Research Article

Myomucosal resection and direct closure of the posterior pharyngeal wall (Mahrous Technique as a novel technique for surgical correction of patients having velopharyngeal disorders).

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Abstract

Different surgical techniques have been described for surgical correction of patients having velopharyngeal disorders according to the pattern of closure of the velopharyngeal sphincter. A new technique is described that is suitable for all patterns of closure. The aim was to evaluate the efficacy of myomucosal resection and direct closure of the posterior pharyngeal wall, in the surgical management of patients having velopharyngeal insufficiency (VPI) and/or incompetence {Mahrous technique}. Thirty patients of both sexes who had velopharyngeal insufficiency (24) and /or incompetence (6) were selected for this study. Their age ranged from 4 to 10 years with a mean age of 6.5 years. They were surgically corrected by mere myomucosal resection and direct closure of the posterior pharyngeal wall. They were phoniatrically evaluated preoperatively, 3 months and 6 months postoperatively by auditory perceptual assessment, videonasoendoscopy and Kay nasometer model 6200. Statistical analysis of the results documented a significant reduction in the velopharyngeal gap dimensions, a significant reduction in the degree of open nasality, glottal articulation, and pharyngalization of fricatives. A significant improvement in the overall intelligibility of speech and audible nasal air emission was detected postoperatively regardless of the pattern of velopharyngeal closure. The results of this study demonstrated that myomucosal resection and direct closure of the posterior pharyngeal wall could be applied as a novel technique effectively in patients with velopharyngeal insufficiency and or incompetence.

Keywords: velopharyngeal insufficiency- Hypernasality- velopharyngeal incompetence- cleft palate- Open nasality

Introduction

The velopharynx is the area situated between the nasopharynx and oropharynx; it is a dynamic port that controls the resonance of speech and prevents regurgitation of food and fluid during swallowing (Matsui et al., 2019). It is a complex structure responsible for the separation of the oral and nasal cavities during speech production and swallowing (Raol and Hartnick, 2015). Velopharyngeal closure refers to the expected opposition of the soft palate, or velum, with the posterior and lateral pharyngeal walls [Visser and Van der Biezen, 2012, El-Anwar et al., 2018].

Velopharyngeal insufficiency is the inability to completely close the velopharyngeal port during the speech, the resultant air leakage from the nasal cavity can lead to abnormal, poorly intelligible speech. This occurs in cleft palate, palatal fistulae, post adenoidectomy, and after cleft palate surgery or tumor resection. Velopharyngeal incompetence reefers to be due to neuromuscular disorders [Rashed et al., 2014].

The common goal of all velopharyngeal surgical techniques is to create a permanent

partial reduction of the velopharyngeal port. [Abdel-Aziz et al., 2010]. When surgical management is indicated for restoration of the velopharyngeal function, the pharyngeal flap and the sphincter pharyngoplasty are among the most commonly used surgical procedures (Abyholm, et al., 2005]. Symptoms of nasal obstruction and hyponasality after pharyngeal flap surgery has been reported by many authors (Dailey et al., 2006). Also, obstructive sleep apnea is a severe complication of the pharyngeal flap, and it was estimated to occur in up to 20% of cases [Lam et al., l 2007, Emara and Quriba, 2012].

The surgery is done to correct the anatomical defect, while phoniatricians is required to help the patient eliminate compensatory productions. Failure to work cooperatively may result in unnecessary surgery, unnecessary speech therapy, or both [Kummer, 2016). Successful interve-ntion in velopharyngeal insufficiency patients is measured by the success of enhancing the communicative ability of these patients [Kummer, 2018].

The purpose of the present study is to evaluate the efficiency of a simple novel surgical technique; myomucosal resection and direct closure of the posterior pharyngeal wall for surgical correction of patients having velopharyngeal disorders: (MAHROUS TECHNIQUE}. The main idea of this study was to narrow the velopharyngeal port and restore the velopharyngeal valve competence without having any complications from those recorded for the classic pharyngoplasty techniques.

