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Bone Auditory Thresholds Variations in Cholesteatoma Middle Ear Surgery

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Abstract

Objective: To investigate the changes of bone auditory thresholds variations in cholesteatoma middle ear surgery and its related factors and its related factors. **Methods:** 122 cases (122 ears) of unilateral cholesteatoma otitis media were treated by mastoidectomy and/or tympanoplasty plus stage I tympanoplasty, and tragus cartilage ring-cartilage membrane (Referred to as cartilage group, 62 ears) and temporalis muscle fascia (Referred to as fascia group, 60 ears) were used as tympanic membrane grafts respectively. The changes of bone conduction hearing threshold were compared between the two groups before and 1, 3, 6 months and 1, 3 years after operation. And compare the difference in the incidence of ossicular chain fixation or necrosis, vestibular window or cochlear window dysfunction between the two groups of patients with increased (positive) and decreased (negative) bone conduction threshold before operation. **Results:** Compared with the healthy side, 95 ears of 122 ears in the two groups had higher bone conduction hearing threshold before operation. Among them, 48 ears were in cartilage group and 47 ears were in fascia group; In 72 ears (76.34%) of these cases, the bone conduction hearing threshold decreased after operation, and the difference between the two groups was statistically significant ($P < 0.01$). During operation, 57 ears (79.17%, 57/72) were found to have ossicular chain or two windows dysfunction, including 30 ears in cartilage group and 27 ears in fascia group. Of the 27 patients with normal hearing threshold, 5 had the above-mentioned lesions, including 3 in cartilage group and 2 in fascia group. **Conclusion:** The improvement of bone conduction hearing threshold in patients with cholesteatoma otitis media is mainly related to the fixation or necrosis of ossicular chain and the dysfunction of two windows. The tragus cartilage ring-perichondrium tympanoplasty can not only reduce the air-bone conduction difference, but also reduce the bone conduction hearing threshold, which has the advantage of stable and lasting hearing improvement.

Keywords

Bone Conduction Threshold, Tympanoplasty, Cholesteatoma, Otitis Media, Cartilage Ring of Tragus

1. Introduction

Chronic suppurative otitis media or cholesteatoma otitis media is mainly in the middle ear. After tympanoplasty, the air-bone conduction threshold will decrease, and the air-bone conduction difference will decrease, while some patients' bone conduction threshold will also decrease after tympanoplasty [1]. From June 2009 to June 2018, patients with unilateral cholesteatoma otitis media were treated with cartilage ring-perichondrium complex (cartilage group) and temporalis muscle fascia (fascia group) as tympanic membrane grafts, and mastoidectomy and/or tympanoplasty plus stage I tympanoplasty were performed. The changes of bone conduction hearing threshold and related factors of the two groups before and after the operation were compared. The report is as follows.

2. Information and Methods

2.1. Material

According to the diagnostic criteria proposed by Gates, *et al.* [2]. 122 patients (122 ears) with normal unilateral cholesteatoma otitis media were treated from June 2009 to June 2018. According to the materials of tympanic membrane grafts, they were divided into two groups: cartilage ring-perichondrium complex group (cartilage group) with 62 cases (62 ears). There were 32 males and 30 females. The aged from 16 to 62 years, with an average of 32.5 years; The course of disease was ≤10 years in 27 cases and >10 years in 35 cases. Temporal myofascial group (fascia group) included 60 cases (60 ears), including 31 males and 29 females; The age ranged from 18 to 68 years, with an average age of 34.5 years. The course of disease ≤10 years in 20 cases, >10 years in 27 cases.

2.2. Operation Method

The two groups were treated with mastoidectomy and/or tympanoplasty with cartilage ring-perichondrium complex or temporomandibular fascia as grafts respectively. If the ossicular chain is intact, it can be directly placed on the ossicular chain with cartilage ring-perichondrium complex or temporalis fascia, and the plane is consistent with the tympanic ring; If the malleus of the incus is damaged and the stapes are intact and active, the partial ossicular prosthesis (PORP) made of Binger titanium alloy in Germany was used to connect the stapes with the transplanted "tympanic membrane" [3]. The location of cholesteatoma, ossicular chain fixation or necrosis, vestibular window and cochlear window lesions were recorded.

Criteria for judging changes of bone conduction hearing threshold [4] [5]

All patients received routine pure tone audiometry within 3 days before operation and 1, 3, 6 months, 1 and 3 years after operation. Compared with the healthy side before operation, the bone conduction threshold of 0.25 - 8.00 kHz increased by at least two or more times ≥ 10 dB, which was positive for the improvement of bone conduction threshold before operation. Compared with pre-operation, the decrease of bone conduction threshold of at least 2 or more frequencies in 0.25 - 8.00 kHz ≥ 10 dB is positive, otherwise it is negative. Record the positive and negative cases respectively; The differences in the incidence of ossicular chain fixation or necrosis, dysfunction of vestibular window or cochlear window between negative group and positive group before operation were compared.

