

Anatomical Position of the Optic Foramen Relative to the Sphenoid Sinus and Orbital Apex Structures

Posición Anatómica del Foramen Óptico en Relación con el Seno Esfenoidal y las Estructuras del Vértice orbitario

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SUMMARY: The orbit is a complex structure with many documented variations in its architecture and adjacent components. These differences are crucial in craniofacial surgery, particularly orbital decompression, which demands precise anatomical knowledge. Effective decompression also relies on appropriate equipment, skilled personnel, and a comprehensive grasp of this anatomy. In this study, we used computed tomography (CT) to define the position of the optic foramen (OF) relative to the sphenoid sinus and orbital apex. In this descriptive study, a radiologist examined CT scans of 100 patients at the Birjand prevalence hospitals between March 20, 2024, and March 20, 2025, using the hospital's imaging archive system. All the patients had been admitted with headaches, but their CT scans were normal. The OF and sphenoid sinus relationship was classified as anterior, posterior, or equal. Our study population consisted of 50 men and 50 women between 18 to 70 y/o. The findings indicated that the OF was symmetrically positioned in both orbits in 60 % of individuals. In the right orbit, the OF was predominantly situated posterior to the anterior wall of sphenoid sinus (ASW) in both sexes, whereas in the left orbit, most had equal positioning. About the right ocular orbit, the average distance from the OF to the ASW was 2.47 ± 0.83 mm when the OF was located anteriorly, while it was 3.2 ± 1.36 mm when positioned posteriorly. In the left eye, the average distance was 2.40 ± 1.23 mm in the anterior position and 3.62 ± 1.42 mm in the posterior position. Significant variation exists in orbital anatomy and neighboring vital structures. In right orbits, the OF was most commonly posterior to the ASW; in left orbits, most showed equal positioning. This refined anatomical understanding can aid surgeons in selecting the optimal approach-external or endonasal-for orbital decompression.

KEY WORDS: Anatomical position; Optic foramen; Sphenoid sinus; Orbital anatomy.

INTRODUCTION

The orbit is a cavity shaped like a cone located in the midface that has an anteriorly positioned base and a posterior apex. This area is quite a complex anatomical region, containing several important structures such as the visual organs and essential neurovascular components (Lieber & Fernandez-Miranda, 2020; Engin *et al.*, 2021). The orbit is closely related to the paranasal sinuses, particularly the sphenoidal sinus near the optic foramen (OF) and the optic canal (OC). These structures contain vital elements such as the optic nerve (CN II) and the major blood supply to the orbit. Consequently, any injury or pathological changes in this region can significantly affect vision and the functioning of the extraocular muscles (Gospe 3rd & Bhatti, 2018). The optic nerve joins the eye socket via the OF and moves directly through the common tendinous ring. Enhanced

understanding of orbital anatomy and its surrounding structures is essential for assessing the impact of diseases and ensuring safe interventions in the orbit. Additionally, the anatomy of the orbit is crucial in craniofacial surgeries, especially during orbital decompression procedures (Gioacchini *et al.*, 2021; Parrilla *et al.*, 2021).

Orbital decompression is a surgical procedure aimed at relieving pressure on the optic nerve and is commonly used to treat Graves' ophthalmopathy, exophthalmos (protrusion of the eyes), diplopia (double vision), optic neuropathy, and advanced proptosis (Gioacchini *et al.*, 2021; Ye *et al.*, 2023, Jellema *et al.*, 2024). Additionally, orbital decompression may be performed for various other conditions, including orbital hemorrhage, as well as benign,

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malignant, and metastatic tumors (In Woo *et al.*, 2021; Mueller & Bleier, 2022). Successful execution of orbital decompression requires appropriate equipment, skilled personnel, and a thorough understanding of orbital anatomy. Consequently, having a detailed understanding of the position of the sphenoidal sinus to the OF is necessary for orbital decompression surgeries and other surgical interventions in this area (Cinaroglu *et al.*, 2022; Nguyen *et al.*, 2023).

Numerous anatomical variations in the orbital apex and surrounding areas have been documented. However, the complexity of these variations necessitates further study to improve understanding and inform surgical planning (Cinaroglu *et al.*, 2022). We sought to establish the position of the sphenoidal sinus relative to the OF and explore other important anatomical connections at the orbital apex using CT scan images. The findings from this research could provide valuable insights for planning orbital decompression surgeries, helping to reduce the risk of optic nerve damage and improving surgical outcomes.

