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Using MRI and Nasopharyngeal Endoscopy for Assessment of Soft Palate Following Cleft Palate Surgical Repair Using Two Surgical Techniques

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ABSTRACT

Purpose: to compare and assess the results obtained by using 2 different surgical techniques that utilize two stage palatoplasty to repair the palate, Furlow's technique and intravelar veloplasty. **Material and Methods:** This study was performed on 14 patients suffering from cleft palate, patients were divided into 2 groups, in group I Furlow's technique was used in palatal repair, in group II IVVP technique was used in palatal repair. All cases were selected from the Outpatient Clinic of the Faculty of Dental Medicine, Al-Azhar University for Girls. **Results**: Postoperative results of the MRI showed that the velum and the length of the muscle has become longer in each group, even though, there was no significant change between both techniques. The postoperative results of the nasopharyngeal endoscope proved that the increase in the levator muscle length increased the movement of the velum, in each group, however, between both group there was no significant difference. **Conclusions:** Both Furlow palatoplasty and intravelar veloplasty are efficient techniques that can be used in the repair of cleft soft palate. Both techniques can lengthen the soft palate together with palatal muscle reorientation; without the need to raise large mucoperiosteal flaps from the hard palate. Both techniques, with their modifications had shown success in the primary closure of different varieties and sizes of cleft gaps. The two stage palatoplasty can eliminate the need to raise large mucoperiosteal flaps from the hard palate.

KEYWORDS

MRI, nasopharyngeal endoscopy, cleft palate surgical repair.

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INTRODUCTION

Proper primary surgical correction of the cleft palate has been the main goal for all techniques of palatoplasties over the decades, to accomplish normal speech, and adequate velopharyngeal function, adequate surgical procedure must be selected carefully according to the size of cleft gap, cleft type, and patient age[1] . Selecting the proper technique to achieve anatomical palatal muscle repositioning, and palatal lengthening to achieve adequate, semi normal velopharyngeal seal during swallowing and during phonation, without adversely affecting maxillofacial growth of the patient, is the ultimate goal for all kinds of palatoplasties[2].

Through the past decades furlow double opposing z-plasty and intravelar veloplasty (IVVP) were of the most popular techniques in both primary and secondary repairing cleft palate. They both carry mix of advantages and drawbacks, both techniques underwent so many modifications to ensure their eligibility to repair any type, size, shape of cleft palate [3].

This study was intended to compare the soft palate repair outcomes between both techniques while using 2 stage palatoplasty.

Evaluation methods were magnetic resonance imaging (MRI), and nasopharyngeal endoscopy (NPE). MRI is one of the most promising imaging techniques that was recently used to evaluate velopharyngeal sphincter,[4] NPE is one the most utilized functional imaging tools in evaluating velopharyngeal sphincter[5], and surrounding structures during rest and phonation, both techniques have lots of advantages and many disadvantages that will be discussed in details throughout the study.

MATERIAL AND METHODS

Patient's selection

This study was conducted on 14 cleft lip and palate patients,5 patients were females, and 9 were males, 8 suffered from unilateral complete cleft lip and palate, 3 suffered from complete bilateral cleft lip and palate, and 3 suffered from isolated cleft palate, age ranged (0.9- 4) years old. All cases were selected from the Outpatient Clinic of the Faculty of Dental Medicine, Al-Azhar University for girls

Cases were divided into 2 groups:

Group I: underwent palatoplasty using furlow double opposing z-plasty.

Group II: underwent palatoplasty using intravelar veloplasty.

All patients were followed for 4 months postoperative. Hard palate repair after 4 months postoperatively. Hard palate repair, using Von Langenbeck, bipedicle palatal flap, or direct closure, according to residual gap size.

The study included patients with non-syndromic cleft palate and primary closure cases.

Pre and postoperative evaluation: clinical examination included: Nasopharyngeal endoscopy, Magnetic Resonance Imaging.

Surgical Procedures: Soft palate procedures: Furlow double opposing z-plasty, Intravelar veloplasty. Hard palate procedures: Von Langenbeck, Bipedicle palatal flap and in some case direct closure.

