The Journal of Laryngology & Otology

cambridge.org/jlo

Comparison of perichondrium-cartilage button technique and traditional over-underlay technique for repairing large perforations

J Sun

Department of Otorhinolaryngology, Yiwu Central Hospital, Yiwu City, China

Abstract

Objective. This study was performed to compare the operation time, graft outcomes and complications between the endoscopic cartilage-perichondrium button technique and over-under technique for repairing large perforations.

Methods. A total of 52 chronic large perforations were randomly allocated to receive treatment using the endoscopic cartilage-perichondrium button technique ($n = 26$) or over-under technique ($n = 26$). The graft outcomes, mean operation time and post-operative complications were compared between the two groups at 12 months.

Results. The study population consisted of 52 patients with unilateral chronic large perforations. All patients completed 12 months of follow up. The mean operation time was 32.3 ± 4.2 minutes in the button technique group and 51.6 ± 2.8 minutes in the over-underlay technique group ($p < 0.01$). The graft success rate at 12 months was 92.3 per cent (24 out of 26) in the button technique group and 96.2 per cent (25 out of 26) in the over-underlay group ($p = 0.552$).

Conclusion. The endoscopic cartilage-perichondrium button technique had similar graft success rates and hearing outcomes for large chronic perforations to the over-under technique, but significantly shortened the mean operation time.

Main Article

Miss J Sun takes responsibility for the integrity of the content of the paper

Cite this article: Sun J. Comparison of perichondrium-cartilage button technique and traditional over-underlay technique for repairing large perforations. *J Laryngol Otol* 2024;**138**:148–152. https://doi.org/10.1017/S0022215123000968

Received: 7 January 2023
Revised: 16 April 2023
Accepted: 28 April 2023
First published online: 29 May 2023

Keywords:
Myringoplasty; button; over-under technique; cartilage; grafts

Corresponding author:
J Sun;
Email: sunjunzhi2019@126.com

Introduction

Chronic tympanic membrane perforation with mucosal chronic otitis media is one of the most common otological entities, and is usually repaired using myringoplasty. The three classic myringoplasty techniques are the underlay, overlay and over-under procedures. The most widely used of these for repairing larger perforations is the over-under technique, which places the graft lateral to the malleus and medial to the tympanic membrane remnant; this approach has the advantage of excellent exposure, while minimising the risks of graft lateralisation and anterior angle blunting, and achieves a high success rate for large anterior perforations.[1,2]

Although endoscopic myringoplasty has been widely adopted, the critical procedures in the over-under or overlay techniques – namely tympanomeatal flap elevation and superficial epithelium removal, required to strengthen the graft and avoid iatrogenic cholesteatoma[1,3] – may be associated with: damage to the chorda tympani, inclusion cholesteatoma in the external auditory canal, longer healing times, pain and longer operation times.[4,5]

Recently, we performed the endoscopic perichondrium-cartilage button technique without raising a flap to repair large tympanic membrane perforations in adult patients. Here, we compare the operation time, graft success rate, audiometric outcomes and complications between the button technique and over-under technique using a cartilage-perichondrium graft for the repair of large tympanic membrane perforations.

Materials and methods

Ethical considerations

Ethical approval for the present study was obtained from the Medical Ethics Committee of Yiwu Central Hospital. All participants provided informed consent.

Patients and methods

This prospective randomised, controlled study was performed between April 2019 and April 2020 in a tertiary care hospital. The inclusion criteria were: adult patients with a unilateral large chronic perforation and residual tympanic membrane around the perforation margin; a dry ear for at least three months prior to surgery; evidence of clear mastoid air cells and middle ear on computed tomography; and the requirement for tympanic membrane repair. Patients with suspected ossicular chain disruption, cholesteatoma,

middle-ear inflammation, myringitis or total tympanic membrane perforations were excluded from the study, as were revision surgery cases.

The patients were assessed using standard pure tone audiometry at frequencies of 0.5, 1, 2 and 4 kHz, both pre-operatively and at 12 months after surgery. We calculated the air–bone gap as the average difference between air and bone conduction at each frequency. Ossicular chain disruption was suspected when the pre-operative air–bone gap exceeded 40 dB; these subjects were excluded from the study.

