

Common Fibro-osseous Lesions of the Paranasal Sinuses

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Within the broad spectrum of disease that can affect the paranasal sinuses is a class of benign bony abnormalities known collectively as fibro-osseous lesions. Fibrous dysplasia, ossifying fibroma, and osteoma are three distinct entities that lie along a continuum from the least to the most bony content. They have similar appearance and makeup; however, their clinical implications vary. This article focuses primarily on sinonasal osteomas, with less emphasis on fibrous dysplasia and ossifying fibroma.

History

Through the years, theories of the origin of bony lesions in the sinonasal and intracranial areas have evolved from that of vestigial horn-forming organs to petrified brain to bony tumors. Summers and colleagues [1] outline the history of sinonasal osteomas and credit Viega with the first documentation of a sinus osteoma, which Viega successfully removed in 1506. Later, Bartholinus and Du Verny documented other bony lesions in the frontal region, but conjectured that they were petrified brain. In 1733, Vallisnieri described a sinus osteoma that protruded into the brain, but asserted that it had a bony rather than a neural origin.

Epidemiology

Osteoma is the most common tumor of the paranasal sinuses. Its incidence is between 0.014% and 0.43% [2–8]. In 1999 Vowles and Bleach

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reviewed 3510 sinus radiographs and found an incidence of 0.43% [9]. Mahabir and colleagues [10] report the number seen on plain film as 0.25%. The true incidence may be higher, as the incidence on computed tomography of the head or sinuses has been reported as high as 3% [5,6].

There is a male predominance in most series [1, 5–8], with a male/female ratio that ranges from 1.5:1 to 3.1:1. Naraghi and colleagues [5] speculate that this is because men have larger sinuses and are more prone to facial trauma, one of the proposed etiologic theories. Age at diagnosis varies, but is predominantly the second and third decade, although patients can be diagnosed later in life [6]. There is no mention of racial predilection in the literature.

Etiology

There are three accepted theories of the etiology of paranasal sinus osteoma: developmental, traumatic, and infectious. No single theory adequately explains all osteomas.

Developmental theory

In the mid-nineteenth century, scientists formalized the concept that adult tissues contain embryonic remnants that generally lie dormant, but can activate to become a neoplasm [11]. The ethmoid bone is a result of endochondral bone formation, whereas the frontal bone is ossified by the membranous pathway. In the developmental theory, the apposition of membranous and endochondral tissues traps some of these embryonic cells, eventually leading to unchecked osseous proliferation [4]. This could explain lesions that develop near the frontoethmoidal suture lines, but does not account for osteomas that arise elsewhere. Naraghi and Kashfi [5] suggest the tumors could arise from rests of cartilage or osseous stem cells present in bone other than at suture lines, but little in the known histopathology points firmly in that direction.

Traumatic theory

The traumatic theory and the infectious theory are very similar. Both rely on an inflammatory process as the inciting force for bony tumor formation. There is moderate evidence for bony trauma as an inciting event. Moretti and colleagues [4] report that up to 20% of sinus osteomas follow some sort of trauma and present the case of an osteoma that developed in a maxillary sinus 9 years after a Caldwell-Luc procedure. Because the primary surgery was not performed by his group, it is unknown whether the lesion went undiagnosed during the original procedure. Sayan and colleagues [7] note that osteomas arising on the mandible have a predilection for places where muscles insert on the bone. In their view, minor trauma could incite an inflammatory process under the periosteum, which could persist as a result of

the constant traction applied by the musculature. Several investigators feel that the increased incidence of trauma in males is responsible for the male predilection [5,7]. However, the traumatic theory fails to explain adequately lesions in older patients or those without a history of trauma.

Infectious theory

The infectious theory suggests that osteitis resulting from chronic infection is to blame. Data from Rawlins [12] from 1938 show a 28% incidence of infection coinciding with sinonasal osteoma. It is difficult to determine if the osteoma or the infection is the primary (or secondary) process. Indeed, tumor and infection frequently coexist at the time of diagnosis. In the senior author's clinical experience, an osteoma has never arisen in a patient with long-standing chronic rhinosinusitis. Furthermore, the type of bone in an osteoma (eburnated or spongy) differs significantly from the bony hyperplasia one would expect to characterize reactive osteitis.

