Objective: To present the experience in cartilage island graft tympanoplasty for advanced middle ear pathologies and evaluate its success rate and audiologic results.

Materials and Methods: The charts of patients who underwent cartilage island graft tympanoplasty for advanced middle ear disease from September 2006 to March 2009 were reviewed and only oto-endoscopy assisted intact canal wall (ICW) / type 3 tympanoplasty procedures have been included in this study. Reviewed parameters were graft take, change between the pre- and post operative pure tone average air bone gap (PTA-ABG) and complications. Audiologic evaluation was made among the patients whom complete ear drum closure was achieved.

Results: Of the 36 procedures, 63.9% were for chronic otitis media with cholesteatoma, 11.1% for chronic otitis media with polyp, 25% for adhesive otitis/retraction pocket with or without cholesteatoma. TORP was used in 14 cases and PORP in 22. Graft take was achieved 88.9% of the patients. There were two attic perforation with cholesteatoma and two anterior perforation. The overall pre-and postoperative PTA-ABG were 28.91± 8.73 dB and 10.42±6.10 dB. PORP subgroups had a statistically significant better hearing results at 0.5 kHz, 4.0 kHz and average.

Conclusion: Results in our study indicate that cartilage island graft is a reliable material in advanced middle ear pathologies with satisfactory anatomical - functional outcomes and it reduces the risk of retraction pockets which can lead to recurrent cholesteatoma.

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Introduction
Cartilage has proved to be a reliable graft material for reconstruction of the tympanic membrane even in advanced middle ear pathologies, such as atelectatic retraction pockets, adhesive otitis and subtotal tympanic membrane defects, either in chronic suppurative otitis media or in cholesteatoma[1]. There are many described techniques for cartilage tympanoplasty such as cartilage butterfly inlay technique, cartilage palisade technique, perichondrium cartilage island technique, cartilage mosaic technique and cartilage reinforcement technique[1-3]. The aim of this study is to present the experience in cartilage tympanoplasty with island technique for advanced middle ear pathologies and evaluate its success rate and audiologic results.

Material and Methods
The charts of patients who underwent cartilage island graft tympanoplasty for advanced middle ear disease from September 2006 to March 2009 were retrospectively reviewed and only oto-endoscopy assisted intact canal wall technique (ICW) / type 3 tympanoplasty procedures have been included in this study. These 36 cases had atelectatic retraction pockets, adhesive otitis and / or cholesteatoma in association with an ossicular chain defect. Middle Ear Risk Index (MERI) was used for determination of the disease severity. All surgery was performed by the same surgeon as a single stage procedure. 30° and rarely 70° oto-endoscopes were utilized for control of the sinus tympani / anterior epitympanum. Ossiculoplasty was performed with total (TORP) or partial ossicular replacement prosthesis (PORP). Middle ear pathology, age, sex, type of the used prostheses, pre- and postoperative audiograms, postoperative findings and follow-up time were obtained from the patient’s chart. Reviewed parameters were the graft take, change in PTA-ABG at each of four frequencies (0.5,1,2,4 kHz) and

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complications such as reperforation, recurrent retraction pockets or cholesteatoma. Audiologic evaluation was made among the patients whom complete tympanic membrane closure was achieved. Statistical comparisons of the audiometric data were performed using Wilcoxon Signed Ranks and Mann-Whitney U tests.

**Technique**

Tragal cartilage was used as a graft material in all cases. In the dome of the tragus, 2 mm cartilage strip was left intact for cosmetic purpose and an insicion was made through the skin and cartilage on the medial side (Figure 1a). It was harvested with perichondrium on both surfaces. Cartilage island graft was prepared by elevating the perichondrium from the convex side of the cartilage. Using a round knife, cartilage was removed to produce a disc of cartilage about 6 to 9 mm in diameter for subtotal TM reconstruction. A notch can be made on the cartilage for manibrium mallei (Figure 1b). A rim of tissue was removed from the perforation edge and posterior tympanomeatal flap was then elevated. Long process of the malleus was cleaned from epithelial remnants. After ICW mastoidectomy and oto-endoscopic (Figure 1c) control of the sinus tympani / anterior epitympanum, the cartilage island graft was placed over the malleus and under the annulus (over-underlay technique). TORP or PORP was interpositioned between stapes superstructure or foot plate and graft. Prostheses were placed in direct contact with the cartilage island graft, minimizing the risk of extrusion. A flap of perichondrium was draped over the posterior canal wall. The middle ear and external auditory canal were packed with gelfoam. Follow-up examinations were made by 0° oto – endoscope (Figure 1d) or oto - microscope.

