Modified One-piece Supraorbital Approach for Orbital Tumors: Widely Preserved Orbital Roof in a Self-fitting Flap

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Abstract

Objectives The one-piece supraorbital approach is a rational approach for the removal of orbital tumors. However, cutting the roof through the orbit is often difficult. We modified the technique to facilitate the osteotomy and improve the cosmetic effect.

Design Three burr holes are made: the first, the MacCarty keyhole (burr hole 1), exposes the anterior cranial fossa and orbit; the second is placed above the supraorbital nerve (burr hole 2); and the third on the superior temporal line. Through burr hole 2, a small hole is created on the roof, 10 mm in depth. Next the roof is rongeuired through burr hole 1 toward the preexisting small hole. Seamless osteotomies using a diamond-coated threadwire saw and the preexisting four holes are performed. Lastly the flap is removed. On closure, sutures are passed through holes in the cuts made with the threadwire saw, and tied.

Keywords

- ▶ orbital roof
- ▶ orbital tumor
- ▶ osteotomy
- ▶ supraorbital approach
- ▶ threadwire saw

Results We applied our technique to address orbital tumors in two adult patients. The osteotomies in the roof were easy, and most parts of the roof were repositioned.

Conclusions Our modification results in orbital osteotomies with greater preservation of the roof. Because the self-fitting flap does not require the use of fixation devices, the reconstruction is cosmetically satisfactory.

Introduction

In the transcranial approach for orbital tumors in the orbital apex, appropriate osteotomies in the orbital rim, added to the removal of the orbital roof, widen the surgical corridor with minimum brain retraction.^{1,2} The supraorbital approach³ in which the frontal bone flap contains the orbital rim and roof (one-piece supraorbital approach) is a rational variation of the transcranial approach in terms of the cosmetic repositioning of the flap; however, osteotomy in the orbital part is often difficult due to the swollen content of the orbit. We present a modified technique to

facilitate osteotomy in the orbital roof and improve the cosmetic effects.

Methods

Prior to surgery, a lumbar cerebrospinal fluid drain is placed to allow the creation of a working space above the orbit by the extradural retraction of the frontal lobe. The patient is positioned supine with the vertex of the head raised to place the orbital roof perpendicular to the floor.

A bicoronal skin incision sufficient for exposure of the supraorbital region is made, and the skin flap is reflected

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anteriorly with the temporal fascia. The anterior tip of the temporal muscle is dissected subperiosteally and retracted posteriorly. In the superior orbital rim, the supraorbital nerve is freed from its bony exit (notch or foramen), and the periorbital lateral to the nerve exit is gently dissected to a

depth of ~20 mm. At dissection, care must be taken that the roof of the orbit is raised in a domelike fashion. Also, in the lateral orbital rim, the upper half of the periorbital is dissected.

Three burr holes are made (→Fig. 1A). The first, the MacCarty keyhole⁴⁻⁶ (defined as burr hole 1), exposes the

Fig. 1 Steps of modified one-piece supraorbital approach in a skull model. Numbers indicate the location of the burr holes defined here. (A) Three burr holes are placed: the MacCarty keyhole (burr hole 1) that exposes the anterior cranial fossa (arrow) and orbit (arrowhead), burr hole 2 just above the medial supraorbital rim, and burr hole 3 on the superior temporal line. (B, C): Outside (B) and inside views (C). Through burr hole 2, a small hole (arrow) is created with a diamond drill bit on the roof of the orbit, ~10 mm in depth from the surface. (D) The cut of the medial part of the supraorbital rim, made with a diamond-coated threadwire saw (diamond T-saw: arrows), introduced into burr hole 2 and the small hole in the roof. (E) Rongeur of the roof through burr hole 1 is continued to as close to the small hole as possible. (F) The cut of the lateral orbital rim made with a diamond T-saw (arrows), introduced into the inferior half of burr hole 1. The small bridge in the roof (asterisk) that was left in the previous step is seen. (G) Frontal osteotomies between burr holes 1 and 3, and between holes 2 and 3. A craniotome is used for osteotomy. The bony bridge (asterisks) left at each corner of the osteotomy is cut with a diamond T-saw (arrows). (H) The flap is raised in a medial to lateral direction, and the remaining small bridge in the roof (asterisk) is cracked. (I) Inside view of the one-piece supraorbital flap. (J) Superior view after completing the craniotomy. The orbital roof has been sufficiently removed en bloc to expose a tumor in the orbital apex (asterisk). The dashed line indicates the rim of the opening of the roof. (K) At repositioning of the flap, sutures are placed through small drill holes (dots) in the cuts made with a diamond T-saw to support the flap.