Pre and Postoperative Nasopharyngeal Endoscopic evaluation:

This evaluation included recording ratings according to 4 points:

1. Velar movements.
2. Lateral pharyngeal wall movement.
3. Posterior pharyngeal wall movement.
4. Shapes of the gap between the soft palate and posterior pharyngeal wall.

Preoperative and postoperative Magnetic resonance imaging evaluation

Imaging of velopharyngeal region of the subjects was done after determining optimal imaging parameters such as pulse sequence, echo time, repetition time, slice thickness, signal to noise ratio, and oblique imaging orientation. Static images of the velopharyngeal region, specifically the LVP muscle in the oblique/coronal plane, and the velopharynx details in the mid sagittal plane were obtained from these subjects, Imaging was done using 1.5 tesla.

Measurements Collected for Data Analysis

Data collection for each subject was completed and analysis was made by software used at the MRI workstation.

– Measurements that were collected from the sagittal plane study at rest were to evaluate the following:

1. Distance between the anterior and posterior nasal spine. ANS-PNS.
2. Length of the velum from the postnasal spine to the end of uvula. PNS- velum
3. Distance from the posterior nasal spine and the posterior pharyngeal wall also known as pharyngeal depth.
4. Velar angle: Angel between hard palate and soft palate.

   Measurements of LVP muscles that were collected from the oblique coronal plane at rest were to evaluate the following:

5. Width of origin: Distance between the left and right points of LVP origins. (reference line)
6. Length of the LVP from the origin to the middle of the velum for both the left and right sides.
7. Angle of origin for both the left and right sides in relation to the reference line and the belly of the muscle along its course into the velum.

Postoperative clinical evaluation:

All patients were followed up clinically immediate postoperative, and for 6 months postoperative. Patients were evaluated for the following:

1. Hemorrhage.
2. Fistula formation.
3. Suture stability.
4. Postoperative nasopharyngeal endoscope.
5. Postoperative MRI.

Statistical analysis

All test data was converted and manipulated by using SPSS software program version 20.0. Data was analyzed, mean and standard deviation was calculated as regarding quantitative data as age, MRI scores and clinical scores while qualitative data as gender, type of cleft palate and pattern of closure were presented by number and percent. Comparisons between pre and post-surgical results were done as well as comparison between subjects who did Furlow surgery or IWP surgery. The quantitative data was compared, and t test was applied for normally distributed data and Mann-Whitney test was done for non-parametric data, while Chi square was calculated among groups as regards qualitative data. P value was established to determine the statistically significant difference between the two groups. The difference between the two groups were considered statistically significant when $p<0.05$ and considered highly statistically significant when $p<0.01$.

RESULTS

Group I included 7 patients 4 patients 57.1% had unilateral cleft palate, 1 case 14.3 % had bilateral complete palate, and 2 cases 28.6% presented with isolated palate. The mean age (months) of the patients in this group was (18.86±8.2). Group II 7 patients 3 patients 42.9% had unilateral complete cleft lip and palate, 3 patients 42.9% had bilateral complete cleft lip and palate, and 1 patient 14.3% with isolated cleft palate. The mean age (months) of the patients in this group was (19.57±12.9). Table (1) shows comparison between studied cases; the results showed that there were no significant differences between the two groups as regarding age, gender or cleft type ($p>0.05$).

Sagittal and coronal MRI measurements:

Comparison between group I and group II revealed a highly significant difference in velar angle difference ($p<0.01$) and significant differences in ans/pns and in left angle of origin ($p<0.05$) according to pre-post mean difference of MRI records

Table (1): *Comparison according to mean difference between group I and group II.*

