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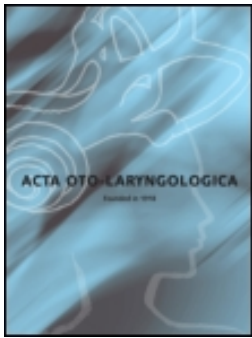
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RESEARCH ARTICLE

How I do it: Anterior pull-through tympanoplasty for anterior eardrum perforations

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ABSTRACT

Conclusions This technique is offered as a convenient and reliable method for cases with anterior TM perforation and inadequate anterior remnant. **Objectives** Chronic otitis media surgery is one of the most common procedures in otology. Anterior tympanic membrane (TM) perforation with inadequate anterior remnant is associated with higher rates of graft failure. It was the goal of this series to evaluate the anatomical and functional outcomes of a modified underlay myringoplasty technique—the anterior pull-through method. **Materials and methods** In a retrospective clinical study, 13 patients with anterior TM perforations with inadequate anterior remnants underwent tympanoplasty with anterior pull-through technique. The anterior tip of the temporalis fascia was pulled through and secured in a short incision lateral to the anterior part of the annulus. Data on graft take rate, pre-operative, and post-operative hearing status were analyzed. **Results** A graft success rate of 84.6% (11 out of 13) was achieved, without lateralization, blunting, atelectasia, or epithelial pearls. The air–bone gap was 21.5 ± 6.8 dB before intervention and 11.75 ± 5.7 dB after surgery ($p = 0.003$).

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Eardrum; hitch; remnant; tab

Introduction

The aims of tympanoplasty are elimination of disease and restoration of function. Restoration of function requires a healthy tympanic membrane (TM); an air-containing, mucosal-lined middle ear (so that the membrane vibrates); and a secure connection between the tympanic membrane and the inner ear fluids [1].

Underlay (medial) and overlay (lateral) techniques are two traditional methods for repair of TM perforations. The underlay technique is easier to perform and less time-consuming [2,3], thus it is often preferred by otologists [4]. The graft is placed medial to the entire TM remnant and the malleus handle and is suitable for posterior perforations [4]. Some of the commonly faced problems in underlay technique include decreased mesotympanic space and a lesser success rate in anterior perforations [5].

In the overlay technique, which is frequently applied to anterior perforations, the epithelial layer is elevated precisely, and the graft is placed lateral to the fibrous layer of TM remnant and annulus [1]. Although the overlay technique has a higher success rate in repairing anterior perforations, it is more technically demanding, and specific potential complications may occur such as graft lateralization, anterior blunting, slower healing, stenosis of the external auditory canal, epithelial pearls, and iatrogenic cholesteatoma [2,6].

Therefore, repairing anterior perforations remain a challenge, especially when using the underlay technique. Factors influencing failure of the underlay technique in those cases include inadequate blood supply [7], lack of residual TM as a source of epithelium, lack of support for the graft anteriorly, and poor exposure. As a solution, this study aimed to apply a modification of several previously reported underlay techniques [8,9] by creating a tunnel in front of the anterior part of the annulus and placing a temporalis fascia graft with a pull-through tab to increase the success rate of the underlay technique in these challenging anterior perforations.

Materials and methods

Seventeen patients from April 2009 to May 2015 who were referred to a tertiary medical center with ~30% anterior perforations and inadequate anterior remnant were selected to undergo the anterior pull through underlay tympanoplasty procedure. Of these, 13 patients had at least 3 months of follow-up and were analyzed further. Pre-operative pure-tone audiograms were collected at frequencies of 250, 500, 1000, 2000, and 4000 Hz, with planned post-operative audiograms to follow. All patients underwent surgery under general anesthesia by the senior author (J.P. Harris) via post-auricular approach. Data involving etiology of perforation, suppuration,



Figure 1. A rim of tissue is removed from the edges of an anterior perforation.

mucosal disease status, and ossicular chain continuity were tabulated.

The procedure begins with a transcanal microscopic examination of the TM. A rim of tissue is removed from the edges of the perforation to ensure complete de-epithelialization of the medial surface of the TM remnant and also to promote future migration of the epithelium (Figure 1). An H-shaped Koerner's flap canal incision is made and back-elevated. A skin incision is placed 0.5–1 cm posterior to the postauricular skin crease. A temporalis fascia graft was harvested in standard fashion using Fomon scissors, pressed, and then dried. After a curvilinear incision is made in the musculoperiosteum and elevated, the vascular strip is everted and held anteriorly with a Perkin's retractor. The tympanomeatal flap is then elevated with the posterior tympanic annulus to enter middle ear space. The status of the middle ear and ossicular chain are also examined for any pathology that requires reconstruction. The tympanomeatal flap is then laid back down in native position.

