Rhinology, 42, 30-34, 2004

The relationship between the sphenoid and the posterior ethmoid sinuses and the optic nerves in Turkish patients*

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SUMMARY

The sphenoid and the posterior ethmoid sinuses are surrounded by more vital structures than any other sinus. With the widespread acceptance and expanding role of endoscopic sinus surgery, a proper understanding of the anatomy of the sphenoid and the posterior ethmoid sinuses is achieved.

We reviewed 100 CT studies of the paranasal sinuses belonging to patients examined for a chronic inflammatory disease of the nasal cavity and the paranasal sinuses. The relationship between the optic nerves and the paranasal sinuses is classified into four discrete categories. Type 1 with a proportion of 64% is observed to be the most often localized optic nerve. Type 2 is detected in 22% of the cases; types 3 and 4 are both 7% of the total number. A bony dehiscence was detected in 13.5% of the total cases, while it was observed in 39% of type 2 and 43% of type 3. We found a pneumatization of the anterior clinoid process in 11% of the patients. The proportion of pneumatization of the anterior clinoid process in type 3 configurations is found out to be as high as 86%. Optic nerve dehiscence was seen with a proportion of 23% in cases of pneumatization of the anterior clinoid process. Pneumatization of the posterior nasal septum was detected in 15% of the 100 cases. When the optic nerves were evaluated in these cases, mostly the type 1 configuration with a proportion of 63% was observed. An extensively pneumatized sphenoid sinus was detected in 4% of the 100 cases. Five of the investigated 8 optic nerves of these 4 cases were found out to be type 3 (62.5%).

No significant optic nerve variations were met in patients with pneumatization of the posterior nasal septum. Nevertheless while performing surgery, it is important to bear in mind that there may be significant optic nerve variations with pneumatization of the anterior clinoid process and extensively pneumatized sphenoid sinuses.

Key words: sphenoid sinus, posterior ethmoid sinus, optic nerve, anterior clinoid process, bony dehiscence.

INTRODUCTION

It is important to have knowledge about the relationship between the sphenoid and the posterior ethmoid sinuses and the optic nerves to avoid operative complications. The most posterior cells of the posterior ethmoids are of greatest importance to the surgeon, since these can develop laterally along and even superiorly over the sphenoid sinus. The sphenoid sinus may be bypassed to some extend, superiorly by ethmoidal cells. These cells, named Onodi cells, which are currently called spheno-ethmoidal cells, can stand in a close spatial relationship with the optic nerve. The optic nerve may appear prominently on the lateral wall of such a spheno-ethmoidal cell and may, in fact be surrounded by such cells. Restricted exposure and inconsistencies in sinus pneumatization place the optic nerve at risk during operations on the sphenoid and the posterior ethmoid sinuses. During surgical procedures the surgeon must always remember that the optic canal may only be covered by a very thin and occasionally fragmented bony layer in the area of the sphenoid and that this vital structure may not be well protected (Stammberger, 1991).

*Received for publication: June 23, 2003; accepted: November 7, 2003

The close location of the optic nerve to the sphenoid and the posterior ethmoid sinuses constitutes an obvious risk factor. Our purpose was to determine the frequency of protrusion of the optic canal into these cells and to define the CT criteria for this anatomical variation in a group of Turkish patients.

MATERIALS AND METHODS

Patients and CT scans

We reviewed 100 CT studies of the paranasal sinuses of patients whom were examined for chronic inflammatory disease of the nasal cavity and the paranasal sinuses by two physicians. All of the patients were affected by chronic inflammatory diseases of the sinuses. The patient population was composed of 47 male and 53 female subjects. The ages ranged between 13 and 52 with a mean of 33.1 years (±11.24 standard deviation). Patients with benign or malignant tumors of the sinuses, nasal polyposis and previous history of intranasal surgery or trauma were excluded in order to minimize the possibility of an acquired defect. Direct axial and coronal CT scans were obtained with a 3-mm section thickness; 2.7-second scan time, 120mAs and 133kV(p) on a Siemens Somatom HiQ CT scanner. Both bone and soft-tissue window (2300-2500 Hounsfield units (HU); level, 300-500HU) scans were available for interpretation. All patients gave their written informed consent before being included in this study, which was approved by the Ethics Committee.