	Group I mean difference	Group II mean difference	Paired t	P value
ANS Velum	-0.49±5.2	-5.8±7.2	3.75	<0.001**
ANS PNS	0.67±0.4	0.48±0.4	2.16	0.034*
PNS Velum	0.74±0.2	0.69±0.1	1.306	0.197
PNS PPW	0.39±0.6	0.39±0.6	0.041	0.967
Left angle of origin	6.34±5.3	3.61±6.5	2.04	0.045*
Right angle of origin	5.43±2.6	3.31±7.7	1.637	0.109
Width of origin	0.45±0.6	0.3±0.4	1.562	0.123
Right LVP length	0.68±0.4	0.77±0.5	0.879	0.383
Left LVP length	0.7±0.4	0.63±0.4	0.722	0.371

Nasopharyngeal Endoscope Statistical Analysis

When performing a statistical analysis on nasopharyngeal endoscopic results for both groups, Mcnemar- Bowker and chi-square test cannot be performed. Because pre and postoperative data had different categories, difference between both data was considered sig ($p<0.05$).

DISCUSSION

Primary Purpose of palatoplasty is anatomical reconstruction of the palate, and to promote development of normal speech while decreasing the incidence of oronasal fistula and ensuring long-term harmonious facial growth [1]. Choosing the proper technique for primary palate closure is a complicated decision that must take into consideration cleft type, cleft gap width, patient age, and skills of the surgeon[1].

This study was designed toward comparing two of the most surgical techniques that are widely used in repairing cleft palate, furlow double opposing z-plasty, and intravelar velar veloplasty. Both techniques were commonly adopted by many surgeons, and both were reported to produce improved speech outcomes and decreased incidence of velopharyngeal incompetence [6].

Since its introduction, the Furlow technique was used widely over many decades. Over the years many studies were performed to evaluate the effect of this technique on the velar function and its ability to reposition the levator veli palatini muscle to a more physiologic position and to lengthen the muscular palate [7]. However, it was reported to be a demanding technique, not easy to be performed or learned, still it had been proven to be beneficial in repairing several types of clefts[7].The same comment was verified in this study as it was judged to be a more complicated and time-consuming technique than the IVVP technique.

IVVP palatoplasty was used in the current study as the other technique to be compared with the Furlow technique[8].The IVVP technique had variable modifications, which were made by different surgeons, all these modifications focused on the musculature and how it was dissected and repositioned[9]. The outcomes of intravelar veloplasty were described to be dependent on proper identification, good handling and extensive levator veli palatini muscles retro positioning. Thus, intravelar veloplasty was described as a more operator dependent technique. To compare the outcome of both techniques on the soft palate, three methods of evaluation were used including clinical assessment, MRI evaluation and NPE examination[10].

Clinical assessment of the postoperative successes of cleft palate surgery is usually evaluated by proper healing without dehiscence, presence of postoperative hemorrhage, airway obstruction, or flap necrosis; and on the long term by speech evaluation. In this study two cases in group I and two cases in group II suffered from postoperative partial wound dehiscence after the first stage palatoplasty. In those cases, this complication was corrected successfully during the second stage of hard palate closure.

MRI as a revolutionary imaging technique, was used in this study to anatomically evaluate velopharyngeal sphincter and to provide a clear view of the changes of its components postoperatively [11]. Nasopharyngeal endoscopy is a valuable tool that allows direct exposure of the velopharyngeal port to detect the presence of a gap during phonation, as well as the individual movement of each component of the velopharyngeal valve (VPV). It is a noninvasive technique and requires limited cooperation from the patient during the procedure. Its true value lies in the assessment of subjects who are candidates for secondary repair of the palate. By direct oral examination only, the VP gap size cannot be determined, the amount of contribution of each wall of the VPV could not be estimated. NPE also helps in determining the closure pattern in the VPV thus allowing a better choice of the type of secondary repair when decided [12].

Literature and studies proved that speech quality is the main real evaluation for the success of any surgical technique, it also assesses in surgical procedure [13, 14]. However, it was not used as evaluation in this study because of the early age group of the patients.

MRI data can be easily analyzed through a digital reader program to obtain required measurements [15]. MRI technology is more capable in assessing anatomical structures than other popular methods. Also, technological advancement of MRI contributed to better investigation of normal and abnormal anatomy, identify normal/ abnormal quantity, and structure of the LVP muscles [16]. However, it is still more of an experimental method for evaluation as it is expensive and requires sedation for young children.