A perforation affecting 25–50 per cent of the eardrum area was defined as large. The perforation position was classified as anterior, posterior or central based on the position of the malleus handle. Age, sex, perforation duration, smoking status, diabetes, myringosclerosis, perforation position, operation time, and pre- and post-operative hearing levels were recorded in all subjects. Operation time was defined as being from the start of surgery following anaesthesia induction to the compression of gauze at the tragal incision site.

Randomisation and blinding

All patients underwent endoscopic myringoplasty without elevation of the tympanomeatal flap. The patients were randomly divided into two groups by the operating theatre nurse using simple random sampling. Specifically, consecutive subjects who met the inclusion criteria and provided written informed consent were assigned random numbers generated by SPSS statistical software (version 20; IBM, Armonk, New York, USA), which allocated them to the button or over-under technique groups. The over-under technique, but not the button technique, involves raising a flap. The surgeon was not blinded to the treatment allocation, but the participants and individual performing the assessment were blinded.

Surgical technique

All operations were performed under general anaesthesia by the same surgeon. Surgical procedures were completed with a high-definition monitor, and a rigid 0° endoscope with a diameter of 4 mm and length of 18 cm. Similar standard ear surgery instruments were used in both groups. The post-auricular approach was not used in any case. The edges of the perforation were de-epithelialised with an angled pick, and the thick sclerotic plaques of the tympanic membrane remnant were preserved. The tympanic membrane was taken off the malleus and the epithelium was denuded off the distal malleus handle if any was present.

A skin incision of 1.0–1.5 cm in length was made on the medial side of the ipsilateral tragus and a tragal cartilage-perichondrium composite graft (with the perichondrium stripped from one side) was harvested. The lateral perichondrium was peeled circumferentially and rolled up, with the pedicle attached to the centre of the cartilage. The cartilage graft was fashioned based on the perforation size. The free perichondrium was trimmed circumferentially so that it was at least 2 mm wider than the cartilage graft. A notch was made in the cartilage to accommodate the malleus handle. In addition, bioresorbable synthetic polyurethane foam (NasoPore; Polyganics, Groningen, The Netherlands) was used to support the graft medially and laterally in both groups. The external auditory canal was packed with gauze soaked in antibiotic ointment up to the tragal incision, which was not sutured.

Cartilage-perichondrium button technique

The cartilage graft was placed transperforation, medial to (under) the tympanic membrane remnant and annulus; a notch of the cartilage graft was used to accommodate the malleus handle. The free perichondrium was placed lateral to the superficial surface of the tympanic membrane remnant, long process of the malleus and the annulus (Figs 1a and 2).

Cartilage-perichondrium over-under technique

The external auditory canal was infiltrated with 2 per cent lidocaine with 1:100 000 adrenaline. The perforation margin was circumferentially freshened. A canal incision was made laterally, approximately 3–5 mm from the annulus, a tympanomeatal flap was elevated, the annulus was identified and the middle ear was entered. The tympanic membrane remnant was elevated until the long process of the malleus was identified. The anterior annulus was not elevated.

The cartilage-perichondrium graft was entered into the middle ear via a transtympanomeatal flap; the cartilage was placed medial to (under) the tympanic membrane remnant and annulus, and a notch of the cartilage graft was used to accommodate the malleus handle. The free perichondrium was placed lateral to the long process of the malleus, and medial to the tympanic membrane remnant and the tympanomeatal flap. The tympanomeatal flap was subsequently repositioned (Fig. 1b).

Post-operative follow up

Post-operatively, all patients received oral amoxicillin/clavulanate potassium for one week to prevent infection. Follow-up visits to the hospital took place at weeks 2 and 4, and at months 6 and 12 post-operatively. The packing gauze was removed from the external auditory canal at 14 days after surgery, and polyurethane foam fragments were aspirated from the external auditory canal to allow endoscopic visualisation of the graft. An audiometric evaluation was carried out to measure the air–bone gaps at the end of the 12th month post-operatively.