MATERIAL AND METHOD

This descriptive study was done in hospitals in Birjand, Iran. All procedures followed the Helsinki Declaration and received ethical approval from the Birjand University of Medical Sciences (Code: IR.BUMS.REC.1403.352). We studied the multi-planar CT scans of eligible patients who visited the hospital between March 20, 2024, and March 20, 2025. A total of 100 individuals were included, chosen through purposive sampling. The cranial CT images from 100 patients were retrospectively evaluated using the hospital's PACS. Images were obtained using a Philips mx 16-slice CT scanner with a bone window and < 0.6 mm axial slices.

Patients in this study were hospitalized for headaches and had normal CT images. The inclusion criteria were considered as individuals above 18 years old with normal CT scan images. Additionally, patients must have no history of systemic diseases affecting the anatomical structures or any history of trauma or injury to the head and face. Those with an orbital surgery history or significant sinus/orbital abnormalities on CT scans were excluded. All the measurements were conducted by a qualified radiologist. In total, 50 men and 50 women aged 18 to 70 years were included in the final evaluations, and multi-planar CTs were obtained.

Orbital Measurements

The Optic Foramen and Anterior Sphenoidal Sinus Wall Distance: Measured using thin axial CT slices from

the margin view of the OF to the junction of the ASW and the medial orbital wall, using a digital caliper in the axial plane.

- Length of the Medial Orbital Wall: Defined as the linear measurement from the medial margin of the OF to the anterior lacrimal crest.
- The Optic Foramen and the Carotid Prominence in the Sphenoid Sinus Distance: The axial plane distance between the medial margin of the OF and the carotid prominence within the sphenoid sinus.
- The Anterior Sphenoid Sinus Wall and the Carotid Prominence Distance: Measured digitally as the interval between the ASW and the carotid prominence.

The association between the OF and the ASW was analyzed and classified into three categories: anterior, posterior, or equal. If the OF's position was the same in both orbits, it was classified as symmetrical. Conversely, those with differing positions were categorized as asymmetrical. The landmarks, correlations, and measurements align with findings from previously published documents. All datasets underwent dual verification to confirm the accuracy of recorded measurements prior to analysis. Analysis was performed using SPSS version 17. Descriptive results are presented as mean \pm standard deviation (SD) for continuous numbers and proportions for categorical data.

RESULTS

We examined CT scans from 50 male patients and 50 female patients ranging from 18 to 70 y/o (47.13 ± 12.55). As shown in Table I, the positions of the OF in the orbits were either symmetrical (60 %) or asymmetrical (40 %).

In Table II, we described the position of the OF relative to the ASW. For the left side orbit, the OF was in equal positions as the ASW in 33 female and 27 male patients. In 7 female and 10 male patients, the OF was located anterior to the sphenoid sinus. Additionally, in 10 female and 13 male patients, the OF was in the dorsal position of the sphenoid sinus. For the right orbit, 11 patients of each sex had the OF at the same level as the ASW. The OF was positioned anterior to the sphenoid sinus in 5 female and 8 male patients. Additionally, in 34 female and 31 male patients, the OF was located posterior to the sphenoid sinus. Considering both sexes together, in the left eye, the OF was aligned with the anterior sphenoid sinus in 60 cases, anterior in 17 cases, and posterior in 23 cases. In the right eye, these numbers were 22, 13, and 65, respectively.

As demonstrated in Table III, the interval between the OF and the anterior surface of the sphenoid sinus varies by position (anterior, equal, or posterior). Average measurements

for several anatomical metrics, including the anterior surface of sphenoidal sinus, carotid prominence, and the anterior lacrimal crest distances, are summarized in Table IV.

Table I. Position of the optic foramen relative to each other.

		Symmetry		Total	
		symmetrical	asymmetrical		
Sex	Male	N	28	22	50
		%	56.0 %	44.0 %	100.0 %
		% of Total	28.0 %	22.0 %	50.0 %
	Female	N	32	18	50
		%	64.0 %	36.0 %	100.0 %
		% of Total	32.0 %	18.0 %	50.0 %
Total	Count	60	40	100	
	% within Sex	60.0 %	40.0 %	100.0 %	
	% of Total	60.0 %	40.0 %	100.0 %	

Table II. Position of the optic foramen relative to the anterior sphenoid sinus wall.