The relationship between the optic nerve and the sphenoid and the posterior ethmoid sinuses was recorded separately for the left and right sides. The nerve making an indentation within the sinus wall or sinus itself and the dehiscence of the bony canal of the optic nerve was noted. The lack of the thin bony density between the air and the optic nerve within the sinus was evaluated as a dehiscence of bone. The length of this dehiscence was interpreted considering the number of sections it was seen. If the continuing dehiscence wasn't observed in the next section, the length of the dehiscence was assumed to be the total sum of the length of the sections before where the dehiscence was seen (e.g., the length of the bony dehiscence was interpreted as 3 mm when the dehiscence was observed in a single section and 6 mm when observed in two sections). The pneumatizations of the anterior clinoid process (PACP), the pneumatizaton of the posterior nasal septum (PPNS) and the extensively pneumatized sphenoid sinuses (EPSS) observed, were taken into consideration, as well as the septations of the sphenoid sinus, especially the ones which extended into the optic canal. Pediatric patients, younger than 13 years, were excluded from the study since the normal development of the sphenoid sinus wasn't completed yet.

Statistics

Statistical analysis was performed by a specialized company using the statistical software package SPSS for Windows release 10.0. The Kolmogorov-Smirmov test was used, and a p-value less than 0.05 was considered to be statistically significant.

RESULTS

The classification defined by Delano, Fun and Zinreich (Delano et al., 1996) was used in evaluating the relationship between the sphenoid and the posterior ethmoid sinuses and 200 optic nerves of 100 patients (Table 1).

The number of cases with only the optic nerve type 1, which lies next to the lateral and superior walls of the sphenoid sinus, was 128 (64%) (Figure 1). The number of optic nerves type 2, making an indentation on the sphenoid sinus was found to be 44 (22%) (Figure 2). Type 3 optic nerves, traversing the sphenoid sinus were counted to be 14 (7%) (Figure 3). The number of the optic nerve variation type 4, which has the location adjacent to the sphenoid and the posterior ethmoid sinuses, was also 14 (7%) (Figure 4, Table 2).

The absence of continuity of the thin bony density over the optic nerve, which should be seen in proximity of the sphenoid

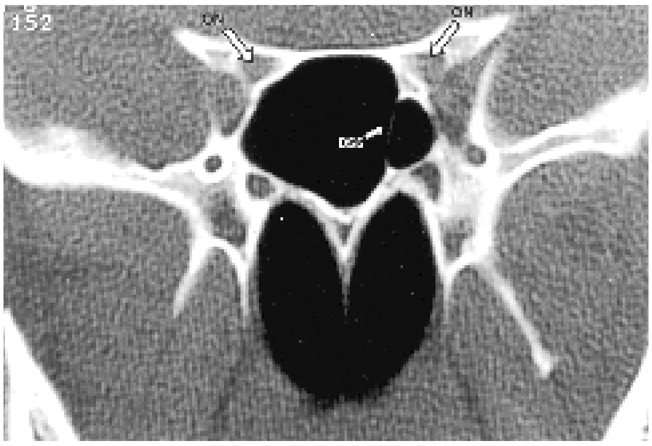

Figure 1. The view of an optic nerve (ON) with a type 1 localization and a potentially dangerous sphenoid septum (DSS) extending to the optic canal.

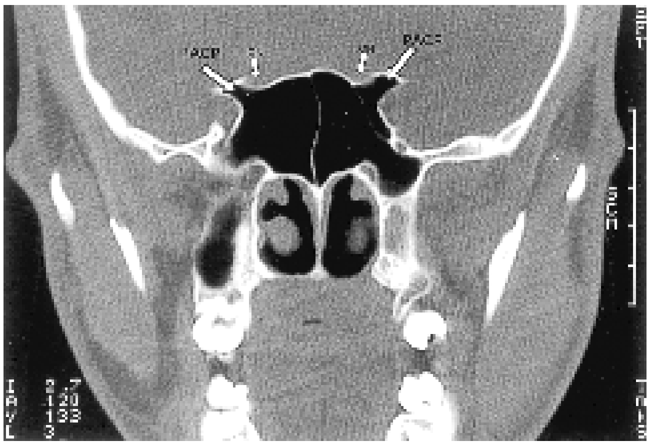

Figure 2. The view of an optic nerve (ON) with a type 2 localization and bilateral pneumatization of the anterior clinoid process (PACP).

