ACTA OTORHINOLARYNGOLOGICA ITALICA 2022;42:273-280; doi: 10.14639/0392-100X-N1871

OSAHS

Management of pharyngeal collapse in patients affected by moderate obstructive sleep apnoea syndrome

Gestione del collasso faringeo in pazienti affetti da sindrome delle apnee ostruttive di grado moderato

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SUMMARY

Objective. This study reports our experience in a selected cohort of patients affected by mild-moderate OSAS, without tonsillar obstruction, and treated with pharyngoplasty.

Methods. In a case-control retrospective study, we compared modified expansion sphincter pharyngoplasty (MESP) to modified barbed reposition pharyngoplasty (MBRP) in adult patients with oropharyngeal transversal collapse with a BMI ≤ 30 kg/m^2, and mild-moderate obstructive sleep apnoea syndrome (OSAS). A clinical evaluation, including collection of anthropometric data and sleep endoscopy, was performed. Six months after surgery, symptoms recording, clinical evaluation and polysomnography (PSG) were repeated.

Results. We enrolled 20 patients: 10 treated with MESP and 10 treated with MBRP. Mean apnoea-hypoapnoea index (AHI) was 22.8 (± 5.63). We observed in both groups a significant reduction of AHI and oropharyngeal obstruction (p = 0.01), with a success rate, according with Sher's criteria, of 90% for MESP and 80% for MBRP, respectively. Post-surgical pain and snoring reduction were significantly lower with MBRP.

Conclusions. We recorded similar success rates for both techniques. MBRP may be considered better than MESP due to less surgical time, no potential mucosal damage, absence of knots, and faster recovery with less pain.

KEY WORDS: soft palate, obstructive sleep apnoea hypopnoea syndrome, sleep-disordered breathing

RIASSUNTO

Obiettivo. *Riportare la nostra esperienza in una coorte selezionata di pazienti affetti da sindrome da apnee ostruttive del sonno (OSAS) lieve-moderata, senza ipertrofia tonsillare, trattati con faringoplastica.*

Metodi. *Confrontare in uno studio retrospettivo caso-controllo la Expansion Sphincter Pharyngoplasty modificata (MESP) e la Barbed Reposition Pharingoplasty modificata (MBRP) in pazienti adulti con collasso trasversale orofaringeo con BMI ≤ 30 e OSAS lieve-moderata. È stata effettuata una valutazione clinica, con raccolta di dati antropometrici e sleep endoscopy. Sei mesi dopo l'intervento sono stati rivalutati i sintomi e ripetuta la polisonnografia (PSG).*

Risultati. *20 pazienti, dieci trattati con MESP e dieci trattati con MBRP. Indice di apnea-ipopnea (AHI) medio di 22,8 (± 5,63). Abbiamo osservato in entrambi i gruppi una riduzione significativa dell'AHI e dell'ostruzione orofaringea (p = 0,01), con un tasso di successo secondo i criteri di Sher del 90% per MESP e 80% per MBRP. Il dolore post-operatorio e la riduzione del russamento erano significativamente più bassi nella MBRP.*

Conclusioni. *Abbiamo registrato percentuali di successo simili per entrambe le tecniche. L'MBRP può essere considerata superiore alla MESP per minor tempo chirurgico, assenza di potenziali danni alla mucosa, assenza di nodi e un recupero più rapido con meno dolore.*

PAROLE CHIAVE: *palato molle, sindrome delle apnee-ipopnee ostruttive nel sonno, disturbi respiratori nel sonno*

Received: October 27, 2021
Accepted: February 21, 2022

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How to cite this article: Lorusso F, Dispenza F, Sireci F, et al. Management of pharyngeal collapse in patients affected by moderate obstructive sleep apnoea syndrome. Acta Otorhinolaryngol Ital 2022;42:273-280. https://doi.org/10.14639/0392-100X-N1871

Introduction

Obstructive sleep apnoea syndrome (OSAS) is a sleep disorder caused by an excessive narrowing of the pharyngeal wall that collapses during inspiration, resulting in increased negative intrathoracic pressure, which further exacerbates the condition [1].

