Role of Magnetic Resonance Imaging in Velopharynageal Insufficiency Correction

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Original Article

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ABSTRACT

Purpose: To explore the role of magnetic resonance imaging (MRI) in the evaluation of patients with velopharynageal insufficiency (VPI) and to use the MRI information obtained to aid in the treatment decision besides its role in the postoperative evaluation of the patients after VPI correction.

Materials & Methods: This interventional study that was carried out on 8 patients with VPI due to decreased velar mobility. Preoperative clinical, nasopharyngoscopy and MRI were done for all patients. All patients were undergone intravelar veloplasty to reposition the muscles in their normal position and increase velar mobility. All patients underwent regular follow-up for three months by clinical, nasopharyngoscopy and MRI.

Results: MR images provided evidence of an interruption of levator veli palatine muscle tissue in the midline and a substantial attachment of levator muscle tissue to the posterior border velopharyngeal insufficiency of the hard palate preoperatively which was coincident with the decreased velar mobility via nasopharyngoscopy in all patients. Postoperatively, velar mobility was increased in all patients which was evident by nasopharyngoscopy and quantitative analysis of LVP by MRI.

Conclusion: MRI has important role in diagnosis of VPI which was confirmed by nasopharyngoscopy beside its role in the postoperative evaluation of the LVP.

Key Words: magnetic resonance imaging (MRI), levator veli palatine muscle (LVP), and velopharyngeal insufficiency (VPI).

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INTRODUCTION

Velopharyngeal incompetence is a complication next to cleft palate surgery, with an incidence ranging from 5 to 38 percent after palatoplasty[1]. VPI effect is not only troubled swallowing, but also interruption of speech and deterioration of communicative ability. It affects speech by many means; principally hypernasality, imprecision of consonants articulation, faulty compensatory articulatory mechanisms, and audible nasal emission of air [2]. Numerous other symptoms of veopharynageal insufficiency include nasal regurgitation of food and liquids during feeding and spitting up, recurring chronic sinus infections, which may be a marker of nasopharyngeal reflux, and persistent nasal cavity contamination. Similarly, persistent otorrhea with a grommet tube in place may be caused by nasopharyngeal reflux that travels through the middle ear and up to the eustachian tube[3].

When the velopharyngeal valving mechanism cannot completely close to separate the oropharynx from the nasopharynx during speech production, veopharynageal insufficiency occurs. The velum (soft palate) and the three pharyngeal walls—posterior, left lateral, and right lateral—are the anatomical components of the velopharynx. Three fundamental factors control the velopharyngeal closure process: (1) superior and posterior movement of the soft palate caused by contraction of the levator veli palatine muscle LVP; (2) medial movement of the lateral pharyngeal walls; and (3) forward bulging of the posterior pharyngeal wall, creating a Passavant's ridge to aid in velopharyngeal closure [4].

Levator Veli Palatini muscles: Each muscle is cylindrical and originates from the base of the skull. It also arises from the petrous part of the temporal bone, the upper part of the carotid sheath, and a small number of fibers from the fibrocartilaginous part of the eustachian tube, which is located immediately anterior to the inferior opening of the internal carotid canal. In 40% of cases, the levator is located in the center of the soft palate, excluding the uvula [5].

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The soft palate and LVP both contribute significantly to the pathophysiology of velopharyngeal incompetence. Velopharyngeal incompetence may be caused by a malfunction of the LVP or a short soft palate, but the treatments are very different. Consequently, accurate diagnosis is essential. The availability of sufficient levator musculature is required for procedures that depend on the reconstruction of a functional levator sling [4].

Speech treatment is started once velopharyngeal incompetence is diagnosed. If the patient doesn't improve their hypernasality enough despite speech therapy, secondary surgical surgery to reinstate a functional velopharyngeal valving mechanism may be necessary.

If the levator muscle sling can be repaired, this may eliminate the need for pharyngeal flap surgery or sphincter pharyngoplasty, which alters the posterior or lateral pharyngeal walls. Furlow palatoplasty[6] or palate re-repair in patients with postpalatoplasty velopharyngeal incompetence, as recommended by Sommerlad and colleagues [7], can be used to perform dynamic reconstruction of the levator sling. However, trying dynamic levator rebuilding would not be successful if the levator mechanism was little or had been replaced with scar after prior surgery[4].

