

Subtotal Petrosectomy: Review of a Surgical Procedure

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ABSTRACT

Subtotal petrosectomy is the surgical technique where the middle ear and mastoid cavity is turned in to a blind sac, so that there is no communication between mastoid cavity and the exterior. This formation of blind sac is achieved by converting the tympanic cavity and mastoid cavity into a single cavity then sealing of the eustachian tube opening and closure of external auditory canal. This blind sac procedure makes the discharging ear dry. But it sacrifices middle ear structures resulting in no hearing preservation. But now a days there are different hearing aids can be fitted during the procedure. It is a challenging and intricate procedure that requires expertise and experience. This article provides a review of some aspects of subtotal petrosectomy.

Key Words: Subtotal petrosectomy, Blind sac closure

INTRODUCTION

The temporal bone is a complex structure that contains multiple important structures such as the inner ear, the facial nerve and the carotid artery. Parts of temporal bone are squamous, tympanic, mastoid, petrous and styloid process. During any ear surgery, it is essential to preserve these vital structures, which can make ear-related surgeries more complex. During early periods of ear surgeries surgeons faced a lot of difficulties. But the paradigm of otologic surgery has been shifted with the invention of microscopy, surgical drill and modern surgical instruments. In the journey of this long history of ear surgery different types of surgical approaches has been practiced within the temporal bone. And the modifications of these techniques have been done continuously. In cases of the surgery of temporal bone usually mastoid cavity is explored. Typically, during temporal bone surgery, the mastoid cavity is explored, and the petrous part is seldom addressed. During subtotal petrosectomy this difficult part is sometimes addressed. There are confusing terminologies present in the literature for

describing this surgery like lateral petrosectomy, subtotal petrosectomy, total petrosectomy.¹ Sometimes lateral temporal bone resection and extended temporal bone resection are described in same heading.² But all of these are not subtotal petrosectomy. Subtotal petrosectomy is the surgery of temporal bone where mastoid cavity along with the middle ear is exenterated and obliteration of the cavity is done with fat or fascia and closure of eustachian tube and external auditory canal is performed to make a blind sac.³ In this review article we have only considered the subtotal petrosectomy and blind sac closure as the same operation. And we reviewed different aspects of subtotal petrosectomy like the background, indication, anesthesia, incision, cavity obliteration, sac closure, eustachian tube obliteration, complications.

Background

Canal wall down mastoidectomy is a different type of surgery where there is no opportunity for the primary closure of the wound during the surgery. As a result, the mastoid cavity remains open after the surgery. For this canal wall down

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mastoidectomy is also known as open cavity mastoidectomy. Many a times this open cavity does not stop its discharging nature in the postoperative period. This makes the suffering of the patient even after the surgery.

Wound healing has different forms like healing with primary intension and healing with secondary intension.⁴ Usually the surgical wounds that remains closed heals in primary intention, but the wound that is created after canal wall down mastoidectomy remains open. This type of wound has not enough surface contact to heal in primary intention. But in the secondary intention of wound healing it requires prolonged time period compared to the primary intention.⁵ In this time period the wound needs adequate vascularity to sustain the wound healing process. But mastoid wound is in the bony confinement and after surgery there is a gap in the wound and soft tissue remain over this gap. These make the area poor in vascularity. This causes the wound to be healed in a more delayed fashion. For this Rambo tried primary closure of the mastoidectomy wound.⁶ But problem is that the area has no support of the tissues that would close the wound. Free skin graft will get limited blood supply, sometimes pedicled flap may be helpful.

In subtotal petrosectomy exenteration of all the mastoid air cells, cavity obliteration and closure of the eustachian tube and the external auditory canal is performed. Sometime this is named as blind sac closure. In recent years this type of surgery is practiced for different types of pathologies. This was first described by Rambo in 1958.⁶ Initially the operation was performed to provide dry ears in uncontrolled otorrhea sacrificing hearing functions. But now a days hearing loss is addressed with cochlear

implantation and other types of implantation devices.⁷ This concept of implantation has overcome all its criticism regarding hearing functions.

In early history it was challenging to treat mastoid abscess. Mastoid drainage was done by different physicians like Rolianus in 1671 then Petit in 1774.⁸ After the drainage some patients got good results, but some did not. This was happened because they had little knowledge about cholesteatoma. Wilde introduced postaural incision and drainage and Schwartze and Eysell described the mastoidectomy procedure using a chisel and hammer for bone removal.⁹ With a better understanding of different pathologies of the ear the aim of the surgery of ear has become the exteriorization of the mastoid cavity. Thus, the development of the radical mastoidectomy has been established. In the radical mastoidectomy the posterior canal wall has been removed to allow drainage of the mastoid and middle ear cavity through the external ear canal. The procedure of radical mastoidectomy does not preserve hearing. Subsequently, the modification was tried to preserve the hearing after mastoidectomy surgery. This modification of radical mastoidectomy is known as the modified radical mastoidectomy. Different Variations in the techniques of radical and modified radical mastoidectomy still remaining.^{10,11} This modified radical mastoidectomy is also known as canal wall-down mastoidectomy. The canal wall-down surgery continued as the standard to the mid twentieth century because this procedure achieved some success in preventing intracranial complications. But some cases like chronic discharge even after recurrent surgery it could not make the ear dry.

