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The superior orbital fissure and its contents

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Summary: Topographic landmarks for the superior orbital fissure are useful for general orientation and approach to the middle fossa, cavernous sinus and orbit. In this study, the microsurgical anatomy and morphometry of the superior orbital fissure and its related structures were examined in 57 disarticulated sphenoid bones, 102 skull bases and 58 adult cadaveric heads. The superior orbital fissure was observed in nine different shapes based on the classification of Sharma et al. (1988), and the most frequently observed was Type VI. The distance from the superomedial to the superolateral edge was measured as 17.3 ± 3.4 mm on the right side and 16.9 ± 2.9 mm on the left side, and from the superolateral to the inferior edge as 20.8 ± 3.9 mm on the right side and 20.1 ± 3.8 mm on the left side. The distance from the superomedial to the inferior edge of the fissure was measured as 9.5 ± 2.2 mm on the right side and 9 ± 2.4 mm on the left side. No right-left differences were observed for these measurements. Measurements regarding the relationship of the oculomotor, trochlear and abducent nerves, the ophthalmic branch of the trigeminal nerve and the superior orbital vein were performed and topographic aspects of the superior orbital fissure region were described.

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La fissure orbitaire supérieure et son contenu

Résumé : Les repères topographiques de la fissure orbitaire supérieure sont utiles pour une orientation générale et l'abord de la fosse crânienne moyenne, du sinus caverneux et de l'orbite. Dans cette étude l'anatomie micro-chirurgicale et la morphométrie de la fissure orbitaire supérieure et des structures en rapport ont été examinées sur 57 os sphénoïdes désarticulés, 102 bases de crâne, et 58 têtes de cadavre adulte. La fissure orbitaire supérieure a été observée selon les différentes formes basées sur la classification de Sharma et al. (1988) et le type le plus souvent observé était le type VI. La longueur de la distance entre les bords supéro-médial et supéro-latéral était de 17,3 ± 3,4 mm du côté droit, et 16,9 ± 2,9 mm du côté gauchre, la distance entre les bords supéro-latéral et inférieur était de 20,8 ± 3,9 mm du côté droit, et 20,1 ± 3,8 mm du côté gauche. La distance entre le bord supéro-médial et le brod inférieur de la fissure était de 9,5 ± 2,2 mm du côté droit, et 9 ± 2,4 mm du côté gauche. Aucune différence droite-gauche n'a été observée pour ces mesures. Les mesures concernant les rapports des nn. oculomoteur, trochléaire et abducens, du n. ophtalmique (du n. trijumeau) et de la v. orbitaire supérieure ont été réalisées et les aspects topographiques de la région de la fissure orbitaire supérieure sont décrites.

Key words: Cranial nerves — Orbit — Sphenoid bone — Orbital vein

The superior orbital fissure (SOF) is a small but functionally very important region. Nerves that provide afferent and efferent information for the visual system pass through this compact bony region [5, 10]. Detailed knowledge of the anatomic relationships of this region is critical for the accurate diagnosis and management of local disorders. Surgical approach to the lesions involving the SOF is made from the cranial or the orbital side. Fronto-temporo-orbital craniotomy and resection of the sphenoid bone, the anterior clinoid process, and the superolateral part of the orbital roof require detailed knowledge of the SOF [3, 9]. Previous studies have dealt with the anatomy of either the soft or hard tissues of the SOF. In this study, we present an analysis of SOF microanatomy with measurements from bony and cadaver specimens. These measurements provide useful information for surgeons in the treatment of lesions involving the wings of the sphenoid bone, posterior part of the orbit, and in particular the SOF.

