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ORIGINAL ARTICLE

# Mastoid obliteration and canal wall reconstruction with posterior auricular artery (PAA) fascia-periosteum flap

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**KEYWORDS**
Mastoid obliteration;
Canal wall reconstruction;
External auditory canal reconstruction;
Revision tympanoplasty;
Mastoidectomy

**Abstract**
*Objective:* Unstable cavities are defined as cavities with cerumen accumulation that need frequent cavity cleaning in the out-patient clinic, cavities that are intolerant to water due to risk of infection or that are subject to frequent infection and otorrhoea. The objective of this study is to address the problem of troublesome mastoid cavities, with the performance of secondary mastoid obliteration and canal wall reconstruction, using a novel posterior auricular artery (PAA) fascia-periosteum flap.
*Materials and methods:* A prospective study was designed, only secondary obliterations were included. Unstable mastoid cavities were defined as Merchant grade 2 or 3 and were included for surgery.
*Results:* At 12 months of follow up, a complete external auditory canal (EAC) and a self-cleaning ear were achieved in all 23 patients. Completely dry ears were achieved in 21 patients (91.3%). An air-bone gap improvement of 5 dB was achieved.
*Conclusion:* Mastoid obliteration and EAC reconstruction are effective procedures to treat troublesome post canal wall down mastoid cavities. They improve quality of life and enable patients to overcome ear discharge. A standard EAC size enables the utilization of conventional hearing aids, it also reduces the need for constant mastoid cleaning and decreases healthcare expenses. The PAA flap seems to be an effective procedure to achieve all these features, as it is used to obliterate the mastoid and becomes a structural component of the neo-EAC.


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**PALABRAS CLAVE**
Obliteración mastoidea;
Reconstrucción de pared posterior;
Reconstrucción del conducto auditivo externo;
Timpanoplastia de revisión;
Mastoidectomía.

**Obliteración mastoidea y reconstrucción del conducto auditivo externo con un colgajo fascio-perióstico de la arteria auricular posterior (AAP)**

**Resumen**
*Objetivo:* Las cavidades inestables se definen como cavidades que presentan acumulación de cerumen que requieren limpieza en la consulta de manera frecuente, son cavidades intolerantes al agua por su elevado riesgo de infección o tienen frecuentes infecciones y otorrea. El objetivo de este estudio es abordar el problema de las cavidades mastoideas problemáticas con una obliteración mastoidea secundaria y reconstrucción del conducto auditivo externo (CAE) usando un colgajo fascio-perióstico de la arteria auricular posterior.
*Materiales y métodos:* Se diseñó y realizó un estudio prospectivo, solo se incluyeron obliteraciones secundarias. Las mastoides inestables fueron definidas según la clasificación de Merchant como grado 2 o 3 y fueron incluidas para la cirugía.
*Resultados:* A los 12 meses de seguimiento, se consiguió un CAE completo y autolimpiable en los 23 pacientes. Se lograron oídos completamente secos en 21 casos (91,3%). Se obtuvo una mejoría media en la brecha aire-hueso de 5 dB.
*Conclusión:* La obliteración mastoidea y la reconstrucción del CAE son procedimientos eficaces para tratar mastoides problemáticas posmastoidectomías abiertas. Mejoran la calidad de vida de los pacientes y son efectivas para solventar la otorrea recurrente. La obtención de un CAE de tamaño estándar es importante para permitir que el paciente pueda utilizar una audioprótesis estándar, además de reducir la necesidad de limpieza de la cavidad de manera constante y la dependencia del paciente a los controles en la consulta, disminuyendo así el gasto en sanidad. El colgajo de arteria auricular posterior parece ser una herramienta útil para lograr todas estas características, y también es usado para obliterar las mastoides y se convierte en un componente estructural del neo-CAE.