Challenge of canal wall down mastoid surgery is that the wound that is created by

bone work cannot be closed primarily. Because our aim is to exteriorize the cavity creating an open cavity. Then the surgical wound is allowed to be healed with a long time. For this in cases of open mastoidectomy patients need long term care of the cavity and swimming is restricted. Patients with ear disease having discharge from the ear even after surgery has a poor quality of life. But in case of blind sac closure of the mastoidectomy wound there is no need for long term cavity care. Ans as there is no opening in the mastoid cavity there is no issue of swimming. But the indications of these two surgeries are not same.

Indications

There are different indications for this subtotal petrosectomy. The main goal of subtotal petrosectomy is to achieve a dry and safe ear.¹² Revision mastoidectomy is performed to achieve a dry ear but discharge may continue due to either cavity problem or due to disease itself. In these cases of recurrent chronic otitis media subtotal petrosectomy can be performed to achieve a dry ear. In the discharging mastoid cavity, the presence or absence of cholesteatoma is not considered as a factor of performing subtotal petrosectomy.¹³ After creating a dry ear in refractory chronic otitis media the issue of hearing comes in the discussion. As the patients with otitis media suffer from chronic infection so there is some infection in mastoid cavity and middle ear that interferes the implantation devices for hearing. After the procedure of subtotal petrosectomy the ossicle is usually exenterated that also creates conductive hearing loss. Then the challenges of hearing rehabilitation using implantation devices is solved as there a sterile and closed cavity is formed. Some cases subtotal petrosectomy is performed for the cochlear implantation

procedure. Usually cochlear implantation is done by cortical mastoidectomy with posterior tympanotomy. But in difficult cases like inner ear malformations, coclear obliteration and ossificans and some revision cases require subtotal petrosectomy to insert the implantation device into the cochlea.³ Hearing reconstruction can be done in the same setting. Some author does the cochlear implantation in second setting as it may give the chance of second look surgery especially in case of cholesteatoma.¹⁴ temporal bone fracture, class B3 tympanomastoid paraganglioma.³ sometimes large vestibular schwannomas are resected as extended trans labyrinthine approach. In that cases some external ear was sealed in blind sac manner to reduce the risk of postoperative CSF leak.¹⁵ Another important indication of subtotal petrosectomy is established CSF leak or CSF otorrhoea.¹⁶

Anesthesia

Many otologic surgery can be performed either local or general anesthesia. But subtotal petrosectomy surgery is performed under general anesthesia.⁷ Because it takes a long time to perform the operation and there are many vital structures need to handle during this procedure. Sometimes nerve monitor is used to monitor the facial nerve.

Antibiotics

The use of antibiotics in subtotal petrosectomy is an important aspect of peri-operative care to prevent infections and ensure a successful outcome of the procedure. Subtotal petrosectomy is a time-consuming surgical procedure. So peri-operative intravenous antibiotic is given that continues for next three days. Intravenous Ampicillin and sulbactam is given

intraoperatively in some centers. Postoperative antibiotic is given orally. oral amoxicillin and clavulanic acid is given for 7 days.¹⁴

Incision

This surgery is usually performed with post auricular incision. This surgery is performed in both primary and revision cases. So, plan of incisions depends on whether the case is primary one or revision. Because in revision surgery there is a previous scar remains in the post auricular region. So, in case of primary surgery wide-based postauricular incision can be given while in revision cases the previous scar can be extended superiorly and inferiorly.⁷

Flap elevation

After making the postauricular incision musculo-perosteal flap is elevated. There are different techniques of elevation of musculoperiosteal flap. Some make the T incision and makes posteriorly based flap.³ Others use anterior based periosteal flap.^{17,18}

Eustachian tube obliteration

The Eustachian tube is a narrow, thin-walled structure that connects the middle ear to the back of the throat and is responsible for maintaining normal middle ear pressure. Obliteration of the Eustachian tube is necessary during subtotal petrosectomy to convert the cavity into a blind sac. This obliteration is very important. Because the aim of the obliteration of the isthmus and the tympanic orifice of eustachian tube is to prevent ascending infection from nasopharynx. The mucosa of orifice of the tube is mobilized so that it can be folded back into the tube. The Eustachian tube is sometimes abraded, and bone wax and soft tissue is used to seal.¹⁰ some author uses

bone to obliterate Eustachian tube.⁷ some author uses oxidized regenerated cellulose along with bone wax.¹⁴ All these procedures are aim to make fibrosis or scaring into the eustachian tube.

