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Technical note

Drilling and control of the internal auditory canal by fixed endoscope

X. Dubernard^{a,*}, J.-C. Kleiber^b, M. Makeieff^a, A. Bazin^b, A. Chays^a

^a Département d'oto-rhino-laryngologie, pôle tête et cou, hôpital Robert-Debré, CHU Reims, 51100 Champagne-Ardenne, France

^b Département de neurochirurgie, pôle tête et cou, hôpital Maison Blanche, CHU Reims, 51100 Champagne-Ardenne, France



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ABSTRACT

Preservation of vestibular structures, particularly the posterior semicircular canal, is essential to ensure hearing preservation in addition to complete tumour resection during retrosigmoid surgical resection of a vestibular schwannoma. Drilling of the internal auditory canal (IAC) is a delicate step, during which these structures can be accidentally perforated. The orientation of the IAC results in the formation of poorly visible zones that can predispose to perforation of these structures when drilling is performed with a microscope. Hand-held endoscopy exposes all of the operative field, but immobilizes one of the surgeon's hands, making this surgery even more delicate. Fixed endoscopy is a solution that gives the surgeon greater freedom of movement, while ensuring precise control of the surgical procedure. It allows identification and avoidance of vestibular structures, while allowing resection as close as possible to the tumour. The schwannoma can be entirely cleaved when the fundus of the IAC is correctly controlled, while sparing the facial and cochlear nerves.

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1. Introduction

The therapeutic objective of vestibular schwannoma surgery is to ensure complete resection of the tumour, from the fundus of the internal auditory canal to the cerebellopontine angle. Improvement of surgical techniques with the advent of microsurgery over the last fifty years has improved the postoperative outcome of these patients. Limitation of functional sequelae, particularly preservation of facial nerve function, is now a primary objective for all surgical teams. Preservation of hearing function is also a newly defined objective in some patients and requires preservation of the cochlear nerve during dissection and preservation of the vestibule during drilling of the internal auditory canal (IAC). The use of a fixed endoscope appears to constitute a major technical improvement in order to preserve these structures and improve dissection of the tumour in the canal, while freeing the surgeon's two hands.

2. Operative technique

The technique described below concerns patients with vestibular schwannoma with no extension to the cochlear fossa, with preserved hearing and in whom preoperative axial CT scan centered

on the lateral semicircular canal shows the presence of a triangle excluding the patient's vestibule. The limits of this triangle are the posterior surface of the temporal bone and the IAC, the origin of the perpendicular line.

Surgical management of vestibular schwannoma can only be considered in an otoneurosurgical setting by a team experienced in cerebellopontine angle surgery, assisted by specially trained anaesthetists to ensure optimal surgical safety based on modulation of intracranial pressure by titration of anaesthetic drugs, while limiting venous pressure and venous return. Control of these parameters facilitates retrosigmoid opening of the cerebellopontine angle, ensuring wide access to this space after aspiration of CSF from the cerebellopontine cisternae. An endoscope can then be introduced to explore this space right from the beginning of surgery in order to identify the position of the various nerves in relation to the tumour, or after having performed debulking of the portion of the tumour protruding into the angle.

Two types of endoscope can be used: a STORZ 30° endoscope (diameter: 4 millimetres, length: 18 centimetres) and a STORZ Endocameleon® endoscope (diameter: 4 millimetres, length: 18 centimetres), allowing variable angulation during surgery without moving the endoscope.

The endoscope, protected by a sterile drape, is fixed to an HD camera head and a cold light source, connected to a video tower placed in front of the surgeon and the assistant. No sheath is attached to the endoscope in order to allow the largest possible surgical space to facilitate the procedure. Absence of a sheath avoids

* Corresponding author. Service d'oto-rhino-laryngologie, CHU Reims, rue du General Koening, 51100 Reims, France.

E-mail address: xdubernard@chu-reims.fr (X. Dubernard).



Fig. 1. Retrosigmoid endoscope fixation and orientation system during drilling of the IAC.

aspiration of nerves or brain tissue during introduction of the endoscope, but does not prevent overheating of cerebellar tissue and the self-irrigating system does not provide any advantages, as irrigation is not directed towards the zone of interest. The force of the irrigation stream can also damage nerves around the operative site.

