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ORIGINAL ARTICLE FACIAL SURGERY

Enlargement of Frontal Sinus, Case Report

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Abstract
Introduction Frontal sinus enlargement has been classified into hypersinus, pneumosinus dilatans and pneumocele.
Case Report A young male presented with aesthetic concerns regarding his forehead swelling. The patient had no functional disturbances. Radiographic assessment proved expansion of the frontal sinus with extreme thinning of the frontal bone.
Discussion The causes of frontal sinus expansion have been listed along with a proposed management plan for each type. If blockage is suspected, functional endoscopic sinus surgery can alleviate the blockage. Open surgery is indicated when the element presents as an aesthetic concern. Obliteration of the sinus is indicated with NF obstruction. And reshaping of the anterior table is the mainstay to correct the enlargement.
Conclusion Frontal sinus enlargement regardless of the cause can be tackled using well known principles. We believe that every plastic surgeon should have a basic understanding of frontal sinus enlargement and its management.
Level of Evidence V This journal requires that authors assign a level of evidence to each article. For a full description of these evidence-based medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

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Introduction

Usually absent at birth, the frontal sinuses are usually evident radiographically at age 4. They gradually expand during the adolescent years and tend to stop at age 16. Unilateral or bilateral agenesis is not uncommon and usually seen in up to 5% of the population [1].

Frontal sinuses tend to have complex and variable anatomy. They are usually found to be asymmetrically paired and separated by a bony septum within the confines of the anterior and posterior tables of the frontal bone. Inferiorly, each sinus narrows down to form the frontal ostium which is the beginning of an area known as the frontal sinus drainage pathway (FSDP) [2]. The FSDP tends to have two compartments. The superior compartment lies in the anterior-inferior frontal bone and the anterior-superior ethmoid bone, while the inferior compartment is represented by the ethmoid infundibulum or the middle meatus [3].

The volume of the frontal sinus is quite variable which explains why it is a powerful tool in forensic medicine [4]. The volume and the pneumatization are quite unique to each individual. In 1920, Schaeffer described the classical dimensions of the adult frontal sinus. The average is 27.9 mm in height, 23.25 mm in width and 19.25 mm in depth [5]. Gray, in 1985, gave somewhat similar numbers with 3, 2.5 and 2.5 cm for height, width and depth, respectively [6]. Urken analyzed the radiographs of 100 asymptomatic patients and determined the upper limits of normal beyond which the sinus may be called abnormally enlarged [7].

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The literature on the enlarged frontal sinus is full of confusing labels. Pneumocele was probably the first term used by Meyes in 1989 [8]. McArthur used to call them gaseous tumors [9]. Later Benjamin in 1918 used the term pneumosinus dilatans [10]. Other terms like sinus ectasia, hyperpneumatization, pneumocele add to the confusion [11]. Urken also classified the enlargement of the frontal sinus into hypersinus, pneumosinus dilatans and pneumocele based on clinical symptoms and CT findings with attention to bone thickness [12]. In this article, we present a case of frontal sinus enlargement and its management.

Case Report

We present a 26-year-old gentleman who had a 10-year battle with chronic sinusitis. His complaint was forehead swelling that has been present for 7 years. The condition seems to have improved with a functional endoscopic sinus surgery (FESS). The patient denied pressure and visual symptoms and was only concerned about the aesthetic appearance (Fig. 1).

A computed tomography showed hyperinflation of the frontal sinus beyond its normal boundaries. Encroachment of the orbital roofs was evident along with mucosal thickening. Areas in the posterior table showed remarkable thinning of the bone (Fig. 2).

The decision for open reshaping of the anterior table was made. Through a bicoronal incision of the scalp, an anteriorly based peri-cranial flap was raised (Fig. 3). The anterior table was removed and was found to be thin and brittle from the long-standing pressure. The frontal ducts were freely draining the sinus, and consequently, the decision to preserve the sinus was undertaken. A titanium mesh was used for reconstruction of the anterior table after the chips of the anterior table were secured to the mesh with screws. Bone paste was used for smoothening the outer contour (Fig. 4).

Discussion

Causes for frontal sinus enlargement are concise despite the confusing terminology found in the literature. Despite the fact that Urken classified frontal sinus expansion back in 1987, confusion still prevails given the interchangeable use of his terms along with many other terms in the literature.

We believe that much like it was first published, the expansion of the frontal sinus can be attributed to three causes based on the patient presenting symptoms and further confirmed with radiographic scans into either a hypersinus, a pneumosinus dilatans or a pneumocele.

