Cartilage Palisades in Type 3 Tympanoplasty: Functional and Hearing Results

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Abstract To evaluate the functional and hearing outcomes using full thickness broad cartilage palisades for tympanic membrane reconstruction in type 3 tympanoplasty with titanium prostheses. The retrospective study performed at a tertiary referral institute included 30 patients with posterior mesotympanic retraction pockets or tympanic membrane perforations requiring tympanic membrane and type 3 ossicular reconstruction. Patients with disease extending beyond the aditus requiring canal wall down mastoidectomy were excluded. Disease removal from posterior mesotympanic and epitympanic recesses was confirmed using angled endoscopy and ossicular reconstruction was performed using titanium partial or total ossicular replacement prostheses. Tympanic membrane reconstruction was done, with or without attic reconstruction, using full thickness broad cartilage palisades harvested from the tragus with perichondrium attached laterally. Patients were assessed at 24 and 48 weeks for graft status and any evidence of implant extrusion. Hearing evaluation was done using subjective assessment and pure tone audiometry. In total, 27 out of 30 patients had intact and completely healed grafts at 48 weeks postoperatively (a success rate of 90 %) showing full union and epithelialization of palisades, and with three patients displaying small defects. The mean pure tone air bone gap pre- and postoperatively was 32.4 and 8.8 dB, respectively, with

most patients reporting satisfactory postoperative hearing. No evidence of implant extrusion was found in the 48-week period. Tympanic membrane reconstruction using full thickness palisades of tragal cartilage provides good functional and hearing outcomes in type 3 tympanoplasty with titanium prostheses.

Keywords Tympanoplasty · Middle ear · Cartilage · Titanium

Introduction

The goals of a successful tympanoplasty procedure are creation of an intact and mobile tympanic membrane, mucosalized and aerated middle ear, and a mobile ossicular conductive apparatus. However, Eustachian tube dysfunction leading to persistent negative middle ear pressure, middle ear granulation and adhesions, chronically discharging ears and previous ear surgery prohibit one or all of the goals of tympanoplasty.

An intact ossicular chain is one of the most desirable attributes of a tympanoplasty procedure and represents the most favorable hearing outcome [1]. Certain conditions, however, mandate a type 3 ossicular reconstruction due to ossicular erosion (resorptive osteitis, cholesteatoma induced) or ossicular disarticulation and removal for epitympanic disease clearance [2]. This can be associated with poorer hearing outcomes due to the primary pathology itself or the less than optimal prosthesis designs, materials and implant extrusions [3, 4].

Cartilage as a graft material resists negative middle ear pressure to a much greater degree than fascia due to its rigidity [5]. Sound conduction of cartilage replicates that of normal tympanic membrane and its properties of resisting

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retraction and conduction depend on the thickness and technique used [6, 7]. Cartilage also seems to offer more resistance to infection and lack of vascularization, often seen in atrophic drums and revision surgery [8].

The current study was undertaken to observe the functional and hearing results of type 3 tympanoplasties with reconstruction of the tympanic membrane using tragal full thickness broad cartilage palisades and ossicular reconstruction using titanium prostheses.

Materials and Methods

A retrospective review at a tertiary referral center between 2010 and 2013 included 30 patients with tympanic membrane perforations or posterior mesotympanic retraction pockets undergoing type 3 ossicular reconstruction. Adult, pediatric and revision cases were included and patients with epithelium/cholesteatoma extending beyond the antrum requiring canal wall down mastoidectomy were excluded from the study.

A written informed consent was obtained from all patients before surgery explaining the procedure and possible outcomes and complications. Patients were informed of the probability of postaural or endaural incisions. Institutional ethics committee clearance was obtained for the study.

Dry ear for 4 weeks before surgery was considered preferable but not necessary in all cases. Pediatric patients and patients with tympanic membrane retractions were operated under general anesthesia whereas adults and patients with tympanic membrane perforations were operated under local anesthesia.

Variables recorded pre-operatively were the size and location of the tympanic membrane perforation. Indications for surgical intervention in posterior mesotympanic retractions were fixity of the retraction to the incudostapedial joint complex, deep pockets with lack of visibility of fundus on microscopy, conductive hearing loss or presence of otorrhoea. Pre-operative and post-operative hearing assessments were performed using pure tone audiometry and averages were calculated as the mean of frequencies at 500, 1,000, 2,000 and 4,000 Hz.

