Systematic Review and Meta-Analysis of the Palatal Surgeries in the Treatment of Obstructive Sleep Apnea

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Abstract

Background: This paper aims to examine published articles between January 2008 and January 2019 on the different palatal surgeries performed on OSA patients and the treatment outcomes, which in turn will be used to determine the effectiveness of various palatal surgical techniques in treating OSAS and the most effective of the palatal surgical techniques in treating OSAS. **Patients and Methods:** The current review followed the guidelines of preferred reporting items for systematic reviews and meta-analysis statement 2009 (PRISMA). The quality of relevant studies was assessed using NIH quality assessment tool for observational cohort and cross-sectional studies as well as NIH tool for quality assessment for case series studies. **Results:** Meta-analyses of relevant studies showed that the surgical technique that achieved the best reduction on AHI (Apnea/Hypopnea Index) was the lateral pharyngoplasty followed by the Anterior Palatoplasty, with a significant mean reduction of [(SMD = -0.848, 95% CI (-1.209 - -0.487), p-value < 0.001) and (SMD = -0.864, 95% CI (-1.234 - -0.494), p-value < 0.001), respectively]. The technique responsible for the best improvement in Epworth Sleepiness Score (ESS) was the Relocation Pharyngoplasty, with a significant mean reduction of [SMD = -0.998, 95% CI (-1.253 - -0.743), p-value < 0.001]. Minimal O₂ saturation level improved most with the Expansion Sphincter Pharyngoplasty, with a significant mean reduction of [SMD = 1.011, 95% CI (0.581 - 1.440), p-value < 0.001]. The surgical procedure that results in the best post-operative Visual Analogue Scale (VAS) was Z-Palatoplasty, with a significant mean reduction of [SMD = -1.551, 95% CI (-2.049 - -1.052), p-value < 0.001]. Soft palate length changes with a significant mean reduction of [SMD = -2.219, 95% CI (-2.730 - -1.708), p-value < 0.001]. Finally, meta-analyses of relevant studies showed that expansion sphincter pharyngoplasty achieved the overall highest success rate [event rate = 77%, 95% CI

(65.4% - 85.5%), p-value < 0.001]. **Conclusion:** The best procedure for treating OSA varies from patient to patient and there is no universal cure-all. Careful patient selection and pre-operative evaluation are mandatory.

Keywords

Obstructive Sleep Apnea, Palatal Surgery, ESS, AHI, VAS, Oxygen Saturation, Meta-Analysis, Systematic Review

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1. Introduction

Charles Dickens in “The Posthumous Papers of the Pickwick Club” published the first description of a patient with obstructive sleep apnea in 1836 [1]. Subsequently, Guilleminault coined the term “upper airway resistance syndrome” in 1993 [2]. There are three types of sleep apneas: Central, Obstructive and Mixed. Central sleep apnea occurs when the brain does not send the signal to the muscles to take a breath. Obstructive sleep apnea happens when the brain sends the instruction to the muscles and the muscles make an effort to take a breath, but they are struggling because the airway becomes obstructed and prevents an adequate flow of air. Mixed sleep apnea is defined when there is both central sleep apnea and obstructive sleep apnea. Obstructive Sleep Apnea is a common condition affecting 4% of men and 2% of women [3]. Presenting symptoms are variable including restless sleep, snoring, excessive daytime somnolence, fatigue, memory loss, decreased cognitive function, mood changes, nocturnal enuresis, nocturnal sweating and observed choking or gasping at night. People with Obstructive Sleep Apnea (OSA) seek help for different reasons. At one end of the spectrum are patients presented with morbid obesity, carbon dioxide retention, hypertension, and right-sided heart failure with an Apnea Index of more than 100. At the other end of the spectrum are those individuals with minimal sleep-disordered breathing whose chief complaint is snoring [4].

We are presenting a systematic review for published articles between January 2008 and January 2019 on the different palatal surgeries performed on OSA patients and the treatment outcomes that could determine the effectiveness of various palatal surgical techniques in treating OSA including those being the most effective in treating OSA.