Patients and Methods

Patients

The current study is a prospective one that had been conducted on forty patients who had velopharyngeal disorders. Twenty-four of them had velopharyngeal insufficiency and six had velopharyngeal incompetence. Thirteen were males (43.3 %) and seventeen were females (56.7%); their ages ranged between four and ten years, and the mean age was 6.5years.

This work was approved by the Research ethical committee of our Faculty of Medicine, and signed informed consent was obtained from the parents/guardians of the children. Selected 30 children came to the Phoniatrics unit at Minia university hospital, complaining of symptoms of open nasality and /or nasal regurge of fluids and solids and well diagnosed as having velopharyngeal insufficiency (VPI) and/or incompetence. They were admitted to the plastic surgery department for surgical correction by myomucosal resection and direct closure of the posterior pharyngeal wall (**Mahrous technique**).

Inclusion criteria:

1. Post cleft repair velopharyngeal insufficiency.
2. Non syndromic patients.
3. Fresh non recurrent cases.
4. Submucous cleft patients.
5. Patients with velopharyngeal incompetence

Exclusion criteria:

1. Syndromic cases.
2. Recurrent cases.

Methods:

A- <u>First step</u>

<u>All the 30 children were subjected to the following protocol of assessment preoperatively in the Phoniatrics unit, Minia university hospital</u>

1- Auditory perceptual assessment (APA) of speech: The speech of each case was assessed for the type and degree of open nasality, glottal articulation and pharyngealization of fricatives, consonant precision, compensatory articulatory mechanisms, facial grimace, audible nasal air escape and overall intelligibility of speech. All these elements were graded along a 5-point scale in which 0 = normal and 4 = severe affection (Kotby et al., 1997).

2- (ENT) Examination: The oropharynx (lips, teeth, tongue, hard and soft palate, uvula, tonsillar pillars, tonsils, lateral and posterior pharyngeal walls).

3- Video nasoendoscopic assessment:

This was done using nasopharyngeal fibrooptic video- nasoendoscopy Henke-Sass-Wolf, type 10. The velopharyngeal valve movement was recorded and graded from grade 0 to grade 4 while the patient was repeating the speech samples (Golding,

1990, Elfatah et al., 2014 and El-Anwar et al., 2016) as follows: 0 is the resting (breathing) position or no movement; 2 is half the distance to the corresponding wall; 4 is the maximum movement reaching and touching the opposite wall.

4- **Assessment of nasal tone of speech:** The nasalance, which is the amount of acoustic energy in the nasal cavity during a speech (Bressmann, 2005) was determined by using Kay nasometer model 6200-2. The main nasalance score is the percentage of nasal acoustic energy of the total energy (nasal plus oral) (Abou-Elsaad et al., 2012, Kummer et al., 2014 and El-Anwar et al., 2016.)

B. The second step included:
(Operative details of MAHROUS technique for surgical correction of velopharyngeal insufficiency)
ANAESTHESIA:

General endotracheal anesthesia with an orotracheal tube plugged inside a channel readymade inside the Dingman retractor.

PATIENT POSITION: Supine with the head hyperextended, the shoulder supported by a pillow, and the head supported by a ring.

TECHNIQUE:

1- Access midline palatotomy was done if the patient had submucous cleft, soft palatal fistula or if the soft palate is long and hindered the view of the velopharyngeal port, otherwise, the soft palate was retracted posteriorly without being incised to have access to the velopharyngeal port **(Fig. 1-3).**

2- The two lateral soft palatal flaps were retracted by vicryl sutures hanged over the transverse arm of the Dingman retractor.

3- The surface area of the myomucosal part to be resected from the posterior pharyngeal wall was judged preoperatively from the videonasoendoscopy proportionate to the width of the gap (marked by methylene blue) (**Fig. 4).**

4- The posterior pharyngeal mucosa was palpated before being incised to rule out velocardiofacial syndrome

5- Submucosal injection of 1/100000 adrenaline**.**

6- The planed myomucosal area was resected down to the prevertebral fascia (like the pharyngeal flap but the margins were completely excised) **(Fig. 5).**

7- The cut ends of the superior constrictor muscles in the posterior pharyngeal wall were undermined and approximated**.**