Intra-operative or post-operative complications were recorded. Graft success was defined as the presence of an intact graft; graft failure was defined as the presence of residual tympanic membrane or re-perforation after surgery. Functional success was defined as an air–bone gap of 20 dB or lower. Each follow-up examination was performed by a surgeon who was not involved in the initial operation.

Statistical analysis

The sample size calculation was performed using Power Analysis and Sample Size software (version 11.0; NCSS, Kaysville, Utah, USA). In our pilot study, the mean operation time was 29 ± 8

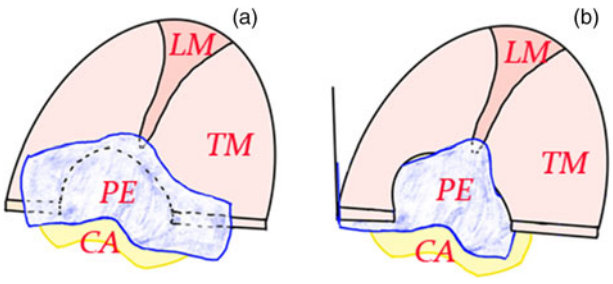

Figure 1. A schematic diagram comparing the two techniques: (a) button technique and (b) over-under technique. LM = long process of the malleus; TM = tympanic membrane; PE = perichondrium; CA = cartilage

https://doi.org/10.1017/S0022215123000968 Published online by Cambridge University Press

