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Pathological Expansion of the Jaw: A Useful Parameter in the Differentiation between Benign and Malignant Lesions

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ABSTRACT

Objective: To describe the pattern of pathological bone expansion among benign and malignant jaw lesions.

Patients and Methods: 98 patients of different age groups (mean age: 39±18 years) with a clinically suspected jaw lesions were included in the study. Dental CT with panoramic and cross sectional reconstruction was carried out to all patients.

Results: Pathological bone expansion occurred in 17% only of malignant lesions versus 44% of benign ones (*p*-value=0.02). A jaw lesion with bone expansion had an Odds ratio of only 0.19 to be malignant (*p*-value=0.39, CI=95%). The direction of expansion (buccolingual versus mesiodistal) has shown an interesting relation to the type and location of jaw lesions.

Conclusion: Pathological bone expansion was found to be an important imaging parameter that should be evaluated by dental CT when differentiating benign from malignant lesions of the jaw.

INTRODUCTION

The diagnosis of jaw lesions is a perplexing clinical problem. Many lesions are similar to each other on radiographs, while they could be totally different in treatment or prognosis. Imaging of a jaw lesion is frequently performed at the dentist's office using conventional techniques such as the commonly used periapical film, however CT is almost reserved for problematic cases and sometimes for local staging of tumors [1]. When a jaw tumor is suspected, the first alarming question is always whether it is benign or malignant. But the overlap of imaging findings is worrisome in many situations so that we usually have to wait for pathology results in order to resolve the existing dilemma [2]. Using dental CT with reformatting protocol, many radiologic features are clearly visualized including bone expansion in different directions induced by the lesion [3].

In the present work, we will describe the occurrence and the pattern of bone expansion among in different categories of jaw lesions and will assess its possible utility in the differentiation between benign and malignant pathologic processes.

PATIENTS AND METHODS

98 patients (54 males and 44 females) of different age groups ranging from 2 to 80 years (mean = 38.8±18.3) were included in the study.

Inclusion criteria:

- Any clinically or radiologically suspected swelling of the jaws.
- Pain over the jaws in which an inflammatory condition is suspected.
- Soft tissue swellings and oral mucosal lesions with possible affection or invasion of the jaw bone.

Sixty seven cases at Johns Hopkins Hospital (Maryland, USA) and thirty one patients at Suez Canal University Hospital (Egypt) were included in the study.

Study algorithm:

History taking and clinical examination were carried out by the clinician, then conventional radiographic assessment was done for some of the cases whenever indicated including: PA, lateral or oblique views of the mandible, Para-nasal sinuses (Waters) view, intraoral radiography (periapical, bite wing & occlusal views) and orthopantomograms.

Dental CT examination with reformatting software was performed to 80 out of 98 patients using SIEMENS Somatom balance (single slice spiral),

and SIEMENS 64 & 16 multislice scanners. A bone algorithm without IV contrast material was generally sufficient in most of the cases. Images obtained included (axial, panoramic & cross-sectional reformatted images). For the remaining 18 patients (without reformatted protocol) only standard axial and direct coronal images were available. Images were reformatted and processes using SIEMENS Syngo workstation. Staff radiologists and oral oncology/pathology consultant participated in reading images.

Biopsy was done in 61% of cases including all neoplastic lesions, and some other non-neoplastic lesions. In some cases repeated reading of histopathology slides by different pathologists was done to ensure accuracy of results especially with rare cases or when the diagnosis is unclear. The remaining 39% of cases were diagnosed on clinical and/or radiological basis as biopsy was not needed or sometimes was contraindicated such as in cases of cemento-osseous dysplasia.

Ethical considerations:

Patients in Egypt were orally informed about the aim of the study then dental CT technique was simply described to every one of them. No written consent was needed as the procedure is totally safe. Radiation exposure was minimal, and examination time was in the range of 3-5 minutes.

In the Unites states, Cases were included in our series after signing a written consent fulfilling the HIPPA (Health Insurance Portability and Accountability Act) ethical regulations of research to ensure patient's privacy and confidentiality.

