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Wide Cortical Drilling and Anterior-Based Periosteal Flap Reconstruction: Innovative Approach for Acquired Stenosis of External Auditory Canal

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후천성 외이도 협착의 혁신적 수술법: 후외이도 피질골 확장과 전방 기반 골막 재건

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In patients with acquired stenosis of external auditory canal, traditional canaloplasty surgery using skin graft may be performed when symptoms are severe or persistent. However, the risk of restenosis during follow-up period remains a main concern for surgeons. Herein, we present a novel surgical technique using wide cortical bone drilling and reconstruction using the anterior-based periosteal flap. We also report the preliminary results of case series using this surgical technique comparing it with the traditional method.
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Keywords Aural atresia; External auditory canal; Myocutaneous flap.

Introduction

Acquired atresia of external auditory canal (EAC) is an uncommon cause of conductive hearing loss.[1] It is caused by various etiologies such as inflammation, post-operation, tumors, and trauma.[2] In acute stage with inflammation or a recent history of trauma, conservative management including antibiotics, frequent dressing and/or EAC packing may be helpful. Nevertheless, if the disease progresses or symptoms persist, surgical management remains the gold standard treatment.[3]

Traditional surgical technique for the acquired atresia of EAC was first reported by Paparella and Kurkjian in 1966.[4] Five fundamental surgical steps are as follows: removal of all connective tissues; preservation of the fibrous layer of the tympanic membrane; bony widening using a drill; covering the bone and tympanic membrane with a skin graft; and finally, packing of the EAC. Since then, several minor modifications of the procedures were reported, but the basic technique has barely changed.[1] Furthermore, a relatively high rate of re-stenosis, ranging from 10% to 30%, was reported after traditional technique using a skin graft in the literature.[1-3,5]

To overcome the risk of restenosis, we have devised a novel surgical technique, the Wide Cortical drilling and Anterior-based Periosteal flap Reconstruction (WCAPR) technique, for the treatment of acquired EAC atresia. In this study, the surgical procedures of WCAPR technique were explained in detail, with the aim of investigating the effectiveness and safety of the technique in the treatment of acquired stenosis of the EAC.

Methods

Patients

All patients who underwent canaloplasty surgery using WCAPR technique for acquired atresia of EAC at a tertiary hospital from October 2019 to February 2022 were reviewed retrospectively. Additionally, one patient who underwent traditional canaloplasty procedure using a skin graft was included for the comparison of the operative results. Surgical intervention was carried out in cases where symptoms such as persistent otorrhea were present or when EAC stenosis was severe enough to induce hearing loss.

Patient evaluations included a comprehensive medical history, and EAC endoscopy was utilized to assess the severity of EAC atresia. Subsequently, temporal bone CT scans were performed for evaluation of stenosis and further differential diagnosis, including tumor assessment. Data collected from patients' medical records included age, gender, past medical history, initial symptoms, duration of symptoms, endoscopic photos of EAC, temporal bone CT results, follow-up duration, pure tone audiometry, and the occurrence of postoperative complications such as restenosis of the EAC. The pure tone audiometry average was calculated from 500, 1000, 2000, and 3000 Hz. This study received approval from the Institutional Review Board of Kyungpook National University Hospital (IRB No. 2024-03-026).

Operative procedures

This surgical technique of WCAPR was all performed by the senior author (Lee) to treat acquired EAC stenosis under general anesthesia. Postauricular skin incision is made as in routine tympanoplasty and extended through subcutaneous tissue while preserving the periosteal layer attached to the cortical bone (Fig. 1A). After dissecting the subcutaneous and muscular tissues anteriorly to the EAC position, a c-shaped incision is made at the periosteum (Fig. 1B). Subsequently, the thin periosteal layer is elevated from the cortical bone using a periosteal elevator (Fig. 1C). Next, posterior EAC wall and posterior mastoid cortex is carefully drilled out in a cylinder shape to broadly widen the EAC (Fig. 1D-F). Throughout the procedure, the skin, and the bony part of the EAC anterior wall is preserved (Fig. 1G).