The simplest of them all is the hypersinus, which is short for a hyperpneumatized sinus. In this condition, the pneumatization goes beyond the upper limits of normal while respecting the confines of the bone in which it is contained. It tends to be found incidentally in an otherwise asymptomatic patient. Special attention to walls and their thickness on CT scans essentially rules out erosion and thinness [12]. Obviously, this condition requires no further management.

On the other hand, however, pneumosinus dilatans extends beyond the boundaries of the frontal bone. Thickness is normal, and walls remain intact in contrast to the hypersinus. The term was coined by Benjamin to describe enlargement of the paranasal sinuses [10]. The frontal sinuses are the most commonly affected giving symptoms such as headache, local pain, frontal bossing, ocular alterations and anosmia [13, 14]. Other paranasal sinuses might be affected as well. Sphenoid, maxillary and ethmoid sinuses follow the frontal sinuses in frequency [15–17].

The ideology is still unclear. Various mechanisms have been postulated nonetheless. A spontaneously draining mucocele and a resolving infection with gas forming microorganisms have been proposed [18, 19]. The male preference led others to believe that growth hormones and sex hormones may have something to do with the sinus enlargement [20]. A one-way valve caused by redundant

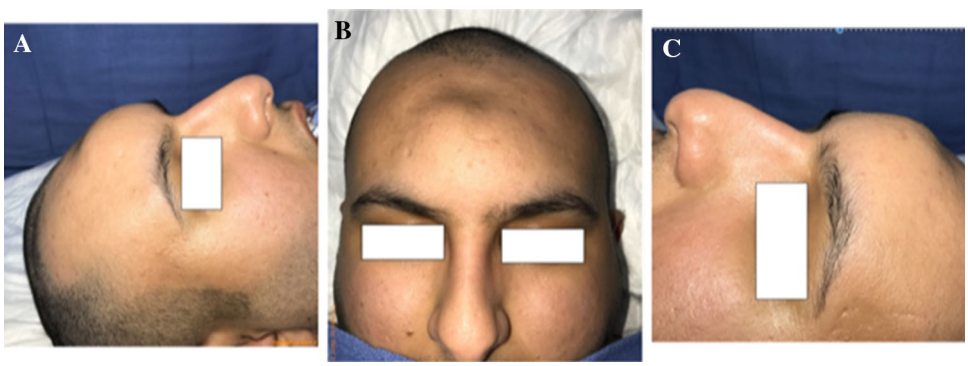

Fig. 1 **a** through **c** preoperative pictures showing the forehead swelling

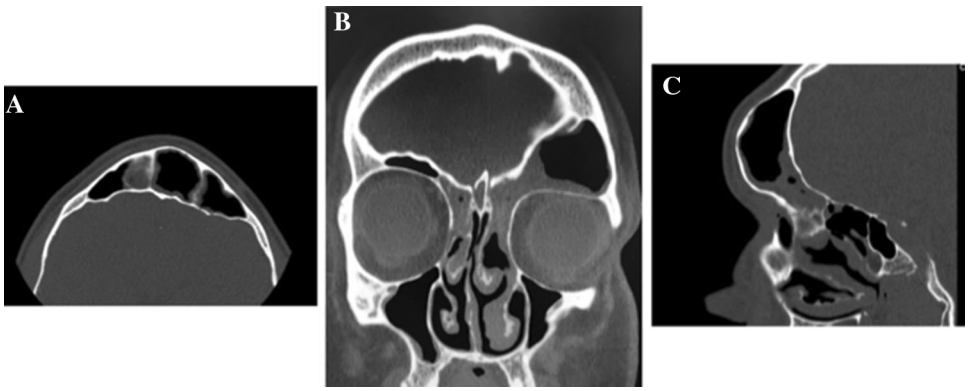

Fig. 2 CT scans of the patient. **a** Axial cuts showing excessive pneumatization of the frontal sinus, with thinning in the posterior table. **b** Coronal cuts showing extension of the sinus beyond the normal boundaries. **c** Sagittal cuts showing extensive pneumatization and thinning of the bone in the posterior table

