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Autologous Fat Injection Combined with Palatoplasty and Pharyngoplasty for Velopharyngeal Insufficiency and Cleft Palate: Preliminary Experience

Yimei Cao, MD1*, Tingting Ma, MD2*, Di Wu, MD1*, Ningbei Yin, MD1, and Zhenmin Zhao, MD1

Abstract

Objective. The aim was to evaluate clinical application of autologous fat transplantation in the posterior pharynx to treat velopharyngeal incompetence and cleft palate.

Study Design. Case series with chart review.

Setting. Cleft Lip and Palate Center of Plastic Surgery Hospital, an academic medical center.

Subjects and Methods. We studied 11 patients (age, 5-26 years) with a cleft palate and velopharyngeal insufficiency who underwent autologous fat injection. Patients were followed for 9 to 40 months. Pronunciation evaluation, visual appearance of the palatopharyngeal area, nasopharyngeal fibroscopy (NPF), palatopharyngeal lateral radiography, and magnetic resonance imaging (MRI) were undertaken before and after the operation.

Results. Speech intelligibility was markedly increased in all patients. Pronunciation was good to excellent compared with the preoperative level (P = .001). Mean velopharyngeal insufficiency rate was significantly reduced from 26.05% to 6.96% (P = .028) by NPF and from 26.42% to 7.11% (P = .017) by MRI (axial plane). Magnetic resonance imaging indicated significantly reduced mean minimum velopharyngeal distance, from 10.39 to 3.65 mm (P = .012) in the sagittal plane, and markedly increased thickness of transplanted fat in the posterior pharyngeal wall (sagittal, 5.43 mm; axial, 4.74 mm). There were few complications (sleep apnea, nasopharyngeal regurgitation).

Conclusion. Autologous fat transplantation in the posterior pharyngeal wall was a good method for treating velopharyngeal incompetence. The safety profile was good in our sample, and we got a consistent result in the follow-up period. In addition, it also could be combined with routine surgery.

Keywords

autologous fat, velopharyngeal insufficiency, posterior pharyngeal wall transplantation

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Velopharyngeal insufficiency (VPI), caused by the inability of the soft palate to completely close the posterior wall of the pharynx during speech and/or swallowing, is commonly seen after cleft palate repair. The percentage of VPI after primary repair has ranged from 5% to 38%.1,2 It manifests clinically as abnormal resonance, rhinolalia, and/or hypernasality. Velopharyngoplasty, posterior pharyngeal flap transplantation, and dynamic sphincter pharyngoplasty are the surgeries most frequently selected to treat VPI.3 Posterior pharyngeal augmentation provides an alternative and/or adjunct to traditional surgery to treat VPI, especially in association with another operation, such as palatopharyngeal ring ligation, Furlow double-opposing Z-plasty, and buccal musculomucosal island flap.4 The history of posterior pharyngeal wall augmentation reaches back many years. Since the first time Gersuny5 used Vaseline in the posterior pharyngeal wall to treat VPI, there have been many varied forms of implants in the posterior pharyngeal wall, including paraffin,6 silicone,7 Teflon,8 collagen,9 calcium hydroxyapatite,10 Proplast,11 autologous and homologous cartilage,12 mucosal and muscle flaps,13 and a dermis fat flap.14 Each of these materials has its advantages and disadvantages. The aim of the study was to evaluate clinical application of autologous fat transplantation in the posterior pharynx to treat velopharyngeal incompetence and cleft palate.
Table 1. Wang classification\(^{20}\) for velopharyngeal insufficiency.

