Subtotal petrosectomy - a tertiary center's experience

Original Article

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Abstract

Introduction: Subtotal Petrosectomy (SPT) is an effective and definitive solution in cases of recurrent chronic otitis media. The expansion of its indications demonstrates its usefulness and safety in resolving various challenging otologic pathologies.

Materials and Methods: A retrospective study of 25 patients (26 ears) who underwent SPT was conducted. Data regarding the indication, surgical procedures performed, complications, and clinical outcomes were collected.

Results: Fourteen (n=14) patients with cholesteatomatous chronic otitis media (COM) were proposed for SPT due to recurrence. None of these patients (n=0) had useful hearing. Five (n=5) had facial palsy.

The second most frequent indication (n=10) was COM associated with profound sensorineural hearing loss, and cochlear implantation was performed simultaneously in these cases. None (n=0) had facial palsy or disease recurrence.

Other indications included tympanomastoid paraganglioma (n=1), anatomical factors in cochlear implant surgery (n=2), and intracochlear schwannoma (n=1).

During the follow-up period (mean = 25 months), no signs or symptoms of recurrence were observed in these patients. Complications occurred in four cases, skin fistulization of SPT cavity (1), electrode array extrusion (1) and postoperative infection of the PST cavity (2).

Conclusion: PST has proven to be a safe and effective surgical technique. PST with simultaneous cochlear implantation is a viable option for patients with COM. Surgical treatment with PST for COM should be considered when a poor audiological outcome is expected in a Canal Wall Down (CWD) mastoidectomy.

Keywords: Subtotal Petrosectomy; Cochlear Implantation

Introduction

Subtotal petrosectomy (STP) was originally described between 1950 to 1960 as the complete removal of tympanomastoid cells,[1] but the term was only introduced by Ugo Fisch in 1965.

Debate still surrounds the extent of surgical resection in STP due to its complex initial description, as well as its association with lateral approaches to the skull base[2,4–5] and with temporal bone tumors.[5–6]

STP is an effective treatment for chronic and recurrent middle ear diseases as it ensures complete removal of the tympanomastoid cells, tube obliteration, and cul-de-sac closure of the external auditory canal (EAC).[2]

Furthermore, STP is a safe surgical technique for cochlear implantation (CI), even in the pediatric age-group. However, cases with active infection require surgical staging.[3]

Therefore, the objective of this study was to elucidate the various contexts associated with STP and its indications. STP is often considered only as a second surgery for recurrent ear disease, even if a poor audiometric result is already expected. Nonetheless, it is the safest and most effective surgery for CI placement in an ear with chronic otitis media (COM) and for complete removal of middle ear tumors.

Materials and methods

This retrospective study examined patients who underwent STP at the otorhinolaryngology service of the Centro Hospitalar de Lisboa Oeste between 2012–2022.

All surgical records available at the service were examined between January 2012–December 2020, and all patients undergoing STP were selected. The exclusion criteria were patients undergoing STP as a preliminary procedure to enable a lateral approach the skull base, particularly when the Fisch type A approach to the infratemporal fossa was used for the excision of jugulotympanic paraganglioma or schwannoma originating from the lower pair of cranial nerves.

In our practice, STP is performed by a postauricular approach with EAC section and cul-de-sac closure involving the skin and cartilage, removal of all skin from the bony portion of the EAC and all of the middle ear mucosa, formation of a cavity by opening all tympanomastoid cells followed by their regularization, auditory tube sealing with previously harvested muscle, and cavity obliteration with abdominal fat. Data collected included the patients' demographic data, indication, surgical procedures, and clinical progression. Patients were categorized into three groups by the surgical objective: (1) chronic otitis media with cholesteatoma (COMC), (2) sensorineural hearing loss (SNHL) with indication for CI by STP, and (3) temporal bone tumors (TBT).

The primary objective in the COMC and TBT groups was disease eradication and prevention of relapses and complications. Facial nerve integrity was the secondary objective, before auditory and vestibular functions.

STP is deemed the safest and most effective approach for CI in patients with SNHL. COM with closed eardrum, suspected cholesteatoma, or anatomic characteristics hindering CI electrode placement by posterior tympanotomy are the essential factors that influence the decision to perform STP and CI at the same surgical time. In these cases, facial nerve integrity, residual hearing, and vestibular function have equivalent importance.