2. Patients and Methods

The current review followed the guidelines of preferred reporting items for systematic reviews and meta-analysis statement 2009 (PRISMA) [5]. The detailed steps of methods were described elsewhere as well as PRISMA checklist [6].

The quality of relevant studies was assessed using NIH quality assessment tool for.

Observational cohort and cross-sectional studies as well as NIH tool for quality assessment for case series studies. (Study Quality Assessment Tools) “Na-

tional Heart, Lung, and Blood Institute (NHLBI)” 2019. Regarding cross section and cohort studies, each study was given a score out of 14 based on answering each question (Yes = 1, No = 0, NA = 0). A score of 10 - 14 indicated a good quality article, 5 - 9 for fair, and 1 - 4 for poor quality article. Regarding case series studies, total evaluation score was 9, a score from 7 - 9 indicated good quality article, whereas score from 4 - 6 for fair, and 1 - 3 for poor quality article.

Statistical analysis was performed as the following: prior to analysis phase, if the published study only reported the mean, the estimated standard deviation (SD) was derived from linear regression of log (published SDs) against log (published means) according to Van Rijkom, H. M., Truin, G. J., & Van't Hof, M. A. (1998) [7]. The published SDs and means were collected from other includes studies. If there was one study with more than one publication reports, they were compared and the publications with complete data set were used. We made pairwise meta-analyses of our outcomes using Comprehensive Meta-Analysis software (CMA version 3) [8]. Standardized mean difference (SMD) with the corresponding 95% confidence intervals (95% CI) was also calculated. Pooled event rate with the corresponding 95% confidence intervals (95% CI) was also calculated. A fixed-effects model was used when there was no heterogeneity. Heterogeneity was assessed with Q statistics and I^2 -test considering it significant with I^2 value > 50% or p-value < 0.10. Publication bias was assessed with the Egger's regression test [9] and represented graphically by Begg's funnel plot when there were ten or more studies. Egger's regression test p-value < 0.05 was considered significant. Whenever publication bias was found, the trim and fill method of Duval and Tweedie was applied adding studies that appeared to be missing to enhance the symmetry [10].

3. Results

3.1. Literature and Study Characteristics

As depicted in **Figure 1**, electronic search yielded 1036 articles from two databases. After 121 duplicates were removed, 863 articles were screened in title/abstract screening, while 377 articles were screened in full text screening for inclusion. Finally, 52 articles were included in the qualitative and quantitative meta-analysis synthesis. The manual search resulted in no additional studies. Detailed characteristics of the included studies are shown in **Table 1**. The surgical steps of the main palatal techniques encountered during out systematic review are outlined in **Table 2**.

3.2. Risk of Bias Assessment

With regard to quality assessment, 44 of 52 studies evaluated showed good quality, whereas the other eight studies showed fair quality (**Table 1**).

3.3. Outcomes

1) AHI (Apnea/Hypopnea Index)

Table 1. Characteristics of the studies included in the meta-analysis.