Multiple modalities such as speech and language assessment tools, nasopharyngoscopy, videofluroscopy and MRI are existing to such teams to confirm the diagnosis of VPI. However, wide variation of opinion occurs as to which investigations are most accurate and helpful when it comes to planning surgery [8] .

Videofluroscopy was the most used investigative tool to diagnose VPI. It provides the surgeon with a rapid, dynamic assessment of palatal function, is non-invasive and consequently more easily tolerated by young patients. However, Videofluroscopy interpretation is difficult because of the shadows introduced by the overlying structures. Moreover, expose patients, frequently of a young age, to a level of radiation which is greater when multi-planar views are performed. Patients with a previous history of cleft palate are likely to undergo frequent radiological investigation during their lifetime and therefore this investigation tool should not be used injudiciously [9] .

Nasoendoscopy is another tool that allows direct visualization of the velopharyngeal mechanism, with no radiation exposure, that can be utilized in an outpatient setting. However, it has invasive nature and that it is tolerated unwell in children when compared with alternative investigative measures. In addition to its invasiveness, nasoendoscopy allows only a single viewpoint (from a ventral and cephalad observation point) of the soft palate [10] .

Imaging of the velopharyngeal mechanism is possible with magnetic resonance imaging, which is noninvasive and free of any radiation danger. The velopharyngeal valving mechanism can be anatomically assessed using magnetic resonance imaging, which is not achievable with other methods now in use [4] . Recently technological advancements of MRI have led to superior investigation of the LVP muscle in normal and abnormal anatomy [11] . Accordingly, we planned this study to explore the application of magnetic resonance imaging (MRI) in the evaluation of patients with Velopharynageal insufficiency (VPI) and to use the MRI information obtained to aid in the treatment decision beside its role in the postoperative evaluation of the patients after VPI correction.

MATERIALS & METHODS

This is an interventional comparative study. It was conducted on eight patients, 48 to 66 months with VPI. The patients were examined both clinically, by magnetic resonance imaging and nasopharyngoscopy and managed at the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Tanta University.

Patient Selection

Patient's age older than 48 months with VPI due to decreased velar mobility. We excluded syndromic patient and patients with relevant systemic disease.

I) Preoperative management:
All patients underwent the subsequent treatments:

Preoperative initial consultation interviews with the patient`s families were conducted primarily to gather demographic information, get medical, surgical, and dental histories, as well as to hear about the patients' functional complaints and the expectations of their relatives for the postoperative period.

Approval for this research was obtained from Research Ethics Committee of Faculty of Dentistry, Tanta University #R-OS-10-22-11,on October 2022. The purpose of the present study was explained to the patient's parents and informed consents were obtained according to the guidelines of human research adopted by the Research Ethics Committee at Faculty of Dentistry, Tanta University.

1. Clinical evaluation:

All patients were examined extraorally to evaluate associated cleft lip, its type, unilateral or bilateral, repaired or not, asymmetry of the alar base, presence of secondary nasal deformity or not and listening to speech and intraorally to evaluate if there is any residual fistula, color and quality of soft tissues and soft palate length and mobility.

2. Magnetic Resonance Imaging:

All patients underwent imaging using proton density weighted images. Patients were given chloral hydrate orally to sedate them prior to imaging in order to avoid motion artefact. The primary dose ranges from 50 to 75 mg/kg up to a total of 2000 mg12.

A General Electric Echo Speed 1.5 Tesla system (Milwaukee, WI) was used to produce head pictures. An oblique coronal sectioning plane was used to scan all of the patients. This was accomplished by predicting the potential course of LVP in a superior-posterior manner from the soft palate and using a sagittal "scout" image12.

The oblique coronal plane was used to measure the following parameters for levator palatine muscle [12] .

