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Reconstruction of ear canal wall with superior pedicled composite multi-fractured osteoperiosteal flap: a new technique and preliminary outcomes

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Abstract

Objective. This study evaluated the functional results of the superior pedicled composite multi-fractured osteoperiosteal flap technique. This method is a novel technique for the reconstruction of the external auditory canal. The study also examined the effect of the superior pedicled composite multi-fractured osteoperiosteal flap technique on patients' disease-related quality of life.

Method. A total of 37 patients who underwent the superior pedicled composite multi-fractured osteoperiosteal flap technique were enrolled in the study. Their functional hearing results and disease-related quality of life scores were evaluated.

Results. A significant improvement was observed in the patients' hearing scores at the post-operative sixth month relative to the pre-operative period, and the patients' disease-related quality of life increased significantly.

Conclusion. The superior pedicled composite multi-fractured osteoperiosteal flap method can be safely used, especially in patients undergoing retrograde mastoidectomy because of limited cholesteatoma. This method contributes to improving patients' hearing levels and disease-related quality of life.

Main Article

Dr A Özgür takes responsibility for the integrity of the content of the paper

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Introduction

Canal wall down mastoidectomy is a mastoidectomy technique in which an open cavity is created by removing the posterior osseous wall of the external auditory canal. The greatest advantage of this technique is that it can reduce residual cholesteatoma risk by creating an increased viewing angle of the areas that are difficult to see. However, a need for periodic cavity cleaning, problems during rehabilitation with hearing aids and regulations (such as swimming restrictions) are major disadvantages to this technique.[1,2] Reconstructing the canal wall with grafts or flaps may be preferable to overcome this problem.[2]

Since the 1950s, various methods for external auditory canal reconstruction have been described. Previously, sole autografts were widely used; however, various biomaterials came into use alongside autografts in the 1990s. The goal of these reconstruction methods is to eliminate open-cavity problems caused by canal wall down mastoidectomy. Depending on the reconstruction technique, either the mastoid cavity can be obliterated to reduce the size of the cavity or the canal wall can be reconstructed.

Reconstructing the canal wall preserves the relationship between the middle ear and the mastoid cavity and maintains the continuity of physiological functions in the remaining healthy mastoid cells. Mastoid cells play an active role in the gas balance of the middle ear.[3–5] Therefore, preserving the physiology of healthy mastoid cells should be considered when selecting reconstruction methods.

This article evaluates the functional results of the superior pedicled composite multi-fractured osteoperiosteal flap technique, a novel method used by the authors in their clinic to reconstruct the ear canal. The study also examines the effects of the superior pedicled composite multi-fractured osteoperiosteal flap technique on patients' disease-related quality of life.

Materials and methods

Patients and study design

This study was performed with the approval of the University of Health Sciences Samsun Education and Research Hospital Non-interventional Clinical Researchers Ethics Board (date: 26 February 2020; number 2020/5/2).

Thirty-seven patients who underwent the superior pedicled composite multi-fractured osteoperiosteal flap technique for external auditory canal reconstruction after canal wall

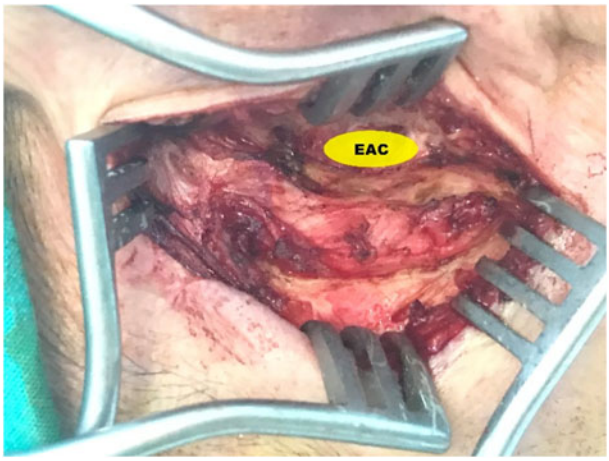

Fig. 1. Determining the borders of the flap. EAC = external auditory canal

down mastoidectomy between April 2017 and October 2019 at the University of Health Sciences Samsun Education and Research Hospital were enrolled in this study.