## Introduction

The primary aim in treating chronic otitis media with cholesteatoma is the complete eradication of the squamosal disease.[1] Surgeons frequently conduct extensive drilling leading to a large mastoid and epitympanic cavity. Multiple recurrences of cholesteatoma require a canal wall down technique (CWD) to ensure the complete eradication of the disease by giving access to hard-to-reach areas located in the middle ear, otherwise difficult using only an operating microscope.[2]

In the last few years, it has been proposed that to significantly reduce the recurrence rate of cholesteatomas, it can be performed either: well-known CWD procedures (with or without EAC reconstruction); or CWU procedures with obliteration of the mastoid cavity and epitympanic space.[3–10]

Unstable cavities are defined as cavities with cerumen accumulation that need frequent cavity cleaning at the out-patient clinic, cavities that are intolerant to water due to risk of infection, and have frequent infection and otorrhoea. Other troublesome problems are calorically induced vertigo from either non-isothermal air or water exposure; and for patients with hearing loss, an inability to wear a conventional hearing aid. Patients with troublesome cavities are characterized by the need for multiple operations and multiple visits to an out-patient clinic each year. As well as affecting the troubled ear, the disorder also restricts patients' activities and social interactions.[11–12]

The problem of recurrent inflammation and infection is mainly caused by the loss of the self-cleaning capacity of the ear, which leads to the accumulation of epithelial debris and this necessitates regular cleaning of the mastoid cavity.

Merchant et al. in 1997 developed a staging system for troublesome mastoid cavities[14]:

- Grade 0: No episode of otorrhea, and no pus or granulation tissue on otologic examination.
- Grade 1: One episode of otorrhea of fewer than 2 weeks duration in a 3-month period or no otorrhea but a subjective feeling of wetness in the ear.
- Grade 2: More than one episode of otorrhea in a 3-month period, or an episode of otorrhea lasting more than 2 weeks, or otologic exam showing localized granulation tissue/pus that was promptly cured with antibiotic drops, curettage, or silver nitrate cautery.
- Grade 3: Constant purulent otorrhea daily, or otologic exam showing extensive granulation tissue, or need for a revision procedure to control infection.

One of the goals of the mastoid and epitympanic obliteration technique is to rebuild an external auditory canal (EAC) with near-normal dimensions. This results in a better self-cleaning capacity of EAC and leads to a better hygienic status of the ear.

The objective of this study is to address the problem of troublesome mastoid cavities with a secondary mastoid

obliteration and canal wall reconstruction. Utilizing a novel posterior auricular artery (PAA) fascia-periosteum flap.

## Materials and methods

*Study design*: A prospective study was designed including patients with the following criteria: (1) adult patients; (2) previous CWD tympano-mastoidectomy of at least 2 years prior to surgical indication; (3) troublesome mastoid cavity (Merchant grade 2 or 3); (4) patients were included with or without an intraoperative finding of cholesteatoma recidivism.

*Patient criteria*: Surgical indication included ears that had been previously operated on with a CWD tympano-mastoidectomy for cholesteatoma at least 2 years prior to the indication of the mastoid obliteration and EAC reconstruction, this is due to give enough time for the mastoid to heal completely. Only patients categorized in a Merchant grade 2 or 3 were due for surgery. Mean audiometric results at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz at air and bone conduction thresholds were obtained preoperatively and 6 months after surgery. Follow-up was 12 months per patient.

This study was performed in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The Institutional Review Board of the authors' institution approved this study (PR243/20).

*Surgical technique*: For the design and harvest of the posterior auricular artery (PAA) fascia-periosteum flap, a conventional postauricular approach that is used for any mastoidectomy is performed. For the elevation of the flap, the incision is required to arrive at the fascia temporalis plane. The length and width of the flap are designed according to surgical needs. Regularly the plausible flap size can fully obliterate any mastoid and reconstruct every EAC. The flap has as anterior, posterior, and superior limits, the limits of the deep temporal fascia. After elevating the fascia temporalis, following a superior to inferior direction, at the level of the linea temporalis (zygomatic arch projection), the fascia is anatomically communicated as a continuum, sharing common vascularization, with the mastoid periosteum. The elevation of the flap is continued until the mastoid tip (Fig. 1). The pedicle of the posterior auricular artery is not identifiable, hence, the mastoid tip is used as a landmark. The flap is retrieved from the surgical area and protected alongside its pedicle at the mastoid tip.