At this point, if the anterior remnant of the residual TM is deemed insufficient to provide confident support of the underlay graft, then the anterior pull-through modification is initiated. A small amount of 1% lidocaine with 1:100 000 epinephrine is injected into the anterior canal skin just lateral to the anterior aspect of the annulus. A round #72 beaver blade is used to make a 2 mm horizontal incision just lateral to the anterior portion of the annulus (Figure 2). The canal skin and anterior annular ring are carefully elevated medially with a Rosen needle, and the middle ear is entered medial to the annulus (Figure 3), often using a 1 mm right-angle hook to penetrate the middle ear mucosa until the tip of the instrument is visible through the TM perforation. Care is taken to preserve the integrity of the annular ring when making this anterior canal skin tunnel. The previously harvested fascia graft is trimmed to appropriate size for full coverage of the perforation, leaving a distinct tab anteriorly that will be later pulled from the middle ear through the anterior canal skin incision (underneath the anterior tympanic annulus). The tympanomeatal flap is then folded anteriorly and the trimmed fascia graft is then placed into the middle ear (prior to placing middle ear packing). The tympanomeatal flap is placed back down

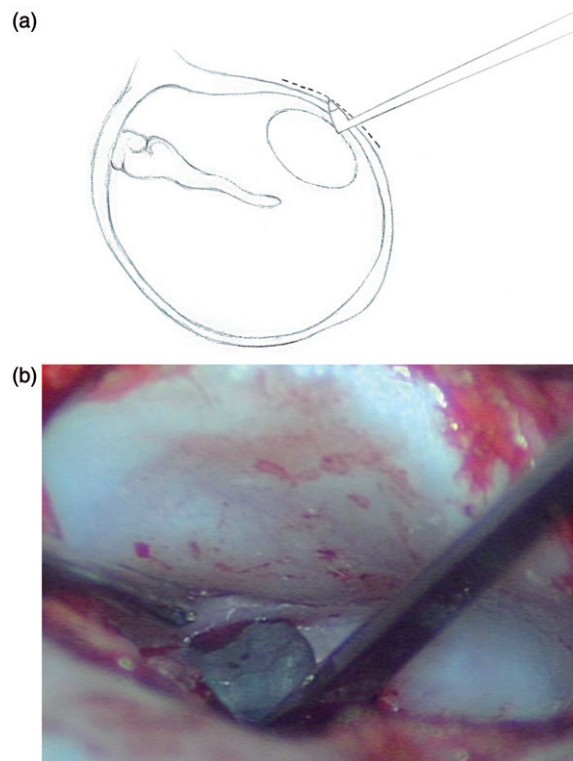


Figure 2. A #72 Beaver blade or lancet knife is used to make an incision just lateral to the anterior portion of annulus.

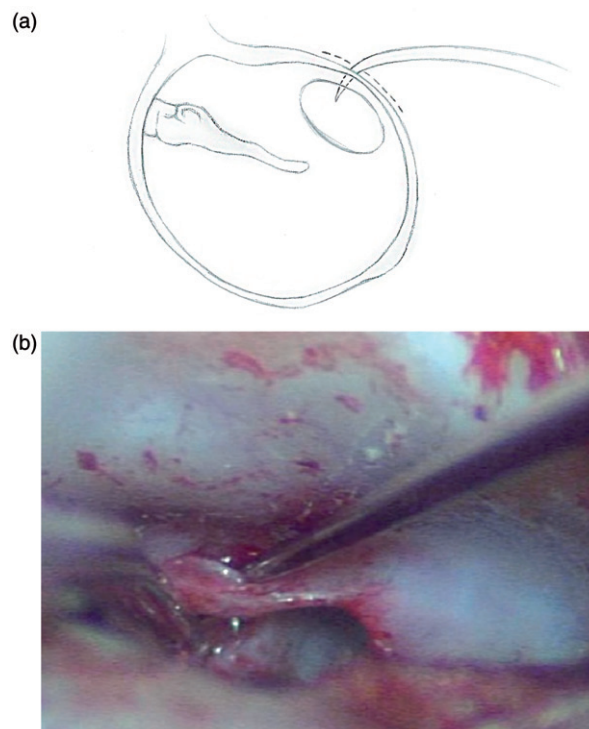


Figure 3. The canal skin is elevated with a Rosen needle, and the middle ear is entered with a right-angle hook medial to the annulus, creating a tunnel anteriorly.

