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The Use of an Ultrasonic Serrated Knife in Transcanal Excision of Exostoses

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Objective: To describe a novel approach for excision of exostoses and evaluate the outcomes of transcanal excision of exostoses using ultrasonic serrated knife-assistance versus microosteotomes only.

Study Design: Retrospective analysis.

Setting: Academic Tertiary Care Center.

Patients/Interventions: Patients receiving a transcanal excision of exostoses between 2007 and 2016.

Main Outcome Measures: The outcomes and postoperative complications of 138 patients who received transcanal microosteotome only technique were compared to 10 patients who received transcanal excision of exostoses using ultrasonic serrated knife-assistance (Stryker Corporation, Kalamazoo, MI).

Results: A total of 175 ears in 128 patients underwent a transcanal microosteotome only technique. Of these, 11 (6.3%) developed an intraoperative tympanic membrane perforation. One developed anterior canal mobilization requiring prolonged (3 wk) packing. One hundred thirty-five ears (77%) were well healed by the 3-week postoperative

visit. All but one ear was well healed by the 6-week visit. In comparison, 11 ears in 10 patients were treated for exostoses using a transcanal approach with the use of ultrasonic serrated knife and microosteotomes. One ear canal (the first in the series) was not well healed by the 3-week postoperative visit due to suspected thermal injury. All patients had well-healed ear canals by 6 weeks, and there were no complications.

Conclusion: This is the first series to report the use of an ultrasonic serrated knife in the transcanal excision of exostoses. When compared with a transcanal microosteotome only excision of exostoses, the addition of the Sonopet seems to result in a similarly low complication rate. Sonopet can allow for more controlled transcanal excision of broad-based exostoses in patients with severe obstruction. **Key Words:** Ear surgery—Exostoses—Microosteotome—Osteoma—Sonopet—Transcanal—Ultrasonic knife.

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Exostoses are lamellar bony growths which can arise in the external auditory canal (EAC) (1,2). These commonly occur as multiple, broad-based outgrowths and are often bilateral. This condition is also known as surfer's ear due to the higher frequency among people exposed to cold wind or water (3–5). This is thought to be due to an evaporative effect resulting in cooling within the EAC (6,7).

Most patients who present with exostoses do not require surgical excision. In a series of 11,000 general otolaryngology patients in Southern California, 70 (0.64%) had symptomatic exostoses (8). Current indications for surgical removal include conductive hearing loss due to near obstruction, uncomfortable water

trapping, aural pain, and recurrent otitis externa that is recalcitrant to medical treatment (9–12).

Multiple methods of exostoses excision have been described, which include transcanal, endaural, endoscopic, and postauricular approaches (13–16). Although there have been decreasing rates of intraoperative complications and improved postoperative healing with more recently described methods, exostoses excision continues to present a surgical challenge to otolaryngologists. Exostoses demonstrate a variable shape and broad bases that can make excision difficult. Exostoses can result in a narrowed or absent EAC lumen that can obstruct tympanic membrane (TM) visualization. This can be further obscured by bleeding and complicate surgical excision.

We herein present a novel approach for the excision of exostoses with the use of an ultrasonic serrated knife. The goal of this article is to evaluate the outcomes and complications of transcanal excision of exostoses using a Sonopet compared with our population of patients who had a transcanal microosteotome only technique. Our

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FIG. 1. Image of the ultrasonic Sonopet with a serrated knife attachment.

objective is to critically analyze the safety and viability of the use of Sonopet in the transcanal excision of exostoses.

METHODS

A retrospective analysis of all patients with exostoses treated with a transcanal excision only by the senior author was performed. Patients were identified using International Classification of Diseases (ICD-9-CM) diagnosis codes for ear canal exostosis 380.81 and Current Procedural Terminology (CPT) codes for exostosis removal (69140). This study was approved by our institutional review board. The EAC stenosis was graded based on the surgeon's intraoperative microscopic assessment of the ear. Grades of complete obstruction (100%); severe (95–99% obstruction), moderate–severe (80–94% obstruction), moderate (60–79% obstruction), and mild (<60%) were assigned. A presurgical and postoperative audiometry was performed for all patients.