Reference ID	Sample size	Type of Study	Technique used	Type of surgery	Follow up period (Months)	QA assessment
Amali/2017/Iran	20	Prospective	UPPP	Classic Palatoplasty	6	Good
Amali/2017/Iran	20	Prospective	MRTA	Classic Palatoplasty	6	Good
Adzreil/2016/Malaysia	31	Prospective	AP + TBD	Anterior Palatoplasty	12	Good
Atan/2017/Turkey	14	Prospective	AP + MESP	Antero-lateral Palatoplasty	6	Good
Binar/2016/Turkey	23	Prospective	ESP	Lateral Palatoplasty	3	Good
Browaldh/2013/Sweden	32	Prospective	UPPP	Classic Palatoplasty	6	Good
Cammaroto/2017/Italy	10	Retrospective	UPPP	Classic Palatoplasty	6	Good
Cammaroto/2017/Italy	10	Retrospective	ESP	Lateral Palatoplasty	6	Good
Cammaroto/2017/Italy	10	Retrospective	BRP	Lateral Palatoplasty	6	Good
Carrasco-Llatas/2015/Spain	10	Retrospective	LP	Lateral Palatoplasty	7	Good
Carrasco-Llatas/2015/Spain	7	Retrospective	UPPP	Classic Palatoplasty	7	Good
Carrasco-Llatas/2015/Spain	10	Retrospective	EP	Lateral Palatoplasty	7	Good
Carrasco-Llatas/2015/Spain	4	Retrospective	ZP	Lateral Palatoplasty	7	Good
Carrasco-Llatas/2015/Spain	22	Retrospective	PPR	Classic Palatoplasty	7	Good
Chen/2015/Taiwan	32	Retrospective	RP	Antero-lateral Palatoplasty	6	Good
Cheng/2008/Taiwan	50	Prospective	MEUP	Anterior Palatoplasty	6	Fair
Chi/2014/Taiwan	25	Prospective	LP	Lateral Palatoplasty	6	Good
Cho K-S/2013/South Korea	23	Prospective	LPMR	Anterior Palatoplasty	6	Good
Choi/2013/Korea	20	Prospective	UPPP	Classic Palatoplasty	6	Good
Despeghel/2016/Belgium	19	Prospective	ESP	Lateral Palatoplasty	6	Good
DizdaR/2015/Turkey	9	Prospective Cohort	UPPP	Classic Palatoplasty	20	Good
Dizdar/2015/Turkey	14	Prospective	LP	Lateral Palatoplasty	20	Good
El-Anwar/2016/Egypt	24	Prospective	EP w/ SS	Lateral Palatoplasty	6	Good
El-Anwar/2017/Egypt	22	Prospective	DSS-ESP	Antero-lateral Palatoplasty	6	Good
Elbassiouny/2014/Egypt	28	Prospective	SPFP	Lateral Palatoplasty	6	Good
Elbassiouny/2016/Egypt	21	Prospective	SPWF	Antero-lateral Palatoplasty	6	Good
Emara/2016/Egypt	38	Prospective	AAP	Anterior Palatoplasty	6	Good
Guler/2018/Turkey	81	Retrospective	ESP	Lateral Palatoplasty	3	Good
Karakoc/2018/Turkey	28	Prospective	LP	Lateral Palatoplasty	6	Good
Karakoc/2018/Turkey	31	Prospective	ESP	Lateral Palatoplasty	6	Good
Karakoc/2018/Turkey	20	Prospective	AP	Anterior Palatoplasty	6	Good
Kim/2013/South Korea	92	Prospective	UPF + LP	Lateral Palatoplasty	6	Good
Lee/2010/Italy	30	Prospective	RP	Antero-lateral Palatoplasty	6	Fair