The primary objectives were to assess facial function, complications, and adverse events in patients undergoing STP.

The data were analyzed using the IBM SPSS software version 26 .

This study adhered to all ethical procedures outlined by the World Medical Association's Declaration of Helsinki, and all data were anonymized prior to analysis.

Results

The study comprised 25 patients (26 ears) after excluding five patients who underwent STP as a preliminary procedure to facilitate a lateral approach the skull base.

There were 15 men and 10 women with an average age of 59 years. STP was not performed in children (age_{max} = 81 years, age_{min} = 22 years). One patient underwent bilateral intervention at different surgical times, and two patients underwent rehabilitation with hearing aids prior to surgery. These two patients underwent STP due to tympanomastoid paraganglioma

and cholesteatoma with recurrent otorrhea. Clinical data and surgical indications are described in Table 1. The average follow-up duration was 25 months (= 25).

STP in patients with COMC

In this subgroup, all patients (n = 14) underwent STP as a revision surgery due to complications related to disease recurrence and most patients had undergone at least one open mastoidectomy to treat cholesteatoma.

Complications leading to surgical intervention comprised cholesteatoma recurrence and hearing loss with no possibility of rehabilitation using hearing aids, i.e., with expected poor audiometric result (n = 7); otitis due to recurrent otorrhea (n = 5); and recurrent facial function worsening (n = 2). The subgroup of patients with expected poor audiometric result comprised two patients with active cerebrospinal fluid (CSF) fistulas (n = 2) and one with lateral sinus thrombosis (n = 1). The two patients who were operated due to facial function worsening showed an improvement a few months after surgery. Of all patients undergoing STP, six (n = 6) had already developed some degree of preoperative facial paresis, which did not worsen after STP. Only one of these patients experienced facial function worsening (n = 1) due to surgical manipulation but recovered facial function some months after the surgery because the entire facial nerve was preserved. In three patients (n = 3), the underlying disease required a combination of STP and labyrinthectomy, with two posterior and one anterior labyrinthectomy. Two patients had petrosectomy cavity infection requiring surgical revision, which is considered a major complication. However, no patient experienced disease recurrence during follow-up. Most patients declined rehabilitation with CI, which was only performed in three patients (n = 3) as the second surgical procedure. Two of them (n = 2) were included in a waiting list for an osseointegrated implant due to complete conductive hearing loss not associated with SNHL to justify a CI. The indications, extent, degree of facial paresis by the House-Brackmann (HB) scale, and complications in patients with COMC undergoing STP are summarized in Table 2.

STP in patients with SNHL with indication for CI

Eleven patients underwent STP for CI, with one undergoing bilateral surgery. None

Table 1
Clinical data and surgical indications

Sex	n
Male	15
Female	10
Laterality	
Right	12
Left	12
Bilateral	1
Hearing	
Useful	2
Not useful	24
Indication	
Chronic otitis media with cholesteatoma	14
Cochlear Implant	10
Middle ear tumor	2

Table 2
STP in patients with COMC

Indication	n
Hearing loss	7
Otitis due to recurrent otorrhea	5
Recurrent facial function worsening	2
Extension	
Labyrinthine extension	3
Postoperative facial function	
HB* I	8
HB* II	1
HB* III	1
HB* IV	1
HB* VI	3
Complications	
STP cavity Infection	2

HB* - degree of facial paresis by the House-Brackmann scale
STP, subtotal petrosectomy; COMC, chronic otitis media with cholesteatoma; STP, conductive hearing loss.

of these patients was eligible for hearing rehabilitation, but all of them experienced full facial function recovery (HB I). Five patients (n = 7) had changes compatible with COM without cholesteatoma. In these cases, STP is the safest and most effective solution to prevent the development of cholesteatoma or otorrhea because patients with CI are at increased risk of labyrinth infections with extension to the central nervous system.

Unfavorable intraoperative anatomy may also lead to CI by STP. In these cases, a protruding sigmoid sinus, narrow posterior tympanotomy, or low middle fossa meninx can limit electrode introduction. Two patients (n = 2) required STP to enhance surgical access to the round window and safely introduce the electrode.