<table>
<thead>
<tr>
<th>Types</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Good movement of the soft palate and the lateral pharyngeal walls. Complete or marginal velopharyngeal closure can be achieved in phonation.</td>
</tr>
<tr>
<td>II</td>
<td>Velopharyngeal insufficiency but good movement of the soft palate and the lateral pharyngeal walls.</td>
</tr>
<tr>
<td>III</td>
<td>Velopharyngeal insufficiency. Good movement of the soft palate but poor movement of the lateral pharyngeal walls.</td>
</tr>
<tr>
<td>IV</td>
<td>Velopharyngeal insufficiency. Poor movement of the soft palate but good movement of the lateral pharyngeal walls.</td>
</tr>
<tr>
<td>V</td>
<td>Velopharyngeal insufficiency. Poor movement of the soft palate and the lateral pharyngeal walls.</td>
</tr>
</tbody>
</table>

Although some studies have focused on autologous fat transplantation in the posterior pharyngeal wall,\(^{15-17}\) they mainly address only mild or moderate VPI, congenital short palate,\(^{18}\) or stress velopharyngeal incompetence\(^{19}\) and examine the procedure only regarding its merits of causing less trauma and being repeatable. However, the combined methods of fat transplantation with palatoplasty for severe types of cleft palate or VPI have not been reported. We describe here combination treatment of cleft palate and VPI that includes autologous fat injection behind the posterior pharynx with a palatal lengthening procedure. The transplanted fat exhibited good survival in the posterior pharyngeal wall.

**Materials and Methods**

**Patients**

Since 2008, we have been engaged in a prospective study of 11 patients with cleft palate and/or VPI whose treatment was combined with autologous fat injection into the posterior pharyngeal wall. Our indication of posterior pharyngeal fat injection would be as follows: (1) VPI types III and V, (2) cleft palate patients with a short soft palate and a huge pharyngeal cavity whose velopharyngeal closure could not be improved completely through simple palatoplasty, and (3) no obvious internal carotid artery aberrance. Eleven patients aged 5 to 26 years (mean age, 18.1) were included in the study (6 males and 5 females). They all underwent autologous fat injection combined with other operations, such as velopharyngeal ring ligation, Furlow double-opposing Z-plasty, or buccal musculomucosal island flap. The patients with vascular aberrant and sleep apnea were excluded preoperatively. According to Wang’s classification for VPI\(^{20}\) (Table 1), our cases were types III and V. No patients had any syndromes. The characteristics of the patients are shown in Table 2. None of the patients were enrolled in speech therapy. All 11 patients had VPI, abnormal resonance, and consistent hypernasality. The 11 patients were followed up for 9 to 40 months (mean, 22.5 months). The study was approved by the Ethical Institutional Committee of the Plastic Surgery Hospital, Chinese Academy of Medical Sciences.

**Surgical Procedure**

All operations were performed under general anesthesia with a ventilation tube through the mouth. Fat was harvested from the lower abdomen in all patients. The surgical procedure was as follows.

When local anesthesia took effect, a 2.5-mm Coleman liposuction cannula connected to a 20-mL sterilized Luer-Lok syringe was introduced, and about 30 mL of fat particles was gently aspirated under negative pressure according to the Coleman technique.\(^{21}\) The syringe with the aspirated fat particles was placed on several sterilized medical gauze pads for filtration. The fat was then washed repeatedly with Ringer’s lactate solution to remove impurities such as blood, liquid anesthesia, cell debris, and fibrous tissue fragments. The fat tissue collected without oil or water was isolated and placed in a 5-mL syringe.

The next step was to identify a velopharyngeal closure plane based on preoperative palatopharyngeal lateral radiography and magnetic resonance imaging (MRI) evidence. A 3- to 4-mm incision was then made at the lower edge of the first cervical vertebra beside the centerline of the retropharynx. A 2.5-mm liposuction needle was placed according to the incision of the posterior pharyngeal wall. An attempt was made to confine fat grafts, evenly placed, at the level of the retropharyngeal space between the deep layer of the superior pharyngeal constrictor and the prevertebral fascia. Fat was then injected within the bounds of 2 cm of the velopharyngeal closure plane. In total, 4 to 17 mL of fat was injected, depending on the size of the area in the posterior pharynx. The method and location of the lipoinjections are shown in Figure 1.