EAC closure

As a part of subtotal petrosectomy, removal of the external ear canal is necessary, and it requires closure to make it a blind sac, which prevents communication between the external ear and the internal cavity. Closure involves transecting the external canal at the level of osseocartilaginous junction and separating the lateral skin from the cartilage to make it free. In some cases, the length of this free skin can be as long as 1 cm. The skin is then closed in two or three layers, and the free skin of the external auditory canal is sutured in an everted manner.

Blind sac

A blind sac in subtotal petrosectomy refers to a cavity created during the surgical procedure that does not have an external opening to the ear canal. The term "blind sac" is used to describe this cavity because it cannot be directly visualized from the outside. Cavity that is formed after subtotal petrosectomy is closed all around forming a blind sac. Tympanic cavity and mastoid cavity are merged into a single cavity. But this cavity has two openings one is the eustachian tubal opening another is external auditory canal as tympanic membrane is being sacrificed during the procedure. These two openings are sealed to make a blind sac. Advantage of this blind sac is that this sac is isolated from the external world.

Cavity obliteration

After the resection of the bone the tympanic cavity and the mastoid cavity is unified to become a single cavity. This tympanomastoid cavity can be obliterated in different ways. Periosteum-muscle flap was first tried to close the gap.¹⁴ Then Rambo proposed to obliterate the cavity with temporalis muscle flap.⁶ Then some modification has come to obliterate the cavity. Cavity is obliterated with free fat along with temporalis muscle flap.^{19,20} Fat can be collected from iliac fossa or abdomen.¹⁷ Some center collect fat from lower abdomen.¹⁴ Fat has some chances of shrinkage and may get infected for this harvested fat is treated with antibiotic before placement into the mastoid cavity.¹⁸ Sometimes the cavity is closed with temporalis muscle flap. Closure of the mastoid cavity with temporalis muscle flap has some advantages. Advantages are that when subtotal petrosectomy is done with the indication of cholesteatoma and the risk of development of recurrent cholesteatoma into the closed sac. Then second look surgery can easily be performed. If the plan is to do cochlear implantation as staged procedure the temporalis muscle flap closure is useful because there is less adhesion with the muscle flap. And this flap also stabilizes the implant too. As the wound area has long term infection or multiple previous surgery the area has less vascularity, but muscle has no issue of impaired vascularity.¹⁴

Cochlear Implantation

Cochlear implantation is preferred method for hearing rehabilitation in patients with severe to profound sensorineural hearing loss. It is preferred because cochlear implantation has a very low rate of complications.⁴¹ If there is infection in the receiver site it increases the complication rates. In case of open mastoid cavities there

is a risk of recurrent mastoid infections, cavity needs its special care it makes the cochlear implant recipients in the risk of implant failure. This risk of recurrent infection in mastoid cavity demands a safe area around the implantation site. Subtotal petrosectomy with mastoid obliteration has shown excellent results in creating a safe cavity.^{22,23} In the early cases of subtotal petrosectomy with cochlear implantation the implantation procedure was staged operation. That means second time they perform it as a part of second look procedure. With the time being more confidence is disease clearance made it possible to perform the cochlear implantation simultaneously during the primary subtotal petrosectomy.^{24,25}

Wound closure

The previous sections have described the closure of the external auditory canal as a blind sac. The size and location of the wound created during this procedure depend on the extent of petrous bone removal. In the case of a subtotal petrosectomy, the closure of the wound is a crucial step to avoid postoperative complications such as wound breakdown. The number of layers used to close the postauricular wound can vary based on the surgeon's preference, with some using two layers and others using three.¹⁴

Complications

Like any surgery subtotal petrosectomy is not a complication free surgical procedure. Rather temporal bone is a complex structure that needs special attention during surgery to reduce postoperative complications. Some complications are seen after subtotal petrosectomy more commonly like post auricular fistula, recidivism, facial nerve palsy.⁷ Wound breakdown due to infection is

also seen. Some authors have seen that infection related complications are seen less commonly in the cases where subtotal petrosectomy is performed after recurrent surgery.⁹ Because they receive multiple antibiotics, topical steroids before surgery. One of the unusual complications is the entrapment of squamous epithelium into the blind sac. This may turn into cholesteatoma formation. As the postoperative cavity closed so clinically it cannot be examined. Diffusion weighted MRI can detect this cholesteatoma. In some center intracranial abscess formation.⁹ Issue of hearing loss sometime considered as a complication of subtotal petrosectomy. Debate may arise whether we call it as a complication or call it as a consequence of the procedure. As middle ear is exenterated as part of the procedure itself. Sometime during procedure there might have some injury to the inner ear that leads to sensory hearing loss and vestibular injury resulting in vertigo, unsteadiness, and difficulty with coordination.

CONCLUSION

Maintaining the integrity of the multiple neurovascular structures during surgery is very much challenging during mastoid surgery. In view of these challenges, blind sac closure is an effective treatment option for cases of chronic ear discharge with severe hearing loss. In addition, hearing restoration after surgery makes subtotal petrosectomy an excellent choice for managing various challenging situations.

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