Posteriorly, a full epithelial cleanse of the mastoid cavity is needed, regularizing bony ridges and irregularities. In cases of intraoperative cholesteatoma finding, it was also fully removed. All signs of epithelium must be removed in order to avoid postoperative iatrogenic cholesteatoma sac development.

Middle ear assessment was made, ossicular chain (OC) status was checked. In the case of a mobile footplate, ossicular chain reconstruction (OCR) was made: (1) with an intact stapes suprastructure, OCR was made with a polyethene partial ossicular replacement prosthesis (PORP); (2) In case of an absent suprastructure, a total ossicular replacement prosthesis (TORP) was utilized for OCR. The tympanic membrane was reconstructed with a full-thickness (from tragus or conchae) cartilage.

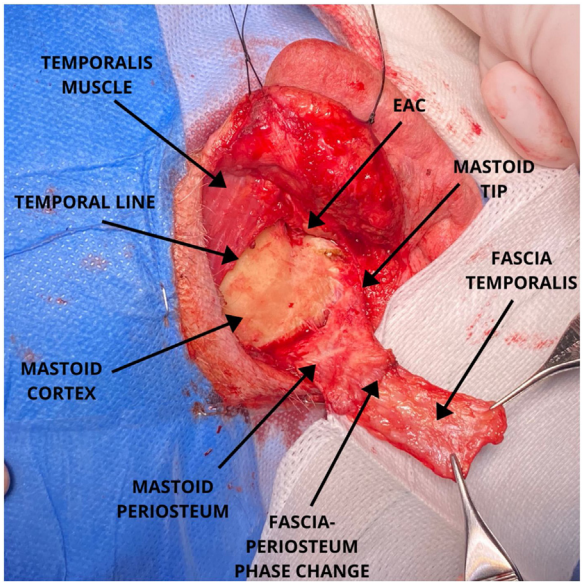


**Figure 1** Fully elevated PAA fascio-periosteal flap (right ear).

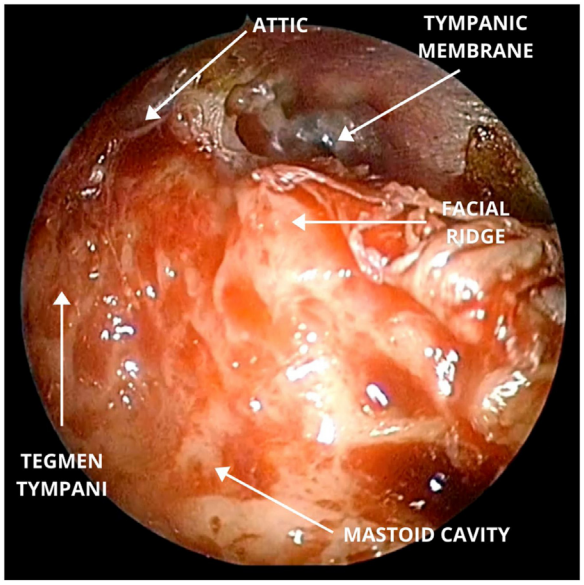


**Figure 2** Endoscopic view of a mastoid cavity (right ear). In this image, an epithelium free CWD mastoid cavity can be observed.

The mastoid cavity was then obliterated and the PAA fascia-periosteum flap, fixated with fibrin glue sealant (Tissucol Duo; Baxter AG, Vienna, Austria). The OCR, tympanic membrane, and flap placement were done with the utilization of endoscopes due to enhanced visualization and precision (Figs. 2–5).

