Comparative Analysis of Effects of Reconstruction and Radical Treatment of the Posterior Ear Canal Wall Using Periosteal Osteocoma and Mastoid Antrum Ventilation

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Abstract To analyze the results of repair defect of the ear canal with autologous bone containing periosteum and hearing reconstruction and postoperative inflation. Retrospective analysis of the 40 cases of surgeries conducted by senior surgeon. All cases received full open surgeries. Pre-operative air conduction (AC) was 67.47 ± 14.32 dBHL, and GAP was 45.95 ± 12.63 dBHL. These cases were divided into two groups: the first 20 ears received repair surgery for radical mastoid cavity with bone slice containing periosteum combined with ear ossicle remodeling, namely the bone slice group. For another 20 ears, inflator was additionally used and the mastoid antrum cavity was inflated twice a day, namely the inflation group. Follow-up: 9–60 months (median follow-up of 26 months). Statistical analysis: U test was adopted. All ear canal showed a smooth appearance. Eight cases received CT scans and presenting re-gasification of attic and/or mastoid cavity. Hearing: AC of 47.32 ± 15.63 dBHL, and GAP of 18.28 ± 15.28 dBHL, both *P* values were <0.01 as compared with that before operation, and the difference was highly significant. 23 cases showed GAP <20 dB, and one case showed GAP >20 at follow-up, but narrowing was >30 dB, and these 24 cases were successful case, with a success rate = 60 %. 16 cases with GAP <10 dB, although 4 cases with GAP >10 dB, narrowing was >30 dB, thus the 20 cases were markedly

effective, and with ratio = 50 %. The gap of 30 cases was narrowed more than 15 dB, although two cases showed gap narrowing less than 15 dB, postoperative GAP was less than 10 dB, both were valid, with an efficacy of $32/40 = 80$ %, 18 cases (45 %) with AC <40 dBHL. Sub-group analysis: age: group *P* < 0.05 when the two groups were compared, difference in ages of the two groups were significant, and the age of the inflation group was older. Both GAP and AC of the two groups showed no significant difference before and after the surgery. One case in the bone slice group showed poor postoperative hearing, adhesion was found between the mesotympanum and attic in reoperation, and best result of GAP Close to less than 10 dB was obtained using the decomposition method after inflation. Bone slice containing periosteum can be used for reconstruct the normal ear canal. Auxiliary inflation of middle ear can even promote the tympanic re-gasification and hearing recovery.

Keywords Otitis media · Adhesion · Cholesteatoma · Ossicular chain reconstruction

Introduction

It was a huge challenge for no matter how experienced aurists to deal with middle ear cholesteatoma surgery on children or adult for decades [1]. Before 1950s, all of the operations were radical treatment or improved radical treatment. Avoiding intracranial complications was primarily considered instead of the radical cavity no matter how much and how huge left after the operation and need periodic cleaning [2]. There were no disputation on whether playing middle ear cholesteatoma surgery or not but on which technology used. Those who insisted open technology believed there were high cholesteatoma residual and recurrence rate after closed

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operation. However, those who proposed closed technology put forward that patients would be under non-physiological conditions could not clear themselves caused by the open mastoid antrum and rely on regular medical help. Moreover, patients would usually be affected on their work and survivability with the very poor hearing. Therefore, some experienced aurists a designed new surgical method reserving the posterior ear canal wall [1, 3, 4], without postoperative radical cavity and with a satisfactory, long-term and ideal effect on hearing. As for the remaining radical cavity, there were constant measures designed to help patients to get rid of crusta and earwax easily accumulated and secondary infection, as well as adhesion of tympanum and tympanic membrane and serious hearing damages. For example, Magliulo [5] reported that filling with osteocomma covered by hydroxyapatite particles could make postoperative positive effect of dry ear, but there were only 46 % of postoperative air-bone gap of hearing reduced to within 30 dB. In recent years Deveze etc. reported reconstruction of mastoid antrum with titanium plate, with a very high postoperative dry ear rate but still un-ideal hearing [6]. We also filled old mastoid antrum with autogenous iliac, similarly with an unsatisfied hearing and only 65 % of effective postoperative air-bone gap reduced to more than 10 dB [7]. Lately, radical defective ear canal wall was repaired with bone cortex pieces with periosteum themselves meanwhile reconstruction of ossicular chain could improve the efficacies [8, 9]. Furthermore, postoperative mastoid antrum ventilation was added to improve gasification of middle ear and hearing. To assess this stage, it was reported as follows.