Material and methods

Variations in the shape and size of the SOF were investigated in 57 sphenoid bones, 102 skull bases and 58 (51 male and 7 female) formalin fixed adult cadaver heads. Specimens were obtained from the skeleton and cadaver collection of the Department of Anatomy, Ege University Faculty of Medicine. Only specimens without gross pathology were included in the study. For cadaver specimens, a frontotemporal incision was made, the skull was opened, and the brain and dura mater removed. The floor of the anterior fossa was drilled under the microscope to resect the lateral edge of the SOF and cranial aperture of the optic canal. Dissections were performed using microsurgical instruments (Jena 390822 × 6.3 dissecting microscope with an OM Olympus photographic attachment). Measurements were taken using a flexible ruler. The distances from the superomedial to the superolateral edge of the fissure (AB line), the superolateral to the inferior edge (BC line) and the superomedial to the inferior edge (AC line) were measured in 57 sphenoid bones (57 right and 56 left fissures) and 102 skull bases (101 right, 102 left fissures). The microsurgical anatomy of the SOF was examined in 58 cadaver specimens (58 right and 58 left side fissures). In this study, the SOF was examined in stepwise dissections. The relationship of each neural and vascular structure to numerous topographic points of the region was examined and measurements involving the vascular and nerve structures were taken with a flexible ruler (Table 1). Mean and standard deviation values were calculated for each parameter and Student's t-test was used for statistical analysis in the assessment of right-left differences.

Fig. 1
Schematic representation of variations in the shapes of the superior orbital fissure (from Sharma et al., 1988)

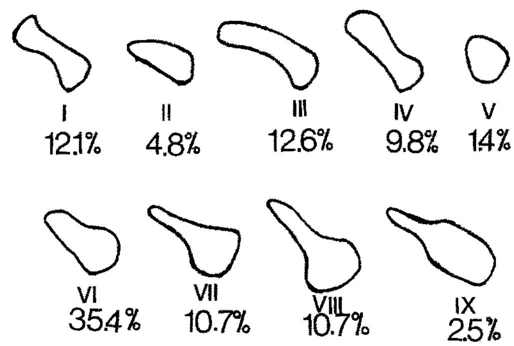
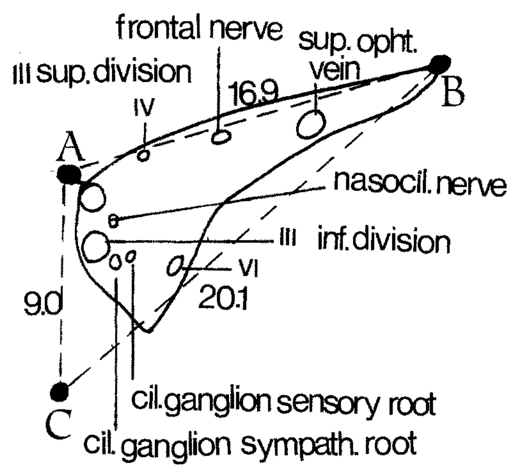


Fig. 2
Schematic representation of posterior view of right superior orbital fissure. **A** superomedial angle; **B** superolateral angle; **C** inferior angle of the SOF (modified from Natori and Rhoton, 1995)



Results

The SOF was bounded superiorly by the inferior rim of the lesser wing and inferiorly by the medial border of the orbital surface of the greater wing of the sphenoid bone and a small portion of the lateral apical border between the greater and lesser wings was completed laterally by the frontal bone. The lateral border of the fissure was formed by the sharp edge of the greater wing of the sphenoid bone, which sloped downward from its lateral to medial end. The superior wall of the fissure consisted of the lower surfaces of the lesser wing, the anterior clinoid process, and the adjacent part of the optic canal. The fissure was broad medially and inferiorly, and narrower laterally. The lower edge of the fissure was separated from the foramen rotundum by a bridge of bone. Nine different types of shape of the SOF were observed based on the classification of Sharma et al. [13] (Fig. 1). In this study, the most frequent type observed was Type VI (35.4%) (Table 1).