Continued

Li/2009/Taiwan	10	Prospective	RP	Antero-lateral Palatoplasty	6	Fair
Li/2013/Taiwan	47	Prospective	RP	Antero-lateral Palatoplasty	6	Good
Li/2015/Taiwan	32	Prospective	RP	Antero-lateral Palatoplasty	6	Good
Li/2016/Taiwan	60	Retrospective	RP	Antero-lateral Palatoplasty	6	Good
Li/2018/Taiwan	25	Retrospective	SP	Lateral Palatoplasty	6	Good
Liu/2013/China	51	Retrospective	H-UPPP/ Z-PPP	Classic Palatoplasty	9	Good
Lunkvist/2008/Sweden	120	Prospective	UPPP	Classic Palatoplasty	12	Fair
Mantovani/2012/Italy	4	Prospective	VUPL	Lateral Palatoplasty	6	Fair
Mantovani/2015/Italy	32	Prospective	BRB	Lateral Palatoplasty	12	Good
Mantovani/2017/Italy	19	Prospective	Alianza	Lateral Palatoplasty	6	Good
Marzetti/2013/Italy	15	Prospective	AP	Anterior Palatoplasty	2	Good
Marzetti/2013/Italy	19	Prospective	UPF	Anterior Palatoplasty	2	Good
Montevecchi/2017/Italy	111	Prospective	BRP	Lateral Palatoplasty	6	Good
Neruntarat/2011/Thailand	83	Prospective	UPF	Anterior Palatoplasty	55	Fair
Pang/2009/Multi-center	77	Prospective	AP	Anterior Palatoplasty	33	Fair
Pang/2016/Multi-center	73	Prospective	AP + ESP	Antero-lateral Palatoplasty	6	Good
Pianta/2017/Italy	17	Retrospective	BESP	Lateral Palatoplasty	6	Good
Piccin/2013/Italy	85	Prospective	FEP	Lateral Palatoplasty	6	Good
Plaza/2019/Multi-center	75	Prospective	ESP	Lateral Palatoplasty	12	Good
Rashwan/2017/Italy	25	Prospective	UPPP	Classic Palatoplasty	6	Good
Rashwan/2017/Italy	25	Prospective	ESP	Lateral Palatoplasty	6	Good
Rashwan/2017/Italy	25	Prospective	BRP	Lateral Palatoplasty	6	Good
Salamanca/2014/Italy	24	Prospective	BAP	Lateral Palatoplasty	6	Good
Soares/2013/ Brazil	18	Prospective	LP	Lateral Palatoplasty	6	Good
Sommer/2016/Germany	23	Prospective	UPPP	Classic Palatoplasty	3	Good
Suslu/2017/Turkey	28	Retrospective	ESP	Lateral Palatoplasty	6	Good
Ugur/2013/Turkey	42	Prospective	AP	Anterior Palatoplasty	24	Good
Vicini/2015/Italy	10	Prospective	BRP	Lateral Palatoplasty	6	Good
Wu/2016/China	24	Prospective	UPPP	Classic Palatoplasty	6	Good
Yi/2009/China	34	Prospective	ZPPP	Classic Palatoplasty	6	Fair
Yousuf/2013/India	22	Prospective Cohort	UPPP	Classic Palatoplasty	6	Good

UPF: Uvulopalatal Flap; LP: Lateral Pharyngoplasty; RP: Relocation Pharyngoplasty; MEUP: Microdebrider Assisted Extended Uvulopalatoplasty; ESP: Expansion Sphincter Pharyngoplasty; UPPP: Uvulopalatopharyngoplasty; LPMR: Limited Palatal Muscle Resection; SPFP: Soft Palatal Webbing Flap Pharyngoplasty; EP + SS: Expansion Pharyngoplasty with Suspension Sutures; PPR: Partial Palatal Resection; ZP: Z-Palatoplasty; MESP: Modified Expansion Sphincter Pharyngoplasty; DSS + ESP: Double Suspension Sutures + Expansion Sphincter Pharyngoplasty; MRTA: Modified Radiofrequency Tissue Ablation; FEP: Functional Expansion Pharyngoplasty; H-UPPP: Han's Uvulopalatopharyngoplasty; Alianza Technique: BAP + BRB; SPW: Soft Palatal Webbing Flap; SP: Suspension Palatoplasty; BRP: Barbed Reposition Pharyngoplasty; BESP: Barbed Expansion Pharyngoplasty; BAP: Barbed Anterior Palatoplasty; BRB: Barbed Roman Blinds.

Table 2. Surgical steps of the major palatal surgical techniques.