Technique

Excision of retraction pockets/epithelium was accomplished after drilling or curetting the postero-superior canal wall. In cases with posterior mesotympanic retractions, epithelium or cholesteatoma removal from posterior mesotympanic recesses was ensured using angled rigid endoscopes. In cases with tympanic membrane perforations, the

tympanomeatal flap was elevated all around the perforation and divided to create “swing door flaps”.

Titanium clip partial ossicular replacement prostheses (PORP) or total ossicular replacement prostheses (TORP) (Vario) (Kurz Medical, Heinz Kurz, Germany) were used in a stapes head present or absent scenario. The clip design of PORP allowed easy and secure crimping of the implant onto the stapes head. In all cases, full thickness cartilage was harvested from the tragus. Perichondrium was removed from the convex side and left attached to the concave side. Two broad semilunar shaped and one narrow full thickness palisades were made using a no.15 scalpel blade. The first broad palisade was placed on the implant head with the perichondrium side facing the ear canal side. Subsequent palisades were placed adjacent to the first palisade and were supported in the middle ear using gel-foam pledgets. In cases with tympanic membrane perforations, the anterior-most palisade was placed medial to the anterior bony annulus to prevent any lateralization. The tympanomeatal flap or canal skin was carefully positioned back on the palisade assembly for early epithelialization of the palisades. The external auditory canal was packed with medicated gelfoam. The post-operative graft and hearing assessment was done subsequently after 24 and 48 weeks. Pure tone air conduction, bone conduction and air-bone gap averages were calculated at frequencies of 500, 1,000, 2,000 and 4,000 Hz (Figs. 1, 2, 3).

Results

The mean age of patients was 25.33 years with 60 % female (18/30) and 40 % male (12/30).

Fig. 1 Titanium Clip PORP placed in the middle ear, clipped onto the stapes head

Fig. 2 PORP in position clipped, with headplate in position

Fig. 3 Cartilage palisades after placement on the implant headplate

Twelve patients (40 %) were operated for chronic mucosal otitis media with tympanic membrane perforations, whereas 18 patients (60 %) were operated for posterior mesotympanic retractions (squamous otitis media). All 18 patients with posterior mesotympanic retractions were primary cases whereas cases with mucosal chronic otitis media were both primary (7/12) and revision (5/12) cases. All primary cases of mucosal chronic otitis media exhibited near-total or total perforation.

In total, 28/30 patients underwent partial ossicular reconstruction and two patients underwent total ossicular reconstruction.

After 48 weeks, 27/30 patients (90 %) had intact and well-healed grafts with complete epithelialization and union of palisades. Three patients had graft defects after surgery consequent to profuse otorrhoea. Two of these patients were re-operated using full thickness conchal cartilage graft in an underlay manner, as described, with successful outcomes.

The pre- and post-operative mean pure tone air-bone gaps were 32.4 ± 25 and 8.8 ± 15 dB, respectively. The mean post-operative air-bone gap for the partial ossiculoplasty group was 7.3 dB, and was 22.5 dB for the total ossicular replacement group. The presence of only two patients in the TORP group as compared to 28 in the PORP group renders the two non-comparable.

Discussion

Synopsis of Key Findings

The current study was undertaken to assess the feasibility and outcomes of using broad full thickness tragal cartilage palisades in type 3 tympanoplasty with titanium ossicular reconstruction prostheses. Reconstruction of the tympanic membrane using full thickness cartilage palisades in type 3 tympanoplasty provides satisfactory functional and hearing outcomes.

Comparison with Other Studies

The ability of autologous cartilage to resist retraction and negative middle ear pressure has been well documented by laser doppler vibrometric studies [5]. Furthermore, cartilage resists infection and lack of vascularization and its use in tympanic membrane reconstructions has been indicated in “high risk” tympanoplasties [8].

Cartilage palisades were first used by Heermann [9] to reconstruct the tympanic membrane to prevent the torsion associated with larger slices of cartilage. Bernal-Sprekelsen et al. [8] modified the technique of Heermann and used fewer, broad palisades and supported them in the middle ear using cartilage slices. In the present study, we used gelfoam to support the palisades anteriorly and found no medialization or displacement of palisades in any case.

The long-term efficacy of cartilage palisades in the reconstruction of postero-superior retraction pockets has been well documented in clinical studies [10, 11]. The rigidity and thickness of cartilage as graft material has raised questions over hearing conduction but most clinical studies have failed to demonstrate any hearing impedance after cartilage tympanoplasty, even in an intact ossicular chain scenario [12–14].

