Objectives: To investigate whether cartilage or temporalis fascia is more ideal for tympanoplasty under the circumstance of Eustachian tube (ET) dysfunction.

Material and methods: Firstly, we summarized some biological comparisons among tympanic membrane, cartilage, and temporalis fascia. Secondly, we conducted a meta-analysis that involved three randomized controlled trials (RCT) to compare their difference in improving hearing level and morphological success rate.

Results: In terms of biological properties, cartilage was stiffer than temporalis fascia. But cartilage could be cut into different thickness to balance the ability of acoustic sensitivity and resistance to negative pressure induced by ET dysfunction, which was impossible for temporalis fascia. When it came to clinical properties, there was no statistical significance between cartilage and temporalis fascia in postoperative air-bone gap ≤ 20dB (p=0.61) and 20dB (p=0.25) in 24 months. However, cartilage showed better morphological success in 12 months with p=0.04.

Conclusions: Cartilage should be cut as thin as possible if ET function was normal. However, under the circumstance of ET dysfunction, cartilage with more than 500um thickness was supposed to be the first choice for tympanoplasty.
cartilage is more ideal than temporalis fascia in tympanoplasty under the circumstance of ET dysfunction. This article aims to investigate whether cartilage or temporalis fascia is more ideal for tympanoplasty under the circumstance of Eustachian tube (ET) dysfunction after comparing their biological and clinical properties.

**MATERIAL AND METHODS**

**Data sources and searches**

Cochrane Library, Pubmed and Embase were systematically searched to identify relative articles that comparing cartilage with temporalis fascia. RCTs were involved in meta-analysis. Ongoing studies were obtained from meta Register and World Health Organization International Clinical Trial Registry Platform.

**Study selection:** Two authors independently determined study eligibility after reading titles, abstracts and full texts. No limitations to studies included in reviewing biological properties. However, only RCTs were involved in meta-analysis in evaluating their clinical properties. Different views were resolved by discussion.

**Data extraction and quality assessment:** Two authors independently extracted data, including study characteristics (eg, title, publication time, and patients amount), patients characteristics (eg, age, gender and hearing level), intervention, control, method (eg, randomization, allocation, blinding, and loss to follow-up), and outcomes.

Methodological quality of included RCTs was conducted by two authors independently using Criteria for risk of bias from Cochrane Handbook for Systematic Review of Interventions.

**Data synthesis and analysis:** Review manager software (version 5.0.2) was applied to analyze data and a fixed-effect model was used. The value of $p$ lower than 0.05 indicated a statistical significance. In terms of heterogeneity among studies, the chi-square test and the $I^2$ index statistic were involved. $I^2 \leq 25\%$ combined with $p \leq 0.10$ indicated a low level of heterogeneity.

Resul **Biological properties of cartilage and temporalis fascia:** Theoretically, an ideal graft for tympanoplasty should possess biological properties similar with tympanic membrane. The properties include elastic modulus, stability to static pressures and acoustic sensitivity.

The **elastic modulus and stability to static pressures:** Tympanic membrane consists of two parts with different values of the elastic modulus. To be more specific, the elastic modulus of pars tensa is $3.3 \times 10^5 \text{N/m}^2$, and that of pars flaccida $1.1 \times 10^5 \text{N/m}^2$. The elastic modulus of temporalis fascia, conchal cartilage and tragal cartilage are $1.5 \times 10^5 \text{N/m}^2$, $0.6 \times 10^5 \text{N/m}^2$ and $0.3 \times 10^5 \text{N/m}^2$, respectively.[13-15].

The measurement of the elastic modulus of different grafts with the same thickness indicates that temporalis fascia is obviously flexible than tympanic membrane, which demonstrates that temporalis fascia is more likely to be unstable, however; cartilage is stiffer than tympanic membrane and its compliance to pressures depends on thickness.

A measurement of deflection-pressure curves indicates that 500-600um thickness cartilage disk shows a slope similar with tympanic membrane within atmospheric air-pressure. Temporalis fascia and cartilage disk thinner than 500um have a sharper slope than tympanic membrane. However, cartilage disk thicker than 600um has a softer slope [16-18].

**Acoustic sensitivity:** Acoustic sensitivity of different grafts was measured as amplitude-frequency curves. The curve for tympanic membrane is much smooth within a wide range of frequencies, revealing its good sound transmission property. Cartilage thinner than 500um have an amplitude-frequency curve similar with tympanic membrane. 500um and original thickness (1mm) cartilage have a loss of about 5 and 30dB, respectively, at 1 kHz. The curve for temporalis fascia is much rough, which indicates that its acoustic sensitivity property is quite different from that of tympanic membrane [16, 17].

To keep the best sound transmission, it is recommended that cartilage should be cut as thin as possible if ET function is normal. However, the thickness of cartilage should not thinner than 500um if ET function is impaired to keep the balance between acoustic sensitivity and stability [19].

**Clinical measurement of cartilage and temporalis fascia**

3 high-level RCTs [20, 21, 22] were included in this review to evaluate the temporalis fascia and cartilage in the aspects of both hearing results and Morphological success. A total of 232 patients (ears) were involved in meta-analysis to evaluate clinical properties and different rate of loss to follow-up among three RCTs was present. Statistical outcomes were performed by RR, 95%CI and $p$.

