Superolateral Orbitotomy for Intraorbital Tumors: Comparison with the Conventional Approach

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Abstract

Objectives This study aims to compare the surgical and functional outcomes of superolateral orbitotomy (group A) and conventional superior orbitotomy (group B) for benign orbital tumors.

Design A retrospective review of 31 consecutive orbital tumor surgeries with the fronto-orbital approach was conducted.

Setting Procedures were performed at two institutions by a single surgeon.

Participants A total of 31 orbital tumor patients participated in this study. Overall, 11 intraconal and 2 extraconal tumors in group A and 11 intraconal and 7 extraconal tumors in group B were resected by superolateral orbitotomy, respectively.

Main Outcome Measures Demographic information, pre- and postoperative neurological findings and neuroimaging data, and pathological data were collected. Surgical and functional outcomes were compared and statistically analyzed between the two different surgical procedures.

Results The surgical outcomes were not significantly different between the two groups. In patients with intraconal tumors, the functional outcome was significantly better in group A than in group B.

Conclusion Superolateral orbitotomy provides better functional outcomes.

Keywords

- orbital tumor
- superolateral orbitotomy
- functional outcome

Introduction

Orbital surgery involves several approaches to the orbit. Transcranial,¹ transconjunctival,² transeyelid, and trans-sinonasal endoscopic³ approaches are used. Representative approaches with craniotomy are the fronto-orbital approach and the lateral orbital approach.⁴ Each approach is used according to the location, size, and histology of the lesion.⁵ In our institutes, we have been introducing the fronto-orbital approach with frontotemporal craniotomy. From 1994 to 2009 superior orbitotomy was used, and since 2010 we have used superolateral orbitotomy with osteoplastic en-

bloc resection of the superolateral orbital wall. Our hypothesis was that a wider surgical field would give rise to a better outcome. This superolateral orbitotomy assured a wider working space with good cosmetic and functional outcomes. In this article, the surgical procedure of superolateral orbitotomy is described, and our hypothesis is verified.

Patients and Methods

A total of 31 consecutive patients with orbital tumors operated by the fronto-orbital approach were investigated. A total of 13 patients, group A, were operated by superolateral en-

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bloc orbitotomy between 2010 and 2015. A total of 18 patients, group B, were operated by conventional superior orbitotomy between 1994 and 2010. In group B, 8 patients underwent only orbital unroofing, and 10 patients underwent combined resection of the orbital roof and superior orbital rim. From the medical records the following data were collected: clinical history of the patients; histology of the tumor; findings of computed tomography and magnetic resonance imaging (MRI); location of the tumor, extraconal or intraconal; relationship between the tumor and neighboring structures; tumor invasion into the optic canal and/or superior orbital fissure; surgical procedure, including type of orbitotomy, superior or superolateral, and the route into the intraconal space; surgical outcome; completeness of the tumor resection; recurrence of the tumor; and functional outcome. Surgical outcome was evaluated by postoperative MRI. Functional outcome was evaluated by the improvement of preoperative symptoms and the worsening, that is, deterioration of preoperative symptoms or the appearance of new neurological complications not present before surgery. In this study, visual function, oculomotor function, eyelid movement, and pupillary function were analyzed for functional outcome. Surgical and functional outcomes were compared between the two groups. All operations were done by one author (M. S.). Optic sheath meningioma and optic glioma were excluded, because the surgical procedure and objective were different.

Surgical Procedure of Superolateral Orbitotomy

Lumbar drainage was placed following the induction of general anesthesia. A bicoronal scalp incision was made, and the scalp flap was turned. The temporal muscle was detached from the temporal fascia and skull, and it was then rotated posteriorly to expose the lateral wall of the orbit. Frontotemporal craniotomy was performed, and the superior and lateral outer walls of the orbit were exposed extradurally. The periorbital was dissected from the superior and lateral inner orbital walls. Thus, the outer and inner surfaces of the superior and lateral orbital walls and rims were exposed. Two holes were made in the orbital wall. The first hole was made in the lateral wall of the orbit just behind the lower margin of the lateral orbital rim. The second hole was made in front of the optic canal. A 0.3-mm, diamond T-saw (Mani, Utsunomiya, Japan) was passed through the first burr hole and reflected, and then the bone cut of the lateral orbital rim was made. The second 0.3-mm, diamond T-saw was passed through the two holes, and they were interconnected. This bone cut passed near the superior orbital fissure. The third 0.3-mm, diamond T-saw passed through the second hole, and the medial orbital bone cut was made (—Fig. 1). The contents of the orbit were protected by the brain spatula during these procedures. The orbital roof, superior orbital rim, and lateral orbital wall and rim were removed en bloc. If necessary, the optic canal and superior orbital fissure were opened, and the anterior clinoid process was removed. In cases of intraconal tumors,