RESULTS

A data-base archive file was created using Microsoft Access 2007 and included all 98 cases, then data was transformed to SPSS version 15, 2006 for computer-based statistical analysis by which Qui-square test, Fisher's exact test (for all 2 x 2 tables), *t*-test, and logistic regression analysis were all performed.

Diagnosis of lesions:

About 58% of lesions were found in the upper jaw (maxilla), while 42% of them were mandibular (lower jaw) lesions. Final diagnosis was established by histopathology in 61% of cases, and by clinical/radiological methods only in the remaining 39% of cases when biopsy was not indicated or was contraindicated.

Of the studied 98 cases, 56 lesions were diagnosed as odontogenic while 42 ones were non-odontogenic. Non-neoplastic pathology was seen in 66 lesions while 32 ones were neoplastic, 12 of them were malignant and 20 were benign. Of the 66 non-neoplastic lesions, most of them (n: 48) were inflammatory, while developmental and fibro-cemento-osseous lesions were seen in 11 and 7 cases respectively (Table 1). A list of the final diagnosis is demonstrated in Table (2) where osteomyelitis (n: 12), periapical abscesses (n: 12), radicular cysts (n: 9), and squamous cell carcinomas (n: 8) were among the leading pathologies included in the study. Giant cell lesions (n: 6), dentigerous cysts (n: 6), fibrous dysplasia (n: 5), ameloblastomas (n: 5), odontogenic keratocysts (n: 4), osteomas (n: 3), and osteoradionecrosis (n: 3) were also included. A rare case of adenomatoid odontogenic tumor, a quiet rare case of primary maxillary meningeoma, a very rare case of bilateral Pindborg tumor and an interesting case of the recently described bisphosphonates-induced osteonecrosis were all included. Other lesions are also shown in the same table.

Size of the lesion, and bone expansion:

About 38% (n: 18), 33% (n: 4) & 29% (n: 2) of inflammatory, malignant and fibro-cemento-osseous lesions respectively were tiny in size (volume: Less than 0.5cc) while three benign tumors (15%) and one inflammatory lesion (2%) were huge (more than 50cc) (Table 3). (p-value = 0.046).

Bone expansion (Figs. 1-4) occurred in about half (n: 44) of benign lesions while only two cases (17%) of malignant lesions were expansile (Table 4). (p-value=0.024).

By applying a logistic regression model, lesions that demonstrated bone expansion had an odds ratio of 0.19 of being malignant (p-value=0.39, Confidence interval 95%), or in other terms expanding lesions had only 19% chance of being malignant rather than being benign.

Table (1): Pathological classification of jaw lesions.

	Frequency	Percentage
Developmental	11	11.2
Fibro-cemento-osseous	7	7.1
Inflammatory	48	49.0
Benign tumors	20	20.4
Malignant tumors	12	12.2
Total	98	100.0

Inflammatory lesions represented the most commonly encountered pathology followed by benign tumors, malignant tumors, developmental and fibro-cemento-osseous lesions.

Table (2): Final diagnosis of studied lesions.

	Frequency	Percentage
Inflammatory lesions:		
Osteomyelitis	12	12.2
Periapical abscess	11	11.2
Radicular cyst	9	9.2
Inflammatory oro-antral fistula	5	5.1
Periodontitis	4	4.1
Periapical granuloma	1	1.0
Post traumatic (periapical) cyst	1	1.0
Pigmented villonodular synoviitis TMJ	1	1.0
Osteonecrosis	3	3.1
Developmental lesions:		
Dentigerous cyst	6	6.1
Nasopalatine duct cyst	1	1.0
Odontogenic keratocyst	4	4.1
Fibro-cemento-osseous lesions:		
Fibrous dysplasia	5	5.1
Cemental dysplasia	2	2.0
Benign tumors:		
Giant cell tumors	6	6.1
Ameloblastoma	5	5.1
Odontogenic myxoma	2	2.0
Osteoma	3	3.1
Adenomatoid odontogenic tumor	1	1.0
Bilateral Pindborg tumor	1	1.0
Inverted papilloma (invasion)	1	1.0
Primary sinonasal meningeoma	1	1.0
Malignant tumors:		
Squamous cell carcinoma	8	8.2
Squamous cell carcinoma without bone invasion	1	1.0
Plasmacytoma	1	1.0
Metastasis (neuroblastoma)	1	1.0
PNET	1	1.0
Total	98	100.0

Table (3): Volume of the lesion (cc) in different pathological conditions.

