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Application of Tragus Cartilage Ring-Perichondrium in Tympanoplasty and Analysis of Related Factors Affecting its Long-Term Outcomes

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Abstract

Objective: To report repair of large tympanic membrane perforation using tragus cartilage ring-perichondrium grafts and factors that can affect the long-term outcomes.

Methods: From January 2004 to December 2013, tragus Cartilage ring-perichondrium grafts were used during myringoplasty in 325 patients (375 ears). Their clinical data, including age, duration of dry ear, preoperative air conduction hearing threshold, postoperative bone conduction hearing threshold, tympanic mucosa condition, tympanosclerosis lesions, ossicular chain lesion, Eustachian tube function, intraoperative blood oozing and follow-up data (more than 3 years), were analyzed using the SPSS 16.2 software. $\chi 2$ test and multiple linear regression analysis were employed with $P<0.05$ being statistically significant.

Results: The mean age of our patients was 36 ± 8.32 (11-62) years and the average disease duration was 21 ± 7.62 (1-36) years. The rate of tympanic membrane healing was 94.8% at 1 year and 91.6% at 3 years. Multivariate analysis of factors influencing operation results indicated correlation to the following: Tympanosclerotic plaque lesions, preoperative air conduction hearing threshold, preoperative bone conduction hearing threshold, duration of disease, Eustachian tube function and intraoperative blood oozing.

Conclusion: Tympanosclerotic plaque lesions, preoperative air conduction hearing threshold, duration of disease, Eustachian tube function and intraoperative blood oozing appear to affect the efficacy of tympanoplasty using tragus cartilage ring-perichondrium grafts.

Keywords: Tragus Cartilage Ring-Perichondrium; Tympanic Membrane; Tympanoplasty; Curative effect

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Introduction

Preventing repeated infection of middle ear and improving hearing are the aims of tympanoplasty. When the tympanic mucosa is normal, well ventilated, the ear is dry, and the tympanic membrane is small to medium-sized perforation, the temporalis fascia and the perichondrium are good choices. However, in some complicated cases such as Eustachian tube dysfunction, adhesive otitis media, tympanic fibrosis and tympanic membrane perforation, the incidence of postoperative perforation recurrence and invagination adhesion is obviously increased [1]. Therefore, we have successfully applied the cartilage ring-perichondrium complex as a graft in tympanoplasty, which has been applied in clinic for more than 10 years, and its tympanic membrane healing rate is high, and the long-term effect is satisfactory [2]. From January 2004 to December 2013, 325 patients who underwent surgery in our hospital. The clinical data of 375 cases of tympanic membrane perforation were analyzed, and the related factors affecting its long-term curative effect were discussed. The report is as follows.

Data and Methods

Inclusion criteria

All cases were classified as otology group of otolaryngology branch of Chinese Medical Association, Department of Otology, Editorial Board of Chinese Journal of Otolaryngology, Head and Neck Surgery. Guidelines for clinical classification and typing of otitis media (2012) [3]. It was diagnosed as chronic suppurative otitis media at rest, with dry ears for more than 3 months. In this case, dry ears are defined as [4]: The tympanum is moist and shiny, but the ear canal is wiped with

cotton wool without pus. Before operation, the tympanic mucosa was normal in 272 ears (72.5%), with moist luster and no purulent secretion in 35 ears (9.3%), slight edema in 43 ears (11.5%), small sclerotic spots in the residual tympanic membrane in 53 ears (14.1%), and a small number of sclerotic foci in the tympanic isthmus of the tympanic wall in 22 ears (5.8%). The perforation size was classified according to Jiang Sichang's classification standard [5]. All cases in this group were tympanic membrane perforation (the diameter of tympanic membrane perforation was larger than 5 mm or tympanic membrane disappeared completely). Pure tone audiometry showed conductive deafness, pinch the nose and air combined with acoustic immittance test indicates that the Eustachian tube has good function; during the operation, it was confirmed that the ossicular chain was not damaged, and there was no cholesteatoma and granulation in the middle ear.