1. Angle of origin in relation to the reference line and the belly of the muscle along its course into the velum.

2. Length of the LVP from the origin to the middle of the velum.

3. Thickness of the levator muscle sling.

3- Preoperative Nasopharyngeal Endoscopic Evaluation:

Nasoendoscopic examination of the patients was done by Phoniatrics specialist to give dynamic visualization of the area allowing assessment of the pattern of velopharyngeal closure during speech and mobility of soft palate, lateral pharyngeal walls and posterior pharyngeal wall.

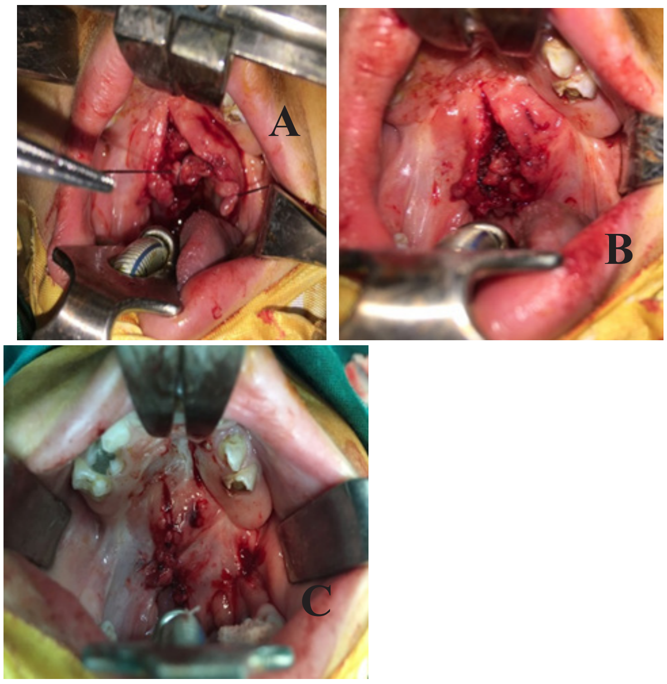
All patients were examined by flexible endoscope after nasal tamponade was applied with topical anesthesia; the nasofibroscope was attached to a digital camera that in turn was connected to a personal computer and saved on the computer for further analysis and ratings.

II) cleft repair surgery

Following the usual patient preparation for surgery. All patients had midline oral endotracheal intubation during the surgical procedures under general anaesthesia. Epinephrine (Adrenaline) was injected into the palate 5-7 minutes before to surgery using a smaller syringe to induce vasoconstriction and hemostasis for simpler hydrodissection in the hard palate region.
According to the surgical procedure,

According to Marsh et al., [13] intravelar veloplasty

In order to achieve a complete anatomic retrodisplacement, the IVV procedure involved carefully separated muscle fibres from the tensor aponeurosis, the posterior constrictor muscle, the back edge of the hard palate shelves, and the nasal mucosa.Then, the muscle was released.



Figuer (1) shows intraoperative photos of patient No. 3 in Group I a. with a midline oral mucosa incision, b. muscle layer closure using non-absorbable 4-0 nylon sutures c. oral layer closure using 3-0 Vicryl absorbable sutures.

Postoperative follow-up:

All patients were followed up clinically, by using magnetic resonance imaging and nasopharyngoscopy for six months.

1.Clinically:

Clinical postoperative follow-up on all patients was conducted for three months. The patients' wound healing, fistula development, and nasal regurgitation during feeding were all assessed.

2.Magnetic resonance imaging:

Magnetic resonance imaging was performed three months post-operatively for all patients to evaluate the followings:

The two levator muscle bundles formed a cohesive sling, and the following measurements were made while using the oblique coronal plane to assess it [12]:

Angle of origin in relation to the reference line and the belly of the muscle along its course into the velum.

Length of the LVP from the origin to the middle of the velum.

Thickness of the levator muscle sling.

3-Postoperative Nasopharyngeal Endoscopic Evaluation:

Nasoendoscopic examination of the patients was done by a Phoniatrics specialist to give dynamic visualization of the area allowing assessment of the pattern of velopharyngeal closure during speech and mobility of soft palate, lateral, and posterior pharyngeal walls.