Further research, possibly at the genetic level, is needed to be certain of what initiates osteoma formation.

Pathology

The surface of an osteoma is smooth and lobulated [2,6]. It may be sessile or pedunculated [2]. It is covered by the sinus mucosa. Histologically, there are three types of osteomas. The eburnated type, also known as the ivory or compact type, is very dense and lacks haversian canals [1,6]. It may arise from membranous elements. The mature type, or osteoma spongiosum, is composed of softer bone more similar to cancellous bone. It is thought to arise from cartilaginous elements [5]. Both are dense lamellar bone with little medullary component, containing fibro-fatty tissue in the interstices (Fig. 1) [6,13]. The mixed type of osteoma contains elements of both the eburnated and mature forms.

Natural history

If untreated, osteomas will continue to grow slowly during the life of the patient, but they are always benign. There are no reported cases of malignant degeneration or metastasis. Recurrence after complete resection is extremely rare; only a few cases have been reported [2,7].

Location

The vast majority (95%) of sinonasal osteomas are found in the frontoethmoidal region (see Refs. [1,2,4,6–8, 14]). More than 80% are in the frontal bone, arising from the floor of the frontal sinus [1,14]. Schick and colleagues [8] report a series of 23 frontal osteomas. Twelve originate

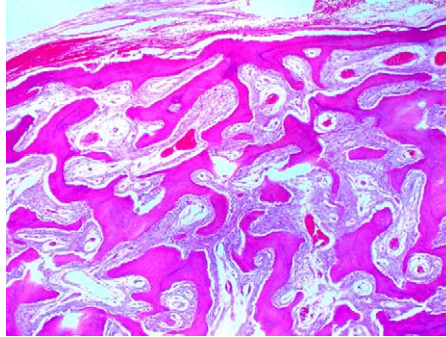


Fig. 1. Low-power photomicrograph of hematoxylin-eosin section of a paranasal sinus osteoma. (Original magnification – 10X).

from the posteroinferior wall of the frontal sinus, medial to the plane of the lamina papyracea. Eleven are lateral to this plane. This distinction is useful in determining the feasibility of endoscopic resection. Lateral tumors often require an external approach. The ethmoid sinuses account for 20% to 30% of sinus osteomas. The maxillary sinus is involved in less than 5% of cases, usually on the lateral wall of the sinus [4]. Sphenoid osteomas are distinctly rare [4,6]. Other reported sites of osteoma formation in the skull include the external auditory canal, the orbital bones, the temporal bone, the pterygoid plates, and the mandible, sphenoid and occipital bones [7].

Symptoms

Symptoms related directly to an osteoma generally arise from a “mass effect” as the lesion impinges on normal structures. As many as 60% of patients with frontal osteomas present with a chief complaint of headache (see Refs. [1,4,6,10,15,16]). The headache can be constant, episodic, mild, or severe. Other symptoms attributed to osteoma include diplopia, facial deformity, sinusitis symptoms, and dizziness. When an osteoma compromises ventilation and drainage from the associated sinus, acute or chronic rhinosinusitis may arise or a mucocele may develop over time [1,4,6]. Often, patients have been treated nonspecifically for “sinus” before subspecialty referral or radiographic evaluation.

Many patients diagnosed with an osteoma of the paranasal sinuses are asymptomatic. These lesions are discovered incidentally during radiographic evaluation for unrelated problems such as minor head trauma.

Radiology

Plain sinus radiographs are usually adequate for detecting osteomas, and between 0.25% and 1% of sinus films will demonstrate one [5,6,10].

However, computed tomography (CT) is more sensitive, with 3% of CT scans through the sinuses demonstrating an osteoma [5,6]. In either type of radiographic study, osteomas appear as very dense, homogeneous, well-circumscribed masses attached with an apparent range of broad to narrow pedicles to adjacent bone (Fig. 2). The surrounding bone is normal and does not have a lytic or moth-eaten appearance. Even for extensive osteomas, surrounding bone is thinned and moved by pressure rather than by direct invasion.