The prevalence of the disease is 3-7%, and many factors are involved in the development of this disorder, such as aging, male gender, obesity, family history, menopausal, craniofacial abnormalities and habits such as smoking and alcohol abuse [2].

Although nasal pathologies are not a direct cause of pharyngeal collapse, a close correlation exists between OSAS and non-allergic rhinitis (NAR), particularly in non-allergic rhinitis with eosinophilia syndrome (NARES). Probably this condition is due to nasal congestion, chronic eosinophilic inflammation, or nervous reflexes. However, the role of these mechanisms is still debated [3].

OSAS also affects children, and in most of cases it is related to adenotonsillar hypertrophy [4]. In this particular group of patients, there is a relationship between sleep breathing disorders and negative effects on mental health, cognitive and behavioural abilities. However, these conditions improve when the patient is treated with adenotonsillectomy [5]. In the last 15 years, several conservative surgical techniques have been developed to treat retropalatal obstruction, including anterior palatoplasty [6], lateral pharyngoplasty [7], expansion sphincter pharyngoplasty [8], relocation pharyngoplasty [9] and barbed reposition pharyngoplasty [10].

It is now clear that determining the sites and patterns of collapse of the upper airway (UA) in OSAS patients is pivotal for selection of the appropriate surgical intervention. In our study, we focused attention on retropalatal transversal collapse.

The purpose of the present study is to report our surgical experience in a selected cohort of patients affected by mild-moderate OSAS, without tonsillar obstruction, treated with a pharyngoplasty technique. The presence of some tonsillar obstruction at oropharyngeal level may cause, in our opinion, a bias in the evaluation of a palatal surgical technique. We compared modified expansion sphincter pharyngoplasty (MESP) and the modified barbed reposition pharyngoplasty (MBRP) in a single stage of treatment in patients with transversal collapse at the oropharyngeal level.

Materials and methods

A case-control retrospective study was conducted from September 2012 to February 2019 at the Department of Otolaryngology, Policlinico Universitario Paolo Giaccone, Palermo, Italy.

We included adult patients with body mass index (BMI) ≤ 30 kg/m^2, who had snoring and OSAS symptoms with apnoea-hypopnea index (AHI) > 5 and < 30 on polysomnography (PSG) examination, and transverse oropharyngeal obstruction pattern. All enrolled patients refused ventilatory therapy with continuous positive airway pressure (CPAP). We excluded patients with upper airway obstruction other than oropharyngeal obstruction such as those caused by the anatomical features of the tongue assessed as Friedman score higher than grade 1, tonsil hypertrophy higher than grade 1 [11], craniofacial abnormalities, evidence of multilevel airway obstruction. The selection process is shown in Figure 1. In the patients with nasal obstruction [12] such as significant deviation of the nasal septum or polyposis, we preferred to anticipate the nasal surgery, followed by the repetition of the PSG six months later and finally oropharyngeal surgery.

All patients underwent anamnestic data collection, with a subjective assessment of the daytime sleepiness with the Epworth Sleepiness Scale (ESS), and a snoring assessment with a 0-10 visual analogue scale (VAS snoring: 0 = no snoring; 10 = maximum loudness of snoring) administered to their bed partners.

