Ceravital Reconstruction of Canal Wall Down Mastoidectomy

Long-term Results

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Objective: To describe long-term outcomes of external auditory canal wall reconstruction using bioactive glass ceramic (Ceravital) after canal wall down mastoidectomy.

Design: Retrospective review of a case series over a 21-year period, with a mean±SD follow-up of 13.1±6.7 years (range, 0.2-20.5 years).

Setting: Private otologic practice.

Patients: The study population comprised 20 consecutive patients aged 12 to 60 years, who had previously undergone canal wall down mastoidectomy.

Intervention: Reconstruction of the canal wall with bioactive glass ceramic.

Main Outcome Measures: Incidence, cause, and timing of reconstruction failure; need for additional surgery; change in hearing; frequency of outpatient visits; and incidence of surgical complications.

Results: Prosthetic walls have remained intact in 16 patients followed for more than 5 years. One had remained intact at 3 months after surgery, but the patient was lost to follow-up. Prosthesis removal was required in 3 patients (because of infection, displacement, and cholesteatoma in 1 patient each). The only perioperative complications were otorrhea in 4 patients and a 5-dB sensorineural hearing loss in 1 patient. Of the 16 intact patients with long-term follow-up, 4 required no further surgery, while 11 underwent an average of 2 subsequent middle ear procedures each (range, 1-3), including 4 planned reexplorations. The mean ± SD air bone gap improved 11±16 dB as of the most recent audiogram (mean ± SD, 7.7±5.8 years after operation).

Conclusion: Canal wall reconstruction using bioactive glass ceramic is a useful option for patients who desire freedom from the frequent mastoid bowl debridements and activity restrictions that may result from canal wall down mastoidectomy.


Goals of Surgical Management of Chronic Otitis Media include the eradication of disease, restoration of hearing, and, to the extent possible, maintenance or restoration of a normal anatomic configuration. Prior to the mid-1950s, the first 2 of these goals were usually accomplished by removal of the posterior external auditory canal wall, resulting in a radical or modified radical mastoidectomy cavity. The past 50 years have witnessed a trend away from mandatory canal wall removal. Many otologic surgeons now prefer intact canal wall mastoidectomy with tympanoplasty except when canal wall removal is required because of extensive disease, inadequate access for cholesteatoma excision, operation on an "only hearing ear," or uncertainty of adequate follow-up. The popularity of intact canal wall mastoidectomy stems from the benefits of maintaining a canal wall, which include freedom from the need for frequent mastoid bowl cleanings, freedom from water intolerance and calorically induced vertigo, and less difficulty in fitting and use of hearing aids.

Immediate or delayed mastoid bowl obliteration with soft tissue, bone pâte, synthetic bone cement, hydroxyapatite granules, or other materials has been used in attempts to reduce mastoid cavity size and reclaim some of the advantages of normal ear canal anatomy. However, mastoid obliteration risks trapping residual cholesteatoma, impedes postoperative surveillance, and can be defeated by infection or resorption or shrinkage of the graft materials. Radical mastoidectomy with complete obliteration of the mastoid, middle ear, and ear canal, with closure of the meatus, can be effective for treatment of recurrent otorrhea due to mastoid bowl obliterative cholesteatoma.

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infections and offers freedom from debridement but causes maximal conductive hearing loss.\textsuperscript{12} In contrast to mastoid obliteration procedures, reconstruction of the posterior external auditory canal wall creates an aerated mastoid cavity that is contiguous with the middle ear space. Whether performed immediately after canal wall resection or delayed, this procedure re-creates an anatomic configuration similar to that which results from intact canal wall mastoidectomy. Multiple materials have been used for this purpose, including autologous and homologous cartilage and bone, hydroxyapatite in granular cement and preformed solid forms, porous polytetrafluoroethylene-carbon filament composite, and titanium mesh.\textsuperscript{1,13-26} The present report details the long-term results in the experience of one surgeon using a synthetic bioactive glass ceramic material, Ceravital (Ernst Leitz, Wetzlar, Germany; Xomed, Jacksonville, Fla), for delayed canal wall reconstruction in 20 ears over a 21-year period.

