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Research Paper

A worthy technique for transcanal drilling during endoscopic ear surgery

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KEYWORDS
Endoscopic;
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Abstract *Objective:* To evaluate the necessity and effectiveness of a preplanned technique for drilling during transcanal endoscopic ear surgery.
Methods: Study design: Retrospective case series study from June 2011 to June 2015. *Setting:* Private tertiary care hospital. *Patients:* Eighty-five ears of 78 patients, age ranging from 9 to 57 years underwent transcanal endoscopic drilling for various types of pathology in their middle and external ear. *Interventions*: Application of a preplanned technique for transcanal drilling in endoscopic ear surgery that involved short timed drilling with use of intermittent irrigation and suction. Every events of the procedure were done one after another with the single hand of the surgeon. An attachment providing protecting sheath around rotating burr was used during each time of drilling. *Main outcomes measure*: Efficacy of such drilling technique in single handed endoscopic ear surgery. Presence of any postoperative thermal injury of facial nerve and any lacerated injury of skin of external ear.
Results: This preplanned technique was found suitable for transcanal endoscopic drilling with the single hand of the surgeon. Postoperative facial nerve palsy or laceration of skin of external ear was not noted in any patient.
Conclusion: After using the present technique, transcanal endoscopic drilling could be done easily and safely with single hand of the surgeon.

Introduction

Transcanal endoscopic bony dissection is demanded while addressing various pathology of ear such as atticoantral cholesteatoma, exostosis etc. To perform such bony dissection, drilling with burr is an important step. During use of this essential powered tool, iatrogenic injury could

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happen. Mechanical injuries by rotating shaft or tip of drill burr could cause potential damages to different structures of ear. Frictional thermogenesis during dissection may cause thermal injury to facial nerve.

Surgical drilling of any bone demands several technical events to happen simultaneously; such as drilling, irrigation and suction clearance. Doing all of these events through the limited space of external auditory canal is really a troublesome job.

Especially it is very much true when endoscopic ear surgeon intends to do these events with his/her single hand that means holding the endoscope with one hand and trying to do all technical events with other hand. For these reasons a preplanned technique is necessary to be setup for safe, effective and easily executable transcanal endoscopic drilling with single hand.

One of such preplanned technique used by the present author has been mentioned in this study. This preferred technique involved short timed drilling, intermittent irrigation and suction clearance and using of a protective sheath/attachment around rotating shaft of burr. This study observed the effectiveness of such transcanal endoscopic drilling technique.

Materials and methods

This retrospective case series study was conducted on 85 ears of 78 patients; age ranging from 9 to 57 years underwent transcanal endoscopic drilling for their middle ear and external ear pathology in the Surgiscope Hospital, a private tertiary care hospital in Chittagong, Bangladesh from June 2011 to June 2015. Procedures that demanded transcanal endoscopic drilling are mentioned in Table 1. Proper medical ethics was practiced in every case.

The preplanned drilling technique involved various operative events done one after another by dominant hand of the surgeon while holding the endoscope with his non dominant hand. These subsequent, stepwise events first started with the drilling for 2—5 s at a speed of 35 000 rpm (35 000 rpm was the maximum speed of the drill machine) without simultaneous irrigation of fluid. After drilling, the operating area was instantly flooded with few milliliters of saline water at room temperature (18 °C—20 °C) and this was followed by suction clearance of the operating area. Two seconds drilling time was strictly maintained while drilling in the facial recess area or in area very closed to the facial nerve. Whereas area around 5 mm way from facial nerve was drilled at a speed of 35 000 rpm for maximum 5 s. Drilling was done with micro motor (Strong model, Saeshin Precision IND. CO. Korea). Steel round cutting burr of 1.8, 2.7 mm diameter and Diamond round burr of 2.7 mm diameter were used during dissection. Drilling time was roughly maintained by counting 1 to 5 individually by the surgeon that corresponded with the timing of 1—5 s. Before doing this the surgeon needed to calibrate his counting speed mentally with timing of second of a clock. During every drilling, an attachment providing protecting sheath around rotating shaft of the burr was used. At the beginning of the study the author had used a self-made attachment and later he used the attachment made by Tian Song Medical Instrument Company, China according to his prescribed design. All surgical procedure was done by single surgeon-the author.

Table 1 Procedures required use of transcanal endoscopic micro-drilling.

Procedures	Number
Transcanal endoscopic atticoantrostomy for excision of atticoantral cholesteatoma	26
Transcanal endoscopic open cavity mastoidectomy during excision of extensive antral cholesteatoma	21
Transcanal endoscopic diagnostic antrostomy hole/window for mastoid antral pathology	34
Transcanal endoscopic excision of canal exostosis	2
Transcanal endoscopic excision of canal osteoma	1
Transcanal endoscopic canaloplasty of stenosed canal due to fibrous dysplasia	1
Total	85

Results

The transcanal endoscopic drilling technique could be applied easily and harmoniously with single hand in every case. No facial nerve palsy or paresis was noted in any case in postoperative period. It was also observed that the skin of the outer half of external auditory canal was free from any injury.