General information

All the patients were from 325 cases (375 ears) treated in the Department of Otolaryngology, the Ninth Affiliated Hospital of Guangxi Medical University from January 2004 to December 2013, Male cases (190 ears, 52%) and female cases (156 ears, 48%); this group of patients ranged in age from 11 to 62 years, with an average of (36 ± 8.32) years. The course of disease ranged from 1 to 36 years, with an average of (21 ± 7.62) years. 208 ears on the right side (55.6%), 117 ears on the left side (44.4%), dry ears for 1 month to 1 year with an average of 3.5 months.

Operation method

Auricular cartilage ring-perichondrium tympanoplasty, according to our practice [2]: The perichondrium cartilage of the ipsilateral pleura is taken and then made into an oval cartilage ring with perichondrium, which is called "cartilage ring-perichondrium complex" as the implant. Under the operating microscope, if the external auditory canal is narrow, make a subcutaneous incision from the tragus wheel space to the tympanic ring to enlarge the external auditory canal. If the width and straightness of the external auditory canal do not affect the visual field, the tympanic membrane epithelium will be directly separated from the external auditory canal along the edge of tympanic membrane perforation, and the external auditory canal will be separated from the tympanic ring by about 5 mm to form the tympanic external auditory canal flap, which will form the implant bed surface. The complex was implanted into the implant bed, and then the external auditory canal flap was covered on the perichondrium, and the periphery was fixed with gelatin sponge particles. The external auditory canal was filled with iodoform gauze and the incision was sutured. Post-tympanoplasty treatment: 7 days after operation, skin stitches were removed, and 12 days after operation, external auditory canal tamponade was taken out. After 1, 3, 6, 1 and 3 years, the tympanic membrane growth, pure tone threshold, acoustic immittance and Eustachian tube function were re-examined.

Main observation indexes

Observe the growth of tympanic membrane in the near and long term after operation; and recent and long-term hearing changes; related factors such as complications after tympanoplasty.

Statistical analysis using SPSS 16.2 software package

Statistical methods include χ^2 test and multiple linear regression analysis. Ten factors that may affect the curative effect were recorded: Age, course of disease, dry ear time, preoperative air conduction hearing threshold, preoperative bone conduction hearing threshold, tympanic mucosa condition, tympanosclerosis, ossicular chain lesion, Eustachian tube function, and bleeding of wound during operation.

Results

Tympanic membrane growth

In 375 ears, external auditory canal tamponade was removed 12 days after operation, among which 3 ears overflowed from the edge of the implant due to infected tympanic secretion, and one week later, the implant was necrotic and displaced, and the tympanic membrane perforation failed to heal. During the operation, the wound bleeding obviously affected the operation field. Five ears were all patients under general anesthesia, of which four ears were operated within one week before and after menstruation. Twelve days after the operation, the implant was displaced and the marginal fissure was seen. The remaining 367 ears are consistent with our original observation [2]: After 12 days of dressing change, cellulose

