Maximising Graft Take-Up in Type1 Tympanoplasty Using Peripheral Cartilage Ring and Perichondrium

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Abstract The aim of this study is to evaluate the results of closure of big central and subtotal perforation by Tympanoplasty using underlay technique with Composite graft of tragal perichondrium supported by a ring of cartilage peripherally. Our hypothesis was that the cartilage support offers an extremely reliable method for reconstruction of the tympanic membrane in cases of advanced middle ear pathology and Eustachian tube dysfunction and also revision cases. Prospective study of patients undergoing tympanoplasty in big central and subtotal perforation with graft supported by a ring of cartilage peripherally between June 2016 and August 2016. Hearing results were reported using four frequency (500, 1000, 2000 and 3000) pure tone average air–bone gap. During the study period, composite graft comprising of tragal perichondrium and peripheral ring of cartilage prepared from ipsilateral tragus was used for tympanic membrane reconstruction in 30 patients. Overall graft take rate was 93.33%. Complications included residual perforation in 6.67%. Cartilage ring support offers an extremely reliable method for reconstruction of tympanic membrane in cases of high-risk perforation (big central perforation, subtotal perforation, anterior perforation of tympanic membrane, revision cases).

Keywords Type1 tympanoplasty · Peripheral cartilage ring · Perichondrium

Introduction

Repair of big central and subtotal perforations are difficult because very little support is there for the graft particularly along the anterior rim of perforation, also there are chances of recurrence of pathology due to Eustachian tube dysfunction. Chances of failure are very high in anterior–superior quadrant, since the graft may fall around the Eustachian tube orifice leading to the medialization of graft and blocking the Eustachian tube. During post operative period shrinkage of graft can occur leading to residual perforation, especially near the anterior annular region. The underlay technique with fascia or perichondrium alone is an uncertain method. The soft material, which is only fixed by adhesion, can easily be displaced during wound healing. Temporalis fascia and perichondrium are the most popular and commonly used graft material. They contain collagen and mucopolysaccharides. These two components give it a high tensile strength and low metabolic rate. For this reason it does not get autolysed in the presence of infection. Cartilage being a bradytrophic tissue allows stable and functionally reliable reconstruction of the ear drum. Reconstruction of tympanic membrane with graft supported by cartilage counteracts tendency to reconstruction of soft autologous materials like temporalis fascia or perichondrium. Because of its low turnover rate, cartilage is more resistant to infection.

The purpose of this study is to evaluate the results of closure of big central and subtotal perforation of tympanic membrane by tympanoplasty using underlay technique with composite graft comprising of perichondrium and peripheral ring of cartilage prepared from ipsilateral tragus. It gives support to the graft all along and prevents it from falling and also decreases the chance of residual perforation in future.

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Materials and Methods

Operative Technique

The general technique of reconstruction begins with harvest of Tragal cartilage with perichondrium attached to one side only. To obtain tragal cartilage, incision is made slightly posterior to the free edge of the tragus to expose the cartilage. Dissection is first taken to free the cartilage on its ventral surface from the overlying muscle and then carefully on its dorsal surface from the thin canal skin. The peripheral ring of cartilage is then prepared using two specially made templates, 9 mm for outer rim and 7 mm for inner rim. The island of cartilage inside the inner rim is gently shaved off using Plester's knife. Thus we get the peripheral ring of cartilage. Next it is scored at 12 o'clock position to facilitate handle of malleus (Fig. 1).

Post auricular incision is given. Subsequently, a D-shaped incision is made. A Farabeuf's periosteum elevator is used to mobilize the periosteum to the level of the ear canal. Horizontal incision is then made on skin of the posterior canal wall. Edges excised with sickle knife and undersurface of the perforation is freshened.

Under operating microscope tympanomeatal flap elevated up to the annulus. Middle ear entered by piercing the middle ear mucosa from the posterior-superior quadrant. Middle ear is examined, handle of malleus is denuded and ossicular chain is checked for continuity and mobility (Figs. 2, 3, 4, 5 and 6).

Gel foam soaked antibiotic solution is packed in middle ear. Tympanomeatal flap replaced. Canal is packed with antibiotic impregnated with gelfoam. Post-operative pure tone audiometry was done after 3 months.