entry into the intraconal space was selected according to the location of the tumor and the optic nerve. If the optic nerve was lateral to the tumor, a medial approach between the superior rectus/superior palpebrae and medial rectus was used. If the optic nerve was medial to the tumor, a lateral approach between the superior rectus/superior palpebrae and lateral rectus was used. The optic nerve was always distal to the tumor. Lateral wall removal of the orbit was very useful when retraction in the lateral direction was necessary. After the tumor was removed, the periorbital was sutured. The orbital bone flap was replaced and fixed by the titanium plate, followed by the usual closing procedure (—Fig. 2).

Results

Patient Analysis

Group A consisted of 8 men and 5 women, ranging in age from 27 to 70 years, with a mean age at surgery of 43.1 ± 14.8 years. Initial symptoms were visual disturbance in six, visual field defect in seven, eye movement disorder in seven, exophthalmos in eight, blepharoptosis in two, dyscoria in three, proptosis in two, eye pain in four, and other symptoms in one. The tumor location was intraconal in 11 and extraconal in 2. The tumor size was from 20 to 50 mm, with a mean size of 30.5 ± 9.8 mm. The histological diagnosis was a solitary fibrous tumor in two, schwannoma in two, granuloma in two, meningioma in two, lymphangioma in one, lymphoma in one, pleomorphic adenoma in one, cavernous angioma in one, and venous angioma in one. The follow-up period was 35.0 ± 17.4 months. Group B included 7 men and 11 women, ranging in age from 7 to 78 years, with a mean age at surgery of 45.5 ± 20.0 years. Initial symptoms were visual disturbance in 10 patients, visual field defect in 2, eye movement disorder in 9, exophthalmos in 14, dyscoria in 1, and eye pain in 1. The tumor location was intraconal in 11 patients and extraconal in 7. The tumor size was from 10 to 35 mm, with a mean size of 23 ± 7 mm. The histological diagnosis was schwannoma in five, cavernous angioma in three, neurofibroma in three, pleomorphic adenoma in two, meningioma in two, angioma in one, solitary fibrous tumor in one, and dermoid cyst in one. The follow-up period was 140.3 ± 50.0 months. There was no basic, clinical difference between group A and group B.

Surgical Results and Outcomes

In group A, the tumor was totally removed in 12 patients and partially removed in 1 patient with an intraconal meningioma. Tumor recurrence was observed in one patient after gross total resection of an intraconal solitary fibrous tumor. In group B with 11 intraconal tumors, 7 were totally, 3 were subtotally, and 1 was partially removed. Of seven extraconal tumors, six were totally removed, and one was partially removed. Recurrence was observed in one intraconal solitary fibrous tumor and one extraconal pleomorphic adenoma. The risk of tumor recurrence was the histological type of solitary fibrous tumor. Surgical outcomes were not significantly different between the two groups (—Table 1).

Fig. 1 Photographs during surgery. (A) Right orbit before en bloc superolateral orbitotomy. Three thin thread saws are placed. (B) Right orbit after en bloc superolateral orbitotomy. (C) Orbit bone flap. (D) Right orbit after reconstruction.

Functional Outcomes

As for the intraconal tumors in group A, six patients had postsurgical improvement and one patient had postsurgical worsening, namely, visual disturbance improved in three patients, oculomotor disorder improved in two patients, and dyscoria improved in one patient, but ptosis appeared in one patient as a surgical sequela. As for the intraconal tumors in group B, two patients had postsurgical improvement and six patients had postsurgical worsening, namely, visual disturbance improved in one patient and oculomotor disturbance improved in one patient, but oculomotor disorder appeared in one patient, ptosis appeared in two patients and dyscoria appeared in three patients as a surgical sequela. Improvement of functional outcome for intraconal tumors was significantly more in group A than group B ($p = 0.0347$, binomial test), and the worsening was significantly less in group A than group B ($p = 0.0028$, binomial test). In intraconal tumors, superolateral orbitotomy provided better functional outcomes (► **Table 2**).