Discussion

Transcanal endoscopic drilling is a difficult procedure while endeavor it with single hand through the restricted space of external auditory canal. Drilling with simultaneous irrigation of fluid and suction clearance as practicing in traditional mastoid surgery is barely possible in transcanal endoscopic surgery since these events require three to four hands to work simultaneously. For this reason, some endoscopic ear surgeons prefer to do this endoscopic drilling as double handed procedure with the support of an endo-holder through endaural route. The technique mentioned in this study is only for performing transcanal endoscopic drilling with single hand.

A useful transcanal endoscopic ear drilling technique must have the followings criteria — it should be easy to be executed with single hand, it must keep the drilling temperature below the critical level of thermal injury of facial nerve, it must avoid lacerated injury by its rotating burr in outer half skin of external auditory canal.

Heat generation during drilling is an inevitable event. Call et al.[1] first experimentally studied various factors such as speed of drill, size and type of burr on the drill related thermogenesis in cadaveric temporal bone.

Factors related to frictional heat production during drilling are mentioned briefly in the Table 2.

Table 2 Factors related to frictional heat production during drilling.

1. Rotational speed of drill.
2. Duration of drilling.
3. Number of flukes of burr.
4. Size of drill burr.
5. Drilling pressure.
6. Drilling depth.
7. Use of coolant.
8. Vascularity of the drilling area.

Modification of these factors may bring change in thermogenesis during drilling. While planning the drilling technique, certain policies had been justified to be effective in reducing the drilling temperature. These were short timed drilling, interval between drilling, application of intermittent irrigation and suction. In the following discussions, each of these was discussed in the light of available evidences.

Short timed drilling

Temperature and its exposure duration, both are equally important to cause thermal injury in any heat labile substances. According to Haveman et al.[2] 44 °C temperature for 30 min (6 °C above body temperature for 30 min) will not cause any thermal injury to peripheral nerve. This temperature and its exposure duration maintain such a inter relationship that same thermal effect can be produced by changing either of these two.[3,4] This relationship was expressed through a complicated mathematical equation which stated that if the temperature was increased by one degree Celsius, the exposure time must be decreased by a factor of two for the same thermal effect.[4] This sort of mathematical equation has been used in Cancer Radiotherapy to determine the thermal dose in order to avoid peripheral nerve injury. According to this mathematical equation, it can be grossly stated that 44 °C temperature for 30 min would produce the same thermal effect as at 45 °C for around 15—20 min. This means if we reduce the exposure duration we can keep the peripheral nerve safe even in higher temperature. For an instance, the recurrent laryngeal nerve was found functionally sound even when exposed to 55 °C temperature for 1 min.[5] Individual nerve could have different threshold for thermal injury since it depends on myelination and vascularity of that particular nerve. The threshold temperature for thermal injury of facial nerve is yet to be determined in living model. Drilling technique could be continuous or intermittent. Continuous drilling means the drilling will go on continuously throughout the drilling time without a pause. In intermittent drilling, two events occur repeatedly throughout the drilling time comprising drilling followed by a pause for a particular time period. In the study on cadaveric dry bone, with continuous drilling around the facial canal for 2 min (120 s) without irrigation at a speed of 40 000 rpm with a 4 mm diamond burr showed mean rising temperature of 33 °C inside the facial canal.[6] Whereas, the study involving an intermittent drilling technique (3 s drill followed by 3 s pause) conducted on preserved human cranial bone, the highest rising temperature in first 3 s of drilling without irrigation at speed of 70 000 rpm with 4.8 mm cutting and diamond burr were around 7 °C and 12 °C respectively.[7] From these studies this has been noted that in intermittent (short timed) drilling mode, the rise of temperature is significantly lower than the continuous drilling mode. Moreover these findings were challenged by the study on living animal model. The study conducted on temporal bone of living guinea pigs by Aslan A et al, the highest rising temperature was 3.9 °C (well below the critical level) over the facial nerve canal after drilling that area without irrigation at a speed of 15,000 rpm for 60 s with a 3-mm diamond burr.[8] This might be due to blood flow present in the living model that mitigated the rising drilling temperature. From above discussions it could be justified that after short timed drilling, the facial nerve would be exposed for a short duration to a higher but tolerable temperature. Furthermore, the finding in living animal model suggested that this rise of temperature could be below the critical level. This present drilling technique also adopted the policy of changing the drilling time depending on the location distance from facial canal (maximum 2 s while drilling close to the facial canal and maximum 5 s while drilling areas at least 5 mm away from facial canal). This policy could bring some beneficiary effects on overall drilling procedure. The bone has low heat conductivity and study showed that for a difference in distance of just 1.6 mm, there was a big difference in drill related temperatures.[9] So Area near to the facial canal has more risk of thermal injury than the area 5 mm away from it. Because of this it was expected that maximum 2 seconds rather than 5 s drilling time near the facial canal would lessen the risk of thermal injury. Whereas areas at least 5 mm away from the facial canal has less risk of thermal injury so increasing the drilling duration to maximum 5 s in those areas would reduce the total drilling time.

