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Original article

Sphenoid Sinus Volume and Carotid artery/Optic Nerve Protrusion: A CT Study in Libyan Population

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ABSTRACT

Background and aims. *The sphenoid sinus is an important anatomical structure at the base of the skull. Due to the proximity to vital neurovascular structures such as the internal carotid artery (ICA) and optic nerve (ON), variations in sphenoid sinus anatomy can have significant implications for transsphenoidal surgical approaches This study investigates the relationship between sphenoid sinus volume and ICA and ON protrusion in a Libyan population using computed tomography (CT) scans.* ***Methods****. This retrospective study included 100 maxillofacial CT scans from adult Libyan patients. Multiplanar CT scans were performed to measure the volume of the sphenoid sinus and to quantify the projection of the internal carotid artery and optic nerve into the maxillary sinus. The relationships between these anatomical parameters were statistically analyzed using SPSS.* ***Results****. Sphenoid sinus volume was significantly larger in men compared to women. A significant association was found between larger sphenoid sinus volume and ICA protrusion, either alone or in combination with ON protrusion. ON protrusion alone showed no significant correlation with sinus volume.* ***Conclusion****. The results suggest that individuals with larger sphenoid sinus volumes are more likely to have ICA protrusion. In contrast, ON protrusion alone does not appear to be associated with significantly larger sphenoid sinus volumes.*

Keywords: Volume Internal Carotid Artery, Protrusion Optic Nerve Protrusion.

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الخلفية والأهداف. الجيب الوتدي هو بنية تشـريحية مهمة في قاعدة الجمجمة. نظرًا لقربه من الهياكل العصـبية الوعائية الحيوية مثل الشـريان السـباتي الداخلي والعصـب البصـري، فإن الاختلافات في تشـريح الجيب الوتدي يمكن أن يكون لها آثار كبيرة على الأسـاليب الجراحية عبر الوتدي. تبحث هذه الدراسة في العلاقة بين حجم الجيب الوتدي وبروز الشريان السباتي الداخلي والعصب البصري في السكان الليبيين باستخدام عمليات مسح التصوير المقطعي المحوسب. **الطرق**. تضمنت هذه الدراسة الاسترجاعية 100 مسح مقطعي محوسب للوجه والفكين من مرضى ليبيين بالغين. تم إجراء عمليات مسح مقطعي محوسب متعدد المستويات لقياس حجم الجيب الوتدي ولتحديد بروز الشريان السباتي الداخلي والعصب البصري في الجيب الفكي. تم تحليل العلاقات بين هذه المعلمات التشـريحية إحصـائيًا باسـتخدام برنامج SPSS. **النتائج**. كان حجم الجيب الوتدي أكبر بكثير عند الرجال مقارنة بالنسـاء. تم العثور على ارتباط كبير بين حجم الجيب الوتدي الأكبر وبروز الشريان السباتي الداخلي، إما بمفرده أو بالاشتراك مع بروز الشريان السباتي الداخلي. لم يظهر بروز الشريان السباتي الداخلي وحده أي ارتباط كبير بحجم الجيب. **الاستنتاج**. تشير النتائج إلى أن الأفراد الذين لديهم أحجام جيب الوتدي الأكبر هم أكثر عرضة للإصابة ببروز الشريان السباتي الداخلي. في المقابل، لا يبدو أن بروز الشريان السباتي الداخلي وحده مرتبط بحجم جيب الوتدي الأكبر بشكل ملحوظ.

INTRODUCTION

The sphenoid sinus is a complex and highly variable paranasal sinus located at the central skull base. It is surrounded by numerous critical neurovascular structures, including the internal carotid artery and optic nerve (1,2). Variations in the anatomy and pneumatization of the sphenoid sinus can affect the proximity and protrusion of these adjacent structures,

which is crucial to consider during surgical procedures in this region(3,4).