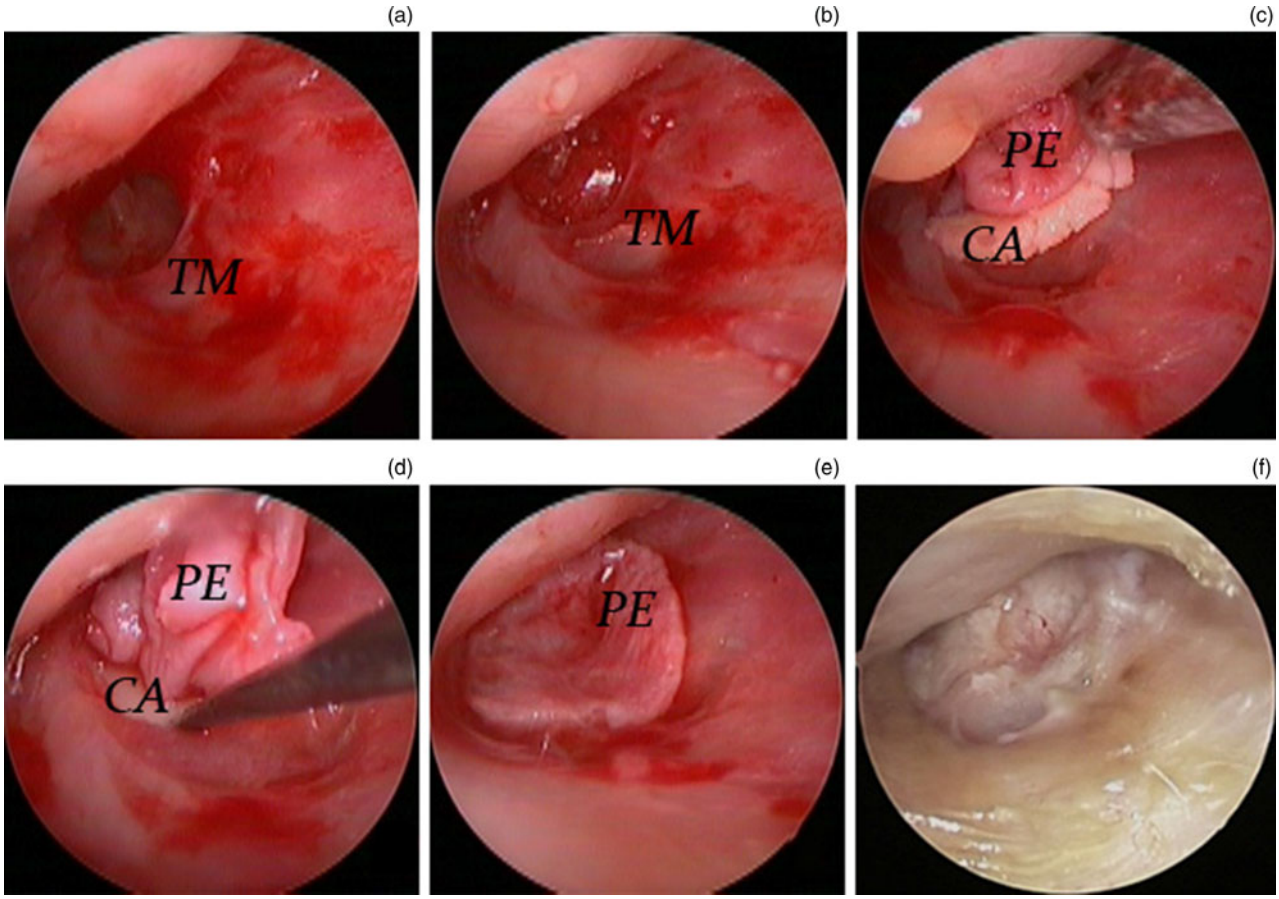

Figure 2. Endoscopic views of the cartilage-perichondrium button technique: (a) de-epithelialisation of perforation edges; (b) middle-ear packing; (c & d) transcanal placement of cartilage with free perichondrium; (e) free perichondrium overlaid on the superficial surface of the tympanic membrane remnant and annulus; and (f) view at six months after surgery. TM = tympanic membrane; PE = perichondrium; CA = cartilage

minutes in the button group and 40 ± 10 minutes in the over-under technique group. For a significance level of 0.05 and power of 0.9, the total sample size required was calculated as 47. Assuming a loss to follow-up rate of 10 per cent, a total of 52 participants were required for randomisation.

Data are shown as mean (standard deviation) values for quantitative variables and frequency (percentage) values for qualitative variables. Group comparisons were performed using the independent samples *t*-test for quantitative variables and the chi-square test for qualitative variables. The paired *t*-test was used to evaluate differences in air–bone gap thresholds between groups. Statistical analyses were performed using SPSS software (version 20; IBM). In all analyses, $p < 0.05$ was taken to indicate statistical significance.

Results

Demographic characteristics

The study population consisted of 52 patients with unilateral perforations. All patients completed 12 months of follow up. Of the 52 ears, 26 were included in the button technique group and 26 in the over-underlay group. Demographic data are shown in Table 1. The groups were matched for sex, mean age, perforation duration, ear side, perforation position, myringosclerosis, smoking status and diabetes status. By post-operative week one, the tragal incision had healed without infection in all patients.

The mean operation time was 32.3 ± 4.2 (range: 26–41) minutes in the button technique group and 51.6 ± 2.8 (range: 48–65) minutes in the over-underlay technique group ($p < 0.001$).

Graft success rate and hearing outcomes

Residual pinhole perforation was seen in two patients in the button technique group and in one patient in the over-underlay group. The graft success rate at 12 months was not significantly different between the button technique and over-underlay groups (92.3 per cent (24 out of 26) *vs* 96.2 per cent (25 out of 26), $p = 0.552$) (Fig. 2).

As shown in Table 2, the mean pre-operative and 12-month post-operative air–bone gaps were significantly different in both the button technique group (20.32 ± 2.56 dB *vs* 9.41 ± 3.13 dB, $p < 0.01$) and the over-underlay group (20.09 ± 3.26 dB *vs* 9.21 ± 3.84 dB, $p < 0.01$). However, there were no significant differences between the pre-operative and 12-month post-operative average bone conduction thresholds in either group. There were no significant differences between the button technique and over-underlay groups in the pre-operative ($p = 0.851$) or 12-month post-operative air–bone gaps ($p = 0.726$), or in the mean 12-month post-operative air–bone gap gains ($p = 0.781$). At 12 months post-operatively, the difference in hearing success rate was not significant between the button technique and over-underlay groups regardless of an air–bone gap of 20 dB or less (80.8 per cent *vs* 88.5 per cent respectively, $p = 0.700$).