The patients underwent to a clinical evaluation, which included the collection of anthropometric data (neck circumference, BMI) and preoperative endoscopic examination of the nose and upper airway to locate and grade the obstruction with drug induced sleep endoscopy (DISE) according to the European position paper [13]. We used the NOHL grading proposed by Vicini et al. [14] to evaluate the obstruction. This grading consists of the evaluation of the obstruction at the nasal level (N), oropharyngeal level (O), hypopharyngeal level (H) and laryngeal level (L). It is a quantitative

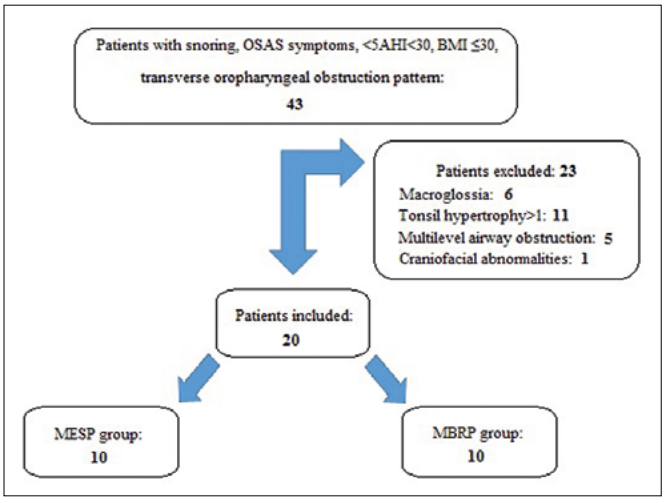

Figure 1. Flow diagram describing the selection process.

evaluation of the obstruction, in which 1 corresponds to a collapse lower than 25%; 2, from 25 to 50%; 3, from 50 to 75%; and 4, more than 75% of collapse. With the aim to select only cases with transverse pharyngeal collapse, we evaluated also the dynamic pattern of pharyngeal wall collapse: circular (c), transverse (t) and antero-posterior (a-p).
All patients underwent a single-step oropharyngeal surgery, and we defined two groups based on surgical procedure performed: Group A modified expansion sphincter pharyngoplasty (MESP), and Group B modified barbed reposition pharyngoplasty (MBRP).
Post-operative pain was evaluated with a 0-10 visual analogue scale (VAS pain; 0 = no pain; 10 = maximum pain you've ever experienced). Daily pain was evaluated as the average of three values taken each day, three times a day, for 10 post-operative days.
Post-operative complications were recorded, divided into: mild complications (bleeding that stops spontaneously and does not require recourse to the operating room, transient dysphagia and sense of foreign body); and serious complications (bleeding that requires surgical treatment, persistent dysphagia).
Six months after surgery, we recorded symptoms, with Epworth sleepiness scale (ESS) and VAS snoring assessment administered to the bed partner.
Clinical evaluation was also repeated, with collection of anthropometric data (neck circumference, BMI), endoscopic upper airways examination with DISE and PSG.
All PSGs were performed at our sleep laboratory, and the results were interpreted by certified sleep medicine physicians.
Both groups of patients had a mean follow-up longer than one year.
The results were expressed as absolute and relative frequencies for the categorical variables, or as the mean with standard deviation (SD) for the continuous variables. A comparison of the quantitative variables between pre- and postoperative was performed using the Student's t-test. All tests were two-sided, and values of $p < 0.05$ were considered statistically significant. Statistical analyses were performed using Microsoft Excel 2003 (Microsoft Corporation, Redmond, WA, US) software and imported into the R-project (R Foundation for Statistical Computing, Vienna, Austria) software, version 2.15.2.

