Nasal emission was scored from 1 to 3 (1=absent, 2=occasional, 3=frequent). Nasal grimace was ranked as absent (=0) and present (=1). The Wilcoxon signed rank test was used for calculating the statistical significance of nasality and nasal emission, and the McNemar test was used for evaluating nasal grimace data. As mentioned in [Table 3](#), test results revealed statistical significance in all three fields.

The mean volume of dermal fat graft, dermal layer height, and fat layer height were 3.9 ml, 2.4 mm, and 13.53 mm, respectively.

During the first week of the postoperative period, patients were evaluated for early (acute) complications. One case of minor bleeding occurred 4 hours after surgery. We think it has been secondary to noncautious mouth suctioning in the recovery room. Bleeding stopped after pain control and humidified oxygen was administered. Sleep apnea occurred in one of our patients. After viewing patient data, we noted that he had neck circumference of 40 cm. Two patients experienced severe pharyngeal pain at surgery site (VAS scores: 7 and 8): one of them suffered for 4-5 days and the other for just 2 days. On examination of these two patients, we observed no apparent problem in the pharynx, such as hematoma, infection, or wound dehiscence. Two patients suffered from otalgia, both in the left side. Otalgia lasted for approximately 5 days and was relieved with oral analgesic, decongestant, and hydration. Their tympanic membrane examination revealed hyperemic timpani. We think otalgia occurred because of inflammation and edema extending from the posterior pharyngeal incision site to eustachian tube. Snoring was the most prevalent complication during the first week after surgery. Five patients experienced snoring, and in all of them, snoring lasted for approximately 3 months; one patient still snored at sleeping in the 6th month visit. Snoring is anticipated in all pharyngeal surgeries, especially if the velopharynx is manipulated or any constriction is applied in that area ([Table 4](#)).

Sixth-month follow-up visit revealed two instances of dermal fat graft absorption. Graft absorption is not simply observable in direct examination because incision and graft insertion sites are at the uppermost portion of the posterior pharynx, just millimeters below the adenoid site. However, at nasoendoscopy evaluation, graft resorption was evident ([Table 4](#)).

Table 4

Short-term and long-term complications.

7 Days after surgery							6 Months after surgery			
Bleeding	Hematoma	Infection	Graft extrusion	Sleep apnea	Severe pain	Snoring	Otalgia	Graft migration	Graft resorption	Graft extrusion
1	0	0	0	1	2	5	2	0	2	0

Discussion

There is a long history of augmentation pharyngoplasty with the use of autologous or alloplastic materials by different surgeons. The goal of this work is to reduce the size of the velopharyngeal orifice in patients with VPD.

The long-term results of this method have been varied, depending on the patient's choice and the type of substance used for augmentation. Generally, the most consistent results were obtained in patients with desirable palatal movements and a small size of velopharyngeal passage.

In 1862, Passavant⁶ was the first to introduce the use of local tissue to augment the posterior wall of the pharynx.

The results of some articles on the use of autologous materials for augmentation of the posterior pharynx are presented in [Table 5](#).

The first attempts to augment the posterior wall of the pharynx with exogenous materials are probably related to Gersuny²⁴, who used petroleum gel for this purpose in 1900 ([Table 6](#)).

Thus far, no alloplastic material has been found to be completely safe, effective, and reliable, but each autoplasmic material has had its own long-term durability.⁴ In the current study, dermal fat was used as an autogenous agent for posterior pharyngeal wall augmentation. As dermal fat has been used for a variety of indications and its effectiveness is evident largely⁴, it seems to be a safe substance with a wide degree of confidence. Most evidence suggests that posterior pharyngeal augmentation in patients who have been selected correctly (i.e., desirable palatal movements with relatively small VP gaps) is likely to be effective.