**Hearing results:** Hearing results include postoperative air-bone gap (ABG) ≤ 20dB and 20dB after 24 months. Meta analysis reveals that tympanoplasty using cartilage and temporalis fascia show no statistical significance in both postoperative ABG ≤ 20dB and 20dB ($p=0.61$ and $p=0.25$ respectively) (Table 1). Interestingly, this is quiet different from previous concepts that cartilage have a poorer sound transmission property compared to temporalis fascia for its high stiffness and strength. Thus, we believe that cartilage tympanoplasty could also perform satisfied hearing results as temporalis fascia tympanoplasty could.

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>CT, n (%)</th>
<th>TF, n (%)</th>
<th>RR</th>
<th>95%CI</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABGs≤20dB</td>
<td>80 (73.4)</td>
<td>74 (78.7)</td>
<td>0.96</td>
<td>0.83 to 1.12</td>
<td>0.51</td>
<td>0.61</td>
</tr>
<tr>
<td>ABG≥20dB</td>
<td>19 (26.6)</td>
<td>20 (21.3)</td>
<td>0.73</td>
<td>0.43 to 1.24</td>
<td>1.16</td>
<td>0.25</td>
</tr>
<tr>
<td>Morphological success</td>
<td>96 (84.2)</td>
<td>83 (72.8)</td>
<td>1.16</td>
<td>1.03 to 1.33</td>
<td>2.06</td>
<td>0.04*</td>
</tr>
</tbody>
</table>

ABG indicates air-bone gap; CT, cartilage; TF, temporalis fascia; n, number of patients; RR, risk ratio; CI, confidence interval; p, the level of statistical significance.

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*Zhang et al. (2014) Email: zhangzz0356@126.com*
Morphological success: “Morphological Success” is defined as a composite variable that includes the absence of perforation, atelectasis, lateralization, atrophy, blunting and otorrhea [20] after 12 months. Meta analysis demonstrates that cartilage tympanoplasty shows higher morphological success rate than temporalis fascia tympanoplasty and the difference is statistically significant (p=0.04) (TABLE 1).

ET dysfunction affects reconstructed tympanic membrane functions

Many middle ear diseases result from ET dysfunction, especially from ET obstruction, such as cholesteatoma in middle ear, secretory otitis media, etc [23,24]. Under this circumstance, middle ear pressure is persistently negative [25], which means that reconstructed tympanic membrane should possess sufficient property to resist negative pressure. Although temporalis fascia is ideal in the aspect of primary hearing improvement, it is softer than normal tympanic membrane, which suggests that it is far more likely to be retracted or reperforated after tympanoplasty [26], which affects hearing improvement finally. By contrast, Cartilage tympanoplasty is less likely to be retracted and reperforated for its sufficient stiffness and strength. Meanwhile, its sound transmission property could be controlled as good as tympanic membrane through cutting it into different thickness, which is impossible for temporalis fascia.

DISCUSSION AND CONCLUSION

Beside from graft properties, surgical techniques are also essential. Cartilage is supposed to be cut as thin as possible in good ET function condition. Otherwise, it should be cut not thinner than 500um (approximately half of original thickness). Most patients with ET dysfunction suffer from serious aural fullness which may be alleviated if tympanic membrane perforates. Tympanoplasty renders open middle ear closed, which could lead patients with ET dysfunction to suffer from aural fullness again. Therefore, cartilage palisade technique is very effective for patients with severe ET dysfunction and that is impossible for temporalis fascia tympanoplasty.

Cabra et al. used the method called cartilage palisade that cut the cymba conchae cartilage into strips with full thickness and positioned them in an underlay fashion described by Eavey [27]. There was statistical difference between cartilage and temporalis fascia in morphological success both within 6, 12 and 24 months. However, there was no different in the aspect of air conduction threshold, bone conduction threshold and air-bone gap. Similarly, Yung et al. also used underlay technique in all...
cases. But they cut cartilage into 500-800um. And they concluded no difference both in morphological success and hearing results. Mauri et al. compared inlay cartilage tympanoplasty described by Lubianca-Neto [28] that was different from original report of Eavey [27] with underlay temporalis fascia tympanoplasty. The morphological success and hearing results showed no significant difference between cartilage and temporalis fascia.

RCTs were strictly included for high level of evidence, however, there were more retrospective study that comparing cartilage with temporalis fascia. Zhang (corresponding author of this article) et al [29]. Suggested that cartilage had superior long-term benefit regarding with both hearing results and morphology. Similar outcomes were presented in some other retrospective studies.

In addition, some secondary outcomes were measured. To be more specific, Mauri et al. reported that cartilage was less likely to be infected than temporalis fascia (p=0.03). Yong et al. reported that there were no significant differences between cartilage and temporalis fascia regarding with the incidence of myringitis, otorrhea and pars tensa retraction after 3, 12 and 24 months. Mauri’s study also revealed that temporalis fascia tympanoplasty tended to be more time-consuming than cartilage tympanoplasty (mean: 62.9 min versus 33.6 min, p<0.0001). And temporalis fascia tympanoplasty was far more likely to make patients suffer from longer period and high rank pain (p<0.0001 and p=0.0002 respectively) reported by Mauri et al.

It is worthy to point that all available studies that comparing cartilage and temporalis fascia have never studied ET dysfunction as an independent factor. We hope there will be sufficient RCTs to explore better grafts when considering the ET dysfunction.

Temporarily, balloon dilation Eustachian tuboplasty (BET) is a novel technique that has been proved to be feasible, safe and effective to improve ET function [30,31]. As a result, we guess its prevalence would render tympanoplasty more effective no matter cartilage or temporalis fascia are selected in the treatment of patients with ET dysfunction.

In concluded, cartilage tympanoplasty is more practical and effective than temporalis fascia tympanoplasty, especially under the circumstance of ET dysfunction.

REFERENCES


Cite this article