8- The cut ends of the mucosa were undermined and sutured **(Fig. 6).**

9- The sutures used for retraction were removed and the soft palate was closed in layers if it has been opened (nasal mucosa, muscles, and oral mucosa). Either the submucous cleft or the soft palatal fistula was closed during the closure **(Video)**

D. The third step included:

- Patients followed up in the plastic surgery department for surgical care and to deal with any possible complications.
- All the patients in the study group received speech therapy sessions three weeks after surgery, 3 times per week (40 min. / session) for 6 months regularly in the Phoniatrics unit.
- Patients were followed up immediately postoperatively, 3 months, and 6 months after the surgical repair by

1. APA of speech.
2. ENT examination
3. Videonasoendoscopy **(Fig7-8)**
4. Kay nasometer model 6200-2

Kendall's test used to compare dependent qualitative data

Non- significant ($p>0.05$), significant ($p<0.05$), -highly significant ($p<0.001$).

Results

As regards the auditory perceptual analysis, the p-value was estimated and revealed a highly significant result which indicated improvement in the grade of open nasality, glottal articulation, and pharyngealization of fricatives **(Table 1)**.

Nasoendoscopic assessment of the patients postoperatively revealed a highly significant improvement in the velopharyngeal gap width in all dimensions during phonation (80% of the cases had no velopharyngeal gap during phonation). Also, there was a significant improvement in the degree of velar movement. The explanation of these findings is based on the fact that the technique is associated

with the reduction of the velopharyngeal gap in all dimensions

P- value for the audible nasal air emission and facial grimace was estimated preoperatively, 3 months postoperatively, and 6 months postoperatively and revealed highly significant results which indicated improvement in the audible nasal air emission and facial grimace **(Table 2)**. P value for consonant imprecision and overall intelligibility of the speech was estimated preoperatively, 3 months post-operatively, and 6 months postoperatively and revealed highly significant results which indicated improvement in the consonant imprecision and overall intelligibility of the speech **(Table 3).**

Patients were examined for nasalence scores preoperatively, 3 months post-operatively, and 6 months postoperatively, p-value was estimated and revealed significant results which indicated improvement in the nanometric studies in both oral and nasal sentences **(Table 4).** In comparison between variables of pre-operative versus 3 months postoperative and 6 months postoperatively, naso-endoscopic evaluation of the patients revealed statistically significant improvements in the degree of velar movement and the lateral pharyngeal wall movements **(Table 5**), the dimensions of the velopharyngeal gap **(Table 6)** and the closure pattern **(Table 7).**

A high positive significant correlation was obtained between the size of the velopharyngeal gap and the open nasality, pharyngealization of frictives, and glottal articulation of the study group 6 months post-operatively ($p<0.001$) **(Table 8).**

All surgeries passed uneventfully. The average operative time was one hour. Patients were discharged on the 2nd postoperative day and followed up in the outpatient clinic.They received parenteral antibiotics, (3rd generation cephalosporin+ clavulinic acid potentiated amoxicillin). They also received mucolytics, oral mouthwash, and gurgles. They have been discharged on a soft diet that was maintained for 3 weeks.

All patients passed without complications except only 2 patients who developed dehiscence of the posterior pharyngeal walls and recurrence of symptoms. They were subjected to surgical redo.

TABLES

Table (1): Open nasality, Pharyngealzation of fricatives and glottal articulation preoperatively, 3 months, and 6 months postoperatively

Item	Preoperative T=30(100%)	3 months postoperatively T=30(100%)	6 months postoperatively T=30(100%)	Significance
Open nasality				
Grade (0)	-	-	12(40%)	
Grade (1)	-	9 (30%)	6 (20%)	**P** =0.001*
Grade (2)	6 (20%)	12 (40%)	12(40%)	
Grade (2-3)	2 (6.7%)	2 (6.7%)	-	
Grade (3)	15 (50%)	7 (23.3%)	-	
Grade (4)	7 (23.3%)	-	-	
Glottal articulation				
No				
Grade (1)	19 (63.3%)	19 (63.3%)	23(76.7%)	**P** =0.001*
Grade (2)	2 (6.7%)	7 (23.3%)	3 (10%)	
Grade (3)	5 (16.7%)	2 (6.7%)	4 (13.3%)	
Grade (4)	2 (6.7%)	2 (6.7%)	-	
	2 (6.7%)	-	-	
Pharyngealzation of fricatives				
No	16 (53.3%)	20(66.7%)	23(76.7%)	**P** =0.001*
Grade (1)	3 (10%)	7 (23.3%)	4 (13.3%)	
Grade (2)	4 (13.3%)	3 (10%)	3 (10%)	
Grade (3)	5 (16.7%)	-	-	
Grade (4)	2 (6.7%)	-	-	