![Figure 1.
](a. Tragal insicion was made through the skin and cartilage on the medial side,
b. Cartilage island graft,
c. 30° and 70° oto-endoscopes,
d. Post-operative, 0° oto-endoscobic view of the tympanic membrane.)
Results

The mean age of the patients consisted of 22 men and 14 women were 27.92±17.10 years (range, 7-58 years). The mean follow up period was 24.8 months (range, 12-48 months). Of the 36 procedures, 23 (63.9%) were for chronic otitis media with cholesteatoma, 4 (11.1%) for chronic suppurative otitis media with polyp, 9 (25%) for adhesive otitis / retraction pocket with or without cholesteatoma (Table 1). Values of MERI were between 8 to 12. Two types of tympanoplasty with ICW mastoidectomy were performed; type 3 using cartilage island grafts with TORP in 14 cases and type 3 using cartilage island grafts with PORP in 22 cases. Graft-take was achieved in 32 patients (88.9%). In remaining 4 patients, there were two attic perforation with residual / recurrent cholesteatoma and two simple anterior perforations. Among the cholesteatoma cases, rate of the residual / recurrent disease were 6.9% (2/29). Prosthesis extrusion or retraction pocket recurrence was not observed. The overall (n=32) pre-and postoperative (least 12 months after surgery) four frequency PTA-ABG were 28.91± 8.73 dB and 10.42±6.10 dB (p<0.0001) (Wilcoxon Signed Ranks Test) respectively (Figure 2, Table 2). In the TORP subgroup (n=13), pre-op PTA-ABG was 32.40±8.12 dB, and post-op PTA-ABG was 14.02±4.16 dB (p<0.0001) (Wilcoxon Signed Ranks Test) (Figure 3). In the PORP subgroup (n=19), pre- and postoperative PTA-ABG were 26.51±8.51 dB and 7.96±6.07 dB (p<0.0001) (Wilcoxon Signed Ranks Test) respectively (Figure 4). Comparis of the two groups, PORP subgroups had a statistically significant better postoperative hearing result at 0.5 kHz, 4.0 kHz and average (p<0.05) (Mann Whitney U Test) (Figure 5, Table 3).

Discussion

Surgical treatment in advanced middle ear disease such as adhesive otitis / retraction pocket with or without cholesteatoma or chronic otitis media with cholesteatoma have been discussed for several decades, but residues and recurrences still occur because of the hidden pathologies and/or chronic Eustachian tube dysfunction often associated with disease\(^{(6)}\). Residual disease is that which is left behind during initial surgery and 75% of all residual disease is thought to be manifested within 2 years after surgery\(^{(9)}\). On the other hand, recurrent cholesteatoma is caused by recurrent retractions from the reconstructed tympanic membrane\(^{(6)}\).

It is difficult to assess the exact origin of the existing cholesteatoma without close follow-up. As an alternative technique to posterior tympanotomy or canal wall down techniques, oto-endoscopic procedures allow a better visualisation and eradication of residual disease from hidden areas not yet reachable by the surgical microscope. The sinus tympani is the most common site of residual disease\(^{(7)}\). All visible cholesteatoma is

<table>
<thead>
<tr>
<th>Table 1. Surgery Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery Indications</td>
</tr>
<tr>
<td>Chronic suppurative otitis</td>
</tr>
<tr>
<td>media with cholesteatoma</td>
</tr>
<tr>
<td>Chronic suppurative otitis</td>
</tr>
<tr>
<td>media with polyp</td>
</tr>
<tr>
<td>Adhesive otitis / retraction</td>
</tr>
<tr>
<td>pocket with cholesteatoma</td>
</tr>
<tr>
<td>Adhesive otitis / retraction</td>
</tr>
<tr>
<td>pocket without cholesteatoma</td>
</tr>
</tbody>
</table>

Table 2. The overall (n=32) pre-and postoperative four frequency PTA-ABG (p<0.0001). (Wilcoxon Signed Ranks Test).