Statistical tables and analysis of data were carried out using Jamovi statistical software [The jamovi project (2020). jamovi (Version 1.2) (Computer Software). Retrieved from https://www.jamov i.org]. Statistical significance was accepted to a maximum *p*-value at the level of .05. For calculating statistical differences for quantitative

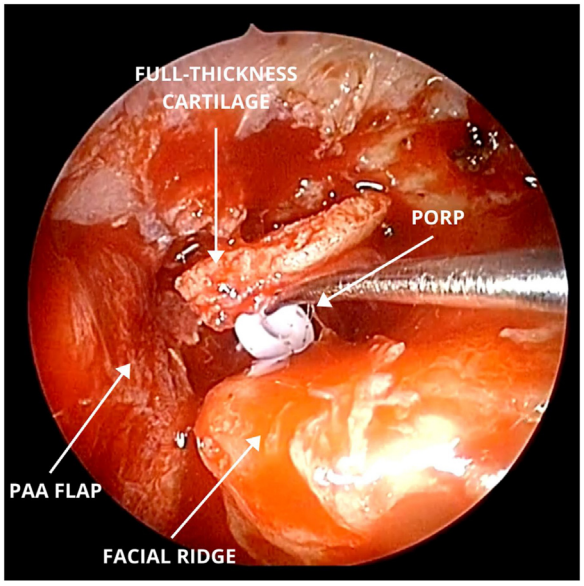


**Figure 3** Ossiculoplasty and tympanic membrane reconstruction (right ear).

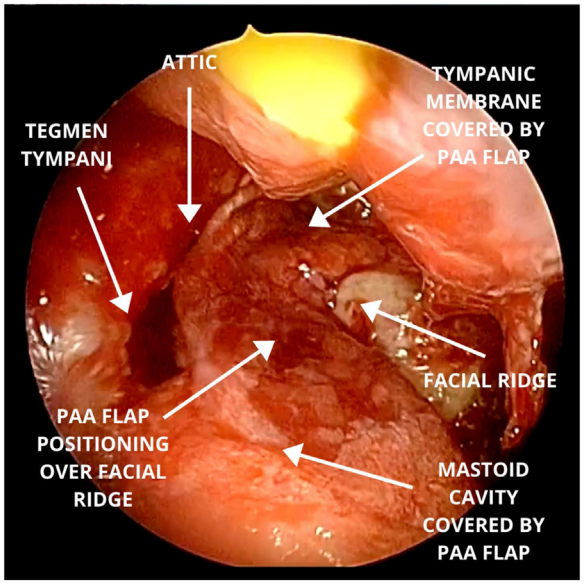


**Figure 4** PAA flap placement over the facial ridge and tympanic membrane (right ear).

continuous variables, an analysis of variance (ANOVA) test was performed comparing the groups.

## Results

Of all the 23 patients operated on, 13 patients were female (57%) and 10 were male (43%). The mean age was 58 years old (range 29–81). Follow up was stipulated to be 12 months per patient.

*Intraoperative findings* (Table 1): Recurrent cholesteatoma was found in 6 patients (26.1%) and granulomatous formations in 17 patients (73.9%). In relation to the OC status, we encountered a fixated stapes footplate in 16 cases (69.6%); 7 footplates were mobile, from those, an intact suprastructure was found in 5 cases (21.7%) and an eroded footplate in 2 cases (8.7%).

For ossiculoplasty materials, a total of 15 PORPs and 8 TORPs were placed.

*Hearing assessment* (Table 2): Hearing results were obtained as follow: mean preoperative air conduction (AC) threshold of 68 dB (SD 15.1); mean preoperative bone conduction (BC) threshold of 33 dB (SD 14.4); mean preoperative air-bone gap (ABG) of 35 dB (SD 9.5); mean postoperative AC threshold of 62 dB (SD 14.6); mean postoperative BC threshold of 32 dB (SD 14.7); mean postoperative ABG of 30 dB (SD 10.3); an obtained ABG improvement of 5 dB.

*Morphological postoperative results* (Table 3): At 12 months of follow up, a complete EAC and a self-cleaning ear were achieved in all 23 patients (Fig. 6). Completely closed tympanic membranes were achieved in 21 patients (91.3%). As for negative results, we found mild attical retractions in 3 patients (14.3%) and tympanic membrane residual perforations in 2 patients (8.7%). No cholesteatoma recurrences were clinically observed during follow-up,