anterior cranial fossa, orbital roof, and orbit simultaneously. It is placed on the frontosphenoid suture 5 to 6 mm behind the anterior limit of the suture. If the hole is in this ideal position, there is a 75% chance that it exposes both cavities.⁷ If, however, it exposes only one cavity, the orbit or the frontal fossa, the hole is enlarged by drilling superiorly or inferiorly. The second and third ordinary burr holes, 10 mm in diameter, are made just above the exit of the supraorbital nerve (burr hole 2) and on the superior temporal line (burr hole 3). Osteotomy of the orbital roof is performed prior to frontal osteotomies between burr holes 1 and 3, and 2 and 3 to avoid epidural bleeding at the craniotomy into the orbital region. The dura between burr holes 1 and 2 is dissected. Through burr hole 2, a diamond drill bit, 4 mm in diameter, is introduced into the epidural space, and a small hole is created on the roof of the orbit, ~ 10 mm in depth from the surface (**Fig. 1B, C**). In this process, cerebrospinal fluid drainage via the lumbar drain and the placement of gelatin sheets between the roof and dura facilitate dural retraction. A diamond-coated threadwire saw (0.64 mm in diameter; diamond T-saw; MANI Inc., Utsunomiya, Japan)⁸ is introduced into the orbit to reach the small hole placed in the roof; it is picked up at the hole through the burr hole 2 (**Fig. 1D**).

An osteotomy in the medial part of the orbit is made between burr hole 2 and the small hole in the roof using the diamond T-saw. Then osteotomy of the roof is performed by rongeur through burr hole 1 toward the preexisting small hole in the roof (**Fig. 1E**). Several types of rongeurs are needed (i.e., a large bite for the lateral thick roof and a small bite for the medial thin roof). Under direct visualization through burr holes 1 and 2, rongeur is continued to as close as possible to the medial small hole. Next the diamond T-saw is passed from the lateral orbital rim to the inferior half of burr hole 1, and the lateral orbital rim is cut on the frontozygomatic suture (**Fig. 1F**). Frontal osteotomies between burr holes 1 and 3, and between holes 2 and 3 are performed using the diamond T-saw (**Fig. 1G**). At a point approximately a third of the way along the length of the osteotomy, a bony bridge is left in place. Using a Gigli saw guide, a diamond T-saw is introduced between the burr holes through the epidural space. The sawblade is placed along both edges of the bony bridge. Reciprocating strokes create a beveled cut. It is important to pull the saw as parallel to the calvarium as possible to create a section ideal for flap fixation. Now the flap is supported by only the remaining bridge in the orbital roof.

Finally, the flap is raised from the dura in a medial to lateral direction to avoid driving the roof into the frontal lobe (**Fig. 1H**). The remaining bridge is cracked and the flap can be removed (**Fig. 1I, J**). After trimming the posterior edge of the osteotomy in the roof, when needed, manipulation in the orbit is performed.

On closure, the opened periorbita is reapproximated with sutures. Small drill holes are made at each corner of the craniotomy and the bridge in the flap (between burr holes 1 and 3, and 2 and 3) and at the cut on the frontozygomatic suture for flap fixation. Nonabsorbable 2-0 sutures are passed through adjacent holes in the window and flap, and

tied (**Fig. 1K**). Methylmethacrylate is applied to the burr holes, and the scalp is closed in the usual fashion.

We used this technique to address orbital tumors in two adult patients, a 50-year-old woman with a cavernous angioma (**Fig. 2A, B**) and a 38-year-old woman with lymphangioma. Osteotomies in the orbital roof were easier than osteotomy through the orbit in the one-piece supraorbital approach we had used in other patients. The orbital roof, ~ 20 mm in depth from the orbital rim (i.e., the most anteroposterior length of the roof) was detached (**Fig. 2C-E**) and repositioned as a part of the flap (**Fig. 2F**). The tumors were successfully removed between the superior and lateral rectus muscles through the sufficiently large bony window. No technique-related complications such as dural laceration or unexpected fracture of the orbit were encountered during the procedures. In the early postoperative period neither patient experienced excessive orbital swelling, enophthalmos, and/or pulsatile exophthalmos. No depression, displacement, resorption, or infection of the flap occurred during the 20- and 60-month follow-up, and both patients were satisfied with the cosmetic results (**Fig. 2G**).

