Ultrasonic bone curettage for optic canal unroofing and anterior clinoidectomy

Technical note

Han Soo Chang, M.D., Masahiro Joko, M.D., Joon Suk Song, M.D., Kiyoshi Ito, M.D., Tatsushi Inoue, M.D., and Hiroshi Nakagawa, M.D.

Department of Neurological Surgery, Aichi Medical University, Aichi, Japan

Extradural unroofing of the optic canal and subsequent mobilization of the optic nerve is a useful technique in the surgical treatment of parasellar tumors; however, the drilling procedure itself is associated with the risk of optic nerve damage. A safer technique would certainly be beneficial. The ultrasonic bone curette is a device developed in Japan for safer bone removal. Its use in intradural anterior clinoidectomy and opening of the internal auditory meatus has been reported before. In this article the authors describe their experience in using this device for extradural unroofing of the optic canal in patients with parasellar tumors.

Between March 2002 and November 2004, the aforementioned technique was used in the treatment of eight patients with parasellar tumors. After undertaking a frontotemporal craniotomy and orbital osteotomy, an ultrasonic bone curette was used to unroof the optic canal via an epidural approach; in five cases anterior clinoidectomy was added subsequently.

Using an ultrasonic bone curette, unroofing of the optic canal was completed safely and required much less expertise than that required for standard drilling. The mortality and major morbidity rates were 0%. The visual function outcome was satisfactory, with the overall visual status improving in all seven patients in whom this symptom was present preoperatively. The ultrasonic bone curette makes the unroofing of the optic canal safer and easier, possibly improving the visual outcome of patients undergoing surgery for parasellar tumors.

Key Words • parasellar tumor • anterior clinoidectomy • optic canal unroofing • ultrasonic bone curette

When we approach parasellar tumors via the pterional route, manipulation of the tumor behind the ipsilateral optic nerve is often difficult. Particularly when the chiasm is prefixed, it is difficult to see behind the ipsilateral optic nerve. In this respect, unroofing of the optic canal and the mobilization of the optic nerve are useful techniques in the surgical treatment of parasellar tumors. For patients undergoing an early decompression of the optic nerve, many authors have recently advocated combined extradural unroofing of the optic canal and anterior clinoidectomy,1,3,6,10,16 which is also our preferred technique.

Drilling of the optic canal, however, has its own risks. It may injure the already compromised optic nerve either directly by mechanical compression or indirectly by the heat produced by the drilling. Therefore, this procedure must be undertaken with extreme care, and it requires a certain degree of expertise.

An ultrasonic bone curette (Fig. 1) is a device with an oscillating metal tip developed for resection of osseous tissues. Use of this device for anterior clinoidectomy and opening of the internal auditory canal has been reported in a small series of patients.8 Using the difference of natural frequencies, this device specifically affects the hard tissues such as bone, leaving the soft-tissue structures such as the dura mater mostly intact. Because the device contains no rotating component, it cannot slip into the surrounding important structures or draw these structures into a rotating shaft. These characteristics are optimal for a device used to resect the bone edge adjacent to the dura mater, which is frequently encountered in both skull base and spine surgeries.

In this article, we describe the technique we developed to use this device for extradural optic canal unroofing and anterior clinoidectomy in the treatment of parasellar tumors. It is our experience that the device made the procedure easier and safer, possibly contributing to improved visual outcome in our patients.

Clinical Material and Methods

Patient Population

During a 32-month period, eight patients with parasellar tumors underwent surgery in which the ultrasonic bone curette was used. Seven patients presented with visual deficits.

Device Description

An ultrasonic bone curette (Sonopet UST-2001; M & M
Co., Ltd., Tokyo, Japan) is composed of an oscillating metal tip attached to a curved handpiece designed for use under an operating microscope (Fig. 1 upper). The handpiece is equipped with an automatic irrigation system. The tip of the ultrasonic bone curette is shown in Fig. 1 center. The width of the tip is 2 mm. The tip is curved on one side, and the tip’s neck makes a reciprocating rotational oscillation of 8.6° (or 300 μm) with a frequency of 25 kHz. Thus, the base of the device’s neck has much less motion than the operating side of the tip. This confers several advantages when resecting the bone edge over the dura. After placing the tip at the bone edge as one would when using a standard curette, the bone can be easily resected by applying ultrasonic oscillation (Fig. 2 left). The power of this oscillation can be controlled by manipulating the digital switch on the apparatus that has settings between 0 and 100. The tip is equipped with an irrigator that can supply saline during the procedure.