Table 1. Comparative study of the types of shapes of the superior orbital fissure

Type	I	II	III	IV	V	VI	VII	VIII	IX	Other
Shapiro	40%	16%	12%	12%	11%	9%	–	–	–	–
Sharma	14%	13%	6.65%	2.8%	1.86%	48.6%	7.47%	3.73%	1.86%	–
Magden	1.5%	2.4%	9.9%	3.4%	0.7%	4.6%	6%	17.6%	38.8%	15.2%
Govsa	12.1%	4.8%	12.6%	9.8%	1.4%	35.4%	10.7%	10.7%	2.5%	–

Table 2. Measurements of the anatomic relationships of the superior orbital fissure

Anatomic structures measured	Measurements (mm)				
Side	Right		Left		p
	Mean ± S	Range	Mean ± S	Range	
Superomedial to superolateral edge (A-B)	17.3 ± 3.4	11-24.7	16.9 ± 2.9	10.2-22.1	0.3
Superolateral to inferior edge (B-C)	20.8 ± 3.9	14.4-26.6	20.1 ± 3.8	13.3-34	0.13
Superomedial to inferior edge (A-C)	9.5 ± 2.2	5.2-14.4	9.0 ± 2.4	5.1-16.4	0.13
Oculomotor n. superior division					
Depth from upper border of SOF	2.34 ± 0.48	1.5-3.1	2.34 ± 0.92	1.4-3.5	0.99
Distance from medial border of SOF	3.33 ± 0.82	2.5-4.5	2.99 ± 0.9	1.3-4.5	0.32
Oculomotor n. inferior division					
Depth from upper border of SOF	3.59 ± 0.96	2.3-4.7	3.49 ± 0.77	2.9-4	0.77
Distance from medial border of SOF	2.85 ± 0.93	1.6-4.2	3.77 ± 0.75	2.3-4.5	0.41
Nasociliary n.					
Depth from upper border of SOF	3.11 ± 1.29	1.4-5.5	3.95 ± 1.13	2.3-5.3	0.14
Distance from medial border of SOF	4.33 ± 1.05	3-5.7	4.13 ± 1.27	2.3-5.8	0.71
Abducens n.					
Depth from upper border of SOF	4.55 ± 1.25	2.1-5.9	4.90 ± 1.16	3.5-7.1	0.44
Distance from medial border of SOF	4.88 ± 1.27	3-7	5.50 ± 1.06	3.8-7	0.17
Superior orbital v.					
Depth from upper border of SOF	0.61 ± 0.05	0-3	0.63 ± 0.04	0-3.19	0.52
Distance from medial border of SOF	7.18 ± 2	5-9.8	7.18 ± 1.67	5.1-11	0.99
Sensory root of the ciliary ganglion					
Depth from upper border of SOF	4.7 ± 1.9	2.7-5.8	4.7 ± 1.4	3.3-6.1	0.41
Distance from medial border of SOF	4.7 ± 1.3	3.4-6	4.7 ± 1.6	2.9-6.3	0.35
Sympathetic root of ciliary ganglion					
Depth from upper border of SOF	4.7 ± 1.8	2.9-6	4.7 ± 1.6	2.9-6.3	0.81
Distance from medial border of SOF	3.8 ± 1	3-4.9	3.9 ± 1	2.9-5	0.44
Frontal n.					
Distance from medial border of SOF	4.5 ± 1.17	3.1-6.4	4.8 ± 1.07	3-5.2	0.47
Trochlear n.					
Distance from medial border of SOF	4.06 ± 1.48	2.2-7.3	4.18 ± 0.72	3-5.2	0.82

The distances between the superomedial and superolateral edges (A-B), between the superolateral and inferior edges (B-C) and between the superomedial and inferior edge (A-C) of the SOF are shown in Table 2 and Figure 2.

At the fissure, the dura covering the middle cranial fossa and the cavernous sinus blended into the periorbita of the orbital apex and the common tendinous ring, which surrounded the anterior end of the optic foramen and the adjacent part of the SOF. It was attached to the supero-medial portion of the lateral border of the fissure, along the upper, medial and lower borders of the optic canal, and to the upper and lateral border of the medial part of the fissure (Fig. 3). The two tendons of the lateral rectus m. divided the SOF into two compartments. The superior part included the trochlear n., the frontal and lacrimal branches of the ophthalmic division of the trigeminal n. and the superior orbital v.; the inferior part contained the superior and inferior branches of the oculomotor, nasociliary and abducent nn. The tendinous ring and connective tissue layer extending backwards from here divided the fissure into lateral, central and inferior com-