into native position, and the fascia graft is manipulated through the TM perforation so that the anterior tab is directly in line with the anterior canal skin tunnel. The anterior tab is picked up (Figure 4) with the right-angle hook and pulled

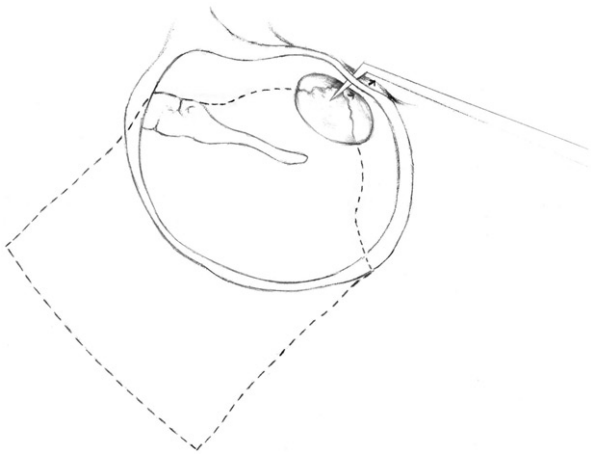
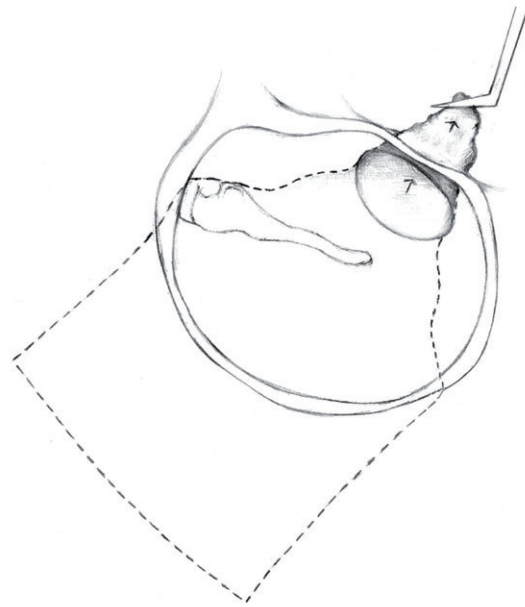


Figure 4. The anterior tab on the graft is picked up within the middle ear using a small right-angle hook.

through the tunnel underneath the tympanic annulus, and out through the canal skin incision (Figure 5). Once the anterior pull-through tab is secured in this manner, it is left as a tag which is laid up against the normal anterior canal skin. The remainder of the graft can be smoothed to provide complete coverage of the TM perforation, and the middle ear is then packed with dry gelfoam followed by gelfoam soaked with fluoroquinolone antibiotic solution. A rosebud dressing of Owen's silk strips and cotton soaked in antibiotic solution or a gelfoam pack is then fashioned lateral to the graft, forming the deep ear canal packing. The post-auricular incision is closed in two layers. The vascular strip is returned to the external canal and secured with bacitracin-coated ribbon gauze packing in the lateral ear canal. A standard ear pressure dressing is applied for the first 24 h and then removed. The outer canal packing (ribbon gauze) is removed in 1 week at the first post-operative visit, and antibiotic drops are initiated twice a day for a week

(a)



(b)