Temporalis fascia is harvested from the temporal area, and a cartilage piece is harvested from the conchae of the auricle for reconstruction materials. The exposed large mastoid cells on the attic side are covered with two layers of thinly minced cartilage to prevent the antrocutaneous fistula and skin retraction near the tympanic membrane from entering the mastoid air cells (Fig. 1H). And then, perichondrium and temporalis fascia are placed over the cartilage layer from the scutum to the middle part of EAC to cover the bare bone and cartilage (Fig. 1I-J). Then, a thin anterior-based periosteal flap is pulled down toward the EAC side to cover the exposed mastoid air cells (Fig. 1K). Finally, gelfoam and Vaseline gauze packing is done in the EAC (Fig. 1L). After 4 weeks, EAC packing is removed at the outpatient clinic.

Results

Total of four patients received WCAPR technique for the treatment of acquired EAC stenosis. Among the four patients who developed acquired EAC atresia, two developed it as a result of recurrent chronic inflammation, while the other two developed it due to temporal bone fractures resulting from head trauma. All patients were male, with a mean age of 58 years old. The average follow-up duration after surgery was 32.5 months. Patient demographic data and postoperative results are listed in Table 1. The average preoperative pure tone air-conduction and air-bone gap (ABG) were 41 dB HL and 18 dB HL, respectively. Postoperative pure tone air-conduction and ABG average were 30 dB HL and 9 dB HL, respectively. During follow-up period, there was no restenosis or other complications among the patients (Figs. 2 and 3).

A thirty-nine-year-old male (case 5), who underwent traditional technique using split-thickness skin graft for the treatment of acquired stenosis, was also reviewed for the comparison of the operative results. The patient received operation due to recurrent inflammation with otorrhea from stenotic EAC (Table 1). Six months after surgery, inflammation recurred, leading to restenosis. Two years after initial operation, he required revision surgery for the recurrent left EAC stenosis (Fig. 4). Following the revision surgery, the patient is undergoing follow-up with conservative management, including dressing and otic drop treatment, on an outpatient basis.

Discussion

Acquired atresia of the EAC has been classified by Tos and Balle into four categories based on its etiology: post-traumatic, post-operative, neoplastic and post-inflammatory.[2,6] Among them, post-inflammatory is most common, but it has an estimated prevalence of less than 0.6 per 100000 people per year.