**METHODS**

**STUDY POPULATION**

Twenty consecutive patients, 13 male and 7 female, aged 12 to 60 years at the time of operation, underwent delayed canal wall reconstruction from 1983 through 2004. One author (S.C.L.) was the surgeon for all cases, and all were performed at Greater Baltimore Medical Center in Baltimore, Md. A retrospective review of patient records was performed by a second surgeon (C.C.D.S.). This study was performed with the approval of the institutional review board of the Greater Baltimore Medical Center. All patients had undergone canal wall down mastoidectomy prior to canal wall reconstruction. The underlying disease leading to prior canal wall down mastoidectomy was cholesteatoma in 16 patients and chronic infection in 4 patients. Recurrent mastoid bowl infection and patient desire for freedom from frequent mastoid bowl debridement were the main indications for canal wall reconstruction in each case. In addition, 16 patients complained of water sport restrictions necessary to keep the mastoid bowl dry.

**MATERIALS**

Ceravital was used for canal wall reconstruction in each case. Ceravital is made from parent glass of controlled composition (silicon dioxide, 40%-50%; phosphorus pentoxide, 10%-15%; sodium oxide, 5%-10%; calcium oxide, 30%-35%; potassium oxide, 0.5%-3.0%; and magnesium oxide, 2.5%-5.0% by weight) melted in a platinum crucible for 3 hours at 1500ºC, then cooled to room temperature.\textsuperscript{27} The resulting glass ceramic is a macroscopically solid, smooth material with a high microscopic surface roughness (pore size of 3-5 nm and an effective surface area of up to 100 m\textsuperscript{2}/g). The ion composition is designed to approximate physiologic body fluid so that the material's solubility in vivo is considerably reduced compared with other ceramics. The elastic modulus (100-150 GPa [gigapascal]) and compressive strength (500 MPa [megapascal]) exceed that of cortical bone. It has been used in middle ear reconstruction for ossiculoplasty\textsuperscript{28,29} and canal wall reconstruction.\textsuperscript{26}

**SURGICAL TECHNIQUE**

The surgical technique used for all cases is similar to that described by Wehrs\textsuperscript{13} for reconstruction of the posterior bony canal wall using homograft knee cartilage. The mastoid bowl is exposed via a postauricular incision, and a fascia graft is harvested (Figure 1A and B). An elliptical incision (approximately the same area as that of the normal external auditory canal cross-section) is made through the soft tissue down to the posterior bony wall of the mastoid cavity. By blunt dissection, the skin overlying the mastoid cavity is carefully elevated, making sure not to tear the thin epithelium. The postauricular flap, canal skin, and remaining drumhead are reflected anteriorly until the entire medial surface of the drum remnant is...
The anterior portion of the homograft. The Ceravital is placed completed. Anteriorly deflected canal skin is replaced superficial to the patient's annulus. Ossicular chain reconstruction is com-
membrane is placed so that the anterior portion lies laterally on the middle ear reconstruction is completed. A homograft tympanic from reconstructed mastoid sinus through the middle ear to the creates an ample aditus ad antrum and allows drainage of air cells over the horizontal semicircular canal and facial nerve. This re-
ent of the edge of the Ceravital is designed to leave an air space its junction with the zygomatic root, defining the coronal plane posterior canal wall using a diamond burr. This groove extends (through) the mastoid tegmen at its junction with the planned trum. A notch is cut in the sheeting to accommodate the ossicular chain and tympanic membrane reconstruction are performed by a technique dictated by intraoperative findings. If the mammary is present, it is preserved and either a temporalis fascia graft or homograft tympanic membrane (obtained from the Midwest Ear Bank, Cincinnati, Ohio) is used. If the mammary is absent, a homograft with malleus attached is used after removal of the head of the mal-
letus to prevent bony ankylosis. A notched incus or partial or total ossicular chain reconstruction prostheses can be used to reconstruct the ossicular chain. If a notched incus is used, the mucosa overlying the stapedial footplate is gently removed from the area of contact between the prosthesis and the footplate. If the promontory has been denuded of mucosa over a large area, a piece of Silastic (Dow Corning, Midland, Mich) silicone sheeting is inserted into the middle ear and draped over the fallopian bony canal to the an-
trum. A notch is cut in the sheeting to accommodate the ossicular reconstruction prosthesis at the oval window niche.