A palatopharyngeal ring ligation was performed with 0-absorbable thread to narrow the pharyngeal cavity. The ligature would be absorbed but the survived fat would sustain the positive effect in palatopharyngeal closure. A Furlow Z-plasty was performed with 2 opposing flaps to elongate the soft palate. The buccal musculomucosal island flap was transferred to repair the palatal cleft or expand the deficient tissue.

**Preoperative and Postoperative Evaluations**

All patients were assessed before and after the operation. The examinations included pronunciation evaluation, visual examination of the palatopharyngeal area, palatopharyngeal lateral radiography, and nasopharyngeal fibroscopy (NPF) except in patients whose diagnosis was complete cleft palate. Patients 5 and 9 were not able to undergo MRI.
before the operation, and patient 10 was too young to cooperate. The pronunciation evaluation, conducted by 3 senior surgeons (ZZ, NY, and DW), was according to the 4-degree evaluation criteria of Song and Liu.22 (Table 3).

With the patient’s head held back at 45° with guidance, he or she pronounced /a:/ while being observed visually by the examiner. Observation details included the mobility of the soft palate, lateral pharyngeal wall bilaterally, and posterior pharyngeal wall.

Nasopharyngeal fibroscopy was undertaken by recording a video at rest and while phonating the vocal sound /a:/.

Table 2. Characteristics of all patients.

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Sex/Age, y</th>
<th>Degree of VPI</th>
<th>Diagnosis</th>
<th>Surgical Procedures</th>
<th>Volume of Fat, mL</th>
<th>Follow-up, mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M/13</td>
<td>III</td>
<td>VPI</td>
<td>BMIP + PPFI</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>2</td>
<td>M/17</td>
<td>III</td>
<td>SCLP</td>
<td>FDZP + PPFI</td>
<td>12</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>F/19</td>
<td>III</td>
<td>VPI</td>
<td>BMIP + PPFI</td>
<td>8</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>F/19</td>
<td>/</td>
<td>BCLP</td>
<td>BMIP + PPFI</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>M/26</td>
<td>/</td>
<td>UCLP</td>
<td>BMIP + PPFI</td>
<td>14</td>
<td>32</td>
</tr>
<tr>
<td>6</td>
<td>M/15</td>
<td>V</td>
<td>VPI</td>
<td>VPRL + FPZ + PPFI</td>
<td>5</td>
<td>28</td>
</tr>
<tr>
<td>7</td>
<td>F/20</td>
<td>/</td>
<td>BCLP</td>
<td>VPRL + PPFI + LM</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>8</td>
<td>F/24</td>
<td>/</td>
<td>UCLP</td>
<td>VPRL + FPZ + PPFI</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>9</td>
<td>M/20</td>
<td>/</td>
<td>UCLP</td>
<td>VPRL + PPFI + LM</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>10</td>
<td>M/5</td>
<td>III</td>
<td>VPI</td>
<td>BMIP + PPFI</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>11</td>
<td>F/21</td>
<td>III</td>
<td>VPI</td>
<td>FDZP + PPFI</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.8</td>
<td>25.5</td>
</tr>
</tbody>
</table>

Abbreviations: BCLP, bilateral cleft palate; BMIP, buccal musculomucosal island flap; F, female; FDZP, Furlow double-opposing Z-plasty; LM, Langenback method; M, male; PPFI, posterior pharyngeal fat injection; SCLP, submucosal cleft palate; UCLP, unilateral cleft palate; VPI, velopharyngeal insufficiency; VPRL, velopharyngeal ring ligation; /, the patients with cleft palate were not involved in the classification of VPI.

Table 3. Four-degree evaluation criteria by Song and Liu.22

<table>
<thead>
<tr>
<th>Degree</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>No different from normal</td>
</tr>
<tr>
<td>Good</td>
<td>A little abnormal but could understand well</td>
</tr>
<tr>
<td>Bad</td>
<td>Fairly abnormal; only already known topic or signified could be understood</td>
</tr>
<tr>
<td>Inferior</td>
<td>Completely abnormal; not understood entirely</td>
</tr>
</tbody>
</table>

Software measurement and analysis system. The rate of velopharyngeal insufficiency (RVPI) was calculated.