Materials and Methods

Individual Patient Data

There were 40 cases of patients for surgery, including 17 males and 23 females, aged 19–74 years old, with the average age of 48.87 ± 5.87 years old and the median age of 48 years old. They had been all treated with open cholesteatoma radical surgery some years ago (17 cases in our hospital) with residual huge radical cavity and infection festering. There were 29 cases of abundant accumulation of cholesteatoma scurf, 28 cases of perforation in pars tense of eardrums, 1 case of chunk granulation in eustachian tube orifice. There were 12 cases of pars tense of eardrums still existing. The preoperative mean air conduction was 67.47 ± 14.32 dBHL (Take 0.5, 1, 2 K as means, similarly hereinafter) and the average air-bone gap was 45.95 ± 12.63 dBHL. 3 cases were received reoperation, so that there were all 43 operations. All cases were inserted with 1 mm plastic pipe from the mouth of eustachian tube, without difficulties to pharyngeal ostium.

Operation Methods

They were divided into two groups: the first 20 cases were osteocomma group; with repair of existing radical cavity with periosteal osteocomma and reconstruction of ossicular chain (Periosteal osteocomma was harvested by special milling head and oscillating saw, as were shown in Figs. 1, 2). The other 20 cases were inflatable group, brought 2 mm silicone tube from reconstructed mastoid antrum on the base of above technology, inflated to mastoid antrum twice per day and 5 s every time through silicone tube with middle ear aerator within 2 weeks in the postoperative (Inflatable method was shown in Fig. 3, aerator was shown in Fig. 4).

Acquisition Methods of Periosteal Osteocomma

After local anesthesia behind ear, skin was cut apart 1 cm away from retroauricular groove. The retractor was framed into it and the subcutaneous tissue was thinned. When the periosteum was only 1 mm thickness, periosteum was cut apart according to the osteocomma size (about 2 cm in diameter). Periosteum near the cut was slightly separated to center to show the surrounding bone. Suture was milled out by microscopic milling drill [8] and bone groove was sawed out to deep level direction by oscillating saw. Periosteal osteocommas were chipped off with broad chisel and for use after being trimmed.

Implant of Periosteal Osteocomma

Periosteal osteocomma was implanted into the radical cavity to repair defective external auditory canal and antrum mastoideum wall. If there was a complete flap stripped out, periosteum would be toward the radical cavity, while if the flap was defective even too thin to use,

Fig. 1 Special milling head milling out osteocomma and suture

Fig. 2 Periosteal osteocoma taken by oscillating saw from behind ears

Fig. 3 Inflatable methods

Fig. 4 Inflator

periosteum would be toward the ear canal and periosteal surrounding were plugged under the ear canal skin, which could get healed as soon as possible.

Reconstruction of Ossicular Chain

There were 22 cases of acetabular column autologous otosteon with stapes existed, 14 cases of gun-column autologous otosteon with only pedal plate existed and four cases of otosteon treatment with all sorts of reasons (two cases of labyrinthine fistula, one case of complete otosteon and one case of oval window scar accumulation) not a period otosteon processing. Exudate in tube was cleared before every postoperative inflating to patients in inflatable groups.

Follow-Up

Follow-up for 9–60 months (the mean 28.5 ± 13.15 months and the median 26 months). Postoperative hearing results were the postoperative hearing test after 2 weeks. Follow-up was played every 2–3 months. The last one was follow-up hearing to those more than 6 months.

Statistical Analysis

U inspection was used.

Results

Closure of Mastoid Antrum and Regasification

40 patients were all received closure of mastoid antrum, with a smooth appearance in the ear canal. There were 8 cases of follow-up CT review, presenting regasification of epitympanum and/or mastoid antrum (shown in Figs. 5, 6).

Hearing Results

The preoperative follow-up mean air conduction (AC) was 47.32 ± 1563 dBHL and the average air-bone gap was 18.28 ± 15.28 dBHL. Compared with preoperative 45.95 ± 12.63 dBHL, $U = 8.82 > u_{0.01} = 2.57, P < 0.01$, the difference was very significant. There were 23 cases of follow-up gap < 20 dB and 1 case of follow-up gap > 20 dB but with gap narrowing > 30 dB. The success rate of 24 cases was 60 %. There were 16 cases of gap < 10 dB and four cases of follow-up gap > 10 dB but with gap narrowing > 30 dB. The significant effect rate of 20 cases was 50 %. And there were 30 cases of effective, with gap narrowing > 15 dB. Two cases were less than 15 dB but with postoperative gap within 10 dB, also effective. $32/40 = 80$ %. There were 18 cases (45 %) of AC < 40 dBHL when follow up.