As for the extraconal tumors in group A, visual disturbance improved in one patient and there was no worsening. As for the extraconal tumors in group B, visual disturbance improved in one patient and oculomotor disturbance improved in three patients. On the other hand, visual disturbance

appeared in one patient as the postsurgical sequela. There was no significant difference in the functional outcomes between the two groups.

Discussion

The above results proved our hypothesis that superolateral orbitotomy provided better outcomes. Our superolateral orbitotomy with a thin thread saw resulted in shorter operative time, smaller bone defect, and lower risk of tissue injury.

Goal of Orbital Surgery

The purpose of orbital tumor surgery is to remove the lesion without functional and cosmetic complications. Surgical and functional outcomes were affected most by tumor location and size. For extraconal tumors, total resection without functional complication was usually possible when orbitotomy was performed properly. In our extraconal series, only one patient in group B with a 25-mm tumor located under the orbital roof suffered from postoperative visual dysfunction. In this patient, the orbital roof and superior limb were removed with a high-speed drill and a surgical chisel. The optic nerve was likely compressed during orbitotomy. This complication would have been prevented by the present orbitotomy. The

Fig. 2 Bone window CT scan after surgery. The right orbit is reconstructed without a bone defect or displacement. CT, computed tomography.

Table 1 Surgical outcome

Outcome	Total resection	Subtotal resection	Partial resection	Recurrence (–)	Recurrence (+)
Group A					
Intraconal (N = 11)	10	0	1	10	1
Extraconal (N = 2)	2	0	0	2	0
Group B					
Intraconal (N = 11)	7	3	1	9	2
Extraconal (N = 7)	6	0	1	6	1

Note: There are no significant differences between groups A and B.

surgical risk of intraconal tumor is greater, and the goal of surgery is different. Total tumor removal is not always the goal. From this point of view, the most important risk factor is the anatomical relationships between the tumor and the optic nerve and the extraocular nerves.

Procedures of Orbitotomy

In the fronto-orbital approach, the orbital roof was removed intradurally with a dural incision over the orbit or extradurally with exposure of the frontal base. In each approach, so far, the orbital roof was removed osteoplastically or osteoclastically with a high-speed drill with a steel or diamond burr.⁶ In orbital surgery, the operating field was

restricted until Jane method, which was a new surgical method with en bloc resection of a frontotemporal bone flap with the superior orbital rim and orbital roof using a Gigli saw.⁷ Al-Mefty enlarged the surgical field using a surgical saw.⁸ Fukushima and Nonaka reported a two-piece craniotomy with superolateral orbitotomy with a surgical drill and oscillating saw.⁹ We introduced two-piece craniotomy and orbitotomy using a thin thread saw. In Fukushima and our techniques, the surgical field was remarkably wide compared with the classical removal of the orbital roof. After the introduction of the thin thread saw, we performed en bloc superior orbitotomy of the superior rim and orbital roof.^{10,11} Since 2010, we have introduced the one-piece

Table 2 Functional outcome

Outcome	
Intraconal	
Group A (N = 11)	Improved 6 ^a (VD 3, OD 2, DC 1) Worsened 1 ^b (PT 1)
Group B (N = 11)	Improved 2 ^a (VD 1, OD 1) Worsened 6 ^b (OD 1, PT 2, DC 3)
Extraconal	
Group A (N = 2)	Improved 1 (VD 1) Worsened 0
Group B (N = 7)	Improved 4 (VD 1, OD 3) Worsened 1 (VD 1)

Abbreviations: DC, dyscoria; OD, oculomotor disorder; PT, ptosis; VD, visual disturbance.

^aImprovement of functional outcome for intraconal tumors was significantly more in group A than in group B ($p = 0.0347$).

