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NEÜ YAYINEVİ

Evaluation of Patients Operated Because of Velopharyngeal Insufficiency with Dynamic Magnetic Resonance Imaging

Velofarengeal Yetmezlik Sebebiyle Opere Edilen Hastaların Dinamik Manyetik Rezonans Görüntüleme ile Değerlendirilmesi

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Öz

Amaç: Yarık damak sebebiyle ameliyat edilen hastaların yaklaşık %30'u velofarengeal yetmezlik(VFY) sebebiyle ek müdahelelere ihtiyaç duyarlar. Ameliyat öncesi planlama için radyolojik değerlendirme kesinlikle gerekirken ameliyat sonrası değerlendirmede de oldukça faydalıdır. Bu çalışmada, velofaringeal yetmezlik sebebiyle opere edilen hastalarda velofarinksin dinamik manyetik rezonans(MR) ile değerlendirilmesi ile ilgili tecrübelerimizi paylaşmayı planladık.
Hastalar ve Yöntem: Nisan 2014- Mayıs 2020 tarihleri arasında VFY ile başvuran ve postoperatif dinamik MR ile değerlendirilen 17 hasta çalışmaya dahil edildi. 7 hastaya faringeal flep, 7 hastaya posterior duvar augmentasyonu (2 kıkırdak, 5 yağ grefti) ve submukoz yarık mevcut 3 hastaya myomukozal onarım yapıldı. Ameliyat öncesi ve ameliyat sonrası 3. ayda tüm hastalara dinamik MRG yapıldı. Ameliyat sonrası sonuçlar dinamik MR ile değerlendirildi.
Bulgular: Bu çalışmaya ortalama yaşı 13± 2.5 (9-29) olan, 11 (%65) kadın ve 6 (%35) erkek hasta dahil edildi. Posterior duvar yerleşimli greftlerin ikinci servikal vertebra seviyesinde ve yaşayabilir oldukları görüldü. Posterior faringeal fleple onarım yapılan hastalarda sagital planda nazal hava kaçağı görülmezken, aksiyel dinamik görüntülerde hava yolu için gerekli açıklık gözlendi. Submuköz kleftli hastalarda levator kas seyrinin normal düzleme geldiği gözlendi. Nazal hava kaçak alanı tüm tekniklerde preoperatif ölçümlere göre belirgin azalmıştı($p<0.05$).
Sonuç: Velofarinks 3-boyutlu ve dinamik yapısı sebebi ile tüm planlarda ve dinamik olarak değerlendirilmelidir. Bu amaçla kullanılan pekçok teknik olmakla birlikte hiçbiri ideal ve objektif değildir. Dinamik MRG planlamada olduğu gibi postoperatif takipte de kullanılabilir. Farengeal flep atrofisi, greftlerin ve velofarengeal açıklığın kalitatif veriler ile değerlendirlmesi sağlanır.

Anahtar Kelimeler: Dinamik MRG, velofarinks, yetmezlik, greft

Abstract

Aim: Nearly 30% of the patients with cleft palate need another surgery for velopharyngeal insufficiency. While preoperative radiologic evaluation is necessary for planning, postoperative evaluation is also so important. In this study, we plan to share our experience about evaluation of the velopharynx with dynamic MRI at patients who were operated oving for velopharyngeal insufficiency.
Patients and Methods: The study included seventeen patients who were presented with velopharyngeal insufficieny and we applied dynamic MRI for postoperative evaluation between April 2014 and May 2020. Pharyngeal flap was applied for 7, posterior augmentation was performed for 7 (2 costal cartilaginous, 5 fat graft) and myomucosal repair was done for 3 patients with submucosal cleft. Dynamic MRI were obtained preoperatively and postoperatively at 3rd month. Postoperative results were evaluated with dynamic MRI.
Results: The study included seventeen patients, with an age range of 9-29 (mean 13± 2.5), 11 women (65%), and 6 men (35%). Posterior wall located grafts were found at the second cervical vertebra and viable. While there was no nasal air escape in superior pharyngeal flap applied patients at sagittal plane, in axial dynamic images, gap was detected which is all essential for airway and must be obtained. The levator muscle direction was observe normal postoperatively at patients with submucous clef. Nasal air escape area was decreased in both methods significantly comparing with preoperative measurement ($p<0.05$)
Conclusion: Because of the three-dimensional and dynamic structure of the velopharynx, it must be evaluated in both planes and dynamic. Although there are many techniques for this purpose, none of them is ideal or objective. Dynamic MRI can be used for postoperative follow-up as it is used for preoperative planning. Evaluation of the pharyngeal flap atrophy, grafts and also gap size are provided with qualitative values.