For all patient's application of nasal tamponade was done using topical anesthesia, and patients were examined by a flexible endoscope; the nasofibroscope was attached to a digital camera that in turn was connected and saved to a personal computer for further analysis and ratings.

Statistical analysis:

Numerical data are analyzed by descriptive statistics as mean, standard deviation and range. Paired t-test was used to compare pre and postoperative readings. P-value <0.05(*) was considered a significant difference & P-value <0.001(**) was considered a highly significant difference. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS version 22).

RESULTS

The preoperative collected data regarding the patients age and gender.

patients were 3 females and 5 males, age ranged from 48 to 66 months, the mean of age was (57) months.

The results of this study were:

1) Clinical:

Without any wound dehiscence or infection, primary wound healing was successfully completed in all patients. There were no oronasal fistulas noted. None of the patients had nasal regurgitation during eating. Figuer (2).

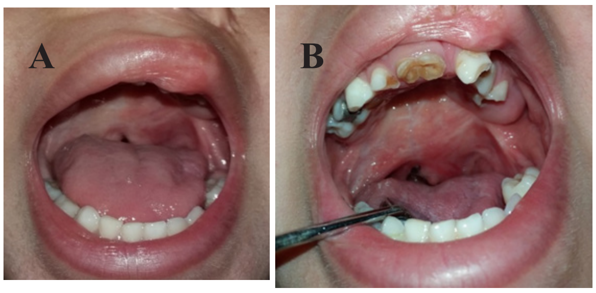


Figure (2) : patient no. (3)

A. preoperative photo displaying scar on the palate;

B. six-month photo displaying full wound healing

2) Magnetic resonance imaging:

Three months after the procedure, magnetic resonance imaging was used to monitor all patients and evaluate the following:

The oblique coronal plane showed the cohesive sling created by the two levator muscle bundles in all patients and the following measurements: the angle of origin Figure (3), Length Figure (4), thickness of the LVP muscles Figure (5).

The MRI post operative measurements of the angle of origin, Length, thickness of the LVP muscles were found to be statistically significantly higher compared to the preoperative measurements (P< 0.001), see table 1.

Table (1): Statistical analysis of angle of origin, Length and Thickness of LVP preoperatively and postoperatively.

Angle of origin	Range	mean	Standard deviation	T	P
Preoperative	55.00-57.25	55.94	0.8939	t=11.02	< 0.0001***
Postoperative	60.50-64.00	62.69	1.287		
Length of LVP					
Preoperative	26.25-29.50	27.69	1.183	t=10.95	< 0.0001***
Postoperative	33.00-35.50	34.05	0.8992		
Thickness of LVP					
Preoperative	4.100-4.550	4.363	0.1788	t=6.645	0.0003***
Postoperative	4.950-6.500	5.525	0.4971		

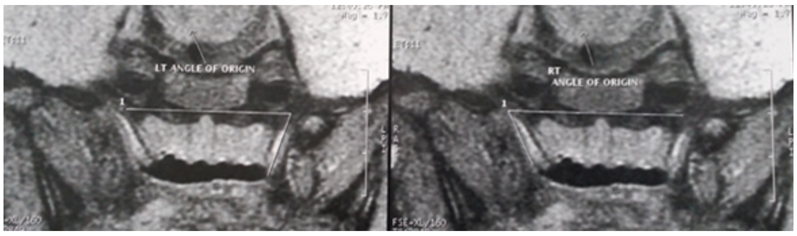


Figure (3) : A postoperative oblique coronal picture of patient no. 4's soft palate illustrates the angle of origin of the right LVP and left LVP;

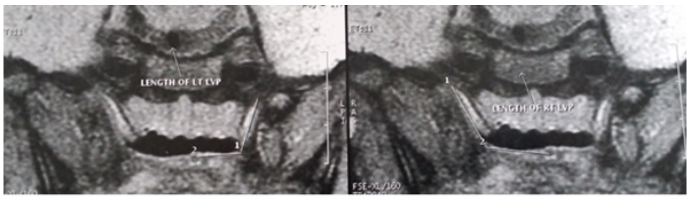


Figure (4) : A postoperative oblique coronal picture of patient no. 4's soft palate illustrates the length of left LVP and right LVP.