Surgical Description

Our surgical procedure for optic nerve unroofing is a slight modification of that described by Lee, et al.\textsuperscript{10,14} We first create a frontotemporal bone flap whose medial limit is the supraorbital foramen or that extends to the midline when lateral retraction of the ipsilateral optic nerve is anticipated. A limited orbital osteotomy is made as a second piece whose medial limit is the medial edge of the craniotomy and whose lateral limit is approximately 5 mm below the frontozygomatic suture. After rigorously resecting the sphenoid ridge, the lateral limit of the superior orbital fissure is identified. After extradural dissection and decompression of the superior orbital fissure, we peeled off the outer dural layer of the cavernous sinus for a limited length to expose the lateral aspect of the ACP; this procedure reduces the dural tension and facilitates exposure of the orifice of the optic canal. After identifying the proximal orifice of the optic canal extradurally, bone resection is initiated from the proximal edge of the canal roof. This is easily accomplished by placing the tip of the ultrasonic bone curette on the edge of the canal roof and applying the ultrasonic energy in short bursts. The bone resection proceeds in a proximal-to-distal direction (Fig. 3). Despite the saline irrigation, the tip of the curette produces heat during its continued high-power use; thus, we typically used this device to provide moderate-power, intermittent short bursts, rather than a long continuous stroke.

In five cases, we also performed an anterior clinoidectomy. Using the ultrasonic bone curette, we can easily resect the medial portion of the optic strut bone, thereby thinning the optic strut as much as we wished. We can then safely fracture the final remnant of the optic strut by slightly turning the ACP laterally. The process can then be removed after carefully dissecting it from the surrounding dura. Bleeding from the cavernous sinus can be easily controlled by applying hemostatic material. The dura is then opened, and the tumor approached after widely dissecting the sylvian fissure. The falciform ligament and the optic sheath are incised, and the ipsilateral optic nerve is released from tension, making it mobile and tenable for careful retraction.

Results

Between March 2002 and November 2004, eight patients with various parasellar tumors (meningioma, craniopharyngioma, pituitary adenoma, and epidermoid cyst) underwent surgery in which the ultrasonic bone curette was used. In
seven patients with preoperative visual symptoms, ipsilateral vision improved in four patients, was unchanged in two, and deteriorated in one. The overall visual status including contralateral vision improved in all seven patients, and normal vision was preserved in one patient without a preoperative visual deficit. In no case was vision worsened by the optic canal unroofing procedure. In the only patient with postoperative worsening of vision—only light perception preoperatively—the deterioration was the result of dissection of the optic nerve from a meningioma that severely invaded the optic canal. Overall, the optic canal unroofing procedure was safely conducted in all eight patients without causing damage to the ipsilateral vision.

There was no major complication. In all cases, the optic sheath and the frontal dura were completely preserved. In one patient with a giant clinoidal meningioma who underwent an additional anterior clinoidectomy, we observed transient partial third cranial nerve paresis on the ipsilateral side; this deficit completely resolved within 2 months. In one patient with a pneumatized ACP that continued to the sphenoid sinus, optic canal unroofing naturally resulted in an opening into the sphenoid sinus. This opening could be easily closed using bone wax, and there was no subsequent cerebrospinal fluid leakage. Except for this case, no opening into the nasal sinuses occurred. Overall, there was no postoperative cerebrospinal fluid leak.

Discussion

Although optic canal unroofing is a useful technique in the surgical treatment of parasellar tumors, the procedure itself poses a certain risk to the optic nerve. To capitalize on the benefit of the aforedescribed procedure, then, it must be conducted using the safest possible technique available. The ultrasonic bone curette provides a useful solution to this problem, in part because of its remarkable safety and easy maneuverability.

The effectiveness of optic canal unroofing in the surgical treatment of parasellar tumors is easily understood if one notes the situation of the optic nerve in such cases. Typically, it is already compressed by the tumor and is vulnerable to further mechanical pressure or stretching. In pterional approach, however, establishing good visualization behind the ipsilateral optic nerve is often difficult without retracting the nerve. Most often, the optic nerve is shifted superiorly and compressed by the sharp edge of the falciform ligament at the orifice of the optic canal. This compression cannot be released until after a significant amount of internal decompression is completed. Even if we perform the debulking first, the optic nerve can be subjected to some tension intraoperatively, and this can have a deleterious effect on its function. In reported series of parasellar tumors, some proportion of the patients suffer postoperative worsening of visual symptoms even when expert surgeons have conducted the procedures.