Interval between drilling

There was a time interval in between successive drill episodes in this preplanned drilling technique involving the following events to be done — removal of the drill burr from external auditory canal, flooding the irrigation fluid to the drilling area followed by suction clearance, finally reinsertion of drill burr before starting the next drilling. This study although neither mentioned a specific time interval nor recorded the time but this unrecorded time interval allowed cooling down the drilling area as well as the drill burr. The study conducted by Neal P Dillon et al[3] showed that after stopping the drilling for approximately 30 s, the raised temperature of drilled area would return to within 3 °C of body temperature.

Application of intermittent irrigation and suction

This preplanned drilling technique involved intermittent rather than continuous irrigation to get better view of surgical field since drilling with the continuous irrigation blurred the endoscopic view of operating field by scattering bone sludge and fluids. It is universally accepted that any irrigation either intermittent or continuous would definitely reduce the drill related temperature. An interesting finding was noted in the study conducted by Chan P. et al.[10] that there was statistically no significant difference in the efficacy between continuous and intermittent irrigation (irrigation at 5 s interval) while drilling at a speed of 35 000 rpm for average 10 s around the optic canal.

The absence of facial nerve palsy in all patients strengthened the predicted efficacy of the present endoscopic drilling technique on keeping the drilling temperature below the critical level of thermal injury.

Application of drill, irrigation and suction, one after another in a synchronized fashion allowed the surgeon to execute entire endoscopic drilling procedure smoothly with single hand through the tight space of external auditory canal.

Another risk of transcanal endoscopic drilling is the abrasive/lacerated injury of the skin of external auditory canal by rotating shaft of drill burr. To avoid such injury a protective sheath/tube around the shaft of rotating burr is necessary. Presently these protecting sheath/tube are available in two forms. The most common form is an individual attachment which after attaching with hand piece of drill provides protecting sheath around the shaft of traditional burr. Every manufacture company has its own unique designed attachment. The other form is the recently developed curved burr having an additional outer nonrotating sheath/tube that requires a particular type of hand piece such as Visao or Midas model of Medtronic USA, Inc. to attach with it. A Chinese company named China Xishan Science and Technology Co. Ltd. also brought this product in the market at cheaper price (Fig. 1).

The outer diameter of this protecting sheath/tube is also a concerning factor. Wider one will definitely compromise the working space within the external auditory canal. The outer diameter of different attachments/curved burr was mentioned in the Fig. 2. The author's first preference was recently developed special curved burr but because of its high price (which is almost 10times higher than conventional steel burr), he found it less suitable to be incorporated within the limited operative budget of his poor patients. His second preference was the attachment made by Tian Song Medical Instrument Company, China. The outer diameter of this newly made shield attachment its narrower than the others and can protect the skin of the canal efficiently from frictional injuries.

However increased operative time was the expected pit fall of this technique as it involved subsequent instrumentations rather than simultaneous instrumentations. The author has advised that this newly adopted transcanal drilling technique should be practiced cautiously since this study expressed the experience of single surgeon/author. Experiences of multi-centers multi-authors would shed more light on this issue in future.

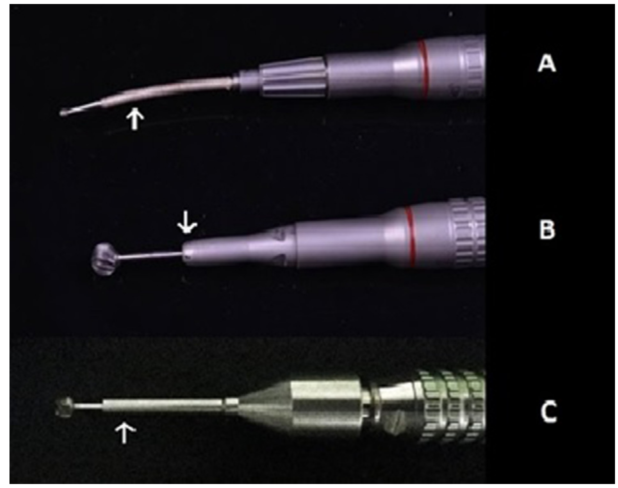

Fig. 2 Picture showing different types of protective attachments/special burr with their hand pieces. A type was the special curved burr with non-rotating outer tube. B type was the commonly used attachment and C type was the attachment made by Tian Song Medical Instrument Company, China. White colored arrow indicated the site where measurement of the outer diameter of attachments/special burr was done. The outer diameter of type A, type B and type C was around 2.8 mm, 5.5 mm and 3.3 mm respectively.

Fig. 1 Picture showing special curved burr with non-rotating outer tube/sheath.

Conclusions

Short timed drilling with intermittent irrigation and suction was found effective and safe while performing transcanal endoscopic drilling as a single handed procedure.

Competing interest

The author has declared that he has no competing interest.

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