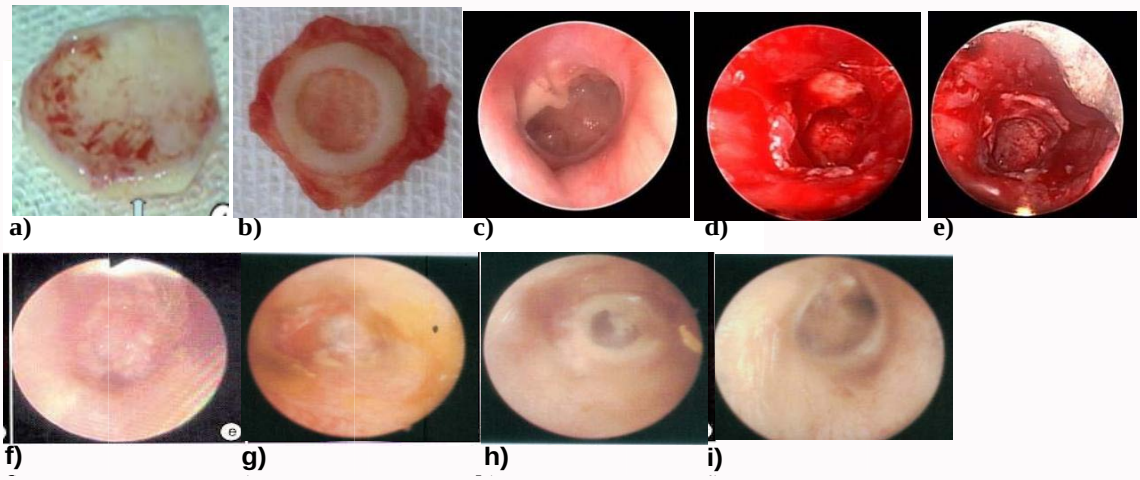

Figure 1: a) Cartilaginous membrane of tragus cartilage; b) Auricular cartilage ring-perichondrium complex; c) Perforation of tympanic membrane; d) Peel off the skin flap of tympanic external. Auditory canal to form the bed surface; e) complete complex transplantation. f) One month after operation, the new tympanic membrane neovascularization increased to less, turbid and thickened; g) After 3 months, the new tympanic membrane continued to grow and repair, gradually became flat and thin, and the new blood vessels decreased obviously; h) After 6 months, the shape of the new tympanic membrane was complete and the color was further improved; i) One year later, the color of tympanic membrane was basically normal, with no invagination, stickiness and perforation.

Table 1: The Coding and value of various factors affecting hearing.

Factor	Value	ξ ± σ
Independent variables		
Age 11~66 years	Real-value/yr	32.3 ± 11.5
Course	Real-value/mon	52.6 ± 12.3
Duration of Dry ear	Real-value/mon	11.8 ± 4.2
Preoperative air conduction threshold	Real-value/dBHL	34.5 ± 3.5
Preoperative bone conduction	Real-value/dBHL	18.5 ± 12.5
The tympanum adherence	normal =0, abnormal =1	_
The tympanosclerosis plaque	normal =0, abnormal =2	_
Ossicular chain lesion	normal =0, abnormal =3	_
Eustachian tube function	normal =0, abnormal =4	_
The amount of bleeding the wound	less =0, more =1	_
Dependent variable		
Postoperative gas bone conductance		22.3 ± 3.5

Table 2: The factors affecting the postoperative air bone gap screened.

	B	Standardized co-efficient Beta	t	p
Constant	2.523	_	0.752	>0.05
The tympanosclerosis plaque	0.326	0.386	5.862	<0.01**
Preoperative air conduction threshold	0.428	0.398	5.425	<0.01**
Preoperative bone conduction threshold	0.367	0.328	5.216	<0.01**
Eustachian tube function	0.124	0.153	3.125	<0.05*
Course	0.112	0.147	2.326	<0.05*
The amount of bleeding the wound	0.231	0.224	2.169	<0.05*

Annotate: *P<0.05; **P<0.01

secretion was attached to the surface of the graft, and new blood vessels began to grow in the periphery. After that, the number of new blood vessels gradually increased, and one month later, the number of new blood vessels transplanted into the tympanic membrane increased from increasing to decreasing. After 3 months, the new tympanic membrane continued to grow and repair, gradually became flat and thin, and the new blood vessels decreased obviously. After 6 months, the shape of new tympanic membrane was complete and the color was further improved. 364 ears were followed up for one year, and 193 ears were found to be close to normal tympanic membrane. 16 ears were turbid; 3 ears were invaginated, 3 ears were tympanitis, 12 ears were adhesive, 7 ears were perforated in the center, and the healing rate of tympanic membrane was 94.8% in one year. 33 ears were followed up for 3 years, and 9 ears were observed for tympanic membrane perforation. The healing rate was 91.6%.

