



Barbed Suspension Bridge Pharyngoplasty: Introducing a Novel Technique for Barbed Pharyngoplasty

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Abstract

Surgical management of Obstructive Sleep Apnea (OSA) and Snoring has undergone many major and minor changes over a period of last decade. The most common surgical approach for OSA is uvulopalatopharyngoplasty (Stuck et al. in *Sleep Med* 50:152–165, 2018). The main goals of treatment of OSA are to decrease the risk of deleterious health effects and improve quality of sleep (Evans et al. in *Otolaryngol Clin North Am* 53: 319–328, 2020). Since bimanual surgical techniques in the depth of oral cavity have been tricky, search for a less demanding & easy to learn technique is always on. The surgical technique should also provide long term results with manageable complications. Barbed suture has been in sporadic use for the last decade amongst sleep apnea surgeons for its advantage of knotless application and distributed suture tension. However, the barbed suture which has been used is absorbable and is used only to close the surgical wound on the soft palate. In this paper we are describing our technique of using the 3-0 Polybutester non absorbable barbed suture to perform a novel technique of palatal surgery, in which we suspend the lower part of the soft palate permanently as a suspension bridge between the right and left Pterygomandibular raphae, so that the lower part of the soft palate cannot move posteriorly to touch the posterior pharyngeal wall preventing airway obstruction whereas it can still move superiorly freely while swallowing or during phonation. This technique can prove to be a technically less demanding one which provides excellent long-term results in snoring and OSA with manageable complications.

Keywords Barbed Pharyngoplasty · Surgery for Snoring · OSA surgery · Suspension bridge Pharyngoplasty · Polybutester barbed

Introduction

Obstructive Sleep Apnea (OSA) along with Upper Airway Resistance Syndrome (UARS) and Snoring are gradually being recognized as the most important non-communicable conditions of the modern times. Snoring, considered to be lowest in disease hierarchy of sleep disordered breathing, is estimated to affect 45% of adults occasionally and 25% regularly [3]. Habitual snorers are also at greater risk of vascular disease [4]. Gone are the days when doctors

and patients were content to accepting these as a part of their body physiology, and advice weight-loss as the only therapy. Though CPAP is still considered as a standard of care, long term compliance is a challenge. Surgical treatment focuses on either expanding the bony box or reducing the soft-tissue bulk/pliability. As up to 90% patients have a Nasal +/- Velum +/- Oro-pharyngeal anatomical problem, correcting the same surgically has been attempted in single sitting with varying degrees of success [5].

The nasal part usually involves, achieving central alignment of nasal septum and clearing both nasal passages from air-obstructing pathologies. These nasal procedures are regularly done by almost all ENT surgeons all over the globe. The correction of palatal and oro-pharyngeal tissues has undergone a drastic change from the time Fujita et al. introduced Uvulopalatopharyngoplasty (UPPP) in 1981 to our innovative recommendation in this paper of using 3-0 Polybutester Barbed Suture, for creating a swing for the

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lower soft palate. We would like to christen this technique as ‘Agrawal’s Barbed Suspension Bridge Pharyngoplasty’.

Lower part of the soft palate is involved as site of collapse in more than 90 percent of cases [6] of Snoring and OSA and majority of cases have anteroposterior type of collapse. Most of the earlier surgical treatments focused on excising and shortening palatal/uvular tissues. Lateral Pharyngoplasty by Cahali [7], Expansion Sphincter Pharyngoplasty (ESP) by Pang & Woodson [8] or Z-Plasty by Friedman [9]; all used an absorbable suture for shortening and stiffening the palatal tissue. Palatal procedure using barbed suture was elaborated initially by Mario Mantovani, Milan, Italy in 2013 [10]. The advantages proclaimed with this suture were; non-requirement of knot, the comfort of suture burying into tissue, ease of running more thread loops around the muscle and creation of a dense mesh into the palatal tissue. However, this was only done on each side of the soft palate and with time the strength of this absorbable barbed PDS suture gradually weans off; reflected by the recent reports of recurrence of symptoms in 12–18 months. The middle point of the soft palate at the base of the uvula was not touched upon as it was believed that any interference of this region might lead to velopharyngeal insufficiency.