Previous studies have investigated the relationship between the sphenoid sinus volume and protrusion of the ICA and ON. These studies reported variable findings, likely due to differences in population characteristics and methodologies(5–8). Accurate quantification of these anatomical relationships is important for preoperative planning and risk assessment in sphenoid sinus and skull base surgeries. Recent advancements in CT imaging have enabled a more detailed and objective assessment of sphenoid sinus anatomy and its relationship to the surrounding structures(9). However, data on these relationships in diverse ethnic populations are limited. Understanding population-specific variations is crucial because genetic and environmental factors can influence paranasal sinus development and neurovascular configuration(10).

This study aimed to investigate the relationship between sphenoid sinus volume and protrusion of ICA and ON using CT scan in a Libyan population. The findings from this understudied population may provide valuable insights to supplement existing literature and guide clinical practice.

METHODS

This retrospective study included 100 patients (47 males and 53 female) aged between 13 and 90 years with a mean age of 40 years. A retrospective assessment of CT scans from the hospital database was performed with measurements taken in three dimensions using multiplanar reformatted images. CT scans showing sphenoid sinus fractures, space-occupying lesions affecting the skull base, or paranasal sinus infections were excluded. A 64-slice Philips CT scanner was used for all scans with the following acquisition parameters: 120kV, 320mAs, tube rotation: 0.6s; reconstruction thickness 1 mm, reconstruction filters sharpe for bone.

The type of sphenoid sinus was identified for each patient and classified as preselar, selar and post selar, and sphenoid sinus volumes were measured in cubic millimeters (mm^3) through assessment of the height, width and anterior posterior diameter of the sinus in the multiplanar reformatted images. The protrusion of the ICA and/or ON was assessed using coronal images. Participants were classified into four groups based on the protrusion status, Group 1: No protrusion, Group 2: Protrusion of the optic nerve, Group 3: Protrusion of the ICA and Group 4: Protrusion of both the optic nerve and ICA. The percentage of cases in each group and average sphenoid sinus volumes were calculated. The Mean sphenoid sinus volume and standard deviation were calculated for males and females. A t-test ($P < 0.05$) indicated significant differences. The mean volumes and standard deviations for each group were calculated, and Tukey's HSD T-test was used to test the differences between certain groups. All statistical analyses were performed using SPSS, with the significance level set at $P < 0.05$.

RESULTS

The mean sphenoid sinus volume is larger in male and was 19.53 ± 7.67 mm^3 and 15.69 ± 7.51 mm^3 for females in this data set (table 1). The difference in mean volumes between males and females was statistically significant ($p < 0.05$) [15], and The Pearson correlation coefficient between age and sphenoid sinus volume was 0.135, indicating a weak positive linear relationship between the two variables. The largest proportion of the sample (56.0%, n=56) had a postselar pneumatization pattern.

The results showed that the largest proportion of the sample, 50.0% (n=50), belonged to Group 1, indicating no protrusion of the optic nerve or ICA. This was followed by group 3, which accounted for 23.0% (n=23) of the individuals and exhibited ICA protrusion. Group 4, characterized by protrusion of both the ON and ICA, comprised 18.0% (n=18) of the sample. The smallest group was Group 2, with 9.0% (n=9) of the participants showing ON protrusion (Table 2), (Graph 1).

ANOVA test revealed a statistically significant difference in the mean sphenoid sinus volume among the four groups ($F 3, 96) = 13.949$, $p < 0.001$). The post-

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hoc Tukey test further identified that the specific group differences with Group 1 had a significantly lower mean sphenoid sinus volume than groups 3 and 4. Group 2 had a significantly lower mean sphenoid sinus volume than group 4. Group 3 had a significantly lower mean sphenoid sinus volume than group 4 (Table 3). These findings suggest that the sphenoid sinus volume varies significantly across the four groups, indicating that in all cases where there was protrusion of ICA, either alone or in combination with the ON, the volume of the sphenoid sinuses was significantly larger than that in the other groups with no protrusion. In other words, the data showed a clear association between a larger sphenoid sinus volume and the presence of ICA protrusion, either on its own or together with ON protrusion. This suggests that individuals with a larger sphenoid sinus volume are more likely to also have ICA protrusion, whereas ON protrusion alone may not be associated with a significantly larger sphenoid sinus volume, unlike the findings for (ICA) protrusion.