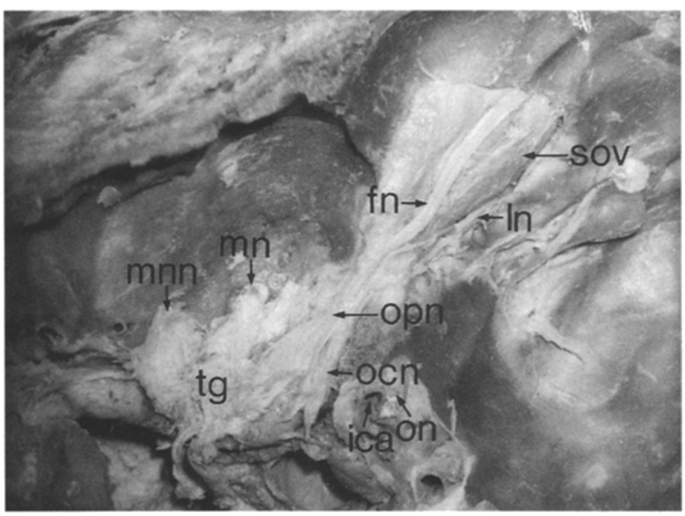


Fig. 3
The dura lining the middle cranial fossa and forming the lateral wall of the cavernous sinus and Meckel's cave are removed. *tg*, trigeminal ganglion; *mn*, maxillary n.; *mnn*, mandibular n.; *opn*, ophthalmic n.; *sov*, superior ophthalmic v.; *tn*, trochlear n.; *ocn*, oculomotor n.; *fn*, frontal n.; *ln*, lacrimal n. Magnification: 6.3 × 0.4

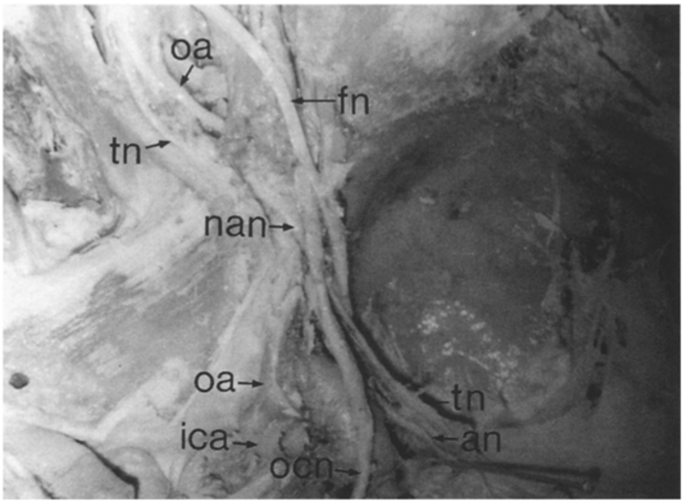


Fig. 4
The roof and lateral wall of the orbit, anterior clinoid process and optic canal are removed. *fn,* frontal n.; *tn,* trochlear n.; *nan,* nasociliary n.; *oa,* ophthalmic a.; *ln,* lacrimal n. Magnification: 6.3 × 0.4