Audiological examinations of the patients were performed pre-operatively and at the post-operative sixth month by averaging pure-tone air- and bone-conduction thresholds at 500, 1000, 2000 and 4000 Hz. Pre-operative and post-operative air–bone gap values were also compared, and the patients' post-operative mean air–bone gap gains were analysed. The complications encountered during and after the operation were evaluated to determine potential problems related to the surgical technique. The volume of the outer ear canal at the post-operative sixth month was evaluated by positioning each patient's head so that the external auditory canal was perpendicular to the ground. The cavity was filled with saline at body temperature to the level of the outer posterior canal border. In patients with an intact reciprocal ear, the external auditory canal volume of the reconstructed ear was compared with the volume of the intact ear. In addition, the effect of this method on the patients' quality of life was evaluated via the Chronic Otitis Media Questionnaire-12, a survey with 12 questions.

Surgical technique

Exhibiting scutum erosion because of cholesteatoma or retraction pocket that cannot be selected and undergoing limited mastoidectomy are the most important indications for using this technique. However, widespread invasive cholesteatoma and revision mastoidectomy are two important contraindications for this technique.

The surgical procedure starts with an incision made approximately 5 mm posterior to the retroauricular sulcus. Then, the subcutaneous connective tissues are incised, and the dissection proceeds forward to the external auditory canal skin. The borders of the planned flap are determined by cutting the periosteum with monopolar cautery (Figure 1).

After the edges of the flap are determined, a superior pedicled flap containing bony fragments is prepared to start from the inferior side. The bony fragments are harvested from the cortical bone by using a bone chisel. Given that the supply of the flap comes from the superior side, meticulous care is essential to avoid damaging the pedicle when preparing the flap (Figure 2).

After the retrograde mastoidectomy procedure is completed, the designed flap is placed over the defective area in the external auditory canal. During this reconstruction, a transition area is created similar to the attic zone, and the

Fig. 2. Superior pedicled composite multi-fractured osteoperiosteal flap.

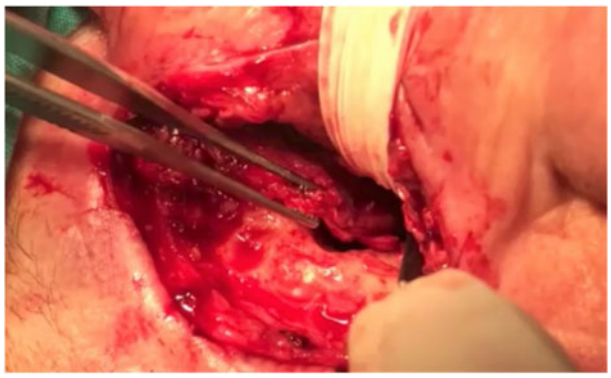

Fig. 3. Reconstruction of the defect in the external auditory canal with a flap.

connection between the middle-ear cavity and the mastoid cavity is created, mimicking normal anatomy. The mastoid cavity is not obliterated (Figure 3).

After the reconstruction of the external auditory canal with the flap, tympanoplasty is performed with a perichondrium cartilage graft taken from the tragal cartilage. In addition, a part of the perichondrium can be laid over the superior pedicled composite multi-fractured osteoperiosteal flap to facilitate the healing of the ear canal epithelium. The surgical steps are summarised in Figure 4.

The tympanomeatal flap is returned to its original position, and gelfoam is placed over the graft. An antibiotic-impregnated nut-sized gauze ball is placed over the area where the tragal cartilage graft is taken. A mastoid pressure dressing is post-operatively applied for 24 hours. If no post-operative complication occurs, the patient can be discharged. In the post-operative period, amoxicillin-clavulanate should be administered twice per day for 10 days; paracetamol can be taken if an analgesic is necessary. The skin sutures and gauze packing in the external auditory canal are removed on post-operative day 7, and ciprofloxacin-containing antibiotic drops can be administered 3 times per day for 10 days. At the end of the post-operative first month, the external auditory canal should be evaluated. The patient will be re-evaluated at three and six months post-operatively. If no problems are found, the patient can be followed up via annual check-ups.