The detailed operative procedure of a transcanal microosteotome only excision of exostoses was described in our previous article (14). The same method was applied when the transcanal excision of the exostoses involved the Sonopet. The Sonopet Ultrasonic Aspirator (Stryker Corporation, Kalamazoo, MI) with a serrated knife attachment (Sonic Control Serrated Aggressive Knife, Ref 5450-815-114) was used in a transcanal approach, in combination with 1 and 2 mm osteotomes, to incrementally remove exostoses. Its dimensions are approximately 2 mm × 0.8 mm (Fig. 1). If the exostoses were noted to be near obstructive and broad based or if there were bony exostosis edges noted after microosteotome excision, a Sonopet was used as the microosteotomes can create unpredictable lines of fracture. The Sonopet was used to initiate a cut in a broad-based exostosis, to split a large exostosis in half to

allow for visualization, or to smooth the base of an exostosis after microosteotome excision.

To summarize operative technique, an operative microscope and otic speculum are used to visualize the EAC. A lateral to medial approach is used in the excision of the exostoses. An angled round knife is used to make an incision over the EAC skin on the lateral aspect of the exostoses. A duckbill elevator is used to elevate the skin over the exostoses. Once the extent of the exostosis is exposed, a Sonopet knife can be used to start the excision of the exostosis (Fig. 2). Aluminum foil is used to protect the EAC skin. Subsequently, 1 and 2 mm osteotomes are used to chisel the exostoses (Fig. 3). Once the TM is visualized, it is protected with small pieces of ofloxacin-soaked Gelfoam. This is performed sequentially to remove all of the exostoses. Alternatively, the Sonopet can be used to smooth bony edges after microosteotome excision. A 0.005 inch silastic sheet was placed in the canal in the form of a stent. The patients were seen postoperatively at a 3-week visit, 6-week visit, and sequentially thereafter until complete healing was achieved. Postoperative audiometry was obtained at approximately 6 weeks, and the pure-tone average (PTA) was compared to preoperative audiometry.

A Fisher's exact test was used to determine if there was a statistically significant difference between complications and short-term (3 wk) EAC healing when using Sonopet versus no Sonopet. A paired *t* test was used to compare the average preoperative and postoperative PTA. A *p* value of <0.05 was considered statistically significant.

RESULTS

A total of 148 patients (186 ears) between 2007 and 2016 had a transcanal excision of exostoses using microosteotomes or Sonopet and microosteotomes. Of those, 138 patients (175 ears) underwent excision of exostoses using transcanal microosteotome technique only. Ten

FIG. 2. Ultrasonic serrated knife being used at the base of an exostosis to initiate the cut. The exostosis is at the center of the view. The device is observed at the inferior part of the image. The suction port is observed at the left of the image.

FIG. 3. Microosteotome used to complete the cut and mobilize the exostosis.

TABLE 1. Patient characteristics and extent of exostoses

		Microosteotomes Only	Sonopet With Microosteotomes
Total number of patients		138	10
Mean age (yr)		44.2	44
Age range (yr)		19–75	23–60
Sex	Male	130	9
	Female	8	1
Laterality	Right	45	6
	Left	46	3
	Bilateral	42	1
Total ears		175	11

patients underwent transcanal excision of exostoses with the addition of an ultrasonic serrated knife for a total of 11 ears. Patient characteristics are shown in Table 1. A large proportion of ears treated had greater than 80% stenosis with the exact rates of preoperative stenosis shown in Table 2.

Of the patients treated with transcanal microosteotome only excision, 12 of 175 (6.8%) developed a complication. Eleven patients developed a slit tympanic membrane perforation. Of these, eight required repair with a fascia graft while three were treated with Gelfoam alone intraoperatively. All of the perforations were healed by the first postoperative visit. One patient developed anterior canal mobilization which required prolonged Xeroform packing for 3 weeks. In this patient, the rest of the exostosis was removed with drill to avoid further destabilization.

In comparison, 0 out of the 11 ears treated with the additional use of Sonopet developed a complication (Table 3). The numbers of ears that exhibited good healing at the 3-week and 6-week postoperative visit are shown in Table 4. In the transcanal microosteotome only group, four ears developed a small adhesion/scar band between the anterior canal and antero-superior quadrant of TM that did not cause a hearing loss and was left untreated. One ear (the first in our series) in the ultrasonic serrated knife group had evidence of exposed bone in the EAC on evaluation at the 3-week postoperative visit, which was suspected to be due to thermal injury from the ultrasonic knife. This patient had well-healed EAC on examination at the 6-week postoperative visit.