Complications

No graft-related complications (e.g. graft lateralisation, significant blunting or graft medialisation) were encountered during the follow-up period. None of the patients reported

https://doi.org/10.1017/S0022215123000968 Published online by Cambridge University Press

Table 1. Demographic characteristics of the two groups

Characteristic	Button technique*	Over-underlay technique†	*P*-value
Sex (female:male) (*n*)	14:12	15:11	0.731‡
Age (mean ± SD; years)	43.2 ± 3.31	44.8 ± 1.51	0.648**
Perforation duration (mean ± SD; years)	11.2 ± 3.47	12.4 ± 0.97	0.713**
Perforation site (anterior:posterior: central) (*n*)	7:3:16	8:3:15	0.794‡
Side of ear (left:right) (*n*)	17:9	16:10	0.541‡
Myringosclerosis? (Yes:no) (*n*)	7:19	9:17	0.611‡
Smoker? (Yes:no) (*n*)	4:22	3:23	0.329‡
Diabetic? (Yes:no) (*n*)	3:23	0:26	0.541‡
Operating time (mean ± SD; minutes)	32.3 ± 4.2	51.6 ± 2.8	<0.001**
Graft success (*n* (%))	24 (92.3)	25 (96.2)	0.552‡
Post-operative ABG ≤ 20 dB (*n* (%))	21 (80.8)	23 (88.5)	0.700‡

*$n = 26$; †$n = 26$. ‡Chi-square test; **independent samples *t*-test. SD = standard deviation; ABG = air–bone gap

sensorineural hearing loss, vertigo or intractable tinnitus. The lateral perichondrium graft gradually formed a crust at two to three months post-operatively in all patients in the button technique group.

Discussion

In this study, the cartilage-perichondrium button technique had similar graft success rates and hearing outcomes for large tympanic membrane perforations compared to the over-under technique, but significantly shortened the mean operation time. The graft outcomes for our button technique were comparable to those obtained when applying the over-under technique for the repair of large perforations.[6–8] Similarly, our button technique showed a comparable graft success rate to those of other techniques used for repairing large perforations; for example, 84 per cent in Babu *et al.*,[1] 90.76 per cent in Zhang *et al.*,[6] 96 per cent in Bao *et al.*[7] and 94.9 per cent in Yigit *et al.*[8] Barake *et al.*[9] reported a success rate of 99.3 per cent using loop underlay tympanoplasty, and Alain *et al.*[10] reported a success rate of 94 per cent (31 out of 33) using the butterfly technique. Other groups reported success rates of 90 per cent, using a double-layer graft,[11] and 91 per cent, using lateral tympanoplasty.[12]

Our button technique is similar to the sandwich graft technique, for which success rates of 93.1 per cent to 98 per cent have been reported.[13–15] However, our method differs from the sandwich graft technique in that the latter involves the application of graft materials, including temporalis fascia and areolar fascia grafts,[13] pedicle posterior deep meatal skin flaps and temporalis fascia,[14] and pedunculated tympanomeatal cutaneous flaps and temporal fascia,[15] which require additional supra-auricular incisions. Furthermore, tympanomeatal flap elevation is unavoidable when using the sandwich graft technique. In the present study, however, we applied the perichondrium-cartilage button graft technique without raising a flap. The perichondrium and cartilage are lateral and medial to the tympanic membrane respectively, while the pedicle of the perichondrium is attached to the central part of cartilage, thereby securing the graft material in place and restoring the integrity of the tympanic membrane. The stiffness of the myringosclerosis plaques and malleus facilitates the procedure by providing a rigid, interlocking surface to prevent the perichondrium graft falling into the middle ear. Moreover, the presence of perichondrium and placement of the lateral end of the cartilage increase the chance of chondrocyte survival.[16]

The over-under technique involves raising a flap and creating a tunnel, while the button technique does not. Our cartilage-perichondrium button group had a significantly shorter mean operation time compared to the over-under technique group, as the raising of a flap and creation of a tunnel are time-consuming procedures, especially for inexperienced surgeons. The short operation time may indirectly reduce the anaesthesia time, and thereby lower the medical cost. Similar to previous studies,[7–11] the post-operative mean air–bone gap showed significant improvement compared with the pre-operative air–bone gap. No graft-related complications (e.g. graft lateralisation, significant blunting, graft medialisation) were encountered during the follow-up period.