Fig. 1 Pre-operative photograph showing subtotal perforation of tympanic membrane

Fig. 2 9 and 7 mm templates

Fig. 3 Template being used to make the ring

Fig. 4 Island of cartilage being removed to make the ring

Fig. 5 Final prepared graft after “scoring” for handle of malleus

Fig. 6 Post-operative photograph after placement of composite graft comprising of perichondrium and peripheral ring of cartilage prepared from ipsilateral tragus

Results

- During the study period, composite graft comprising of perichondrium and peripheral ring of cartilage reconstruction was done in 30 patients and followed up at At 1, 2, 4, 8, 12 weeks post-operative period. Of these 17 (56.67%) were female cases and 13 (43.33%) were male cases. Deafness was the chief complaint in 93.67% cases and it was mainly conductive type (50%) with that of moderate degree in 40% cases. Severe degree of conductive deafness is present in 10% cases. Tympanoplasty was done using post-aural approach in all the cases. Subtotal perforation was seen in all cases Type I tympanoplasty was done in all cases. The average duration of follow up was 6 months ranging from 3 months to 9 months.

Overall graft take-up rate was 93.33%. Only two patients had partial take-up due to development of postoperative

infection. Air bone closure up to 25 dB was found in 26 patients (86.67%). Only 6.67% cases had residual perforation. Tympanogram revealed A curve in 24 cases (80%) C curve in 4 cases (13.33%) and B curve in 2 patients (6.67%).

Discussion

Hearing is one of the most important and visible functions of the ear. Impairment of hearing, results in substantial disability. Perforation of tympanic membrane causes conductive hearing loss. This is a serious health concern worldwide, not only because of the distress it causes to the patients and relatives, but also the associated hearing impairment imposes substantial economic burden on the patient and health care system.

Permanent restoration of hearing is the goal of functional reconstruction of the perforations of tympanic membrane by tympanoplasty. Otologists to repair subtotal perforation now practice various techniques.

Problems with Closure of Subtotal Perforation

- Very little support is provided by the remnant of tympanic membrane anteriorly.
- Graft may fall around the Eustachian tube orifice.
- Medialization of graft and blocking of Eustachian tube opening.
- Residual perforation in anterior quadrant.

Perforation fails to close in approximately 10% of tympanoplasty surgeries. Reason for failure are graft displacement, improper placement, shrinkage, autolysis, infection, haemorrhage, Eustachian tube dysfunction etc.

The use of cartilage support is experiencing a renaissance in ear surgery because it appears to offer an

extremely reliable method for reconstruction of tympanic membrane in cases of middle ear pathology and Eustachian dysfunction. Conceptually, one might anticipate a significant conductive hearing loss with a tympanic membrane that is rigid and thick, a fact that has hampered the routine acceptance of cartilage as a grafting material.

Heerman [5] showed in cartilage tunnel at the Eustachian Tube Entrance that it has been very useful in all types of tympanoplasty in maintaining the patency of the tubal entrance and in reconstructing the antero-inferior aspect of the tympanic membrane. The proper direction of this tunnel and cartilage bridge will lead to an easy construction of the remainder of the tympanic membrane by use of multiple pieces of fascia or cartilage.

Heerman also used small cartilaginous chips for reconstruction of the eardrum and introduced it as Palisade Cartilage Tympanoplasty. Reconstruction of subtotal perforation of tympanic membrane with cartilage palisades counteracts the tendency of retraction of soft autologous materials like temporalis fascia or perichondrium. Cartilage is more resistant to the prolonged absence of neovascularisation from the periphery in large central and subtotal perforation making it more resistant to infection.

Borkowski et al. [1] introduced a perichondrium–cartilage composite graft for closure of total perforations of the tympanic membrane. An oval shaped piece of cartilage with perichondrium on one side was harvested from cavum conchae. The cartilage was cut in the shape of U without removing the inner layer of perichondrium. The inner diameter of the cartilage ring should be nearly the same as the diameter of the tympanic ring. This cartilage framework stabilizes and fixes the perichondrium and prevents the perichondrium from subsiding into the middle ear cavity. The cartilage ring also reduces shrinking of the perichondrium. In all patients, the tympanic membrane was closed and no residual perforation occurred (27 patients). The hearing results in tympanoplasty were the same as in other techniques with a residual air–bone gap of 20 dB.

Dornhoffer [2] compared the hearing results of patients with cartilage tympanoplasty with results of patients who underwent revision tympanoplasty using perichondrium. He showed 100% take up rate of cartilage tympanoplasty compared to 85% of perichondrium with no difference in hearing improvement.

Indorewala [6] introduced approach to middle ear by lifting the anterior annulus tympanicus and anchorage the graft underneath the anterior tympanomeatal flap and named the technique as anterior tympanotomy, author did 1,113 tympanoplasties by this technique and his failure rate was only 0.09%.

Dornhoffer [2] showed good anatomical and audiologic results in cartilage tympanoplasty. In cases of high-risk perforation, reconstruction with cartilage yielded

anatomical and functional results that compared favourably to primary tympanoplasty using traditional techniques, which have showed high rates of retraction and failure. He classified high-risk cases as those, which are of revision surgery, a perforation near to anterior annulus and larger than larger than 50% or bilateral perforations. Significant hearing improvement was realized in all pathological groups (subtotal perforation, atelectatic ear, cholesteatoma) and chances of recurrence or displacement are minimal.