The posterior canal wall is then reconstructed with Ceravi-
tal (Figure 1C-E). A small groove is made in (but not entirely through) the mastoid tegmen at its junction with the planned posterior canal wall using a diamond burr. This groove extends from medial to lateral up to the cortex of the mastoid cavity at its junction with the zygomatic root, defining the coronal plane in which the reconstructed canal wall will lie. A similar groove is made inferiorly. A piece of Ceravital is sculpted with a drill to fit snugly into the superior and inferior grooves. The medial ex-
tent of the edge of the Ceravital is designed to leave an air space over the horizontal semicircular canal and facial nerve. This recreates an ample aditus ad antrum and allows drainage of air cells from reconstructed mastoid sinus through the middle ear to the Eustachian tube. The Ceravital is temporarily set aside while middle ear reconstruction is completed. A homograft tympanic membrane is placed so that the anterior portion lies laterally on the patient's annulus. Ossicular chain reconstruction is com-
pleted. Anteriorly deflected canal skin is replaced superficial to the anterior portion of the homograft. The Ceravital is placed back into position and then covered with bone pâte where it is in contact with the bone. The temporalis fascia free graft is placed on the canal side of the Ceravital (superficial to the homograft tympanic membrane) and wraps around the lateral edge of the Ceravital. Redundant canal skin may be trimmed so that the skin lies flat against the anterior surface of the Ceravital. A thin layer of bone pâte is placed between the temporalis fascia and Cer-
avital. The reconstructed external auditory canal is packed up to the bone-cartilaginous junction with pieces of Gelfoam absorbable gelatin sponge (Pharmacia Corp, Kalamazoo, Mich) soaked in antibiotic solution and then further packed with an antibiotic ointment–impregnated ear wick in the cartilaginous ear canal. The postauricular incision is closed by suturing mast-
oid peristeum to the subcutaneous tissue of the soft tissue flap. A pressure dressing is applied for 48 hours, followed by routine posttympanoplasty care.

DATA ANALYSIS

The following data were logged for each patient: age at time of reconstruction; interval from canal wall down mastoidectomy to reconstruction; prereconstruction and postreconstruction symptoms; visit frequency before and after reconstruction; sur-
gercy duration; duration of follow-up; prereoperative and most recent air and bone pure-tone audiometric averages; subsequent surgical procedures; and ultimate state of the reconstruction were logged. Air and bone stimulation pure-tone averages (PTAs), which were measured in the same session for each au-
diogram, were defined as the linear average of decibel hearing level (dB HL) thresholds of 0.5, 1, 2, and 4 kHz. Paired, 2-sample, 1-tailed t tests were used to compare prereoperative and postoperative PTA, using a significance threshold of P<.05 and excluding the 2 patients for whom postoperative data were not available. Data are given as mean ± SD.

RESULTS

The mean ± SD time from canal wall down mastoidectomy to the time of canal wall reconstruction was 9.4 ± 6.7 years, and the frequency of outpatient visits for debride-
ment or infection during the 2 years leading up to the decision to reconstruct was 8.1 ± 4.3 visits (range, 3-20 visits) per year (Table). The reconstruction procedure took 5.0 ± 0.7 hours to complete, including ossiculoplasty and tympanoplasty.

Patients were followed for 13.1 ± 6.7 years (range, 0.2-
20.5 years), with 17 patients followed for at least 5 years. Prosthetic walls have remained intact in 16 of the 17 pa-
tients followed for more than 5 years. One additional pa-
tient had an intact reconstruction at 3 months after sur-
gery but was then lost to follow-up. Prosthesis removal was required in 3 patients—1 because of infection during the first 3 months postoperatively, 1 because of recurrent cholesteatoma in the mastoid cavity 10 months postop-
eratively, and 1 because of a recurrent retraction pocket medial to the Ceravital prosthesis (beginning 2 years af-
ter reconstruction) with subsequent cholesteatoma for-
mation and displacement of the prosthesis (which was ul-
timately removed 8 years after reconstruction). Of the 16 intact patients followed for more than 5 years, 4 required no further surgery, while 11 underwent an average of 2 subsequent middle ear or mastoid procedures each (range, 1-3), including 4 planned "second-look" surgical explo-
rations, 3 excisions of cholesteatoma (without removal of Ceravital), and placement of Silverstein tubes through the Ceravital wall or other long-term ventilation tubes through the tympanic membrane in 4 patients.