Dermal fat graft

Dermal fat graft is used for reconstructing facial and forehead defects^{39,40}, reconstructing orbit in anophthalmic patients⁴¹, covering nerves and tendons⁴², lip augmentation, closing palatal fistulas⁴³, aesthetic treatment for first web of hand atrophy⁴⁴, and coverage of cartilage grafts in cleft lip–nose deformity repair⁴⁵.

Dermal fat is usually harvested from the lower abdomen, suprapubic and umbilical regions, gluteal cleft, inframammary folds, iliac crest, and even forearms (in hand surgery)⁴⁶.

A study performed in pigs found that in the eighth week, the volume of this graft was reduced by 33%⁴⁷. This volume reduction is primarily attributed to the fat portion of the graft. Additionally, dermal revascularization was observed in microscopic studies. Other researchers have confirmed that fat tends to disappear over a period of 10 weeks in swine models⁴⁸.

In a human study, Peer in 1950s concluded that 45% of the fat content in the graft was lost in 1 year. Interestingly, he also showed that in patients with weight gain at postoperative time, graft volume increases. These studies led to the creation of a general guideline indicating that dermal fat graft should be designed 40% larger than the estimated diameter needed^{49,50}.

Since 1862, when Passavant⁶ introduced the initial method of posterior pharyngeal wall augmentation, many authors have tried to refine this technique to attain better outcomes and lessen the side effects. Having tried many exogenous and endogenous materials, there emerged the relative fact that endogenous grafts are preferred for the purpose, the main reason of which is lesser complication rate and wider safety margin of the autografts. However, endogenous grafts have their own limitations, namely, being mentioned, graft absorption and misplacement. This may be due to the relative disappointing outcomes after performing posterior pharyngeal wall augmentation that many surgeons, currently, do not even mention this technique as an option for correcting VPI. Even fat graft injection

Table 5

Studies on the posterior pharyngeal wall augmentation with autologous materials.

Year	Author	n	Implant Material	Results
1862	Passavant ⁶	DNA	Suturing the palatopharyngeal muscles together in the midline	After disappointing results, the technique was abandoned
1879	Passavant ⁶	DNA	Use of a pedicled flap of the posterior pharyngeal mucosa, rolled upon itself and inset across the posterior pharyngeal wall	
1912	Hollweg and Perthes ⁷	DNA	Use of autologous cartilage grafts inserted through a cervical incision (later modified by others utilizing a transoral approach)	Many authors have reported some success with cartilage grafts placed into the posterior pharynx, The results and durability of these procedures have been variable
1950	Hynes ⁸	12	Use of myomucosal flaps containing the salpingopharyngeus (and later the palatopharyngeus) muscles	In every completed case, there has been an improvement in speech
1993	Denny ⁹	20	Retropharyngeal bone or cartilage grafts*	Elimination of hypernasality in 25% of 20 patients. Lesser degrees of improvement seen in another 65% of patients. Follow-up studies of the same cohort of patients, however, failed to document durability of the results achieved.
2006	Desgain ¹⁰	2	Autologous costochondral cartilage	<u>Case 1:</u> No oronasal reflux and nasal escape. Persistent nasality without daily affect <u>Case 2:</u> No oronasal reflux Normal voice
1997	Witt ¹¹	14	Use of a rolled, superiorly based pharyngeal flap	Noting no significant improvement in the speech of 14 patients treated
1999	Gray ¹²	14	Using folded flaps in young patients with desirable velar motion	Hypernasality: normal in 10
2001	Dejonckere ¹³	13	Isolated fat injection in the posterior pharyngeal wall	Decreased nasalance
2001	Klotz ¹⁴	2	Fat injection in the soft palate, pharyngeal arches, and pharyngeal wall	Corrected nasal emission
2004	Guerrerosantos ¹⁵	57	Fat injection in the soft palate, pharyngeal arches, and pharyngeal wall (57 patients)	49 patients had normal resonance, 2 improved but still hypernasal, 1 hyponasal, 4 lost to follow-up
2007	Bardot ¹⁶	6	Fat injection in the soft palate, pharyngeal arches, and pharyngeal wall	Decreased hypernasality and nasal emission in all patients Decreased nasalance

