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Transcanal Micro-Osteotome Only Technique for Excision of Exostoses

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Objectives: To evaluate the outcomes and complications of transcanal excision of exostoses using micro-osteotomes, without a postauricular incision or the use of the drill.
Study Design: A retrospective chart review of patients undergoing exostoses excision.
Setting: Tertiary Care Medical Center.
Subjects and Methods: All of the patients underwent surgical removal of the exostoses using only a 1 or 2 mm micro-osteotomes. Patients were followed postoperatively and associated complications were evaluated.
Results: One-hundred thirty-eight ears in 106 patients were treated for obstructive exostosis. The average age of patients was 43 ± 16 years. Of these, 99 were man (93%) and 7 were woman (7%). A majority of the patients (84%, $n = 89$) had 90 to 100% obstruction of the ear canal. Complete ear canal healing was observed in 80% of patients by 3 weeks. All but one patient had healed by 6 weeks postoperatively. There were 9 (6.5%) slit tympanic membrane perforations that healed with intraoperative gelfoam or fascia myringoplasty. One patient had an anterior canal mobilization which required Xeroform packing for 3 weeks for stabilization. There were no postoperative vertigo, facial paresis, conductive/sensorineural hearing loss, soft tissue stenoses, and no skin grafting required.
Conclusions: This is the first study to report a series of patients performing solely a transcanal approach using micro-osteotomes for removing exostoses. Results indicate that it is a safe procedure with low complication rate and expeditious healing. Patients with 100% obstruction can have this procedure performed with no significant increase in morbidity. **Key Words:** Exostosis—External ear canal—Surgical removal.

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Exostoses are bony growths arising in the external auditory canal which can occur as multiple, unilateral, or bilateral lesions (1). Environmental factors, such as exposure to cold water and wind, as well as low air temperatures, have been implicated in the pathogenesis of exostoses (2). Given the above risk factors, exostoses are commonly observed in water sport enthusiasts, including surfers, swimmers, and divers, with a prevalence of up to 73.5% (3–7).

These bony protrusions are typically found anterior and posterior to the isthmus of the external auditory canal. Increasing size of the lesion leads to obstruction that can result in hearing loss, recurrent infections, aural fullness, and cerumen entrapment (7–9). Additionally, large exostoses may prevent access to the tympanic membrane for other otologic surgeries. The mainstay of treatment is surgical removal, where otologic drills have been typically used for excision.

The goal of this article is to evaluate the outcomes and complications of transcanal excision of exostoses using micro-osteotomes only. The outcomes of the technique have been described in the literature (10,11); however, our series differs in that drilling was not performed in any of the ears with the exception of the one patient who developed anterior canal mobilization intraoperatively, and no meatal incisions were performed as in the endaural approach. Our objective is to critically analyze the safety and viability of the technique in treating exostoses.

MATERIALS AND METHODS

A retrospective chart review of patients was performed. Patients were identified using International Classification of Diseases (ICD-9-CM) diagnosis codes for ear canal exostosis and Current Procedural Terminology (CPT) codes for exostosis removal by the senior surgeon from 2007 to 2014. From these patients, those who underwent surgical removal of the exostoses using solely the micro-osteotomes with the transcanal technique were selected for this study. The external auditory canal stenosis was graded on the basis of the surgeon's microscopic assessment of the ear (Fig. 1). Exostoses were graded on the basis of the extent of external auditory canal stenosis observed

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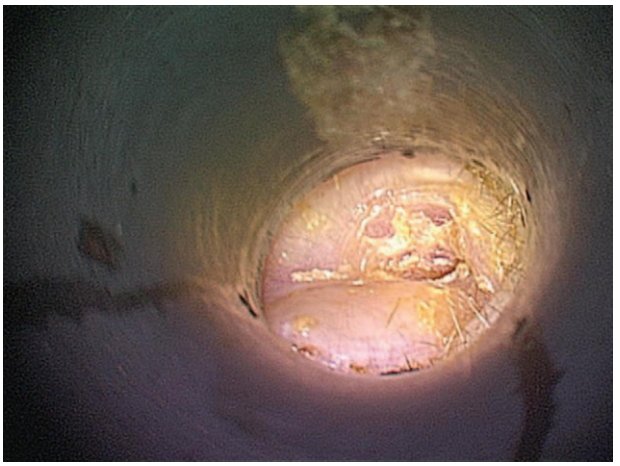

FIG. 1. Ear canal before surgery showing near 100% obstruction by exostoses.