Pure tone threshold test

The mean preoperative air conductance was (42.66 ± 6.40) dB HL, and the difference of bone air conductance was (26.05 ± 6.15) dB HL. One month after operation, the hearing was (30.58 ± 7.45) dB HL and (19.61 ± 6.41) dB HL; respectively. At 3 months, it was (25.18 ± 7.02) dB HL and (12.63 ± 7.59) dB HL; at 6 months, the air conductance increased by 19 db (23.55 ± 7.70) dB HL and the difference of bone air conductance decreased by 16 dB (10.79 ± 5.52) dB HL; 6 months is basically the same as 1 year and 3 years. One month after operation, the hearing was significantly improved compared with that before operation, and 3 months after operation, the hearing was significantly improved compared with that after operation (average P<0.01). However, there was no significant difference between 6 months, 1 year and 3 months after operation (average P>0. 05).

Acoustic immittance detection

In order to know the situation of tympanum and Eustachian tube function after operation, postoperative observation depends on tympanogram analysis and Eustachian tube function test. 375 ears were examined 3 months after the tympanic membrane grew stably, Tympanogram: 236 ears (63.0%) were of type A; 102 ears (27.2%) had as pattern; 22 ears (5.8%) with B pattern; Type C figure 15 ears (4.0%). One year after operation, 364 ears were followed up, and the results were as follows: 245 ears (67.3%) had A-type image; 87 ears (23.9%) had as pattern; 19 cases (5.2%) were B pattern; 13 ears (3.6%) had type C figure. There was no significant difference between 3 months and 1 year after tympanometry (P<0.05). Eustachian tube function (measured by German Maike acoustic immittance instrument) combined with pinching nose and inflating air: 3 months after operation, 286 ears showed normal (76.3%), 89 ears showed poor (23.7%); in one year, 83.8% of 305 ears showed normal, and 16.2% of 59 ears showed poor.

Related factors affecting postoperative hearing

Using multiple linear regression backward step method to screen the independent variables, value and screen the independent variables. The results are shown in Table 1 and Table 2.

Then six independent variables (P<0.05 or P<0.01) are included in the regression equation, and the regression equation test has significant significance (F=8.316, P<0.01). From the absolute value of the standardized coefficient Beta, it shows that the effects of independent variables on the hearing (air-bone conduction difference) after tympanoplasty are as follows: Tympanic lesion, preoperative air conduction hearing threshold, preoperative bone conduction hearing threshold, course of disease, Eustachian tube function, and intraoperative wound bleeding.

Statistical analysis and use

SPSS 16.2 software package, statistical methods include χ^2 test and multiple linear regression analysis, and record 10 factors that may have an impact on the curative effect: Age, course of disease, dry ear time, preoperative air conduction hearing threshold, preoperative bone conduction hearing threshold, tympanic mucosa condition, tympanosclerosis, ossicular chain lesion, Eustachian tube function, and bleeding of wound during operation.

Factors related to successful operation

Multiple linear regression backward step method is used to screen the independent variables, and the success or failure of long-term surgery is used as the dependent variable. See Table 3 & Table 4 for the results. According to the OR value, the effect of independent variables on the success of long-term surgery is shown in descending order: tympanosclerosis, course of disease, Eustachian tube function, intraoperative wound bleeding (the wound always oozes blood when the graft is peeled off during the operation, and those who can't stop bleeding by pressing with adrenaline cotton ball), preoperative air conduction hearing threshold and preoperative bone conduction hearing threshold.

Discussion

Advantage of tragus cartilage and perichondrium

As a graft material, tragus cartilage and perichondrium is

Table 3: Multiple linear regression analysis of 301 cases of tympanoplasty.

