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The Significance of Sinonasal Radiodensities: Ossification, Calcification, or Residual Bone?

Peter M. Som and Mika Lidov

PURPOSE: To determine whether very radiodense material within a sinonasal soft-tissue mass on CT can be differentiated as calcification, ossification, or residual bone. **METHODS:** We retrospectively described the radiodensities within 235 sinonasal soft-tissue masses as discrete, solitary or multiple, or as a diffuse process with either a well-defined or poorly defined margin. They were also classified as calcification, ossification, or residual bone. Findings were correlated with pathologic specimens. **RESULTS:** Residual bone was underdiagnosed; calcification was overdiagnosed. A solitary discrete density was most likely to be calcification within an inflammatory mass. However, multiple discrete densities were as likely to be in a tumor as in an inflammatory lesion. If the process was diffuse with a well-defined margin, it was most likely to be a benign fibroosseous lesion. If the process was diffuse with a poorly defined margin, it was most likely to be a high-grade sarcoma. Densities within inverted papillomas were shown to be residual bone, not calcifications; densities within esthesioneuroblastomas were calcifications. **CONCLUSION:** Radiodensities may help in refining a CT diagnosis, but one may not know based on CT whether the density is a calcification, ossification, or residual bone.

Index terms: Paranasal sinuses, computed tomography; Images, interpretation

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A priori, one might expect that the relatively uncommon presence on computed tomography (CT) of very radiodense material, presumed to be either calcification or ossification, within a sinonasal soft-tissue mass would be a helpful imaging finding that would allow one to either make a specific diagnosis or offer a very limited differential diagnosis. However, there is a great variety of disease that may contain these densities. Focal or more diffuse calcification or ossification can be seen in a number of inflammatory conditions, a few epithelial tumors, a variety of uncommon sarcomas, as well as in fibroosseous-type lesions. The purpose of this report is to review retrospectively our experience with 235 such cases in order to establish whether one can reliably differentiate on CT between calcification, ossification, or resid-

ual bone, and if any diagnostic conclusions can be drawn regarding the presence of radiodensity within a sinonasal mass.

Materials and Methods

We retrospectively examined our CT case material looking for sinonasal soft-tissue masses that contained radiopaque areas of suspected calcification or ossification. Excluded from the study were lesions with no identifiable soft-tissue component such as osteomas, "ground glass" fibroosseous lesions, and purely radiodense lesions such as some odontomas. We collected 235 cases, summarized in Table 1. All CT scans were evaluated by two radiologists who assessed the radiodense areas as either calcification, ossification, or residual bone. These assessments were somewhat arbitrary, based on the everyday judgments radiologists make about radiodensities.

If there was more density than could be grossly accounted for by destruction of adjacent bone, the diagnosis of either ossification or calcification, rather than residual bone (or in addition to residual bone) was made. Similarly, if a suspected "bone density" was seen well within a soft tissue mass, ossification or calcification rather than residual bone was diagnosed.

Subjective distinction between calcification and ossification was based on the size, shape, location, degree, and number of the radiodensities. Calcifications were preferen-

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tially diagnosed when the densities were small, spherical, multiple, clumped in one area, or ringlike in appearance. This included the calcification seen in cartilaginous matrix, which is often characterized by small rings or broken rings, and arcs of calcification. Ossification was suggested by the presence of a trabecular pattern within the mass.

TABLE 1: CT diagnosis of density (parentheses) versus pathologic diagnosis (no parentheses) in 235 study cases

Diagnosis	Number of Cases	Calcification	Ossification	Residual Bone
Rhinolith	8	(8)7	(0)1	
Sinolith	19	(16)14	(3)5	
Mucocele/polypoid	66	(60)55	(2)0	(4)11
Aspergillosis	12	(12)6		(0)6
Inverted papilloma	10	(10)2		(0)8
Squamous cell carcinoma	31	(8)0		(23)31
Esthesioneuroblastoma	9	(9)5		(0)4
Melanoma	3	(3)1		(0)2
Large cell lymphoma	2	(2)0		(0)2
Osteogenic sarcoma	7		(7)7	
Chondroma/chondrosarcoma	6	(6)5	(0)1	
Undifferentiated sarcoma	2	(1)0	(1)2	
Benign mixed tumor	1	(1)1		
Mucoepidermoid carcinoma	1	(1)1		
Primitive neuroectodermal tumor	1		(1)1	
Metastatic carcinoma	2	(2)2		
Ossifying fibroma	11		(11)11	
Fibrous dysplasia	24		(24)24	
Osteochondroma	2	(2)1	(0)1	
Healed brown tumor	2		(2)2	
Reparative granuloma	7	(1)0	(2)0	(4)7
Odontoma	2		(2)2	
Cementifying fibroma	2	(1)0	(1)2	
Meningioma	3	(2)3		(1)0
Radiation necrosis	2			(2)2

Only masses very radiodense on CT (those that presumably contained calcification or bone) were evaluated in this study. Masses with areas of material similar to or somewhat greater than the attenuation of muscle (and therefore considered by some to be radiodense) were not included in this study. This eliminated from this study cases of dense, proteinaceous material such as seen in chronically obstructed secretions and fungal diseases.