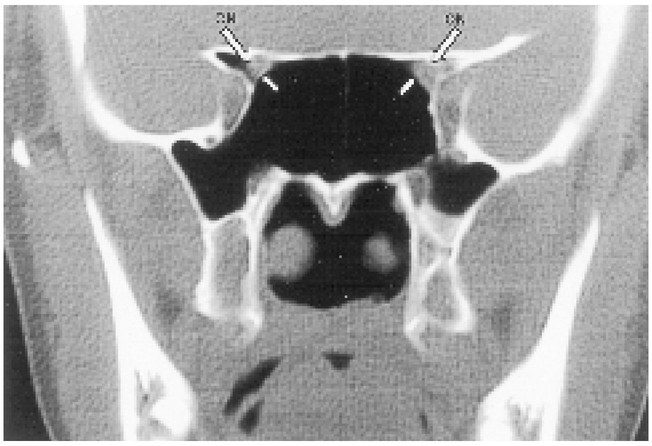

Figure 3. The view of an optic nerve (ON) with a type 3 localization in an extensively pneumatized sphenoid sinus and a dehiscence of the bony canal of the optic nerve (small arrow).

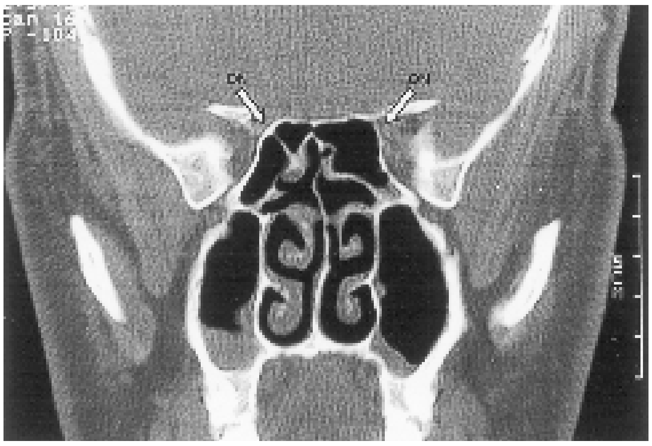

Figure 4. The view of a type 4 optic nerve (ON) continuing into the posterior ethmoid sinus sections.

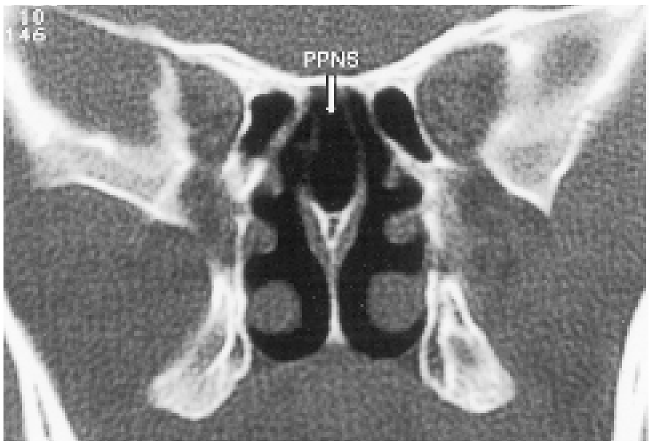

Figure 5. The view of a pneumatization of the posterior nasal septum (PPNS).

Table 1. Description and frequency of the optic nerve types (Delano, Fun and Zinreich classification).

Type	Description
1	Adjacent to sphenoid sinus
2	Indentation on sphenoid sinus
3	Optic nerve traversing sphenoid sinus
4	Adjacent to sphenoid and posterior ethmoid sinuses

Table 2. Frequency of the optic nerve types and the bony dehiscence of the optic nerve.

Type	Right	Left	Total	Bony Dehiscence of Optic Nerves	
				(+)	(-)
1	63	65	128 (64%)	4 (3%)	124 (97%)
2	24	20	44 (22%)	17 (39%)	27 (61%)
3	6	8	14 (7%)	6 (43%)	8 (57%)
4	7	7	14 (7%)	0 (0%)	14 (100%)
Total	100	100	200 (%100)	27 (13.5%)	173 (86.5%)

[The frequency of bony dehiscence in groups type 2 and 3 is statistically higher ($p<0.0001$)]

Table 3. Frequency of pneumatization of the anterior clinoid process.