Radiotherapy for external ear squamous cell carcinoma is an indication for CI by STP due to increased risk of infection. One patient in our study had this indication (n = 1).

These patients may develop cavity skin fistula with chronic purulent exudate and electrode extrusion due to probable biofilm formation. Despite these complications, no patient experienced facial function worsening.

Table 3 shows STP indications and complications in these patients.

Table 3
STP in patients with SNHL with indications for auditory rehabilitation with CI

Indication	n
Post-irradiation	1
Unfavorable anatomy for electrode insertion via posterior tympanotomy	2
COM with no cholesteatoma	7
Complications	
Skin cavity fistula	1
Electrode extrusion	1

STP, subtotal petrosectomy; COM, chronic otitis media; SNHL, sensorineural hearing loss; CI, cochlear implant.

Table 4
STP in patients with TBT

Indication	n
Tympanomastoid paraganglioma	1
Cochlear schwannoma	1

STP, subtotal petrosectomy; TBT, temporal bone tumors

STP in patients with TBT

The TBT group included two patients, one with tympanomastoid paraganglioma and one with intracochlear schwannoma. Neither of these patients exhibited facial function disorders. The patient with paraganglioma is awaiting an osseointegrated implant due to a preserved labyrinth and sensorineural hearing (Table 4).

Discussion

STP is recommended for patients with chronic and recurrent middle ear disease. Table 5 shows the STP indications according to Prasad et al.[2] The STP method is similar regardless of the indication, involving a postauricular approach with EAC section and cul-de-sac closure involving the skin and cartilage, removal of all skin from the bony portion of the EAC and all of the middle ear mucosa, removal of all tympanomastoid cells followed by cavity regularization, auditory tube sealing with muscle, and cavity obliteration with abdominal fat.[7] The postauricular incision should be wide to prevent fistulas resulting from friable skin and scarring caused by previous surgeries. The cul-de-sac closure must carefully include skin and cartilage layers in patients who were previously operated, and all skin flaps should be removed from the cavity. Total disease eradication can be ensured by removing all middle ear cells and mucosa, EAC skin,

