Frontal Sinus Anatomical Variations with Potential Consequences for the Orbit. Study on Cadavers

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Summary

Anatomical variations of the frontal sinuses that may play a role in the correlation between frontal sinusitis and orbital complications are described. There were used 18 cadavers during routine educational cadaver dissections, one month after theirs withdrawal from the formol basin. The dissections of the cranial cavity and the orbits were performed so as to reveal the frontal sinuses. An unusual bilateral posterior extension of the frontal sinus mucosa was found in two of the cadavers. The projection of the mucosa was covering half of the orbital roof in a 60 year old male and one third of the orbital roof in a 59 year old male. Among the other cadavers that presented normal variations of the frontal sinuses, there was also a case of a 57 year old female with a complete aplasia of the frontal sinuses. Such anatomical variations with unusual extension of the frontal sinuses above orbital roof may support the correlation between frontal sinusitis and the possible complications from the orbit and these cases may be considered as ‘high risk’ cases for orbital complications during a frontal sinusitis.

Key words: Anatomy. Frontal. Sinusitis. Orbit. Cellulitis.

INTRODUCTION

The nasal cavity and its associated sinuses form a complex interconnected system. The mucosa of the posterior part of the nose is continuous with the mucosa of the upper respiratory passages and extends to the paranasal sinuses.

Among these sinuses, the frontal, due to its “strategic” position and close anatomic relationship to the orbit, the orbital nerves and the base of the anterior cranial fossa, plays a major role in the pathology of these anatomic regions not only due to its anatomical relations but also due to the rich anastomotic plexuses of veins, tributaries of the facial vein, and lymphatic vessels.

The frontal sinuses undergo most of their development upon opening the 0.5 mm thick orbital plate of the frontal bone. They are sited posterior to the supciliary arches between the tables of the frontal bone. They extend upwards and backwards next to the medial part of the roof of the orbit. Each frontal sinus may be of a different size (1-4).

Anatomical variations of their size and site may reflect on the pathology of the anatomically related areas by direct extensions, or through the extensive plexuses of the related veins and lymphatic vessels.

METHODS

Three interesting malformations of the frontal sinuses were found in a series of routine educational cadaver dissections. The cadavers were dissected one month after their withdrawal from the formol basin. The dissections of the cranial cavity and the orbits were performed so as to reveal the frontal sinuses. In the great majority of the studied cadavers the structure of the frontal sinuses revealed only the usually described anatomical characteristics. In the three described cases however, the malformations found were quite interesting and are presented.

RESULTS

Case one: Cadaver of a 60 year old male

Upon opening the 0.5 mm thick orbital plate of the frontal bone, a bilateral posterior extension of the frontal sinus mucosa was found extending posterior to the half of the distance between the optic foramen and the frontal bone with an approximate length of 2.5 cm. Medially the frontal mucosa extended up to the olfactory sulcus and laterally it...
reached the boundary of the orbital part of the frontal bone and the lateral wall of the orbit. This projection of the mucosa, covering half of the orbital roof, was cushion-like having a 4 mm thickness at its center and 2 mm at its border. Under this projection of the mucosa of the frontal sinus there was a second bone plate, 0.5 mm in thickness, covering as a second ceiling the orbit. After the removal of this “second ceiling” the orbital fascia was exposed (fig. 1-3).

**Case two: Cadaver of a 59 year old male**

Upon opening the 0.5 mm thick orbital part of the frontal bone, a 2 cm long bilateral, posterior projection of the mucosa of the frontal sinus was revealed. Posteriorly it covered one third of the distance between the optic foramen and the frontal bone, medially it reached the olfactory sulcus, and laterally the boundary of the orbital part of the frontal bone and the lateral wall of the orbit. This projection of the mucosa of the frontal sinus covered about one third of the roof of the orbit. At its center it was approximately 3 mm thick and at its border 1.5 mm. Under this mucosal projection there was a thin bone plate (0.1 mm thick) covering the orbital fascia, which was revealed after its removal (fig. 4-6).

**Case three: Cadaver of a 57 year old female**

There was a complete aplasia of the frontal sinuses. Upon sectioning serially the frontal bone a brownish site was revealed within the bone in the area were the sinuses should be sited (fig. 7).