Surgical procedure

Each surgical procedure was performed under general anaesthesia by the same surgeon. In MESP [14] the first step of the surgery consists of bilateral tonsillectomy with identification of the palato-glossal and palato-pharyngeal muscle and preservation of the covering mucosa. The palato-pharyngeal muscle is then isolated from the surrounding tissues, preserving the fibres of the upper pharyngeal constrictor. At this point, two ligatures are placed at the level of the distal margin of the muscle to keep the muscle fibres together and to ensure better haemostasis, since the muscle is sectioned downwards creating a superior hinged muscle flap, in part connected to the upper constrictor of the pharynx.
At this point, the original technique [8] involves an incision of the palato-glossus muscle fibres at the palatine arch plane, the suture of the distal portion of the flap at this level, and the subsequent suturing of the superficial mucous planes. In our experience, this passage was modified by creating a tunnel in the context of the soft palate with a 45° angle in the direction of the pterygoid hamulus, tipping the muscular flap inside the tunnel and fixing it with two resorbable stitches in position to obtain an antero-lateral palate stretching. At this point, the palatine pillars are joined with a resorbable suture. A partial uvulectomy is performed depending on the laxity of the uvular mucosa.
In MBRP, the first step consists in tonsillectomy with careful preservation of the mucosa of the anterior and posterior pillars, therefore the lower portion of the palate-pharyngeal muscle is partially incised to weaken it. Next, unlike BRP proposed by Vicini et al. [10], we do not perform a removal of full-thickness mucosa and muscle triangle at the upper lateral edge of the tonsillar loggia. The needle is then introduced at the level of the posterior palatal spine, made to pass completely through the palate in a lateral direction, then around the pterigo-mandibular raphe, and is taken out of the bed of the tonsillectomy and then passed through the upper part of the palate muscle pharyngeal making it come out near the mucosa of the posterior pillar, but not crossing it. Then, the needle is passed again through the palatopharyngeal muscle and through the raphe by suspending the posterior pillar. By allowing the posterior pillar to be positioned in a more lateral and anterior position, this passage is repeated several times up to the most distal part of the palate-pharyngeal muscle and therefore the thread is passed through the soft palate to block it.

Results

A total of 20 patients with moderate OSAS were selected as suitable for the study, 10 in group A and 10 in group B. There were no significant preoperative differences between the two groups (Tab. I).
The sample consisted of 20 men, with an average age of 45 years (± 9.42), mean BMI of 28.55 (± 3.04) and mean neck circumference of 40.75 cm (± 1.9). All patients had a history of snoring associated with mild to moderate apnoea, and, in most cases, also with frequent arousal and sudden awakening. The patients had a mean AHI of 22.8 (± 5.63).

Table I. Preoperative clinical data comparation between group A and B: there were no differences between groups in baseline characteristics.

PRE-OP	MESP	MBRP	t-test
Age	48.4 (sd 4.8)	41.6 (sd 11.77)	P = 0.16
BMI	28.4 kg/m^2(sd 3.06)	28.7 kg/m^2 (sd 3.02)	P = 0.07
Neck	40.2 cm (sd 1.8)	41.3 cm (sd 2.1)	P = 0.06
AHI	23.9 (sd.61)	22.03 (sd 5.05)	P = 0.12
Grade N	1.3 (sd 0.48)	1.2 (sd 0.35)	P = 0.06
Grade O	3.4 (sd 0.51)	3.6 (sd 0.51)	P = 0.07
Grade H	1.8 (sd 0.9)	1.6 (sd 0.69)	P = 0.07
ESS	10.4 (sd 3.1)	9.1 (sd 2.07)	P = 0.08
Snoring	9.1 (sd 1.8)	9.1 (sd 1.37)	P = 0.07

BMI: Body Mass Index; AHI: Apnoea-Hypopnea Index; ESS: Epworth Sleepiness Scale; Grade N: nasopharyngeal collapse at Mueller's maneuver; Grade O: oropharyngeal collapse at Mueller's maneuver Grade H: hypopharyngeal collapse at Mueller's maneuver.

In Group A, one patient had previous tonsillectomy, and for that reason had tonsillar grade 0; nine patients had tonsillar grade I. In Group B, two patients had previous tonsillectomy with tonsillar grade 0; eight patients had tonsillar grade I.

All patients had prolapsed soft palate, with hypertrophy of the uvula and posterior palatine pillars.

Seven patients were taking pharmacological treatment for hypertension in group A, and six in group B. Two patients of group B had a history of mild depressive disorder with anxiety; three patients were smokers in group A and four in group B. None of them usually drank alcohol. Respiratory allergies were reported by three patients in group A and five in group B.

