

Reconstruction of Old Radical Cavities and Long-Term Results

Giuseppe Magliulo, MD, Raffaello D'Amico, MD,
and Massimo Fusconi, MD

Abstract

Various techniques and materials have been proposed to deal with the problems that concern radical cavities, such as recurrence of the inflammatory process, the need for regular medication, and social inconvenience (eg, inability to practice water sports, working in an adverse environment). This article provides a detailed report of the results of revalidation of old radical cavities using hydroxyapatite granules as a filling. The material was incorporated with fibrin adhesive to fill the mastoid cavity and was covered with a sheet of bone pate sealant. Twenty-eight patients with chronic discharging old radical cavities were selected for this study (mean follow-up 11.4 years; range 10–14 years). At the 6-month follow-up, grafting was successful in 25 patients, whereas the functional outcomes showed an air–bone gap below 30 dB in 18 patients. No postoperative sensorineural hearing loss was observed. The long-term follow-up demonstrated a slight worsening of the initial findings; four other patients had reperforation of the tympanic membrane, and hearing deteriorated in five patients to above 30 dB air–bone gap. These results could be a consequence of an alteration in the function of the eustachian tube and of the severity of the preoperative pathologic processes.

Sommaire

On a utilisé plusieurs techniques et matériaux pour tenter de contrer les problèmes associés aux cavités de mastoïdectomie radicale, comme la récurrence d'inflammation, le besoin de médicaments et les désagréments sociaux (impossibilité de pratiquer les sports aquatiques, de travailler dans des environnements hostiles etc). Cet article offre un rapport détaillé de notre expérience avec les granules d'hydroxyapatite pour remplir ces cavités. Ce matériel est intégré avec un adhésif de fibrine et recouvert d'un scellant de pâte d'os. Nous avons sélectionné 28 patients avec une otorrhée sur une vieille cavité de mastoïdectomie radicale (suivi moyen 11.4 ans [10-14 ans]). À six mois, la greffe était efficace chez 25 de ces patients et le rhine audiométrique inférieur à 30 dB chez 18 patients. Nous n'avons observé aucune perte d'audition neuro-sensorielle. Par contre, les résultats se sont un peu détériorés à long terme, puisque 4 patients ont reperforé leur membrane tympanique et que le rhine est remonté au-dessus de 30 dB chez 5 patients. Ces résultats peuvent être le résultat d'une altération de la fonction de la trompe d'Eustache et de la sévérité de la pathologie.

Key words: chronic purulent otitis media, hydroxyapatite, radical mastoidectomy

The management of unsuccessfully treated chronic discharging radical cavities represents one of the most controversial issues in ear surgery. The otologist faces numerous dilemmas. Should surgery be performed to reconstruct the posterior auditory canal wall partially or totally? Should this procedure be associated with obliteration of the mastoid cavity? Which type of biologic or nonbiologic materials should be used?

In each possibility, there are specific advantages and potential risks, and the outcome is not always predictable.^{1–37} Several aspects must be taken into consideration to be able to draw conclusions. First, candidates should be selected carefully to reduce the variables that could influence the final results. To do so, cases with similar histories, degree of infection, and bacteria type should be grouped together. Second, the analysis should be made over a long period of follow-up on an ample cross-section of patients who have been subjected to only one form of treatment or reconstruction technique.

The purpose of this study was to investigate the long-term anatomic and functional hearing outcomes of a group of patients following oblitative reconstruction surgery on the old radical cavity. The mastoid was obliterated with hydroxyapatite, which, being a nonreabsorbable substance, was then evaluated for its biocompatibility and stability.

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Giuseppe Magliulo, Raffaello D'Amico, and Massimo Fusconi: Department of Otorhinolaryngology, Audiology and Phoniatics, G. Ferreri, University "La Sapienza," Rome, Italy.