We acknowledge that these radiographic assessments are inexact, but such diagnostic decisions are part of the everyday mental machinations most radiologists use routinely to diagnose radiodensities grossly on CT; it was this assessment (which the radiologist often believes to be fact) that was being tested against pathology.

The radiodensity was also classified as either a discrete solitary density, a collection of discrete densities, a diffuse process (widespread throughout the process) with a well-defined margin, or a diffuse process with a poorly defined margin.

All CT findings were correlated with pathology specimens; however, this pathology correlation itself was imperfect. The specimen was correlated as closely as possible with the CT study in order to locate the area of radiodensity on CT. When there was only one density, the correlation was clear. However, if numerous densities were present, the best possible correlation was made to match the specimen with the CT scan. The pathologic diagnosis of the radiodensity was based on the presence of one or more of the following: focus (or foci) of calcification, a site(s) of abnormal or tumoral bone production (ossification), or the presence of normal (residual) bone.

Because it is a referral center, many patients come to our institution with outside imaging studies. The CT examinations performed at our institution were done on a GE 9800 (General Electric, Milwaukee, Wis) scanner as axial and coronal 5-mm contiguous studies. Routinely, contrast was not used unless there was a clinical diagnosis of tumor. The CT scans in this article are representative of this case material (Figs 1–5).

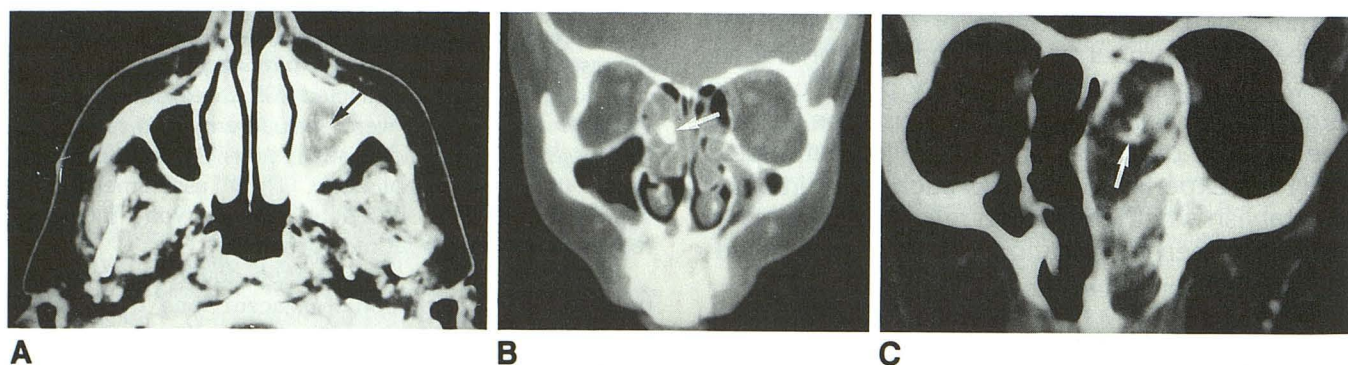


Fig. 1. A, Axial CT scan shows a solitary, discrete sino'lith" (arrow) within the soft-tissue density opacifying the left maxillary sinus. This was a calcification within sinus secretions and inflammatory mucosal reaction.

B, Coronal CT scan shows soft-tissue disease involving the ethmoid sinuses, upper nasal fossae, and maxillary sinuses. A solitary, discrete rhino'lith" (arrow) was a calcification, not an ossification.

C, Coronal CT scan shows polypoid inflammatory disease in the left ethmoid sinuses, maxillary sinuses, and nasal fossa. Within the mass is a solitary, discrete radiodensity (arrow), initially thought on CT to be a calcification. It was residual bone.