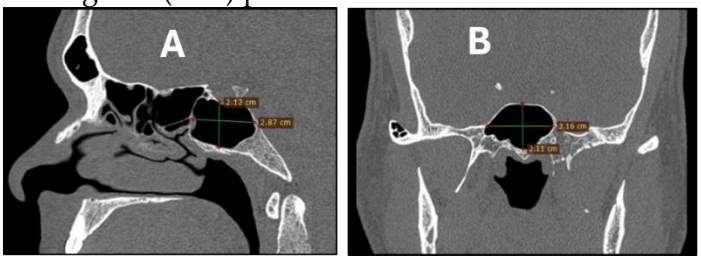
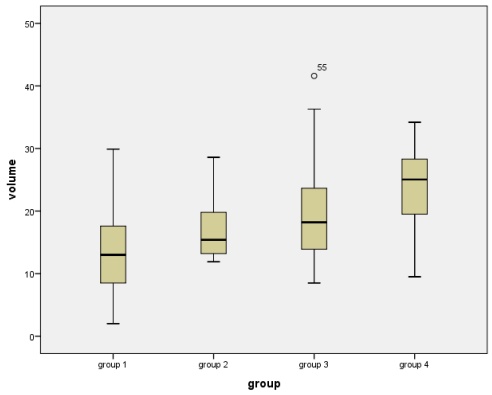


Figure 1: Volume measurement in the in sagittal (A) and coronal (B) reformatted images

Table 1: Sphenoid Sinus Volume by Gender

Gender	Mean volume (mm^3)	Standard Deviation (mm^3)	P-value
male	19.53	7.67	<0.05
Female	15.69	7.51	



Graph 1: Boxplot of Sphenoid Sinus Volumes by Group

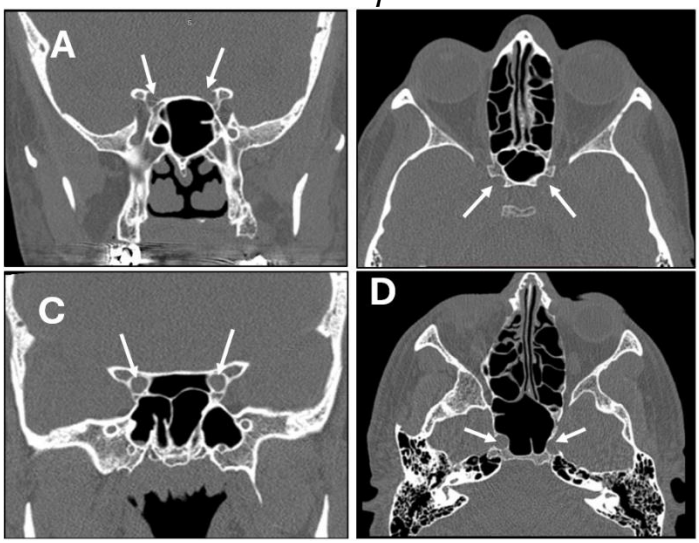


Figure 2: Transverse and coronal view shows no protrusion of ON (A) or ICA (B), protrusion of ON (C), protrusion of ICA(D), ICA internal carotid artery; ON optic nerve.

Table 2: Sphenoid Sinus Volume by Group

Gender	Description	Frequency	Percentage (%)	Mean Volume (mm^3)	Standard Deviation (mm^3)
Group 1	No protrusion of the optic nerve or ICA	50	50%	13.34	6.03
Group 2	Protrusion of the optic nerve	9	9%	17.47	5.66
Group 3	Protrusion of the ICA	23	23%	19.9	8.2
Group 4	Protrusion of both the optic nerve and ICA	18	18%	24.34	6.34

Table 3: Results of Tukey HSD Test Applied to Volumes of Sphenoid Sinuses in Different Groups

Tukey HSD Test	Group 1 No protrusion	Group 2 Protrusion of ON	Group 3 Protrusion of ICA	Group 4 Protrusion of ON & ICA
Group 1 No protrusion		P > 0.05	P < 0.01	P < 0.01
Group 2 Protrusion of ON	P > 0.05		P > 0.05	P > 0.05
Group 3 Protrusion of ICA	P < 0.01	P > 0.05		P > 0.05
Group 4 Protrusion of ON & ICA	P < 0.01	P > 0.05	P > 0.05	