Address reprint requests to: Dr Giuseppe Magliulo, Via Gregorio VII n 80, Rome, 00165, Italy; e-mail: giuseppemagliulo@yahoo.com.

Materials and Method

The study group consisted of 28 patients admitted to the Second and Fourth ENT Clinics of La Sapienza University of Rome between 1988 and 1992 with the primary diagnosis of chronic discharging radical cavities that had been treated without success. Their clinical records were reviewed, and they were postoperatively recalled and reassessed several times by otomicroscopy, pure-tone audiometry, and tympanometry, including Valsalva's manoeuvre. Each patient was subjected to computed tomography (CT) at least once after surgery.

Eleven patients were male and 17 were female (age range 18 to 57 years; average age 41.2 years). Preoperatively, 23 patients had inflammation of the mastoid cavity associated with granulations and 5 patients had recurrent cholesteatoma. The radical cavity in the latter group had previously been reconstructed at other hospitals using homologous cartilage for the obliteration in one case and hydroxyapatite in the other.

The surgical technique used on the study group has been described in detail elsewhere.²⁹ This is a two-stage procedure in which all of the patients underwent obliteration of the mastoid with hydroxyapatite granules. The posterior canal was reconstructed with one of three different procedures: (1) modelling the granules, (2) coating the granules with a sheet of nasal cartilage, or (3) coating the granules with a mixture of bone pate-fibrin sealant trimmed and inserted to cover the bone defect following the removal of the posterior canal. The first method was applied in 7 patients, whereas cartilage or bone pate was used in 8 and 13 patients, respectively.

The latest revalidated cavity status was updated in the current year, providing a minimum follow-up period of 10 years (range 10–14 years; mean 11.4 years).

Results

Anatomic Findings

In this series, each pre- and postoperatively reconstructed cavity was evaluated by a single otologist, who

analyzed the data taken from the clinical reports. Particular attention was paid to assess the ear infection, the epithelialization of the external ear canal, its contour, the reabsorption of the ceramic granules and their stability or eventual extrusion during the entire follow-up period, and, finally, the state of the reconstructed tympanic membrane (Table 1).

Three different periods (6 months, 5 years, and 10 years) were evaluated. A 10-year follow-up was determined to have more reliable data, which would enable the whole study group to be assessed over a precise observation period that was common to all.

The epithelialization of the external ear canal after surgery healed rapidly in the majority of patients and usually remained stable after 2 months. Some granulation tissue was found in 2 of the 28 ears, but, subsequently, this was cured medically. The contour and the size of the external ear canal wall appeared to be normal or nearly normal in all of the group analyzed. In one patient, the cartilage was reabsorbed owing to the retraction of a short cutaneous flap. The uncoated hydroxyapatite granules were partially extruded, leaving a shallow concavity at the level of the attic after 2 months.

It took a minimum of 1 year for the obliterated mastoid cavity to become osteointegrated in the surrounding bone, as demonstrated by CT routinely performed before the second stage of the operation. The short-term follow-up showed the stability of the obliteration to be excellent in 27 patients. In the remaining patient, the granules became infected and were totally extruded. This failure could be connected to incomplete removal of the mastoid cells around the eustachian tube and the labyrinth, which caused granulation tissue to develop and continuous ear discharge. This obliged us to operate again on the patient.

Three patients had occasional ear discharge that recovered after local treatment in the short-term follow-up, whereas one patient had otorrhea, which was cured with antibiotic therapy. In the long-term findings, two more patients were seen to have occasional

Table 1 Postoperative Anatomic Findings (N = 28)

	Postoperative, 6 mo (%)	Postoperative, 5 yr (%)	Postoperative, 10 yr (%)
Infection			
Occasional discharge with local treatment	3 (10.5)	1 (3.5)	1 (3.5)
Occasional discharge with antibiotic treatment	1 (3.5)	2 (7.0)	—
Stability of revalidated cavity			
Partial hollowing	1 (3.5)	—	—
Total removal of the granules	1 (3.5)	—	—
Tympanic membrane			
Retraction pocket	6 (21.0)	2 (7.0)	1 (3.5)
Reperforation	3 (10.5)	2 (7.0)	2 (7.0)

Within each follow-up period, only newly occurring events are considered.

discharge that did not require local treatment, and two other patients were cured with antibiotics. None of these patients had permanent ear discharge.