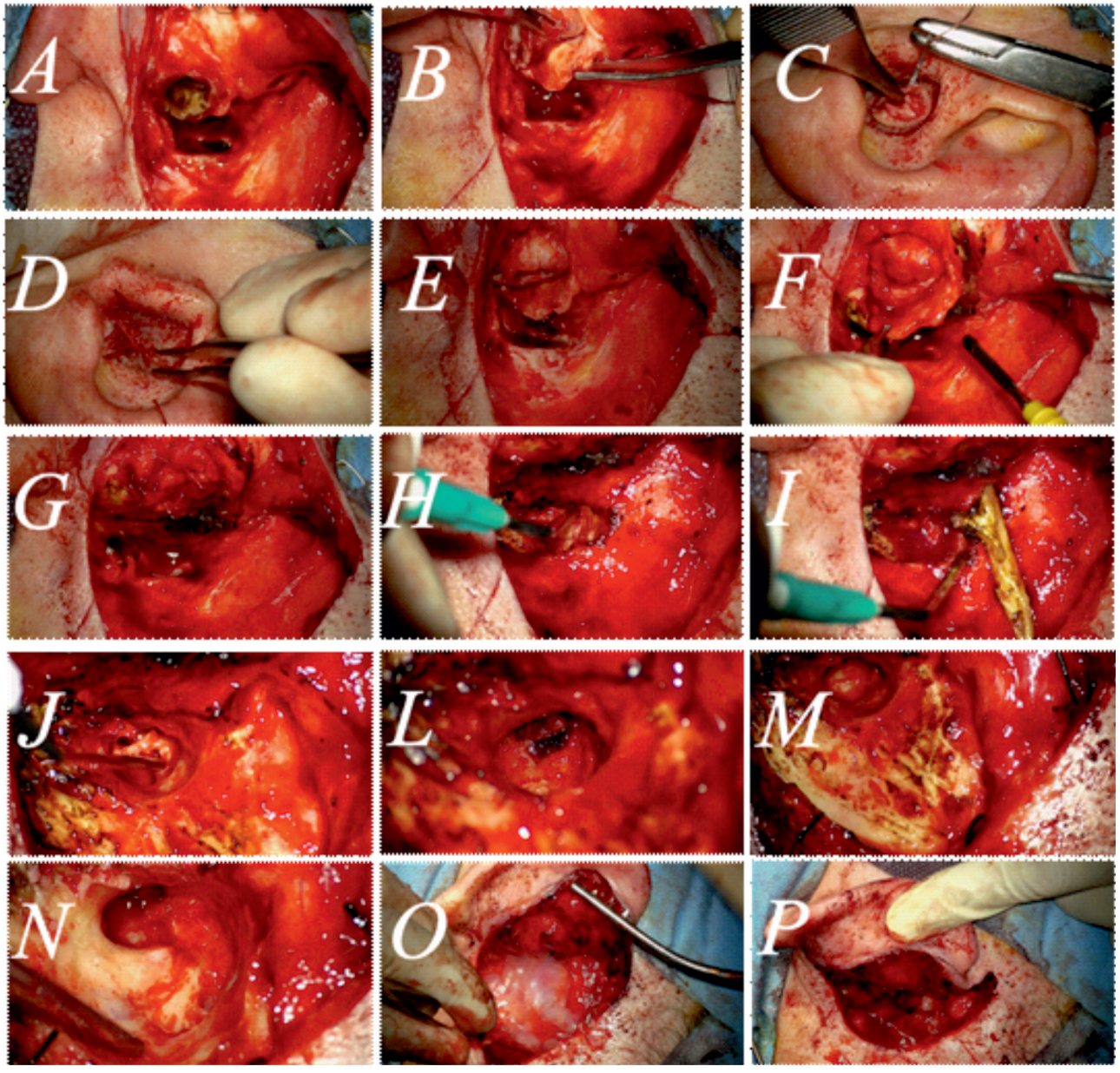
Table 5
STP indications

Indications	Pathology
Disease eradication by removal of all tympanomastoid cells, without petrous apexor internal auditory canal extension	Middle ear cholesteatoma
	Petrous bone cholesteatoma (limited to peri-labyrinthine cells or the labyrinth)
	Osteoradionecrosis
	Paraganglioma with tympanomastoid extension
	Otitis due to recurrent otorrhea
Tumor removal without intradural extension	Facial nerve tumors (tympanic and mastoid portions) limited to the middle ear
	Other tumors limited to the middle ear
	Temporal bone fractures extending to the optic capsule
Exclusion of the middle ear to avoid ear infections due to dura mater and perilymph exposure	Meningoencephalocele
	CSF fistula
CI in cases of difficult access or active COM	Cochlear obliteration and ossification requiring improved access
	Inner ear malformations
	Temporal bone fractures extending to the optic capsule
	Cases requiring revision

STP, subtotal petrosectomy; CI, cochlear implant; COM, chronic otitis media; CSF, cerebrospinal fluid.

tympanic membrane, malleus, and incus. Canaloplasty should be performed in the lower portion of the bony EAC for better exposure and total epithelium removal. Bipolar coagulation should be used to inactivate the matrix when it is adherent to the dura mater, decreasing the risk of resection-related CSF fistula. Bipolarization should also be used to retract meningoencephaloceles to allow correction of the defect with cartilage. [7] The auditory tube should be obliterated with autologous material such as muscle, perichondrium, or cartilage, or a synthetic material such as bone wax or Surgicel® (Figure 1).

Figure 1
A – Sectioned external auditory canal (EAC); B – Skin and cartilage detachment; C – Foreground suture (external); D – End of foreground closure (external); E - End of foreground closure (internal); F – Creation of a second plane (internal); G – End of second plane closure (internal); H – Skin removal from the EAC; I – Periosteal incision; J – Removal of the tympanic membrane and ossicular chain (preoperative sensorineural hearing loss [SNHL]); L – Auditory tube obliteration with temporal muscle and Surgicel; M – Pre-drilling bone exposure; N – End of the subtotal petrosectomy (STP) cavity; O – Obliteration with fat and glue; P – Periosteal closure.