(continued on next page)

Table 5 (continued)

Year	Author	n	Implant Material	Results
2010	Leuchter ¹⁷	18	Isolated fat injection in the posterior pharyngeal wall	Decreased nasalance
2011	Cantarella ¹⁸	10	Fat injection in the soft palate, pharyngeal arches, and pharyngeal wall	Decreased nasalance Improved VP closure rating Decreased hypernasality and nasal escape Improved intelligibility
2011	Leboulanger ¹⁹	22	Fat injection in the soft palate, pharyngeal arches, and pharyngeal wall	Notable improvement in 77% of patients
2011	Teixeira ²⁰	1	Fat injection in the soft palate, pharyngeal arches, and pharyngeal wall	Normal resonance, decreased nasal emission, and correction of VP gap on videofluoroscopy despite two debulking procedures for OSA secondary to fat graft hypertrophy
2011	Filip ²¹	9	Fat injection in the soft palate, pharyngeal arches, and pharyngeal wall	Reduction in VP gap area and VP distance during phonation Reduced nasal turbulence No improvement in hypernasality, nasal emission, and intelligibility
2013	Filip ²²	16	Fat injection in the soft palate, pharyngeal arches, and pharyngeal wall	No reduction in VP gap area but reduction in VP distance during phonation Reduced hypernasality; No improvement in nasal turbulence, nasal emission, and intelligibility
2013	Lau ²³	11	Isolated fat injection in the posterior pharyngeal wall	Decreased nasalance 47% had persistent hypernasal speech No cases of obstructive sleep apnea

* The body of evidence suggests that some degree of graft migration and resorption after pharyngeal augmentation with cartilage appears inevitable.

DNA: Data Not Available

in the posterior pharyngeal wall did not gain satisfaction for VPI decline, and as mentioned by Bishop and colleagues⁵¹, questions remain as to patient selection, safety, and optimal graft volume and injection sites. Therefore, we decided to find a way for reviving the method. The purpose was clear, but when it came to graft material, it sounded fantastic to us to try the favorite tissue used by many plastic surgeons: dermal fat graft. Dermal fat graft biology was studied earlier by many authors, of whom, Peer⁴⁵ clarified relatively the exact understanding of that. He mentioned that dermal fat graft loses 45% of its fat content in 1 year. Therefore, we estimated that the required graft size was 40–45% larger than the size of the prepared pocket. Although we were anxious about the possibility of graft extrusion, fortunately, there were no instances of that. The technique of operation is relatively simple for experienced cleft surgeons and actually has a short learning curve. Retraction of the soft palate during a modified Hynes pharyngoplasty has been mentioned by Colbert and Mercer⁵², but we do not have enough experience with palatal retraction instead of division. Operation time is not much longer than any other VPI correction surgery such as posterior pharyngeal flap or sphincter pharyngoplasty. When we compared hypernasality, improvement was statistically significant 6 months after surgery. We guess that the decline in hypernasality severity is related to decreased velopharyngeal gap size after surgery. Nasality analysis confirmed our assumption. To assess the correlation between hypernasality improvement and variables such as demographics or graft specifications, statistical tests

Table 6

Studies on the posterior pharyngeal wall augmentation with exogenous materials.