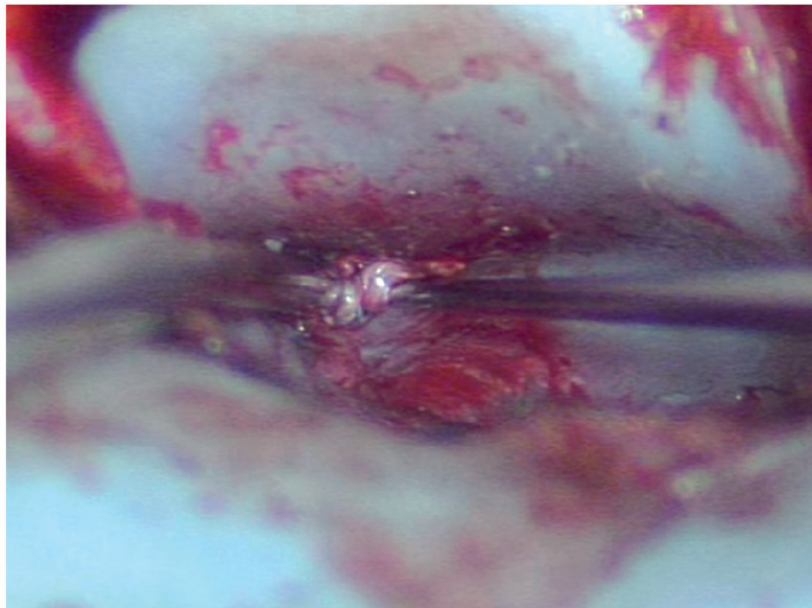


Figure 5. The fascia graft anterior tab is pulled through the incision underneath the anterior portion of the annulus and laid up against the anterior canal skin.

until the second post-operative visit, whereupon the deep canal packing (rosebud dressing) is removed.

Results

Successful closure of the perforation and excellent graft result was achieved in 11 out of 13 patients. Mean follow-up time was 15 months (range = 3–38 months). Two patients had persistent anterior–inferior slit-like perforations despite undergoing the anterior pull-through technique. Therefore, out of the 13 patients who underwent the anterior pull-through modification of underlay tympanoplasty, 84.6% (11 out of 13) had successful closure of the perforation. None of the grafted ears exhibited anterior marginal blunting, graft lateralization, or

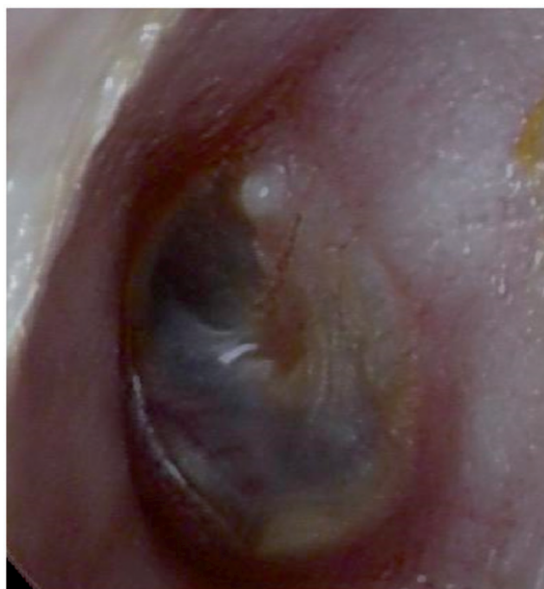


Figure 6. The otoscopic finding of one of the first patients in the study, 2 years after the left ear underlay tympanoplasty with anterior pull-through modification operation. The patient was 73 years old at the time of surgery. Perforation was 30% anteriorly located, now completely healed. Note the complete healing without anterior angle blunting, graft lateralization, or keratin pearls.

epithelial pearls (Figure 6). In those patients where pre- and post-operative audiometric data was available ($n = 10$), there is improvement in the mean pre- and post-operative air–bone gaps, as shown (21.5 ± 6.8 dB vs 11.75 ± 5.7 dB, $p = 0.003$) (Figure 7, Table 1). There was no significant post-operative change in the bone conduction thresholds.

Discussion

It is generally acknowledged that closure of an anterior perforation is technically more difficult than the repair of a posterior perforation. Many techniques have been proposed to improve tympanoplasty results for anterior tympanic membrane (TM) perforation in these ears. These include overlay tympanoplasty, underlay tympanoplasty, gelfilm sandwich tympanoplasty, Crown cork tympanoplasty, swinging door tympanoplasty, sandwich graft tympanoplasty, window shade tympanoplasty, and palisading cartilage technique. Schuknecht [10], in 1976, described a method termed ‘collar-button suture’, which involves making an incision in the TM itself anterior to the perforation and a bit of the fascial graft is drawn through it with a small hook or aspiration tip. However, this requires adequate space anterior to the perforation, as well as requiring creation of a second perforation in the most delicate portion of the TM.

Underlay and overlay techniques are the most commonly used because of simplicity. However, the overlay technique can be more challenging to perform, more time-consuming, with inherent complication risks and delayed healing. Nevertheless, in the underlay technique, there are difficulties due to lack of anchorage and proper support for the graft, and the presence of an anterior bony overhang can hinder access to the anterior margin of the perforation.