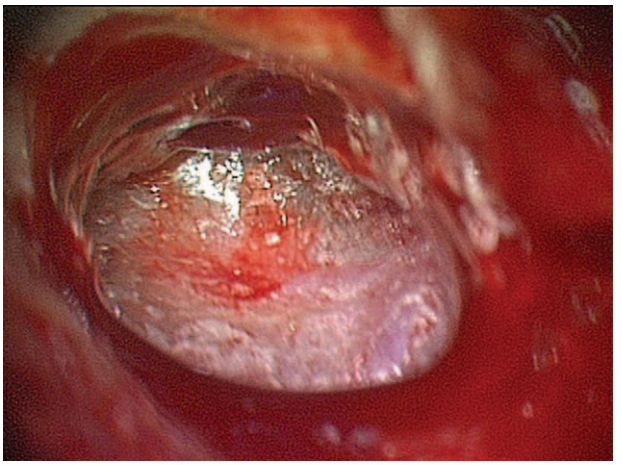

FIG. 2. Ear canal at the end of the surgery showing the TM.

on otoendoscopy. Grades of complete obstruction (100%); severe (95–99% obstruction), moderate–severe (80% to 94% obstruction), moderate (60–79% obstruction), and mild (<60%) were assigned. If otoscopic examination revealed asymmetric obstruction, the subject's grade corresponded to the more severely affected ear. A presurgical audiometry was performed for each patient.

All the patients underwent the procedure under general anesthesia. After the induction of anesthesia, the external auditory canal skin was injected in four quadrants with 1% Lidocaine with 1:100,000 Epinephrine. Intraoperative facial nerve monitor was placed. The ear was then sterilely prepared with 10% iodine solution and the head was draped in the usual fashion for otologic procedures. The ear canal was then additionally irrigated with iodine and saline solution under microscopic visualization if it was discovered that the Betadine had not penetrated the depth of the canal.

A lateral to medial approach was used to incrementally remove the bone in all patients. First, a round knife was used to make a circumferential incision lateral to the lateral edge of the exostosis, which was then elevated using a duckbill elevator. The canal skin was elevated from all aspects of the exostoses and lifted medially, with care taken to preserve the skin. Then, a combination of 1 and 2 mm osteotomes was used to chisel the exostoses at their base, which was continued medially until the tympanic membrane was encountered. In the cases of 100% obstruction where the tympanic membrane could not be visualized, one of the exostoses was removed incrementally to permit a necessary level of visualization of the tympanic membrane; typically starting with the anterior exostosis. Once the tympanic membrane was visualized, small pieces of Ofloxacin soaked Gelfoam were placed against the membrane to minimize the chances of trauma to the tympanic membrane. Thereafter, the other exostosis was removed completely from its base. The procedure was continued similarly for all exostoses until 100% visualization of the tympanic membrane was achieved (Fig. 2).

The canal wall was then irrigated with normal saline, and any remaining bone fragments were removed. Pinpoint or slit perforations, when encountered, were covered with a small piece of Gelfoam if the edges could be approximated. If the edges could not be approximated, a small piece of areolar fascia was obtained from a postauricular stab incision and used as a dumb-bell with some Gelfoam medially and laterally to hold the graft in place. The auditory canal skin flaps were then laid back into position, and a piece of silastic sheeting of 0.005 inches, in the form of a stent, was placed in the canal.

All patients in this series had symptomatic obstructive exostoses and underwent excision with a combination of 1 mm straight, 1 mm curved, and 2 mm straight micro-osteotomes. The patients were then followed postoperatively until complete healing was achieved. A post-op visit and audiometry was performed 6 weeks after surgery for each patient. The commonly reported complications including tympanic membrane perforation (12,13), canal wall mobilization (13), vertigo, facial paralysis (12–14), hearing loss (12,15), chorda tympani injury, and soft tissue stenosis were evaluated (12,15). This study was approved by UCI IRB board review.

RESULTS

From 2007 to 2014, 138 ears were treated in 106 patients for exostoses in our medical center. The average age of patients was 43 ± 16 years, among which 99 were man (93%) and 7 were woman (7%). A majority of the patients ($n = 89$, 83.9%) had 90 to 100% obstruction of the ear canal (Table 1).