2.3. Statistical Methods

Using SPSS 16.2 system statistical software package, X^2 and *t*-tests were used to judge the difference in middle ear lesions between normal bone conduction hearing threshold (negative group) and increased bone conduction hearing threshold (positive group) before operation. At the same time, the follow-up results of two groups with different operation methods and different times were compared.

3. Results

The average bone conduction threshold of affected ears in cartilage group and fascia group was higher than that in healthy ears, and the difference was statistically significant ($P < 0.01$), but there was no difference between the two groups ($P > 0.05$).

The bone conduction hearing threshold of cartilage group and fascia group before and after operation is shown in Table 1.

Cartilage group: the bone conduction hearing threshold decreased significantly

Table 1. Bone conduction threshold of cartilage group and fascia group at different times (dB HL, $\overline{x} \pm s$).

Test time	Cartilage group	Fascia group
Preoperative	23.71 ± 6.87	24.42 ± 8.12
1 month after operation	19.61 ± 6.41*	20.58 ± 7.36*
Three months after operation.	15.38 ± 4.27**	13.12 ± 3.26**
Six months after operation.	14.19 ± 3.16	16.56 ± 6.56$^{\#}$
1 year after operation	12.34 ± 3.68$^{\Delta}$	16.17 ± 4.56*
Three years after operation	11.53 ± 2.87$^{\Delta}$	17.56 ± 5.45*

Note: Compared with this group before operation, $P < 0.01$; **Compared with 1 month after operation, $P < 0.01$; $^{\Delta}$Compared with fascia group, $P < 0.01$; $^{\#}$Compared with the fascia group 3 months after operation, $P < 0.01$.

(X^2 = 6.04, P < 0.01) one month after operation and three months after operation. Compared with 3 months after operation, the bone conduction hearing threshold did not decrease significantly at 6 months, 1 year, 3 years after operation (X^2 = 1.39, P > 0.05).

Fascia group: the bone conduction hearing threshold decreased significantly (X^2 = 4.12, P < 0.01) one month after operation compared with that before operation, and three months after operation compared with that after operation, but it increased at six months, one year and three years after operation (X^2 = 12.17, P > 0.05).

Comparison between the two groups: there was no significant difference in bone conduction hearing threshold between the two groups before operation (X^2 = 1.92, P > 0.05), and there was no difference between the two groups at 1, 3 and 6 months after operation (X^2 = 1.43, P > 0.05), but there were significant differences between the two groups at 1 and 3 years after operation (X^2 = 3.73, P < 0.01).

The relationship between the changes of bone conduction hearing threshold and middle ear lesions in the two groups before and after operation is shown in Table 2 and Table 3.

Compared with the healthy side, 95 ears in the two groups had positive

Table 2. 72 Middle ear lesions (ears) in patients with positive bone conduction threshold increase before operation.

Group	Ear number	Fixation or necrosis of ossicular chain	Dysfunction of vestibular window or cochlear window	Total (%)
Cartilage group	38	18	12	30 (78.95)
Fascia group	34	16	11	27 (79.41)
Total	72	34	23	57 (79.17)

Table 3. Positive cases of bone conduction hearing threshold decrease in cartilage group and fascia group at different times.

Test Time	Cartilage group Positive cases/total cases (%)	Fascia group Positive cases/total cases (%)
Preoperative	13/62 (20.97)	12/60 (20.00)
1 month after operation	38/62 (61.29)*	35/60 (58.33)*
Three months after operation.	48/62 (77.42)**	47/60 (78.33)**
Six months after operation.	51/59 (86.44)$^{\Delta}$	43/58 (74.14)
1 year after operation	47/56 (83.92)$^{\Delta}$	38/55 (69.09)
Three years after operation	42/52 (80.77)$^{\Delta}$	31/50 (62.00)$^{\#}$

Note: Compared with this group before operation, P < 0.01; **Compared with one month after operation, P < 0.01; $^{\Delta}$Compared with fascia group, P < 0.01; $^{\#}$Compared with 3 months after operation, P < 0.01.

improvement of bone conduction hearing threshold before operation: 48 ears (50.53%) in cartilage group; 47 ears (49.47%) in the fascia group. After operation, bone conduction threshold decreased in 72 ears, including 38 ears in cartilage group and 34 ears in fascia group. During the operation, 57 ears (79.17%, 57/72) were found to have ossicular chain fixation or necrosis, and two windows dysfunction, including 30 ears in cartilage group and 27 ears in fascia group. The changes in middle ear lesions and bone conduction threshold in the two groups were basically the same ($P > 0.05$) (see Table 1 and Table 2).

Cartilage group: Compared with preoperative one month after operation, 3 months after operation and 1 month after operation, the number of cases with decreased bone conduction threshold was significantly increased ($X^2 = 16.04$, $P < 0.01$); Compared with 6 months, 1 year, 3 years and 3 months after operation, there was no significant change in the number of positive cases of bone conduction hearing threshold decline ($X^2 = 0.82$, $P > 0.05$), which showed that the hearing was stable and lasting.

Fascia group: Compared with preoperative one month after operation and 3 months after operation and 1 month before operation, the number of cases with decreased bone conduction hearing threshold was significantly increased ($X^2 = 11.32$). $P < 0.01$); It was the same at 6 months, 1 year and 3 months after operation, but the number of positive cases decreased at 3 years, which was different from that at 3 months after operation ($X^2 = 4.35$, $P > 0.05$).