Table (2): Audible nasal air emission and facial grimace preoperatively, 3 months, and 6 months postoperatively

Item	Preoperative T=30(100%)	3 months postoperatively T=30(100%)	6 months postoperatively T=30(100%)	Significance
Audible nasal air emission				
Absent	6(20%)	8(26.7%)	24(80%)	**P** =0.001*
Grade (1)	4(13.3%)	18(60%)	2(6.7%)	
Grade (2)	16(53.3%)	4(13.3%)	4(13.3%)	
Grade (3)	2(6.7%)	-	-	
Grade (4)	2(6.7%)	-	-	
Facial grimace				
Absent	3(10%)	10(33.3%)	24(80%)	
Grade (1)	10(33.3%)	16(53.3%)	2(6.7%)	**P** =0.001*
Grade (2)	15(50%)	4(13.3%)	4(13.3%)	
Grade (3)	2(6.7%)	-	-	
Grade (4)	-	-	-	

Table (3): Consonant imprecision and overall intelligibility of speech preoperatively, 3 months, and 6 months postoperatively

Item	Preoperative T=30(100%)	3 months postoperatively T=30(100%)	6 months postoperatively T=30(100%)	Significance
Consonant imprecision				
Absent	-	10(33.3%)	24(80%)	**P** =0.001*
Grade (1)	12 (40%)	13(43.3%)	2(6.7%)	
Grade (2)	9 (30%)	7 (23.3%)	4(13.3%)	
Grade (3)	7 (23.3%)	-	-	
Grade (4)	2 (6.7%)	-	-	
Overall intelligibility of speech				
Grade (1)	4(13.3%)	-	-	**P** =0.001*
Grade (2)	16(53.3%)	4(13.3%)	-	
Grade (3)	10(33.3%)	16(53.3%)	6(20%)	
Grade (4)	-	10(33.3%)	24(80%)	

Table (4): **Nasometry among study group preoperatively, 3 months, and 6 months postoperatively**

Item of Nasometry	Preoperative mean ± SD.	3 months postoperatively mean ± SD.	6 months postoperatively mean ± SD.	Significance
/a/	44.87±17	15.2± 9	8 ±3	
/i/	50.6 ± 32	21±5	19.3±8	
/u/	49.76±10	15±3	10±5	**P** = 0.001*
/m/	87.4±4	86.4±4	83.3±3	
Oral sentence	55.58±5.42	20±6	13±4	
Nasal sentence	87.54±0	60±10	51±6	

Table (5): Palatal mobility and lateral pharyngeal wall mobility preoperatively, 3 months, and 6 months postoperatively

Item	Preoperative T=30(100%)	3 months postoperatively T= 30(100%)	6 months postoperatively T=30(100%)	Significance
Palatal mobility				
0/ IV	14(46.7%)	-	-	**P** =0.001*
II / IV	10(33.3%)	14(46.7%)	5(16.7%)	
IV/IV	6(120%)	16(53.3%)	25(83.3%)	
Lateral pharyngeal wall mobility				
0 / IV	8(26.7%)	2(6.7%)	-	**P** =0.001*
II / IV	16(53.3%)	14(46.7%)	6(20%)	
IV/IV	6(20%)	14(46.7%)	24(80%)	

Table (6): VP gap among cases preoperatively, 3 months, and 6 months postoperatively

VP gap	Preoperative T=30(100%)	3months postoperatively T=30(100%)	6 months postoperatively T=30(100%)
NO	-	22 (73.3%)	24 (80%)
2mm	-	3 (10%)	3 (10%)
3mm	4 (13.4%)	2 (6.7%)	2 (6.7%)
4mm	5 (16.6%)	3 (10%)	1 (3.3%)
5mm	3 (10%)	-	-
6mm	8 (26.6%)	-	-
7mm	10 (33.4%)	-	-