For patients with an osteoma where there is any question of extrasinus extension or intracranial involvement, MRI is recommended [1,14,17]. MRI is able to show dural involvement or transgression, and can distinguish mucocèles from neoplasms. Mucocèles vary in appearance with protein content, hydration, and viscosity. On T1 imaging with gadolinium, mucocèles usually have a thin peripheral linear enhancement with a low central signal [14]. Soft tissue neoplasms show more uniform enhancement, even with extensive central necrosis.

Complications from osteomas

Extrasinus complications can be divided into orbital and intracranial problems. Osteomas may expand slowly into the orbital vault, displacing the orbital contents. This may lead to diplopia, epiphora, facial distortion, and even blindness [1,2,6,8]. Removal of the osteoma usually restores normal vision. In rare instances of extreme expansion, the orbital vault requires reconstruction.

Intracranial complications occur when an osteoma penetrates the dura. These complications include mucocèles, meningitis, frontal abscess secondary to hematologic seeding across the bridging veins, cerebrospinal fluid (CSF) leak, or pneumatocele (see Refs. [1,3,8,10,13,17–20]). Overall,

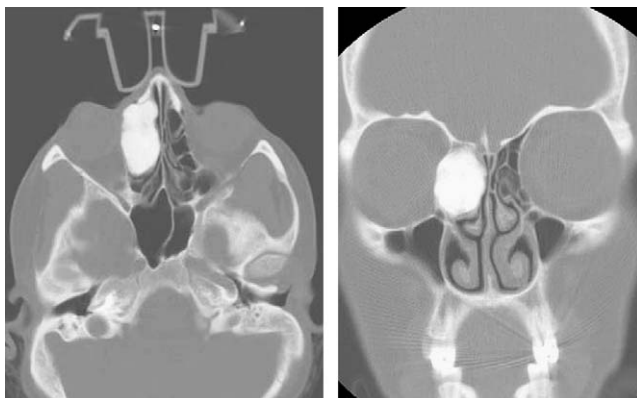


Fig. 2. Axial and coronal sinus CT images of an ethmoid osteoma.

mucoceles are present in 12% to 50% of osteoma cases [13]. However, there are less than 25 reported cases of intracranial mucoceles associated with osteomas [13,17]. It has been postulated that osteomas with mucoceles follow a more aggressive clinical course than those without mucoceles [17]. This may be because the mucocele expands at a faster rate than the typical osteoma, but Akay and colleagues [17] suggest that calcification of the mucocele can occur, leading to rapid expansion of the complex.

Meningitis and brain abscesses can result from direct intracranial osteoma or mucocele extension [1,17,18], but they can also be seeded from adjacent or nonadjacent sinuses [1,20]. Summers and colleagues [1] report a case of an osteoma contributing to maxillary sinusitis, which presumably seeded the veins in the “danger triangle” with subsequent cerebral abscess.

Two other possible problems are CSF leak and pneumatocele. Both of these can occur with a breach in the dura. They may occur independently or together. Seventy-five percent of pneumatoceles are secondary to surgery or trauma; only 13% are secondary to a tumor [3]. Johnson and Tan state that most of the 13% are accounted for by frontal and ethmoid osteomas. Air can become trapped in the cranial vault by two mechanisms. The first pathway is analogous to an inverted water bottle: air goes in when water goes out. Thus, after a rent is created in the dura, CSF flows out, creating a vacuum drawing air in. The second mechanism involves a valve and pressure. A rent in the dura is maintained in the closed position by the CSF pressure. When the extracranial pressure changes, such as during a sneeze, the flap is forced open and air is pushed into the intracranial space. Mahabir and colleagues [10] report a case where this was caused by air travel in a patient with an undiagnosed frontal osteoma, and Johnson and Tan [3] report a case of intraparenchymal tension pneumatocele with a frontal osteoma.