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Preoperative PTA-ABG</th>
<th>Postoperative PTA-ABG</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>32.03±14.13 dB</td>
<td>11.25±8.9 dB</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>1000</td>
<td>31.56±12.85 dB</td>
<td>8.91±6.92 dB</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>2000</td>
<td>21.72±9.38 dB</td>
<td>5.31±4.90 dB</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>4000</td>
<td>30.31±10.15 dB</td>
<td>16.09±8.95 dB</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Average</td>
<td>28.91±8.73 dB</td>
<td>10.42±6.10 dB</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

Table 3. PORP subgroups had a statistically significant better postoperative hearing result at 0.5 kHz, 4.0 kHz and average (p<0.05) (Mann Whitney U Test).

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Postoperative PTA-ABG (TORP) (n=13)</th>
<th>Postoperative PTA-ABG (PORP) (n=19)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>16.15±8.45 dB</td>
<td>7.89±7.87 dB</td>
<td>&lt; 0.05 (0.012)</td>
</tr>
<tr>
<td>1000</td>
<td>11.15±5.83 dB</td>
<td>7.37±7.33 dB</td>
<td>&gt; 0.05 (0.080)</td>
</tr>
<tr>
<td>2000</td>
<td>7.31±5.63 dB</td>
<td>4.00±3.93 dB</td>
<td>&gt; 0.05 (0.087)</td>
</tr>
<tr>
<td>4000</td>
<td>21.15±4.63 dB</td>
<td>12.63±9.62 dB</td>
<td>&lt; 0.05 (0.012)</td>
</tr>
<tr>
<td>Average</td>
<td>14.02±4.16 dB</td>
<td>7.96±6.07 dB</td>
<td>&lt; 0.05 (0.007)</td>
</tr>
</tbody>
</table>
removed under the surgical microscope and 2.7 mm 30° / 70°, oto-endoscopes are used for identifying any peroperative residual disease[8]. This minimally invasive surgical procedure, significantly decreases the frequency of canal wall down mastoidectomy and recourse to posterior tympanotomy with excellent access to cholesteatoma by the transmeatal approach [7,8,9]. Oto-endoscopy does not eliminate but reduces the risk of residual cholesteatoma [10].

Cartilage tympanoplasty has been well described for the management of the atelectatic retraction pockets, adhesive otitis and high risk perforations, either in chronic otitis media or in cholesteatoma with satisfactory anatomic and audiologic outcomes[11-14]. The stiffness of
the cartilage is resistant to the potential infections and to
anatomic deformation caused by negative middle ear
pressure[11,12]. Furthermore, many surgeons have found that
the thickness of the cartilage does not impair the
audiologic results[13-14].

Because of the pre- and peroperative risk factors have a
significant effect on prognosis in tympanoplasty[17], we
used the MERI. Of the 36 procedures, 23 (63.9%) were
for chronic otitis media with cholesteatoma, 4 (11.1%) for
chronic suppurative otitis media with polyph, 9 (25%) for
adhesive otitis / retraction pocket with or without
cholesteatoma. Six ears were diagnosed with combined
presence of adhesive otitis and cholesteatoma. In this
report, values of MERI were between 8-12 (severe
disease).

The perichondrium - cartilage island graft and cartilage
palisades graft with perichondrium on both sides, are two
main types of perichondrium cartilage composite
graft[18,19]. Mürbe et al reported that cartilage island grafts
are suitable for improving the acoustic transmission
characteristics of the reconstructed TM in the
experimental study. They have recommended this
technique for patients who has TM perforations with
adequate surrounding membrane remnants[13]. Its acoustic
properties are comparable to those of fascia[12].

Cartilage graft harvested from concha or tragus is easy to
obtain and convenient for re-shaping according to the size
of the perforation[3,12]. These grafts are nourished mainly
by diffusion and become excellent incorporated in
tympanic membrane. The donor area heals without
significant deformity[11,18]. A potential drawback of
cartilage tympanoplasty is the graft opacity and detection
of the residual or recurrent cholesteatoma may be more
difficult[12]. Nevertheless, as the cartilage island graft does
not cover all parts of the tympanic membrane, residual or
recurrent cholesteatoma is detectable[11]. However, the
fascia is often not transparent[12].

In this study, tragal cartilage was used as a graft material
in all cases. An incision was made through the skin and
cartilage on the medial side. Preparation of the
perichondrium cartilage island graft is very easy and
prolongs the operation time only to eight to ten minutes.
Since 2 mm cartilage strip was left intact in the tragal
dome, we have not observed any cosmetic problems
related to tragal cartilage harvesting. The long process of
the malleus was cleaned from epithelial remnants. Of the
36 procedures, after ICW mastoidectomy and 30° oto-
endoscopic control (rarely 70°) of the sinus tympano,
two different type 3 tympanoplasty were performed; placing
cartilage island graft over the malleus and under the
annulus (over-underlay technique) with TORP in 14
cases and with PORP in 22 cases.