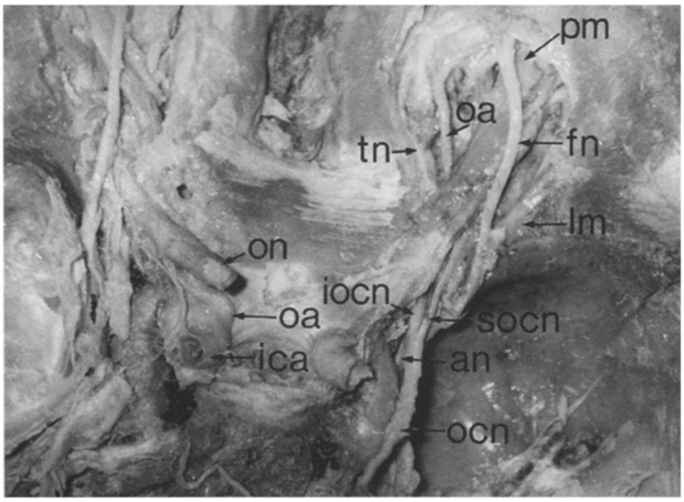


Fig. 5
The tendinous ring has been opened between the origin of the superior and lateral rectus mm. *(lm). Socn,* superior division of the oculomotor n.; *pm,* levator palpebrae superioris m.; *iocn,* inferior division of oculomotor n.; *on,* optic n.; *oa,* ophthalmic a. Magnification: 6.3 × 0.4

partments. The trochlear, frontal and lacrimal nn. and the superior ophthalmic v. passed through the lateral compartment. The central compartment, or 'oculomotor foramen', transmitted the oculomotor, nasociliary and abducent nn. and the sensory and sympathetic roots of the ciliary ganglion (Fig. 4). The inferior compartment was situated below the tendinous ring. The inferior rectus m. arose from the ring at the upper border of this part (Fig. 5).

Measurements of the depth and distance from the medial border of the fissure for the superior and inferior divisions of the oculomotor n., abducent n. and sensory root of the ciliary ganglion, and of the distances from the medial border of the fissure for the frontal and trochlear nn. are shown in Table 2. No right-left differences were observed for these parameters ($p > 0.5$).

Discussion

The SOF is a very complex region including many nerves and arteries that traverse the orbital apex and optic canal. Classical textbooks describe the fissure as transmitting the oculomotor, trochlear and abducent nn., the three branches of the ophthalmic n., the orbital branch of the middle meningeal a., the recurrent meningeal branch of the lacrimal a., and the ophthalmic vv., without giving much information about the topography of its contents [4, 14].

The shape of the SOF is described as triangular or club shaped in classical textbooks [4, 14]. In early hominids, Rak et al. [11] described the shape of the SOF as a 'foramen'. Shapiro and Janzen (1960) were the first to make a classification on the shape of the SOF and described six different shapes, later Sharma et al. (1988) added three new shapes to this classification [12, 13]. Magden et al. added eight original types of SOF to Sharma's classification [7]. Comparative studies of the shape of the SOF are shown in Table 1. In our study, variations in the shape of the SOF were observed consistent with the classification of Sharma et al.; we observed the most common type as Type VI (35.4%), consistent with their findings. The variations in the percentages may be accepted as a racial characteristic.

Natori et al. measured the distance from the superomedial to the superolateral edge of the SOF as 15.9 mm (7.7-22.1 mm), the distance from the superolateral to the inferior edge as 17.6 mm (10-24.3 mm), and the distance from the superomedial to the inferior edge as 7.0 mm (5.6-8.2 mm)[10]. We measured the distance from the superomedial edge to the superolateral edge (A-B) as 17.3 ± 3.4 mm on the right side and 16.9 ± 2.9 mm on the left side, the distance from the superolateral to the inferior edge (B-C) as 20.8 ± 3.9 mm on the right and 20.1 ± 3.8 mm on the left side, and the distance from the superomedial to the inferior edge (A-C) as 9.5 ± 2.2 mm on the right and 9.0 ± 2.4 mm on the left side.

Berlis et al. investigated the SOF using computed tomography and concluded that it could be best visualised in coronal sections [1].

The superior orbital fissure is susceptible to various diseases and injuries. Nerves and arteries may be damaged within the canal by sphenoid fractures, edema, hemorrhage, stretching or tension after trauma. Visual deficits also may arise from neoplasms such as gliomas and meningiomas, which traverse the optic canal. Surgical intervention may reverse the visual deficit caused by these lesions and injuries. The diagnosis and surgical treatment of these lesions require an intimate knowledge of the microanatomy of the orbital apex [2, 10]. The "superior orbital fissure syndrome" is a symptomatologic complex consisting of retrobulbar pain, paralysis of extraocular mm., and impairment of the first trigeminal branches with frequent involvement of the optic n. [6, 15]. For ophthalmologists and neurosurgeons venturing into this region, knowledge of detailed microanatomy of the SOF is very important in making better clinical and radiographic diagnoses and minimizing the complications that may result from misdirected surgery in a region where critical structures are separated by millimeters.