In cases involving tuberculum sellae meningiomas, postoperative improvement has been reported in 28 to 79% and deterioration in 5 to 38%. By unroofing the optic canal, opening the optic sheath, and mobilizing the optic nerve, we can avoid these problems to some degree and possibly improve the visual outcome in patients with parasellar tumors.

The drilling of the optic canal, however, poses its own risks to the optic nerve. First, any inadvertent contact of the rapidly rotating drill bit with the optic sheath or the frontal dura will create a tear and may even damage the nerve or the frontal lobe. Second, the rotating shaft of the drill can engage important structures, especially when it is used intraorbitally. Entangling of cottonoids into the shaft is also dangerous. Third, the heat produced by the drill bit can damage the nerve in the absence of any mechanical compression. These disadvantages make the procedure difficult and necessitate a certain degree of expertise.

Using the technique described in this article, we were able to unroof the optic canal and remove the ACP without damaging the optic canal sheath or frontal dura, not to mention the optic nerve itself. Our technique requires less expertise than that involved in the drilling technique. Because there was no rotating moment, the tip of the device is much more stable. The surgeon does not have to worry that the tip of the device will suddenly slip over the bone edge, as would often be the case in drilling. Therefore, the device can be safely held in one hand, while the other hand holds a suction near its tip. Because the oscillating energy is applied on the side of the tip, we can efficiently and safely resect the bone by simply placing the tip at the bone edge with its end slightly touching the dura, delivering the ultrasonic oscillation while slightly pulling up the tip (Fig. 2 upper). In this way, we did not have to insert any instrument between the bone and the dura. Because we did not direct the tip toward the dura itself, there was little danger of dural laceration.
Additionally, because we applied the energy in short bursts with an appropriate power setting, there was no danger of causing thermal injury to the optic nerve as the heat was controlled by the device’s irrigation system.

In addition, the ultrasonic bone curette has another technical advantage. During the unroofing procedure, we are always able to identify the edge of the bone. This means that we could resect just as much of the bone over the canal as is necessary, always knowing how much of the canal has been opened (Figs. 2 left and 3). In contrast, in the drilling technique, a thin layer of bone is usually left over the canal, and this shell is later removed with a curette or a microdissector (Fig. 2 right); thus, the exact location of the canal is not known during drilling, which can cause one to drill a larger area than is necessary. Therefore, because the device allows one to avoid unnecessary bone resection around the canal, the ultrasonic bone curette is less prone to creating an inadvertent opening into the nasal sinuses.

In this series, we also undertook anterior clinoidectomy in selected cases. In our opinion, the need for the unroofing of the optic canal and the anterior clinoidectomy should be considered separately. If our aim is early decompression and mobilization of the optic nerve, optic canal unroofing and opening the optic sheath are sufficient to this end; the addition of anterior clinoidectomy will not much enlarge the operative field unless the distal dural ring is incised around the internal carotid artery. Thus, we believe that anterior clinoidectomy should be added to the procedure only in cases in which mobilization of the internal carotid artery is really necessary or those in which one needs to approach the cavernous sinus. Because anterior clinoidectomy itself is associated with possible complications, the indication of this adjuvant should be considered carefully.

Despite its many advantages, the ultrasonic bone curette has certain disadvantages. First, the handpiece is somewhat bulky and hinders visibility in a deep and narrow operative field. This is especially true when a right-handed surgeon tries to resect the bone on the right side, rotating the curved tip to the right; in such a situation, the surgeon sometimes has to manipulate the device with the left hand; however, the use of this device in bone resection is so safe that left-handed manipulation appears sufficiently feasible. Second, because the tip is relatively smaller than larger regular drill bits, resection of a large amount of bone is time consuming. Therefore, we do not believe that the bone curette is suitable for resecting an extensive amount of bone. In cases in which such debulking is necessary, an initial drill-based rough bone resection followed by finer resection with an ultrasonic bone curette would be advisable.

Finally, we would like to emphasize that use of this device does not automatically protect the soft tissues. If the working side of the tip is applied directly to the dura, a dural tear will certainly occur. Thus, the angle of the tip and the optic canal should be as close to perpendicular as possible. As described in our cases, it is important that partial dissection of the outer layer of the cavernous sinus expose the slack dura to allow the insertion angle of the device such that the tip will not be oriented directly toward the optic sheath (Fig. 3).

Conclusions

An ultrasonic bone curette can be used safely in optic canal unroofing and anterior clinoidectomy, which, technically, can be performed with less expertise than that required to use a high-speed drill. Application of this technique hopefully provides a better chance of preserving visual function in patients with parasellar tumors.

References