UPPP	UPF	LP	AP	ESP	RP	Roman Blinds
Bilateral tonsillectomy with trimming and resection of excess pharyngeal mucosa. Arch shaped incisions are then made on either side of the uvula followed by blunt dissection to remove the fat from the spatium veli palate. The free palatal mucosa is then sutured together and the anterior and posterior pillars are sutured together	The Uvula is reflected upwards on the palate and an outline is marked. A diamond shaped segment of mucosa and submucosa starting from the outline downwards is removed in addition to the anterior aspect of the uvular mucosa. The uvular tip is shortened. Finally, the uvula is then reflected onto the soft palate and sutured into place	The technique entails performing a tonsillectomy. If the patient had previously undergone a tonsillectomy, then a vertical myotomy is done in the tonsillar bed in order to access the Superior Pharyngeal Constrictor (SPC) muscle. The SPC is then vertically sectioned resulting in two flaps, the lateral of which is sutured to the anterior pillar on the same side. A half thickness incision is made in the oral aspect of the soft palate extending supero-laterally from the base of the uvula to the lateral soft palate margin. The Palatopharyngeus muscle is sectioned transversely. Z plasty is used to suture the upper palatopharyngeal muscle flap with the palatine flap created previously. The lower palatopharyngeal muscle flap is then sutured to the anterior pillar on the same side. The same steps are repeated on the opposite side.	A rectangular strip of mucosa midway between the hard palate and the uvula is removed down to the muscle layer without removing any of the muscles. The skin edges are then approximated thus bringing the soft palate antero-superiorly. Partial uvulectomy may be done if needed	Tonsillectomy followed by identification and horizontal transection of the Palatopharyngeus muscle near its inferior end. A superolateral incision is made extending from the base of the uvula to the soft palate margin, in order to uncover the arching palatoglossal fibers of the soft palate. A suture is taken through the bulk of the Palatopharyngeus muscle and attached to the arching palatoglossal fibers. The anterior and posterior pillars are then sutured together. The same steps are repeated on the opposite side. Partial Uvulectomy for patients with enlarged uvula.	Tonsillectomy is the first step followed by bilateral incisions extending from the base of the uvula supero-laterally to a point (near the pterygoid hamulus) and then from there downwards to connect to the base of the anterior pillar. The mucosa, submucosa and adipose tissue in the superolateral corner of the palate bounded by the incisions made previously is dissected. The Palatopharyngeus (PPM) muscle near the uvula is rotated supero-laterally to be sutured to the area previously dissected. The medial aspect of the Superior Pharyngeal Constrictor muscle (SPC) is sutured to the ipsilateral Palatoglossus (PGM) muscle thus splinting the SPC to the ipsilateral tonsillar fossa. The remaining PPM is sutured to the remaining PGM	Three stab incisions are made in the palate. Two at the pterygoid hamulae and one just before the posterior nasal spine. Using a 2-0 non-resorbable polyester thread mounted on a cutting needle, the periosteum and fibromuscular layer of the posterior nasal spine is entered sideways. The thread is then guided downwards to the free edge of the soft palate using multiple in and out sutures, each through the same hole. The needle emerges on one side of the uvular base and then passed sideways through the uvular base to emerge on the contralateral side. The thread is then passed upwards towards the posterior nasal spine in the same manner as before. At the posterior nasal spine, the thread is tightly knotted and buried in the stab incision which is subsequently close using resorbable thread. The same steps are repeated twice more on either side of the palate at the Pterygoid hamulae

Figure 1. PRISMA flow diagram of the search and review process.

Meta-analyses of relevant studies showed that the surgical technique that achieved the best reduction on AHI was the lateral pharyngoplasty followed by the anterior palatoplasty, with a significant mean reduction of [(SMD = -0.848 , 95% CI (-1.209 - 0.487), p -value < 0.001) and (SMD = -0.864 , 95% CI (-1.234 - -0.494), p -value < 0.001), respectively] (**Figure 2**). On the other hand, the surgical technique that achieved the least reduction on AHI was barbed roman blinds, with a significant mean reduction of [SMD = -4.956 , 95% CI (-6.218 - -3.693), p -value < 0.001] (**Figure 2**). The mean reduction of AHI for the classical Uvulopalatopharyngoplasty (UPPP) was [SMD -1.466 , 95% CI (-1.880 - -1.052), p -value < 0.001] (**Figure 2**). Random model was used, as heterogeneity was significant with $I^2 = 87.814$, and p -value < 0.001 .

2) ESS (Epworth Sleepiness Scale)

Meta-analyses of relevant studies showed that the surgical technique that achieved the best reduction on ESS was the relocation pharyngoplasty, with a significant mean reduction of [SMD = -0.998 , 95% CI (-1.253 - -0.743), p -value < 0.001] (**Figure 3**). On the other hand, the surgical technique that achieved the

worst reduction on ESS was barbed roman blinds, with a significant mean reduction of [SMD = -2.448, 95% CI (-3.149 - -1.827), p-value < 0.001] (Figure 3). The mean reduction of AHI for the classical UPPP was [SMD -1.388, 95% CI (-1.855 - -0.922), p-value < 0.001] (Figure 3). Random model was used, as heterogeneity was significant with $I^2 = 87.814$, and p-value < 0.001.