MRI was utilized to evaluate the velopharyngeal sphincter, soft palate, and the LVP muscles. This evaluation was accomplished by studying the measurements obtained from both the sagittal view, and the oblique coronal view for both groups. Four measurements were obtained from sagittal view: the velar angle, ANS/PNS length, PNS/velum angle, and PNS/PPW length. Measurements were taken twice by same operator, and average rating was recorded, however the analysis program did not allow for saving the points of interest and every time new points were selected which may have affected the accuracy of the readings.

The velar angle in group I showed no statistical difference between preoperative and postoperative, which was also the case for group II. However, postoperatively there was statistically significant difference in the mean between both groups showing a significant decrease in group II compared to group I, noting that all patients in this study were sedated during the examination. Previous studies [17,18] evaluated velar angle by using dynamic MRI with voice recording to evaluate the change that happened in the angle and reported that changes in that angle indicate the tightness of VP closure and degree of mobility. In other words, as the angle decreased, velar elevation increased. This explanation was not substantiated by this study, as the MRI examination was static, and patients were sedated.

A study[19]found that the velar angle is affected by the length of the palate which is shorter than in the normal patients thus the problem in cleft patient not only deficiency in muscle mass but also in the length of the hard palate which acts as a lever from which the soft palate is suspended.

The ANS/PNS which represents length of the bony palate in group I increased postoperatively,

and this increase was statistically highly significant. At the same time group II, showed increase in the mean of the ANS/PNS length and was statistically significant. The difference between the mean in both groups was also significant. This measurement is the length of the hard palate and can be attributed to normal growth of the hard palate. A study was' made,[19] to compare the hard palate length in children with repaired cleft palate to hard palate of normal children and concluded that children with cleft palate had shorter hard palate than normal children, this may be due to longitudinal scarring in the hard palate that contributed to constricted maxillary growth, some cleft cases even reported missing the posterior extension of the hard palate. Previous investigators, have reported worse craniofacial morphology in individuals with repaired cleft palate compared to a more typical pattern of growth observed in age-matched individuals with unoperated cleft palate, however, the previously mentioned study was performed using cephalograms[20].however, in this study no groups of normal palate was included in the study of comparison which is a limitation, due to difficulty of convincing parents of normal child to undergo MRI specially that it is done under sedation. Further investigations can be done to know the effect of two stage palatoplasty on palatal growth.

In this study the PNS/velum length, was observed that the mean velar length (PNS/velum) showed significant increase postoperatively in both groups. This finding is a positive finding regarding the VP closure as it reflects better chance for forming a good seal. A study [21] was conducted on the effect of the velar length on the degree of velar closure that can be achieved surgically. They concluded that the velar length is an important to be evaluated prior to surgery to predict which patients were likely to benefit from Furlow Palatoplasty. If the uvula reaches as far as the posterior pharyngeal wall, the patient is likely to achieve velopharyngeal competency [20].

Palatal length is an important factor while performing palatoplasty. Previous research, [21] showed that patients with adequate palatal length had better speech outcomes compared with patients with shorter palates. However, palatal length was not the only variable necessary to achieve normal closure of the velopharyngeal port. A study,[22] noted that complete tensionless closure of the entire palate and construction of an adequately functioning soft palate with a muscle sling, at an early age, were even more crucial than the length of the palate. However, when considering using Furlow technique in wide cleft tensionless closure will not be achieved unless utilizing suitable case related modification, as was mentioned in earlier literature, and was conducted in this study. During this study, it was noted that length of soft palate should be elevated as a percentage in relation to the hard palate and could be determined clinically.

Although, the difference between the results of Furlow palatoplasty and IVVP was reported in favor of the Furlow double opposing z-plasty, no significant difference was detected in this study and both groups recorded comparable increase in the velar length postoperatively. This was attributed to the horizontal incision between the soft and hard palate that was added to IVVP technique that led to increase in the length of velum [23].