The endoscope fixation system consists of a STORZ articulated arm composed of two 16 cm articulated elements and a 30 cm initial segment, 16 mm in diameter. Installation of this system requires the addition of a cramp on the operating table before sterile draping. The sterile arm is installed at the last moment by attaching the shaft through the cramp underneath the drapes. The camera head attached to the endoscope is held by a specific toothed clamp, and the endoscope is then placed directly in the cerebellopontine angle (Fig. 1). Once the endoscope has been correctly positioned, it is firmly fixed in the position desired by the surgeon by means of a screw.

The microscope, not required during this phase of the operation, remains sterile and at hand if required, for example to control bleeding. Endoscopic drilling of the IAC is performed after placing cottonoids designed to prevent dissemination of bone powder in the angle. The Neuropatch[®] used to protect the cerebellum in the retrosigmoid approach is left in place underneath the endoscope. The surgeon's hands are placed on either side of the endoscope, one hand holding the suction tube and the other holding the motor connected to the drill. The assistant places the irrigation syringe on top of the endoscope by guiding it towards the drilling zone, while cooling the endoscope and moistening adjacent structures, which considerably decreases the risk of thermal burns.

Angulation of the endoscope provides complete exposure without no blind drilling zones in contrast with the operating microscope. The IAC is opened progressively by creating a half-arch using a 6 mm faceted drill and is limited superiorly by the superior petrosal sinus and inferiorly by the superior bulb of the jugular vein, as exposure of these structures is rarely necessary. Drilling is continued with a 3 mm diamond drill, avoiding injury to the dura mater of the IAC enveloping the intrameatal portion of the schwannoma (Figs. 2 and 3).

The fundus of the IAC is exposed, as confirmed by palpation of the falciform crest by the operator. Tumour resection is performed after opening the dura mater anteroposteriorly, by reclining the mass towards the cerebellopontine angle, while controlling the position of the facial nerve and cochlear nerve. All of the lesion is removed under endoscopic control as close as possible to nerve structures [1]. Preservation of vestibular structures, particularly the posterior semicircular canal (PSCC), is mandatory when hearing preservation is considered. There is no reliable anatomical landmark to identify the PSCC, as the surrounding bone is white,



Fig. 2. Fixed endoscopic half-arched drilling of the IAC revealing the dura mater.



Fig. 3. Appearance of the IAC after drilling and tumour resection. Preservation of the facial and cochlear nerves.

compact with no air cells. The endoscope can identify the position of the PSCC by revealing a bluish line, indicating the presence of labyrinthine fluid. The endoscope is used to perform skeletonization of the canal by precise drilling, while preserving the PSCC without fistula by adapting the position or the angle of the endoscope, if necessary. The semicircular canal is not systematically identified if it is not discovered during the procedure.

After completion of tumour resection, the microscope is used to check haemostasis and fill the IAC drilling zone with pieces of fascia to avoid CSF leak due to possible perforation of mastoid air cells. A hand-held endoscope may be useful to detect and fill any CSF leaks.

Fixation of the endoscope avoids repeated changes of the endoscope and surgical instruments in the angle, which decreases the risk of cerebellar, vascular or nerve injuries. Direct control of drilling spares the vestibule and allows the possibility of hearing preservation.

3. Discussion

The primary objective of surgical management of vestibular schwannoma is to ensure complete resection of the tumour. Regardless of the surgical approach used, particular attention must be paid to exposure and inspection of the fundus of the IAC, the main site of residual tumour.

When a retrosigmoid approach is used, exposure of the fundus of the IAC is never a problem unless the anatomical structures of the inner ear (vestibule, PSCC) need to be preserved. Drilling is performed with an operating microscope, allowing enlargement of the IAC, as required, as far as the fundus of the canal, the only limits being the large veins (superior petrosal sinus and superior bulb of

the jugular vein). Resection is then performed under visual control in an anteroposterior direction as far as the porus.