Daytime sleepiness was evaluated with the ESS; a pathologic score was achieved by nine patients, with an average value of 10.4 (± 3.1) in group A, and five patients in group B with a main value of 9.1 (± 2.07).

After surgery (Tab. II), postoperative assessment revealed a reduction in daytime sleepiness in all patients, with the persistence of a pathological score in two patients belonging to group A. The postoperative ESS mean score results was of 5.1 (± 3.17) (p = 0.02) in group A and 4.5 (± 2.5) (p = 0.04) in group B.

The preoperative mean snoring score was 9.1 (± 1.8) in group A and postoperatively was reduced to 3.5 (± 2.1) (p = 0.03). In group B, the preoperative mean snoring score was 9.1 (± 1.37) and was post-operatively reduced to 1.4 (± 1.25) (p = 0.02).

Considering anthropometric data, the mean BMI was of 28.4 kg/m^2 (± 3.06) in group A and 28.7 kg/m^2 (± 3.02) in group B. In the postoperative evaluation, six months after surgery, the BMI remained substantially unchanged in all patients. The mean preoperative neck circumference was 40.2 cm (± 1.8) in group A and 41.3 cm (± 2.1) in group B, and no changes were recorded in the postoperative evaluation in either group.

As expected, we did observe modification in the nasal obstruction that was 1.3 (± 0.48) in group A and 1.2 (± 0.35) in group during DISE in the pre- and post-operative evaluations. We observed (Tab. II) a reduction in oropharyngeal obstruction that was predominantly transverse in all patients according to the selection criteria, and decreased postoperatively from a mean of 3.4 (± 0.51) to 1.3 (± 0.48) (p = 0.01) in group A. In group B, it decreased from a mean of 3.6 (± 0.51) to 1.2 (± 0.42) (p = 0.01).

Regarding hypopharyngeal obstruction, we observed a preoperative reduction from a mean of 1.8 (± 0.9) to 1.1 (± 0.31) (p = 0.01) in group A, and in group B from 1.6 (± 0.69) to 1.5 (± 0.7) (p = 0.07). No laryngeal modifications were observed.

Comparison between pre- and postoperative PSG data confirmed the success rates according to Sher criteria (AHI reduction > 50% and AHI value < 20) [15].

In group A, we noted a reduction of 40.9% in mean AHI, which from a mean of 23.9 (± 6.61) decreased to 11 (± 3.31) postoperatively (p = 0.01), with a success rate, according to the Sher's criteria of 90%; similar results was obtained in group B with reduction of 38.07% of AHI, which from 22.03 (± 5.05) decreased to 12.47 (± 5.03) (p = 0.01), with a success rate according to the Sher's criteria of 80%.

Comparing the results obtained in the post-operative phase between the two techniques, we highlighted a significant difference in the reduction of hypopharyngeal obstruction and snoring (Tab. II).

Postoperative pain was treated with paracetamol 1 g every 8 hours for the first 3 post-operative days, and then administered as needed the following days. In group B, we recorded a significant decrease in post-operative pain compared to group A (p = 0.02).

After the fifth postoperative day, none of the patients of group B needed analgesic therapy; on the contrary, in group

Table II. Comparation of results between MESP and MBRP.