^bThe worsening was significantly less in group A than in group B ($p = 0.0028$).

superolateral orbitotomy, which provided a wide surgical field with good cosmetic outcomes.

Surgical Approach to the Intraconal Space

Maroon and Kennerdell applied the fronto-orbital approach to tumors located medial to the optic nerve and recommended the route between the medial rectus and superior levator palpebrae/superior rectus muscles to prevent injury to the optic, oculomotor, and abducens nerves.⁶ MRI now provides the precise intraorbital anatomy with the location of the optic nerve, oculomotor/abducens nerves, extraocular muscles, and tumor, and surgeons are able to avoid the optic tract and oculomotor/abducens nerves that prevent access to the lesion.¹² This means selecting the tumor side. In many cases with large intraconal tumors, the space between the neighboring muscles is opened at the tumor side. During surgery, this opening has an advantage for dissection. Superolateral orbitotomy expands the options of intraconal entry. Fukushima and Nonaka showed five routes: medial approach, central approach, superior approach, superolateral approach, and inferolateral approach. From the viewpoint of the relationship between the optic nerve and the tumor, the medial approach is recommended for tumor located medial to the optic nerve, the central or superior approach is recommended for tumor located over the optic nerve, and the superolateral or inferolateral approach is recommended for tumor located lateral to the optic nerve.⁹ For intraconal dissection, attention to the oculomotor and abducens nerves located lateral to the optic nerve is needed, because identification of these extraocular nerves is more difficult than identification of the optic nerve. Dissection of extraocular nerves needs lateral dissection of the optic nerve. The wide operating field of superolateral orbitotomy provides enough space to identify these nerves.

Advantages of En Bloc Superolateral Orbitotomy

Since the orbit is a restricted space filled with fatty tissue that disturbs microsurgical dissection, a wide and shallow surgical field is desirable. In this study, the surgical outcomes of superolateral orbitotomy and the previous superior orbitotomy were compared, and superolateral orbitotomy was found to have a significant advantage. The morbidity rate of the present series with superolateral orbitotomy was also significantly superior to that of previous reports of the functional outcomes of superior orbitotomy.^{13–15} Superolateral orbitotomy was especially useful for large intraconal tumors and orbital apex tumors, the functional outcomes of which were poor as a consequence of excessive retraction, reduced working space, blind dissection behind the increased bulk of the tumor, or release of tight adhesions between the tumor and the surrounding orbital structures.¹⁶ Exposure, dissection, and removal of the tumor after superolateral orbitotomy were easier than after classical orbitotomy. Retraction of the surrounding nerves, vessels, and extraocular muscles and obstruction by fat were not significant problems. Postoperative oculomotor disorders, ptosis, and dyscoria were rarer in group A. Ptosis occurs due to longstanding retraction of the superior levator muscle. The shorter surgical time and wide surgical field of superolateral orbitotomy prevented postoperative ptosis. A wider surgical field without obstruction by the intraconal fat prevented this postoperative complication. The advantage of superolateral orbitotomy was also emphasized by the tumor size, which was larger in group A. In extraconal tumors, almost the whole tumor was exposed. For intraconal tumors, lateral retraction and shift of the lateral rectus were possible, and then the intraconal structures were well visualized. Since preoperative visual dysfunction is a risk factor for postoperative visual dysfunction,¹⁷ superolateral orbitotomy is indicated especially in patients with visual dysfunction. Suitable and ample exposure of the orbit has been repeatedly emphasized.^{18–20} With our superolateral orbitotomy, cutting of the annulus of Zinn was not necessary in apical tumors or tumors with cavernous sinus invasion. Opening of the optic canal and superior orbital fissure guaranteed a good horizontal view, and we could observe the cavernous sinus through the intratumoral space. Preservation of the annulus of Zinn prevented postoperative ptosis.²¹

Conclusion

The goal of surgery for a benign orbital tumor is total removal without neurological deficits and cosmetic complications. A risk factor has been the narrow surgical field with expanding fat and complex nerves, arteries, and veins. Neurological deficits might occur by blind manipulation, resection, and excessive retraction. The risk of residual tumor and neurological deficits were decreased by the improved orbitotomy with direct vision of the tumor and surrounding structures without excessive retraction. These goals could be achieved by superolateral orbitotomy.

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