ORIGINAL ARTICLE

Anatomic variations of posterior paranasal sinuses and optic nerve

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ABSTRACT

Aim To define direct anatomical relations of the sphenoidal (*alae minores*), ethmoidal sinuses and optic nerve, with an emphasis on determining the effect of age on pneumatisation and dehiscence.

Methods This retrospective, descriptive study involved 60 consecutive patients: 30 patients younger than 30 and30 patients older than 60 years of age. All patients underwent computerized tomography (CT). The relationship of the optic nerve and the sphenoidal and ethmoidal sinuses was classified. The presence of dehiscence in the bone structures, forming the optic canal, was checked. Dehiscence was defined as absence of visible bone density located between the sinus and the optic nerve. Protrusion of the optic nerve into the sphenoidal sinus was defined as optic nerve surrounded by pneumatised space.

Results The most common type of relation between the optic nerve and sphenoidal sinus was type I, where the optic nerve was immediately adjacent to the lateral or superior wall of the sphenoidal sinus, without impression on the sinus wall. Dehiscence was documented in 15 (25%) cases, it was more common in older patients (8, 27%) than in younger ones (7, 23%). The pneumatisation processes were more frequent in patients over 60 (5, 17%) than in those younger than 30 years (4, 13%).

Conclusion Surgeons and ophthalmologists should be aware of high frequency of dehiscence of sphenoidal sinus walls when treating adult patients in our population, especially when evaluating risks and complications of surgical procedures or when diagnosing inflammatory or tumorous processes in the close vicinity of posterior paranasal sinuses.

Keywords: ethmoid sinus, sphenoid sinus, intraoperative complications

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INTRODUCTION

The sinonasal tract and orbit are often the overlapping fields of otolaryngology and ophthalmology (1), sometimes reffered to as a "no man's land" in which otolaryngologists feel as uneasy in the orbit as ophthalmologists do in the nose (2). The anatomical variations of the posterior paranasal sinuses greatly affect the choice of surgical approaches when operating within their anatomical region, and can influence the character of postoperative complications. Anatomic or radiologic variations, especially dehiscences related to disease or previous surgery come as an important risk factor for complications of endoscopic surgery (3).

Pre-intervention assessment of sphenoid sinus pneumatization is mandatory in approaching the sella and skull base structures either via the nose or open skull base surgery to avoid injury of the nearby structures and reduce the possibility of CSF leakage (4).

Within the optic canal, the fibers of the optic nerve are very close to the sphenoidal sinus cavity, which leaves them exposed to mechanical or inflammatory processes, especially if there is dehiscence in the bone walls of either the optic canal or the sphenoidal sinus, or if the canal wall is particularly thin (5-13). There are numerous reports of variations of anatomy of posterior paranasal sinuses and optic nerve (15). The optic nerve often bulges into the superior-lateral wall of the sphenoid sinus, with different frequencies found in literature, ranging from 8 to 100% (16). The canal of the optic nerve protrudes into the sphenoid sinus by half of its diameter in 8% cases, and in 1% of cases large lateral recess of the sphenoid sinus (well pneumatized anteriorclinoid processes) passes partially "freely" through the sphenoid sinus or through a posterior ethmoidal sinus (17).

The prevalence of anatomical variations (18) of posterior paranasal sinuses differs in various populations. It is clear that development of the paranasal sinuses is directly linked with the development of the facial part of the skull and with dentition (19), but it is not clear when it finishes definitely. The development of paranasal sinuses should be definitely over in persons older than 60 (20-23). There were no similar studies published on this topic among the population of Bosnia and Herzegovina (B&H).

The aim of this study was to determine direct anatomical relationships between the sphenoidal and ethmoidal sinuses and the optic nerve in Zenica Cantonal Hospital, especially related to age (comparision of persons younger than 30 with those over 60 years of age).

PATIENTS AND METHODS

Patients and study design

The study was performed at the Department of Radiology,Cantonal Hospital, Zenica, Bosnia and Herzegovina (B&H) between January 1, 2012 and December 31, 2012. The investigation was approved by the Director of the Hospital.

The research was conducted using a pool of 60 consecutive patients undergoing CT examination of head regardless of the diagnosis: 30 patients were younger than 30, 30 patients were older than 60 years of age. Anatomic relations of the optic nerve and the sphenoidal and ethmoidal sinuses, level of sphenoid pneumatization, presence of dehiscence in the bone structures that form the optic canal, protrusion of the optic nerve into the sphenoidal sinus cavity were investigated.