Indorewala [7] showed that in repair of subtotal perforation, temporalis fascia result in 83% primary closure with only 67% had no recurrent perforation as compared to fascia lata, which has resulted in 95% closure and 89% had no recurrence. Temporal fascia has been shown to shrink and thicken more. In subtotal perforation with very small margin of remnant tympanic membrane, shrinkage of graft causes a high failure rate.

Graft Take Up Rate and Hearing Improvement

In our study, graft take rate is 98.94%. Only 1 out of 30 cases had residual perforation of tympanic membrane. That patient has not come for follow-up for initial 1 month, during which he had develop URI and otomycosis. This has resulted in small residual perforation that gets healed on conservative treatment. So taken this in consideration our results were almost 100%. 95.74% has closed air–bone–gap within 0–30 dB (social hearing), 21.28% within 10 dB and 56.38% within 20 dB in this series was obtained. 4.26% cases has > 30 dB hearing, they are cases of unsafe variety.

Dornhoffer [3] reported success rate of 85% with perichondrium. He achieved air–bone–gap < 20 dB by cartilage palisade technique.

Borkowski et al. and Dornhoffer [1] reported 100% results with cartilage palisade tympanoplasty and cartilage-perichondrium grafting.

Singh et al. [10] reported a graft-take up rate of 93.3% for large central and subtotal perforation. They reported an overall hearing gain in 92.8% cases.

Indorewala [7] reported 83% success rate with temporalis fascia and 95% success rate with fascia lata (Table 1).

Postoperative Complications

In this series incidence of postoperative complications was very low. In two patients i.e. 6.67% of cases residual perforation was present.

Medialization of graft and blockage of Eustachian tube are common problems associated with closure of subtotal perforation of tympanic membrane did not occur in this series. None of the cases developed facial nerve palsy, labyrinthitis or sensorineural deafness post operatively.

Table 1 Take up and hearing results of various authors in cases of subtotal perforation *Source:* Reproduce with Mundra et al. [8]

Author	Type	Take up in %	Hearing
Dornhoffer [3]	Perichondrium	85	Air bone-gap < 10 dB
Borkowski et al. [1]	Cartilage-perichondrium	100	Air bone-gap < 20 dB
Singh et al. [10]	Temporalis fascia	93.3	Air bone-gap < 30 dB
Neumann et al. [9]	Cartilage palisade	100	Air bone-gap < 30 dB
Dornhoffer [2]	Cartilage palisade	100	Air bone-gap < 20 dB
Indorewala [7]	(a) Temporalis fascia	66	Air bone-gap < 10 dB
	(b) Fascia lata	95	Air bone-gap < 20 dB
Present series	Temporalis fascia/perichondrium graft with cartilage slice support	98.94	Air bone-gap < 30 dB

Glasscock et al. [4] reported sensorineural hearing loss in > 1% cases post operatively.

Dornhoffer [2] reported post-operative perforation in 4.2% cases, revision surgery for conductive deafness in 1.9% cases and delayed facial weakness (temporary) in 0.5%. He also had secondary cholesteatoma in 1.3% cases.

Neuman et al. [9] reported post operative recurrence in 1.6% cases with no facial weakness and otorrhea.

Hence, it was found that closure of subtotal perforation of tympanic membrane can be done effectively with near 100% success rate by underlay technique of tympanoplasty by perichondrium with supporting the graft all around by a cartilage ring at the periphery.

Conclusion

Results in our patients series indicate that this tympanoplasty technique i.e. graft supported by cartilage ring, achieve good anatomical and audiological results. Cartilage in spite of being rigid and thick, a fact that has hampered its routine acceptance, does not significantly affect post operative hearing results. With this technique, whole of tympanic membrane does not become opaque. Middle ear structures can be seen through semi transparent graft in post operative period. Cartilage support offers an extremely reliable method for reconstruction of the tympanic membrane in cases of advance middle ear pathology and Eustachian tube dysfunction. It is somewhat difficult to keep asymptomatic patient on follow up, especially in developing countries. In them cartilage support is useful in preventing recurrence due to its tensile strength as well as low rate of absorption. Cartilage slice support gives a very high success rate in cases of high-risk perforation (big central, subtotal perforation, anterior perforation of tympanic membrane). Ring cartilage graft does not fold and helps in smooth growth of epithelium over it. Tympanoplasty using perichondrium with graft supported by cartilage ring is a safe and reliable procedure.

Compliance with Ethical Standards

Conflict of interest The authors declare that there is no conflict of interest.

Ethical Approval All procedures performed in studies 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.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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