	Pre-op MESP	Post-op MESP	t-test	Pre – op MBRP	Post- op MBRP	t-test	Post-op A vs B t-test
Age	48.4 (SD 4.8)	48.4 (SD 4.8)	P = 0.11	41.6 (SD 11.77)	41.6 (SD 11.77)	P = 0.18	P = 0.16
BMI	28.4 kg/m^2 (SD 3.06)	28.4 kg/m^2 (SD 3.06)	P = 0.06	28.7 kg/m^2 (SD 3.02)	28.7 kg/m^2 (SD 3.02)	P = 0.07	P = 0.07
Neck	40.2 cm (SD 1.8)	40.2 cm (SD 1.8)	P = 0.06	41.3 cm (SD 2.1)	41.3 cm (SD 2.1)	P = 0.07	P = 0.06
AHI	23.9 (SD 6.61)	11 (SD 3.31)	P = 0.01	22.03 (SD 5.05)	12.47 (SD 5.03)	P = 0.01	P = 0.01
Grade N	1.3 (SD 0.48)	1.3 (SD 0.48)	P=0.07	1.2 (SD 0.35)	1.2 (SD 0.35)	P = 0.06	P = 0.06
Grade O	3.4 (SD 0.51)	1.3 (SD 0.48)	P=0.04	3.6 (SD 0.51)	1.2 (SD 0.42)	P = 0.02	P = 0.07
Grade H	1.8 (SD 0.9)	1.1 (SD 031)	P=0.01	1.6 (SD 0.69)	1.5 (SD 0.7)	P = 0.08	P = 0.07
ESS	10.4 (SD 3.1)	5.1 (SD 3.17)	P=0.02	9.1 (SD 2.07)	4.5 (SD 2.5)	P = 0.04	P = 0.08
Snoring	9.1 (SD 1.8)	3.5 (SD 2.1)	P=0.03	9.1 (SD 1,.37)	1.4 (SD 1.25)	P = 0.02	P = 0.03

BMI: Body Mass Index; AHI: Apnoea-Hypopnea Index; ESS: Epworth Sleepiness Scale; Grade N: nasopharyngeal collapse at Mueller's maneuver; Grade O: oropharyngeal collapse at Mueller's maneuver; Grade H: hypopharyngeal collapse at Mueller's maneuver.

A the patients required some analgesic treatment until the 10th post-operative day.

In group A, we reported 2 cases of serious complications with early bleeding on the first postoperative day. No case of fluid reflux into the nose was noted. In group B, no serious complications were reported. In both groups, two patients presented a feeling of a persistent foreign body in the throat for a few months after the intervention; however, this symptom spontaneously resolved.

Discussion

OSAS is a relatively common sleep disorder, affecting an estimated 3-7% of adults [3].

This disease also affects children, with a prevalence of 1.8% [16] and in most of cases is related to adenotonsillar hypertrophy; about 80% of children benefit from surgery [4].

The consequence of the collapse of the upper airway is a reduction in blood oxygenation; for this reason, OSAS is considered a systemic disease, and over the last decades, attention to persistent snoring, particularly when associated with apnoea syndrome, has increased greatly [6].

It can be considered a multisystem disease because poor oxygenation of the body at night leads to important repercussions on the entire organism.

Rashid et al. evaluated in a recent systematic review the desaturation index (ODI) for diagnosis of OSAS. According to this review, a diagnosis of OSAS should be considered with a 4% ODI of ≥ 15 events/hour; further evaluation is instead required with a 4% ODI ≥ 10 events/hour. Screening is recommended for the detection of OSAS associated with cardiovascular risk in middle-aged men without comorbidities [17]. In fact, untreated OSAS, in addition to causing depressive symptoms and reduced quality of social, economic and family life, can cause sudden death, uncontrolled hypertension, coronary heart disease and congestive heart failure [18]. As suggested by the literature, many snoring and obstructive episodes seem to be related to anatomical features of the soft palate and, for this reason, OSAS surgery is often focused on widening the retropalatal space [13].

In 1963, Ikematsu introduced uvulopalatopharyngoplasty (UPPP) as a single step procedure. This technique was then adopted and disseminated by Fujita et al. in 1981, and, in the following two decades, was widely performed and extensively investigated despite low success rates and many complications [15].

In the last 15 years, researchers shifted to more conservative surgical options to treat palatal obstruction.

In 2003, Cahali [7] was the first to focus attention on the lateral pharyngeal wall in the development of OSAS by using lateral pharyngoplasty (LP). The main purpose of this technique is the stiffening and enlargement of the lateral walls, unlike uvulopalatopharyngoplasty, in which the surgical goal is to shorten and stiffen the soft palate.