Perioperative complications included persistent otor-
rhea in 4 patients (2 of whom ultimately underwent pros-
thetic wall removal), early recurrence of cholesteatoma (1 patient, whose reconstructed wall was removed for cho-
olesteatoma removal), and a 5–dB HL PTA worsening of sen-
sorineural hearing thresholds in 1 patient. There were no instances of facial nerve injury or cerebrospinal fluid leak.

The postoperative visit schedule included visits at 10 days, 3 weeks, 6 weeks, 3 months, 6 months, and 1 year after reconstruction, so healing time can only be re-
ported to that resolution. By otoscopic examination, all patients except 1 (patient 4) were healed by the 3-month postoperative visit, with no evidence of canal skin edema or dehiscence of canal skin over the Ceravital wall. Of patients surgically reexplored within the first year for sec-
dond-look procedures, only 1 (patient 4) had dehiscence of the skin over the prosthetic wall and apparent failure of Ceravital to form a solid interface with bone.

The most recent audiogram available, obtained 7.7 ± 5.8 years (range, 0.3-17.8 years) after reconstruction, re-
vealed a mean air PTA of 43.9 ± 20.5 dB HL, bone PTA of 16.8 ± 13.8 dB HL, and air-bone gap of 27.1 ± 11 dB HL. Compared with the prereconstruction audiograms (mean
air PTA of 52.3±20.6 dB HL, bone PTA of 15.5±13.6 dB HL, and air-bone gap of 36.8±14.6 dB HL), this represents a significant improvement (reduction) in air PTA ($P$=.03) and air-bone PTA gap ($P$=.004), with no significant change in bone PTA ($P$=.20). Of note, the sample size was sufficient for a power of 0.7 to detect a true bone PTA shift of 10 dB and 0.3 to detect a true shift of 5 dB; conversely, 24 subjects would be needed for 0.8 power to detect a true 10-dB shift, and 93 would be required to for 0.8 power to detect a true 5-dB shift.

As of the most recent follow-up contact, 12 of the 16 patients with intact reconstructions followed for more than 5 years were free from water activity restrictions, while 4 remain on dry ear precautions owing to the placement of long-term ventilation tubes.

In 2 patients surgically explored for conductive hearing loss 14 years after initial reconstruction, no evidence of significant Ceravital resorption was observed. Figure 2 shows a coronal computed tomographic scan acquired in a patient (patient 11) 14 years after initial Ceravital reconstruction. The prosthetic wall is intact, and the mastoid cavity well aerated. She subsequently underwent revision ossiculoplasty for conductive hearing loss due to displacement of the ossicular prosthesis. Figure 3 shows an intraoperative view of her mastoid cavity and middle ear. The Ceravital prosthetic wall was rigidly incorporated with the adjacent temporal bone, and canal skin adhered to it as it would to normal bone. The aditus ad antrum and facial recess medial to the Ceravital were still patent. After replacement of the displaced ossicular prosthesis, she has remained free of symptoms except for a conductive hearing loss with air-bone gap of 23 dB HL, which is still 25 dB better than at her initial presentation.

**COMMENT**

Bioactive glass ceramics such as Ceravital and Bioglass (NovaBone Products, LLC, Alachua, Fla) are designed to engender surface reactions that lead to osseointegration.28,29 Within minutes of exposure to body fluids, sodium ions are lost from the surface of the glass via ion exchange with hydrogen ions, creating a dealkalinized surface layer with a net negative surface charge. The loss of sodium causes a breakdown of the silica network near the surface, with resultant formation of silanol [Si(OH)$_4$]$_2$ groups that repolymerize to form a silica-rich surface layer. Although microscopically solid and smooth, this surface is porous on a microscopic scale, with an average pore diameter of 3 to 5 nm and an effective surface area of up to 100 m$^2$/g. An amorphous calcium phosphate layer forms on the glass surface and adsorbs blood proteins, growth factors, and collagen. Within 3 to 6 hours, the calcium phosphate layer crystallizes to form hydroxyapatite, which is chemically and structurally similar to bone matrix, which therefore acts as a bonding layer that eventually reaches a thickness of 100 to 150 µm. By the time reactive osteogenic cells infiltrate the bone defect into which a bioactive glass implant is embedded, which normally takes 24 to 72 hours, the implant...
is coated with a surface of synthetic bone-like material that promotes bone deposition and mitigates the otherwise expected foreign body reaction.