3) Minimal Oxygen Saturation Percentage

Meta-analysis for changes in AHI regards different surgical techniques

Random effect model, Heterogeneity: $I^2=87.814$, P-value<0.001

Figure 2. Meta-analysis for the changes in AHI regarding the different surgical techniques.

Meta-analysis for changes in ESS regards different surgical techniques

Random effect model, Heterogeneity: $I^2=87.814$, P-value<0.001

Figure 3. Meta-analysis for the changes in ESS regarding the different surgical techniques.

Meta-analyses of relevant studies showed that the surgical technique that achieved the most reduction in O₂ saturation was the expansion sphincter pharyngoplasty, with a significant mean reduction of [SMD = 1.011, 95% CI (0.581 - 1.440), p-value < 0.001] (**Figure 4**). On the other hand, the surgical technique that achieved the worse reduction in O₂ saturation was relocation pharyngoplasty, with a significant mean reduction of [SMD = 0.524, 95% CI (0.315 - 0.733), p-value < 0.001] (**Figure 4**). The mean reduction of AHI for the classical UPPP was [SMD 0.990, 95% CI (0.565 - 1.414), p-value < 0.001] (**Figure 4**). Random model was used, as heterogeneity was significant with $I^2 = 82.776$, and P-value < 0.001.

4) VAS (Visual Analogue Scale) for Snoring

Meta-analyses of relevant studies showed that the surgical technique that achieved the best reduction in VAS was Z-Palatoplasty, with a significant mean reduction of [SMD = -1.551, 95% CI (-2.049 - -1.052), p-value < 0.001] (**Figure 5**). On the other hand, the surgical technique that achieved the worse reduction in VAS was expansion sphincter pharyngoplasty, with a significant mean reduction of [SMD = -4.579, 95% CI (-5.381 - -3.788), p-value < 0.001] (**Figure 5**). The mean reduction of VAS for the classical UPPP was [SMD -2.560, 95% CI (-3.059 - -2.061), p-value < 0.001] (**Figure 5**). Random model was used, as heterogeneity was significant with $I^2 = 94.172$, and p-value < 0.001.

5) Soft Palate Length

Meta-analyses of relevant studies showed that the UPPP surgical technique achieved soft palate length change with a significant mean reduction of [SMD = -2.219, 95% CI (-2.730 - -1.708), p-value < 0.001] (**Figure 6**). While, relocation pharyngoplasty achieved reduction in soft palate length, with a significant mean [SMD = -1.549, 95% CI (-2.063 - -1.035), p-value < 0.001] (**Figure 6**). Random model was used, as heterogeneity was significant with $I^2 = 96.706$, and p-value < 0.001.

6) Success Rate

Meta-analyses of relevant studies showed that expansion sphincter pharyngoplasty achieved the overall highest significant success rate [Event rate = 77%, 95% CI (65.4% - 85.5%), p-value < 0.001] (**Figure 7**). While, Z-Palatoplasty achieved the least success rate [Event rate = 52.5%, 95% CI (20.1% - 82.9%)] (**Figure 7**). Random model was used, as heterogeneity was significant with $I^2 = 73.015$, and p-value < 0.001.

4. Discussion

OSA management can be divided into surgical and non-surgical with the earliest surgical technique being the UPPP. Subsequent modifications to the original technique and introduction of novel techniques have all been aimed at achieving consistently higher success rates and fewer complications.

This study included papers published in the last 10 years, starting in 2008. The reason being that the majority of the techniques with the exception of the Lateral

Pharyngoplasty and modifications on the original UPPP, were introduced starting 2007. Therefore, including earlier papers would have possibly skewed the results in favor of older techniques.

Meta-analysis for changes in minimal O2 saturation % regards different surgical techniques

Random effect model, Heterogeneity: $I^2=82.776$, P-value<0.001

Figure 4. Meta-analysis for the changes in minimal oxygen saturation percentage regarding the different surgical techniques.

Meta-analysis for changes in VAS regards different surgical techniques

Random effect model, Heterogeneity: $I^2=94.172$, P-value<0.001

Figure 5. Meta-analysis for the changes in VAS for snoring regarding the different surgical techniques.