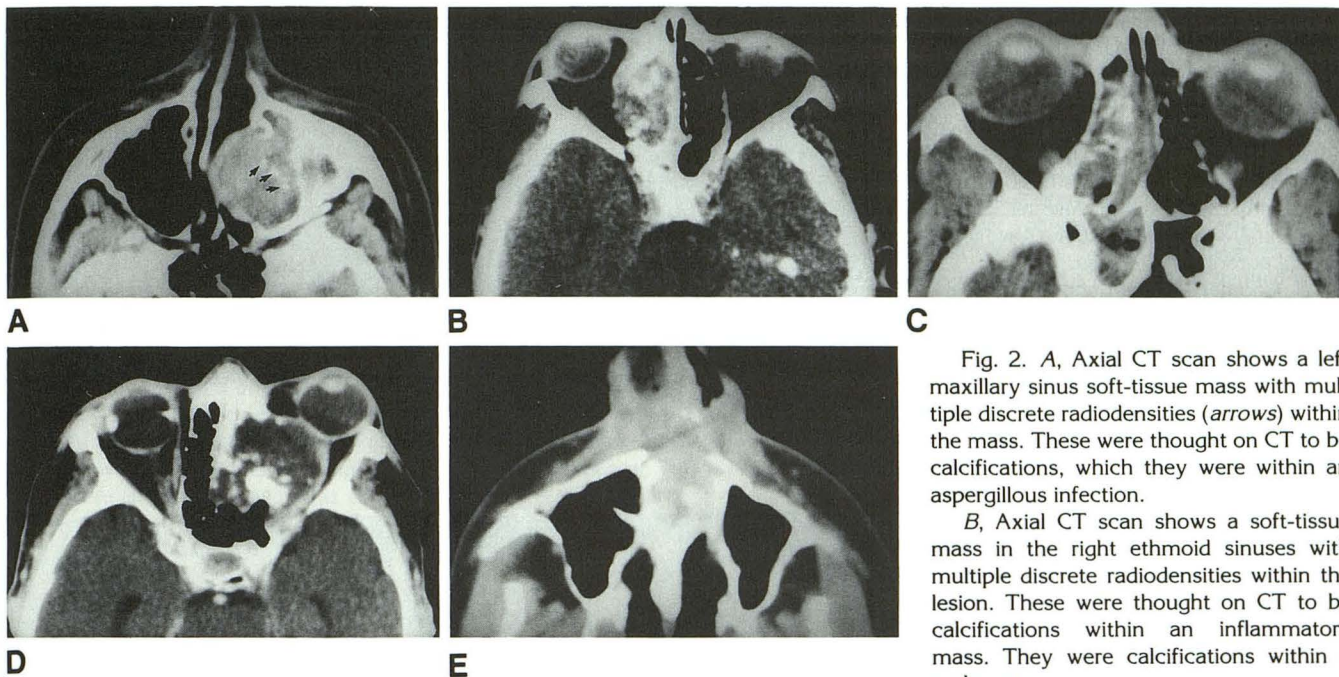


Fig. 2. A, Axial CT scan shows a left maxillary sinus soft-tissue mass with multiple discrete radiodensities (arrows) within the mass. These were thought on CT to be calcifications, which they were within an aspergillous infection.

B, Axial CT scan shows a soft-tissue mass in the right ethmoid sinuses with multiple discrete radiodensities within the lesion. These were thought on CT to be calcifications within an inflammatory mass. They were calcifications within a melanoma.

C, Axial CT scan shows soft-tissue

disease within the right ethmoid and sphenoid sinuses. Multiple discrete radiodensities were present within the ethmoid sinuses. These were thought on CT to be residual bone. They were both residual bone and calcifications in inflammatory disease.

D, Axial CT scan shows a destructive mass in the left ethmoid sinuses and left orbit. There are multiple discrete radiodensities within the mass, which were thought on CT to be calcifications. These were calcifications within a chondrosarcoma.

E, Axial CT scan shows a partially destructive nasal mass with multiple discrete radiodensities within it. These were thought on CT to be calcifications. They were both calcifications and residual bone in this chondrosarcoma.

Results

The results of the CT assessments of the causes of the radiodensities compared with pathology are summarized in Table 1; the results of the CT classification of the organization of the radiodensities compared with pathology are summarized in Table 2. Although the small number of cases in some sections of this study limits the value of any statistical conclusions, the tables show that when the densities were discrete (either solitary or multiple), calcification was diagnosed on CT 140 times but was actually present only 101 times; ossification was diagnosed seven times but was present 10 times; and residual bone was diagnosed 30 times but was present 66 times.

When the density was a more diffuse process, ossification was diagnosed 47 times and was present 49 times; calcification was diagnosed five times but was present only two times; and residual bone was diagnosed four times but was present seven times.