Year	Author	n	Implant Material	Results
1900	Gersuny ²⁴	DNA	Use of petroleum jelly	Achieved some success in improving patients' speech but with several serious complications including blindness and death
1904	Eckstein ²⁵	DNA	Injection of paraffin	Without untoward complications
1963	Blocksma ²⁶	27	Using implantable blocks and injectable fluid Silastic	Although he noted improvement in speech in many patients, a high incidence of implant infection and extrusion led him to recommend the use of autologous implants as the preferred method for pharyngeal augmentation
1965	Lewy ²⁷	1	Teflon injection	Effectively eliminated nasal emission of air and hypernasality
1968	Bluestone ²⁸	12	Teflon injection	No instances of infection, extrusion, or foreign-body reaction.
1977	Smith and McCabe ²⁹	80	Teflon injection	Complete elimination of hypernasality: 60%
1982	Furlow ³⁰	35	Teflon injection*	Improved voice quality: 18% successful treatment: 74%
1989	Wolford ³¹	26	Use of Proplast implant	Postoperatively, 18: elimination of VPI 3: minimal residual VPI 4: lost the implants secondary to infection with residual VPI 1: significant residual VPI without the loss of the implant
1990	Remade ³²	5	Collagen injection	Improved VPI Stable results
2002	Hallén ³³	12	Injection of cross-linked hyaluronan (animal study)	After 6 months, gel was still present
2007	Wise ³⁴	12	Submucosal injection of micronized acellular Dermal matrix (animal study)	Fails to demonstrate any degree of durability at oropharyngeal submucosa
2008	Ulkur ³⁵	10	Use of porous polyethylene implant	7: normal speech 2: nasal escape postoperatively
2009	Lypka ³⁶	119 (40 years of experience)	89 Textured silicone pillow 20 Gortex block 6 Rolled gortex 3 Smooth silicone block 1 Rib cartilage	73% normal or near-normal speech 25% mild nasal speech 2% not improved
2010	Brigger ³⁷	12	Calcium hydroxylapatite injection	8 demonstrated success
2016	Cofer ³⁸	50	Injectable dextranomer and hyaluronic acid copolymer	93% no or mild hypernasality 83% resolution of nasal grimace 96% resolution of audible nasal emission

* The risk of potentially serious complications has led the Food and Drug Administration to withdraw approval of Teflon use for augmentation pharyngoplasty.

DNA: Data Not Available.

were performed. Although test results showed some relation, none of the values were statistically significant. We believe that it is due to the low sample size.

It is our belief that dermal fat may have some size change during time (decline or increase). Therefore, we planned to follow-up patients at least every 6 months for 3 years. At late follow-up visits, speech analysis will be repeated and if any significant nasality change has occurred, lateral fluoroscopy will be performed to assess velopharyngeal gap size. Yet, authors have no distinct plan for possible future occurrences, namely, graft hypertrophy or resorption, but it is an opinion to debulk the graft with open access, if severe obstructive sleep apneas persist or occur after 6 months of initial operation, and also perform another method of velopharyngeal surgery such as pharyngeal flap, if hypernasality

worsens secondary to gap size increase. The authors have no judgment about repeat augmentation in case of graft loss or resorption.

The authors believe that posterior pharyngeal wall augmentation is worth attempting at present. Significant improvement in speech indexes and a low complication rate are required for any surgical technique. This technique has been forgotten because of low efficacy and high complication rates. After a 6-month follow-up period, we assume that augmenting the posterior pharyngeal wall with dermal fat graft can be effective in treating VPI in patients with prior veloplasty and current VPD. This technique is practical at any age, even in adolescents. It is our belief that larger sample size, longer follow-up period, and control groups are definitely required to make our thoughts come true (or false). At this stage of this pilot study, we aimed to answer a clear question: Does posterior pharyngeal wall augmentation with dermal fat graft, apart from having low complication profile, have any efficacy in improving hypernasality? The answer is: YES!

Conclusion

The authors believe that augmenting the posterior pharyngeal wall with dermal fat graft is effective in improving hypernasality in patients with moderate velopharyngeal gap size and relatively desirable velar motion. This method has a minimal complication rate because of autologous tissue application.

Author's role/participation in the authorship of the manuscript

Hossein Abdali, M.D.: senior surgeon and study supervisor, Mohammad Yaribakht, M.D.: junior surgeon, data analyzer, and study coordinator.