Type	PACP		Total
	(+)	(-)	
1	3 (2%)	125 (98%)	128 (100%)
2	7 (16%)	37 (84%)	44 (100%)
3	12 (86%)	2 (14%)	14 (100%)
4	0 (0%)	14 (100%)	14 (100%)
Total	22 (11%)	178 (89%)	200 (100%)

[The group in which the frequency of PACP is the highest statistically, is the group type III. ($p<0.0001$)]

Table 4. Distribution of the types of optic nerve in cases with PPNS and frequency of the bony dehiscence of the optic nerve and PACP.

Type	PPNS	Bony Dehiscence of Optic Nerves	PACP
1	19/30 (63%)	2/30 (7%)	0/30 (0%)
2	7/30 (23%)	3/30 (10%)	4/30 (13%)
3	2/30 (7%)	0/30 (0%)	2/30 (7%)
4	2/30 (7%)	0/30 (0%)	0/30 (0%)
Total	30/30 (100%)	5/30 (17%)	6/30 (20%)

[There is no statistically significant relationship between the types and PPNS ($p>0.005$)]

and posterior ethmoid sinuses, was evaluated as a bony dehiscence (Figure 3). This dehiscence was observed in 27 of the 200 cases (13.5%). The length of the dehiscence was interpreted to be 3 mm in each of these cases. The proportion of the bony dehiscence was detected for each group within itself as 4/128 (3%) for type 1, 17/44 (39%) for type 2, and 6/14 (43%) for type 3. Types 2 and 3 were statistically similar ($p>0.05$). The bony dehiscence was statistically highly significant in type 2 and type 3 groups ($p<0.0001$) (Table 2).

PACP was seen in 22 of the 200 optic nerves examined (Figure 2). When distributed according to the types, type 3 had the highest number of PACP with a number of 12 (86%). This number was 7 (16%) in type 2 and 3 (2%) in type 1. Statistically the number of PACP in type 3 was detected to be very significant when compared to the others ($p<0.0001$) (Table 3). In 7 of the cases, PACP was observed to be bilateral. In these 7 bilateral cases, 4 had bilateral type 3, 1 had bilateral type 2, and one side of the other 2 had type 2 and the other side type 3. In 5 cases (23%) with PACP, optic nerve bony dehiscence was detected.

PPNS was detected in 15 of the 100 cases (15%) examined (Figure 5). The evaluation of 30 optic nerves of these 15 cases revealed 19 (63%) type 1, 7 (23%) type 2, 2 (7%) type 3 and 2 (7%) type 4 configurations. No statistically significant relation was found to be present between the types and the PPNS ($p>0.05$). Furthermore, 5 (7%) bony dehiscence and 6 (20%) PACP were detected in these 30 investigated optic nerves in cases with PPNS (Table 4).

EPSS was detected in 4 of the total 100 investigated cases (Figure 3). Five of the investigated 8 optic nerves of these 4 cases were found to be type 3 (62.5%), 2 of them were type 1 (25%) and 1 of them (12.5%) type 2. Furthermore bony dehiscence was observed in 2 (25%) of the optic nerves.

A single sphenoid septum (potentially dangerous sphenoid septum) extending either to the right or left optic nerve was detected in 21 of the 100 investigated cases (Figure 1). Also in 5 (5%) of the sphenoid sinuses, multiple septations were observed.

DISCUSSION

The optic nerve runs along an arcuate course medially toward the optic chiasm, which then can be seen bulging into the lumen of the sphenoid sinus. The length of the canal is 4-12 mm. The optic nerve is usually protected by the solid bone of the greater wing of the sphenoid bone without visible surrounding fat at the optic canal (Bansberg et al., 1987; Stammberger, 1991; Delano et al., 1996; Basak et al., 1998).

