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Technical note: Orbitozygomatic craniotomy using an ultrasonic osteotome for precise osteotomies

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Abstract

Background—The orbitozygomatic craniotomy is a fundamental procedure in neurosurgery, allowing access to orbital and skull base pathology.

Objective—Determine the feasibility of using an ultrasonic osteotome to safely perform orbitozygomatic osteotomies in patients with intracranial pathology.

Methods—The medical records of patients undergoing orbitozygomatic craniotomy using an ultrasonic osteotome (Aesculap BoneScalpel™) for tumor resection at Johns Hopkins Hospital between November 2009 and March 2013 were retrospectively reviewed.

Results—Six patients underwent orbitozygomatic craniotomy for tumor resection using an ultrasonic osteotome at the Johns Hopkins Hospital during the study period. All patients were female and the average age was 53.2 years. Patients were followed for an average of 375 days. There were two cases of transient diplopia. There were no cases of periorbital violation, orbital injury, enophthalmos, or orbital hematoma. Post-operative imaging showed the cuts were well opposed and no cosmetic issues were encountered.

Conclusion—Use of an ultrasonic osteotome allows for precise cuts under direct visualization with minimal risk to critical adjacent structures in our cohort of patients undergoing a two-piece orbitozygomatic craniotomy. This appears to be a safe instrument for osteotomy creation in skull base approaches.

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Conflicts of interest

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Keywords

Orbitozygomatic approach; Craniotome; Ultrasonic osteotome

1. Introduction

Neurosurgical tools have significantly *evolved* since the development of trephines that were used for craniotomies described as early as 8000-5000 BC [1]. The orbitozygomatic approach and its modifications allow for increased exposure of orbital suprasellar, parasellar, and middle fossa pathology while minimizing brain retraction [2–4]. The orbitozygomatic craniotomy is classically created by making a series of cuts in the orbital rim and zygoma in conjunction with a frontotemporal craniotomy. These osteotomies can be performed in a controlled fashion by instruments such as osteotomes, reciprocating saws, or craniotomes [4,5]. While these devices have been widely used with proven safety, the width of the osteotomies can result in large bony defects with associated cosmetic deformities or inadvertent injury to neural or orbital structures.

Ultrasonic osteotomes are able to make precise osteotomies, as thin as 0.5 mm, while protecting soft tissues deep to the cutting surface. This is achieved via high frequency (22,500 Hz) oscillations over a small surface area (35-300 μ). Underlying soft tissues, such as dura and periorbital are theoretically spared due to their ability to deform, increasing the surface area in which energy is applied and dampening the energy transferred upon contact with the device [6].

While Parker et al. reported that an ultrasonic osteotome was safe and efficacious for use in laminectomies, no published study has reported its use in cranio-orbital applications [7]. We report our initial experience using an ultrasonic osteotome in two-piece orbitozygomatic craniotomies for tumor resection and comment on surgical outcome and complications as a result of its use.

2. Methods

2.1. Subjects

The electronic medical records of patients undergoing first-time craniotomy for tumor resection with the BoneScalpel™ (Aesculap Inc., Center Valley, PA, USA), an ultrasonic osteotome, at the Johns Hopkins Hospital between November 2009 and March 2013 were retrospectively reviewed from a prospectively accrued, IRB-approved database. Electronic medical records were queried for demographic data, surgical approach, radiologic studies, and intra-operative and post-operative complications including orbital violation, periorbital ecchymosis, diplopia, disconjugate gaze, and cosmesis.

2.2. Surgical technique

All patients underwent an orbitozygomatic approach for tumor resection. The technique for performing a two-piece orbitozygomatic craniotomy used in our institution has been previously reported [5]. In brief, patients are placed in a supine position on the operating

room table followed by standard anesthesia and head fixation in a three-pin Mayfield frame. After fixation, the head is translated, extended and rotated according to the target pathology. Following skin incision, the two layers of the superficial temporalis fascia are incised and a subfascial flap is elevated with the skin flap with careful attention to spare the frontal branch of the facial nerve. The temporalis muscle is then subperiosteally elevated by blunt dissection of the deep temporal fascia. After creation of a tailored frontosphenotemporal craniotomy, dura is elevated off of the skull base and attention is then directed to the orbitozygomatic osteotomies.