Acknowledgments

The authors thank Dr. Mojtaba Akbari, epidemiologist, for his wonderful assistance in designing the study and analyzing study data.

Funding

None.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Ethical approval

Not required.

References

1. Moll KL. Velopharyngeal closure on vowels. *J Speech Hear Res.* 1962;5:30–37.
2. Karnell MP, Folkins JW, Morris HL. Relationship between perceived and kinematic aspects of speech production in cleft palate speakers. *J Speech Hear Res.* 1985;28:63–72.
3. Karnell MP, Linville RN, Edwards BA. Variations in velar position over time: a nasal videoendoscopic study. *J Speech Hear Res.* 1988;31:417–424.
4. Kirschner Richard E, Baylis Adriane L. Velopharyngeal dysfunction. In: Rodriguez Eduardo o, Losee Joseph E, eds. *Plastic surg.* Vol. 3. 3rd ed. Washington: Elsevier; 2013:614–619.
5. Chitra S, Deep D, Anubhav Titli N, Manoj K, Satinath M, Subhankar C. Neck height ratio is an important predictor of metabolic syndrome among Asian Indians. *Indian J Endocrinol Metab.* 2016 Nov-Dec;20(6):831–837.
6. Passavant G. Ueberdieverbesserung der sprachenache der uranoplastik. *ArchKlinChir.* 1879;23:771.
7. Hollweg E, Perthes G. *Treatment of cleft palates.* Franz Pietzcher; 1912.
8. Hynes W. Pharyngoplasty by muscle transplantation. *Br J Plast Surg.* 1950;3:128–135.
9. Denny AD, Marks SM, Oliff-Camerol S. Correction of velopharyngealinsufficiency by pharyngeal augmentation using autologous cartilage: a preliminaryreport. *Cleft Palate Craniofac J.* 1993;30:46.