Table (7) Closure type preoperatively, 3 months, and 6 months postoperatively

Type of closure	Preoperative T=30(100%)	3 months postoperatively T=30(100%)	6 months postoperatively T=30(100%)	Significance
Circular Sagittal Coronal	6 (20%) 18(60%) 6 (20%)	22(73.3%) 6(20%) 2(6.7%)	22(73.3%) 6(20%) 2(6.7%)	**P** =0.001*

Table (8): correlation between Size of the velopharyngeal gap post-operative and open nasality, Pharyngealzation of fricatives, and glottal articulation of the study group 6 months post-operative

	Size of the velopharyngeal gap post-operative	
	R	**P value**
Open nasality	+0.886	<0.001*
Audible nasal air emission	+0.701	<0.001*
glottal articulation	+0.078	<0.001*

FIGURES

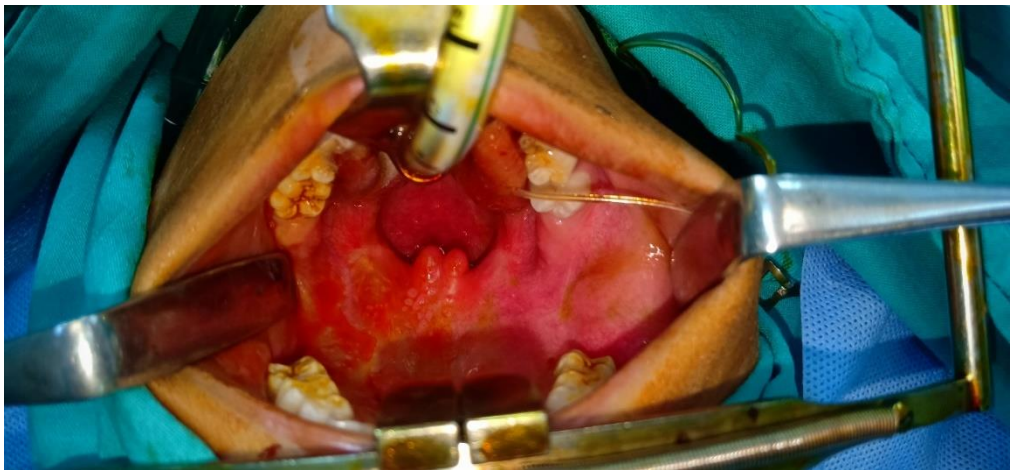

Fig (1): Submucous cleft palate with wide velopharyngeal port - Preoperative clinical finding.

