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Sound energy absorbance characteristics of cartilage grafts used in type 1 tympanoplasty

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ABSTRACT

Objective: The purpose of this prospective case-control study is to evaluate the sound energy absorbance characteristics of cartilage grafts in patients, who have undergone type 1 cartilage tympanoplasty.
Methods: Thirty-four operated ears of 32 patients and 70 ears of 35 control subjects were included. Differences of pure-tone audiometry thresholds and wideband ambient-pressure absorbance ratios with respect to the graft material, graft thickness, cartilage surface area ratio and elapsed time after surgery were analyzed. Receiver operating characteristics curve was generated to detect the absorbance level at which the reconstructed tympanic membrane behaves as 'near-normal tympanic membrane'.
Results: In the surgical group, wideband energy absorbance ratios at all 1/2-octave band frequencies were significantly worse than normal ears. Energy absorbance ratios at 2000 and 2828 Hz frequencies were higher in patients with tragal cartilage grafts. Higher absorbance ratios at 250–750 Hz range were obtained in patients with 400 μm cartilage graft thickness, <50% cartilage surface area ratio and ≥5 years since surgery. A multivariate generalized linear model revealed common effects of the independent variables at 8000 Hz. The receiver operating characteristics analysis generated a cut-off level of 63.20% of sound energy absorbance at 1400 Hz with 83% sensitivity and 88% specificity.
Conclusion: Even though no differences in hearing thresholds were observed; graft material, graft thickness, cartilage surface area ratio and elapsed time after surgery affected the course of sound energy absorbance after type 1 cartilage tympanoplasty as evidenced by wideband tympanometry.

1. Introduction

In recent years, cartilage has been the graft material (GM) of choice not only in advanced cases such as cholesteatoma, atelectatic ears, high-risk recurrent perforations and revision surgeries; but also in pure tympanic membrane (TM) perforations [1–3]. While, there are still speculations for its routine use due to the possible adverse effects of cartilage on acoustic transmission [1,2]. However, the hearing results appear to be comparable and very similar to the less rigid GMs in the literature [1–5].

Although cartilage has the advantage of rigidity against retraction and resorption, acoustic conduction might be detrimentally affected after type 1 cartilage tympanoplasty (T1CT) by some factors; the origin of harvest, the thickness, the design of preparation, the technique of placement and the

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cartilage proportion of graft composition [2,6,7]. Hearing becomes closely related to acoustic coupling after TM perforations or operations such as tympanoplasty [8]. Therefore, the goal of T1CT should be to restore sound energy transmission to the oval window by coupling an intact TM and to provide sound protection for the round window membrane by establishing a safe, dry ear with protected healthy middle ear [9].

Tympanometry is an objective method for simultaneous evaluation of the integrity of the TM, the ossicles and their attachments, and the tympanic cavity [10]. After introduced by Colleti in 1976, multifrequency tympanometry has brought new insight, as it was able to measure the three elements of the middle ear mechanical system; mass, stiffness and friction [11]. Although it is very helpful, wideband tympanometry (WBT) adds more information to the middle ear sound energy transmission system as it can estimate the admittance characteristics of the middle ear using a click stimulus over a wide spectral range between 226 Hz and 8000 Hz at a fixed pressure. WBT measures the sound energy absorbed through the middle ear mainly and finally a portion of it reflected back from the TM [12]. Its discovery has provided the test battery; three dimensional tympanometry, wideband sound energy absorbance (SEA), ipsilateral and contralateral reflexes, reflex decay, reflex latency and Eustachian tube functions [12–15].

The primary aim of this study is to evaluate the effects of the cartilage grafts on SEA with respect to GM, graft thickness (GT), cartilage surface area ratio (CSAR) and elapsed time after surgery (ETAS), in patients who had undergone T1CT for subtotal TM perforations. The secondary aim was to reveal the cut-off WBT SEA percentages, which discriminate the near-normal reconstructed TM.

2. Materials and methods

The present study was conducted in the Department of Otorhinolaryngology and Head & Neck Surgery of Dokuz Eylul University after it was approved by Ethics Committee of Dokuz Eylul University in March 2014.

The written informed consent was obtained from both the patient and control subjects before the study was initiated.

Study design: prospective case-control study.

2.1. Subjects

Forty-four adults, who were admitted to our outpatient clinic with subtotal TM perforations as T1CT candidates or for postoperative control after T1CT undergone to repair subtotal TM perforations, with below inclusion criteria participated into this study. Thirty-five adult volunteers, negative for otologic and systemic disease history, constituted the control group of this study. The participants' full history was taken, all their medical records were reviewed and a complete otorhinolaryngologic examination was performed. The otoendoscopic examinations and the tests of pure-tone audiometry (PTA) and WBT were recorded by same researchers and with same methods.

2.2. Patient inclusion criteria

1) Patients, who underwent T1CT for TM perforation without additional middle ear disease in whom the integrity of the ossicular chain, healthiness of middle ear mucosa and other middle ear structures was approved by the surgical findings.
2) Patients whose preoperative PTA findings of operated ear were suitable to the criteria; mean air conduction thresholds (ACTs) <40 dB and air-bone gaps (ABGs) <30 dB for 500, 1000, 2000, 3000 and 4000 Hz frequencies.

2.3. Patient exclusion criteria

1) Patients, whose postoperative otoendoscopic findings revealed pathology of outer ear canal, middle ear and graft related disorders with respect to structure and location of the graft.
2) Patients, in whom postoperative middle ear/ossicular chain disorders could not be ruled out because the mean PTA ACTs were >30 dB for 500, 1000, 2000, 3000 and 4000 Hz frequencies or mean ABGs were >15 dB for those frequencies or tympanometry did not deliver normative C1 values.

Forty-four patients were subjected to the above exclusion criteria. Thereafter, six patients were excluded from the study because their C1 values were high beyond normal values. Other six patients with postoperative ABG > 15 dB were also excluded from the study. Thirty two patients whose T1CT achieved successful results, namely; more than 15 dB improvement of mean ACTs at PTA or postoperative mean ACTs of 30 dB or better and postoperative ABG lesser than 15 dB, plus cartilage graft showing good healing and position at postoperative condition, were included.

The control group was selected of volunteered subjects between 18 and 60 years from both genders with normal PTA/WBT profile and without history of ear disease. Finally 34 ears of 32 patients and 70 ears of 35 adult volunteers composed the T1CT and control groups respectively.

2.4. Pure tone audiometric study

PTA was performed in a sound-proof room using an Interacoustic Clinical Audiometer AC 40 (Assens, Denmark). The tests were carried out and recorded according to the guideline of Hearing Committee of the American Academy of Otolaryngology, Head and Neck Surgery [16]. The tests were performed within one month prior to surgery and repeated on the first, third and sixth months of the surgery. After postoperative first year, PTA was repeated annually during follow-ups. The PTA revealed ACTs and bone conduction hearing thresholds (BCTs) at 250, 500, 1000, 2000, 3000, 4000 and 8000 Hz frequencies for each ear. Normal hearing was defined as thresholds ≤20 dB HL. The average ACT and BCT were calculated as the mean value of the thresholds for 500, 1000, 2000, 3000 and 4000 Hz frequencies. The ABGs, plus the differences between preoperative and postoperative ACTs and BCTs were also calculated.

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