In this paper we describe our pioneering technique of suspending the lower soft palate at the level of base of uvula over Pterygomandibular raphe on both sides using Polybutester Non-Absorbable 3-0 Barbed Suture passing across the midline of the soft palate resulting in stability of the region of base of the uvula. The said suspension akin to a suspension bridge would be able to swing superiorly during swallowing and during phonation, avoiding VPI but not be able to fall posteriorly hence preventing palatal collapse during snoring and OSA. Post-operative results are further expected to gradually improve over a period of time considering the constantly increasing fibrosis caused by barbed suture.

The elasticity of this Polybutester suture provides clinical advantage by allowing substantial swelling of the palatal tissues without cutting through and maintains tissue approximation throughout healing. Although post operative AHI is not a part of this study, subjective evaluation on the basis of snoring improvement & Epworth Sleepiness Scale (ESS) have provided a valuable insight into the effectiveness by this technique.

Materials & Methods

This is single-center retrospective analysis of 87 patients who have undergone Suspension Bridge Pharyngoplasty using Polybutester (PBT) 3-0 Barbed Suture. All the patients were operated by the senior most Sleep Surgeon at Speciality E.N.T. Hospital, Kandivali (E), Mumbai; during the period between 1st January 2020 and 31st December 2022.

The medical charts of all the patients were evaluated retrospectively. The pre-operative surgical files, detailed operative notes and available post-operative records were evaluated. The minimum post-operative follow ups noted was for 3 months.

Inclusion Criteria

1. Patients with AHI > 15 on a level 3 Polysomnography or snoring as primary complaint.
2. Age more than 18 years.
3. Drug Induced Sleep Endoscopy (DISE) confirming a retropalatal and/or oropharyngeal and/or base-tongue collapse with/without nasal obstruction.
4. Surgical Procedure included Suspension Bridge Pharyngoplasty using Polybutester (PBT) 3-0 Barbed Suture.

Exclusion Criteria

1. Any previous surgery for nose or oral cavity or oropharynx.
2. Serious Psychiatric, Cardiopulmonary or Neurological issues impeding prolong general anesthesia.
3. DISE indicating Epiglottis obstruction.
4. Significant craniofacial abnormalities.
5. Central/Mixed apneas.
6. Case records not documenting all pre-operative, operative and/or post-operative details.

BMI, AHI and Epworth Sleepiness Scale (ESS) data were available for all patients in the pre-operative records.

A CT scan of nose & paranasal sinuses was done with Carestream CS 9600 CBCT / other standard CT Scanner machine to evaluate the structural nasal airway abnormality, if any. All the patients had undergone a level 1 or at least a level 3 Polysomnography (using ApneaLinkAir ResMed device), admitted overnight at Speciality E.N.T. Hospital. The fixation of finger probe and nasal prongs with the chest device were done by trained hospital nursing staff.

For all cases in which the Sleep Study showed an AHI of more than 15, a CPAP trial was also advised with/without Drug Induced Sleep Endoscopy (DISE). Rest of the patients with AHI less than 15 but significant snoring were counseled for DISE for finding the level of obstruction.

All the patients agreeing for DISE were evaluated using Pentax VNL9-CP Naso-Pharyngo-Laryngoscope with VIV-IDEO CP-1000 processor or with scope of other similar configuration. DISE was always done in Operating Room with Bispectral Index (BIS) monitoring keeping BIS scores between 60 and 80, monitored by the anesthesiologist using Covidien BIS Complete Monitoring System. Dexmedetomidine along with Midazolam was commonly used for DISE.

Propofol was very rarely used. The levels of obstruction were evaluated and video recorded with commentary.

After the DISE, when patients were completely out of sedation, a detailed session was conducted for each patient in presence of bed-partner/ relatives explaining the level of obstruction and modalities of non-surgical/ surgical treatment options available. Patients with collapse at nasal/velum/oropharyngeal/base-tongue level were then explained about possible surgical plan along with post-op precautions and discharged. The patients with collapse at epiglottis level were excluded from this study. The patients would take time to take informed decision for surgery after evaluating their options and CPAP trial.

Usually, a multilevel surgery was needed in majority of cases; involving nasal corrections and/or adenoidectomy and/or Base-Tongue reduction along with a Suspension Bridge Pharyngoplasty. In multilevel surgeries the sequence was always from pharyngeal surgery followed by nose surgery, in order to avoid a trickle of plasma fluid/ blood to the operative field. All the surgeries were done in a head-neutral position.