With the patient’s ear plane parallel to the floor, an x-ray line was projected during vocal rest and while pronouncing /a:/

Magnetic resonance imaging was done without sedation at rest and during phonation of /a:/ in each of the axial, sagittal, and coronal planes. The 1.5-T MRI apparatus (Avanto; Siemens, Erlangen, Germany) provided T1 imaging with the following parameters: TR, 5.18 ms; TE, 2.54 ms; thickness, 3 mm; matrix, 256 × 128; angle, 0°; and single-image scanning time, 10 s. We evaluated the RVPI during both vocal rest and movement and the velopharyngeal distance while pronouncing /a:/ before and after the operation.24 Also, the thickness of the transplanted fat in the posterior pharyngeal wall (bright signals) in the sagittal and axial planes was measured. We obtained not only T1-weighted (T1W) but also T1W with fat suppression (TIFS) images to observe the change in signal intensity on images of the transplanted fat. Postoperative MRI varied according to

Figure 1. Method for autologous fat injection for pharyngeal augmentation.

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the follow-up period in Table 1. Images were evaluated by the eFilm 2.1.0 software measurement and analysis system.

**Statistical Analysis**

The Wilcoxon signed rank test was used to compare the preoperative and postoperative parameters of RVPI obtained with NPF and the velopharyngeal distance during phonation of /a:/ obtained by MRI. The results of the 4-degree evaluation criteria determined by the 3 senior surgeons’ perceptual evaluation of each patient were analyzed by Pearson’s χ² test. Statistical analysis of RVPI by MRI preoperatively and postoperatively was executed with the paired t test. Patients whose preoperative statistics were absent were not included. All statistical analyses were performed using SPSS version 17.0 (SPSS, Inc, an IBM Company, Chicago, Illinois). *P* < .05 was considered significant.

**Results**

Eleven patients with cleft palate or VPI combined with posterior pharyngeal wall augmentation with autologous fat were included in this study. They all recovered quickly from the surgery. Snoring occurred in 2 patients due to tissue swelling within 5 to 7 days after the operation, but it did not develop to sleep apnea. We did not find preoperative and postoperative nasopharyngeal regurgitation. All patients complained of dysphagia caused by pain within 5 to 7 days after the operation. At follow-up, the color and luster of the mucosal blood supply to the posterior pharynx were normal. The posterior pharynx was much more rigid than before the operation, as seen by visual examination and NPF (Figure 2). According to the 4-degree evaluation criteria by Song and Liu,22 the intelligibility of speech was markedly increased in all 11 patients, and the levels were evaluated as excellent or good. The analysis of preoperative and postoperative evaluation of speech quality (ESQ) parameters is presented in Table 4. The χ² test showed that there was significant improvement from the preoperative to postoperative ESQs (*P* = .001). There was a significant reduction in the mean RVPI calculated by NPF, from 26.05% to 6.96% (*P* = .028), and a significant reduction in the mean RVPI calculated by MRI in the axial plane, from 26.42% to 7.11% (*P* = .017). We also found a significant reduction in the mean minimum velopharyngeal distance, from 10.39 to 3.65 mm (*P* = .012), in the sagittal plane. The MRI results indicated that the posterior pharynx had thickened. The mean thickness of transplanted fat (bright signals) in the posterior pharyngeal wall was 5.43 mm in the sagittal plane and 4.74 mm in the axial plane. There were obvious bright TI signals in most patients, but there was heterogeneity in patient 7. The bright signal intensity of the transplanted fat particles on T1W images was totally suppressed on the T1FS images (Figures 3 and 4). Of the patients who returned to the hospital, patient 10 had not undergone MRI because of being too young. In addition, patients 5 and 9 had not undergone preoperative MRI. In all cases, the RVPI, by NPF or MRI, and the palatal parapharyngeal space had increased since before the operation (Table 4).