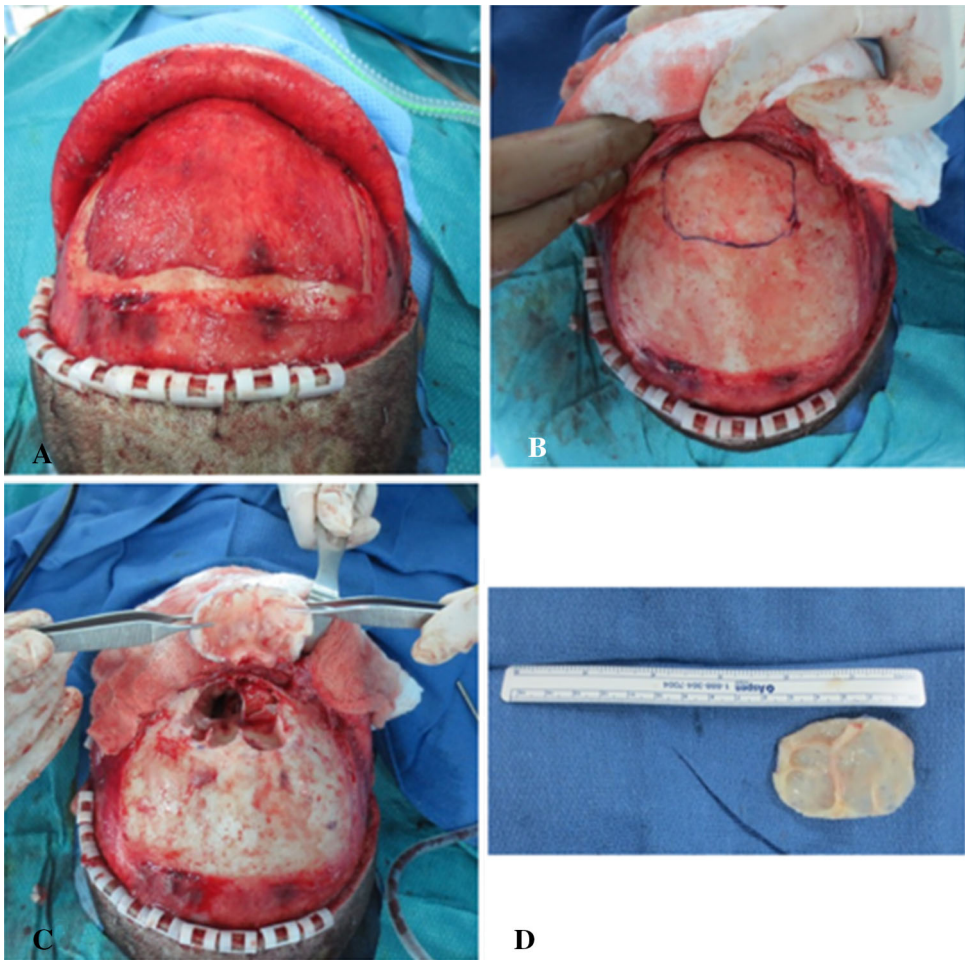

Fig. 3 Intra-operative pictures. **a** Bicoronal incision, anteriorly based peri-cranial flap raised. **b** Deformed frontal bone marked for excision. **c** Excised anterior table. **d** Excised anterior table, showing brittle copper-beaten appearance

inflamed mucosa tends to be the most acceptable theory [21].

Given the current understatement of the disease, PD can be classified into primary PD and secondary PD. Secondary PD tends to be associated with brain tumors, fibrous dysplasia, faulty CSF shunting, cerebral hemi-atrophy, Von Recklinghausen's disease and Melnick-Needles Syndrome, hemangiomas and vascular malformations among many others [13, 22–28]. Trauma and previous surgical interventions have also been reported in the literature [29].

Age at presentation was quite variable. Five years and 76 years were the youngest and oldest ages reported in the literature, respectively. Patients in their third or fourth decade seem to be the most commonly affected [15, 20, 30].

Unlike the pathogenesis of PD, the treatment for this condition is clear. Obstructive symptoms without contour

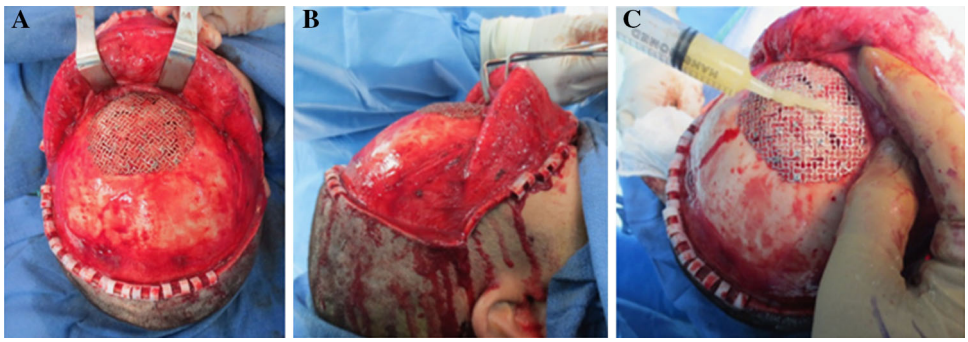

Fig. 4 Intra-operative picture. **a**, **b** Anterior table reconstructed with titanium mesh. **c** Bone paste used for contouring after securing the mesh