Exposing the fissure and its parts requires at least a limited exposure of the cavernous sinus posteriorly and the orbit anteriorly. The nerves of the cavernous sinus, except for the abducent n. can be exposed by opening or removing the outer layer of dura in the sinus wall while leaving the inner layer intact. Schwannomas and meningiomas may grow along the nerves and require opening of various parts of the fissure. The anterior clinoid process and the lesser wing of the sphenoid are frequently removed when dealing with ophthalmic and superior hypophyseal aneurysms. The greater wing may also be removed in tumors involving the middle fossa and cavernous sinus. Care is required in removing the anterior clinoid process to avoid damage to the optic n. on its medial side and the oculomotor n. on its lower side. Both the anterior clinoid process and the optic strut may contain air-cells which communicate with the sphenoidal sinus [8, 9, 10]. The trochlear n. can be injured when removing the upper border of the lateral part of the fissure formed by the lesser wing, because this nerve passes through the upper border of the lateral part above the ophthalmic n.

This study presents many topographic features and measurements related to neural and vascular structures of the SOF region from bony and cadaver specimens of Turks as a guide for ophthalmologists and neurosurgeons during surgical intervention and to help in the development of new strategies by precisely defining the anatomy of structures in the orbital apex, superior orbital fissure, and oculomotor foramen.

References

1. Berlis A, Putz R, Schumacher M (1992) Direct and CT measurements of canal and foramina of skull base. Br J Radiol 65: 653-61
2. Brazis PW (1993) Palsies of the trochlear nerve. Mayo Clin Proc 68: 501-509
3. Hassler W, Egger HR (1985) Extradural and intradural microsurgical approaches to lesions of the optic canal and the superior orbital fissure. Acta Neurochir-Wien 74: 87-93
4. Kopsch F (1955) Lehrbuch und Atlas der Anatomie des Menschen. Band I Georg Thieme Verlag, Stuttgart, pp 189
5. Lang J (1995) Skull base and related structures. Schattauer, Stuttgart, pp 114
6. Lenzi GL, Fieschi C (1977) Superior orbital fissure syndrome. Eur Neurol 16: 23-30
7. Magden O, Icke C, Arman C, Ozyurt D, Kaynak S (1995) Fissura orbitalis superior'un original tipleri. MN Oftalmoloji 2: 130-135
8. Morard M, Tcherekayev V, de Tribolet N (1994) The superior orbital fissure: a microanatomical study. Neurosurgery 35: 1087-1093
9. Natori Y, Rhoton AL Jr (1994) Transcranial approach to orbit: microsurgical anatomy. J Neurosurg 81: 78-86
10. Natori Y, Rhoton AL Jr (1995) Microsurgical anatomy of the superior orbital fissure. Neurosurgery 36: 762-775
11. Rak Y, Kimbel WH, Johanson DC (1996) The crescent of foramina in Australopithecus afarensis and other early hominids. Am J Phys Anthropol 101: 93-99
12. Shapiro R, Janzen AH (1960) The normal skull. Paul B. Hoeber Inc., Medical Division of Harper and Brothers. In: Sharma PK, Malhotra VK, Tewari SP (1988) Variations in the shape of the superior orbital fissure. Anat Anz 165: 55-56
13. Sharma PK, Malhotra VK, Tewari SP (1988) Variations in the shape of the superior orbital fissure. Anat Anz 165: 55-56
14. Williams P and Bannister L (1995) Gray's Anatomy. 38th edn, Churchill Livingstone, Edinburgh, pp 555, 560, 571
15. Zachariades N, Vairaktaris E, Papavassiliou D, Papademetriou I, Mezitis M, Triantafyllou D (1985) The superior orbital fissure syndrome. J Maxillofac Surg 13: 125-128

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