After the first operation, there were only three graft failures, with a slight perforation of the neotympanum. During the long-term follow-up, these worsened, and there were a further four cases of reperforation. Reoperation in four of these patients was successful, whereas the other patients decided not to undergo surgery.

Initially, six patients were found to have a small retraction pocket in the posterior quadrant of the tympanic membrane, with good aeration of the anterior middle ear. Afterward, three more patients developed this slight atelectasis of the tympanic membrane but without any significant hearing impairment. In seven patients, otitis media with effusion was occasionally associated. Four of them were treated with tympanotomy tubes to maintain the stability of the graft.

Repeated high-resolution CT failed to detect any recurrent cholesteatoma behind the obliterated space.

Functional Findings

Table 2 summarizes the hearing results. The patients who had graft failures were not included. A comparison was made between the preoperative and postoperative air-bone gap at the frequencies of 250 to 4000 Hz. The primary postoperative results (25 patients) were evaluated on audiograms performed within the first 6 months. The other postoperative results included audiograms taken within 5 years (23 patients) and 10 years (21 patients). At the 6-month follow-up, the functional outcomes showed an air-bone gap below 30 dB in 18 patients. No postoperative sensorineural hearing loss was detected. The long-term results demonstrated a progressive worsening of the initial findings. The incidence rate of patients with a hearing level above 30 dB air-bone gap increased from 28 to 42.8%.

The different methods of reconstruction of the posterior canal wall did not influence the improvement in hearing (or the anatomic results). No differences were observed in the three groups.

The evaluation of the impedance and tubal tests followed the same pattern (Table 3). At short-term follow-up, 44% of the cases had type A tympanograms, whereas type B and C tympanograms were observed in 32% and 24% of the revalidated cavities, respectively.

Table 2 Preoperative and Postoperative Hearing Results

	Air-Bone Gap (dB) (%)		
	0-15	20-25	≥ 30
Preoperative (n = 25)	1 (4.0)	6 (24.0)	18 (72.0)
Postoperative, 6 mo (n = 25)	8 (32.0)	10 (40.0)	7 (28.0)
Postoperative, 5 yr (n = 23)	4 (17.4)	10 (43.5)	9 (39.1)
Postoperative, 10 yr (n = 21)	3 (14.2)	9 (42.8)	8 (42.8)

The eustachian tube tested with Valsalva's manoeuvre was patent in 84% of the cases. The long-term outcomes showed an increasing deterioration of these parameters (33.3% type A, 33.3% type B, and 33.3% type C with 71% of the all series had tubal patency with Valsalva's manoeuvre). Again, no differences emerged among the three techniques.

Discussion

The goal of mastoid cavity reconstruction is to completely remove all local disease and to eliminate the source of the persistent ear discharge after canal wall down mastoidectomy.

There is some controversy as to whether the reconstruction of the posterior canal wall should be performed alone or combined with mastoid obliteration. Although creating a large air-containing reservoir should, in theory, represent a procedure that would allow the middle ear to be well aerated, no substantial data support this hypothesis. A thorough review of the literature demonstrates variably successful outcomes with both techniques depending on which of the great variety of methods and materials has been adopted.¹⁻³⁷ These controversial aspects point out the need to analyze a homogeneous series for the surgical techniques and materials used. Furthermore, long-term results are essential in this type of disease owing to the frequent recurrence of infection. In the present series, these variables were overcome using only one nonbiologic material, hydroxyapatite, and studying only cases who underwent an oblitative technique performed by one of the authors (G.M.).

