REVIEW

Mastoid Obliteration and Reconstruction: A Review of Techniques and Results

Ching Yee Chan, *MBBS, MRCS (Glasg),* Yew Meng Chan, *FRCS (Edin), FAMS (ORL)*
Department of Otolaryngology, Singapore General Hospital

ABSTRACT

The aim of cholesteatoma surgery is to obtain a safe, dry and self-cleaning ear. Several methods have been tried and tested to achieve this goal with varying degrees of success. This article reviews some of the more common methods for mastoid reconstruction and obliteration and their results. Current trends appear to favour a combination of mastoid obliteration and reconstructive techniques, with biologic materials such as muscle flaps and bone chips preferred over non-biologic materials such as hydroxyapatite crystals and ceramic. However, there is large variation among the type of biologic flap used, which can vary between fascia, muscle and periosteum. After an extensive review, there is no ideal method for mastoid obliteration and reconstruction, as most methods appear to have a certain degree of success. The basic principles of a low facial ridge, large meatoplasty and an oval mastoid cavity should be adhered to, and the surgeon should choose a method that he or she is comfortable with.

Keywords: Flap, Mastoidectomy, Mastoid Obliteration, Reconstruction

INTRODUCTION

Canal wall down mastoidectomy is one of the management options for patients with cholesteatoma. The long-term goal of the surgery is to provide the patient with a safe, dry and 'self-cleaning' ear. However, a significant number of patients (ranging from 20-60%)[1] have a discharging mastoid cavity which is distressing and predisposes them to recurrent infections that may lead to further complications.

Factors contributing to discharging cavities may be divided into mechanical and mucosal factors. Mechanical risk factors include a high facial ridge, small meatoplasty, large cavity and patent Eustachian tubes[2]. The main preventive mucosal factor is the presence of a lining with epithelial migration as this produces a dry and 'self-cleaning' cavity[3]. This review article discusses the options for mastoid reconstruction and obliteration.

METHODS

Background

Current treatment options for cholesteatoma are medical management of superimposed infection with topical antibiotic eardrops and surgical management in the form of either (a) Canal wall up (CWU) mastoidectomy or (b) Canal wall down (CWD) mastoidectomy. The first operation has a low to intermediate risk for otorrhoea but has an increased risk of cholesteatoma recurrence (30-63%)[4]. The risks for canal wall down mastoidectomy are reversed – lower risk of recurrence (2-10%) but higher risk of otorrhoea (20-60%)[5]. As such, patients need to be adequately counselled prior to surgery about the different

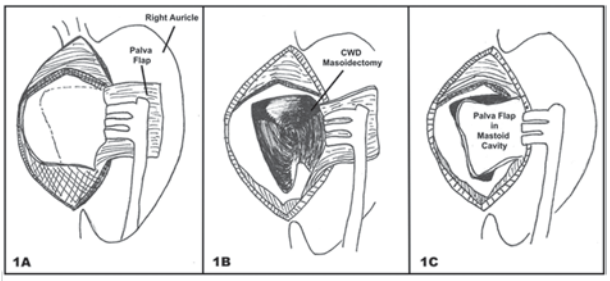

Fig. 1A. The palva flap is held under the blade of the retractor and the mastoid surface is exposed.
Fig. 1B. A canal wall-down mastoidectomy is carried out.
Fig. 1C. The palva flap is placed in the cavity, reconstructing the ear canal wall and partially obliterating the cavity.

risks before making an informed choice. Mastoid reconstruction and obliteration procedures can be performed in patients undergoing CWD mastoidectomy to assist in creating a dry and 'self-cleaning' cavity. These should be performed as a primary procedure in the same sitting as the CWD mastoidectomy but may be conducted as a secondary revision procedure in mastoid bowls with chronic otorrhoea and poor healing.

Mastoid obliteration may also be used in other scenarios where there is a chronically discharging ear, such as in patients with chronic suppurative otitis media (CSOM) with no useful hearing. Obliteration of the entire mastoid, middle ear and Eustachian tube (total tympanomastoid obliteration) can be used to prevent and manage cerebrospinal fluid leaks through the temporal bone, such as that occurring following acoustic neuroma surgery, temporal bone resection or severe temporal bone trauma. Mastoid reconstruction with flaps or free tissue transfer may also be required depending on the defect following temporal bone resection[6]. Sometimes, patients for cochlear implantation with a history of CSOM also undergo tympanomastoid obliteration to eradicate infection and inflammation and provide a protective soft tissue layer over the electrode array[7].