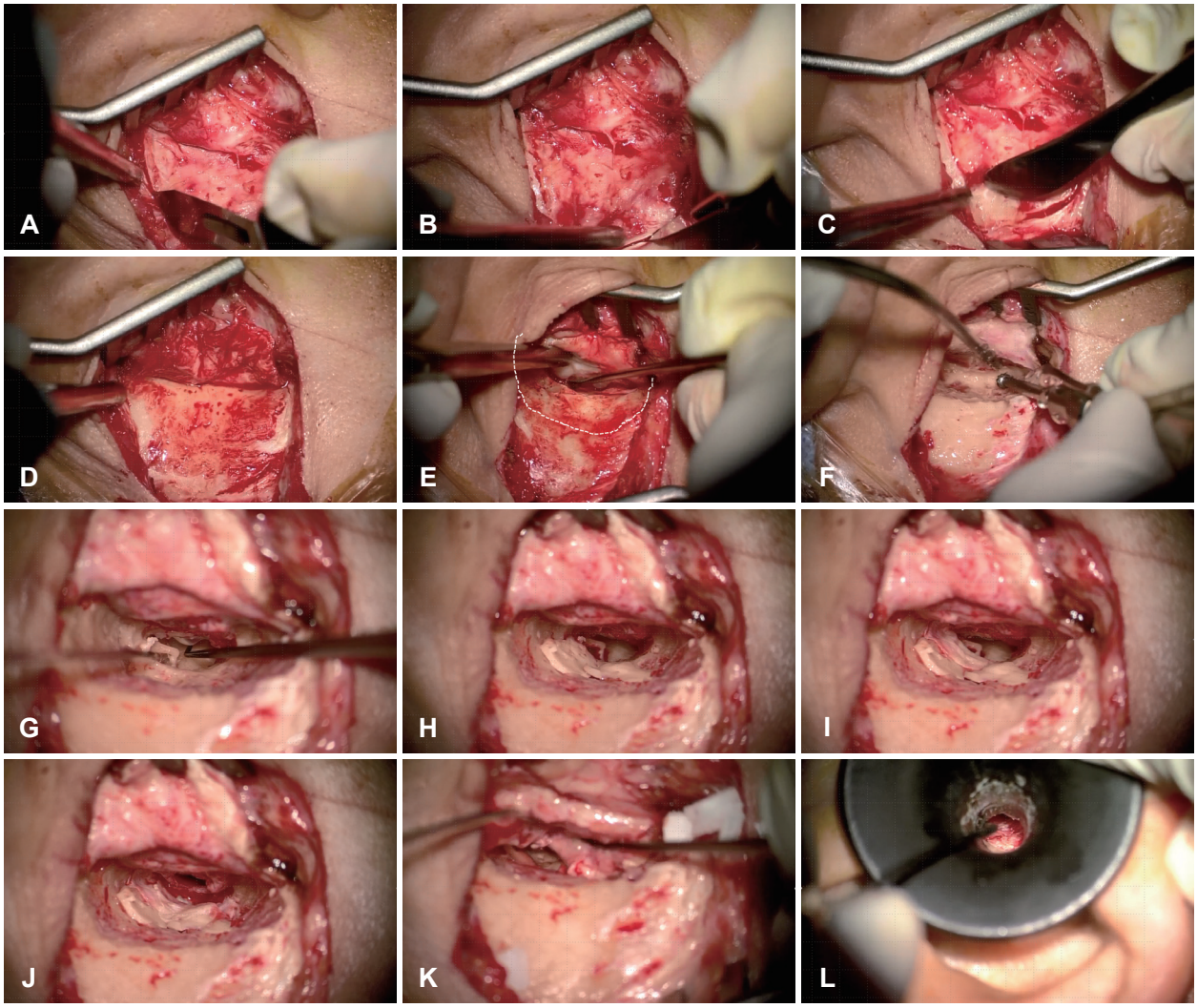

Fig. 1. Stepwise photos of wide cortical drilling and anterior-based periosteal flap reconstruction procedures. A: After the postauricular skin incision, the subcutaneous and muscle layer is attached to the auricle side, leaving the thin periosteum attached to the mastoid cortex. B: C-shaped incision in the periosteum. C: Elevation of the periosteum from the cortical bone. D: The external auditory canal (EAC) is exposed after elevation of the periosteum. E: Highlighted with a white dotted line, indicating the region where the EAC is widened using a drill. F: Widening of the EAC through drilling. G: Removal of the EAC posterior wall, with a view of the incus and tympanic membrane. H: Coverage of the exposed mastoid air cell with thinly minced cartilage in a two-layer technique. I: Covering the scutum area with perichondrium above the cartilage flap. J: Covering the bare bone and cartilage with temporalis fascia. K: Pulling the anterior-based periosteal flap towards the EAC, covering the exposed mastoid air cells. L: Packing the EAC with Vaseline gauze.

Table 1. Patient characteristics and operative results

Case	Sex	Age	Etiology	Surgery technique	Preop AC PTA	Preoperative ABG	Postop AC PTA	Postoperative ABG	ΔBC	Restenosis	F/U duration (months)
1	M	42	Trauma	WCAPR	10	5	9	0	4	No	37
2	M	73	Inflammation	WCAPR	46	9	50	10	2.5	No	22
3	M	63	Trauma	WCAPR	78	53	30	16	0	No	23
4	M	53	Inflammation	WCAPR	30	4	31	8	0	No	48
5	M	39	Inflammation	Conventional canaloplasty, skin graft	34	20	64	36	0	Yes	60