Methods

All patients underwent computerized tomography (CT) scans. The patients were scanned using the Somatom Definition AS (Siemens, Erlangen Germany) according to the following parameters: slice thickness – 1 mm, rotation time 0.6 seconds. The obtained scans were direct axial CT scans beginning with the frontal sinus and ending with the hard palate. Multiplanary reconstructions, created using an evaluation console were used during the analysis and enabling the review of the images in the coronal and sagittal plane as well.

The relationship of the optic nerve and the sphenoidal and ethmoidal sinuses was classified based on the criteria developed by De Lano et al. (15): type I – the optic nerve is immediately adjacent to the lateral or superior wall of the sphenoidal sinus without impression on the sinus wall, type II – the course of the nerve is the

same, but there are indentations on the lateral sphenoidal sinus wall, type III – the optic nerve courses through the sphenoidal sinus rather than simply run adjacent to it, and type IV – the nerve runs immediately lateral to the posterior sphenoidal and ethmoidal sinuses, with the contact to the ethmoidal sinus usually located at the sphenoethmoidal junction.

A greater wing of a sphenoid is pneumatized when pneumatization is visible laterally of the vertical line that goes through maxillary nerve canal (24). The level of sphenoid pneumatization could be classified in 3 stages: pneumatization type I in which less than 50% of the sinus is pneumatized, type II with more than 50% but not totally pneumatized sinus, and type III in which the sinus is totally pneumatized (25).

The presence of dehiscence in the neighboring bone structures, forming the optic canal, was checked in every patient. Dehiscence was defined as the absence of visible bone density located between the sinus and the optic nerve. Certain cases, in which there was no possibility of clearly determining whether the bone density is completely absent, or so thin that it is almost invisible, were also regarded as dehiscence.

Protrusion of the optic nerve into the sphenoidal sinus cavity was noted in every case in which the optic nerve was surrounded by pneumatised space (24). Examinations of pneumatisation were limited to the lesser wings of the sphenoid (*alae minores*).

Statistical analysis

The data were analyzed by the means of descriptive statistics and by using $\chi 2$ test to evaluate the association between the anatomic variants. $p<0.05$ was accepted as statistically significant. Bilateral and unilateral differences were evaluated separately.

RESULTS

The research was conducted using a pool of 60 patients: one half of them was younger than 30, while the other half was older than 60. The first group of patients comprised 17 (57%) males and 13 (43%) females, and the second comprised 16 (54%) males and 14 (47%) females. The average age was 27.67 and 64.45 years, in the first and second group, respectively.

The following variations in the relationship of the sphenoidal sinus and the optic nerve were detected: type I was observed in 21 (70%) patients belonging to the first group, and 22 (73%) patients belonging to the second one. Indentations in the sphenoidal sinus walls were present in four (13%) patients in the first group (in three males and one female, 18% and 8%, respectively), and in three (10%) patients in the second group (two males and one female, 12% and 7%, respectively). Protrusion of the optic nerve into the sphenoidal sinus was detected in five (17%) patients in younger than 30 (one male and four females, 6% and 31%, respectively). The older group of patients also comprised five (17%) patients with protrusion (two males and 3 females, 12% and 21%, respectively) (Table 1).

Table 1. Variations of positions of optic nerve and sphenoidal sinus

Age group (No)	No (%) of patients								
	I type			II type			III type		
	Both sides	Right	Left	Both sides	Right	Left	Both sides	Right	Left
Younger than 30 years									
Males (17)	13 (76)	-	-	2 (12)	-	1 (6)	-	1 (6)	-
Females (13)	8 (61)	-	-	-	1 (8)	-	-	3 (23)	1 (8)
Older than 60 years									
Males (16)	12 (76)	-	-	-	1 (6)	1 (6)	-	1 (6)	1 (6)
Females (14)	10 (72)	-	-	-	1 (7)	-	-	1 (7)	2 (14)

Pneumatisation in the lesser wings of the sphenoid was found in four (13%) patients (three males and one female, 18% and 8%, respectively) in patients younger than 30 years, and in five (17%) patients older than 60 years (two males and three females, 12% and 21%, respectively) (p=0.72).

In the patients younger than 30, unilateral dehiscence of sphenoidal sinus wall was detected in eight (27%) patients (four males and three females, 24% and 23%, respectively). In one male a bilateral dehiscence was diagnosed.

In older than 60 years, dehiscence of the sphenoidal sinus wall was detected in eight (27%) patients (three males and five females, 19% and 36%, respectively). One of the female patients had bilateral dehiscence (p=1.00).

The younger group of patients was found to contain only two of the four types of relationships of the

optic nerve and the sphenoidal and ethmoidal sinus: type I was found in three (10%) patients (two males and one female, 12% and 8%, respectively); type II was found in one (6%) male patient.

The older group of patients had only one type of relationship between the optic nerve and the posterior paranasal sinuses matching type I in the first group of patients (one male).