**Discussion**

Frontal sinus anatomy may play an important role in the causes of sinusitis and possibly in the causes of orbital cellulitis. Clairmont and Per-Lee have expressed the belief that the thin bone separating the frontal sinus from the anterior cranial fossa and orbit, and the interrelated venous drainage system in these areas, form the anatomic basis for the serious orbital and intracranial complications of acute frontal sinusitis (5). Schramm and colleagues noted a 74% incidence of clinical and radiographic evidence of sinusitis in patients with orbital cellulitis, fact that may explain the higher incidence of orbital cellulitis in winter than in summer (6). Similarly, Bergin and Wright reviewed 49 cases of orbital cellulitis and found sinus disease radiographically in 61% (7).

The clinical significance of the inflammations of the frontal and paranasal cavities in general and their correlation with the orbit is well known. Cases of acute orbital inflammation with preseptal cellulitis, subperiosteal abscess or orbital cellulitis in the presence of nasosinusitis are often found in the bibliography. Moloney and colleagues announced 34 such cases (8). Bertran and Martinez-Vidal summarized 40 cases of orbital complications of sinusitis: 34 cellulitis, 4 exophthalmos and 2 neuritis of the optic nerve (9). Pender described even a Pott’s puffy tumor as a complication of frontal sinusitis (10). Magnano and colleagues described 8 patients with orbital complications of complicated frontal and ethmoid-maxillary sinusitis (11). Altman and colleagues included complications from the orbit in their presentation of 7 cases with frontal sinusitis in adolescents (12).

Weiss and colleagues reported that orbital cellulitis was more frequent in children older than 5 years and frequently associated with sinusitis (90%) (13). Slavin and Glaser announced three cases of acute irreversible loss of vision in...
patients with orbital cellulitis and sphenoethmoiditis. They presumed the irreversible blindness in these cases as a consequence of a combination of intracanalicular edema and vasculitis causing optic nerve infarction (14). Swift and Charlton reviewed 68 children with orbital sepsis and 30 of them had associated acute sinusitis (15). Martin-Hirsch and colleagues believe that orbital cellulitis is an emergency and although isolated eyelid erythema and swelling usually indicate primary infection anterior to the orbital septum, they may also be the first signs of an underlying frontal or ethmoidal sinusitis (16). Piazza and colleagues described 15 young patients with orbital cellulitis secondary to fronto-ethmoidal sinusitis (10 cases), to maxillary sinusitis (4 cases) and to craniofacial trauma (1 case) (17). Durant and colleagues though that the most common complication of paranasal sinusitis is orbital cellulitis followed collectively by all the intracranial complications (18). Luchikhin and colleagues presented 78 patients with pre- and postseptal orbital rhinosinusogenic complications (19).

Perkin and Geifford believe that there is also an association between optic neuritis and nasosinusitis and this consideration is very old (20). Examples of purulent sinusi-tis, from both operative and post-mortem examination, with perforation of adjacent bone and secondary optic nerve or chiasmatic involvement were used to support this association. However, the great number of negative investigations of the paranasal sinuses in patients with optic neuritis led to a quest of other likely sources as teeth and tonsils. The results were negative and in this way the association between nasosinusitis and optic neuritis remains a big question with sporadic case reports in the recent bibliography. Rothstein and colleagues reported five cases that presented pathophysiological correlation between nasosinusitis and optic neuritis (21). Compressive optic neuropathy secondary to mucoceles and/or pyoceles, direct extensions of sinus infection to the optic nerve from suppurative paranasal sinusitis and one case from osteomyelitis of the ethmoid and sphenoid sinuses were included.

Duvoisin and Schnyder reviewed CT studies of 198 consecutive patients and from the results it seems highly probable that abnormal frontonasal duct may cause frontal sinusitis (22). However, though Earwaker found variations that could produce obstruction of the drainage pathways, an equal prevalence of patients with and without sinus disease was found in the presence of the same variant combination (23).
In our cases appears a great extend of contiguity between a big frontal sinus and a great part of the roof of the orbit and that makes these cases interesting for clinical associations. The presented anatomical findings obviously coincide with the CT scan findings of one of our cases as shown in fig. 8. It should be considered as very important to correlate such cases with the possible anatomical peculiarities and apparently the value of the pictures of the presented cases is much higher than a simple description. The association of frontal sinusitis and orbital cellulitis is theoretically strongly amplified by the presence of such anatomical variations.

CONCLUSION

The correlation between frontal sinusitis and the possible complications from the orbit is very old. Such anatomical variations with unusual extension of the frontal sinuses above orbital roof, which may provoke the extension of an inflammation from the sinus to the orbit, may support this correlation and these cases may be considered as ‘high risk’ cases for orbital complications during a frontal sinusitis.

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REFERENCES