Despite their osteoinductive characteristics, bioactive glasses have been less successful than titanium alloys for high load-bearing bone reconstruction applications, such as dental and mandibular reconstruction. However, they are better suited for middle ear ossicular reconstruction and canal wall reconstruction, for which load-bearing is less important.30-32 While resorption of Ceravital ossicular chain prostheses after initially good results was observed in one study,32 with a mean time to failure of approximately 6 years, we have not yet observed resorption-related failures in our series of patients followed for a mean of more than twice as long. This may be because the canal wall prostheses are much thicker than ossicular chain prostheses so that the surface reactions described previously do not reach the central portion of the material.

### Table. Preoperative Characteristics, Perioperative Findings, and Postoperative Course for 20 Patients Who Underwent Reconstruction of the Posterior External Auditory Canal Wall Using Ceravital® After Canal Wall Down Mastoidectomy (cont)

<table>
<thead>
<tr>
<th>Patient No./Sex</th>
<th>Subsequent Surgical Procedures; Indications/Finding</th>
<th>Time Since Most Reconst, y</th>
<th>Air PTA, dB HL</th>
<th>Air-Bone Gap PTA, dB HL</th>
<th>Air-Bone Gap Change vs Preop, dB HL</th>
<th>Follow-up Duration, y</th>
<th>Mean Status of Prosthetic Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M 1987, OCR for CHL</td>
<td>Aug 2001</td>
<td>17.8</td>
<td>48</td>
<td>31</td>
<td>-6</td>
<td>17.8</td>
<td>Intact</td>
</tr>
<tr>
<td>2/M 1993, Silverstein tube for OME</td>
<td>Jan 1999</td>
<td>7.7</td>
<td>39</td>
<td>19</td>
<td>-6</td>
<td>7.7</td>
<td>Intact</td>
</tr>
<tr>
<td>4/M 1984, Conversion to CWDM due to infection of Ceravital</td>
<td>Mar 1984</td>
<td>0.3</td>
<td>60</td>
<td>33</td>
<td>-5</td>
<td>0.3</td>
<td>Removed (infection)</td>
</tr>
<tr>
<td>6/M 1989, OCR for CHL</td>
<td>July 1997</td>
<td>12.2</td>
<td>61</td>
<td>21</td>
<td>-19</td>
<td>12.2</td>
<td>Intact</td>
</tr>
<tr>
<td>8/M 1992, Second look identified TM perforation; 2000, TICWM for CHL</td>
<td>Jan 2000</td>
<td>8.4</td>
<td>57</td>
<td>40</td>
<td>-3</td>
<td>8.7</td>
<td>Intact</td>
</tr>
<tr>
<td>10/F No further operations</td>
<td>Aug 1999</td>
<td>6.2</td>
<td>85</td>
<td>32</td>
<td>3</td>
<td>12.0</td>
<td>Intact</td>
</tr>
<tr>
<td>12/F No further operations</td>
<td>Feb 1985</td>
<td>0.3</td>
<td>16</td>
<td>13</td>
<td>-15</td>
<td>20.7</td>
<td>Intact</td>
</tr>
<tr>
<td>13/F 1985, Revision tympanoplasty; 1990, revision OCR</td>
<td>Dec 1990</td>
<td>5.7</td>
<td>56</td>
<td>46</td>
<td>10</td>
<td>5.7</td>
<td>Intact</td>
</tr>
<tr>
<td>14/F No further operations</td>
<td>Apr 1985</td>
<td>0.3</td>
<td>20</td>
<td>20</td>
<td>-4</td>
<td>20.5</td>
<td>Intact</td>
</tr>
<tr>
<td>15/M No further operations</td>
<td>July 1988</td>
<td>0.3</td>
<td>15</td>
<td>12</td>
<td>-48</td>
<td>15.3</td>
<td>Intact</td>
</tr>
<tr>
<td>16/F No further operations</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>LTF (intact at 2 y)</td>
</tr>
<tr>
<td>17/M NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.2</td>
<td>0.2</td>
<td>LTF (intact at 3 mo)</td>
</tr>
<tr>
<td>18/F 1998, TICWM for TM perforation</td>
<td>Sep 1998</td>
<td>14.0</td>
<td>54</td>
<td>32</td>
<td>-10</td>
<td>4.0</td>
<td>Intact</td>
</tr>
<tr>
<td>19/M 1985, Second look identified pearl in TM; 1985, CWDM for cholesteatoma identified adhesions and OME</td>
<td>Mar 1985</td>
<td>0.3</td>
<td>35</td>
<td>25</td>
<td>-28</td>
<td>1.0</td>
<td>Removed (cholesteatoma)</td>
</tr>
<tr>
<td>20/M 1990, Surgical reexploration identified adhesions and OME</td>
<td>Nov 1995</td>
<td>5.8</td>
<td>10</td>
<td>5</td>
<td>-5</td>
<td>15.3</td>
<td>Intact</td>
</tr>
<tr>
<td>Mean</td>
<td>7.7</td>
<td>43.9</td>
<td>27.1</td>
<td>-11.2</td>
<td>10.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>5.8</td>
<td>20.5</td>
<td>11.0</td>
<td>16.0</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:** CHL, conductive hearing loss; CWDM, canal wall down mastoidectomy; dB HL, decibel hearing level; LTF, lost to follow-up prior to 2 years after surgery; NA, data not available; OCR, ossicular chain reconstruction; OME, otitis media with effusion; Preop, preoperation; PTA, pure-tone auditory threshold for 0.5, 1, 2, and 4 kHz; Reconst, reconstruction; SNHL, sensorineural hearing loss; TICWM, tympanoplasty with intact canal wall mastoidectomy; TM, tympanic membrane.