Preop AC PTA, preoperative air-conduction PTA (dB HL); Postop AC PTA, postoperative air-conduction PTA (dB HL); PTA, pure tone audiometry; ABG, air-bone gap; ΔBC, change in bone conduction (postoperative bone conduction PTA - preoperative bone conduction PTA (dB HL); F/U, follow-up; M, male; WCAPR, wide cortical drilling and anterior-based periosteal flap reconstruction

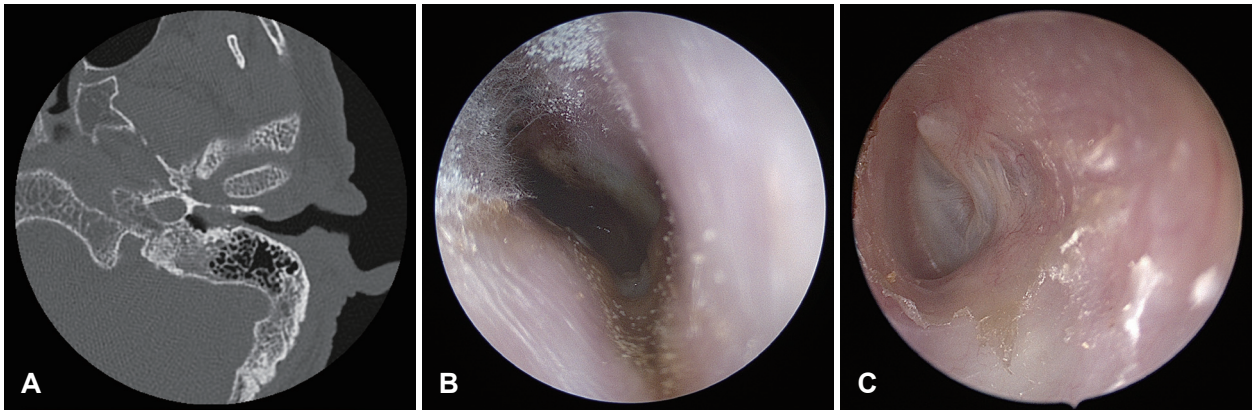

Fig. 2. Temporal bone CT and endoscopic photo of left external auditory canal (EAC) from case 2, who underwent wide cortical drilling and anterior-based periosteal flap reconstruction. A: Preoperative axial CT scan showing erosion of anterior EAC wall, and a narrowed canal filled with soft tissue density. B: Preoperative endoscopic photo revealing anterior wall protrusion with otomycosis at superior portion. C: Postoperative endoscopic photo showing widened posterior wall with a well- visualized tympanic membrane.