Factor	value	ξ ± σ	P
Independent variables			
Age 11~66 years	Real-value/yr	32.3 ± 11.5	0.517
Course	Real-value/mon	52.6 ± 12.3	0.032*
Duration of Dry ear	Real-value/mon	11.8 ± 4.2	0.343
Preoperative air conduction threshold	Real-value/dBHL	34.5 ± 3.5	0.015*
Preoperative bone conduction	Real-value/dBHL	18.5 ± 12.5	0.030*
The tympanum adherence	normal =0, abnormal =1	_	0.364
The tympanosclerosis plaque	normal =0, abnormal =2	_	0.004**
Ossicular chain lesion	normal =0, abnormal =3	_	0.056
Eustachian tube function	normal =0, abnormal =4	_	0.045*
The amount of bleeding the wound	less =0, more =1	_	0.047*
Dependent variable			
Whether the operation is successful or not	Successful =0, unsuccessful =1		

Annotate: *P<0.05; **P<0.01

Table 4: Factors related to the success of the screening of 301 cases.

Factor	Coefficient of regression	War value	P Value	OR value
The tympanosclerosis plaque	0.002	5.672	0.004**	1.365
Eustachian tube function	0.212	5.537	0.045*	1.453
Course	0.436	5.762	0.032*	1.436
The amount of bleeding	0.635	5.467	0.047*	1.232
Preoperative air conduction threshold	0.031	5.861	0.015*	1.146
Preoperative bone conduction	0.045	5.369	0.030*	1.025
Constant	-1.762	26.372	0.001**	0.156

Annotate: *P<0.05; **P<0.01

one of the topics that domestic and foreign otologists are keen to study [1,2,6,7,8]. Fat and autologous temporalis fascias are commonly used clinically. The former is mostly used for small perforation of tympanic membrane, because the fat block used for large perforation is correspondingly larger, the growth time of new blood vessels is prolonged, and the fat is prone to liquefaction and necrosis; the latter tissue is soft and thin, so it is not easy to shape when repairing large perforation, and it is difficult for skin flap to survive. It is considered that the cartilage membrane of tragus has the advantages of good elasticity, certain hardness, fixed shape, easy implantation in implant bed and strong anti-infection. Use the elasticity and hardness of cartilage to support tympanic membrane, prevent postoperative tympanic membrane retraction and ossicular adhesion, and improve the long-term curative effect of surgery [8]. We have made a comparative study on the morphological changes and hearing changes of the grafts of temporalis fascia and tragus cartilage ring-cartilage membrane after tympanoplasty, and found that the healing rate of the perforated tympanic membrane repaired by tragus cartilage ring-cartilage membrane complex is 96.2%, while the perforated tympanic membrane repaired by temporalis fascia has different degrees of invagination and adhesion after operation [2]. This may be due to the fact that the fibrous tissue or adipocytes in the middle of the squamous epithelial layer and mucosal lining of the reconstructed tympanic membrane do not have the function of resisting external pressure, and the arrangement of the fibrous cells in the middle layer of the reconstructed tympanic membrane is different from that of the normal tympanic membrane [9]. Other scholars have studied the sound transmission performance of cartilage, and found that when the thickness of cartilage is about 0.5 mm, it has enough mechanical stability and good sound transmission function; when the thickness is 0.2 mm, the loss of low frequency sound energy is small [10-15]. When the thickness is 0.1 mm, the loss of high-frequency sound energy is small; the thickness of normal tragus cartilage is about 1 mm. In order to solve the problem of tragus cartilage thickness, we made it into cartilage ring-cartilage membrane complex, and used the elasticity and hardness of cartilage to support tympanic membrane, so as to prevent the graft from deforming and curling when it meets water or blood during operation and prevent the tympanic membrane from retracting after operation. At the same time, it can reduce the influence of full-thickness cartilage on postoperative hearing [16,17].