**Discussion**

The aim of posterior pharyngeal augmentation is to form a neo-Passavant ridge in the posterior pharyngeal wall, which reduces the anteroposterior diameter of the cavum pharyngis, making the velum more accessible. Since Gersuny5 first advocated putting Vaseline in the pharyngeal wall to correct VPI, numerous materials have been used to augment the posterior pharynx. They can be divided into solids and liquids. The former can be shaped as a bladder below the superior constrictor muscle in the posterior pharynx wall if a moderate-sized implant is needed. Liquid implants are more convenient because they can be injected into the velum, the submucosa of the posterior pharyngeal wall, the deep layer of the superior constrictor muscle, or the muscle itself. Nonabsorbent biological material with poor biocompatibility can cause inflammation and extrusion.25 Cartilage and other autologous tissues used for grafting, such as fat masses, muscular tissue, fascia, and dermis fat, exhibit little extrusion but have high absorption, which is especially damaging to the donor site. Obviously, the ideal implant has not yet been found. Other studies15-17,26 have reported injecting autologous fat into the posterior pharyngeal wall to treat VPI. Most treated VPI only and focused on a velopharyngeal gap of less than 5 mm. We also chose this method combined with another operation and achieved good surgical results. Its use decreases hospital costs and lessens pain to some extent.

It is well known that fat transplantation is associated with high absorption, although there is no agreement on the extent because it varies widely, ranging from 5% to 100%.27 Also, the transplanted fat can alter its volume to fit the recipient site if the patient’s weight changes (described in a patient with a 16-year follow-up28 who had a good survival). Because of the high absorption rate of transplanted fat, some research projects are focusing on how to increase the survival rate of fat. Three aspects of fat transplantation must be addressed. The first involves the choice of the donor site. Although the best site is still not clear, many surgeons29 have selected the outer thigh as an ideal source of fat because it contains little fiber and is a relatively bloodless area. Other researchers30,31 found that the activity of transplanted fat has no relation to the donor site, and the lower abdomen and inner thigh are chosen as the better donor sites for fat transplantation.32 The second problem relates to the recipient site. The survival of the transplanted fat depends on early revascularization, and transplanting fat in areas with an abundant blood supply could increase the survival of the transplanted fat. An animal experiment33 proved that intramuscularly injected autologous fat favored both inosculcation and neovascularization. The third aspect deals with the fat purification process. The aim of purification is to remove as much as possible of the useless or harmful materials in the fat aspirate, including anesthesia drugs, dead cell fragments, and excessive mixtures of blood and fatty oil. Rinsing fat removes the fibrous component so the fat can revascularize rapidly.34 Centrifugation effectively purifies fat, but even in comparative studies,35 there is no consensus on whether it is harmful to fat survival.
Table 4. Results of speech quality, nasopharyngeal fibrescopy, and MRI.