Expansion sphincter pharyngoplasty (ESP), developed by

Pang and Woodson in 2007 [8], is based on the fundamental concept that at pharyngeal level the obstruction linked to the collapse of the lateral walls of the pharynx plays a fundamental role. This technique is much more conservative and respectful of the palatal anatomy than the previous approaches. Increasing the transverse space at the level of the pharynx allows the dislocation of the palate-pharyngeal muscle, which is not completely isolated from the upper pharyngeal constrictor and creates sufficient tension on the side walls. ESP also tends to widen further, in the anterolateral sense, the space at the level of the oropharyngeal vestibule during the healing phases. This is due to the cicatricial retraction of the palate-pharyngeal muscle flap that stretches the palate and lateral walls of the pharynx by creating centrifugal healing vectors [19].

In 2009, Pang et al. [6] described anterior palatoplasty as a minimally invasive technique for OSA, based on the concept of obtaining expansion and stabilisation of the collapsible pharyngeal soft tissues via tissue preservation.

Functional expansion pharyngoplasty (FEP) [20] was suggested by Sorrenti for the treatment of lateral pharyngeal wall collapse; physiological correction can be obtained by taking advantage of the anatomical characteristics of the palatal pharyngeal muscle. However, similar to ESP, the technique requires dissection and relocation of mucosa-deprived muscles that are not devoid of mucosal tear and muscle trauma, weakness and/or fibrosis.

Barbed reposition pharyngoplasty (BRP) proposed by Vicini et al. [10], arises from the idea of using self-locking wires applied to a technique similar to relocation pharyngoplasty [9], but being more conservative with respect to palatal anatomy. It is based on the principle that the palatine pillars and palate are considered as a tripod and therefore, weakening the posterior palatine pillar and moving it forward tends to unbalance the entire system forward by increasing the transversal mesopharynx space. Recently, Babademez et al. [21] proposed a modification of barbed pharyngoplasty, using a single continuous suture technique in patients with retropalatal collapse. Our study compared the results obtained between BRP and MBRP with this new suturing technique concluding that there are no significant differences in terms of outcomes. Although in the literature there are several studies that have shown good anatomical and functional results with the use of barbed sutures, some authors have reported a possible extrusion in both the medium and long term. However, a recent study concluded that barbed wire extrusion did not lead to any significant worsening of the long-term outcomes of OSAS surgery [22].

In 2018, Askar and El-Anwar [23] proposed double suspension sutures, a simple and easy technique for the single step treatment of palatal obstruction with the objective of respecting and preserving the anatomical and physiological components of the velopharyngeal sphincter.

Despite the numerous techniques proposed for the treatment of retropalatal collapse there are a limited number of studies evaluating the success of recent techniques in the literature. Studies comparing the results of ESP and barbed pharyngoplasty are also scarce.

From the limited number of studies evaluating the success of recent techniques in the literature, Pang et al. [24] showed a success rate of 82.6% based on Sher's criteria [13] for ESP in their randomised controlled clinical trial.

In another study analysing 77 mild-moderate OSAS patients, a success rate for anterior palatoplasty (AP) of 71.8% was reported [25].

However, Pang reported that a combination of ESP and AP gives better results for patients with all grades of AHI with a success rate of 83.2% [26].

Vicini et al. [10] reported a success rate of 90% for BRP for patients with all grades of AHI, although in a multicentre prospective study performed on 111 patients, Montevecchi et al. reported that the success rate was 73% in the group with a mean AHI of 33.4 [27].

Karakoc et al. reported outcomes of patients with mild to moderate OSAS treated with AP, LP and ESP in their prospective study with success rates of 45, 64 and 74%, respectively [28].

Babademez et al. [29] compared the outcomes of ESP combined to AP and BRP in patients with mild to moderate OSAS, obtaining, respectively, a success rate of 84.9 and 86.6%.