STP allows CI at the same surgical time; CI should only be staged in case of active disease or uncertainty regarding complete disease eradication.[2]

In the past, STP was viewed as a procedure with significant risks, primarily related to increased recurrence rates, with particular concerns regarding the potential entrapment of cholesteatoma. When a cavity is closed, recurrence is identified later due to the onset of complications such as facial paresis, hearing loss, or vestibular deficit. Nonetheless, diffusion-weighted magnetic resonance imaging can identify recurrent lesions of around 2 mm earlier,[8] and enhanced surgical techniques and microscopes have reduced recurrence rates compared to open techniques.[2]

In this study, patients with COMC undergoing STP showed worse facial function compared to the other two groups. Five of these patients already had some degree of preoperative paresis; only one worsened after surgery due to excessive surgical manipulation, but fully recovered previous facial function due to the preservation of facial nerve integrity. In the second largest case series published worldwide which included 529 ears, two cases were reported to experience facial function worsening.[2]

Of the patients undergoing STP, two had previously received rehabilitation with hearing aids prior to surgery, one in the COMC group and the other in the TBT group. However, due to disease extent, an inadequate audiometric result was expected and STP was indicated. One of these patients is waiting for rehabilitation with an osseointegrated implant, and the other was rehabilitated with CI due to poor speech discrimination.

Patients undergoing STP for COMC are at higher risk of severe complications. They have all undergone surgery at least once, resulting in greater difficulties in cul-de-sac closure of the EAC and musculoaponeurotic flaps after postauricular incision due to the previous meatoplasties. Additionally, there is always a risk of cholesteatoma recurrence, although reduced, in at least 1.1% of the patients.[2]

In addition to eradicating disease and creating a viable CI environment, STP can be an efficient solution for CI access and placement in ears with an adverse anatomy. Some examples of an unfavorable anatomy include sclerotic mastoids, inner ear malformations, and anterior lateral sinus prolapse.[3]

One case of CI extrusion occurred in a patient undergoing STP and CI. This complication was also described in at least one case in the largest world series on CI by STP.[2] A systematic review reported a lower complication rate (12.4%) in patients undergoing STP and CI[3] than in patients with CI and canal wall-down (CWD) mastoidectomy cavity (30%).[9]

Therefore, more studies are required to define the precise indications for STP in cases of cholesteatoma recurrence in CWD mastoidectomy cavity. Regardless of the degree of hearing loss or speech discrimination, the key question is when to perform STP to prevent worsening of facial function and vestibular deficit outcomes, thus reducing the quality of life of patients.

STP permits broader exposure and more meticulous cholesteatoma removal.

According to Yan et al.,[3] cholesteatoma has a lower reappearance rate in STP cavities than in mastoidectomy cavities.[10]

Furthermore, STP cavities require no regular follow-up and are less restrictive in terms of activities such as swimming, which may cause vertigo due to temperature or pressure changes in mastoidectomy cavities.[3]

The choice between STP and CWD mastoidectomy is particularly critical for CI-eligible patients with COM and closed eardrum, suspected cholesteatoma, or anatomic characteristics hindering CI electrode placement via posterior tympanotomy.

Conclusion

In conclusion, STP is a safe and effective surgical technique across several contexts and indications, although it entails the removal of the entire middle ear amplification system, leading to conductive hearing loss

that cannot be rehabilitated with auditory aids. STP and CI at the same surgical time increase CI viability, particularly in patients with COM with closed eardrum, suspected cholesteatoma, or anatomic characteristics hindering CI electrode assignment by posterior tympanotomy. These are important factors for decision-making regarding STP and CI at the same surgical time.

In case of COM, surgical treatment should be considered when poor audiometric results are expected with CWD mastoidectomy cavity. Further studies should investigate STP indications in COMC, particularly in cases of hearing loss that can be rehabilitated prior to surgery with auditory aids to determine if it is beneficial to forgo hearing in favor of facial nerve integrity and vestibular function.

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Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

Data Confidentiality

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

Protection of humans and animals

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the 2013 Helsinki Declaration of the World Medical Association.

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Availability of scientific data

There are no datasets available, publicly related to this work.

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