Management options

The primary dilemma in patients with osteoma is determining if surgical removal is indicated. Because the majority of osteomas are asymptomatic, observation with periodic re-evaluation is reasonable. Pain may or may not be related to an osteoma, especially if the locations of the pain and the osteoma are not congruent. Even when they do correspond, in some instances a thorough neurologic evaluation for pain may reveal another treatable cause, such as migraine. Since most osteomas are asymptomatic, many investigators advocate periodic imaging to follow growth and allow intervention before the development of complications [3]. Initially, a 3- to 6-month follow-up and an annual follow-up thereafter are recommended if no growth is detectable on CT and the patient remains asymptomatic. Patients should be educated about the potential for and nature of symptoms and should be instructed to seek evaluation if they change clinically. Acute

complications, especially intracranial problems, must be managed by the professional most capable of normalizing the situation. The osteoma can be managed at the same time or after the patient is more stable.

Indications for operation

Most authors agree that small, asymptomatic lesions do not need surgery (Figs. 3 and 4) [1,3,4,6,8]. There is also agreement that symptomatic tumors should be removed. Rapid growth, infection, compression of vital structures, severe pain, and facial deformity are some of the possible symptomatic indications (Fig. 5) [4]. For example, if a patient complains of headache in the vicinity of an osteoma, and other pathology leading to headache has been ruled out, excision is indicated [8]. For larger asymptomatic lesions, or those that are certain to cause problems in the future, several investigators have developed guidelines. Summers and colleagues [1] and Johnson and Tan [3] recommend that if the tumor occupies more than 50% of the frontal sinus it should be removed, regardless of symptoms. Rappaport and Attia [21] suggest that posterior-based frontal lesions should be considered for early excision due to the increased likelihood of intracranial complications. Lesions in the frontal recess and any osteoma in the ethmoid cavity are also indications for removal [8].

Surgical techniques

Multiple surgical approaches have been described for removal of this neoplasm from the paranasal sinus. In general, approaches can be categorized as transnasal endoscopic, external, or combined. Regardless of the technique chosen, two primary tenets should be followed. First and foremost is the complete removal of the osteoma, which is the most important

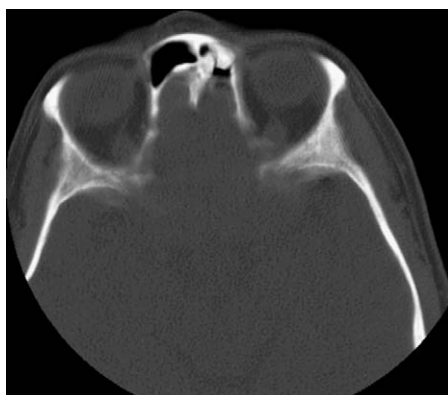


Fig. 3. Axial sinus CT image of a left frontal recess osteoma.



Fig. 4. Coronal sinus CT image of a left frontal recess osteoma.

step toward a cure. The second is minimizing trauma to the surrounding normal structures and to the sinonasal mucosa. This will result in more rapid healing and enable long-term endoscopic surveillance (Fig. 6).

The choice of a transnasal endoscopic, external, or combined approach is based on the size and location of the tumor. The authors agree that almost all ethmoid tumors are amenable to endoscopic removal (Figs. 7 and 8) [4,12]. To determine if the endoscopic approach is feasible for frontal sinus



Fig. 5. Coronal sinus CT of a large frontal osteoma with obstructive sinusitis and mucocele formation.



Fig. 6. Coronal sinus CT of a left frontal recess reactive bony hyperplasia after endoscopic drill out to remove osteoma with resultant frontal sinusitis.

lesions, Schick and colleagues [8] recommend that the anteroposterior diameter of the frontal sinus drainage pathway be measured to ensure that it is large enough for instrumentation. They recommend an appropriate ethmoidectomy and usually a Draf II or III procedure. Furthermore, they feel that lesions that are lateral to the sagittal plane of the lamina papyracea or that are anterior based should undergo an external osteoplastic procedure. Chen and colleagues [2] and Selva and colleagues [22] have similar recommendations and suggest that an endoscopic modified Lothrop procedure may be necessary to remove many frontal sinus lesions.



Fig. 7. Postoperative view of the ethmoid cavity after endoscopic removal of an osteoma.



Fig. 8. Postoperative view of the frontal recess after endoscopic removal of an osteoma.