10. Desgain O, de Burbure, Mazy C, Verheyden C, Monnoye PJ, LevieP JP. costochondral cartilage implant in two cases of velopharyngeal insufficiency. *B-ENT*. 2006;2(1):39–42.
11. Witt PD, O'Daniel TG, Marsh JL, et al. Surgical management of velopharyngealdysfunction: outcome analysis of autogenous posterior pharyngealwall augmentation. *PlastReconstr Surg*. 1997;99:1287.
12. Gray SD, Pinborough-zimmerman J, Catten M. Posterior wall augmentation for treatment of velopharyngeal insufficiency. *Otolaryngol Head Neck Surg*. 1999 Jul;121(1):107–112.
13. Dejonckere PH, van Wijngaarden HA. Retropharyngeal autologous fat transplantation for congenital short palate: a nasometric assessment of functional results. *Ann OtolRhinolLaryngol*. 2001 Feb;110(2):168–172.
14. Klotz DA, Howard J, Hengerer AS, Slupchynskj O. Lipoinjection augmentation of the soft palate for velopharyngeal stress incompetence. *Laryngoscope*. 2001;111:2157–2161.
15. Guerrerosantos J, Chicas M, Rivera H. Palatopharyngeallipoinjection: an advantageous method in velopharyngeal incompetence. *PlastReconstr Surg*. 2004 Feb;113(2):776–777.
16. Bardot J, Salazard B, Casanova D, Pech C, Magalon G. [Velopharyngeal sequels in labial-alveolar-velopalatine clefts. *Pharyngoplasty by pharynx Lipostructure*].*Rev StomatolChirMaxillofac.*. 2007 Sep;108(4):352–356 Epub 2007 Aug 6.
17. Leuchter I, Schweizer V, Hohlfeld J, Pasche P. Treatment of velopharyngeal insufficiency by autologous fat injection. *Eur Arch Otorhinolaryngol*. 2010 Jun;267(6):977–983.
18. Cantarella G, Mazzola RF, Mantovani M, Mazzola IC, Baracca G, Pignataro L. injections for the treatment of velopharyngeal insufficiency. *J Craniofac Surg*. 2012 May;23(3):634–637.
19. Leboulanger N, Blanchard M, Denoyelle F, Glynn F, Charrier JB, Roger G, Monteil JP, Garabedian EN. Autologous fat transfer in velopharyngeal insufficiency: indications and results of a 25 procedures series. *Int J PediatrOtorhinolaryngol*. 2011 Nov;75(11):1404–1407.
20. Teixeira RP, Reid JA, Greensmith A. Fatty hypertrophy cause obstructive sleep apnea after fat injection for velopharyngeal incompetence. *Cleft Palate Craniofac J*. 2011 Jul;48(4):473–477.
21. Filip C. Autologous Fat Injection Combined with Palatoplasty and Pharyngoplasty for Velopharyngeal Insufficiency and Cleft Palate: Preliminary Experience. *Otolaryngol Head Neck Surg*. 2014 Jun;150(6):1094.
22. Filip C, Matzen M, Aagenæs I, Aukner R, Kjøll L, Høgevold HE, Tønseth K. Autologous fat transplantation to the velopharynx for treating persistent velopharyngeal insufficiency of mild degree secondary to overt or submucous cleft palate. *J PlastReconstrAesthet Surg*. 2013 Mar;66(3):337–344.
23. Darryl Lau BA, Adam J, Oppenheimer MD, Steve R, Buchman MD, Mary Berger MS, CCC, Steven J, Kasten MD. Posterior Pharyngeal Fat Grafting for Velopharyngeal Insufficiency. *The Cleft Palate-Craniofacial Journal*. January 2013;50(1):51–58.
24. Gersuny R. About a subcutaneous prosthesis. *ZschrHeilk*. 1900;21:199–204.
25. Eckstein H. Demonstration of a paraffin prosthesis in defects of the face andpalate. *Dermatologica*. 1904;11:772.
26. Blocksma R. Correction of velpharyngeal insufficiency by Silasticpharyngealimplant. *PlastReconstr Surg*. 1963;31:268.
27. Lewy R, Cole R, Wepman J. Teflon injection in the correction of velopharyngeal insufficiency. *AnnOtolRhinolLaryngol*. 1965 Sep;74(3):874–879.
28. Bluestone CD, Musgrave RH, McWilliams BJ, et al. Teflon injection pharyngoplasty. *Cleft Palate J.*. 1968;5:19.
29. Smith JK, McCabe BF. Teflon injection in the nasopharynx to improve velopharyngeal closure. *Ann OtolRhinolLaryngol*. 1977 Jul-Aug;86(4 Pt 1):559–563.
30. Furlow LT, Williams WN, Eisenbach CR, et al. A long term study on treating velopharyngeal insufficiency by teflon injection. *Cleft Palate J*. 1982;19:47.
31. Wolford LM, Oelschlaeger M, Deal R. Proplast as a pharyngeal wall implant to correct velopharyngeal insufficiency. *Cleft Palate J*. 1989 Apr;26(2):119–126 discussion 126–8.
32. Remacle M, Bertrand B, Eloy P, Marbaix E. The use of injectable collagen to correct velopharyngeal insufficiency. *Laryngoscope*. 1990 Mar;100(3):269–274.
33. Hallén L, Dahlqvist A. Cross-linked hyaluronan for augmentation of the posterior pharyngeal wall: an experimental study in rats. *Scand J PlastReconstrSurg Hand Surg*. 2002;36(4):197–201.
34. Wise JB, Cabiling D, Yan D, Mirza N, Kirschner RE. Submucosal injection of micronized acellular dermal matrix: analysis of biocompatibility and durability. *PlastReconstr Surg*. 2007 Oct;120(5):1156–1160.
35. Ulkur E, Karagoz H, Uygur F, Celikoz B, Cincik H, Mutlu H, Ertas I, Ciyiltepe M. Use of porous polyethylene implant for augmentation of the posterior pharynx in young adult patients with borderline velopharyngeal insufficiency. *JCraniofac Surg*. 2008 May;19(3):573–579.
36. Lypka M, Bidros R, RizviM Gaon M, Rubenstein A, Fox D, Cronin E. Posterior Pharyngeal Augmentation in the Treatment ofVelopharyngeal Insufficiency. *Annals of Plastic Surgery*. 2010 July;65(1):48–51.
37. Brigger MT, Ashland JE, Hartnick CJ. Injection pharyngoplasty with calcium hydroxyapatite for velopharyngeal insufficiency: patient selection and technique. *Arch Otolaryngol Head Neck Surg*. 2010 Jul;136(7):666–670.
38. Cofer SA, Baas B, Strand E, Cockerill CC. Augmentation pharyngoplasty for treatment of velopharyngeal insufficiency in children: Results with injectable dextranomer and hyaluronic acid copolymer. *Laryngoscope*. 2016 Oct;8(126Suppl):S5–S13.
39. Davis RE, Guida RA, Cook TA. Autologous free dermal fat graft: reconstruction of facial contour defects. *Arch Otolaryngol Head Neck Surg*. 1995;121:95–100.
40. Lapiere JC, Aasi S, Cook B, Montalvo A. Successful correction of depressed scars of the forehead secondary to trauma and morpheaeen coup de saber by en bloc autologous dermal fat graft. *DermatolSurg*. 2000;26:793–797.
41. Bonavolonta G, Tranfa F, Salicone A, Strianese D. Orbital dermis-fat graft using periumbilical tissue. *PlastReconstr Surg*. 105:23–26. 2000.
42. McClinton MA. The use of dermal fat grafts. *Hand Clin*. 1996;12:357–364.
43. Vandeput JJ, Droogmans B, Tanner JC. Closure of palatal fistulas using a dermis-fat graft. *PlastReconstr Surg*. 1995 May;95(6):1105–1107.
44. Ghobadi F, Zangeneh M, Massoud BJ. Free fat autotransplantation for the cosmetic treatment of first web space atrophy. *Ann Plast Surg*. 1995 Aug;35(2):197–200.
45. Nakakita N, Sezaki K, Yamazaki Y, Uchinuma E. Augmentation rhinoplasty using an L-shaped auricular cartilage framework combined with dermal fat graft for cleft lip nose. *Aesthetic Plast Surg*. 1999 Mar-Apr;23(2):107–112.