Influence of complications on curative effect

The purpose of myringoplasty is to improve hearing and prevent other complications caused by repeated infection of middle ear. We found that tympanosclerosis can lead to the fixation of ossicular chain, often accompanied by blockage of Eustachian tube, which leads to invagination and adhesion of new tympanic membrane after operation. The displacement of the new tympanic membrane or the perforation of the anterior and lower marginal fissure is related to the skill and operation mode of the operator. Yan Xia [18] and Sun Jianjun [19] think that in tympanoplasty, attention should be paid to the treatment of tympanic ring, the making of skin flap of external auditory canal, and the placement of skin graft, etc., so as to facilitate the formation of tympanic membrane-ear canal angle and taper, which is an important technique to repair tympanic membrane perforation and reshape its shape. In addition, the obvious bleeding from the wound during operation is also an important reason. In this group of cases, there were 5 ears with obvious bleeding during

operation, which affected the accuracy of implant placement. After operation, the implant moved out and the anterior and inferior marginal fissure appeared which affected the surgical effect. Especially, it was more likely for female patients to have one week before and after menstruation, so it was suggested that the operation should be avoided during this period. Preoperative air conduction and bone conduction decreased, and postoperative hearing failed to improve. This is related to chronic suppurative otitis media caused by long-term otitis media bacterial toxin or loss of inner ear with ototoxic drugs, which can lead to bone conduction hearing loss. The reasons are comprehensive [20]. Chronic inflammation can affect the stiffness and quality of middle ear sound transmission structure at the same time; Thickening of the round window membrane, increased permeability, changes of local vasoconstriction, inner ear ischemia and hypoxia, and the effect of toxins can cause cochlear dysfunction, resulting in the loss of bone conduction hearing [21]. The results of this study show that tympanoplasty is not easy to succeed for ossicular chain fixation and Eustachian tube blockage caused by tympanosclerosis. However, the stenosis or blockage of the Eustachian tube caused by chronic inflammation does not affect the surgical effect. Zhang Quanan et al. [22] believe that the mucocartilage membrane of the Eustachian tube is less damaged in the development of otitis media, and its tissue structure and function are basically normal, and the lesion only affects the bone segment of the Eustachian tube. Yu Li et al. [23], also observed that the Eustachian tube of chronic suppurative otitis media is narrow or not smooth, accounting for only about 10%, and it will be smooth after cleaning, so it is unnecessary to consider the main factors that affect the operation. We also found that the hearing gradually improved after 3 months of cartilage ring-cartilage membrane tympanoplasty ($P<0.01$), and after the new tympanic membrane grew stably, the hearing was stable from 6 to 3 years, and there was no significant difference between the two groups ($P<0.05$). Acoustic immittance test indicated that the function of tympanum and Eustachian tube was gradually improved. Type B tympanogram is a case of tympanosclerosis, which will cause complications such as tympanic membrane invagination and adhesion after operation. Therefore, we think that whether tympanoplasty should be used only for patients with tympanosclerosis after chronic suppurative otitis media needs further study. Therefore, Zhang Zhigang et al. [24], used cartilage tympanoplasty combined with type III tympanoplasty to treat adhesive otitis media and achieved good results. As a tympanic membrane graft, the cartilage-perichondrium complex has been successfully used in clinic for more than ten years [1]. From the observation results of this group of cases, the healing rate of tympanic membrane in one year is 94.8%, and that in three years is 91.6%. It has certain advantages in tympanoplasty, and it is worthy of clinical application and further research.