The greatest risk when using the button technique is the potential for middle-ear cholesteatoma because the superficial epithelial layer is not removed. However, Ahmed *et al.*[17] performed chondroperichondrial clip myringoplasty by directly spreading the overlying perichondrium over the superficial surface of the tympanic membrane and did not observe any middle-ear cholesteatoma during a follow-up period of 12–26 months. Lou and colleagues[18,19] applied the cartilage and perichondrium double-layer graft technique without removing the superficial epithelium to repair large perforations, and found

Table 2. Comparison of hearing gain, ABG and average bone conduction between the two groups

Parameter	Pre-operation (mean ± SD; dB)	Post-operation (mean ± SD; dB)	*P*-value*	Gain (mean ± SD; dB)	*P*-value†
Button technique group‡					
– ABG	20.32 ± 2.56	9.41 ± 3.13	0.001**	10.54 ± 4.29	
– Bone conduction	13.68 ± 2.89	13.41 ± 3.11	0.614		
Over-underlay group§					
– ABG	20.09 ± 3.26	9.21 ± 3.84	0.001**	10.49 ± 2.46	0.781
– Bone conduction	13.79 ± 2.92	13.01 ± 2.97	0.758		

*Intra-group comparisons of pre- and post-operative air–bone gap and bone conduction (paired samples *t*-test). †Inter-group comparisons of pre- and post-operative air–bone gap gain (Mann–Whitney U test). ‡$n = 26$. **$p < 0.01$. §$n = 26$. ABG = air–bone gap; SD = standard deviation

https://doi.org/10.1017/S0022215123000968 Published online by Cambridge University Press

no middle-ear cholesteatoma over a follow-up period of 28.2 ± 6.1 months. However, other groups reported middle-ear cholesteatoma following application of the underlay technique.[20,21] Therefore, we speculate that the development of middle-ear cholesteatoma is not directly related to removal of the superficial epithelium. Endoscopically, we observed that the lateral perichondrium became crust by two to three months post-operatively, and finally migrated into the external auditory canal, similar to previous observations.[21] Gülşen and Erden[22] reported that excess perichondrium and the cartilage part of the chondroperichondrial graft lateral to the tympanic membrane remnant became necrotic within a short period (two to four weeks post-operatively) after butterfly inlay cartilage tympanoplasty. Therefore, it appears that grafts placed over the superficial epithelial layer of the eardrum or annulus would not have survived. In addition, the medial cartilage graft could prevent the superficial epithelium from migrating into the middle ear.[23]

- The endoscopic cartilage-perichondrium button technique and over-under technique had similar graft success rates and hearing outcomes for large chronic perforations
- The button technique significantly shortened the mean operation time compared with the over-under technique
- The over-under technique, but not the button technique, involves raising a flap and entering the middle ear

This study has some limitations, including a small sample size and short follow-up time. Further studies with larger sample sizes and longer follow-up times are required.

Conclusion

The endoscopic cartilage-perichondrium button technique had similar graft success rates and hearing outcomes for large chronic perforations to the over-under technique, but significantly shortened the mean operation time.

Acknowledgements. This study was financially supported by the Health Commission of Zhejiang Province, China (grant number: 2021KY1186), and the Science and Technology Agency of Yiwu City, China (grant number: 2018-3-76).