In our case series, we adopted modifications to both the original ESP and BRB techniques with the aim of being more respectful of the anatomical structures involved in the surgical incisions. We are not aware of any literature studies comparing ESP and BRP in the treatment of mild-moderate OSAS in selected subjects with 0 or I tonsil grading. Our goal was to evaluate the impact of the two techniques on improving OSAS regardless of the action of the tonsils that have an important role at the oropharyngeal level in reduction of the respiratory space and in worsening of the collapse. In fact, it is known that patients with more voluminous tonsils have greater post-operative improvement [30].

By comparing the two groups that were homogeneous with regards to the pre-operative characteristics, we did not observe significant differences in patients treated with MESP compared to those treated with MBRP considering daytime sleepiness evaluated with ESS, BMI and anthropometric data.

Regarding the data of DISE, we observed a comparable reduction of oropharyngeal obstruction that was predominantly transverse, but we noted a significantly higher reduc-

tion ($p = 0.01$) at the hypopharyngeal level in patients subjected to MESP compared to those treated with MBRP. This is probably due to the greater action at the hypopharyngeal level due to the low resection of the palatopharyngeal muscle, which increases the transverse space more at this level. No modifications were observed at the laryngeal level.

The success rates were similar to those according to Sher's criteria of 80% for MESP and 70% for MBRP.

We observed a significant difference in reduction of snoring in patients subjected to MBRP compared to those subjected to MESP, probably due to the greater stabilisation and stiffness at the palatal level obtained with multiple passages of the barbed wires anchored to the fibrous points of hamulus, raphe and posterior nasal spine. In addition, the multiple lateral sustaining suture loops performing by barbed suture provides more stable soft palate suspension than the single pulling tip suture of ESP, with no risk of tearing the muscle fibres, respecting the mucosa and muscular structure.

This allows to obtain a greater palatal rigidity, without causing side effects such as rhinolalia and oral-nasal reflux, but considerably reducing snoring.

It is known that ESP is a more invasive technique compared to BRP, since the palatopharyngeal muscle is dissected while performing ESP. We did not perform muscle-mucosal incisions on the palate in either MESP or MBRP, but we have also observed a significant decrease in post-operative pain ($p = 0.02$) and dysphagia in the MBRP group, with less use of analgesics in the post-operative period.

As previous studies have reported, the operation time for MBRP is shorter than MESP as a result of using a barbed suture and a minor surgical dissection.

The most important feature of both these techniques, which makes them more advantageous than traditional palatal surgeries is that there is no prominent tissue resection and, thus, major drawbacks like regurgitation and velopharyngeal insufficiency are less frequent. The major complication that we had in both techniques was post-operative bleeding, which was more frequent and of greater importance in MESP due to the greater extent of surgical dissection.

Conclusions

We compared outcomes after MESP and MBRP, two recent techniques of palatopharyngeal surgeries in patients with OSAS. Although MBRP allows for slightly less functional results compared to MESP, it should be preferred as it has lower surgical invasiveness due to reduced manipulation of muscular structures and stable anchorage to the pterygomandibular raphe and posterior nasal spine due to the use of knotless resorbable suture technology. Although the results support the use of MBRP for its lower surgical time, no potential mucosal damage, absence of knots and probably faster recovery with less pain, further prospective studies of larger case series are needed to establish its superiority over MESP.

Conflict of interest statement

The authors declare no conflict of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

Conceptualisation: FL, SG and FD; methodology: FL and FD; validation: SG; investigation: FS and AI; resources: FS and AI; formal analysis: PI; writing – original draft preparation: FL; writing – review and editing: AI and PI; project administration: SG.

Ethical consideration

This study was approved by the Comitato Etico of Policlinico "Paolo Giaccone" of Palermo (Ref n° 27/06). All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from each participant/patient for study participation and data publication.

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