Base-Tongue reduction, whenever deemed necessary; was done with a Naso-tracheal tube with E-Vac 70 Extra-HP wand of Coblator II plasma system of Smith-Nephew along with palate surgery but excluding the nose surgery at that sitting.

Adenoidectomy, if required was performed with EVAC-70 Extra HP wand (Bent manually at non-acute angle to allow trans-oral wand insertion), under nasal endoscopic vision.

Palatal Surgery was Performed Using Our Novel Technique as Described Below

The patients were intubated with a regular oro-tracheal tube with a light throat pack. Bilateral tonsillectomy was performed using EVAC-70 Extra HP wand under microscopic vision using Zeiss Vario S88, taking care not to damage the palatopharyngeus and palatoglossus muscles unintentionally. In case of absent palatine tonsils (Tonsillectomy done in past), the fossae were bared to expose the muscles. After the tonsillar fossae become bare, the oblique arching fibers of palatopharyngeus were freed near the superior pillar and a sharp cut released the posterior pillar to allow later rotation in a supero-lateral direction. Palatopharyngeus was then rotated laterally and superiorly to suture it to Pterygomandibular raphe. This suture was taken with 2-0 vicryl/Absorbable barbed suture to approximate the palatopharyngeus into the upper part of tonsillar fossa. The anterior wall of pharynx which was formed by the oblique palatopharyngeus now forms the lateral wall of pharynx. Following this in certain cases the redundant part of uvula and the additional bulk of soft palate was trimmed below the attachment of levator

palati muscle to the palatine aponeurosis; identified at area just above the line joining the summit of the anterior pillars again using plasma ablation. Polybutester (PBT) 3-0 Barbed Suture (V-Loc 3-0 2 Metric 9" 23 cm with needle at one end and loop at the other) was used for performing Suspension Pharyngoplasty. The first insertion was done lateral to the right Pterygomandibular raphe (PMR) and needle brought out from the midpoint of right half of soft-palate. After applying adequate stretch force, second insertion was done again from the withdrawal point and taken out almost to the midline. The oro-tracheal ventilation tube needed readjustment to facilitate working on the contralateral side of the soft palate. The suture was again inserted besides the withdrawal point in midline and taken on the left side to the midline to reach the left PMR. All insertions and withdrawals were carefully done to avoid exposure of any suture material. Without cutting the suture, the direction was reversed and a similar suture line was then followed in the opposite direction from the left to right side, again making sure at all points that the suture material is not exposed. After reaching lateral to the right PMR, the suture was interlocked, buried in tissue and cut (Figs. 1, 2 and 3).

This resulted in formation of a suspension bridge anchored on left and right PMR. The 2 rounds of PBT barbed suture acts as its cables. The cable sutures will not allow it to prolapse and hence keeping the retro-palatal airway open. However, there is no restriction in superior movement of soft palate when levator palati contracts during swallowing and phonation, thus preventing any VPI (Figs. 4 and 5).

Septoplasty whenever needed was performed endoscopically using Storz 0-degree 4 mm 18 cm rigid scope with Storz Spies camera system. Reduction of the hypertrophied bone of the inferior turbinates was done with Sonopet Ultrasonic Surgical System UST-2001 by Stryker. Xomed IPS-1 debrider system was used for debulking the soft tissue of inferior turbinate and mucosal disease of sinuses, wherever necessary. Clearance of mucosal disease was usually performed under Medtronic Stealthstation FlexENT navigation system, to ensure comprehensive clearance. Coblation adenoidectomy was performed in selected cases. The details of other procedures are not discussed here, as found to be out of ambit of this study.