Mastoid reconstruction and obliteration procedures can be classified into two main categories: (a) Free grafts, which are further sub-divided to biologic and non-biologic and (b) local flaps.

Free Grafts – Biologic Techniques
These include the use of cortical bone pate, allogenous/autogenous bone chips, cartilage, fat and fascia[8] to fill the mastoid cavity after CWD mastoidectomy has been performed. The cartilage is often harvested from the conchal cartilage whereas cortical bone pate is obtained from the lateral mastoid cortex, taking care not to enter diseased air cells. The bone chips and pate are washed in an antibiotic solution and dried. They are placed in the cavity after the mastoidectomy is completed and molded according to the required shape.

Free Grafts – Non-biologic Techniques
These include use of hydroxyapatite crystals[9,10], calcium phosphate ceramic granules and bioactive glass ceramic to fill or reconstruct the canal wall following CWD mastoidectomy[11]. Obliteration using hydroxyapatite is recommended only over non-cholesteatomatous sites because of the risk of residual disease and the difficulty re-exploring these cases[10].

Local Flaps
A lining with epithelial migration is important for a dry and 'self-cleaning' cavity. Pedicled flaps resurface the cavity, covering raw surfaces that interfere with re-epithelisation. Their robust blood supply also ensures a conducive surface for epithelial migration.

Several types of flaps have been described, including the Palva flap (Meatally-based musculoperiosteal flap)[12], middle temporal artery flap, Hong Kong flap[13], temporoparietal fascial flap (TPFF)[14], pedicled superficial temporalis fascial flap[15], postauricular-periosteal-pericranial flap[16], temporalis muscle flap[17], inferiorly based fascioperiosteal flap[18] and postauricular myocutaneous flap[19]. Often a combination of various techniques is used to achieve the most favourable result. Here, we will discuss several techniques of interest and their results.

The Palva flap (Fig. 1) is a musculoperiosteal flap

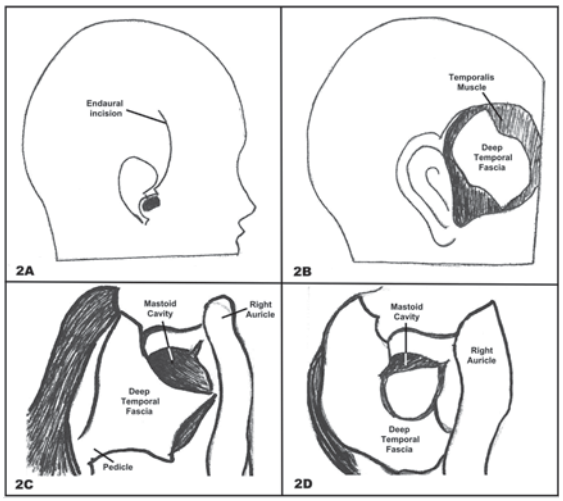

Fig. 2A. An endaural incision is made on the right ear.
Fig. 2B. The deep temporal fascia is separated from the temporalis muscle. A 1cm pedicle is preserved.
Fig. 2C. The temporal fascia is swung on its pedicle to overlay the mastoid cavity.
Fig. 2D. The fascia lining the mastoid cavity.

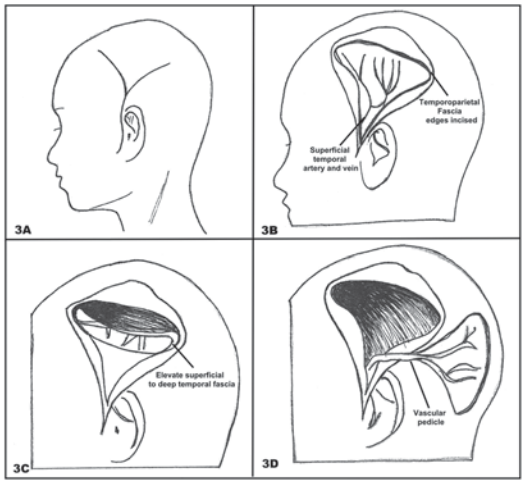

Fig. 3A. An incision is made in the preauricular area in a 'Y' shape.
Fig. 3B. The skin flaps are elevated and the superior aspect of the superficial temporal fascia flap is incised down to the deep temporal fascia.
Fig. 3C. Elevation of the flap is performed superficial to the deep temporal fascia.
Fig. 3D. The flap is isolated on the vascular pedicle and may be swung into the area of need.