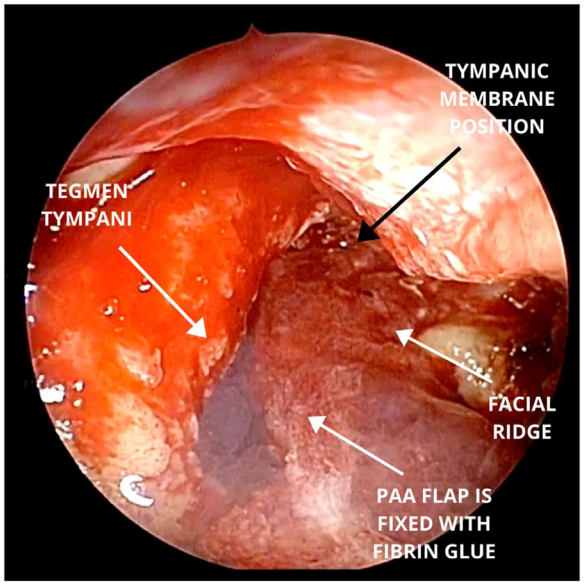


**Figure 5** PAA flap is fixed with fibrin glue (right ear).

**Table 1** Intraoperative findings.

| | *N* | % |
|---|---|---|
| Cholesteatoma | 6 | 26.1 |
| Fixed footplate | 16 | 69.6 |
| Intact stapes suprastructure | 5 | 21.7 |
| Absent stapes suprastructure | 2 | 8.7 |

**Table 2** Hearing assessment.

| | Preoperative | Postoperative | *p*-Value |
|---|---|---|---|
| AC dB (SD) | 68 (15.1) | 62 (14.6) | 0.18 |
| BC dB (SD) | 33 (14.4) | 32 (14.7) | 0.81 |
| ABG dB (SD) | 35 (9.5) | 30 (10.3) | 0.09 |

**Table 3** Morphological postoperative results.

| | *N* | % |
|---|---|---|
| Complete EAC | 23 | 100.0% |
| Self-cleaning ears | 23 | 100.0% |
| Dry ears | 21 | 91.3% |
| Mild attical retraction | 3 | 14.3% |
| TM residual perforation | 2 | 8.7% |

EAC: external auditory canal; TM: tympanic membrane.

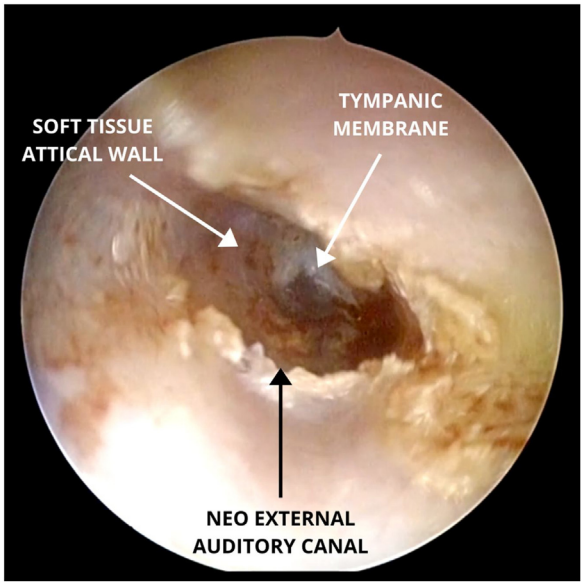


**Figure 6** Six months postoperative otoendoscopy (right ear).

neither at a diffusion-weighted (DWI) MRI conducted at 12 months postoperatively.

## Discussion

Unstable, troublesome post-CWD mastoid cavities are a common problem for otologic surgeons. The objective of this study is to report our outcomes of revision surgery including the obliteration of the mastoid bowl of troublesome mastoid cavities. The impact of unstable cavities on quality of life (QoL) is notable, with hearing loss and foul-smelling drainage driving to discomfort and potential social restraint and isolation. Moreover, the need for frequent mastoid cavity cleanings also leads to patient nuisance and healthcare expenses.[19–21] Patients usually are unable to wear conventional hearing aids due to chronic drainage and distorted anatomy of the external auditory canal.[22]

Mastoid cavities with a grade 2 or 3 of Merchant classification were considered as troublesome and were addressed for revision surgery with secondary mastoid obliteration with a novel posterior auricular artery fascia-periosteum flap.