External approaches to the sinuses continue to evolve. Although the Lynch frontoethmoidectomy was once standard, it is used rarely now because of expected stenosis of the frontal recess. An osteoplastic flap is still very useful, and most agree that the coronal incision is cosmetically and neurologically superior to brow (“gull-wing”) or midforehead approaches. Almost all investigators reporting on osteoma maintain the coronal osteoplastic flap as part of their surgical practice [2,4,6,8,22]. However, concomitant obliteration of the frontal sinus has become less common [8]. When intracranial complications occur, or when there is a large defect of the posterior frontal sinus wall, cranialization with obliteration of the frontal recess is recommended [3,13,17].

Some lesions lend themselves to combined endoscopic and external approaches. Frequently, endoscopic and osteoplastic flap procedures are combined to preserve frontal sinus health after tumor removal. A full osteoplastic flap procedure is not always necessary, and frontal trephines may be used for small symptomatic frontal sinus osteomas [23]. Chen and colleagues [2] and Selva and colleagues [22] report using orbital approaches to access difficult lesions, avoiding craniotomy in some cases.

The development of computer-aided surgery (CAS) in the last decade, combined with microdebrider technology, has enabled surgeons to remove extensive osteomas using transnasal endoscopic approaches. Previously, these tumors were simply too large to remove through the nasal cavity, and required an external approach. Now, by combining these two technologic advances, a large tumor can be reduced sufficiently before cleavage, while maintaining a safe relationship between the lesion and the skull base or lamina papyracea (Fig. 9). The position of the ethmoid roof and lamina papyracea are defined easily and accurately in several planes, allowing more safety in skull base and orbital dissection. The disadvantage, however, is that real-time confirmation of complete tumor removal is not possible from

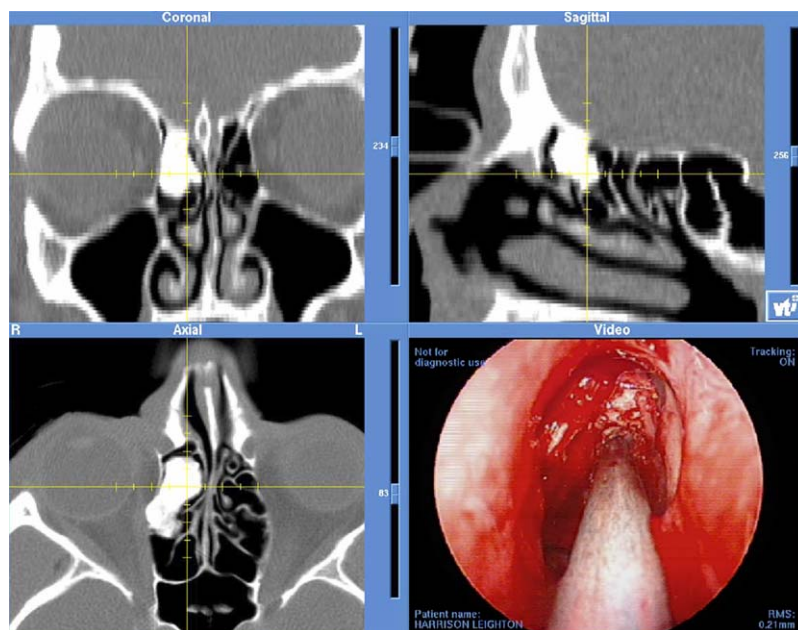


Fig. 9. Intraoperative screen capture obtained during surgical navigation performed for localization for endoscopic excision of a left ethmoid osteoma.

preoperative images alone. To account for this, Selva and colleagues [22] recommend also using stereotactic fluoroscopy during especially challenging cases where the real-time knowledge of spatial relationships is imperative.

Regardless of the approach used, violation of the skull base or bony orbit, while not common, should be anticipated. This is especially true when dividing the cleavage plane at the base of the bony tumor where it attaches to the lateral lamella of the cribriform plate or a significantly thinned ethmoid roof or lamina papyracea (Fig. 10). The resources and skill to reconstruct necessary defects should be in place prior to surgery. In patients with existing CSF leaks or apparent uncomplicated intracranial extension, lumbar drainage and neurosurgical support may be necessary.