Reevaluation of the patients should be performed with
otoscopy and determination of a four-frequency PTA-
ABG at least 12 months after surgery[9]. Dornhoffer
reported the perforation closure rate for cartilage
tympanoplasty as 95.8% in 215 high risk patients after
four years of follow-up[9]. This rate was reported as 66.7%
for type 3 tympanoplasty with cartilage reinforcement
technique by Uslu et al[11], Milewski (5 year follow up)
and Evitar (one year follow up) achieved a 96.5% and
91.2% success closure rate in type 3 tympanoplasty
respectively[12,20].

Sheehy and Glasscock reported the cholesteatoma
recurrence rates as 5% and 14% respectively[22,23]. This
rate was reported as 3.6% by Dornhoffer[12]. Cavaliere
reported a 2.29% recurrence rate for cholesteatoma
cases[12]. Bernal – Sprekelsen reported 2.2% recurrence
cholesteatoma, and 2.5% retraction pockets[12].

The mean follow up period was 24.8 months (range, 12-
48 months) in our study. Graft-take was achieved in 32
patients (88.9%). In remaining 4 patiets, there were two
attic perforation with residual / recurrent cholesteatoma
and two simple anterior perforations on follow-up
otoscopic examination. Among the cholesteatoma cases,
rate of the residual / recurrent disease were 6.9% (2/29).
These results are consistent with the literature. As
reported by Milewski[16], blunting or lateralization did not
occur in our cases.

Cavaliere et al. reported the overall mean pre- and
postoperative (1 year after surgery) PTA-ABG as
43±7.07 dB and 10.43±5.25 respectively for cartilage
type 3 tympanoplasty. In TORP (n=36) subgroup, pre-
and postoperative PTA-ABG were reported as
53.89±3.19 dB and 14.25±7.27 dB. Whereas in PORP
(n=40) subgroup, pre- and postoperative PTA-ABG were
reported as 45.0±5.06 dB and 11.06±3.97 dB
respectively. In the PORP group, pre- and postoperative
frequency PTA-ABG was 28.91±8.73 dB, whereas the
pre- and postoperative (54 months after surgery) four
frequency PTA-ABG as 34.4 dB and 18.1 dB
respectively. In the TORP group, pre- and postoperative
PTA-ABG were reported as 40.5 dB and 19.4 dB
respectively. In the PORP group, pre- and postoperative
PTA-ABG were reported as 28.3 dB and 16.8 dB
respectively[19].

In our study, the overall (n=32) pre-operative four
frequency PTA-ABG was 28.91±8.73 dB, whereas the
postoperative (least 12 months after surgery) PTA-ABG
was 10.42±6.10 (p<0.0001) (Wilcoxon Signed Ranks
Test). In the TORP subgroup (n=13), pre- and
postoperative PTA-ABG were 32.40±8.12 dB and
14.02±4.16 dB (p<0.0001) (Wilcoxon Signed Ranks
Test). In the PORP subgroup (n=19), pre- and
postoperative PTA-ABG were 26.51±8.51 dB and
7.96±6.07 dB respectively (p<0.0001) (Wilcoxon Signed Ranks Test). These results are consistent with the literature.

Although, advanced middle ear disease without stapes superstructure impairs the audiologic results, the influence of prosthesis type on audiologic outcomes continues to be controversial in the literature. Zenner et al reported that in their series better results were obtained in PORP group\(^{22}\). Contrary to this report, Neumann et al. reported better results in the TORP group\(^{5}\). Dornhofer and Bernal – Sprekelsen reported no difference in the outcome between TORP and PORP\(^{2,13}\). In our study, comparison of the two groups, PORP subgroups had a statistically significant better postoperative hearing result at 0.5 kHz, 4.0 kHz and average (p<0.05) (Mann Whitney U Test). Further studies with larger numbers of tympanoplasties are necessary to investigate the influence of prosthesis type (TORP or PORP) on hearing results.

The results of this study represent relatively short-term follow-up and these preliminary anatomic and audiologic outcomes may change with time.

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**References**