Sex	Equal	Left orbit		Right orbit		
		Anterior	Posterior	Equal	Anterior	Posterior
Female	33	7	10	11	5	34
Male	27	10	13	11	8	31
Total	60	17	23	22	13	65

Table III. Mean values of parameters based on the position of the optic foramen relative to the anterior sphenoid sinus wall.

Parameters	N	Mean ± SD	Min	Max	95 % Confidence Interval for Mean Values	
					Min	Max
OF- AS W (right) (mm)						
Equal	22	0	0	0		
Anterior	13	2.47±0.83	1	3.9	1.9	2.9
Posterior	65	3.2±1.36	1	6.6	2.8	3.5
OF- AS W (left) (mm)						
Equal	23	0	0	0		
Anterior	17	2.40±1.23	0	5.68	1.7	3.0
Posterior	60	3.62±1.42	0	6.66	3.2	3.9

Table IV. The mean values of parameters based on sex.

Parameters	Sex	Orbit	N	Mean ± SD	95 % Confidence Interval for Mean Values	
					Min	Max
ASW-CP	Female	Right	50	11.23 ± 2.08		
			50	11.49 ± 3.21	10.42	12.40
	Male	Left	50	11.02 ± 2.57	10.28	11.75
			50	10.82 ± 3.31		
OF-CP	Female	Right	50	9.36 ± 2.60		
			50	9.92 ± 3.39	8.62	10.87
	Male	Left	50	9.11 ± 2.31	8.45	10.30
			50	9.40 ± 3.19		
MOF-ALC	Female	Right	50	46.11 ± 4.03		
			50	47.16 ± 4.56	44.96	48.45
	Male	Left	50	46.52 ± 4.02	44.95	47.98
			50	46.47 ± 5.34		

DISCUSSION

OF position concerning the sphenoidal sinus and the orbital apex components hold significant importance in the fields of anatomy, radiology, and surgery. This area, because of the proximity to the ON, ophthalmic vessels, and other critical structures, presents a potential site for complications during surgical procedures. Therefore, a thorough understanding of the anatomical variations in this area can improve surgical techniques and reduce the risk of damage to these sensitive structures (Cinaroglu *et al.*, 2022; Nguyen *et al.*, 2023). Previous studies indicate that the anatomy of the OF can vary based on individual differences, sex, and conditions like bone hyperplasia. This radiological analysis assessed the anatomical correlation of the OF with the sphenoidal sinus using CT scans from 100 patients, aiming to improve anatomical understanding of this area for surgeons performing orbital surgery. A strong understanding of orbital anatomy is crucial for ensuring safety during these procedures.

According to our findings, the OF was located in the anterior margin of the sphenoidal sinus in 15 % of orbits, posteriorly in 44 %, and at the same level in the remaining orbits. Measurements indicated that in the right orbit, the position of the OF was mostly posterior to the sphenoid sinus (in both sexes), while in the left orbit, the majority were reported to be in equal positions. In 2023, Nguyen *et al.* (2023) analyzed 200 CT scans to evaluate the positional relationship of the OF relative to the sphenoidal sinus wall and reported an anterior OF position in 48.5 % of orbits and a posterior location in 51.5 %. These findings align with Cinaroglu *et al.* (2022) and Aujla *et al.* (2021), who reported an anterior OF position relative to the ASW in 46 % and 50 % of orbits, respectively. Additionally, a Japanese cohort study analyzed CT scans of 261 participants and found that in 49.2 % of cases, the lateral ASW was positioned anterior to the optic canal (Wada *et al.*, 2015). The anatomical interplay between the OF and sphenoid sinus is crucially important for surgeons, as it highlights the relationship between the optic canal and posterior paranasal sinuses. When the OF lies anterior to the ASW, the optic canal likewise originates from that position (Itagi *et al.*, 2017; Aujla *et al.*, 2021). Clinically, this may help decide between external and endoscopic surgery for optimal posterior orbital decompression. In cases requiring surgical access to the sphenoidal sinus, endoscopic transnasal orbital decompression may be the preferred approach (Aujla *et al.*, 2021; Nguyen *et al.*, 2023).