The length PNS/PPW for both groups recorded statistically insignificance, which means that this length was the same among the patients in both groups and this could be due to the fact that this length was recorded at rest while all the patients where sedated, and the significance of this length is mainly during phonation as it represents the pharyngeal seal during swallowing and phonation[16] This measurement shows that the patients were allocated to each group, regardless the degree and severity of cleft condition without bias between the two groups.

The angle of origin in the Furlow group recorded significant increase in the angle than the IVVP

group that increase was only on the left side, this measurement represents the angle the LVP muscle as it descends from its origin in the middle cranial fossa, and inserts in the palatine aponeurosis. It indicates the degree of muscle contraction and velar elevation. Previous studies [17, 19] indicated that the more acute (smaller) the angle, the more its ability to contract, thus giving idea about coarticulatory effects that achieves adequate seal with the posterior pharyngeal wall [18]. Although, the angle of origin increased in the IVVP group, which contradicts both the clinical and the NPE results, that showed improvement in the velar movement.

The LVP length in both groups reported significant increase in the postoperative for both groups than the preoperative, and there was no difference between both groups indicating similar positive effect of both techniques on the elongation of the LVP muscles. Studies [18] that used both static and dynamic MRI reported that the levator muscle got to its greatest length during rest and becomes progressively shorter during speech. Which depends on contractility of the muscle, a factor that was not tested in this study.

There were limitations to the MRI study, most of all was the cost as it was an expensive method of evaluation. Moreover, working with the age group of the study mandated sedation of the patients to perform the examination and this eliminated the ability to examine the velum dynamically during phonation.

Nasopharyngeal endoscopy was a valuable tool that allowed direct visualization of the velopharyngeal port to detect the presence of a gap during phonation as well as the individual movement of each component of the velopharyngeal valve (VPV) [24]. It is a noninvasive technique and requires limited cooperation from the patient during the procedure.

In this study, nasopharyngeal endoscopy helped in estimating other structures such as adenoids and tonsils and their contribution in the VPV closure. NPE proved to be a valuable tool that was used not only to evaluate the difference in the anatomical state before and after surgery by estimating the gap size, but also it helped in assessing the functional state of the VPV closure [23]. The latter was estimated by two things, the amount of movement of each wall before and after surgery and the closure pattern changes. However, the patterns of closure of the VPV are not useful in assessing the efficacy of a certain procedure, because all patterns can be normal, as they demonstrate that the contractile vectors of velopharyngeal muscles exist and may result from the congenital difference in the aggregate of the anatomic vectors of various velopharyngeal muscles and/or different acquired habits on how to use those muscles [23, 24].Change in VPV closure postoperatively even though the other wall were not addressed.

In this study, the velar movement showed high significant improvement in the patient's results in group I, and significant improvement group II, these results denotes the success of both surgical techniques for providing lengthening of the velum, however, there was no significant difference between both groups. Lengthening of the velum is one of the main goals for both techniques and could lead to a reduction in the VP gap size as well as better function of the velum individual components. This should reflect on the auditory perceptual degree of the subject's hypernasality and better articulatory outcome on speech [25]. Such changes are essential for management of velopharyngeal insufficiency, and hence are responsible for better speech outcomes.

Not only is adequate VP closure achieved by the posterior movement of the velum but also by the medial motion of the lateral pharyngeal walls. Assessment of these motions would hopefully explain the physiological cause of VPI after palatal repair and therefore help to select the appropriate treatment or tailored treatment plan the secondary surgery for individual patients [26, 27].

The main advantage of Furlow palatoplasty, as mentioned earlier was the restoration of a functional muscle sling capable of obtaining a competent velopharyngeal valve, avoidance of median scar of soft palate then the postoperative shortening in anteroposterior direction In this study, the Furlow double-opposing Z-palatoplasty achieved these objectives through primary palatal lengthening, levator sling reconstruction and repositioning in a more anatomic position with avoidance of midline longitudinal scar within a single operation[8]. These findings proved by the significant increase in velar length postoperatively as measured by MRI and the improvement of velar closure and degree of closure by NPE.

