Results of Hearing Outcome According to the Alloplastic Ossicular Prosthesis Materials

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Received: 14 June 2015 / Accepted: 10 December 2015 / Published online: 16 December 2015
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Abstract The aim of this study is to compare the functional results and extrusion rates according to the type of ossicular alloplastic prosthesis. In this study, a retrospective analysis was performed. Sixty-one patients were involved in partial ossicular replacement (POR) cases and 70 patients were involved in total ossicular replacement (TOR) cases. In POR cases, Plastipore was used in 21 cases, hydroxyapatite in 20 cases, and titanium in 20 cases. In TOR cases, Plastipore was used in 20 cases, hydroxyapatite (HA) in 25 cases and titanium in 25 cases. We reviewed postoperative ABG (less than 20 dB or more than 20 dB) and the extrusion rate for more than 1 year follow-up period. In POR cases, ABG less than 20 dB were 71.4, 80.0, 85.0 % in plastipore, HA, and titanium prosthesis and in TOR cases, ABG less than 20 dB were 25.0, 28.0, 32.0 % in plastipore, HA, and titanium prostheses, respectively. In POR cases, extrusion rates (ER) were 9.5, 5.0, 5.0 % in plastipore, HA, and titanium prosthesis, respectively. In TOR cases, ER were 15.0, 8.0, 4.0 % in plastipore, HA, and titanium prosthesis, respectively. There were no significant differences in hearing gain results among plastipore, HA, and titanium in both POR and TOR

cases, but the ER was significantly low in titanium. Clinically relatively better hearing gain and low-rate of extrusion were found in titanium prosthesis and thus this material is recommended in cases of ossicular alloplastic replacement surgery.

Keywords Ossicular prosthesis · Plastipore · Hydroxyapatite · Titanium · Hearing gain

Introduction

Chronic otitis media commonly affects the middle ear bones with erosion which results in the discontinuation of the ossicular chain. A defective incudostapedial joint and stapes suprastructure create a conductive hearing loss. Ossicular reconstructions can be generally divided into two types of models: partial ossicular replacement prosthesis (PORP) and total ossicular replacement prosthesis (TORP). The success of the ossicular reconstruction mainly depends on the characteristics of the material used for the prosthesis; the ideal prosthesis should be biocompatible, stable, easy to fit, and capable of optimal sound transmission [1]. Although a variety of materials have been used for reconstruction of the ossicular chain such as auto-graft, gold prosthesis, ceramic prosthesis, hydroxyapatite, and polyethylene, none of them has been proved to have a overwhelming superiority over the others. The new method of titanium ossiculoplasty was first used in ossicular reconstruction in 1993, and was reported to have good prognosis in 1999 by Stupp et al. [2]. The goal of this study involved the review of long-term hearing result of patients undergoing ossicular chain reconstruction with three different types of alloplastic material which are plastipore, hydroxyapatite and titanium.

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Materials and Methods

We performed a retrospective study of all the data from patients undergoing ossicular chain reconstruction with three different types of prosthesis at our department from 2010 to 2013, which included 131 ossiculoplasties performed by different surgeons in our department. POR prostheses were used in the absence of an incus, or when it was eroded, and there were stapelial superstructures. TORP prostheses were used in the absence of the incus and stapes suprastructures. Cartilage was used in all cases, placed between the tympanic membrane and the prosthesis. The prostheses were fixed using Gelfoam.

PORP were used in 61 cases and TORP in 70 cases. All patients had a minimum follow-up of at least 1 year, with audiological evaluation.

We determined the pure-tone average (PTA) air-bone gap (ABG) through the mean increase in air conduction at 4 frequencies (0.5, 1, 2, and 4 kHz).

The criteria for a successful ossiculoplasty was defined as postoperative ABG less than 20 dB with a minimum follow-up of 1 year [3–5]. The secondary outcome was the extrusion of the prosthesis or exposure of the head plate versus nonextrusion.

Statistical Analysis

The Student *t* test was used to determine the statistical significance of hearing results data, and a Fisher exact test was used to determine the statistical significance of any difference in 3 materials.

Results

Types of Prosthesis in the PORP and TORP Groups

A total of 131 cases were evaluated. 61 in POR cases and 70 in TOR cases. In POR cases, 21 plastipore, 20 HA and 21 titanium. In TOR cases, 20 plastipore, 25 HA and 25 titanium (Table 1).