References

1. Yu LS. Application of cartilage in the middle ear peration. Clin Otorhinolaryngol Head Neck Surg (China). 2013;27(22):1223-6.
2. Liu XG, Zhou Q, Zhang CP, Guang BX. Tragus cartilage ring with perichondrium for repairing tympanic membrane perforation. J Audiol Speech Pathol. 2005;13(4):245-7.
3. Otolaryngology Head and Neck Surgery Branch of Otology Group of Chinese Medical Association, Editorial Committee of Otology Group of Chinese Journal of Otorhinolaryngology Head and Neck Surgery. Clinical Classification and Surgical Classification Guide for Otitis Media (2012) [J]. Chinese J Otorhinolaryngol Head Neck Surg. 2013,48(2):5.
4. Wang CH, Zhao SQ, Dai HJ, Xia Y, Zheng J, Zhao YL, et al. Long term results and an analysis of surgically related factors in myringoplasty with sandwich method. Chinese J Otorhinolaryngol Head Neck Surg. 2008;43(4);277-80.
5. Jiang SC. Otol. Second Edition. Shanghai: Shanghai Science and Technology Press. 2002;178-9.
6. Li HA, Sun JJ, Qian J. Application of the composite of tragus cartilage with perichondrium in tympanoplasty. J Otorhinolaryngol Head Neck Surg (China). 2002;9(4):195-96.
7. Dornhoffer J. Cartilage tympanoplasty indications, techniques, and outcomes in a 1,000-patient series. Laryngoscope. 2003;113(11):1844.
8. Zhang ZG, Huang QH, Zheng YQ, Sun W, Chen YB, Yu Si. Three autologous substitutes for myringoplasty: A comparative study. Otol Neurotol. 2011;32(8):1234.
9. Deng XC, Shao YL, Li CL. Clinical effects of treatment in large perforation of tympanic membrane with the tragus cartilage perichondrium. Clin Otorhinolaryngol Head Neck Surg (China). 2015;29(4):361-62.
10. Teh BM, Shen Y, Friedland PL, Atlas MD, Marano RJ. A Review on the use of hyaluronic acid in tympanic membrane wound healing. Expert Opin Biol Ther. 2012;12(1):23-36.
11. Ding D, Xu W, Wang Y, Wan G. The postoperative outcome of the cartilage-perichondrium complex reconstructed tympanic membrane perforation in guinea pig. J Audiol Speech Pathol. 2016;24(3):251-5.
12. 12. Du J, Xu WQ, Zhao HJ. The measurements of the thickness and application of tragus cartilage-perichondrium complex in tympanoplasty. J Audiol Speech Pathol. 2014;22(3):257-60.
13. Yu Y, Wei XD, He J. Application of the tragus cartilage in the tympanoplast. Clin Otorhinolaryngol Head Neck Surg (China). 2015;29(1):31-3.
14. Zahnert T, Huttenbrink KB, Murbe D, Bornitz M. Experimental investigations of the use of cartilage in tympanic membrane reconstruction. Am J Otol. 2000;21(3):322-28.
15. Gersdorff M, Garin P, Decat M, Juantegui M. Myringoplasty: Long-term results in adults and children. Am J Otol. 1995;16(4):532-35.
16. Zhang TY, Wang ZM, Wu LW, Zhang Y, Wang W. Postoperative morbidity of graft tympanic membrane in tympanoplasty and the relevant factors. J Clin Otorhinolaryngol(China). 2002;16:528-529;532.
17. Khan MM, Parab SR. Average thickness of tragal cartilage forslicing techniques in tympanoplasty. J Laryngol Otol. 2015;129(5):435-9.
18. Xiao Y. Canalplasty and Myringoplasty: House versus Fisch Techniques. Chinese J Otol. 2017;15(1):4-8.
19. Sun JJ, Yan ZQ, Lin YS. Surgical techniques for restoration of the anterior tympanomeatal angle and conical shape of the reconstructed tympanic membrane in myringoplasty. Chinese J Otol. 2012;10(1):48-51.
20. Liu XG, Zhou Q, Hong YG. The tragus cartilage ring perichondrium tympanoplasty and bone conduction threshold change analysis. J Audiol Speech Pathol. 2009;17(1):69-71.
21. Papp Z, Rezes S, Jbkay L, Szilklai I. Sensorineural hearing loss in chronic otitis media. Otol Neurotol. 2003;24(2):141-4.
22. Zhang QA, Kuang GX, Paparella MM. Histopathologiely observational study of cartilage mucosa on the Eustachian tube isthmus of temporal bone with otitis media. J Clin Otorhinolaryngol(China). 1999;13(4):161-3.
23. Yu LS, Han CG. Some basic concepts of middle ear surgery. Chinese J Otorhinolaryngol Head Neck Surg. 2005;40(1):74-6.
24. Zhang ZG, Chen SJ, Liu X. Cartilage myringoplasty combined with type III tympanoplasty in the treatment of adhesive otitis media. Chinese J Otorhinolaryngol Head Neck Surg. 2009;44(9):777-9.