The sphenoid and the posterior ethmoid sinuses are surrounded by more vital structures than any other sinus. With the widespread acceptance and expanding role of endoscopic sinus surgery, a proper understanding of the anatomy of the sphenoid and the posterior ethmoid sinuses is achieved. One of the serious complications of intranasal sinus surgery is damage to the optic nerve. Protrusion of the optic canal into the sphenoid and the posterior ethmoid sinuses is a major risk factor. The enormous variability of the anatomy of the sphenoid and the posterior ethmodal sinuses is well documented (Hudgins, 1993). Accurate evaluation of these structures is possible with a computed tomography (CT). A CT can clearly show the relationship between the optic nerve and the paranasal sinuses.

The relationship between the optic nerves and the paranasal sinuses was first defined in 1908 by a researcher named Onodi. Onodi stated the frequent intimate relation of the optic nerve with the last ethmoid air cell in his cadaveric study. The term Onodi cell was subsequently coined in reference to the most posterior ethmoidal air cell, implying that this cell directly abuts the optic nerve. Onodi observed that the optic canal wall might be extremely thin and occasionally dehiscent (Stammberger, 1991).

Teatini et al. (1987), who studied 62 patients with sinus diseases and 6 normal subjects, found a 70.7% of intrasphenoid dehiscence, while Bansberg et al. (1987), who studied 80 healthy subjects found an incidence of 50%, including a 23% with an exposure of more than 10% of the circumference of the nerve. Dessi et al. (1994) on the other hand, found the proportion of protrusion to the sphenoid quite low; that is, protrusion of the optic nerve into the posterior ethmoid sinuses was never found, but bulging into the sphenoid sinus was seen in 8%. In all these cases, an extremely thin bony shell surrounded the nerve and pneumatization of the ipsilateral anterior clinoid process was visible.

When looked up in the literature, it is found out that the most systematic study with the widest spectrum has been published by Delano et al. (1996). They classified the relationship between the optic nerve and the paranasal sinuses into four discrete categories. Type 1 includes those optic nerves coursing immediately adjacent to the sphenoid sinus without an indentation on the wall or contact with the posterior ethmoid sinuses. This type is the most common, occurring in 76% of the patients. Type 2 nerves course adjacent to the sphenoid sinus, causing an indentation on the sinus wall, without a contact with the posterior ethmoid sinuses. Type 3 nerves course through the sphenoid sinus with at least 50% is surrounded by air. Type 4 nerves course immediately adjacent to the sphenoid and the posterior ethmoid sinuses. The optic nerve is exposed without a bony margin in all cases where it travels through the sphenoid sinus (type 3) and in 82% of cases where the nerve is impressed on the sphenoid sinus wall (type 2). Delano et al. also found that 85% of the optic nerves, associated with a pneumatized anterior clinoid process were of type 2 or 3 configurations, and 77% were dehiscent.

Because of its understandability and practicality, we used the classification of Delano, Fun and Zinreich (1996). According to this classification, type 1 with a proportion of 64% is observed to be the most often localized optic nerve. Type 2 is detected 22%, types 3 and 4 are detected in 7% of the cases. While bony dehiscence was detected in 13.5% of the total cases, it was observed in 39% of the type 2 and 43% of the type 3. The observation of a high proportion of the bony dehiscence in types 2 and 3 was accepted to be statistically significant. Moreover, PACP was found out to constitute a proportion of 11% in our study. The high proportion of 86% of the PACP in type 3 configurations was found to be statistically significant. The optic nerve dehiscence was seen with a proportion of 23% in cases of PACP. Therefore the presence of PACP is an important indicator of the optic nerve vulnerability during FESS because of the frequent associations with bony dehiscence, as well as type 2 and 3 configurations.

PPNS was another anatomic variation seen in the screened patients. It was detected in 15% of the 100 cases. When optic nerves were evaluated in these cases, mostly type 1 configuration with a proportion of 63% was observed. No statistically significant relationship between the types and the PPNS could be found.

The detection of the type 3 configuration in 62.5% and the observation of bony dehiscence in 25% of the cases with EPSS show that there seems to be a high possibility of facing the optic nerve in the sinus while performing a surgery in these patients.

As a conclusion, no significant optic nerve variations were met in patients with PPNS in our study made up of examination of 200 optic nerves. Nevertheless while performing surgery, it is important to bear in mind that there may be significant optic nerve variations with PACP and EPSS.

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