The ultrasonic osteotome is then used to complete the orbital and zygomatic osteotomies (Fig. 1). A more in depth review of the modified orbitozygomatic craniotomy is reviewed elsewhere but in brief, the first osteotomy involves an oblique cut of the inferior, posterior edge of the zygomatic arch. Next, the frontal process of the zygoma is released from the body with care not to invade the periorbital. To release the temporal process of the zygoma, an osteotomy is made along the inferior edge of the temporal process of the zygoma toward the previous osteotomy. To remove the roof of the orbit, the osteotomy begins lateral to the supraorbital notch and continues in the direction of the superior orbital fissure and then directed laterally down the wall of the orbit. The adjacent periorbital and dura are protected under direct visualization by the assistant surgeon. To release the lateral wall of the orbit, osteotomy begins in the inferior orbital fissure and is continued to join the previous osteotomy [5]. The bone flap is pre-plated to provide optimal alignment when complete (Fig. 2).

3. Results

The mean age of the six patients was 53.2 years (range: 40–77 years). All patients were female. The primary pathologies included meningioma ($n = 5$) and craniopharyngioma ($n = 1$). Patients were followed for an average of 375 days (range: 52–1293 days). During the post-operative and follow-up period, complications included transient diplopia ($n = 2$) and temporary restriction of ocular movements ($n = 3$). A single patient required a tissue rearrangement surgery as a result of eye pain and diplopia. No cosmetic complications were noted on last follow up (Table 1). Two patients required a second operation as a result of tumor progression. A representative post-operative CT scan of the first operation for a patient presenting with a craniopharyngioma is shown in Fig. 3.

4. Discussion

The orbitozygomatic approach allows for removal of the lateral wall of the orbit and zygoma providing access to the orbital contents, orbital apex, lateral sphenoid wing, cavernous sinus, clivus, frontal fossa, and temporal fossa. Furthermore, addition of a fronto-spheno-temporal craniotomy improves visualization and enhances the surgical corridor while minimizing brain retraction, potentially decreasing patient morbidity as a result of the procedure [5].

Description of the orbitozygomatic approach was first reported in 1982, when Jane et al. reported a modification of the frontal craniotomy by creating a bone flap that included the orbital roof with further exposure possible via the use of rongeurs [3]. Since then, multiple

groups have expanded on the use of a single bone flap for access the orbit and anterior skull base. Al-Mefty reported a modification of the pterional approach by connecting three burrholes located in the frontal bone above the nasion, the frontosphenoidal junction posterior to the zygomatic process, and at the floor of the temporal fossa. This allowed a single bone flap and less tissue dissection to larger lesions of the skull base [2]. Pellerin et al. expanded on this approach by incorporating removal of the zygoma while maintaining a single bone flap [8].

Others have reported modifications that utilize multiple bone flaps in order to tailor the orbitozygomatic craniotomy to the individual lesion. Alaywan et al. reported that an orbitozygomatic bone flap in addition to the sub-temporal, sub-frontal, and pterional approach, increased the view-angle of the skull base by 86%, 75%, 46% respectively [9]. Gonzalez et al. expanded on this study by reporting that maxillary extension to the orbitozygomatic approach increased the working area as compared to the pterional or orbitozygomatic approach without maxillary extension [10]. McDermott et al. reported successful tumor resection of sphenoid wing pathology with good cosmetic outcomes using a pterional craniotomy in addition to a bone flap composed of the zygomatic arch and superior and lateral orbital wall [11]. Delashaw et al. reported the creation of two bone flaps; a frontotemporal flap with secondary removal of the zygomatic arch, to enhance exposure to the anterior fossa, orbit, middle fossa, and cavernous sinus [12].