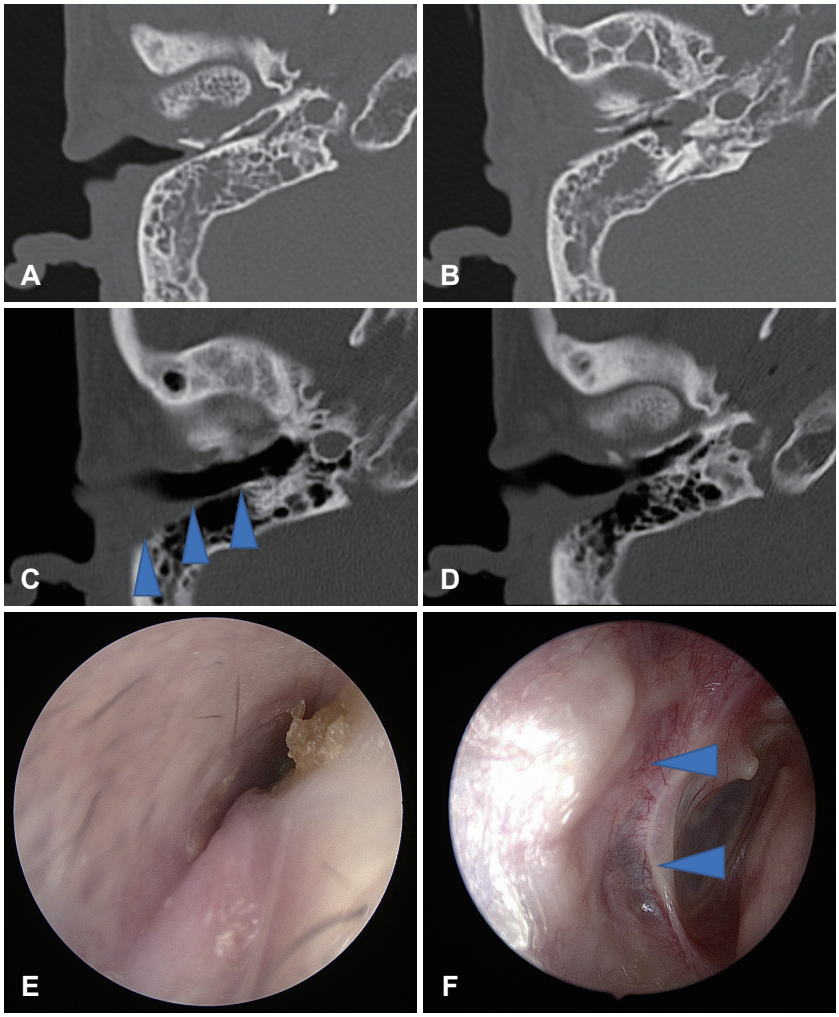

Fig. 3. Temporal bone CT and endoscopic photo of right external auditory canal (EAC) from case 3, who underwent wide cortical drilling and anterior-based periosteal flap reconstruction. A and B: Preoperative axial CT scan showing fracture of anterior EAC wall and a narrowed canal. The middle ear and mastoid cavity are also filled with soft-tissue density due to trauma. C and D: Postoperative axial CT scan 1 year after surgery showing a clear, broad canal. Periosteal flap and cartilage reconstructed posterior wall is indicated with blue arrowheads. E: Preoperative endoscopic photo showing a narrow EAC with tympanic membrane not visible. F: Postoperative endoscopic photo showing widened canal. Blue arrowheads indicate the EAC expanded through wide drilling.