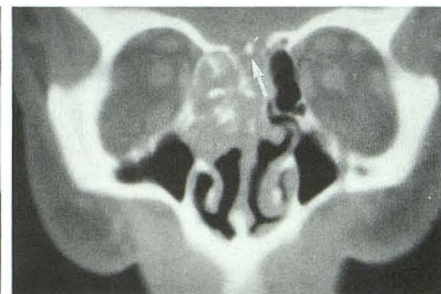
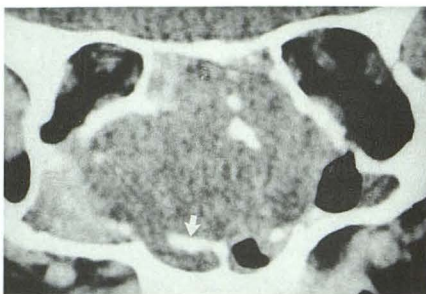
In correlating the CT densities with pathologic diagnoses, solitary calcifications were identified

44 times in four different inflammatory diseases, once in a benign tumor, and four times in three different malignant tumors. When the densities were multiple and discrete, they were seen 63 times in two inflammatory diseases, 66 times in 11 different tumors, and in the cases of radionecrosis. If the diffuse process had a well-defined margin, it was found four times in osteogenic sarcoma and 46 times in five different benign fibroosseous type lesions. If the diffuse process had a poorly defined margin, it was found in eight cases (in five different high-grade malignancies), six of which were sarcomas.

Discussion

In general, the CT visualization of radiodensities within sinonasal masses is uncommon. The relative paucity of reports in the literature probably testifies to this observation (1-13). Most often, the radiologist believes that identification of such radiodensities as either calcification or ossification is innate. However, in our study, when the density was discrete, calcification was overdiagnosed

Fig. 3. A, Coronal CT scan shows an extensive soft-tissue mass that fills both ethmoid sinuses and nasal fossae, and obstructs and partially fills the maxillary sinuses. Within the mass are several discrete radiodensities. These were thought on CT to be calcifications. This was an esthesioneuroblastoma with calcifications. Also as diagnosed on CT, there was residual bone (arrow) in the caudal portion of the mass.



B, Coronal CT scan shows a soft-tissue mass in the right ethmoid sinuses and both upper nasal fossae. There is apparent erosion of the cribriform plate (arrow). Multiple discrete radiodensities are present within the mass. These were interpreted on CT as being both residual bone and calcifications. They were all residual bone in this inverting papilloma.

A

B

Fig. 4. A, Axial CT scan shows an expansile diffuse process involving the maxillae, sphenoid bone, and mandibles. The nasal fossae and maxillary sinuses have been obliterated. There is an intact cortex about the involved bones and there are multiple diffuse radiodensities within the mass. This process was interpreted on CT to be diffuse with a well-defined margin. This was fibrous dysplasia.



A

B

B, Coronal CT scan shows an expansile mass in the right nasal cavity, ethmoid sinuses and maxillary sinus. The medial wall and floor of the right orbit as well as the nasal septum have been remodelled by the mass. There is a fairly intact bony-appearing rim around the mass and within the lesion there are irregular diffuse areas of radiodensity. The impression on CT was that this was a diffuse process that had a well-defined margin. This was thought to be a benign fibroosseous process with bony-radiodensities. This was an ossifying fibroma.

nearly 40% of the time (140 of 101), and ossification was underdiagnosed 30% (1 to 7 of 10) of the time. The discrepancy was accounted for by the misdiagnosis of residual bone approximately 55% (1 to 30 of 66) of the time. Our figures indicate that pieces of displaced or eroded bone are not often thought of as a diagnosis and cannot be easily distinguished on CT from dystrophic or tumoral calcification or ossification.

When the radiodensity was part of a more diffuse process within the lesion, an ossified structure was correctly identified 96% (47 of 49) of the time, but calcification was overdiagnosed more than twice as often as it was present (five of two), and residual bone was underdiagnosed about 40% of the time (one to four of seven).

Because ours is a referral center for head and neck tumors, our data probably have a higher percentage of tumors than one would expect to find in the general community. Thus, it might be a reasonable assumption that the percentage of

tumors in a general community practice should be lower than in our study. With this in mind, when there was a diffuse process with a well defined margin, it was a benign fibroosseous type lesion 92% of the time (46 of 50). When there was a diffuse process with a poorly defined margin, the radiodensities were ossifications in all cases and the lesion was a sarcoma 75% of the time (six of eight), and metastatic undifferentiated carcinoma in 25% of the patients (two of eight). When one further correlates pathology with the presence of a discrete density, the lesion was inflammatory about 92% (44 of 4) of the time. However, when there were multiple discrete densities, the lesion was about 49% (63 of 129) as likely to be an inflammatory process as a tumor.