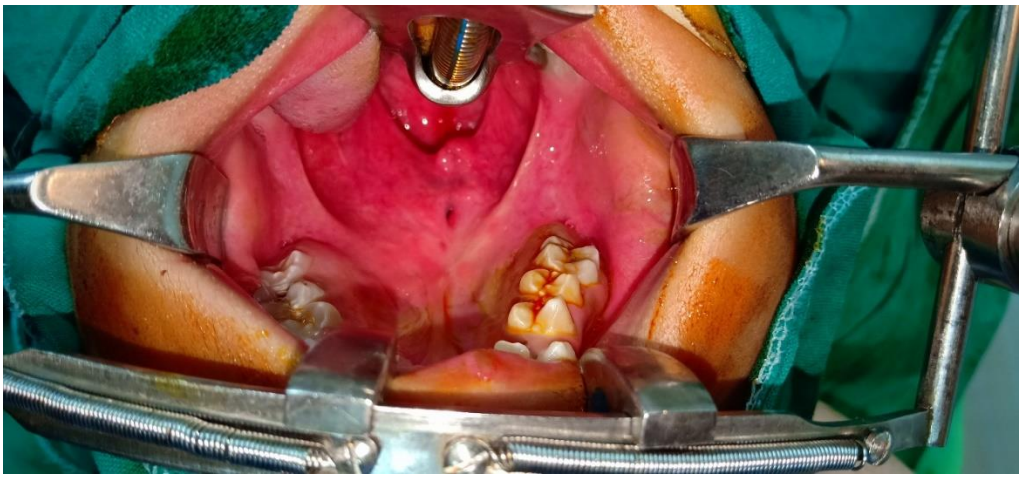

Fig (2): Soft palatal fistula necessitated midline access palatotomy

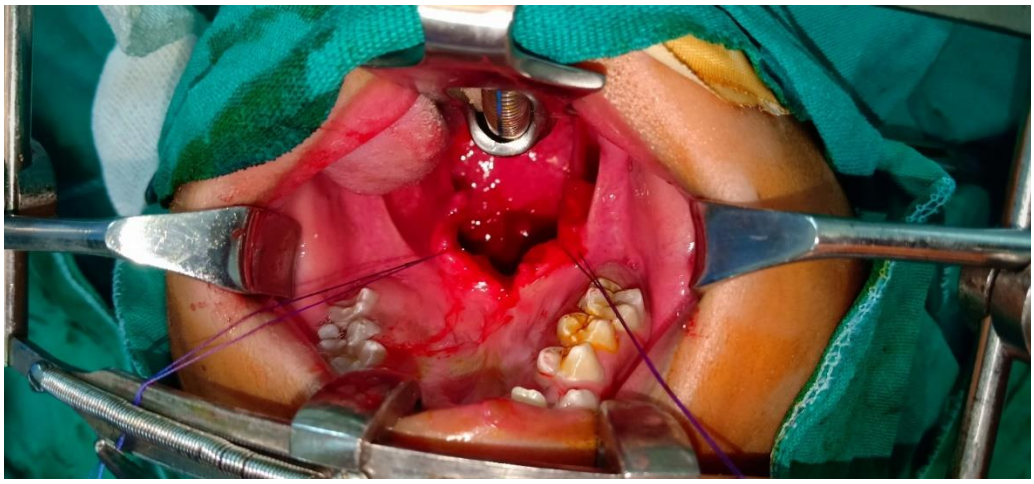

Fig (3): Midline access palatotomy and retraction of the flaps.

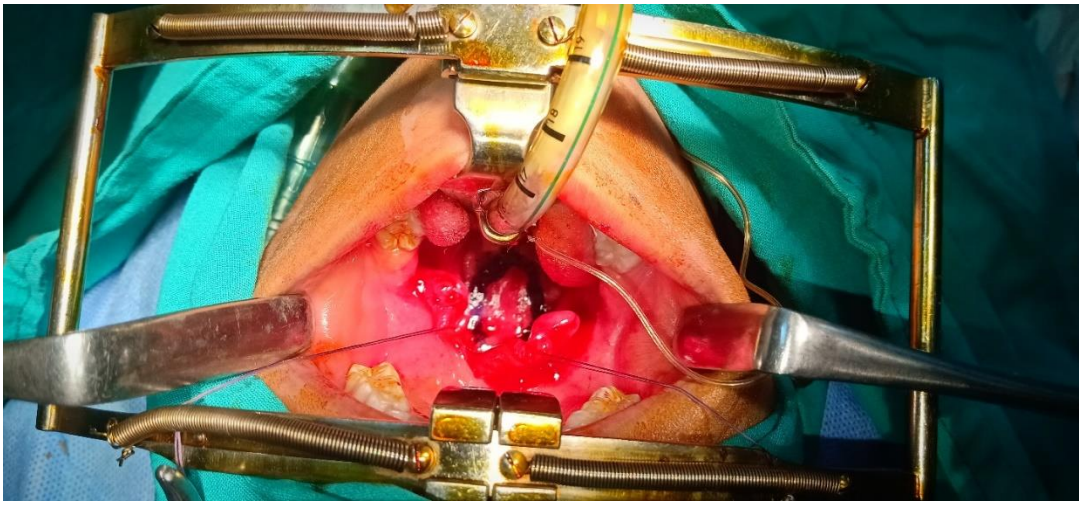

Fig. (4): The area to be resected from the posterior pharyngeal wall is marked by methylene blue.