Our study showed that within the right orbit, the average interval between the OF and ASW was 2.47 ± 0.83

mm when the OF was positioned anteriorly to the sphenoid sinus. In contrast, this distance increased to 3.2 ± 1.36 mm when the OF was located posteriorly. In the left eye, the mean distances were 2.40 ± 1.23 mm and 3.62 ± 1.42 mm respectively. Nguyen *et al.* (2023) reported a mean distance of 3.82 ± 1.25 mm between the OF and the ASW. Additionally, mean distances from the OF to the carotid prominence and from the ASW to the carotid prominence measured 7.67 ± 1.73 mm and 7.95 ± 2.53 mm, respectively. These distances were also measured and reported in our study. According to our results, the OF position exhibited symmetry in 60 % of participants. However, Aujla *et al.* (2021) showed that this symmetry rate was 80 % and Nguyen *et al.* (2023) reported a 65 % symmetry in their study. These insights could help surgeons in revision surgery when anatomical landmarks have changed or disease affects one side. Understanding the structural correlations and variations in this region can serve as a valuable guide for surgeons performing procedures in this area. The association between the OF and the sphenoid sinus shows important insights for surgeons, allowing them to evaluate the proximity of the optic canal to the paranasal sinuses, which is crucial for surgical preparation and minimizing risks during endoscopic procedures. It is important to note that racial and sex differences may contribute to anatomical variations. Future studies should focus on investigating these variations to further refine surgical approaches and anatomical understanding.

CONCLUSION

There are various structural differences in the anatomy of the orbital apex. Our descriptive study found that, in the right orbit, the OF was primarily located posterior to the sphenoid sinus. In contrast, most cases in the left orbit showed equal alignment. Furthermore, the position of the OF was symmetrical in more than half of the participants (60 %). These observations not only deepen our comprehension of orbital anatomy but also carry significant clinical relevance regarding orbital surgeries, especially in procedures involving orbital decompression. The results provide valuable insights for surgeons carrying out orbital decompression or posterior orbital surgeries.

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MIRZAEI, M. & MOHAMMADIFARD, M. Posición anatómica del foramen óptico en relación con el seno esfenoidal y las estructuras del vértice orbitario. *Int. J. Morphol.*, 44(2):399-403, 2026.

RESUMEN: La órbita es una estructura compleja con numerosas variaciones documentadas en su arquitectura y componentes adyacentes. Estas diferencias son cruciales en la cirugía craneofacial, en particular en la descompresión orbitaria, que exige un conocimiento anatómico preciso. Una descompresión eficaz también depende del equipo adecuado, personal capacitado y un conocimiento exhaustivo de esta anatomía. En este estudio, utilizamos tomografía computarizada (TC) para definir la posición del foramen óptico (FO) en relación con el seno esfenoidal y el vértice orbitario. En este estudio descriptivo, un radiólogo examinó las tomografías computarizadas de 100 pacientes en los hospitales de prevalencia de Birjand entre el 20 de marzo de 2024 y el 20 de marzo de 2025, utilizando el sistema de archivo de imágenes del hospital. Todos los pacientes habían sido ingresados con cefaleas, pero sus tomografías computarizadas eran normales. La relación entre la órbita y el seno esfenoidal se clasificó como anterior, posterior o igual. Nuestra población de estudio consistió en 50 hombres y 50 mujeres entre 18 y 70 años. Los hallazgos indicaron que la órbita estaba posicionada simétricamente en ambas órbitas en el 60 % de los individuos. En la órbita derecha, la órbita estaba predominantemente situada posterior a la pared anterior del seno esfenoidal (PAE) en ambos sexos, mientras que en la órbita izquierda, la mayoría tenía una posición igual. En la órbita ocular derecha, la distancia promedio desde el foramen óptico (FO) hasta el seno esfenoidal anterior (SEA) era de $2,47 \pm 0,83$ mm cuando el FO se ubicaba anteriormente, mientras que era de $3,2 \pm 1,36$ mm cuando se ubicaba posteriormente. En el bulbo ocular izquierdo, la distancia promedio era de $2,40 \pm 1,23$ mm en la posición anterior y de $3,62 \pm 1,42$ mm en la posición posterior. Existe una variación significativa en la anatomía orbitaria y las estructuras vitales adyacentes. En las órbitas derechas, el FO se ubicaba con mayor frecuencia posterior al SEA; en las órbitas izquierdas, la mayoría presentaba una posición similar. Este conocimiento anatómico más preciso puede ayudar a los cirujanos a seleccionar el abordaje óptimo —externo o endonasal— para la descompresión orbitaria.

PALABRAS CLAVE: Posición anatómica; Foramen óptico; Seno esfenoidal; Anatomía orbitaria.

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