When the objective of treatment also includes hearing preservation, the anatomical structures of the inner ear must be preserved. The angulation of the IAC requires large and deep drilling with the operating microscope to access the fundus. “Blind zones” during drilling make it difficult to ensure control of the PSCC, the main structure at risk during this phase of the operation.

To limit this risk, some authors measure the distances between anatomical landmarks on the preoperative axial CT scan [2,3]. Patients are then classified according to the risk of perforation of the inner ear. Some teams also use sterile phantoms or templates applied to the temporal bone during surgery, especially to limit the maximum depth of drilling in order to predict the position of and preserve the PSCC. These techniques appear somewhat complicated and of limited practical value, as the patient’s operative position does not correspond to that during acquisition of the CT scan. These CT measurements can be falsely reassuring, as the risk of perforation of the inner ear varies considerably according to the level at which these measurements were performed. CT also only provides a two-dimensional volume, which differs from 3D surgical anatomy.

Other teams use an intraoperative neuronavigation system integrated directly in the drill or a Digipointeur® neuronavigator [4]. Fusion of anatomical and CT data by the surgeon helps to guide the procedure. However, the resolution of these devices is about one millimetre [5], which can be insufficient when the IAC must be opened as close as possible to the PSCC and the risk of perforation persists when the drilling zone remains invisible to the microscope. This problem can be resolved by using an endoscope, allowing exposure of all of the drilling zone when it is placed as close as possible to the IAC [6]. The use of endoscopy in the cerebellopontine angle was proposed and popularized by J. Magnan and A. Chays in the context of minimally invasive retrosigmoid approaches for the treatment of schwannomas and neurovascular compression [7]. However, it is not always easy to perform when the endoscope is hand-held by the operator, as, in order to ensure a stable image, one of the operator’s hands must hold the endoscope, making it impossible to simultaneously use suction during drilling. The surgical assistant can replace the surgeon by holding and immobilizing the endoscope, but even for skilled operators, accidental mobilizations of the camera can damage adjacent structures and may not provide direct vision of drilling. Depth landmarks are often lost during this procedure, associated with a high risk of perforation of the PSCC despite the improved exposure.

These limitations are largely resolved by using a fixed endoscope. The good exposure is preserved, the surgeon’s hands are freed and the stable image allows more accurate assessment of depth. The mobility of the articulated arm allows the endoscope to be turned in in all directions and the use of the Endocameleon® also facilitates exposure. Skeletonization of the PSCC is performed under visual control, limiting the risk of perforation. The number of endoscope and drilling instrument changes in the cerebellopontine angle is decreased, thereby reducing the risk of accidents (nerve, vessel, cerebellar injuries). Use of an endoscope, particularly a fixed endoscope, is associated with a risk of thermal burns of the nerves, blood vessels or cerebellum, which can be prevented by ensuring that the endoscope remains at a minimum distance from vital structures, while protecting the cerebellum from the endoscope by a piece of artificial dura mater. The light intensity must be limited to 40% maximum power. Continuous irrigation with normal

saline, directed by the surgical assistant, is essential to limit any local temperature rise, which is then not more dangerous than the heat released by the operating microscope.

Fixed endoscopy is also indicated in the retrolabyrinthine approach, which constitutes a real otoneurosurgical alternative to the retrosigmoid approach. The choice between the two techniques simply depends on the surgeon’s usual practice. With the same advantages and disadvantages, the endoscope allows visual control of the fundus of the IAC either during tumour resection or to verify the absence of residual tumour. The endoscope is less useful for preservation of vestibular structures and the superior bulb of the jugular vein, which are identified during bone drilling.

4. Conclusion

The use of a fixed endoscope helps to improve the surgical management of patients operated for vestibular schwannoma, particularly when the preoperative objective includes hearing preservation. However, preservation of the anatomical structures of the inner ear alone cannot guarantee maintenance of the patient’s hearing thresholds, as release of the cochlear nerve from the tumour always remains a delicate procedure. This technical refinement can therefore be added to existing techniques and should be considered in the appropriate indications.

Disclosure of interest

The authors declare that they have no competing interest.

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