At the postoperative visits, complete external auditory canal healing was observed in 110 ears (80%) at the 3-weeks follow-up, which is when the silastic stent was removed. All but one patient had healed by 6 weeks postoperatively and the skins in the canals were well-healed. There were nine (6.5%) tympanic membrane perforations that all healed at the first postoperative visit. These TM perforations were all central and six of them required a tissue graft and the remainder were treated with Gelfoam.

One patient had an anterior canal mobilization which required Xeroform packing for 3 weeks for stabilization. The rest of the exostosis was removed using a drill. Postoperative physical examination of the patients did not show any signs of vertigo, facial paresis, conductive or sensorineural hearing loss, soft tissue stenosis, and also no skin grafting was required for external canal skin repair. Two patients developed a small adhesion between the anterior canal and a small portion of the anterior

TABLE 1. *Characteristics of the patients with exostosis*

Sex		
Male	99	
Female	7	
Total	106	
Mean age (yr)	42.9	
Age range (yr)	19–75	
Laterality		
Left	36	
Right	38	
Bilateral	32	
Total	138	
Preoperative Stenosis (%)	**No. of Patients**	**Percentage**
100	43	40.6
95–99	27	25.5
80–94	33	31
60–79	3	2.8
	106	100.0
Surgical Complications	**No. of Ear Canals**	
Slit TM perforation	9	
Anterior canal mobilization	1	
Vertigo	0	
Facial paralysis	0	
Hearing loss	0	
Soft tissue stenosis	0	
Skin grafting	0	

superior quadrant of the tympanic membrane. The adhesions did not cause a conductive hearing loss and the patients elected no intervention. Post-op audiometry testing has shown improvements of conductive hearing loss in 98% of the cases. Based on the post-op audiometry, there was not any case of conductive hearing loss or Sensorieneural hearing loss. Mean 6 months follow-up for all patients did not show any stenosis of the ear canals or scar formation.

DISCUSSION

Our experience supports that the micro-osteome only technique is a safe and valid option for treating exostoses. The study indicates that the process of the ear canal healing was not affected and complications from the procedure were uncommon.

Surgery for removal of exostoses is indicated if the lesions cause intolerable obstructive symptoms, such as hearing loss, recurrent infections, refractory aural fullness, and cerumen entrapment in the external auditory canal (7–9). Patients can usually manage their stenotic ear canals with conservative methods, such as regular cleansing and topical antimicrobials for otitis externa if indicated. However, when conservative management fails, operative intervention is indicated. Typically, the procedure has been performed using an otologic drill via a postauricular incision, an endaural or a transcanal approach (9–11,13,16–18). Additionally, in recent years, there has been a growing body of evidence in literature reporting use of the osteotome technique.

Hetzler and Barret et al. reported excellent results with the osteotome; however, both series included patients that required the use of a drill (10,11). Hetzler (10) demonstrated that the removal of ear canal exostosis with osteotomes, combined with selective drilling, was safe and effective. Barrett et al. (11) also further evaluated the use of osteotomes, but acknowledged that the drill technique may be needed in certain difficult patients.

In contrast, our data substantiate the fact that a micro-osteotome *only* technique, via a transcanal route, without any drilling, is also safe, effective, and according to the outcomes of this study, it has certain advantages over drilling. Among the patients in this series, 41% of patients had 100% external auditory canal stenosis, with 84% presenting with over 90% stenosis. However, even at this level of severity of canal stenosis, the overall immediate complication rate was very low (7.2%), and there were no long-term complications, representing a success rate of 100%. The most commonly encountered complication was a tympanic membrane perforation, which was managed with either tissue graft tympanoplasty, or conservatively with Gelfoam covering. One patient had mobilization of the anterior canal wall, with no temporomandibular joint disturbance. The patient was managed conservatively with Xeroform occlusive packing, and healed without any further intervention.

There are several advantages to completely eliminating the need for drilling. First, the entire procedure can be performed via a transcanal approach, which minimizes recovery time, scarring, and pain and there will be no need for a postauricular incision. As observed in Table 1, 80% of the ears in this series had completely healed when evaluated at their 3-week follow-up. Second, the micro-osteotome has a flat distal end, which is different from the rounded edges of a drill bit. The osteotome may be advantageous in the setting of 100% canal stenosis because it allows the surgeon to incrementally remove bone for the full length of the exostosis which allows earlier visualization of the tympanic membrane. As a result, early visualization of the tympanic membrane allows for a safer approach to the medial portions of the exostosis, by promoting awareness of the location of the tympanic membrane at all times. It also permits easy placement of shields such as Gelfoam or Silastic to minimize perforation. When perforations do occur, they are limited to small, slit perforations that require no extensive intervention.