Surgical complications

All of the known complications of sinus surgery are possible during resection of a paranasal sinus osteoma. Injury to the periorbita, optic nerve, cribriform plate, or other important structures is possible. However, in experienced hands, complications are rare. Schick and colleagues [8] report on the endoscopic removal of 23 tumors. They had three instances of minor injury to the periorbita without symptomatic complication, and three instances of injury to the dura. These were repaired endonasally at the time

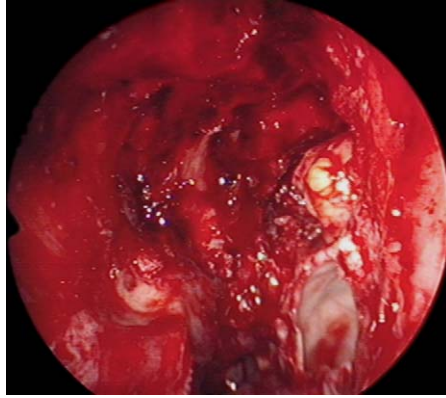


Fig. 10. Endoscopic view of orbital fat protrusion through an opening in the left medial orbital wall after orbital and optic nerve decompression for fibrous dysplasia.

of the initial surgery and there were no symptomatic complications noted. They also performed 11 osteoplastic flaps, and had four dural injuries and one injury to the periorbita, all without short- or long-term problems. Chen and colleagues [2] further report on the complications of osteoplastic flaps. In addition to CSF leak, frontal pain, and paresthesia/anesthesia, frontal bossing, and fracture or necrosis of the bone flap can occur.

With either endoscopic or external approaches, disruption of the sinus walls and violation of the mucosa can establish a reactive bony hyperplasia. This is commonly considered a reason for surgical failure in the frontal sinuses after functional endoscopic sinus surgery for chronic rhinosinusitis. Reactive bony hyperplasia should be distinguished from tumor recurrence and managed appropriately.

Postoperative course

Postoperative morbidity depends generally on the surgical approach used and whether or not the dura or periorbita were violated. When the dura and periorbita are uninjured, outpatient surgery with standard postoperative sinus care is adequate. For patients with significant orbital involvement, ophthalmologic evaluation is imperative both before and after surgery. If CSF rhinorrhea is encountered or repaired, lumbar drainage may be employed, but is often unnecessary. It is imperative that the patient be cared for by nursing staff familiar with lumbar drainage, as mismanagement can lead to significant morbidity and mortality.

Following discharge, the patient should return to the office on a weekly basis until all mucosal surfaces have healed. Monthly visits may be necessary to prevent and manage evolving stenosis. Once the area has stabilized, yearly visits with CT imaging for a total of three years are required to ensure continuing health and identify recurrent/persistent tumor.

Gardner's syndrome

There is one syndrome associated with sinus osteoma that should be considered when evaluating these patients. Gardner's syndrome, the triad of colorectal polyps, skeletal abnormalities, and supernumerary teeth, is also characterized by the presence of multiple osteomas. This disease is autosomal dominant and carries a 100% risk of malignant transformation of the colonic polyps by the age of 40. Thus, early diagnosis is important. Usually, patients become symptomatic in the second decade of life, with rectal bleeding, diarrhea, or abdominal pain [7]. Extracolonic manifestations can complicate treatment and increase morbidity [24]. It is important to investigate this possibility when taking the history of patients with osteomas and follow any leads with appropriate studies or referrals.

Fibrous dysplasia

Fibrous dysplasia (FD) is another slow-growing fibro-osseous lesion that can be located in the paranasal sinuses. Seventy-five percent of patients with FD are diagnosed before the age of 30 [19]. There are two forms: polyostotic (15%–30%), involving more than one bone, and monostotic (70%–85%), involving only one bone [25]. McCune-Albright syndrome (precocious puberty, fibrous dysplasia, café-au-lait spots) has the polyostotic form. Twenty-five percent of monostotic cases arise in the facial skeleton [16]. The maxilla and mandible are the most common sites in the head and neck, although it has been reported throughout the maxillofacial skeleton, including the sphenoid intersinus septum [12,25].

