Studies on the Migratory Properties of Epithelial Cells of Cholesteatoma: Clinical Investigation

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A total of 302 cholesteatoma cases were surgically treated with or without utilizing the cholesteatoma matrix to cover the defect of the eardrum. The recurrence rate, the number of days required for the skin to dry (epithelialization), findings of the external ear canal, the degree of postoperative crust formation (migration property), and the number of infections were compared between these two groups. Recurrence of cholesteatoma was seen in only one case, a case in which the cholesteatoma matrix was not used. The average number of days required for the skin to dry after surgery was 7.1 days in patients in whom the cholesteatoma epithelium was utilized, while it was 9.4 days in patients in whom cholesteatoma matrix was not utilized. The number of cases that had crust formation was significantly greater among patients in whom the cholesteatoma matrix was not utilized. From these results, we concluded that one-stage tympanoplasty with mastoid obliteration using the cholesteatoma matrix is a rational surgical procedure.

Key Words: Migratory Properties, Cholesteatoma, One-stage tympanoplasty, Migration Theory

INTRODUCTION

Since cholesteatoma causes bone destruction, it must be removed surgically. It is now believed that cholesteatoma is caused by the accumulation of desquamating keratinized epithelium in the retraction pocket generated by retraction of a part of the tympanic membrane into the epytympanum or middle ear cavity. Evidence which has been accumulating shows that the epithelium of the cholesteatoma matrix has similar properties to that of the external ear and tympanic membrane, but without the migratory properties (self-cleaning ability) in the reports of Boxall (1993)[1], Bonding (1993)[2] and Proops (1984)[3].

We studied the migrating property of epithelial cells obtained from the external ear canal skin and cholesteatoma as early as 1982 and confirmed the presence of such migrating properties [4]. On the basis of these basic studies, we developed "one-stage tympanoplasty with mastoid obliteration" in which the external ear canal and tympanic membrane are reconstructed using the cholesteatoma matrix which has recessed into the middle ear [5][6]. In this paper, we compare the results of 302 patients who either received such surgery or those on whom an operation was performed without using the cholesteatoma matrix.

CASE STUDIES

From January 1989 through December 1993, 313 cases of middle ear cholesteatoma received surgery at the Otorhinolaryngology Department of Tokai University Hospital. Among these, 154 ears from 150 patients received tympanoplasty using the cholesteatoma matrix and were followed by observation for more than 3 years thereafter. The control group included 148 ears from 141 patients in which the cholesteatoma matrix could not be separated and therefore could not be utilized for reconstructive surgery. These patients were also followed for more than 3 years. The average age of these patients at surgery (302 ears) was 44.1 years with a range of six to seventy-one years of age. Among them, 155 were male (164 ears) and 136 were
female (138 ears). These patients were classified into three groups depending on the type of cholesteatoma: A: pars flaccida type, B: posterior-superior quadrant (PSQ) type, and C: extensive progression type (Table 1). Use of the cholesteatoma matrix in reconstructive surgery for Group B patients tended to be difficult because of continuous separation of the epithelium and its lifting. However, we could use the cholesteatoma matrix in more patients in the A group. There were no differences among the three groups even after subdividing the ossiculoplasty (ossicular reconstruction) into four groups including Type I, modified Type III (cases in which the stapes superstructure were present), modified Type IV (cases in which the stapes superstructure was missing), and no ossicular reconstruction surgery.

SURGICAL PROCEDURE

The procedure we used for surgery of middle ear cholesteatoma was one-stage tympanoplasty with mastoid obliteration which was characterized by the use of cholesteatoma matrix for the surgery. This procedure was similar to the conventional open method except that: (1) the posterior bony wall of the external ear canal was removed; (2) the skin of the posterior and superior walls of the external canal was maintained as much as possible; and (3) the cholesteatoma matrix was separated and lifted from the mastoid cells, antrum, and epitympanum along with the epithelium of the external ear canal (Figures 1-A and 2-A). In patients with posterior-superior quadrant (PSQ) type cholesteatoma, the adherent drum was separated along with the cholesteatoma matrix and the epithelium of the external ear canal, and was lifted to the physiologic position. After cleaning the middle ear cavity, the defects of the external ear canal and tympanic membrane were covered completely with the epithelium of the cholesteatoma and underlaid with the fascia. When the epithelium of the cholesteatoma was used continuously, we positioned the cholesteatoma matrix so that the migration direction was always towards the outside of the ear. This cholesteatoma matrix was used as a flap without disconnecting it from the tympanic membrane and external ear canal (Figures 1-B and 2-B). The mastoid cavity, which had been opened by surgery, was obliterated with the cortex of the temporal bone in a stratified fashion.