The osteotome technique has several advantages compared with the drill for removing obstructive exostoses. Primarily, the use of a drill in the removal of exostoses is associated with tinnitus and high-frequency hearing loss (12,13,15,19–24). Some authors have thus advocated minimizing drilling (15), using shields to protect the tympanic membrane (10), and using osteotomes to decrease acoustic injury (11,13). In Barrett's series, only the patients who required drilling experienced hearing

loss (11). Similarly, our series found no evidence of hearing loss or tinnitus in our patients postoperatively.

Studies have also demonstrated other complications, including facial nerve paralysis, temporomandibular joint derangements (12,13,19,21,22), soft tissue stenosis (12,13,15), anterior canal wall dehiscence (22), as well as the need for skin grafting to cover denuded canal (19). However, our data show less than 1% occurrence of these complications, as only one operated ear had anterior canal mobilization. Facial nerve paralysis is most likely to occur in the posterior inferior aspect of the canal where the facial nerve is approximately 2–4 mm away from the annulus (25). The facial nerve may be at the level of or lateral to the annulus. Particular attention should be given to the imaging before the surgery and when working in this area. We generally evaluate the axial and sagittal images to evaluate the relationship between the facial nerve and the annulus.

Even though our series found a very low risk in the micro-osteotome only technique, the above-mentioned complications remain a true possibility. Given the paucity of controlled trials with sufficient power to delineate statistically significant differences, only anecdotal evidence is available to suggest that eliminating the use of drilling prevents postoperative hearing loss.

There are a few technical points that we have learned that we think will help the novice surgeon or the occasional exostoses surgeon prevent complications. 1) It is best to obtain a CT of temporal bones without contrast and view the images in axial, coronal, and sagittal planes to understand the three-dimensional anatomy of the exostoses and their proximity to the tympanic membrane, especially the lateral process of the malleus. Trauma to the lateral process of the malleus or transmission of drilling vibration to this structure may be the most likely cause of postoperative tinnitus and hearing loss, which may be further minimized by preoperative radiographic analysis. 2) In most patients, it is advisable to remove the anterior exostosis first. This allows early visualization of the TM in the operation, which is beneficial for orientation. The only exception to this rule is when a posterior or superior exostosis prevents the removal of a portion of the anterior exostosis. In such patients, a small portion of the superior or posterior exostosis should be removed to allow for removal of the anterior exostosis. 3) Once the TM has been identified it is best to cover it with gelfoam to prevent small bony spicules from etching or perforating the TM. The gelfoam has to be intermittently removed and replaced for reorientation and to gauge the completion of resection. 4) For large, broad-based exostoses it is best to not attempt removal of the entire exostosis in one piece. The large exostoses are best removed in longitudinal slices and blindly starting at the base of an exostosis when the TM is not visualized is not advisable. On occasion the large mobilized exostosis cannot be removed because of obstruction of other exostoses. In a patient in whom the large mobilized exostosis cannot be removed, only a small portion of the obstructing exostosis should be removed to allow for removal of the large mobilized exostosis. The senior author has observed a patient in whom another surgeon attempted to remove an obstructing exostosis blocking the removal of the large mobilized exostosis. This maneuver had pushed the large exostosis into the middle ear fracturing the incus causing a mixed loss and tinnitus. 5) The use of the curette near the tympanic membrane, especially when removing superior exostoses, should be avoided. The back of the curette can cause pressure against the TM or the manubrium or lateral process of the malleus and cause a perforation or dislocation of the malleus.

CONCLUSION

The transcanal approach using micro-osteotomes without the use of drills for removing exostoses is safe, effective, and feasible, and may have advantages over techniques involving the use of drills. The transcanal, micro-osteotomes *only* approach afforded quicker recovery, lower complication rates, and greater postoperative canal opening. Patients with 100% obstruction can have this procedure performed with no significant increase in morbidity. However, there is a learning curve and the novice surgeon is encouraged to start by using the micro-osteotome on less severe exostoses first to become comfortable with the technique before attempting patients with near total or total obstruction.