Comparison between the two groups: before operation, there was no difference in the number of positive ears with bone conduction threshold and 1 and 3 months after operation ($X^2 = 0.83$, $P > 0.05$); However, there were significant differences between the two groups at 6 months, 1 year and 3 years after operation ($X^2 = 4.51$, $P < 0.01$). It can be seen that the hearing of the patients who used cartilage ring-perichondrium as tympanic membrane graft was stable and lasting, while that of the patients who used fascia as graft was unstable, with a decreasing trend year by year.

4. Discussion

As we all know, the resonance frequency of human ossicular chain is about 1500 Hz - 2000 Hz. When the middle ear lesions involve ossicular chain, the weakening or disappearance of its resonance will affect the bone conduction hearing threshold in this frequency range, while when the lesions involve cochlear window and affect its mobility, the high-frequency bone conduction hearing may decline. Chronic inflammation, cholesteatoma and granulation can affect the sound transmission mechanism of the middle ear, and at the same time affect the stiffness and quality of the sound transmission structure of the middle ear. Thickening of the round window membrane, increased permeability, changes of local vasoconstriction, ischemia and hypoxia of the inner ear, and the effect of toxins can hinder cochlear function, resulting in the loss of bone conduction hearing [6]. From the results in this paper, 95 of 122 ears showed positive im-

provement of bone conduction hearing threshold before operation. The pathological changes were as follows: all ears had tympanum or superior tympanum, and cholesteatoma was found in the entrance of tympanic sinus, tympanic sinus or mastoid; at the same time, there are destruction of ossicular chain, ossicular chain fixation and tympanosclerosis. In cartilage group and fascia group, 78.95% and 79.41% of the ears were positive for the improvement of bone conduction hearing threshold before operation. There was no difference in the positive cases of bone conduction hearing threshold decline between the two groups at 1 month and 3 months after operation. However, at 6 months, 1 year and 3 years, the bone conduction hearing in cartilage group improved steadily. However, in the fascia group, the bone conduction hearing threshold decreased by 74.14%, 69.09% and 62.00%, respectively, and the hearing gradually decreased. However, in 23 ears, the threshold of bone conduction was increased before operation, but the patients with no change after operation were all older, and the course of disease was longer. It was analyzed that the lesions were not only in the middle ear, but also in the inner ear. In this group, the tragus cartilage ring-perichondrium is used as the graft, which overcomes the influence of simple perichondrium and temporomandibular fascia surgery in the past, such as being difficult to fix, easy to curl and deform when exposed to water or blood, etc., and the postoperative hearing is improved and stable, which proves that the activity of ossicular chain is not affected and there is no adhesion phenomenon. At the same time, it may be related to the fact that there is enough space in the drum chamber and the air-containing cavity is not reduced [7] [8] [9]. When the tympanic membrane is transplanted with temporal fascia, it tends to shrink when it meets water or blood, and gelatin sponge needs to be placed in the tympanic cavity as a scaffold during the operation. Gelatin sponge can cause tissue reaction, leading to fiber proliferation and the formation or adhesion of new bone under the mucosa [10], which may lead to the adhesion between the new tympanic membrane transplanted after the operation and the tympanic isthmus mucosa, or the adhesion and fixation with the ossicular chain, thus leading to the increase of bone conduction hearing threshold. We have observed that the average hearing threshold of air conduction increased and the gap between the average air conduction and bone conduction increased in some cases [5]. The results of this study show that as a new tympanic membrane graft, the effect of cartilage ring-perichondrium complex is obviously better than that of temporomandibular fascia [3], and the hearing recovery after moderate mixed deafness is remarkable, but the hearing after severe neurological deafness is unchanged.

5. Conclusion

The whole trigonal cartilage-perichondrium complex was modified into a cartilaginous ring perichondrium, which was used in unilateral cholesteatoma otitis media patients for mastoid lesion resection and/or tympanic lesion removal during tympanoplasty, and the changes of bone guidance threshold at different

times before and after surgery were analyzed. It overcomes the influence of simple perichondrium and temporal muscle fascia, which is not easy to be fixed and easy to shrink and deform when it meets water or blood. At the same time, it reduces the quality and thickness of tympanum and avoids the malpractice of affecting hearing due to the abnormal increase in quality and thickness. After surgery, the hearing is improved and stable and lasting, and the postoperative bone guide threshold is decreased, which proves that the activity of ossicular chain is not affected and there is no adhesion phenomenon. At the same time, it may be related to sufficient space in the tympanum and no reduction of the air chamber. From the observation results of this group, the healing rate of the eardrum was 94.8% [5], and the hearing improved by 83.9% in 1 year. The 3-year healing rate was 91.6% [5] and the hearing improved by 80.8%. It has certain advantages in tympanoplasty and is worthy of clinical application and further study.

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Ethics Declaration

The ethics committee approval from the authors' institution and patients' informed consent have been obtained for this study.

Data Availability Statement

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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