After completion of nasal clearance, both nostrils were packed with CMC-infused 7.5 cm bilateral nasal pack made with self-lubricating fabric, inflated with about 25 cc of air divided over both nasal packs (Rapid Rhino by smith & nephew). The nasal pack was gradually deflated by 1–2 cc over every 2 h in the post-op period till adequate balance between hemostasis and patient comfort was reached. A pain-relief Buprenorphine 10 mg transdermal patch was applied on the left upper back in most cases. Broad spectrum antibiotics and analgesics were also given in syrup form till solid diet was started. The patient was kept on liquid diet till

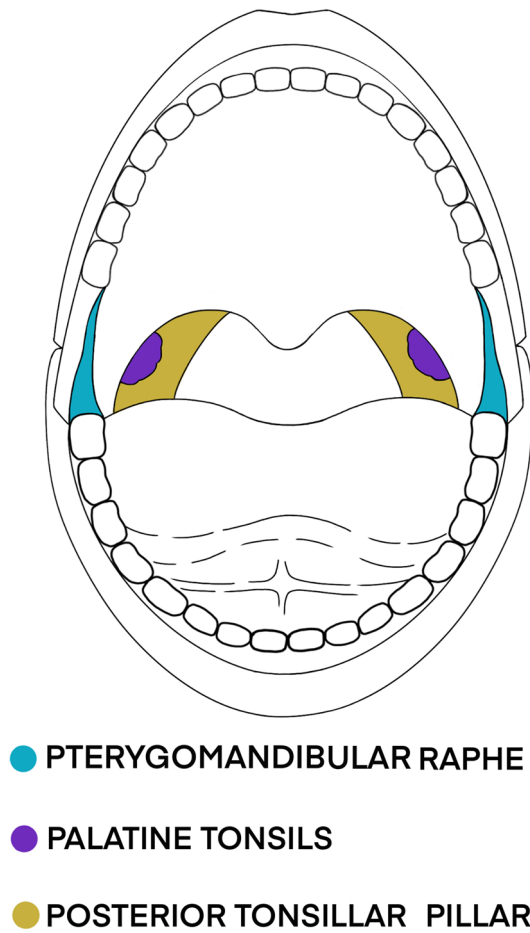


Fig. 1 Location of Pterygomandibular Raphe

72 h and then gradually started on semisolids. Nasal packs were removed after 2 days. Betadine gargles were given and saline douching was advised for 1 month.

Patient’s bed-partner was questioned to score the snoring after 1st, 2nd and 3rd post-op month. They were told to rate it on a scale of 1–10; with 10 being the pre-op snoring and 1 being no snoring at all.

ESS was also compared from pre-op, to that at the end of 1st, 2nd and 3rd post-op month.

Immediate and late complications were also noted till 3rd post-operative month.

Main Outcome: Improvement in Epworth Sleepiness Scale (ESS) score after 3 months of surgical management.

Secondary Outcome: Reduction in snoring as per bed partner’s subjective grading scale.

Results

Only 6 out of our 87 patients were females (Table 1).

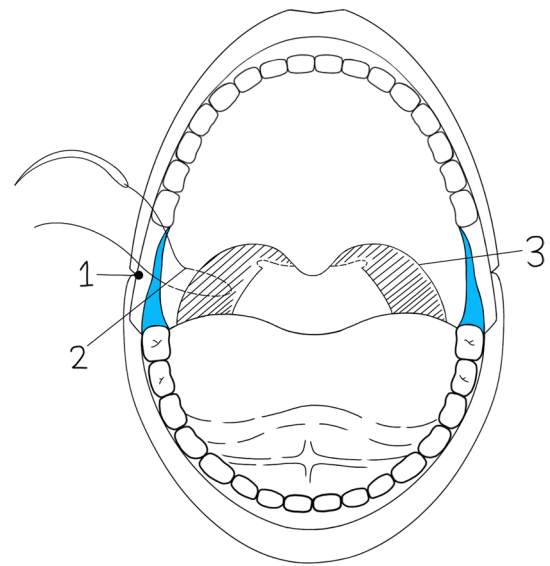


Fig. 2 Tonsillectomy done. (3) The oblique arching fibers of Palatopharyngeus are released and a sharp cut is made at the upper end. Vicryl 2-0 suture is inserted lateral to PMR from point (1) and after looping around exposed fibers of Palatopharyngeus; the suture is taken out medial to PMR (2) and tied loosely