DISCUSSION

The present study aimed to investigate the relationship between sphenoid sinus volume and protrusion of the internal carotid artery and optic nerve based on a comprehensive analysis of maxillofacial CT scans. The findings of this research build upon and corroborate the existing literature on this subject. Consistent with previous studies, the results demonstrate a significant gender-based difference in sphenoid sinus volume, with males exhibiting larger mean sinus volumes than females(11,12). This observation highlights the importance of considering patient sex when analysing sinus-related imaging and clinical findings as anatomical variations can have important implications for surgical planning and risk assessment.

Furthermore, the data revealed a weak positive correlation between age and sphenoid sinus volume, indicating that sinus pneumatization and expansion continue into adulthood, as documented in existing literature (13). This knowledge can inform the interpretation of sinus-related imaging findings and guide clinicians in the management of conditions involving the sphenoid sinus region across different age groups. One of the key findings of the present study was the significant variation in sphenoid sinus volume among the groups categorized based on the protrusion status of the ICA and ON. Notably, the results demonstrated that the presence of ICA protrusion, either alone or in combination with optic nerve protrusion, was associated with a significantly larger sphenoid sinus volume compared to the other groups.

This observation aligns with the findings of previous studies that have consistently reported a strong association between larger sphenoid sinus volumes and the presence of ICA protrusion(14,15). This relationship is clinically relevant because it suggests that individuals with larger sphenoid sinuses may be at an increased risk of encountering ICA protrusion during surgical interventions involving the sphenoid sinus region, such as endoscopic sinus surgery or pituitary gland procedures.

In contrast to the findings for ICA protrusion, the data indicated that ON protrusion alone may not be associated with a significantly larger sphenoid sinus volume. This distinction highlights the need to consider the specific anatomical variations involved when assessing the relationship between sinus volume and the surrounding neurovascular structures, as the mechanisms underlying these interactions may differ(16).

The high prevalence of the postselar pneumatization pattern observed in the present study, accounting for over 50% of the participants, is consistent with the findings of previous studies (16,17). This observation underscores the importance of comprehensive preoperative evaluation of sinus anatomy to identify potential anatomical variations that may impact surgical approaches and outcomes.

Overall, the findings of this study contribute to the growing body of evidence on the complex relationship between sphenoid sinus volume and protrusion of the ICA and ON. These insights can inform clinical decision making, surgical planning, and risk assessment, ultimately leading to improved patient care and outcomes in the management of conditions involving the sphenoid sinus region.

CONCLUSION

This multiplanar study of maxillofacial CT scans provides valuable insights into the relationship between sphenoid sinus volume and protrusion of the internal carotid artery and the optic nerve. Gender differences were observed, with males exhibiting significantly larger mean sphenoid sinus volumes than females, underscoring the importance of considering patient sex in sinus-related analyses. Additionally, a weak positive correlation between age and sinus volume suggests continued pneumatization into adulthood, guiding the interpretation of imaging findings across the age groups.

The study also revealed that larger sphenoid sinus volumes were associated with ICA protrusion alone or in combination with ON protrusion, implying an increased surgical risk in these anatomical scenarios. Conversely, ON protrusion alone did not correlate with sinus volume, highlighting the need to consider specific anatomical variations when assessing the relationship between sinus volume and the surrounding neurovascular structures. The high prevalence of postselar pneumatization further emphasizes the importance of comprehensive preoperative sinus anatomy evaluation to inform surgical planning and mitigate risks. These findings contribute to the understanding of the complex relationship between sphenoid sinus volume and the surrounding neurovascular structures, with insights that can guide clinical decision-making, surgical planning, and risk assessment to improve patient care in conditions involving the sphenoid sinus region.

Ethical compliance

All procedure performed in the study were in accordance with the ethical standards of the institutional medical ethics committee.

Declaration of interests

We have nothing to declare

Author contributions

Fatma Abdurahman Alfagei design and implement the research plan and manuscript writing, Mohamed Sherfad data analysis and manuscript writing, Mohamed Shaka data collection, data analysis and manuscript writing

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