As an implant connecting tympanic membrane to the stapes head or footplate, titanium is favored because of its rigidity, light weight and biocompatibility [15]. In addition, titanium TORPs and PORPs require cartilage interposition between the implant headplate and the tympanic membrane/fascia to prevent extrusion [16]. A thin slice of cartilage with or without perichondrium is ordinarily recommended as an interposition graft to cause minimal impedance to hearing [16]. By providing nourishment to the cartilage, perichondrium maintains its vitality, especially in the long term, and hence maintains its structure and shape, avoiding resorption [17, 18]. However, perichondrium attached to a thin slice of cartilage can lead to unacceptable curling and can offset the assembly. Furthermore, a rate of 50 % re-retraction has been documented by some authors while using half thickness cartilage in patients with Eustachian tube dysfunction [19]. In the present study, we used full thickness cartilage with attached perichondrium (facing the ear canal side) for better resistance to retraction and encountered no problems with curling. Perichondrium on adjacent palisades helps in their early union because of tissue fluid and promotes early epithelialization.

Cartilage placement over PORP headplates has previously raised queries with regard to possible displacement of prostheses during manipulation with possible loose anchorage over the stapes head, leading to suboptimal assembly and loss of sound energy [15]. The new Clip design in titanium PORPs enables easy and secure crimping to the stapes head, thus leading to a more secure assembly with better acoustic transfer [4].

In their series of more than 300 patients, Bernal-Sprekelsen et al. [8] used cartilage palisades in type 3 tympanoplasty with autologous incus, and inserted Ceravital and Ionos prostheses in both canal wall up and down situations. They observed a closure of the four-frequency pure tone average air-bone gap from 34.4 to 18.1 dB, with 62.1 % of patients having an air-bone gap closure within 20 dB and 29.8 % within 10 dB. In the present study, the mean pure tone average pre- and post-operative air-bone gaps were 32.4 and 8.8 dB, respectively, which is highly significant ($p < 0.01$). The difference can be attributed to a more limited pathology (tympanic membrane perforations and retractions) with exclusion of patients with canal wall down mastoidectomies, along with use of titanium clip prostheses that lead to a more secure sound transmission. Canal wall down mastoidectomies were excluded in our study as the most significant benefit of full thickness cartilage palisades as a tympanic membrane graft seems to be in preventing retraction by resisting negative pressure, which is of great advantage in situations avoiding canal wall down mastoidectomies. Further, a significant percentage of patients undergoing canal wall down

mastoidectomies have more extensive disease, possibly active purulence and a poorer state of middle ear mucosa. One or all of these factors can have implications in the use of ossicular prostheses, extrusions and middle ear sound conduction. Similar hearing outcomes have been observed in other studies on type 3 ossicular reconstruction using titanium prostheses [16, 20, 21].

A re-perforation rate of 1.6 % with a 2.2 % rate of recurrent cholesteatomas was observed by Bernal-Sprekelsen et al. [8], whereas we observed a re-perforation rate of 10 % in our study, but a far lower sample size confounds this figure. Velepici et al. [22] reported a 3.5 % re-perforation rate after full thickness cartilage palisade tympanoplasty in a pediatric and adult population with several additional major cartilage resorptions.

Out of three patients with graft defects after surgery, two were immediate with profuse otorrhoea immediately post surgery. Both patients were treated with systemic and topical antibiotics and completely dry ears were attained approximately 8 weeks after surgery, revealing moderate sized graft defects based anteriorly. Both of these patients have been re-operated with successful closure of graft defects with the use of full thickness conchal cartilage in an underlay fashion, as described. The implant was not changed or removed. One patient, however, developed localized retraction anteriorly, which progressed to a small sized perforation at the end of 6 months. The patient is in serial follow-up with no complaints of hearing loss or otorrhoea at the present time.

Limitations and Recommendations

Obvious limitations of the present study include its relatively small sample size and a relatively short follow-up period. With most patients coming to the institute from distant regions in the country involving both regional and ethnic considerations, long-term follow-up can certainly be daunting. Early observations, however, convey a significant message in this sub-group of patients with encouraging results. More research with a larger sample size and longer follow-up would certainly shed more light on the subject.

Conclusion

Tympanic membrane reconstruction using full thickness broad cartilage palisades with type 3 ossicular reconstruction using titanium implants provides satisfactory functional and hearing outcomes in patients with tympanic membrane perforations and limited retraction of the posterior mesotympanum.

Conflict of interest None.

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