REFERENCES

1. DiBartolomeo JR. Exostoses of the external auditory canal. *Ann Otol Rhinol Laryngol Suppl* 1979;88 (6 Pt 2 Suppl 61):2–20.
2. Collins JG. Prevalence of selected chronic conditions: United States, 1990–1992. *Vital Health Stat* 1997;194:1–89.
3. Kennedy GE. The relationship between auditory exostoses and cold water: A latitudinal analysis. *Am J Phys Anthropol* 1986;71:401–15.
4. Alexander V, Lau A, Beaumont E, et al. The effects of surfing behaviour on the development of external auditory canal exostosis. *Eur Arch Otorhinolaryngol* 2015;272:1643–9.
5. Kroon DF, Lawson ML, Derkay CS, et al. Surfer's ear: External auditory exostoses are more prevalent in cold water surfers. *Otolaryngol Head Neck Surg* 2002;126:499–504.
6. Sheard PW, Doherty M. Prevalence and severity of external auditory exostoses in breath-hold divers. *J Laryngol Otol* 2008;122: 1162–1167.
7. Moore RD, Schuman TA, Scott TA, et al. Exostoses of the external auditory canal in white-water kayakers. *Laryngoscope* 2010;120: 582–590.
8. Wong BJ, Cervantes W, Doyle KJ, et al. Prevalence of external auditory canal exostoses in surfers. *Arch Otolaryngol Head Neck Surg* 1999;125:969–72.
9. Kozin ED, Remenschneider AK, Shah PV, et al. Endoscopic transcanal removal of symptomatic external auditory canal exostoses. *Am J Otolaryngol* 2015;36:283–6.
10. Hetzler DG. Osteotome technique for removal of symptomatic ear canal exostoses. *Laryngoscope* 2007;117 (1 Pt 2 Suppl 113):1–14.
11. Barrett G, Ronan N, Cowan E, et al. To drill or to chisel? A long-term follow-up study of 92 exostectomy procedures in the UK. *Laryngoscope* 2015;125:453–6.
12. Fisher EW, McManus TC. Surgery for external auditory canal exostoses and osteomata. *J Laryngol Otol* 1994;108:106–10.
13. Reber M, Mudry A. Results and extraordinary complications of surgery for exostoses of the external auditory canal. *HNO* 2000;48:125–8.

14. Green JD Jr, Shelton C, Brackmann DE. Iatrogenic facial nerve injury during otologic surgery. *Laryngoscope* 1994;104:922–96.
15. Frese KA, Rudert H, Maune S. Surgical treatment of auditory canal exostoses. *Laryngorhinootologie* 1999;78:538–43.
16. Seftel DM. Ear canal hyperostosis: Surfer's ear. An improved surgical technique. *Arch Otolaryngol* 1977;103:58–60.
17. Longridge NS. Exostosis of the external auditory canal: A technical note. *Otol Neurotol* 2002;23:260–1.
18. Selesnick S, Nguyen TP, Eisenman DJ. Surgical treatment of acquired external auditory canal atresia. *Am J Otol* 1998; 19:123–30.
19. Portmann D, Rodrigues E, Herman D, et al. Exostosis of the external auditory canal: Clinical and therapeutic aspects. *Rev Laryngol Otol Rhinol (Bord)* 1991;112:231–5.
20. Oostvogel CW, Hüttenbrink KB. Recurrences of ear canal exostoses. *Laryngorhinootologie* 1992;71:98–101.
21. Bordure PH, Legent F, Sene JM, et al. Complications in surgery of the external auditory meatus exostoses. *JFORL* 1994;43:336–40.
22. Whitaker SR, Cordier A, Kosjakov S, et al. Treatment of external auditory canal exostoses. *Laryngoscope* 1998;108:195–9.
23. Stougaard M, Tos M. Less radical drilling in surgery for exostoses of the external auditory canal. *Auris Nasus Larynx* 1999;26:13–6.
24. Hurst W, Bailey M, Hurst B. Prevalence of external auditory canal exostoses in Australian surfboard riders. *J Laryngol Otol* 2004;118:348–51.
25. Zaghal ZA, Raad RA, Nassar J, et al. Anatomic relationship between the facial nerve and the tympanic annulus. *Otol Neurotol* 2014;35:667–71.