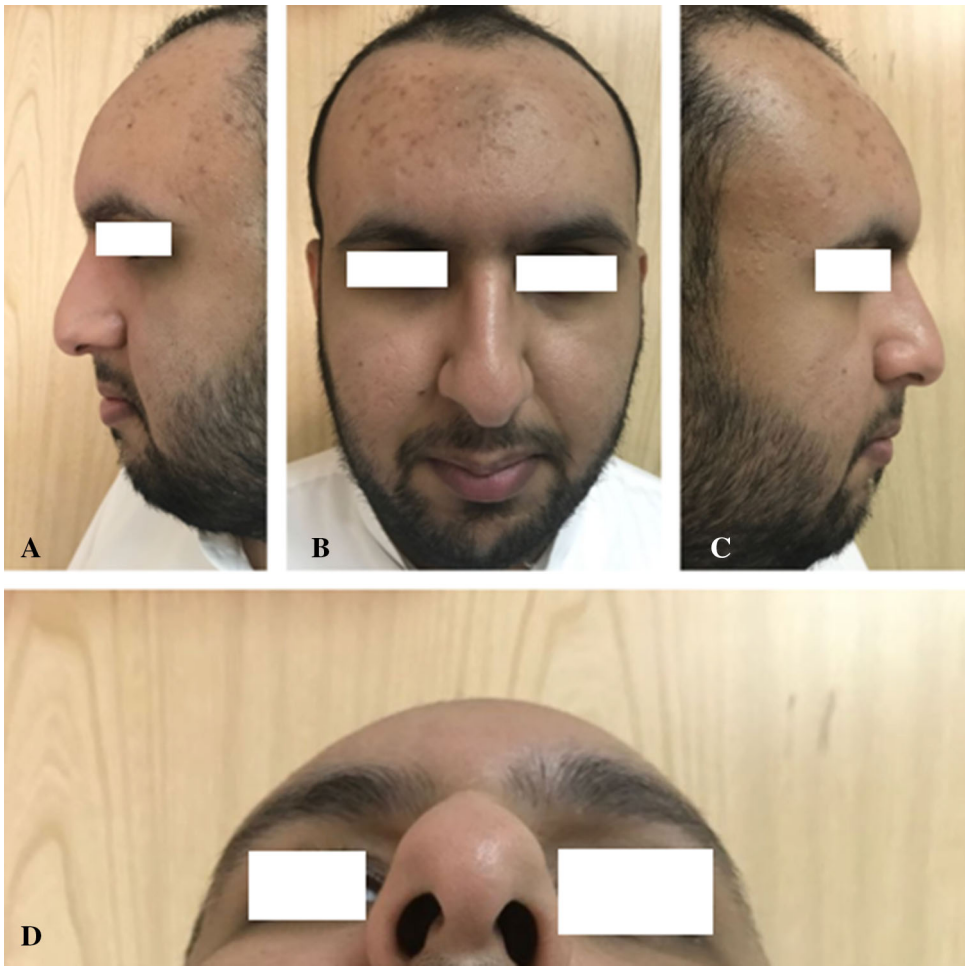

Fig. 5 Post-operative picture. **a** through **d** showing resolution of the forehead swelling

deformities might be amenable to endoscopic sinus surgeries, FESS [31]. Open surgeries are the gold standard when cosmetic deformities are the presenting complaints. Various techniques have been published. Some may advocate sinus obliteration [11, 12], while others advocate reshaping the anterior table while preserving the sinus [20, 30, 32–36].

At the end of the spectrum the pneumocele is the entity in which the frontal bone expansion causes the walls to thin or even lose their integrity and encroach upon adjacent structures producing pressure symptoms [12]. An obstructing valve that allows secretions to drain yet is slow in achieving pressure equilibrium is the most accepted theory behind a pneumocele. This air trapping theory is given credence by patient's complaints of exacerbations of the pressure symptoms upon airplane ascent or even during sneezing.

Causes include trauma, surgery, tumor and infection. A pneumocele is managed in the same way a pneumosinus dilatans is usually managed.

In our case, the patient presented with aesthetic concerns regarding his forehead swelling while denying pressure symptoms. Radiographic assessment showed thinning in the walls of the frontal sinus, features that are consistent with a pneumocele. The decision for open reshaping was undertaken along with frontal sinus preservation.

Upon follow-up visits, no recurrence was evident and satisfactory results were attained (Fig. 5).

Conclusion

Every plastic surgeon should have a basic understanding of the causes for frontal sinus enlargement. The classification of Urken into hypersinus, pneumosinus dilatans and pneumocele is still valid, and once accurate diagnosis is made, treatment follows the frontal sinus reconstruction algorithm.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest to disclose.

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