*Ceravital* (Ernst Leitz, Wetzlar, Germany; Xomed, Jacksonville, Fla).
Surgical, Inc, Jacksonville), Ceravital does not bend without breaking and must be machined intraoperatively using a diamond drill burr to fit predrilled tegmen and inferior mastoid grooves. Manufacture of crescent-shaped wafers of Ceravital stock would greatly reduce the time required for intraoperative sculpting.

In this series, the main complications of canal wall reconstruction were persistent postoperative otorrhea, recurrent or residual cholesteatoma, and subsequent surgery for removal of the Ceravital.

Persistent otorrhea in the first several months after surgery occurred in 4 patients and heralded the early removal of Ceravital for persistent postoperative infection and exposure in 1. Otorrhea resolved before planned second-look procedures during the first postreconstruction year in the other 3, and exploration revealed uninfected otitis media with effusion and an intact Ceravital reconstruction in each, plus a persistent tympanic membrane perforation in 1. As might be expected in a group of patients who have undergone canal wall down mastoidectomy, Eustachian tube dysfunction (ETD) was common in this series. Appropriate medical therapy, nose-pinching Valsalva or Politzer maneuvers, and ventilation tubes may be required to prevent complications related to persistent ETD after canal wall reconstruction. Persistent early infection in patient 4 was likely related to his poorly controlled diabetes. Use of prosthetic material for canal wall reconstruction should probably be avoided in patients with poor immune function or other risk factors for impaired healing, such as poorly controlled diabetes, prior radiation treatment to the temporal bone, vasculopathy, hypothyroidism, malnutrition, and anemia.

Recurrent or residual cholesteatomas occurred in 4 patients and ultimately necessitated Ceravital removal in 2 patients (at 1 and 8 years postreconstruction). In 3 cases, recurrence of cholesteatoma was apparently due to retraction of the soft tissue part of the graft (ie, either the homograft tympanic membrane or temporalis fascia graft) medial to the intact Ceravital wall prosthesis. As is the case after tympanoplasty with intact canal wall mastoidectomy, the mechanism driving these recurrences was likely a combination of ETD and inadequate support between the anteromedial edge of the Ceravital wall and the middle ear reconstruction prosthesis (or homograft malleus). The risk of recurrence can be reduced through appropriate long-term treatment of ETD and care in designing the Ceravital wall prosthesis to re-create a sufficient scutum. Residual cholesteatoma was identified in the mastoid at the planned second-look procedure in the fourth case, supporting the use of planned second-look procedures when cholesteatoma is removed from the mastoid in more than a single intact piece.

In conclusion, reconstruction of the external auditory canal wall is an option for patients who desire freedom from lifelong mastoid bowl cleanings after canal wall down mastoidectomy. The indications and contraindications of staged canal wall reconstruction are similar to those for intact canal wall mastoidectomy. Ceravital appears to be an excellent synthetic material for canal wall reconstruction. The ease of use would be improved by production in preshaped forms approximating the shape of the external auditory canal wall.

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REFERENCES