46. Stephen J. Mathes, Vincent R. Hentz. *Plastic Surgery, Volume 1, 2nd edition. Repair and grafting of dermis, fat and fascia.* p: 578-9.
47. Sawhney CP, Banerjee TN, Chakravarti RN. Behaviour of dermal fat transplants. *Br J Plast Surg.* 1969 Apr;22(2):169–176.
48. Mackay DR, Manders EK, Saggars GC, Schenden MJ, Zaino R. The fate of dermal and dermal-fat grafts. *Ann Plast Surg.* 1993 Jul;31(1):42–46.
49. Peer LA. Loss of Weight and Volume in Human Fat Grafts. *PRS.* 1950(5):217.
50. Peer LA. The neglected free fat graft, its behavior and clinical use. *Am J Surg.* 1956 Jul;92(1):40–47.
51. Bishop A, Hong P, Bezuhly M. Autologous fat grafting for the treatment of velopharyngeal insufficiency: State of the art. *Journal of Plastic, Reconstructive & Aesthetic Surgery: JPRAS.* 2014;67(1):1–8.
52. Comment on Colbert and Mercer. Retraction of the Soft Palate During a Modified Hynes Pharyngoplasty: A Technical Note. Sainsbury DC, Hodgkinson PD. *Cleft Palate Craniofac J.* 2017 Jan;54(1):119.