Table 3 Postoperative Impedance and Tubal Test Responses

	Tympanogram Type (%) Valsalva's			Manoeuvre, %
	A	B	C	
Postoperative, 6 mo (n = 25)	11 (44.0)	8 (32.0)	6 (24.0)	84
Postoperative, 5 yr (n = 23)	9 (39.2)	7 (30.4)	7 (30.4)	78
Postoperative, 10 yr (n = 21)	7 (33.3)	7 (33.3)	7 (33.3)	71

Hydroxyapatite appeared to be an ideal grafting material because it allowed for a biocompatible reconstruction without the detrimental effects of resorption and/or retraction. There is no doubt that this represents an unquestionable advantage when compared with other biologic materials, such as pedicled muscle flap, which has a well-known tendency to shrink. Hydroxyapatite granules were well tolerated by the mastoid cavity, and long-term osteointegration was the norm in our experience. They proved to be resistant to infection and, in fact, were extruded in only one patient. This failure was not attributable to the nature of the material but to insufficient removal of the residual mastoid cell tracts. This step is a fundamental prerequisite to obtain successful results. The validity of the long-term stability of the revalidated cavities is also confirmed by the contour of the external canal wall, which was normal or nearly normal in all cases.

Ceramic granules should be covered by thick connective tissue (eg, fascia) to achieve stable, morphologically valid, and, above all, reproducible anatomic results. This covering may be reinforced with other materials, such as cartilage and the bone pate used in the techniques of total posterior canal reconstruction analyzed in this study, and this reinforcement adds to the effectiveness of the technique. It also guarantees ideal epithelialization of the obliterated cavity, creating smooth edges in the ear canal and adequate prevention of extrusion of hydroxyapatite. In fact, only 2 of the 28 ears had recurrent granulation tissue during the follow-up period. These outcomes were confirmed by other authors, who recommended avoiding sharp edges in the reconstructed ear canal, which encourages the formation of granulation tissue.^{23,35-37} Our previous publication pointed out that preference was given to the reconstruction procedures that accurately covered the ceramic granules, favouring the final anatomic findings.²⁹ In view of this, since 1993, we have abandoned the other two methods of totally reconstructing the posterior canal wall of the external ear canal in favour of the fibrin glue and bone pate technique.

In the present series, no recurrence of cholesteatoma in the bowl mastoid occurred. This underlines the importance of the barrier formed by hydroxyapatite osteointegration against potential cholesteatoma growth into the mastoid.

Postoperative ear discharge proved to have a higher incidence rate. Seven of 28 patients suffered from this annoying symptom, even if only occasionally. This, however, seems to depend on the state of the middle ear and eustachian tube functioning rather than on the mastoid obliteration. The results of tympanic membrane reconstruction and of postoperative hearing improvement may also be interpreted similarly. There is no doubt that in these patients, the resulting poor tubal function had negative effects on the possibility of reperforation of the neotympanum and on the development

of retraction pockets and of episodes of otitis media with effusion. Abnormal tubal patency could also account for the decreasingly successful postoperative hearing results. The latter deteriorated progressively, reaching an air-bone gap above 30 dB in 42.8% of cases at the last follow-up compared with the initial 28% and the 39.1% at the 5-year follow-up. These data also include the subset of patients who needed ventilation tube insertion and who subsequently showed an improvement in hearing. If these audiograms had been ruled out in our calculations, the hearing results would have been worse.

In conclusion, mastoid cavity reconstruction using hydroxyapatite granules represents a useful surgical technique to heal chronic discharging radical cavities. The long-term results showed good stability and excellent osteointegration of the hydroxyapatite with the surrounding bone, confirming it as a reliable method of treatment. The method did not, however, seem to have a particular influence on tympanic reconstruction or postoperative hearing. The successful restoration of sound mechanisms would depend fundamentally on tubal patency.

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