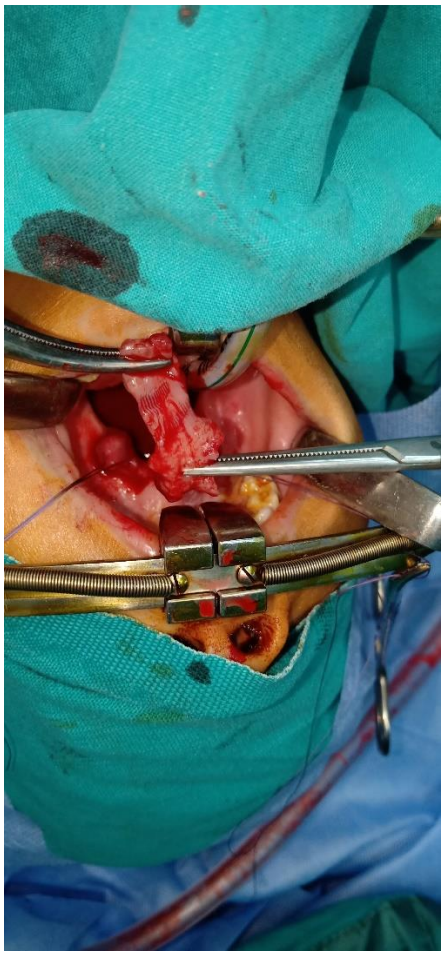

Fig (5): The resected myomucosal area from the posterior pharyngeal wall is hanged between hemostats.

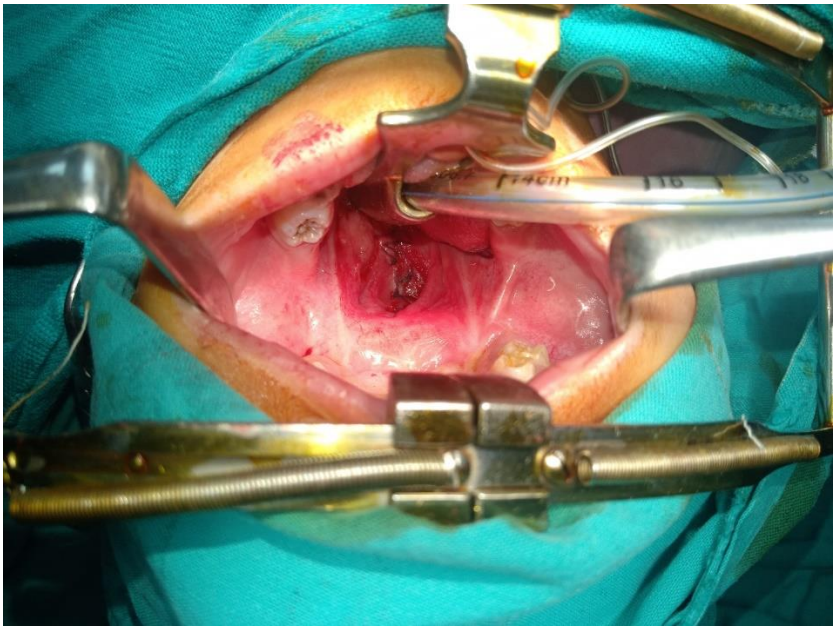

Fig. (6): Final closure of the posterior pharyngeal wall mucosa and marked improvement of the width of the velopharyngeal port.

Fig. (7): Preoperative nasoendoscopic photo during phonation showing wide velopharyngeal port

Fig. (8): Three months Postoperative nasoendoscopic photo during phonation for the same previous patient showing marked improvement of the width of the velopharyngeal port

Discussion

The age of the patients in the current study ranged between 4& 10 years. Kummer, in 2016 advocated the age of 3 years as the appropriate time to evaluate resonance and velopharyngeal function while Orticochea, in 1999, recommended an earlier age of two and half years for sphincter pharyngoplasty.