Meta-analysis for changes in soft palate length regards different surgical techniques

Random effect model, Heterogeneity: $I^2=96.706$, P-value<0.001

Figure 6. Meta-analysis for the changes in soft palate length regarding the different surgical techniques.

Meta-analysis for success rate regards different surgical techniques

Random effect model, Heterogeneity: $I^2=73.015$, P-value<0.001

Figure 7. Meta-analysis of the success rate regarding the different surgical techniques.

The success of palatal surgical techniques in treating OSA is graded according to improvements in different parameters. These namely being the AHI, ESS, Oxygen desaturation index & VAS for snoring. Overall success in the majority of the papers was defined using Sher's Criteria introduced by Sher & Colleagues in their 1996 publication [11]. The criterion states that surgical success for a given procedure is defined as 50% or more decrease in the AHI with a post-operative AHI less than or equal to 20/ hour. Based on Sher's criteria, our results show that the Expansion Sphincter Pharyngoplasty achieved the highest success rate. Our findings are consistent with those of other authors.

In 2018, Pang *et al.* published a Systematic review and meta-analysis which concluded that ESP resulted in better post-operative outcomes than other traditional surgeries, namely the Anterior Palatoplasty, Classical UPPP and Uvulopa-

latal Flap procedures [12]. It should be noted, however, that this result is by no means universal, in the sense that not every patient suffering from OSAS will respond to ESP. There is no one-size-fits-all.

After reviewing the literature, several points of note have been identified:

- There is a general consensus that UPPP is no longer the best option for treating OSA. It is associated with significant post-operative pain and out of the previously discussed palatal surgeries has the highest risk of post-operative bleeding. Furthermore, UPPP can result in the much-disliked complication of velopharyngeal stenosis due to scar contracture according to Katsantonis, G. P., Friedman, W. H., Krebs, F. J., & Walsh, J. K. (1987) [13].
- BRP is a quicker and easier technique to perform than the ESP and fully respects the anatomical integrity of the palate. It is also the technique associated with the least blood loss. The success of the BRP and ESP techniques stems mainly from the widening of the lateral retro-palatal diameters. That being said, despite the ESP achieving the highest success rate in our analysis, the ESP procedure has been associated food residues in the pyriform fossae due to interruption of the pharyngeal muscles that protect them [14].
- The Barbed roman blinds technique tensions the lateral wall without interrupting palatopharyngeal muscles unlike FEP and ESP and this tension occurs along the whole length of the thread. Barbed suturing allows muscles to be moved along different vectors (anteriorly, posteriorly, laterally) as required based on DISE evaluation.
- Pre-operative evaluation and identification of the site of obstruction is critical to optimizing post-operative results. DISE has proven to be the best diagnostic procedure suited to this purpose. By correctly locating the site of collapse the surgical technique that best addresses that site can be chosen and techniques which do not adequately address the pathological site can be avoided, even if it means forgoing palatal surgery altogether because the collapse is hypopharyngeal for example.
- There isn't always a single site of airway collapse and hence more than one surgery might be needed at different levels (multi-level surgery) to achieve a response.
- OSA severity can be graded as mild, moderate or severe. In many of the papers reviewed, authors would initially include only those patients with mild to moderate OSA. The main reasoning behind this was that they realized that the surgery they were proposing would not achieve adequate results in severe OSA patients. Nevertheless, this subsequently results in a distorted outcome.
- Some patients suffer from positional OSA. These patients tended to be in the mild to moderate group of OSA sufferers, whereas non-positional OSA subjects usually had severe OSA [15]. Consequently, positional OSA individuals tended to have higher post-operative success rates than their non-positional counterparts.
- Each procedure has its claimed advantages, however, objectively speaking, the best procedure would undoubtedly be the one that achieves the best

post-operative results whilst minimizing palatal anatomical distortion and post-operative complications.

5. Conclusion

The best procedure for treating OSA varies from patient to patient and there is no universal cure-all. Careful patient selection and pre-operative evaluation are mandatory.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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