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Preoperative, %</th>
<th>Postoperative, %</th>
<th>Preoperative, %</th>
<th>Postoperative, %</th>
<th>Preoperative, mm</th>
<th>Postoperative, mm</th>
<th>Preoperative, mm</th>
<th>Postoperative, mm</th>
<th>Preoperative, mm</th>
<th>Postoperative, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bad</td>
<td>Good</td>
<td>21.4</td>
<td>11.9</td>
<td>21.0</td>
<td>10.8</td>
<td>6.3</td>
<td>1.1</td>
<td>0/0</td>
<td>7.2/6.5</td>
</tr>
<tr>
<td>2</td>
<td>Good</td>
<td>Excellent</td>
<td>13.4</td>
<td>0</td>
<td>9.6</td>
<td>0</td>
<td>3.3</td>
<td>0</td>
<td>0/0</td>
<td>6.5/5.9</td>
</tr>
<tr>
<td>3</td>
<td>Bad</td>
<td>Excellent</td>
<td>23.3</td>
<td>4.1</td>
<td>24.3</td>
<td>5.7</td>
<td>14.2</td>
<td>2.0</td>
<td>0/0</td>
<td>4.8/3.9</td>
</tr>
<tr>
<td>4</td>
<td>Inferior</td>
<td>Good</td>
<td>/</td>
<td>10.4</td>
<td>/</td>
<td>12.5</td>
<td>17.1</td>
<td>5.0</td>
<td>0/0</td>
<td>7.3/6.8</td>
</tr>
<tr>
<td>5</td>
<td>Inferior</td>
<td>Good</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>4.7</td>
<td>/</td>
<td>3.4</td>
<td>/</td>
<td>6.7/6.0</td>
</tr>
<tr>
<td>6</td>
<td>Bad</td>
<td>Good</td>
<td>37.9</td>
<td>8.4</td>
<td>42.7</td>
<td>8.1</td>
<td>13.0</td>
<td>6.2</td>
<td>0/0</td>
<td>2.4/2.1</td>
</tr>
<tr>
<td>7</td>
<td>Inferior</td>
<td>Good</td>
<td>/</td>
<td>13.7</td>
<td>/</td>
<td>9.3</td>
<td>14.0</td>
<td>3.0</td>
<td>0/0</td>
<td>2.2/1.7</td>
</tr>
<tr>
<td>8</td>
<td>Inferior</td>
<td>Good</td>
<td>/</td>
<td>6.3</td>
<td>/</td>
<td>7.8</td>
<td>7.3</td>
<td>1.2</td>
<td>0/0</td>
<td>6.3/5.3</td>
</tr>
<tr>
<td>9</td>
<td>Inferior</td>
<td>Good</td>
<td>/</td>
<td>8.9</td>
<td>/</td>
<td>9.8</td>
<td>/</td>
<td>4.2</td>
<td>/</td>
<td>7.4/6.6</td>
</tr>
<tr>
<td>10</td>
<td>Bad</td>
<td>Good</td>
<td>25.3</td>
<td>4.6</td>
<td>/</td>
<td>/</td>
<td>/</td>
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<td>/</td>
<td>/</td>
</tr>
<tr>
<td>11</td>
<td>Good</td>
<td>Excellent</td>
<td>35.0</td>
<td>1.3</td>
<td>34.5</td>
<td>2.4</td>
<td>7.9</td>
<td>0.5</td>
<td>0/0</td>
<td>3.5/2.6</td>
</tr>
</tbody>
</table>

Mean (P = .001) 26.05 6.96 (P = .028) 26.42 7.11 (P = .017) 10.39 3.65 (P = .012) 0/0 5.43/4.74

Abbreviations: MRI, magnetic resonance imaging; ESQ, evaluation of speech quality; RVPI, rate of velopharyngeal insufficiency (palatal pharynx cavity minimum area contraction while pronouncing /a:/ ÷ palatal pharynx cavity area × 100%); /, data were not available.

*Pearson’s χ² test.
*bWilcoxon signed rank test.
*cPaired t test.
Filip et al\textsuperscript{24} and Cantarella et al\textsuperscript{15} used 3.8 to 6.4 mL and 3.5 to 8 mL in their studies, respectively, but they both injected the fat into the posterior nasopharyngeal wall, the lateral walls, and the soft palate. In our study, patients with severe disorders in articulation were chosen, and they all had other operations simultaneously. We lacked experience at the beginning, but we knew that we needed to inject the fat into the correct site so that it could play its role in palatopharyngeal closure. Because the syringe needle was directed downward, the fat would partly flow under the palatopharyngeal plane, so we also increased the volume of fat in the previous cases. For this reason, the range of the injected fat was a bit large. Special care must be taken during injection so that the needle does not turn excessively toward the lateral pharynx, thereby avoiding vital vessels and nerves such as the cervical part of the sympathetic trunk, carotid sheath, internal carotid in the parapharyngeal space, and prevertebral fascia. It was reported that the maximum area of movement was the hard palate plane via Towne’s view\textsuperscript{23}. We therefore decided that injecting fat into the posterior pharyngeal wall at the hard palate level would reduce the palatopharyngeal space to the greatest extent.