Statistical analysis

Pre-operative and post-operative audiological scores and the quality of life questionnaire data of the patients were compared using a *t*-test. A *p*-value of less than 0.05 was considered

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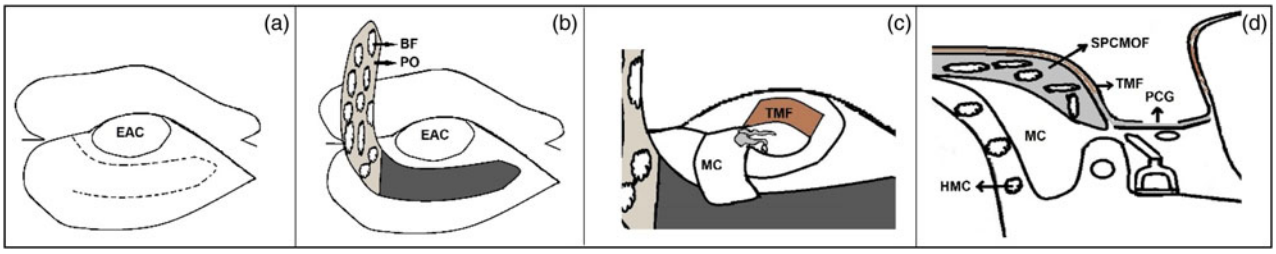

Fig. 4. (a) Determining the limits of the flap. (b) Preparation of the flap. (c) Elevation of tympanomeatal flap and retrograde mastoidectomy. (d) Reconstruction of the canal wall with superior pedicled composite multi-fractured osteoperiosteal flap, performing tympanoplasty with perichondrium cartilage graft and placing the tympanomeatal flap. EAC = external auditory canal; BF = bony fragment; PO = periosteum; TMF = tympanomeatal flap; MC = mastoidectomy cavity; SPCMOF = superior pedicled composite multi-fractured osteoperiosteal flap; PCG = perichondrium cartilage graft; HMC = healthy mastoid cell

Table 1. Pre- and post-operative pure-tone threshold averages of the patients

Parameter	Air conduction (dB nHL)	Air–bone gap (dB nHL)	Air–bone gap reduction (dB nHL)
Pre-operative	48.8 ± 14.1	25.5 ± 9.0	
Post-operative sixth month	35.4 ± 15.4	12.4 ± 7.6	13.2 ± 10.9

significant. All statistical analyses were performed using the SPSS® (version 24) statistical software.

Results

A total of 37 patients (21 males, 16 females) were enrolled in the study. The average age of the patients was 35.1 ± 11.8 years (range: 18–65 years). The patients were followed up for an average of 19.6 ± 9.8 months (range: 6–37 months). Table 1 summarises the patients' pre-operative and post-operative sixth-month audiological evaluations. Significant improvement was observed in the patients' average pure-tone air conduction threshold and air–bone gap values ($p < 0.001$). At the post-operative sixth month, 31 patients (83.8 per cent) had an air–bone gap of less than 20 dB.

At the post-operative sixth month, the external auditory canal volume measurements of 21 patients with an intact reciprocal ear were 1.24 ± 0.24 cc (0.9–1.8 cc) in the reconstructed ear and 1.23 ± 0.23 cc (0.9–1.7 cc) in the intact ear. Thus, the difference between the external auditory canal volumes of the reconstructed and intact ears was not statistically significant in these patients ($p = 0.08$).

According to the results of the Chronic Otitis Media Questionnaire-12 questionnaire, the mean pre-operative quality score was 27.2 ± 10.9 (range: 10–50), and this score was 8.5 ± 8.9 (range: 0–50) at the post-operative sixth month. In 26 patients (70.3 per cent), quality of life scores of 8 or below were achieved, which previous studies considered to be the normal cut-off score for the Chronic Otitis Media Questionnaire-12 questionnaire.[6,7] Thus, the surgical method applied to these patients significantly increased their disease-related quality of life ($p < 0.001$).

A ruptured pedicle of the flap was observed in one patient during the operation. The pedicle of the flap was sutured and used for reconstruction, and this patient had no complications in the post-operative period. During the post-operative period, purulent secretion in the external ear canal because of local infection was detected in four patients. These patients were treated locally with ciprofloxacin eardrops, and the signs of infection disappeared within two weeks of treatment. In one patient, a defect and a retraction pocket in the external auditory canal, possibly because of flap failure, were observed at the eighth post-operative month. This patient received surgery again, and the retraction pocket was cleaned and the defect was repaired using a cartilage graft.