The purpose of this paper is to describe a more secure procedure, which consequently results in less morbidity, for the repair of anterior TM perforations of all sizes. The traditional underlay procedure entails a post-auricular approach with incision into the posterior external auditory

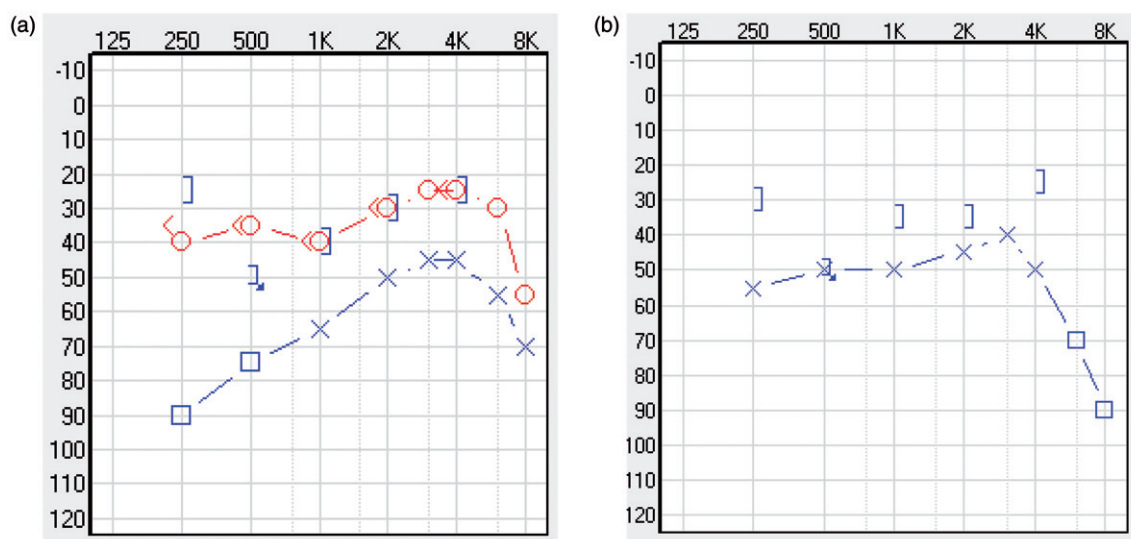


Figure 7. Pre-operative and post-operative audiogram of the same patient as in Figure 6, demonstrating mixed hearing loss. (a) Pre-operative. (b) Post-operative. Average of air–bone gap at 500, 1000, 2000, and 4000 Hz decreased from 22.5 dB to 12.5 dB, an improvement of 10 dB.

Table 1. Characteristics of patients with pre-operative and post-operative findings.

ID	Age	Sex	Side	Size	Etiology	Surgery date	Intra-op findings	Suppuration	OCR	Result	Follow-up time (months)	Pre-op ABG (dB)	Post-op ABG (dB)	Δ (dB)
1	73	F	L	30%	OE	5/26/2010	Normal	Yes	No	Healed	38	22.5	12.5	-10
2	38	M	L	25%	Traumatic	12/1/2010	Normal	Dry	No	Healed	30	11.25	3.75	-7.5
3	38	M	R	40%	PET	1/12/2011	Cholest, extensive granulation	Yes	No	Healed	19	16.25	22.5	6.25
4	34	M	R	40%	Trauma	1/12/2011	Normal	Dry	No	Slit	4	16.25	11.25	-5
5	24	F	R	20%	CSOM	2/23/2011	T-bone fractures	Yes	No	Healed	4	6.25		
6	40	M	R	Two anterior perforations	Unknown	8/1/2012	Normal	Dry	No	Healed	30	18.75	8.75	-10
7	51	F	L	60%	Cholest	1/30/2013	Scar bands	Dry	No	Healed	22	21.25	11.25	-10
8	69	M	L	40%	Unknown	9/11/2013	Normal	Dry	No	Slit	15	32.5	20	-12.5
9	55	F	R	70%	Chronic OE	9/25/2013	TS	Yes	No	Healed	16	32.5	10	-22.5
10*	37	F	L	70%	Cholest	5/21/2014	Cholest, granulation	Yes	PORP	Healed	4	12.5		
11	59	M	L	50%	Trauma	9/3/2014	TS	Dry	No	Healed	5	21.25	11.25	-10
12	55	F	R	30%	CSOM	2/18/2015	Thickened scar	Yes	No	Healed	6	22.5	6.25	-16.25
13	25	F	L	30%	CSOM	5/20/2015	Normal	Yes	No	Healed	3	33.75		

All surgeries were primary tympanoplasties.