Key words: Dynamic MRI, velopharynx, insufficiency, graft

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INTRODUCTION

Velopharyngeal insufficiency (VPI) is an inability of velopharyngeal valve closure while oral sound production because of structural or anatomical defect. It is the subset of velopharyngeal dysfunction due to insufficient tissue or mechanical restriction (1). Common causes of VPI are submucous cleft, cleft palate, and surgeries like adenoidectomy(2). Nearly 30% of the patients with cleft palate need another surgery for velopharyngeal insufficiency related to speech problems (3). Since the velopharynx is a three dimensional anatomical structure, it must be overviewed in each projection (4). There are four different closure patterns of velopharynx as coronal, sagittal, circular, and both and it is too important to detect the defect of the closing pattern for planning the treatment method.

Nasoendoscopy, videofluoroscopy, magnetic resonance imaging (MRI), cephalometric studies, nasometry and speech tests are techniques for follow-up and diagnosis (5). These methods obtain anatomical and functional evaluation but usually, objective measurement is not possible. While preoperative radiologic evaluation is necessary for planning, postoperative evaluation is also so important for the assessment of flap contracture at pharyngeal flaps, graft viability of fat or cartilaginous tissue also placement of them at posterior wall augmentation. Additionally, evaluation of nasal air escape and dynamic closure function is too important for speech outcome. Especially in patients with speech disorders despite surgery, nasal air leakage and functional evaluation are provided, and the correct planning of additional interventions is ensured.

In this study, we plan to share our experience about the evaluation of the patients that were operated because of VPI by using the pharyngeal flap, posterior wall augmentation, and muscle repair in submucosal cleft palate through with dynamic MRI.

PATIENTS AND METHODS

The study included seventeen patients who were presented with velopharyngeal insufficieny and we applied dynamic MRI for postoperative evaluation between April 2014 and May 2020. Patients younger than 7 years old and patients with orthodontic treatment were excluded related to artifact. No patient has required sedation. Preoperative Dynamic MRI and videofluoroscopy had been applied for detecting the closure pattern of the velopharynx to choose the treatment modality. Pharyngeal flap was applied for 7, posterior augmentation was performed for 7 (2 costal cartilaginous, 5 fat graft) and myomucosal repair was done for 3 patients with submucosal cleft. Posterior wall augmentation was added to 2 patients after pharyngeal flap because of insufficient closure of the sphincter mechanism in two planes, sagittal and coronal. Approval was obtained from the ethics committee for clinical researches at a local university hospital (Registration number: 2021/392).

All the patients were followed-up by speech therapists. Preoperative and postoperative endoscopic videos were taken during preoperative and postoperative periods. Speech records were taken by reading a standard text. Dynamic MRIs were obtained preoperatively and postoperatively at 3rd month. Levator muscle was evaluated in axial and coronal images. Patients were asked to say "MMMM, PPPP, Pokemon" and palate movement was observed. Anatomical structures, levator muscle anatomy, and function, pharyngeal wall movements, graft placement and size, flap size, and nasal air leakage were evaluated.

MR imaging technique

Magnetic Resonance Imaging subjects were scanned with a 1.5 Tesla MRI scanner (Siemens MAGNETOM Aera, Erlangen, Germany) and a 16-channel head coil in the supine position. All examinations were performed without any sedation. To evaluate the anatomic structure, T1 fast spin echo [repetition time (TR) 650 ms; time to echo (TE) 20 ms; slice thickness (ST) 4 mm] weighted investigations in axial, sagittal, and coronal planes during rest were performed. In addition, we used the half-Fourier acquisition single-shot turbo spin-echo (HASTE) (TR=1,860 ms, TE=116 ms, ST= 4 mm, Voxel size: 1.6×1.6×4.0 mm, field of view (FOV) 300 mm) and true fast imaging with steady-state precession (TrueFISP) sequences (TR=3.45 ms, TE=1.45 ms, ST= 4 mm, voxel size: 0.8×0.8×4.0 mm, FOV 300 mm).

We used the below protocol for dynamic MRI after a localizer view:

1) T2 HASTE in the axial and sagittal planes according to the localizer during rest,
2) Repeated sagittal, axial, and coronal TrueFISP sequences without speech and during the speech

The T2 HASTE sequences lasted 48 seconds, the TrueFISP sequences lasted an average of 20 seconds, coronal images were taken with 22 seconds and all MR examination took about 15 minutes. Axial images were taken as parallel to the axis of the hard palate. Sagittal TrueFISP sequences were

taken according to the median sagittal T2 HASTE image and axial planes were taken at the height of maximal velopharyngeal closure in the sagittal planes. The images of all MR imaging patients were archived in the picture archiving and communication system (PACS) system. In addition, all images were transferred to the workstation (Syngo.via) for better evaluation and measurement. In dynamic images, the movement of the uvula and the velopharyngeal patency was investigated. Velopharyngeal area, and nasal air escape area was measured by a semiotomatic software program. Percentage of VPO closure was calculated by comparing preoperative and postoperative images. Statistical analysis was applied by Paired Student's t-test through with SPSS-Statistics-22 program. Differences in means or percentages were considered significant if a P value was below 0.05.