It was difficult to detect the survival of transplanted fat objectively and precisely. We used MRI to assess the effect of fat augmentation in the posterior pharyngeal wall. Magnetic resonance imaging recently had been described for evaluating the velopharyngeal muscle\textsuperscript{24,36}. Velopharyngeal muscle anatomy is reliably visualized by MRI, and MRI can characterize the changes in velopharyngeal function after surgical correction of VPI or cleft palate. Fat shows high signal intensity on T1 sequences, T2 sequences, and proton density images in MRI. The posterior pharynx consists of mucous membrane, submucous tissue, and the superior constrictor muscle. It exhibits a lower T1 signal, which might be explained by a slightly lower fat content. Bright signal intensity on T1-weighted imaging was a statistically significant MRI feature that favored an indication for fat injection in the retropharyngeal wall, which survived well. Bright signal intensity depicted on T1W images would be suppressed by using T1FS\textsuperscript{37}. Based on this mechanism, it could differentiate the innate tissue from surviving transplanted fat. Regarding the MRI results, Filip et al\textsuperscript{24} revealed a similar but more impressive outcome using the phonation sound /e/ on MRI within a 1-year follow-up period. However, most patients involved had mild or moderate VPI. In contrast, we evaluated the volume of the transplanted fat by thickness in the sagittal/axial MRI plane. This would probably explain the difference.

The important reasons for choosing MRI to analyze the velopharyngeal closure in this study were to use a noninvasive process, achieve accurate measurements, and provide good security of the velopharyngeal distance in the sagittal, axial, and coronal planes without exposing the patients to ionizing radiation. Magnetic resonance imaging also could multidimensionally observe the soft palate, retropharyngeal wall, and lateral pharyngeal wall at rest or during movement. We also could observe vascular malformations in the
pharynx and reconstruct the pharynx 3-dimensionally. There were some limitations to the study. Our technique recorded only 1 state rather than a series of continuous states resulting from movement of the velopharyngeal closure. Also, the examination was expensive, the metallic dental implants influenced interpretation of images, and it was difficult to attain children’s cooperation in phonating vocal sounds for 10 seconds. In summary, MRI is not suitable at present for large-scale application as a routine examination.

We achieved satisfactory surgical results when we applied autogenous posterior wall augmentation plus another operation for cleft palate repair and VPI correction in 11 patients. These patients had a retropharyngeal movement disorder. The transplanted fat survived well after the operation, as assessed by NPF and MRI.

Conclusion

On the basis of clinical observation of 11 patients during a 9- to 40-month (mean, 25.5 months) follow-up period, we believe that autologous fat transplantation in the posterior pharyngeal wall is a good method for treating velopharyngeal incompetence. The safety profile was good in our sample, and a consistent result was maintained for the relatively short follow-up period. The technique can be used in combination with adjunct methods to repair retropharyngeal dyskinesia of a cleft palate or the VPI of a huge palatopharyngeal space. Autologous fat is an ideal filler because of its many familiar merits—abundant sources, nonimmunogenicity, and minimal invasion—although the absorption rate of transplanted fat is not as clear. Postoperative observations and measurements, especially with MRI, are needed to ensure that the procedure has gone well. Long-term follow-up, the most advantageous volume of fat to transplant, and reducing absorption of the transplanted fat need further study.

Acknowledgments

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Author Contributions

Yimei Cao, data acquisition, manuscript creation; Tingting Ma, data acquisition and interpretation of data, design and drafting the manuscript; Di Wu, database management, manuscript writing/editing; Ningbei Yin, database management, manuscript editing; Zhenmin Zhao, provided cases, study design, editing, approval of the final manuscript.

Disclosures

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