Figure (5) : A postoperative oblique coronal picture of patient no. 4's soft palate illustrates the thickness of right and left LVP.

3.Nasopharyngoscopy

After examination of all patients by a Phoniatrics specialist with flexible endoscope after nasal tamponade was applied with topical anesthesia; and attachment of the nasofibroscope was done to a digital camera that in turn was connected and saved to a personal computer, all patients showed better speech quality with improvement of the anterior-posterior closure due to increased mobility of the velum without change of closure pattern.

DISCUSSION

Treatment considerations for most surgeons in cleft palate surgery include (1) proper growth and development of the palate and facial structures, (2) development of normal dental occlusion, (3) integrity of the repair without fistula formation, and (4) understandable speech. Irrespective of the procedure employed for the initial palatoplasty, 20 to 30 percent of individuals who have palatoplasty suffer velopharyngeal incompetence, which results in an ineffective velopharyngeal valve mechanism[14]. The treatment of velopharyngeal incompetence may require secondary surgical intervention in a significant majority of these patients [15].

In the current study, we selected patients who suffered from VPI due to decreased mobility of the velum which appeared from nasopharyngeal endoscopy.

Because of MRI's technological breakthroughs, we are now able to collect specific anatomical information, such as muscle direction and distribution, as well as a good soft tissue contrast [11]. We chose to utilize it in our study since it is also simple to replicate, noninvasive, and does not involve ionizing radiation. videofluoroscopy uses ionizing radiation and produces overlaid pictures that may confuse the distinctions between bone and soft tissue in addition to having a limited ability to distinguish between soft tissue [16]. These drawbacks justify the use of MRI in our study.

According to Kuehn DP et al.,(2004)[12], proton density-weighted images provide the highest contrast of LVP in relation to surrounding soft tissue structures when compared with either T1- or T2-weighted images. All subjects were imaged using a sagittal plane and an oblique coronal sectioning plane which was achieved in reference to a sagittal ‘‘scout’’ image and by estimating the probable course of the levator palatini muscle in a superior posterior direction from the soft palate[17] because of the LVP muscle is the primary muscle responsible for soft palate elevation during speech and swallowing[18].

In the present study, MR images provided evidence of an interruption of levator veli palatine muscle tissue in the midline and a substantial attachment of levator muscle tissue to the posterior border of the hard palate preoperatively which was coincident with the decreased velar mobility via nasopharyngoscopy in all patients. Moreover, quantitative analysis of LVP showed decreased angle of origin, length, and thickness of LVP preoperatively.

In the current investigation, palatal surgery significantly altered the course of LVP. The levator muscle's course was made steeper relative to its origin at the base of the skull by severing the fibers from the hard palate and releasing the anterolateral attachments in the area of the pterygoid hamulus. This was accomplished by a significant increase in the angle of origin when comparing preoperative and postoperative images. According to Kuehn DP et al., (2004) [12] and Ettema SL et al., (2002) [18] , a more acute angle of origin would result in less advantageous leverage for raising the soft palate.

In this study, the significant increase of length, thickness, and the angle of origin of the LVP muscle postoperatively is likely a favorable outcome in improving velar elevation and this was clinically proved by better speech and improved velar mobility with nasopharyngoscopy Which agree with Bosi V, (2016) [19] and Ravishanker, (2006) [20] respectively who reported Speech was near normal with a low rate of hypernasality.

Finally, the analysis of the clinical, magnetic resonance, and nasopharyngoendoscope results of the current study, proved that MRI is a valuable method for diagnosis of VPI besides its role in the postoperative evaluation of tightening and retropositioning of the levator musculature with improved velopharyngeal closure.

CONCLUSION

1-Magnetic resonance imaging is a trustworthy and efficient method for photographing children with VPI's palates and getting precise anatomical details such muscle distribution and orientation.

2- Repair of the palate utilising retropositioning of the velar muscles proved beneficial in the therapy of VPI. This procedure adheres to basic plastic surgical principles in aiming to restore normal architecture as much as possible and entails very little morbidity.

3- Quantitative analysis of LVP by MRI has very important role in comparing the postoperative with preoperative values.