RESULTS

The study included seventeen patients, mean age of 13± 2.5 years, 11 women (65%), and 6 men (%25). In the evaluation of anterior, posterior, and lateral wall movements, the best plane was detected as axial (Video 1). Preoperative closure patterns were suitable for planning. The location and viability of the posterior wall located grafts were evaluated, found at the second cervical vertebra and viable. The cartilage graft was seen as hypointense and the fat graft was seen as hyperintense (Video 2a, Video 2b). All of the pharyngeal flaps were superior pharyngeal flap. While there was no nasal air escape at sagittal plane, in axial dynamic images, gap was detected which is all essential for the airway and must be obtained. According to the preoperative images, the decrease in leakage was evident (Video 3a, Video 3b).

Video 1. Anterior, posterior and lateral wall movements are best observed in the axial T2 weighted dynamic images.

Video 2a. In sagittal dynamic T2 weighted images, cartilage grafts are observed as hypointense (a) and fat grafts as hyperintense (b).

Video 2b. Fat grafts as hyperintense

Video 3a. Video 3b. In sagittal dynamic T2 weighted images, while there is no nasal air leakage, the required opening for the airway is observed in the axial dynamic images.

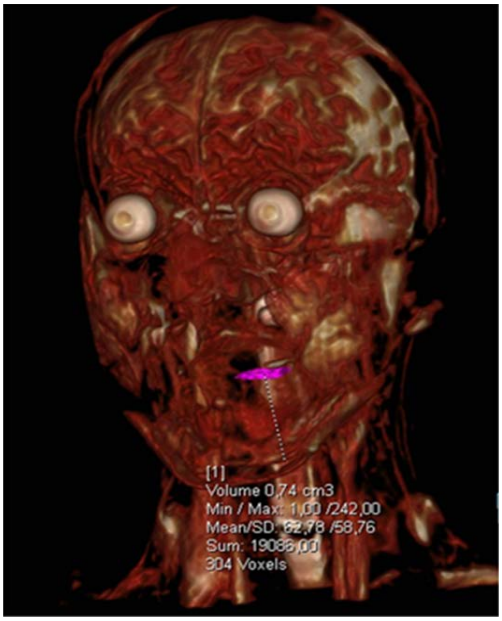

Figure 1. Three dimension volume rendered image is shown the nasal air leak area in detail.

Levator muscle was examined in all patients. While the levator muscle structure and functions were normal in the preoperative and postoperative images in patients who were operated for cleft palate at an early ages and has been refered us for VPI, the dramatical change was observed in preoperative and postoperative images of submucous cleft palate patients who were operated first time in our clinic because of changing the direction of the muscle from vertical to horizontal. Nasal air escape areas were examined in the axial plane and compared with preoperative images. It was decreased in both methods significantly compared with preoperative measurement ($p<0.05$) (Table 1). The nasal air leak area was also shown in detail through 3D images (Figure 1).

At 3rd month, posterior wall augmentation procedure was added for two patients who have detected with speech pathology also insufficiency in the flap size and closure in dynamic MRI.

DISCUSSION

Velopharyngeal insufficiency (VPI) is incomplete closure of the muscular valve or sphincter mechanism between oropharynx and nasopharynx during speech and there becomes hipernasality, and articulation errors during nasal voices (mmm, nnn). Velopharyngeal sphincter mechanism is consist of anteriorly velum,

Table 1. Preoperative and Postoperative MR values of VPO (cm^2) at Rest

	Preoperative	Postoperative	P value
mean±SD	1.96 ±0.86	1.43±0.38	0.032

Table 2. Treatment methods accoring to the closure patterns

Surgical Technique	İdeal Patient
Posterior wall augmentation	Sagittal closure pattern
Pharyngeal flap	Sagittal closure pattern
Sphincter pharyngoplasty	Coronal closure pattern
Furlow palatoplasty	Submucous cleft

lateraly lateral wall, posteriorly posterior wall, and muscles name of tensor veli palatini, levator veli palatini, palatopharyngeus, palatoglossus, constrictor pharyngeus superior and uvula (6). Except of nasal sounds closes and prevents nasal air escape. There are 4 closure patterns. Coronal, sagittal, circular and both.