The pharyngeal flap operation in which a myomucosal flap is harvested from the posterior pharyngeal wall and sutured to the nasal layer of the soft palate is indicated in velopharyngeal disorders with good lateral pharyngeal wall movement and deficient velar mobility (sagittal pattern of closure), while the sphincter pharyngoplasty, which utilizes bilateral palatopharyngeal myomucosal flaps from the posterolateral pharyngeal walls is indicated if the lateral pharyngeal wall movement is deficient and the velar movement is good (coronal pattern of closure) (Rodriguez et al., 2012- Paniagua et al., 2013 - Abdel-Aziz et al., 2012, and Marsh, 2004). Also, Armour et al., 2005, further emphasized this and confirmed that pharyngeal flap surgery is less effective in treating velopharyngeal insufficiency in patients with coronal closure. On the contrary, the current technique proved to be suitable for all patterns of closure.

The change in the pattern of closure postoperatively was explained by the improvement in both palatal mobility and lateral pharyngeal wall mobility, (73,3%, 20%, and 6.7% of all cases had circular, sagittal, and coronal closure respectively). These results denoted that the technique was effective for all velopharyngeal insufficiencies regardless of their closure patterns

In a study done by Yamashita and Trindade, 2008, that compared the speech results after pharyngeal flap surgery, they noted that the perceptual and auditory evaluation of speech detected hyponasality in 22% of the studied sample after surgery, in addition to the symptoms of obstructive sleep apnea. In the current study, no postoperative hyponasality was observed in any case. Also 80% of patients had absent audible nasal air emission and absent facial grimace.

Postoperative speech results revealed significant improvement in consonant imprecision and compensatory articulation errors, which are glottal articulation and pharyngealization of fricatives. This is explained due to the role of postoperative speech therapy, which is usually required to help the individual learn to use the new velopharyngeal mechanism for oral airflow and to correct remaining compensatory and placement errors, these findings are comparable with Kummer, 2018, and Ysunza et al., 2009, who stated that the goal of speech therapy for velopharyngeal insufficient patients is to establish an appropriate placement for each speech sound.

In the current study, postoperative speech results also revealed significantly improvement in nanometric evaluation for oral and nasal sentences for all patients in midtest assessment. These data match with Kummer, 2016 and Dejonckere and Esch, 2003.

Postoperative mean$\pm$ SD of nasalance score for the nasal sentence was 51$\pm$ 6 and for oral sentence was 13$\pm$4 as compared to preoperative measurements which were 87.54/0 and 55.58/5.42 respectively as compared to standardized, average values which are 10$\pm$5 for oral sentence and 47$\pm$8 for nasal sentence (Abou-Elsaad, et al., 2012). No hyponasality was recorded in any case. Fukushima, et al., 2015 recorded 40 cases out of 159 had hyponasality after pharyngeal flap surgery. (14% of the patients).

Another advantage of the new technique is that it is a simple procedure and can be done without access palatotomy except if the patient had a submucous cleft, soft palatal fistula, or if the soft palate is long and hindered the view of the velopharyngeal port. On the other hand, in pharyngeal flap surgery midline access palatotomy is mandatory Iida et al., 2017.

The current new technique carried no risk of obstructive sleep apnoea (OSA). On the other hand, Ysunza et al., 2009, reported 15 cases of pharyngeal flaps out of 585 had OSA as verified by polysomnography. Abdel-Aziz et al., 2018 assessed the impact of 3 velopharyngeal surgical techniques on the airway. They detected that the Furlow technique has the least worsening effect on the airway, with 25% of patients demonstrating mild OSA. The pharyngeal flap has a more impact on the airway where 78% of patients demonstrated OSA (mild in 56% and moderate in 22%). However, 56% of the patients undergone sphincter pharyngoplasty showed OSA (mild in 45% and moderate in 11%). Losken et al., 2003, reported that complications for a sphincter pharynxgoplasty are higher than for a pharyngeal flap, with revision rates of 12 to 16 percent and hyponasality in up to 22 percent of patients. Ettinger, et al., 2012 ,reported an increased incidence of OSA and higher-than-average apnea-hypopnea indices postoperatively after dynamic sphincteroplasty. Yamashita and Trindade 2008, found the onset of respiratory complaints after a pharyngeal flap surgery in 36% of cases, about a year after surgery.

Also, this new technique is amenable to surgical redo if the gap is still wide where excess area from the posterior pharyngeal wall can be excised.

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