Fig. 5 Preoperative CT: arrow showed huge radical mastoid antrum and perforation of eardrum

Fig. 6 Postoperative CT: arrow showed regasified middle ear after closure of mastoid antrum and repair of eardrum

Bulk Segregant Analysis

Age: Osteocomma groups were aged 43.75 ± 17.73 and ventilation groups were aged 54.95 ± 9.89 . Comparing between two groups, U value = $2.46 > u0.05 = 1.96$, $P < 0.05$. The age differences were very significant. Preoperative gap contrast: In osteocomma group preoperative

gap was 43.15 ± 14.12 dBHL and in ventilation group preoperative gap was 48.75 ± 10.56 dBHL. The compared U value = $1.41 < u0.05 = 1.96$, $P > 0.05$. The difference was not significant. Postoperative gap contrast: In osteocomma group postoperative gap = 22.15 ± 14.85 dBHL and in ventilation group postoperative gap was 22.15 ± 14.85 dBHL. The compared U value = $1.63 < u0.05 = 1.96$, $P > 0.05$. The difference was not significant. Preoperative AC contrast: In osteocomma group preoperative AC was 63.4 ± 16.02 dBHL and in ventilation group preoperative AC was 71.55 ± 11.38 dBHL. The compared U value = $1.85 < u0.05 = 1.96$, $P > 0.05$. The difference was not significant. Postoperative AC contrast: In osteocomma group postoperative AC was 42.75 ± 16.79 dBHL and in ventilation group postoperative AC was 41.3 ± 13.25 dBHL. The compared U value = $1.91 < u0.05 = 1.96$, $P > 0.05$. The difference was not significant. Although there were no significant differences in preoperative and postoperative AC, preoperative and postoperative gap between two groups, but in age, with ventilation group older. Moreover, there was one case of poor hearing in osteocomma group found adhesion between middle tympanum and epitympanum during reoperation, which got the best results of gap closed to within 10 dB by using inflatable method after decomposition.

Discussion

What is the significance of mastoid antrum to maintain normal middle ear function? And how it would influence postoperative middle ear function completely removing middle ear function by radical “eliminating walls” surgery? It used to be ignored that normal human mastoid antrum played an important role in maintaining and mediating the normal air pressure of middle ear. Bluestone, etc. [10, 11], once pointed out that the relationship between eustachian tube and mastoid antrum could be analogized as that among throat, bronchia and lung. Eustachian tube and throat were both channels, while mastoid antrum and lung were both gas storage organs; in spite of respective other complex functions. This reminded us that eustachian tube and mastoid antrum complemented one another indispensably in regulating the functions of whole middle ear. Takahashi, etc. [12], found in the second surgery of whether the micro air pressure increase or not there would be pressure increase in mastoid antrum if any parts of mucosa, while no any pressure increase in patients had been given “eliminating walls” surgery because of no mucosa in mastoid antrum. It was also observed in practice that self-insufflations could not get obvious inflation to those patients who were actually unobstructed in eustachian tube but with adhesion in epitympanum. But after epitympanum

and mastoid antrum were reconstructed, this kind of ventilation would be very easy and effective, the following implanted otosteon was not easy to be shifted, and the hearing effect was more likely to be available.

Methods of reconstructing mastoid antrum: Generally it was suggested to use autogenous iliac bone filling or autogenous bone meal filling to the huge radical mastoid antrum. These filling methods could only narrow the huge chamber to a smaller one, but not to form really gasified mastoid antrum with function of air conditioning and communicated with tympanic cavity. But in this research the true cavity could be formed by repair using periosteal osteocoma. But after this osteocoma implanted, some clearance should be set aside between middle tympanum and epitympanum for prevention of adhesion with implanted otosteon, wherein soft tissue wall was easy to adhere with inwall. It was found that this kind of adhesion was very easy to happen from one case of review because of postoperative poor hearing and another case of CT review. There was one case of satisfied success in hearing, without adhesion through inflating with aerator during reoperation (shown in Figs. 7, 8). It could be seen that perioperative inflation was helpful to reconstruct the parichnos between mastoid antrum and middle tympanum and was more effective to prevent adhesion.

At present there were problems that periosteal osteocoma used to the huge radical cavity was still difficult to cover the whole defect area, so that collapse was easily appeared. Even with the perioperative inflating, it could still not make regasification of mastoid antrum. Because of

Fig. 7 Arrow showed periosteal osteocoma adhered with inwall of mastoid antrum and no effective air cavity in middle ear

Fig. 8 White arrow showed well-shifted periosteal osteocoma after ventilation. Blank arrow showed good air cavity around otosteon, with a satisfactory hearing

the traction of collapse tissues, the implanted otosteon could be shifted. The postoperative success rate was improved compared with the preoperative success rate (50 %), but still hovering around 60 %, with a very big improvement compared with the primary hearing effect of many technologies of cholesteatoma intact canal wall (success rate 85 % [13]). Huge radical cavity might be resided by they previous performer (For example, emphasizing the radical lesions, cutting low posterior wall of external auditory canal) or huge acquired cholesteatoma gasified by inborn mastoid antrum, which would become huge destructive cavity once attacked. There need furthermore researches and more effective comprehensive technologies to satisfactorily repair huge mastoid antrum and form a true gasified chamber, and then make otosteon no longer shifted.

Conflict of interest The authors declare that they have no conflict of interest.

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