The CT determination whether a diffuse lesion was well margined or poorly margined was based on observation of the outer cortical margin of the process. If there was a sense that the bone was intact and remodelled around the main mass

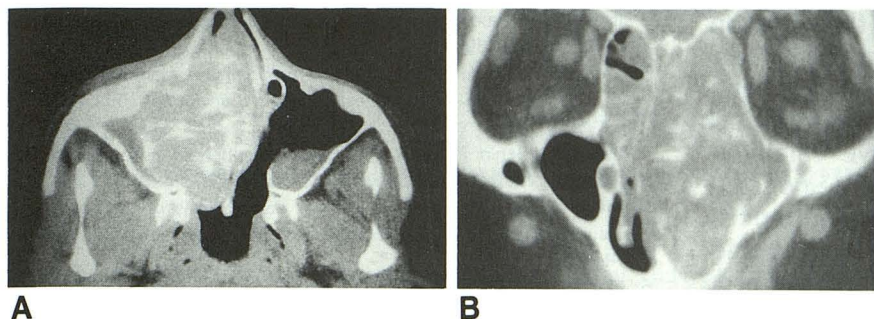


Fig. 5. A, Axial CT scan shows a partially expansile, partially destructive mass in the right nasal cavity. The remaining right maxillary sinus has obstructed secretions and there is apparently unrelated inflammatory tissue in the left maxillary sinus. Most margins of the lesion have no "bony" cortex and there are diffuse irregular radiodensities within the mass. This was considered a diffuse process that had poorly defined margins. The radiodensities were thought to be sites of ossification rather than calcification. This was an osteogenic sarcoma. B, Coronal

CT scan shows a mass in the left nasal fossa, ethmoid sinuses, and maxillary sinus which appears to be displacing the nasal septum to the right. There are also possibly unrelated soft tissues in the right ethmoid sinuses and the right nasal fossa. The bone surrounding the left sided soft-tissue mass is grossly intact, however, there is no "bony" rim containing the lesion. There are diffuse radiodensities within the mass which were initially thought on CT to be calcifications. This mass was considered to be diffuse with poorly defined margins. These were all ossifications in this complex undifferentiated sarcoma.

TABLE 2: Distribution by CT evaluation of radiodensities in 235 cases

Diagnosis	Number of Cases	Discrete		Diffuse Process	
		Solitary	Multiple	Well-defined Margin	Poorly Defined Margin
Rhinolith	8	8			
Sinolith	19	19			
Mucocele/polypoid	66	12	54		
Aspergillosis	12	3	9		
Inverted papilloma	10	2	8		
Squamous cell carcinoma	31		31		
Esthesioneuroblastoma	9	2	7		
Melanoma	3	1	2		
Large cell lymphoma	2	1	1		
Osteogenic sarcoma	7			4	3
Chondroma/chondrosarcoma	6		6		
Undifferentiated sarcoma	2				2
Benign mixed tumor	1		1		
Mucoepidermoid carcinoma	1		1		
Primitive neuroectodermal tumor	1				1
Metastatic carcinoma	2				2
Ossifying fibroma	11			11	
Fibrous dysplasia	24			24	
Osteochondroma	2		2		
Healed brown tumor	2			2	
Reparative granuloma	7			7	
Odontoma	2		2		
Cementifying fibroma	2			2	
Meningioma	3		3		
Radionecrosis	2		2		
Total	235	48	129	50	8

of the lesion, the lesion was said to have a well-defined margin. If this outer (or peripheral) bone was destroyed either in part or in its entirety, it was said to be poorly marginated. Our data sug-

gest a correlation between the CT identification of a diffuse process with a poorly defined margin and the pathologic diagnosis of a poorly organized undifferentiated tumor.

An additional point of interest is the data on inverted papillomas and esthesioneuroblastomas. Traditionally in the radiologic literature it has been mentioned that the two most common nasal fossa/paranasal sinus tumors to have calcifications are esthesioneuroblastomas and inverted papillomas (13). Yet we could find no references in the pathologic literature to calcifications being a feature of inverted papillomas. Our data suggest that radiologists may have been misdiagnosing residual bone as calcification. The association of calcification and esthesioneuroblastoma was confirmed in our data and is established in the pathologic literature (10, 13).

Within the limitations of our present initial study, we suggest that the presence of radiodensity(s) within a sinonasal mass may assist the radiologist in prioritizing a differential diagnosis. However, in some cases it is not as easy as one might have thought to differentiate on CT between calcification, ossification, and residual bone.

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