Volume in cc	Classification of lesions					Total
	Developmental	Fibro-cemento-osseous	Inflammatory	Benign tumors	Malignant tumors	
<0.5	0	2	18	0	4	24
0.5-1	1	1	3	2	0	7
1-30	10	4	26	14	8	62
30-50	0	0	0	1	0	1
>50	0	0	1	3	0	4
Total	11	7	48	20	12	98

p-value = 0.046.

Most of the lesions lied between 0.5 and 50cc, tiny size (<0.5cc) was recorded in inflammatory, malignant and fibro-osseous lesions.

Table (4): Bone expansion in benign versus malignant lesions.

	Benign versus malignant		Total
	Benign	Malignant	
Expansion	44	2	46
No expansion	42	10	52
Total	86	12	98

p-value = 0.024.
Two malignant lesions only were expansile versus 44 benign ones.

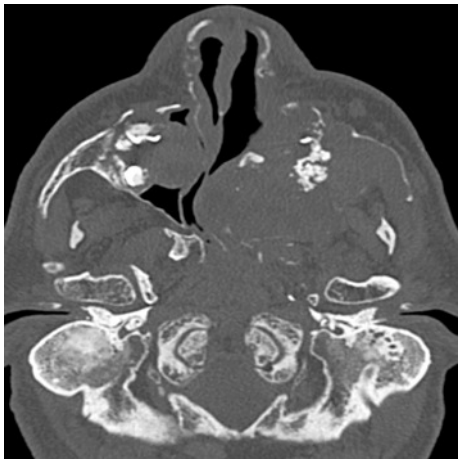

Fig. (1): Bilateral Pindborg tumor (Calcifying epithelial odontogenic tumor) a benign lesion showing marked bone expansion in almost all directions.