A significant increase in velar length also was observed in the IVVP groups, no difference was observed between both groups. The same finding was observed with NPE results, for both IVVP and Furlow groups. With the Furlow double-opposing Z-palatoplasty, both objectives of palatoplasty, primary palatal lengthening and levator sling reconstruction and repositioning in a more anatomic position with avoidance of midline longitudinal scar (thus avoiding velar shortening) were achieved within a single operation and were proved by the significant increase in velar length postoperatively and the improvement of velar closure and degree of closure by NPE.

This is in accordance with reports from previous literature[28] the Furlow palatoplasty narrows the nasopharyngeal port by lengthening the velum, without the risk of significant morbidity as seen in techniques like the pharyngeal flap, with the attendant complications of obstructive sleep apnea, snoring, hypo nasal speech, and mouth breathing.

It has been reported [29] that the double opposing z-plasty made a significant improvement in the speech outcomes. In the same study, number of modifications: For short nasal mucosal flap, a turnover vomer flap was utilized for small defects, while a superiorly based pharyngeal flap was described to close larger defects. For short oral mucosal flap, a back-cut extending along the inside of the alveolus was made, also, buccinator myomucosal flap was also described when the mucoperiosteal flaps where too short to close the hard palate. All the previously mentioned modifications were adopted in this study to enable application of the Furlow palatoplasty in all cases, to increase palatal lengthening and to achieve a low fistula rate and prevent displacement of the retro positioned palate. In one case the oral layer was too short, and it was difficult to approximate the tissue to be sutured without tension, and a buccal unilateral flap was used to help close the wound, as was described by previous studies. Which is considered as a variable that was done for the benefit of the patient.

The IVVP technique underwent many modifications to make it more suitable for various kinds and various shapes of clefts. It had a simple surgical design, which was easy to follow and postoperative recovery period that is short. The technique involved complete dissection of the hard palate attached muscles, and relocating them in the midline, forming a palatal sling.

That sling is the new insertion of the palatal muscles, this muscle repositioning was conducted in this study, also the modification of choice in this study was separating the oral mucosa between the hard and soft palate with a horizontal incision and not suturing it back in order to maintain the backward positioning of the soft palate. Doing that kind of modification had proven its effectiveness in providing adequate lengthening and retro positioning of the palate, because of the small number of the studied cases, further studies are needed to adequately test this modification [29,30].

Studies were made to compare the two techniques regarding, the palatal lengthening and the need for secondary palate repair, those studies revealed that in patients affected by unilateral cleft lip–cleft palate, straight-line repair combined with intravelar veloplasty was associated with an increased risk of

a secondary operation (1.64 times) compared with the Furlow group[31].As regarding the short term effect of the 2 stage repair that was observed during the limited scope of the current study, in many cases 2 stage palatoplasty allowed for easier, tension free, direct closure of the hard palate in most of the cases in both Group I and Group II, except for 2 cases where the hard palate had to be closed using V-Y technique or two flap palatoplasty.

Speech quality remains the single most important standard by which successful palatoplasty are evaluated,[32- 36]most of the patients in the current study did not perform speech evaluation, because the age of the patient was under the optimum time for speech assessment, and due to the short scope of the study. Regarding the long-term effect that of the two stage have over cranial or maxillary growth there are limited number of studies conducted to evaluate this effect. These studies are restricted by many factors and variables and concluded that the scientific evidence was too weak to determine whether two- stage palate repair would lead to favorable maxillary forward and antero-posterior growth or not. Further well controlled and long-term follow-up should be continued on the patients in order to evaluate maxillary and cranial growth.

CONCLUSIONS

Both Furlow palatoplasty and intravelar veloplasty are efficient techniques that can be used in the repair in cleft soft palate. Both techniques can lengthen the soft palate together with palatal muscle reorientation; without the need to raise large mucoperiosteal flaps from the hard palate. Both techniques, with their modifications had shown success in the primary closure of different varieties and sizes of cleft gaps. The two stage palatoplasty can eliminate the need to raise large mucoperosteal flaps from the hard palate. Both techniques showed similar velar length and nasopharyngeal endoscopic results.

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