based on the pinna that extends posteriorly over the mastoid. Its use started in the early 1950s for obliteration and simultaneous reconstruction of the posterior canal wall. The long, laterally based postauricular musculoparietal flap is rotated into the cavity at the end of the procedure. Palva has advocated the use of bone pate and chips together with the flap to obliterate the mastoid defect as muscle tissue tends to atrophy with time[12].

The middle temporal artery flap is an axial, superiorly based flap, immediately deep to the temporalis muscle. It can be used to reline the mastoid cavity and facilitate epithelialisation. Due to its limited size, it is not bulky enough for mastoid obliteration when used alone.

The Hong Kong (HK) flap (Fig. 2) can be used during mastoid reconstruction for actively discharging mastoid cavities or as a primary procedure immediately after CWD mastoidectomy for resurfacing of the mastoid lining. An endaural incision extending 4cm superiorly is made and CWD mastoidectomy is performed. After eradication of the chlolesteatoma, the sharp edge of bone between the attic roof and the lateral surface of the skull is taken down to the middle cranial fossa dura to create a gutter along which the pedicle may pass. The deep temporal fascia flap is harvested by raising and detaching it from the temporalis muscle, leaving a 1cm pedicle. It is then swung on its pedicle to line the mastoid bowl. The lower edge of the flap may be used to repair any defect in the tympanic membrane as an underlay graft[13].

The temporoparietal fascial flap (TPFF) (Fig. 3) is based on the superficial temporal fascia with the superficial temporal artery as the vascular pedicle. The flap is thin and pliable with a good blood supply and can drape into concavities and over convexities[14]. It is also resistant to infection and useful in trauma and devascularised tissue beds. It may also be used when standard pedicled muscle or periosteal flaps are not available such as in revision cases with scar tissue or in patients post-radiotherapy.

A similar flap, the pedicled superficial temporalis fascial flap has an axial blood supply derived from the middle temporal artery and can be raised independently from the overlying temporoparietal fascia or the underlying deep temporal fascia[15].

The postauricular-periosteal-pericranial flap consists of only the mastoid periosteum and pericranium and is obtained with elevation of the temporalis muscle[16]. A variation of this flap by a Korean group includes harvesting the deep temporalis fascia together with the periosteum so as to obtain adequate length to reach the epitympanum[20].

RESULTS

A study of 39 ears by Beutner et al[21] using autologous bone pate and conchal cartilage for mastoid obliteration in CWD tympanomastoidectomy showed that 38 ears maintained a small, dry, healthy mastoid cavity. Cholesteatoma recurrence occurred in one patient and 92% of patients were satisfied with the result.

In a study of 20 patients who underwent CWD mastoidectomy with reconstruction of the canal wall using bioactive glass ceramic, 16 walls remained intact after five years. Three patients needed prosthesis removal due to infection, displacement and cholesteatoma (1 patient each). The only perioperative complication was that of otorrhoea in four patients[11].

Hussain et al[22] performed mastoid cavity reconstruction using hydroxyapatite cement and a postauricular flap on 29 patients. During the mean follow-up period of 21.6 months, there was no clinical evidence of recurrent cholesteatoma or cement resorption. However, Minatogawa et al[23] reported extrusion of hydroxyapatite granules with a local inflammatory response and uncontrollable secretions.