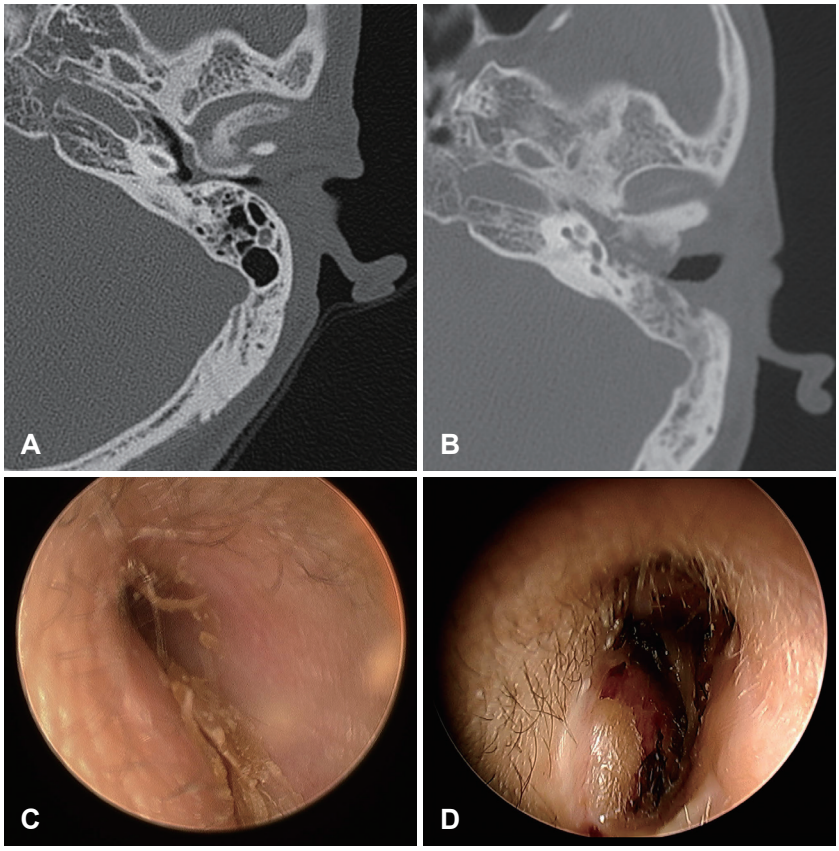

Fig. 4. Temporal bone CT and endoscopic photo of right external auditory canal (EAC) from case 5, who underwent traditional canaloplasty using skin graft. A: Preoperative axial CT showing stenotic right EAC. B: Postoperative axial CT scan two years after surgery showing soft-tissue density filling the medial part of EAC. C: Preoperative endoscopic photo showing a narrow EAC. D: Postoperative endoscopic photo showing a narrow canal filled with crusts.

Various terminologies, including "medial meatal fibrosis," "obliterative otitis externa," and "acquired medial canal fibrosis," have been used to describe this entity. There are still many controversies in underlying etiologies and management of this disease entity.[2)]

The conventional method of canaloplasty to treat acquired atresia of EAC typically involves widening the narrowed EAC and reconstructing the exposed bony defect and widened EAC through split-thickness skin grafting. However, this approach has disadvantages, including the risk of skin graft failure or recurrence of EAC stenosis.[2,7)] Since the harvested skin from forearm or postauricular area lacks the physiological quality of the EAC skin, with absent sebaceous and ceruminous apocrine glands, the graft may result in scarring and contractures.[2)]

The advantage of our surgical WCAPR technique is that it does not require skin grafting. Therefore, postoperative use of long-term packing/stenting, as in traditional canaloplasty procedure, is not usually required with this technique because skin grafting is not involved.[8)] Furthermore, morbidities related with skin harvesting at the harvest site can also be prevented.

And especially in cases where the EAC's anterior wall becomes narrowed due to a posterior displacement of the temporomandibular (TM) joint, as seen in temporal bone fractures, the conventional technique may result in restenosis due to the TM joint's posterior displacement during the follow-up period. However, our technique can prevent restenosis by widening the posterior wall of the EAC while maintaining the posteriorly displaced anterior auditory canal despite the posterior pushing of the anterior wall of the EAC, even when it is narrowed. Complications such as antrocutaneous fistula, which can result from the exposure of the bony defect, are effectively prevented by the anterior-based periosteal flap. This technique not only ensures the maintenance of the EAC, but also prevents associated complications, keeping the stability of the EAC posterior wall over several years.

Significant improvement in hearing after surgery has been reported in both short- and long-term results in the literature.[2,9)] In our case series, a patient with a large ABG (case 3; 53 dB)

showed a significant improvement after the WCAPR operation, while others with minimal ABG did not experience hearing improvement after the operation. Stultiens, et al.,[9] suggested indication criteria for preoperative audiometry, recommending an ABG more than 20 dB HL and an air conduction more than 35 dB HL for canaloplasty operation in acquired EAC atresia. Therefore, proper patient counseling is crucial to achieve appropriate patient expectations for hearing outcomes after surgery.

There are several limitations to our study. Firstly, this study presents preliminary results based on only four cases, and future studies with a larger number of cases will be needed to strengthen the evidence. Secondly, as late restenosis has been reported to occur as far as 9 years post-operatively,[2] longer follow-up observations may be necessary to detect the occurrence of restenosis. Additionally, since this study relies on retrospective medical records, future research might benefit from a prospective randomized controlled trial comparing our technique with traditional surgical methods to assess its effectiveness.

In conclusion, the use of WCAPR technique for the treatment of acquired stenosis of the EAC appears to be an effective, fast-recovery, and safe surgical method with a low risk of recurrence.

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Author Contribution

Conceptualization: Kyu-Yup Lee. Data curation: Myung Hoon Yoo, Kyu-Yup Lee. Formal analysis: Myung Hoon Yoo, Kyu-Yup Lee. Funding acquisition: Myung Hoon Yoo. Investigation: Myung Hoon Yoo, Kyu-Yup Lee. Supervision: Kyu-Yup Lee. Writing—original draft: Myung Hoon Yoo. Writing—review & editing: Kyu-Yup Lee.

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