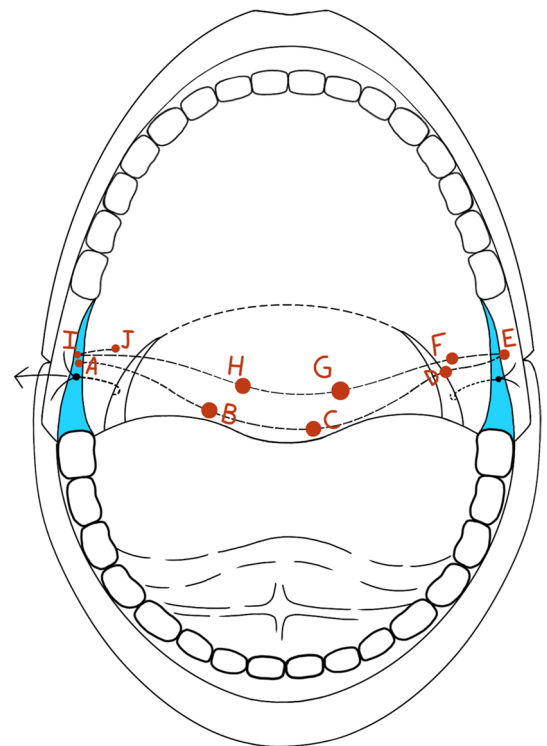
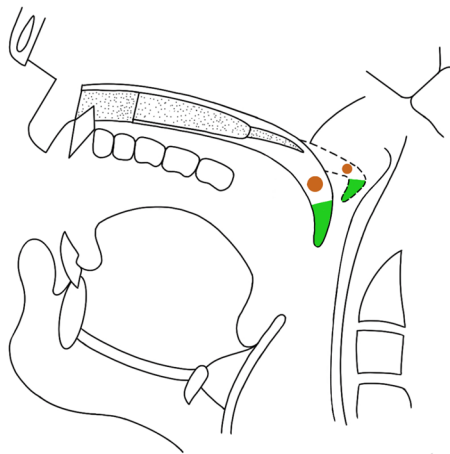
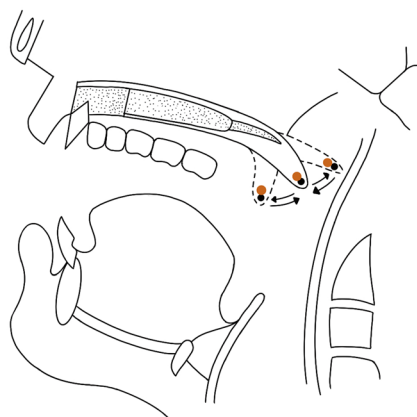


Fig. 3 Journey of Barbed PBT 3-0 suture. Insertion from A just lateral to right PMR. Coming out and again going in at B, C, D, E lateral to left PMR. The direction is then reversed to F, G, H, I lateral to right PMR and then cut after locking at J. The tension is kept just sufficient to hold the palate



● TISSUE RESPONSIBLE FOR SNORING AND OBSTRUCTION
● LEVATOR VELI PALATINI MUSCLE

Fig. 4 The palatal and uvular tissue below the attachment of Levator Veli palatine & Tensor Veli Palatini. This tissue (Green) can be sacrificed in selected cases without causing any VPI



↔ SWING OF SUSPENDED PALATE
● LEVATOR V.P. MUSCLE AFTER PLACEMENT OF BARBED PBT SUTURE (.)

Fig. 5 After Barbed Suspension Pharyngoplasty, the soft palate gets suspended over both the PMR

Table 1 Sex distribution of our cases

Sex	No. of patients	%
Male	81	93
Female	6	7

More than 2/3rd of the patients belonged to the 30–50 years age group. This reaffirms the involvement of people in peak working age with this disease condition (Table 2).

Table 2 Age distribution of our operated patients

Age group	No. of patients	%
20–30	15	17
30–40	33	38
40–50	27	31
50–60	9	10
60–70	3	3

Table 3 Body mass index (weight kgs/height in meters²) to first decimal point

BMI range	No. of patients	%age of patients
Equal or less than 20	0	0
20.1–25	16	18
25.1–30	45	52
30.1–35	26	30
> 35.1	0	0

Table 4 Apnea Hypopnea Index was noted from the automated report retrieved from Polysomnography device

AHI	No. of patients	%age
<5	6	7
5–15	13	15
15–30	8	9
31–45	24	28
46–60	18	21
61–75	15	17
> 76	3	3

Body Mass index of the patients was documented. Our cut-off for surgery was BMI of less than 35. More than half of our patients were overweight (i.e., BMI of 25–30) and about 30% were obese (BMI > 30) (Table 3).