Discussion

Canal wall down mastoidectomy is a widely preferred technique in cholesteatoma surgery because of its advantages in providing a wide field of view. Many techniques have been described for repairing the external auditory canal defect caused by this method. In addition to autografts, which have been used for many years, various biomaterials and even tissue engineering products, have been employed recently.[4,8]

One of the main purposes of these techniques is to increase the patient's quality of life by preventing problems associated with an open cavity caused by canal wall down mastoidectomy. In recent years, the authors adopted the superior pedicled composite multi-fractured osteoperiosteal flap technique described here for external auditory canal reconstruction after canal wall down mastoidectomy in their clinic. According to their results, the superior pedicled composite multi-fractured osteoperiosteal flap technique can be used safely in external auditory canal reconstruction, provide satisfying hearing results and greatly improve patients' quality of life.

Using a composite multi-fractured osteoperiosteal flap in ear canal wall reconstruction was first described by Ucar as an inferior pedicled flap.[9] In this technique, all the mastoid cells were cleaned, and the mastoid cavity was obliterated to support the flap. Another superior pedicled composite multi-fractured osteoperiosteal flap technique was defined by Liu *et al.* Similar to the technique presented in this article, the flap was a superior pedicled flap. However, the mastoid cavity was obliterated, as in Ucar's technique.[10] Unlike these two previous techniques in the literature, the currently described reconstruction method avoids the obliteration of the mastoid cavity, allowing healthy mastoid cells to continue their physiological functions. In addition, the results suggest that the method provides a similar reconstructed external auditory canal volume to healthy external auditory canal while preserving the physiological functions of mastoid cells.

Besides removing the pathological tissues in chronic otitis surgery, one of the main purposes is reconstructing hearing. However, the results of different external auditory canal reconstruction techniques indicate that many factors can affect patient hearing, such as the pre-operative condition of a patient's ossicles (e.g. fixation, destruction), different methods used for hearing reconstruction (e.g. incudostapediopexy, malleo-stapedopexy) and different ossicular chain reconstruction materials used

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(e.g. autologous bone, total or partial prostheses, bone cement). Despite these factors, very promising results have been achieved.[11,12] In the present study, during the post-operative period, the patients achieved hearing results similar to those reported in the literature.

One of the important issues in ear canal reconstruction is that detecting recurrent cholesteatoma is more difficult because a closed cavity has been created. However, newly developed diffusion-weighted magnetic resonance imaging (MRI) techniques have largely resolved this problem by determining recurrent cholesteatoma with very high rates of sensitivity and specificity.[13] The current authors use diffusion-weighted MRI for follow-up in patients who undergo reconstruction with superior pedicled composite multi-fractured osteoperiosteal flap. During the follow-up periods of the sampled patients, no residual or recurrent cholesteatoma was detected. In only one patient, a defect and a retraction in the flap area were observed. The defective area in this patient was reconstructed with cartilage.

- The superior pedicled composite multi-fractured osteoperiosteal flap method can be easily applied to most patients undergoing canal wall down mastoidectomy
- When placing the flap, care should be taken not to interrupt the relationship between the middle-ear cavity and the mastoid cavity
- This method contributes to improving patients' hearing levels and disease-related quality of life

One of the objectives of chronic otitis surgery is to improve patients' disease-related quality of life. In this research, the Chronic Otitis Media Questionnaire-12 questionnaire was used to evaluate this parameter, and it has been previously validated in several languages.[7,14] In a study conducted by Baetens *et al.*, 50 per cent of patients who had undergone bony obliteration tympanoplasty received a quality score of 8 or below, which is considered the normal cut-off in the Chronic Otitis Media Questionnaire-12 questionnaire.[6] In the current study, the authors observed a significant improvement in the patients' quality of life during the post-operative period relative to the pre-operative period. The post-operative Chronic Otitis Media Questionnaire-12 questionnaire scores were within normal limits for 26 patients (70.3 per cent). These results indicate that the superior pedicled composite multi-fractured osteoperiosteal flap technique increases patients' disease-related quality of life.

This study was the first to present the outcomes of the novel superior pedicled composite multi-fractured osteoperiosteal flap technique described here. However, the short follow-up period and the comparatively small patient cohort were the most important factors limiting this study's effect. In addition, the patients were not categorised according to the method of hearing reconstruction (e.g. autologous bone, prosthesis), and the hearing evaluations were not compared within these different groups.

Conclusion

The superior pedicled composite multi-fractured osteoperiosteal flap method is a novel external auditory canal reconstruction technique that can be safely applied, especially in patients undergoing retrograde mastoidectomy because of limited cholesteatoma. A remarkable improvement in hearing can be achieved, and disease-related quality of life can be increased in these patients.

Competing interests. None declared

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