DISCUSSION

The results of our study have confirmed a great deal of variability on the relationship of the optic nerve and the posterior paranasal sinuses. Dehiscence in minor wing of sphenoid was found in 25% of the patients and was more frequently found in the group of patients older than 60, in comparison with the group of patients younger than 30, 26% vs. 23%. Dehiscence in the sphenoidal sinus wall was found in 27%, being more frequent in female patients of the older group than in the group of female patients as a whole. Our results concerning this closely relate to the results found in the available literature (15).

The processes of pneumatisation were also slightly more frequent in the older group of patients compared to the younger group (26% vs 13%) in this study, which corresponds with the results other researchers in which pneumatisation of *alae minor* was encountered in 11 – 29.3% (15, 26).

Research about the anatomical variations of the sphenoidal sinus using CT have not yet clearly defined radiological diagnostic criteria. Due to a very wide spectrum of anatomical variations, sometimes it is very difficult to distinguish normal anatomy from pathologic processes (15). These variations still can be classified, which helps in distinguishing normal anatomy from pathologic processes.

Using the classification provided by DeLano et al. (15), our results did not differ much from the other authors' findings, e.g. I and II type of relation positions of optic nerve and sphenoidal sinus, while there were some differences in case of type III. The available literature shows a varying presence of type III in different studies, ranging from 6% to 65% (15,27,28) with the corresponding percentage in our study being 17%.

Our research also detected variations in the relationship of the optic nerve and the posterior paranasal sinuses. The optic nerve was found to be in direct contact with the ethmoidal sinus wall in 3-10% of the cases (percentages taken from the second and the first group of patients, respectively). Literature on this subject mention percentages varying from 5.9% to 7% regarding the presence of this variation (15,29,30).

In 56 – 76% of individuals, the optic nerve does not come into contact with the bone walls of the posterior paranasal sinuses. The remaining cases are such that the nerve is either in direct contact with them or located within their cavity (15,26,28). Some studies have shown connections between the anatomical relationship of the optic nerve and paranasal sinuses and ethnicity (30,31).

Our study revealed a large variability of the anatomical relationship of the optic nerve and the posterior paranasal sinuses in our population. Otorhinolarynogologists, neurosurgeons and ophthalmologists have to bear in mind that every forth adult patient has dehiscence of sphenoidal sinus walls, especially when evaluating risks and complications of surgical procedures or when diagnosing inflammatory or tumorous processes in the close vicinity of posterior paranasal sinuses. The CT is a valuable radiologic method for evaluation of anatomical positions and pathological processes.

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Competing interests: None to declare.

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Anatomske varijacije paranazalnih sinusa i optičkog živca

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SAŽETAK

Cilj Definirati direktne anatomske odnose klinaste kosti (mala krila), etmoidalnih sinusa i optičkog živca, s naglaskom na određivanje utjecaja starenja na pneumatizaciju i dehiscenciju.

Metode U retrospektivnu deskriptivnu studiju bilo je uključeno 60 konsekutivnih pacijenata: 30 pacijenata mlađih od 30 godina i 30 pacijenata starijih od 60 godina. Svim pacijentima je urađena kompjuterizirana tomografija i utvrđena relacija odnosa sfenoidalnog i etmoidalnog sinusa. Istraživano je prisustvo dehiscencije u koštanim strukturama koje formiraju optički kanal. Dehiscencija je definirana kao odsustvo vidljive koštane mase između sinusa i optičkog nerva. Protruzija optičkog živca u sfenoidalni sinus je definirana kada je zamijećeno da je optički nerv okružen pneumatiziranim prostorom.

Rezultati Najčešći odnos optičkog živca i sfenoidalnog sinusa bio je tip I, u kojem je optički živac bio neposredno uz lateralni ili gornji zid sfenoidalnog sinusa, bez utiskivanja u zid sinusa. Dehiscencija je ustanovljena u 15 (25%) slučajeva, a bila je češća u starijih (8,27%) u odnosu na mlađe pacijente (7,23%). Pneumatizacija je bila češća u pacijenata starijih od 60 godina (5,17%) u odnosu na mlađe od 30 godina (4,13%).

Zaključak Hirurzi i oftalmolozi trebali bi biti svjesni visoke učestalosti dehiscencije zida sfenoidalnog sinusa pri liječenju odraslih pacijenata u bosanskohercegovačkoj populaciji, osobito pri evaluaciji rizika i komplikacija hirurških procedura ili pri dijagnosticiranju inflamatornih ili tumorskih procesa u neposrednoj blizini paranazalnih sinusa.

Ključne riječi: etmoidalni sinus, sfenoidalni sinus, intraoperativne komplikacije