FD is generally assumed to “burn out” as the patient reaches skeletal maturity, although this is debated [16,19,25]. Monostotic FD in the long bones and mandible does not cross the joint line and is contained within the diseased bone. However, in maxillofacial skeleton, it can cross bony sutures and involve more than one facial bone. While disfiguring, FD has a low rate of malignant transformation [16,19,25]. However, transformation occurs in 0.5% of polyostotic forms and in 4% of lesions in patients with McCune-Albright syndrome [25].

In the paranasal sinuses, diagnosis can be accomplished via radiographic appearance, although some investigators recommend biopsy of FD lesions in the jaw [25]. In plain film and CT radiographs, FD lesions are characterized by hazy borders and a fairly homogeneous “ground glass” appearance representing the disorganized spicules of bone that characterize FD's histology (Fig. 11) [15,25]. As the lesion scleroses, “cotton wool” areas arise. On MRI, the T1 signal is intermediate and the T2 signal is hypointense [25].

Because FD has a tendency to stabilize over time and a low malignancy potential, most investigators recommend conservative management, operating only for symptomatic lesions or to recontour cosmetic deformity. In the paranasal sinuses, this is usually accomplished via an endoscopic technique,



Fig. 11. Axial CT scan of fibrous dysplasia in the left ethmoid sinuses. Note the heterogeneous ground glass appearance.

and radical or complete resection is not necessary [12,19]. Patients should be followed up with periodic imaging to guide management of any regrowth that occurs.

Ossifying fibroma

Ossifying fibroma (OF) is the most concerning of the paranasal sinus's fibro-osseous lesions. Also known as cemento-ossifying fibroma, psammomatoid ossifying fibroma, and juvenile-aggressive ossifying fibroma, this lesion can be locally destructive. It involves the mandible in 75% of cases, but is considered more aggressive when found outside the mandible. Histologically, there are islands of osteoid rimmed by osteoblast-forming lamellar bone. The cellular fibrous stroma shows a parallel and whorl arrangement of collagen and fibroblasts [16]. Radiographically, it is a sharply circumscribed round or oval lesion with an eggshell rim and a central radiolucency. OF will absorb tooth roots, whereas FD usually encompasses the healthy roots [25]. Because of the aggressive and locally destructive nature of OF, complete removal is recommended.

Summary

Osteomas are the most common fibro-osseous lesions in the paranasal sinuses. They are infrequent, with an incidence of 0.43%, and are seen in up to 3% of sinus CT series. Histologically, they are made of dense lamellar bone without haversian canals, or otherwise mature bone. Thus, they appear radiographically as well-circumscribed dense masses attached to the originating bone by either a broad- or narrow-based pedicle. The three theories

of pathogenesis are developmental, traumatic, and infectious. They may arise from residual cartilaginous rests or as a reaction to an inciting event. Most frequently, osteomas are asymptomatic and are discovered incidentally. When they do cause symptoms, headache is most frequent, followed by sinusitis, pain, and facial or cranial deformation. Complications arise when an osteoma has grown large enough to impinge on surrounding structures. Obstructive sinusitis, mucocele formation, and intrusion on the intracranial and orbital spaces with resultant maladies have all been reported in association with paranasal sinus osteomas. Treatment is by surgical excision, frequently possible via endoscopic techniques, although some of the more lateral frontal sinus lesions are more easily removed via an osteoplastic or combined approach. It is often necessary to perform a Draf II or III, or an endoscopic modified Lothrop procedure, to gain adequate endoscopic exposure. A surgeon should expect and be prepared to manage periorbital and dural injuries, as they are occasionally unavoidable when removing these lesions via either endoscopic or external approaches.

Fibrous dysplasia and ossifying fibroma are other fibro-osseous lesions found in the paranasal sinuses. Fibrous dysplasia affects children and characteristically “burns out” during puberty. It is deforming but not destructive and appears as a ground glass density on plain film radiograph or CT. In the polyostotic form, it is associated with McCune-Albright syndrome. A conservative treatment strategy is recommended, reserving surgical intervention for symptomatic lesions. Ossifying fibroma is more serious. Appearing as a well-circumscribed lesion with an eggshell-thin wall and a hypodense center, OF can be locally destructive and should be aggressively and completely excised.

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