The surgical procedure used for patients whose cholesteatoma matrix could not be used was also a one-stage tympanoplasty with mastoid obliteration. In these patients, it was difficult to separate the cholesteatoma matrix continuously, either from the outer ear canal side or from the drum sides. As a result, when we separated it from the mastoid cavity and lifted it, it caused perforations in the pars flaccida or defects on the external ear skin. In such cases, we doubly underlaid these areas with temporal fascia and connective tissue (Figures 1-C and 2-C).

METHODS

We have compared the results of 302 patients who either received tympanoplasty using the cholesteatoma matrix or those on whom an operation was performed without using the cholesteatoma matrix with the following indications.

1. Recurrent and residual cholesteatoma

Patients after surgery were followed up by examination of the ear drum and high-resolution CT (HRCT) scanning. For those patients

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<thead>
<tr>
<th>Table 1 Type of cholesteatoma and type of ossiculoplasty</th>
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<td>Surgery with cholesteatoma</td>
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<td>154 ears</td>
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<td>Surgery without cholesteatoma</td>
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<td>148 ears</td>
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PSQ: posterior superior quadrant
Migratory Properties of Cholesteatoma Matrix: Clinical Investigation

who had poor hearing improvement after initial surgery, we surgically examined the existence of residual or recurrent cholesteatoma.

2. Drying of the ear drum after surgery (epithelialization)

Since the cholesteatoma matrix is a kind of skin, we assumed that the use of the cholesteatoma matrix to cover the defective area of the external ear canal and tympanic membrane would shorten the time required for the healing of the skin. To study the time required for epithelialization of the skin defect, we measured the number of days necessary for the epithelium to dry after surgery.

3. Examination of postoperative external ear canal

We classified the patients into the following six groups based on the differences in the findings of the external ear canal on the last day of examination: (1) normal; (2) presence of a slight retraction pocket; (3) presence of a moderate retraction pocket (bottom of the pocket

| Surgery with cholesteatoma matrix | 83 ears | 27 | 4 | 35 | 2 |
| Surgery without cholesteatoma matrix | 76 ears | 23 | 4 | 36 | 5 |

Follow up: more than 3 years
could be observed; (4) presence of a severe retraction pocket (bottom of the retraction pocket could not be observed); (5) widening of the external ear canal; and (6) presence of a radical cavity (see Table 2).

4. Postoperative crust formation (self-cleaning ability) and infection

The self-cleaning ability of the epithelial cells of the tympanic membrane and external ear canal was studied by the number of removals of crust (number of hospital visits) between 3 months and 2 years after surgery.

RESULTS

1. Recurrent and residual cholesteatoma

Revision surgery was performed on one case in which the cholesteatoma matrix was utilized and two cases in which the cholesteatoma matrix was not utilized. Among these patients, one of the latter cases was attributed to recurrence while the other two were found to have a postoperative mastoid cyst without recurrence of cholesteatoma. There were no cases of residual cholesteatoma.

2. Drying of the ear drum after surgery (epithelialization)

The average number of days for recovery among patients in whom the cholesteatoma matrix was used was 7.1 ± 0.2 days, while it was 9.4 ± 1.6 days in patients in whom the cholesteatoma matrix was not utilized. This difference was small but statistically significant, indicating that the use of the cholesteatoma matrix shortened the time for drying of the epithelium.

3. Examination of postoperative external ear canal

The three patients who received a second operation for the examination of recurrence were all in the severe retraction pocket group. There was no difference between the patient groups in which the cholesteatoma matrix was used or not used (see Table 2).

4. Postoperative crust formation (self-cleaning ability) and infection

The average number of hospital visits of the patient group in which the cholesteatoma

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Fig. 2-A PSQ-type cholesteatoma

Fig. 2-B Surgery with cholesteatoma matrix

Fig. 2-C Surgery without cholesteatoma matrix
epithelium was used was 3.2 with a minimum of two and maximum number of eight. On the other hand, the average number of hospital visits of the patients in whom the cholesteatoma matrix was not used was 4.5 with a minimum number of two and maximum number of 16. The number of patients who had postoperative infection was 2/154 ears (1.3%) in the patient group in which the cholesteatoma epithelium was used, while it was 6/148 ears (4.1%) in the patient group in which the cholesteatoma epithelium was not used. Among the six infected ears in the patient group in which the cholesteatoma matrix was not used, two ears had postoperative perforation. No perforation was noted in the group in which the cholesteatoma matrix was used.