The incidence of VPI after cleft surgery is high as 20% to 50% despite successful surgery and it is one of the most controversial the velopharynx to to about cleft palate due to speech, and social problems (7). VPI can occur due to insufficiency of superior and posterior movement of the velum because of levator dysfunction he velopharynx to tion, malposition, or shortens of the soft palate. On the other hand, lateral and posterior wall movement problems and additional surgeries like adenectomy, tonsillectomy… etc can cause incompetence. Besides, patients come in older age with speech problems with nondiagnosed submucous cleft palate. Multidisciplinary team approach with the otolaryngologist, speech therapist, orthodontist, pediatrician, plastic surgeon, psychologist and prosthodontist is required for the management of velopharyngeal insufficiency. For treatment there are surgical and nonsurgical techniques (2). Prosthetic matherials and speech therapies are nonsurgical options for suitable patients. For surgical treatment, it is important to evaluate the gap size, location of the defect, and closure pattern (Table 2) (2).

For preoperative and postoperative evaluation there are clinical and instrumental methods. While intraoral physical examination, evaluation of speech, and history of previous surgeries are clinical methods, cephalometric studies, videofluoroscopy, nasoendoscopy, nasometry, MRI, and electromyography (EMG) are instrumental methods for evaluation. Videofluoroscopy, cephalometric studies, nasoendoscopy, and speech tests are the most common techniques used for diagnosis and follow up (5) but none of these methods is ideal or objective (2,8). Goal of instruments is to assess structure, movement, the extent of closure, and timing (9). Nasoendoscopy is applied by inserting a flexible fiberoptic laryngoscope through a nasal cavity. Posterior and lateral pharyngeal wall movement, orientation of the levator veli palatini, soft palate, and any gaps during speech can be evaluated. It is still gold standard in evaluation for many institutes (10). It was found insufficient in the evaluation of the lateral wall (11). Difficulty of patient cooperation and obtaining qualitative values are disadvantages.

Radiographic views are obtained by injecting contrast via syringe into a nose to coat the nasopharynx through with videofluoroscopy. Length of velum, posterior, anterior, and lateral wall movement and timing can be assessed (4). Compliance and exposure to ionizing radiation are disadvantages of this technique. It is showen as one of the two primary state-of-the-art tools for examination like endoscopy in recent studies and recommend to do lateral videofluoroscopy as the first stage not to exposure high radiation than nasoendoscopy as a next stage if videofluoroscopy is not enough (4). Nasometry obtains ability of objective measures the amount of nasal acoustic energy and air escape from velum to nose but it is unable to estimate the anatomic and physiological problem and the closure pattern (12).

Velopharenx is a three dimensional anatomical structure, because of this must be overview in each projection (4). Dynamic MRI is another available technology for preoperative and postoperative evaluation with qualitative values (13,14). It is a non-

invasive method that obtains images and videos in each of three planes (15, 16). So it is very usefull for anatomical and also physiological examination due to being objective, noninvasive, effective, fast, reliable, and easy to tolerate without contrast and ionizing radiation. Patient compliance is easier than nasoendoscopy the because of not being invasive method. Surgical follow up with dynamic MRI is not common but can be used safely. It provides a complete anatomical assessment compared to other methods (17). Movement of the pharyngeal walls can be evaluated during speech. And we can assess our questions in postoperative period like if there is an the atrophy of the flap, atrophy of the graft whether graft position is like our plan or changed, and if there is an air leak in sagittal, coronal, or axial plane. Disadvantages of this technique are cost, claustrophobia, toleration difficulty in children due to sound and long-term period, and taking images at supine position because gravity may affect the speech and closure (12).

In the evaluation of the velopharyngeal area, only sagittal images were used in some studies, while in our study, axial and coronal images were used as well as sagittal images. Anterior, posterior and lateral wall movements were best evaluated on axial T2-weighted images. In addition, nasal air leakage was best evaluated on axial images, and a significant reduction in air leakage was detected in postoperative images, which was found to be consistent with the literature. The limitation of this study is that being designed with a small patient group. We think that it offers a new concept in the evaluation of common atrophy problems, especially of autologous grafts and pharyngeal flaps, or other anatomical or physiological problems after VFI surgery. On the other hand, there is a need for large series, comparing dynamic MRI with videofluoroscopy and nasoendoscopy.

In conclusion, Dynamic MRI can be used for postoperative follow-up as it used for preoperative planning. Evaluation of the atrophy of the pharyngeal flap and grafts that are used for augmentation and also gap size are provided with qualitative values. With limitations like cost, claustrophobia, and toleration problem in children, dynamic MRI obtains three- dimensional, objective, and anatomical also physiological evaluation of the velopharyngeal valve without ionizing radiation, contrast, and invasive techniques.

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