Saunders et al[24] used the Palva flap in 28 patients with chronically draining ears from 1987 to 1990. Twenty-six (93%) had successful tympanic membrane reconstruction with dry ears, and two (7%) had persistent perforation with otorrhoea. Charachon et al[25] used the Palva flap (and bony pate or ceramic granules in selected cases at the second stage) in 199 patients. Ninety-seven percent achieved tympanic membrane closure, 17% had residual cholesteatoma removed during the second look and late residual cholesteatoma occurred in five cases. Gantz used the Palva flap with bone chips, bony pate, temporalis fascia graft and silastic sheeting for canal wall reconstruction tympanomastoidectomy with mastoid obliteration. Ninety-eight and a half percent of 130 ears remained dry without recurrent disease[26].

The axial superiorly based middle temporal artery flap has been used with an inferiorly based random pedicled musculoperiosteal flap for mastoid obliteration. Of 51 patients undergoing the procedure, 43 (84%) had a small dry healthy mastoid cavity and three ears had occasional otorrhoea that was easily managed by topical therapy[27].

Of 313 cases of HK flap performed from 1987 to 2006 by the Chinese University of Hong Kong with an average follow-up period of 72.3 months (range 1-210), the median time from flap reconstruction to a dry ear is two months with a range of 1 to 107 months; 91.3% of patients were clear of cholesteatoma after the first operation. The main complications include residual or recurrent tympanic membrane perforations (6%), recurrent or residual cholesteatoma (6%), meatal stenosis (10.9%) and discharging cavity (1%)[13]. The six percent recurrence rate of cholesteatoma is within the expected range of 2 to 10% as mentioned by Karmarkar et al[28] and the incidence of discharging cavity is also much lower than in patients undergoing mastoidectomy without flap (20-60%). A Nigerian study in 34 patients using the HK flap showed the technique decreased hospital stay and also controlled otorrhoea in 55% of patients[8].

The TPFF was used by Cheney et al[14] in 11 patients (2 with persistent otitis media, 9 were post-temporal bone resection. None of the patients had cholesteatoma); 100% achieved a dry, fully epithelialised canal. One patient had EAC stenosis, one had epidermolysis at the scalp incision site and another developed cholesteatoma deep to the TPFF in the mastoid bowl that was removed without recurrence. Stow et al[29] performed TPFF flaps in 65 patients who underwent ear and lateral skull base reconstructive operations of which 88% (n=57) had cholesteatoma and chronic otitis media. All epithelialised at six weeks and five percent developed complications (mastoid-cutaneous fistula, mastoid haematoma, canal stenosis).

In a Japanese study comparing the TPFF and HK flap, (TPFF 6 patients, DTF 21 patients) the TPFF had a faster rate of epithelialisation compared to the HK flap. The mean period to epithelialisation was 25.5 days for the TPFF and 38.4 days for the HK flap. Aside from this, there were no statistical differences between the two groups in terms of postoperative complications or re-aeration of the mastoid cavity[30].

The pedicled superficial temporalis fascial flap used by Olson in 15 patients for reconstruction following otologic procedures had no complications related to reconstruction except for one episode of perichondritis[15].

Ramsey et al[16] performed CWD mastoidectomy in 60 patients with active chronic otitis media

Table 1. Summary Table of Study Methods, Results and Complications.