Competing interests. None declared

References

1 Babu S, Luryi AL, Schutt CA. Over-under versus medial tympanoplasty: comparison of benefit, success, and hearing results. *Laryngoscope* 2019;**129**:1206–10
2 Kartush JM, Michaelides EM, Becvarovski Z, LaRouere MJ. Over-under tympanoplasty. *Laryngoscope* 2002;**112**:802–907
3 Şen A, Özdamar K. Endoscopic tympanoplasty with limited tympanomeatal flap elevation in pediatric cases: comparison of anatomic and audiological results of grafts. *Eur Arch Otorhinolaryngol* 2019;**276**:2427–32
4 Atchariyasathian V, Suwannajak R, Plodpai Y, Pitathawatchai P. A comparison of endoscopic transtympanic myringoplasty and endoscopic type I tympanoplasty for repairing medium- to large-sized tympanic membrane perforation: a randomized clinical trial. *Eur Arch Otorhinolaryngol* 2020;**277**:2199–207
5 Berglund M, Suneson P, Florentzson R, Fransson M, Hultcrantz M, Westman E *et al.* Tinnitus and taste disturbances reported after myringoplasty: data from a national quality registry. *Laryngoscope* 2019;**129**:209–15
6 Zhang X, Ji C, Li A, Xu Z, Zhang X. Microscopic over-under versus medial tympanoplasty for larger tympanic membrane perforations. *Ear Nose Throat J* 2022. Epub 2022 Jun 19
7 Bao JW, Zhan KY, Wick CC. Comparison of endoscopic underlay and over-under tympanoplasty techniques for type I tympanoplasty. *Laryngoscope Investig Otolaryngol* 2022;**7**:1186–93
8 Yigit O, Alkan S, Topuz E, Uslu B, Unsal O, Dadas B. Short-term evaluation of over-under myringoplasty technique. *Eur Arch Otorhinolaryngol* 2005;**262**:400–3
9 Barake R, El Natout T, Bassim M, El Natout MA. Loop underlay tympanoplasty for anterior, subtotal and total tympanic membrane perforations: a retrospective review. *J Otolaryngol Head Neck Surg* 2019;**48**:12
10 Alain H, Esmat NH, Ohad H, Yona V, Nageris BI. Butterfly myringoplasty for total, subtotal, and annular perforations. *Laryngoscope* 2016;**126**:2565–8
11 Bedri EH, Korra B, Redleaf M, Worku A. Double-layer tympanic membrane graft in type I tympanoplasty. *Ann Otol Rhinol Laryngol* 2019;**128**:795–801
12 Angeli SI, Kulak JL, Guzmán J. Lateral tympanoplasty for total or near-total perforation: prognostic factors. *Laryngoscope* 2006;**116**:1594–9
13 Farrior JB. Sandwich graft tympanoplasty: experience, results, and complications. *Laryngoscope* 1989;**99**:213–17
14 Raghavan U, Malki DS, Mahmoud NA. Myringoplasty: update on onlay pedicle skin flap and temporalis fascia sandwich graft. *J Laryngol Otol* 2000;**114**:174–7
15 Pagnini P, Scarpini L, Fanfani F, Norberti A. Sandwich-graft myringoplasty: the authors' personal technique and results [in Italian]. *Acta Otorhinolaryngol Ital* 1992;**12**:153–63
16 Elwany S. Histochemical study of cartilage autografts in tympanoplasty. *J Laryngol Otol* 1985;**99**:637–42
17 Ahmed S, Raza N, Ullah S, Shabbir A. Chondroperichondrial clip myringoplasty: a new technique for closure of tympanic membrane perforations. *J Laryngol Otol* 2013;**127**:562–7
18 Lou Z. Transcanal endoscopic cartilage and perichondrium graft myringoplasty for large tympanic membrane perforations. *Otol Neurotol* 2021;**42**:1172–6
19 Lou Z, Lou Z, Jin K, Sun J, Chen Z. Comparison of long-term outcome of two endoscopic transtympanic myringoplasty without tympanomeatal flap elevating for repairing large chronic perforations. *Eur Arch Otorhinolaryngol* 2022;**279**:2293–301
20 Celik H, Samim E, Oztuna D. Endoscopic "push-through" technique cartilage myringoplasty in anterior tympanic membrane perforations. *Clin Exp Otorhinolaryngol* 2015;**8**:224–9
21 James AL. Endoscope or microscope-guided pediatric tympanoplasty? Comparison of grafting technique and outcome. *Laryngoscope* 2017;**127**:2659–64
22 Gülşen S, Erden B. In reply to the comparison of endoscopic butterfly-inlay and push-through myringoplasty. *J Laryngol Otol* 2020;**134**:277–8
23 Fishman AJ, Marrinan MS, Huang TC, Kanowitz SJ. Total tympanic membrane reconstruction: AlloDerm versus temporalis fascia. *Otolaryngol Head Neck Surg* 2005;**132**:906–15