Of the patients treated with transcanal microosteotome excision only, 98% demonstrated no change or improvement in postoperative audiometry when comparing the

TABLE 2. Preoperative stenosis (percentage in parentheses)

	Microosteotomes Only	Sonopet With Microosteotomes
100%	70 (40.0%)	8 (72.7%)
95–99%	46 (26.3%)	1 (9.1%)
80–94%	52 (29.7%)	2 (18.2%)
60–79%	7 (4.0%)	0

TABLE 3. Surgical complications (percentage in parentheses)

	Microosteotomes Only	Sonopet With Microosteotomes
Slit TM perforation	11 (6.3%)	0
Anterior canal mobilization	1 (0.6%)	0
Vertigo	0	0
Facial paralysis	0	0
Tinnitus	0	0
Soft tissue stenosis	0	0
Total number of complications	16 (9.1%)	0

TM indicates tympanic membrane.

PTA to preoperative audiometry. All patients in the Sonopet group demonstrated no change or slight improvement in audiometry. The average change in the PTA postoperatively was an improvement of 4.3 dB, which is not statistically significant ($p=0.112$). No patient in the group treated with the ultrasonic serrated knife developed hearing loss or tinnitus postoperatively.

There was no difference in the complication rate when ultrasonic serrated knife was used in addition to the microosteotomes ($p=0.470$). The healing rate was equivalent in the two groups ($p=0.080$). Since the use of the ultrasonic serrated knife seems to be most beneficial in the most obstructive exostoses, we compared the rate of complications in patients with >95% obstruction. Of those treated with transcanal microosteotome excision, 11 of 116 ears (9.5%) developed an intraoperative complication. In comparison, 0 of 11 ears who had Sonopet for excision of exostoses developed complications ($p=0.424$).

DISCUSSION

The use of ultrasonic serrated knife has not been described in the treatment of EAC exostoses. The authors present a short surgical series on the novel use of this device for transcanal exostoses excision. The ultrasonic serrated knife can be useful in initiating the cut in broad-based exostoses where there is a fear in using microosteotomes that could mobilize the EAC or in smoothing the base after microosteotome excision of an exostosis. We further compared the outcomes and complications of these patients to those patients who received a transcanal microosteotome only technique. Our experience supports that the additional

TABLE 4. EAC healing (percentage in parentheses)

	Microosteotomes Only	Sonopet With Microosteotomes
Number of EACs well healed by 3 weeks	135 (77.1%)	10 (90.9%)
Number of EACs well healed by 6 weeks	174 (99.4%)	11 (100%)
Adhesion/scar bands	4 (2.3%)	0

EAC indicates external auditory canal.

use of this device in the transcanal excision of exostoses in select cases is a safe and valid option for treating exostoses through a transcanal approach.

Challenges in intraoperative management of exostoses have been well documented in the literature. Multiple intraoperative complications to exostoses have been described, including facial nerve injury, TM perforation, temporomandibular joint injury, anterior canal wall mobilization, and mastoid air cell entry (9,13,14,17). Other postoperative complications include sensorineural hearing loss (SNHL), facial paralysis, TM lateralization, chronic myringitis, wound infection, hematoma/seroma, canal swelling, prolonged healing, exposed bone, canal stenosis, and the need for revision surgery (9,10,13,18). Surgery requires preservation of EAC skin over the exostoses to allow for appropriate EAC healing.

The different described surgical methods for excision of exostoses aim to minimize intraoperative and postoperative complications. The rate of intraoperative complications from the different surgical methods has been shown to be overall low (6,13,19,20). Our standard transcanal excision of exostoses with microosteotome only similarly demonstrates an overall low rate of complications (6.3%) with an even lower rate with the transcanal use of Sonopet (0%), despite this patient population having a higher rate of preoperative stenosis.

SNHL did not occur in either of our populations. Although it is certainly a concern with vibration injury during the drilling process (13,21), it is less likely to be of concern with the ultrasonic system. The ultrasonic serrated knife has decreased sound transmission in the range of human hearing compared with a drill as well as improved tactile feedback. Clinically in our case series, all patients demonstrated no change or improvement in audiometry, without evidence of SNHL. This suggests that the ultrasonic serrated knife can be a safe means for excision of exostoses with low rates of sound or vibration injury.