Reported complications of the orbitozygomatic approach include cranial injury via uncontrolled fractures through the optic canal and superior orbital fissure, and ocular movement restriction via injury to the extra-ocular muscles or muscle entrapment into osteotomy gaps. Additionally, poor cosmetic outcomes have been described as a result of bony gaps created by osteotomies through the superior orbital ridge and body of the zygoma or sphenoid ridge resection [13]. Use of a standard craniotome results in a significant bony defect and possible risk to neural or orbital structures by direct injury, and often requires use of cranioplasty bone cement material to avoid cosmetic deformities. In the series reported here, complications included transient decreased ocular movements and diplopia. One patient required surgery for tissue rearrangement and two patients required reoperation for progression of the primary tumor.

To minimize the complications associated with the orbitozygomatic approach, multiple strategies are employed. Specifically tailored osteotomies are made to facilitate a more stable and cosmetic reconstruction. These include releasing the root of the zygoma using an oblique angle and releasing the temporal aspect of the zygoma toward the previous cut in the body of the zygoma. Various drill bits and footplates have been used at our institution in an attempt to decrease the size of the groove between the bone flap and skull and include use of a pediatric osteotome and footplate. Meticulous periorbital and dural dissection as well as protection under direct visualization by the assistant surgeon can significantly decrease peri-orbital, orbital, and cerebral injuries. When traditional drill bits are used in conjunction with a footplate during cranio-orbital osteotomies these injuries are less likely but at the expense of increased bone loss. Furthermore, because of the deep cuts required to complete this approach, bone cement can be used to fill in the bony defect surrounding the bone flap. To improve the cosmetic result of temporalis muscle wasting, preservation of the

deep fascia and the neurovascular structures of the muscle is achieved through subperiosteal dissection. Cosmesis can also be augmented by placement of pterional implants.

In our series, use of an ultrasonic osteotome allows for precise cuts under direct visualization with minimal risk to critical adjacent structures. The small, high frequency oscillations minimized bony defects when compared to traditional osteotomy devices. While we found the use of an ultrasonic osteotome to be safe in orbitozygomatic craniotomies, the study population is limited to six patients, which limits our ability to detect other complications as a result of its use. No permanent injuries to cranial nerves or orbital structures were seen post-operatively. Furthermore, bony defects at osteotomy sites measured as little as 0.5 mm, which carries a theoretical advantage for improved bone healing, and results in decreased use of cranioplasty bone cement.

5. Conclusion

The reported initial experience with an ultrasonic osteotome in orbitozygomatic approaches resulted in thin osteotomies with minimal perioperative complications. As a result, we consider use of an ultrasonic osteotome as a safe alternative to traditional osteotomy instruments.

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Fig. 1.
Intraoperative photograph showing the orbital rim prior to osteotomy with the ultrasonic osteotome.

Fig. 2.
Intraoperative photograph showing alignment of the bone flap following osteotomy with the ultrasonic osteotome. To improve alignment, the bone flap was pre-plated.

Fig. 3.

Axial pre-operative CT of a 45 year-old female undergoing repeat surgery following initial resection of a craniopharyngioma. Present on the patient's left side is bony defect following pterional craniotomy with a traditional craniotome (white arrow). Present on the patient's right orbital rim is the bony defect following osteotomy with a craniotome (green arrow) and on the patient's left orbital rim, the bony defect following osteotomy with the ultrasonic osteotome (red arrow). When repeating the orbitozygomatic craniotomy for tumor recurrence, the original osteotomy created by the ultrasonic osteotome could not be visualized intraoperatively.

Table 1

Demographic data, follow-up, and complications of patients undergoing orbitozygomatic craniotomy with an ultrasonic osteotome.

Age	Sex	Pathology	Extent of resection	Complications	Length of follow-up (days)
45	F	Craniopharyngioma	Sub-total	Transient diabetes insipidus	1293
40	F	Inferior temporal fossa meningioma	Total	Eye pain and diplopia requiring tissue rearrangement	488
42	F	Sphenoid wing meningioma	Sub-total	Transient ptosis and limitation of extraocular movements that improved once peri-operative swelling resolved	214
63	F	Meningioma involving the sphenoid wing, frontal, and temporal fossa	Gross Total	Transient ptosis and limitation of extraocular movements that improved once peri-operative swelling resolved	129
52	F	Sphenoid wing meningioma	Gross Total	None	74
77	F	Sphenoid wing meningioma	Sub-total	None	52