AHI (Apnea–Hypopnea Index) was noted from the Polysomnography. More than 2/3rd of our patients had severe OSA (i.e. AHI of more than 30). 1/5th of our patients with AHI less than 15 were primarily operated for snoring (Table 4).

DISE findings overwhelmingly favored Circumferential Collapse at Velum.

Isolated AP and lateral collapse was found in only 6 and 1% case respectively on DISE. About 93% cases had a circumferential collapse at velum.

DISE findings overwhelmingly favored Circumferential Collapse at Velum (Table 5).

An overwhelming 58 (67%) patients required a nasal septal correction & turbinoplasty, with about 11% requiring adenoidectomy. Tongue base reduction was done for patients presenting with grade 3 and grade 4 lingual tonsils (Table 6).

Table 5 Level of collapse at Velum on Drug Induced Sleep Endoscopy

Type of collapse at velum on DISE	Isolated antero-posterior	Isolated lateral (side to side)	Circumferential
No. of patients	5	1	81
%	6%	1%	93%

Table 6 Additional surgeries besides Suspension Bridge Pharyngoplasty

Additional surgery	No. of patients	%
Nose	58	67
Adenoid	10	11
Tongue Base	10	11

Epworth Sleepiness Scale (ESS) was enquired in the immediate pre-op period and improvement at the ends of each of the first 3 months of post-operative period, was recorded. A medium-term perspective of about 3 months

gave an 8-point reduction in up to 56% of patients (Table 7).

Snoring was evaluated based on bed-partner's history. Bed-partner was asked to score the improvement in snoring on a scale of 1–10; with 10 being the pre-op snoring and 1 being no snoring at all. As evident from the results, about 78% of patients had no or minimal snoring sound left after 3 months of surgery. About 5 patients did not report any benefit in snoring in the immediate post-op month. These were those patients in whom no uvular resection was performed. Two of these 5 patients, 2 improved satisfactorily over a period of 12 weeks (Table 8).

Complications related only to the palatal procedure were evaluated in the post-op period. Though spotting was observed in about 4% patients, the technique of performing intracapsular dissection along with coagulating a segment of lower pole vessels; was found helpful. No patient needed to be explored again under GA for achieving palatal hemostasis (Table 9).

Although about 17% patients had a temporary VPI, all but 1 patient recovered in 7–8 weeks. Even this patient had his VPI recovered in 3 months, by the time this paper was written.

Table 7 Reduction in Epworth Sleepiness Scale after surgery

Score Reduction	Reduction in ESS at the end of 1st post-operative month	Reduction in ESS at the end of 2nd post-operative month	Reduction in ESS at the end of 3rd post-operative month
No improvement	4	1	0
1–2 points	4	9	2
3–4 points	31	10	12
5–6 points	47	55	24
7–8 points	1	11	49

Table 8 Improvement in Snoring after Surgery

Post-Op. period	Excellent improvement no snoring (1)	Good improvement (2–5)	Satisfactory improvement (6–9)	No improvement snoring same as pre-op. (10)
After 1st month	6	40	36	5
After 2nd month	7	50	27	3
After 3rd month	12	56	16	3

Table 9 Surgical complications

Complication	No. of patients	Percentage
Post-Op bleeding requiring shifting back to O.R	0	0
Temporary Velopharyngeal insufficiency (VPI)	15	17.2%
VPI not resolving in 3 months	0	0%
Globus Pharyngeus sensation	12	13.8%
F.B. reaction to barbed suture not leading to extrusion of suture	0	0%
Exposure of barbed suture material requiring trimming	3	3.4%

Discussion

Surgical Management of OSA & Snoring has come a long way from the limited OPD procedures for inducing stiffening of uvulo-palatal complex to our novel recommendation of using a PBT 3-0 barbed suture to produce predictable long-lasting results. From 2013 when Mantovani first used the barbed suture, many modifications in its usage have been described. Though the cost and availability of barbed suture, being about 5 times more than the Vicryl stitches [9], proved to be an initial hindrance at some centers; its usage has grown exponentially for these surgeries.