CONFLICT OF INTEREST

The authors have no competing interests to declare that are relevant to the content of this article

REFERENCES

1. Witt PD, D'Antonio LL. VPI and secondary palatal management: A new look at an old problem. Clin. Plast. Surg. 1993;20:707

2. Kotby MN, Basuny S, El-Zomor M and Mohsen E.Standardization of an articulation test. Proceedings of the 9th Annual Am Shams Medial Congress.1986.

3. Conley SF, Gosain AK, Marks S, Larson DL. Identification and assessment of velopharyngeal inadequacy. Am J Otolaryngol. 1997;18:38–46.

4. Dennis S. Kao, David A. Soltysik, and James S. Hyde Magnetic Resonance Imaging as an Aid in the Dynamic Assessment of the Velopharyngeal Mechanism in Children. Plast Reconstr Surg. 2008 Aug; 122(2): 572–577.

5.Huang H, Lee T, Rajendran K. A fresh cadaveric study of the paratubal muscles: Implications for eustachian tube function in cleft palate. Plast Reconstr Surg. 1997;100:833.

6. Sommerlad BC, Henley M, Birch M, Harland K, Moiemen N, Boorman JG. Cleft palate re-repair: A clinical and radiographic study of 32 consecutive cases. Br. J. Plast. Surg. 1994;47:406.

7. Conley SF, Gosain AK, Marks SM, et al. Identification and assessment of velopharyngeal inadequacy. Am J Otolaryngol 1997;18:38e46.

8. Havstam C, Lohmander A, Persson C, et al. Evaluation of VPIassessment with videofluoroscopy and nasoendoscopy. Br J Plast Surg 2005;58:922e31.

9. Henningsson G, Isberg A. Comparison between multiview videofluoroscopy and nasendoscopy of velopharyngeal movements. Cleft Palate Craniofac J 1991;28:413e7.

10. Ha S. LVP in Cleft Palate Anatomy and Its Implications for Assessment Velopharyngeal Function: A Literature Review. Korean J Commun Disord, 2007;12(1):77–89.

11. Kuehn DP, Ettema SL, Goldwasser MS, Barkmeier JC. Magnetic resonance imaging of LVP before and after primary palatoplasty. Cleft Palate-Craniofacial J. 2004;41(6):584–92.

12. Ettema SL, Kuehn DP, Perlman AL, Alperin N. Magnetic resonance imaging of LVP during speech. Cleft Palate-Craniofacial J. 2002;39(2):130–44.

13. Marsh, JL, Grames LM, Holtman, B. Intravelar veloplasty: a prospective study. Cleft Palate J. 1989;26(1):46–50.

14. Witt PD, D'Antonio LL. Velopharyngeal insufficiency and secondary palatal management: A new look at an old problem. Clin. Plast. Surg. 1993;20:707.

15. Akgüner M. Velopharyngeal anthropometric analysis with MRI in normal subjects. Ann. Plast. Surg. 1999;43:142.

16.Beer AJ, Hellerhoff P, Zimmermann A, Mady K, Sader R, Rummeny EJ et al. Dynamic near-real-time magnetic resonance imaging for analyzing the velopharyngeal closure in comparison with videofluoroscopy. J Magn Reson Imaging. 2004;20(5):791–7.

17.Kuehn DP, Ettema SL, Goldwasser MS, Barkmeier JC. Magnetic resonance imaging of the levator veli palatini muscle before and after primary palatoplasty. Cleft Palate-Craniofacial J. 2004;41(6):584–92.

18.Ha S. The Levator Veli Palatini Muscle in Cleft Palate Anatomy and Its Implications for Assessment Velopharyngeal Function: A Literature Review. Korean J Commun Disord, 2007;12(1):77–89.

19.Bosi V, Brandro G, Yamashita R. Speech resonance and surgical complications after primary palatoplasty with intravelar veloplasty in patients with cleft lip and palate. Rev Bras Cir Plast. 2016;31:43-52.

20.Ravishanker R. Furlow’s palatoplasty for cleft palate repair. Med J Armed Forces India. 2006;62(3):239–42.