Study	Mastoid reconstruction/ obliteration method	Follow-up (months)	Cholesteatoma recurrence	Other complications	% Dry ear
Beutner et al[21] n=39	Bone pate Conchal cartilage	NM	1 (2.6%)	NM	97.4
Della at al[11] n=20	Bioactive glass ceramic	60	1 (5%)	Infection=1 Displacement=1	20
Hussain at al[22] n=20	Hydroxyapatite Postauricular flap	6-48 m=21.6	Nil	Infection=2 Canal stenosis=1	100
Saunders et al[24] n=28	Palva flap	m=17	4 residual cholesteatoma (14.3%)	Persistent perforation and otorrhoea 7%	93
Charachon et al[25] n=199	Palva flap Bony pate Ceramic granules	NM	17% residual cholesteatoma 2.5% late residual recurrence	NM	NM
Gantz et al[26] n=130	Palva flap, bone chips, bone pate, temporalis fascia graft, silastic sheeting	2-94 m=48	1.5% 7.6% residual cholesteatoma	Infection 7.7% Perforation post-ossiculoplasty 1.5% Safe retraction 7.7%	98.5
Singh, Atlas[27] n=51	Middle temporal artery flap, musculoperiosteal flap	12-60 m=31	NII	Occasional otorrhoea 6% Infection=1 Flap necrosis=1 Meatal stenosis=1	84
Hung et al[13] n=313	Hong Kong flap	1-210 m=72.3	6%	TM perforation 6% Meatal stenosis 10.9% Otorrhoea 1%	99
Cheney et al[14] n =11	TPFF	1-43	None of the patients had cholesteatoma initially but 1 developed cholesteatoma under the TPFF	EAC stenosis 9% Epidermolysis at scalp incision site 9%	100
Stow et al[29] n=65	TPFF	NM	NM	Canal stenosis, mastoid-cutaneous fistula, mastoid haematoma 5%	100
Olson, Manolidis[15] n=15	Superficial temporalis fascia flap	2-25 m=15	NM	Perichondritis=1 (6.7%)	82
Haginomori et al[30] n=27	TPFF n=6 Hong Kong flap n=21	NM	NM	HK flap 9.5% graft necrosis with infection	NM
Ramsey et al[16] n=60	Bone pate Periosteal-pericranial flap	12-80 m=31	Nil	Meatal stenosis 6.7%	82
Lee et al[20] n=5	Deep temporal fascial-periosteal flap	1-6	NM	NM	NM

NM - not mentioned m=mean TM=Tympanic membrane

with an inferiorly pedicled, periosteal-pericranial flap in conjunction with autologous bone pate for mastoid obliteration. They were followed-up for a minimum of 12 months (mean 31 months, range 12-80 months). Forty-two patients (82%) maintained a small, dry, healthy mastoid cavity, five ears (8%) had intermittent otorrhoea easily controlled by topical treatment and six ears (10%) had sub-optimal control of which four had meatal stenosis. A variation of this was performed by Lee et al[20] on five patients, using a deep temporal fascial-periosteal flap. There was no flap necrosis or perforation and epithelialisation occurred in 41.6 ±6.5 days. None of the patients had otorrhoea.

The postauricular myocutaneous flap based on the occipital artery and sternocleidomastoid muscle has been used to reconstruct mastoid defects after surgical procedures for chronic ear disease and skull base operations. The

skin muscle flap reduces the mastoid cavity and promotes rapid healing of the defect[19].

DISCUSSION

There is no perfect solution for mastoid reconstruction or obliteration. The ideal procedure should be simple and quick to do, heal quickly and promote complete epithelialisation of the mastoid cavity lining, leading to a dry, self-cleaning ear. There should be minimal complications including decreased risk of recurrence, dizziness and hearing loss. The cavity should be easy to inspect and monitor for signs of recurrent disease.

Current trends appear to sway towards a combination of methods; mainly the axial superiorly based middle temporal artery flap with bone chips and an inferiorly based random pedicled musculoperiosteal flap with temporalis fascia closure of the tympanic membrane. Axial pattern flaps such as the middle temporal artery flap, TPFF and superficial temporalis fascial flap are useful as they have an excellent arc of rotation with robust blood supply. In repeat cases, the TPFF may be used as it is resistant to infection and useful in trauma and devascularised tissue beds or when standard pedicled muscle or periosteal flaps are unavailable (as in revision cases with scar tissue or in patients post-radiotherapy).

Non-biologic materials seem to be less preferred and muscle flaps alone are seldom used as they atrophy with time, leading to an increase in the cavity size.

Regardless of the technique used, principles to adhere to include creating a mastoid cavity with an oval shape, leaving a low facial ridge and creating a fair sized meatoplasty for easy toileting and surveillance. Overall, the surgical approach used should be suited to the patient's diagnosis, defect size and surgeon experience as the result obtained is dependent not just on the type of obliteration or reconstruction method, but also surgeon expertise.

CONCLUSION

There are many techniques to mastoid obliteration and reconstruction. No one method is perfect. The technique chosen should be one that is suited to the patient's anatomy and intra-operative findings. Of course, it should also be one that the surgeon is familiar with, bearing in mind the principles to adhere to. The ultimate aim is to create a dry, safe, self-cleaning ear postoperatively that is easy to follow-up and monitor for signs of recurrence.

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