We consider our described technique to be less challenging to learn, providing reproducible surgical outcomes with low long term complication rate. Though the search for an ideal technique may never end; our technique may provide an opportunity for surgeons looking to provide stable results to their patients. Temporary VPI though not very infrequent, resolves completely in a period of 7–8 weeks. This technique is excellent for control of snoring, as 97% of our cases had significant improvement in snoring, 78% had almost complete cessation of snoring within 3 months. Adequate resection of redundant soft palatal tissue is considered paramount in achieving swift and long-lasting snoring control. Partial extrusion of the barbed suture was a common complication according to a multicenter study done by Montevecchi et al. [11]. However, we noticed this complication in only about 3% of our cases. The subjective scores in the Epworth Sleepiness Scale also noted an up to 8-point improvement in more than 56% cases.

The two specific carry home messages from our novel technique, which have been attempted for the first time are:

1. The used on a non-absorbable barbed suture.
2. Passing of the suture through the level of line joining anterior pillars as the same is seen in DISE.

Lacunae in our study would be the non-availability of a follow up sleep study in post-op period to objectively quantify the AHI values. Also, AHI and BMI correlation with post-op results in a prospective study design could throw more light on this surgical technique. A further prolonged follow-up would reaffirm the efficacy of our technique.

Conclusion

Agrawal's Suspension Bridge Pharyngoplasty using Polybutester 3-0 barbed suture, is a viable alternative to absorbable barbed sutures for performing UPPP. The use of a

non-absorbable barbed suture in our current technique in double loops across the midline has been attempted for the first time in history. It negates the risk of results wearing off, after absorption of suture material by providing a sustained palatal suspension. Also, complete preservation of levator and tensor palati muscles preserves the movements in superior direction, hence refuting the chances of dreaded permanent Velopharyngeal insufficiency and voice change while providing a sustained control of snoring and sleep apnea.

References

1. Stuck BA, Ravesloot MJL, Eschenhagen T, de Vet HCW, Sommer JU et al (2018) Uvulopalatopharyngoplasty with or without tonsillectomy in the treatment of adult obstructive sleep apnea—a systematic review. *Sleep Med* 50:152–165
2. Evans EC, Sulyman O, Froymovich O (2020) The goals of treating obstructive sleep apnea. *Otolaryngol Clin North Am* 53(3):319–328
3. Ieto V, Kayamori F, Montes MI, Hirata RP, Gregório MG, Alencar AM, Drager LF, Genta PR, Lorenzi-Filho G (2015) Effects of oropharyngeal exercises on snoring: a randomized trial. *Chest* 148(3):683–691
4. Vaughn BV, Cruz ONFD (2016) Sleep & breathing disorders E-book. Cardinal manifestations of sleep disorders, 4–14
5. Madkikar N (2019) Multi level single stage: barbed reposition pharyngoplasty and nasal surgery in treatment of OSA—our experience. *Indian J Otolaryngol Head Neck Surg.* 71(3):309–314
6. Lin H-Y, Lin Y-C, Hsu Y-S, Shih L-C, Nelson T, Chang W-D (2020) Yung-An Tsou comparison of findings between clinical examinations and drug-induced sleep endoscopy in patients with obstructive sleep apnea syndrome. *Int J Environ Res Public Health* 17:6041
7. Cahali MB (2003) Lateral pharyngoplasty: a new treatment for obstructive sleep apnea hypopnea syndrome. *Laryngoscope* 113(11):1961–1968
8. Pang KP, Woodson BT (2007) Expansion sphincter pharyngoplasty: a new technique for the treatment of obstructive sleep apnea. *Otolaryngol Head Neck surg* 137(1):110–114
9. Friedman M, Ibrahim HZ, Vidyasagar J et al (2004) Z-Pharyngoplasty (ZPP): a technique for patients without tonsils. *Otolaryngol Head Neck Surg* 131:89–100
10. Mantovani M, Minetti A, Torretta S et al (2013) The “Barbed RomanBlinds” technique: a step forward – letter to the editor. *Acta otorhinolaryngol ital* 33:128
11. Montevecchi F, Meccariello G, Firinu E et al (2017) Prospective multicentre study on barbed reposition pharyngoplasty standing alone or as a part of multilevel surgery for sleep apnoea. *Clin Otolaryngol* 43(2):483–488

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