All grafts were harvested from true temporalis fascia, except (*) patient 10 used composite false and true fascia.

All surgeries were performed after medical treatment and with no active drainage.

Air-bone gap (ABG) and pure-tone average (PTA) calculated at 500, 1000, 2000, and 4000 Hz.

OCR: ossicular chain reconstruction; ABG: air-bone gap; OE: otitis externa; PET: pressure equalization tube; CSOM: chronic suppurative otitis media; Cholest: cholesteatoma; TS: tympanosclerosis; PORP: partial ossicular chain prosthesis.

canal, raising of a standard tympanomeatal flap, and placement of a graft that spans from the posterior TM to the anterior-most aspect of the middle ear. The most common place of graft failure in such a scenario is the most anterior aspect of the perforation. The anterior 'pull-through' technique has been described to rectify this problem. This method provides an anchor for the graft within a slit anterior to the annulus, thus reducing the graft failure rate in the most challenging location in an anteriorly-located perforation, while preserving the anterior angle of the external ear canal. This method is advantageous over other complicated techniques because the initial portion of the procedure is identical to a standard underlay tympanoplasty; the decision to proceed with the anterior pull-through modification can be made immediately before trimming and placing the fascia graft. In our series, the post-operative TMs have an almost normal appearance upon removal of the rosebud dressing at 2 weeks, as shown in Figure 6. The end of the fascia tab, which is visibly obvious at the end of the surgical procedure prior to packing the ear canal, becomes essentially atrophic by the time the rosebud packing is removed at the 2-week post-operative visit. The anterior sulcus is clearly defined and sharp, with no evidence of keratin pearls.

Primrose and Kerr [8] originally describes a similar method termed the 'anterior hitch' technique by elevating the anterior annulus (over the area of the Eustachian tube), but leaving it tethered superiorly and inferiorly. The 2–4-mm tunnel that is created allows the surgeon to pull the graft underneath the annulus and laterally under the anterior canal skin. Sharp et al. [9] used this technique to achieve successful healing in 45/47 patients (95.7%). However, Primrose and Kerr's [8] original paper in 1986 warns that the 'procedure can be difficult and time consuming'. Their described technique puts the anterior canal incision as far as 2 mm lateral to the TM, which demands more time and a wider elevation than our preferred method described in this paper where the incision is immediately lateral but adjacent to the annulus, thereby minimizing the

needed dissection. In addition, our clinical experience has shown that the end of the small residual fascial graft tab atrophies away quickly without sequelae.

Our closure rate of 84.6% is consistent with the 95.7% success rate by Sharp et al. [9] cited above, as well as more recently a prospective randomized trial involving 111 children by D'Eredità and Lens [11] where they compared closure rate by 'anterior tab flap' (93.2%) vs 'standard underlay' (84.6%), although the difference was not statistically significant. The use of the anterior tab for enhanced security of the graft evidently yields success rates exceeding 90%, in contrast to other cited studies utilizing standard underlay techniques in cases with limited anterior remnant support (54.5–66%) [12].

Caution should be exercised with regard to maintaining the integrity of the annular ring anteriorly. In one patient who was excluded from our series, the bony ear canal was dehiscence into the glenoid fossa, which severely attenuated the tympanic annulus anteriorly as well. As such, the tunnel could not be adequately created and the anterior pull-through technique was not performed. Fortunately this patient's graft was able to heal with a standard underlay tympanoplasty. In these circumstances, the shorter tunnel length we describe in conjunction with lower profile instruments such as a Rosen needle would likely be an improvement over the longer tunnel length in the original description by Primrose and Kerr [8].

Another patient that was excluded from analysis due to short follow-up time, had undergone six previous tympanoplasties at an outside institution with persistent failure to heal an anterior slit perforation. After using the anterior pull-through technique, his TM was healed at 5 week follow-up, despite continuing to smoke. Although he has been lost to longer-term follow-up, this case is demonstrative of the capability of this technique where the anterior graft is securely tethered in position by suspension rather than simply surface tension alone.

Conclusion

The anterior 'pull-through' technique is a reliable technique for the repair of anterior perforations that lack adequate anterior remnant support. This technique overcomes a number of disadvantages and potential complications of overlay technique in this sub-group of patients and can be performed in a much shorter time.

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Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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