Regarding morphological postoperative results, our cohort reports that structural results are comparable to some published in the literature regarding mastoid obliteration and canal wall reconstruction.[15–18] The flap appears to become a structural component of the canal wall, forming a soft-tissue neo-canal wall in every case. The fascia and the periosteum are fibroblast abundant tissues and when well-vascularized, active tissue metaplasia occurs, obtaining a well-formed neo-canal. We exclusively reported cases of revision surgery (secondary obliteration), but in cases in which a CWD procedure is required, mastoid obliteration and EAC reconstruction can be performed during the primary procedure. A proper mastoid obliteration was achieved without using additional autograft or allograft materials other than the PAA flap. There was no need for harvesting additional autogenous materials for the reconstruction of the posterior EAC wall.

About intraoperative findings, it was remarkable that a considerable proportion of patients produced a fixed stapes footplate (approximately 70%), apparently, this is a common finding in this type of cavities due to chronic inflammation or, due to the chronic retraction pocket that is inherent to CWD mastoid cavities.[15] Also in 26% of the patients, some cholesteatoma pearls were detected that had not been assessed clinically prior to the surgery.

In regard to hearing outcomes, an ABG difference between preoperative and postoperative findings of 5 dB was noticed, and the improvement was not statistically significant. This finding disagrees with studies such as one from Cox et al.[23] in 2016, who reported an ABG improvement of 16.9 dB and 40% of proportion to close the gap to less than 20 dB, also in a cohort of only secondary obliterations.

Following the first description of mastoid obliteration surgery, several surgical procedures have been developed, employing a variety of obliteration materials, and can be divided into two different subgroups: free graft obliteration (autologous or synthetic) and soft tissue flap obliteration. Vascularized soft tissue flaps are mobilized and rotated into the empty mastoid cavity.[24] Materials including soft tissues, bone, cartilage, or synthetic biomaterials are applied to fill the empty mastoid and epitympanic space. The primary surgical principle is the purpose to reduce the mastoid size and to normalize the size of the EAC, and according to current literature, most materials have provided the conditions to fulfil these requirements.[13]

A few recent studies have reported a significant increase in QoL for patients who underwent mastoid obliteration and EAC reconstruction, and that improvement in QoL was not related to a hearing recovery.[25,26]

In other studies, flap reconstructions of the mastoid cavities have a major disadvantage and have thus been almost abandoned (see e.g. the Palva-flap) for obliteration procedures, using instead autologous or synthetic materials. It appears that the main disadvantage is the retraction at its tip turning the epitympanum and attic space into an open space. In this flap, this problem appears not to occur as the tip of the flap is placed on the inferior end of the TM and not covering the attic.

The success rate for EAC reconstruction with soft-tissue obliteration with the PAA flap seems to be effective and the results are according to current literature. The flap appears to become a structural component of the neo-canal. Although the flap is not bulky, it is sufficient to obliterate a sclerotic mastoid cavity without the need for additional materials. It seems to contract less than a muscular flap during the healing process.

Weaknesses of the study: The first weakness point of the study is the number of patients, we believe that a larger number of patients is needed for more accurate results.

Also, prospective cohort studies do not provide an elevated level of evidence, so controlled clinical trials should be conducted to address this matter in a better way. The follow up is only 12 months, on many occasions, the tissue retraction appears to occur 4 or 5 years in the postoperative period. So even though dry and self-cleaning ears were obtained a year after surgery, long term complications could not be discarded. More studies on this matter are required for long term results.

## Conclusion

Mastoid obliteration and EAC reconstruction are effective procedures in order to treat troublesome post-CWD mastoid cavities. They improve the QoL and allow patients to overcome ear discharge that could drive them to self-isolation, also the recovery of a standard EAC size enables the utilization of conventional hearing aids. Mastoid obliteration also reduces the need for constant mastoid cleaning and decreases healthcare expenses. The PAA flap seems to be an effective procedure to achieve all those features, as it is used to obliterate the mastoid and becomes a structural component of the neo-EAC.

## Authors' contribution

The authors alone are responsible for the content and writing of this article.

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## Conflict of interest

The authors report no conflicts of interest.

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