Discussion

There are two variations in osteotomy of the orbital part in the supraorbital approach, that is, osteotomy of the orbital rim and roof after completing a frontal craniotomy (two-piece supraorbital approach),^{9,10} and simultaneous osteotomy of the orbital rim and roof and frontal craniotomy (one-piece supraorbital approach).^{2,3,11} The two-piece approach is easy for creating a wide osteotomy on the orbital rim and roof in the intended line through the already performed frontal craniotomy. However, the orbital component with the bone gap requires fixation with titanium plates to obtain correct alignment. However, in the one-piece approach, the flap including the orbital component can rapidly be secured back into its original position with fewer fixation devices, but there are technical difficulties with respect to osteotomy in the orbital roof. Because of this difficulty in approaching the deep portion of the roof through limited spaces via the MacCarty keyhole and the space between the orbital rim and the periorbita, the one-piece supraorbital approach may not be appropriate in some patients (e.g., elderly individuals whose dura is tightly adherent to the bone and in patients with pathologic hypertrophy in the orbital roof).⁹

Techniques for osteotomy of the orbital roof in approaches whose cranial flaps contain the roof (i.e., the one-piece supraorbital and orbitozygomatic approaches) are divided into two styles: direct-vision osteotomy and blind cracking. Direct visualization from inside the orbit and cutting the roof with a chisel or reciprocating saw^{9,11,12} is difficult in cases with orbital tumors because the swollen content of the orbit may be an obstacle. Iatrogenic penetration of the roof and damage to the dura and brain with surgical instruments are possible risks. Cutting with a Gigli saw passed between pterional and supraorbital burr holes^{2,3,13} is also difficult for depressing and protecting the orbital content. Blind cracking of the orbital roof between the lateral and medial

Fig. 2 Findings of a patient with a cavernous angioma in the left orbit who underwent the modified one-piece supraorbital approach. (A) Preoperative gadolinium-enhanced T1-weighted magnetic resonance image (MRI) and (B) postoperative T1-weighted MRI. The tumor (arrow in A) is totally removed. (C–E) Intraoperative photographs. Completion of the cutting of the flap (C). Arrows show thin cut line created by a diamond-coated threadwire saw (diamond T-saw). After completing the craniotomy, the orbital roof (asterisk) has been sufficiently removed en bloc (D) and the periorbita (double asterisks) has been exposed (E). Numbers indicate the location of the burr holes defined in Fig. 1. (F, G) Postoperative computed tomography scans. The axial bone window image (F) and the three-dimensional image obtained 20 months after the operation (G) show cuts in the bone and excellent fitting of the bone flap. The most anteroposterior length of the roof is repositioned as a part of the flap. There is no flap absorption. Thin arrow shows cut made with a diamond T-saw; thick arrow shows cut produced by rongeur; arrowhead shows cut made by cracking; asterisk indicates MacCarty keyhole; double asterisks indicate small drill hole.

end of the craniotomy by elevating the flap raises the risk of unintended extension of the fracture.^{11,14} Thus these osteotomy methods may result in less preservation of the orbital roof and increase the risk of postoperative enophthalmos and/or pulsatile exophthalmos.^{7,15} Consequently, an easy and secure orbital osteotomy with greater preservation of the roof is the ideal method.

The present technique has two advantages. The first is easy osteotomy of the roof with greater preservation. The small hole created on the roof is important for extending the osteotomy anteroposteriorly by providing an entry for the diamond T-saw and by being a landmark for lateral rongeur of the roof. Because the remaining bridge between the small hole and the anteromedial end of rongeur is short, the direction of cracking in the bridge can be controlled. The burr hole above the supraorbital rim (burr hole 2) aids placing the small hole on the roof and helps illuminate the upper

plane of the roof. Avoidance of viewing the deep part of the roof from the orbit helps avoid undesirable maneuvers resulting in damage to the eyeball and adjacent structures by excessive depression. Second, seamless craniotomy with the diamond T-saw and a minimal bone gap (< 1 mm) secures the flap including the orbital component in its original position without fixation devices. Favorable cosmetic results in the repositioning of bone flaps cut with the diamond T-saw have been reported.⁸ Titanium fixation devices may produce undesirable bulges and raise the risk of skin erosion.¹⁶ Therefore, we do not recommend their use in cosmetically important areas especially in patients with thin skin or a malignant pathology whose skin may be damaged by adjuvant therapies. Bony bridges with minimal bone gaps not only assure matched bone fixation and resistance to compression forces¹⁶ but also revitalization and remodeling of the flaps. As revascularization of and osteoblast infiltration into the flaps occur

from the adjacent bone edge,¹⁷ the bridges may help these processes, and the flaps created with the diamond T-saw can be expected to be protected from resorption and infection even in cases with exposed frontal sinuses. This produces favorable cosmetic results. One possible cosmetic disadvantage of the present technique is placement of the burr hole above the supraorbital rim (burr hole 2); this requires careful recapping with filling materials.

The present modification of the one-piece supraorbital approach yields an orbital osteotomy with greater preservation of the roof, avoids use of fixation devices for the flap, and results in cosmetically satisfactory reconstruction. This technique is also applicable to the one-piece orbitozygomatic approach and its variations in patients with pathologies other than orbital tumors.

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