Postoperative EAC healing and resultant canal stenosis can be of concern when there is inadequate intraoperative skin coverage of the EAC. Minimizing trauma to the native EAC skin during surgery and preserving its vasculature is critical to allow for postoperative EAC healing (13). Although one patient developed thermal injury due to the ultrasonic serrated knife which resulted in slower ear canal healing, our study indicated that the process of ear canal healing was overall unchanged when compared with a microosteotome only technique. This occurred in the first patient in our series.

We think that the ultrasonic serrated knife allows for more controlled excision of broad-based exostoses which can help prevent mobilization of the EAC or inadvertent drifting of the cut due to the lamellar nature of the exostoses. While using the ultrasonic serrated knife, we protected the EAC skin with the use of foil, similar to what has been described in other series where drilling is performed (19,22,23). Overall, all of the patients in our series demonstrated well-healed EACs postoperatively with the transcanal use of Sonopet with an average healing time of 3.3 weeks.

Tympanic membrane perforation with the transcanal approach is a concern among many authors due to the obstructive nature of exostoses which blocks TM visualization. Previous studies on the transcanal approach have shown rates of TM perforation ranging from 5.4 to 13.6% (10,14,16). Our currently reported series of patients who underwent the transcanal microosteotome only approach had a rate of 6.2%. This rate continues to be higher than that achieved by the postauricular approach (6,13,19). TM perforation was managed conservatively with an intraoperative fascia graft tympanoplasty or Gelfoam covering with no long-term consequences in any of the patients. Since starting the Gelfoam technique, we have not had perforations in our last 56 ears. Notably, none of the patients who had ultrasonic serrated knife-assisted excision of exostoses developed a TM perforation. We think that this device allows for a more controlled excision of exostoses and allows for bony fragments to be safely removed without damaging the nearby TM.

A few technical points were learned from our series. The first is to ensure proper irrigation before engaging the ultrasonic knife with the bone as the irrigation tends to start in a delayed fashion. The settings on the device that we found to work the best were 100 on the power, 50 on suction, and 15 on irrigation. The second is to use a larger suction, e.g., 5 Fr to ensure that the field is clear to visualize the area of engagement between the knife and the bone. The third is to engage the bone for short durations of time using an on-off-on technique to prevent over heating of the bone which can cause a burn and associated prolonged healing. If the bone does burn during the technique, the burned bone has to be removed with the ultrasonic serrated knife using good irrigation until normal bone is reached to prevent poor skin healing later.

At our institution, we have found that the ultrasonic serrated knife offers a novel approach to the treatment of large sessile exostosis with its powerful, yet precise, dissection in the EAC. Due to its small width (approximately 2 mm × 0.8 mm), it is another tool that allows for a transcanal approach, which minimizes recovery time, scarring, and pain (14). The ultrasonic serrated knife can be useful to initiate a cut in an exostosis when there is near-obstructive exostoses. It can also be used to split an exostosis in half longitudinally to allow for early TM visualization and protection. Lastly, we have found it useful to smooth the bony ragged edges of an exostosis and smooth the canal wall after exostosis excision with microosteotomes. Its ultrasonic vibrations allowed for a controlled means of excision that is not afforded by a drill.

While the primary purpose of this study is to describe a novel application of ultrasonic serrated knife, this study is limited by the small sample size. We had an adequate sample size of patients who received the transcanal microosteotome only technique. However, we began using ultrasonic serrated knife in exostoses excision on June 2014, which limited the number of patients in this study. Due to the cost of the knife and the associated suction tubing (~\$800), we limit its use to the most severe cases or in very broad-based exostoses. There are also inherent

limitations to any retrospective review. Prospective evaluation of this technique with a larger population is necessary to confirm efficacy of this device in exostoses excision. A future study could compare the addition of Sonopet in transcanal versus postauricular approaches. The senior author only performs transcanal excision of exostoses, thus we are unable to perform this analysis. Despite the small population size, this study shows that this device can be a safe and effective method in the excision of exostoses, particularly in near or complete obstruction. It was shown to be at least as safe and effective as a transcanal microosteotome only approach.

CONCLUSIONS

The transcanal approach using an ultrasonic serrated knife and microosteotomes is a safe and effective means of removing larger, broad-based exostoses. The patients who had this device used in addition to microosteotomes had a similar complication rate with equivalent EAC healing compared with our patient population who had a transcanal excision of exostoses with microosteotomes only. While thermal injury as a result of this device can rarely prolong EAC healing, the rate seems to be no different than the transcanal microosteotome only population. The ultrasonic serrated knife can allow for a safe, more controlled means for transcanal excision of exostoses.

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