DISCUSSION

The following theories have been proposed concerning the mechanism of the formation of cholesteatoma(7, 8, 9, 10). They are the immigration theory in which the skin of the tympanic membrane migrates into the middle ear cavity; the metaplasia theory in which basal cells proliferate in a papillary form; and the implantation theory in which implantation of squamous epithelium takes place as a result of injury. Concerning the cause of migration of the skin of the tympanic membrane into the middle ear cavity, there are the retraction (invagination) theory in which it is initiated by the retraction of the tympanic membrane and the basal cell hyperplasia theory in which basal cells of the skin proliferate and migrate into the middle ear cavity.

Results of our surgery in which the cholesteatoma matrix is utilized suggest that the latter theory is not likely. If the latter theory is correct, it is assumed that the cholesteatoma will recur after surgery because the cholesteatoma matrix is used for the surgery. However, as shown in our three-year study, there was no recurrence of cholesteatoma in the patient group in which the cholesteatoma epithelium was used. These results suggest that the metaplasia theory and hyperplasia theory are unlikely to be the cause of cholesteatoma formation.

The implantation theory may apply under certain conditions such as postoperative cholesteatoma, but it cannot explain ordinary middle ear cholesteatoma, which seems to be formed by retraction of the tympanic membrane. As reported by Sade (1979)(11), Tos (1988)(12) and Moriyama (1987)(13), retraction of the tympanic membrane involves blockage of the middle ear and epitympanum, which causes the accumulation of debris due to a change in migration direction.

Inflammation in these areas further promotes the development of cholesteatoma. For this reason, cleaning of the blocked area, enlargement of the middle ear cavity, and smoothing of the retraction pocket will prevent recurrence of the formation of a retraction pocket.

Our previous reports(4) and those by Boxall(1) and Bonding (2) show that the migration rates of the external ear canal skin and cholesteatoma epithelium differed among patients, yet their speeds were consistent in each individual patient. This indicates that migration of cultured epithelium obtained from the pars flasidita-type and PSQ-type of cholesteatoma is similar to that of the external ear canal skin. Therefore, if the epithelium is continuously connected by using the cholesteatoma matrix rather than implantation of skin from other parts of the body, migration from the drumhead to the external ear canal is restored and the crust (cerumen) accumulates near the entrance of the external ear canal. Although the degree of crust formation cannot be determined by the number of hospital visits, our results suggested that if the epithelium defect of the external ear canal and tympanic membrane was covered by the patient's own epithelium and if the external canal and tympanic membrane were physiologically smooth, accumulation of crust did not take place; therefore, the patient did not need to visit the hospital.

On the other hand, patients in whom cholesteatoma matrix could not be used and a significant defect in the epithelium resulted showed increased postoperative crust formation. Therefore, in these patients, restoration of the external ear canal and tympanic membrane with normal migration capacity was difficult.

According to Boxall (1) and Bonding (2), the patients who received classical radical mastoidectomy showed migration (self-cleaning ability) but there were areas where there was
no migration. They found that crust accumulated specifically in these areas. It seems that crust formation and the cavity problem due to infection associated with classical radical mastoidectomy and modified radical mastoidectomy are caused by the formation of a skin defect of significant size and coverage of the area with skin or fascia which lacks migratory ability.

Our patients who underwent operations which covered the surface smoothly with the cholesteatoma matrix did not require hospital visits to remove crust after surgery, including those who had an enlarged external ear canal. These results coincide with the report of Bonding (2) who had many patients with migration capacity among those who received classical radical mastoidectomy. The cavity problem after classical radical mastoidectomy may not be the result of an enlarged mastoid cavity, but caused by the accumulation of crust and infection as a result of the removal of the patient's own external ear skin with normal self-cleaning ability. Considering these facts, our one-stage tympanoplasty with mastoid obliteration, which creates a large middle ear cavity and reconstructs the external ear canal and tympanic membrane with a physiological function, is a rational procedure.

REFERENCES