Table 1 Types of alloplastic prosthesis in POR and TOR groups

	POR	TOR
Plastipore	21	20
Hydroxyapatite	20	25
Titanium	20	25
Total	61	70

POR partial ossicular replacement, TOR total ossicular replacement

Fig. 1 The effectiveness of sound transmission in POR cases. ABG air-bone gap

Fig. 2 The effectiveness of sound transmission in TOR cases. ABG air-bone gap

The Effectiveness of Sound Transmission in POR Cases

The postoperative ABG less than 20 dB for plastipore, HA and titanium were 71.4, 80.0, 85.0 % respectively (Fig. 1). No significant difference was found among these three groups regarding hearing gain ($P > 0.05$).

The Effectiveness of Sound Transmission in TOR Cases

The postoperative ABG less than 20 dB for plastipore, HA and titanium were 25.0, 28.0 and 32.0 % respectively (Fig. 2). Hearing gain in titanium cases showed priority over other two prosthesis, however no significant difference was found ($P > 0.05$).

Extrusion Rate (ER) of Prosthesis in PORT and TORP Cases

The ER in POR cases were 2 cases (9.5 %), 1 case (5.0 %), and 1 case (5.0 %) in plastipore, HA and titanium. In TOR

Fig. 3 Extrusion rate of prosthesis in POR and TOR cases

cases, 3 cases (15.0 %), 2 cases (8.0 %), and 1 case (4.0 %) in plastipore, HA and titanium (Fig. 3). Titanium prosthesis showed priority in ER over other two prosthesis ($P = 0.019$) in TOR cases. Total extrusion rate were 6.6 % (4 cases in 61 patients) and 8.6 % (6 cases in 70 patients) in POR and TOR cases ($P > 0.05$).

Discussion

The primary goal of surgery for chronic otitis media is the achievement of a safe and dry ear, disruption of recurrent ear drainage, and hearing improvement. Erosion of the long process of the incus is the most common ossicular chain pathology and successful ossiculoplasty requires a firm connection between the vibrating tympanic membrane and the inner ear [6]. Several synthetic biocompatible materials have been used for the production of incus replacement prostheses. PORPs and TORPs have the advantage of being readily available, but extrusion and stability problems are a definite disadvantage. Plastipore was the first alloplastic material that was commercialized and used worldwide [7]. It is a semi-soft white sponger of high-density polyethylene. Although the short-term results were encouraging, there was an unacceptable long-term extrusion rate [8–10]. The most popular alloplastic material to date is hydroxyapatite (HA). HA [$\text{Ca}_5(\text{PO}_4)_3(\text{OH})$] is a natural constituent of bone and seems to exhibit superior properties when compared with bioactive ceramics that were introduced in 1981 [11]. It is still being used worldwide and has so far stood the test of time. Titanium implants have become popular in 1993 and is widely used nowadays [12]. The material is light and strong, allowing many possibilities in the prosthetic design. Open head plate allows surgeons to observe the position of the bottom end of the

prosthesis during the placement of the prosthesis. We compared the 3 materials in the clinical setting. Postoperative hearing gain was better in PORP than in TORP but there were no differences in hearing gains among the 3 materials in PORP and TORP. Plastipore showed the highest extrusion rate of 12.2 % (5 out of 41 patients), followed by HA (3 out of 45 patients; 6.7 %) and titanium (2 out of 45 patients; 4.4 %). The overall extrusion rate of TORP was higher than that of PORP (8.6 % vs. 6.6 %). In terms of hearing results, there was no difference among the three types of prosthesis in PORP and TORP respectively. We obtained similar results in partial ossicular reconstructions and in total ossicular reconstructions in various types, and also found out that our hearing results were similar to those of other series that used different prosthetic materials. But the extrusion rate was slightly higher than those of other authors. Most ossiculoplasties in PORP improved hearing conditions but TORP was not as satisfactory. Three types of prosthesis material showed no significant hearing outcome differences in PORP and TORP, but clinically titanium prosthesis revealed the best results. Significantly lower rates of extrusion were found in titanium prosthesis. Therefore, we recommend this material when performing ossicular chain reconstruction surgery.

Compliance with Ethical Standards

Conflict of interest None.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

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