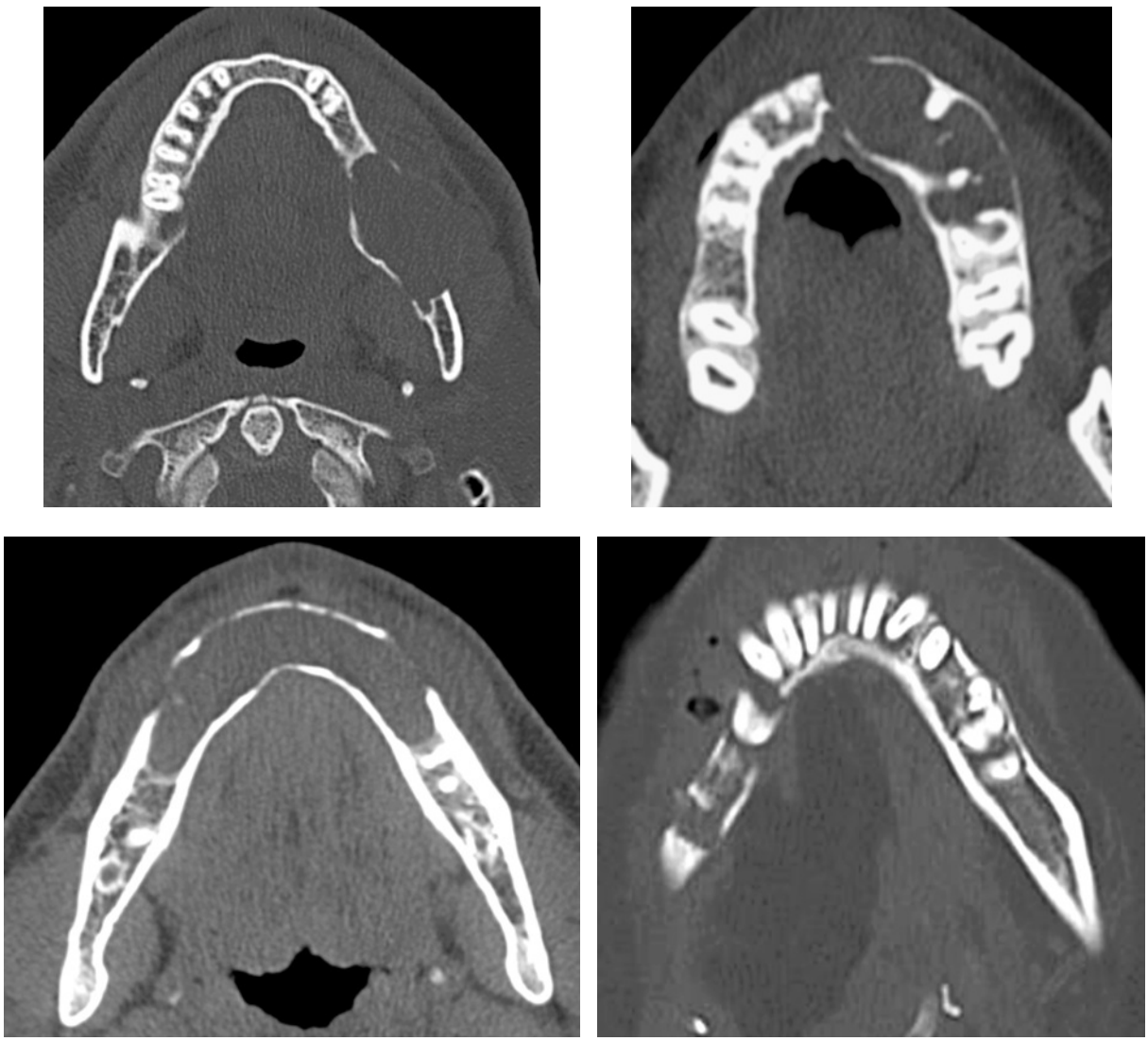

Fig. (2): Four different benign lesions showing variable degrees of bone expansion. Ameloblastoma (top left), Odontogenic keratocyst (top right), Giant cell lesion (bottom left), and Osteoradionecrosis (bottom right).

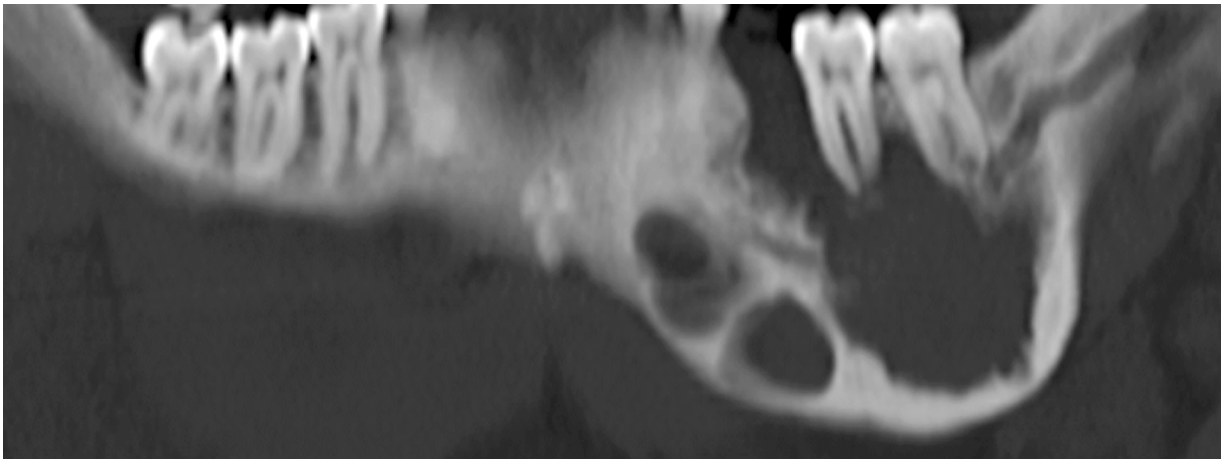

Fig. (3): Ameloblastoma on reformatted panoramic CT showing remarkable expansion in the vertical plane.

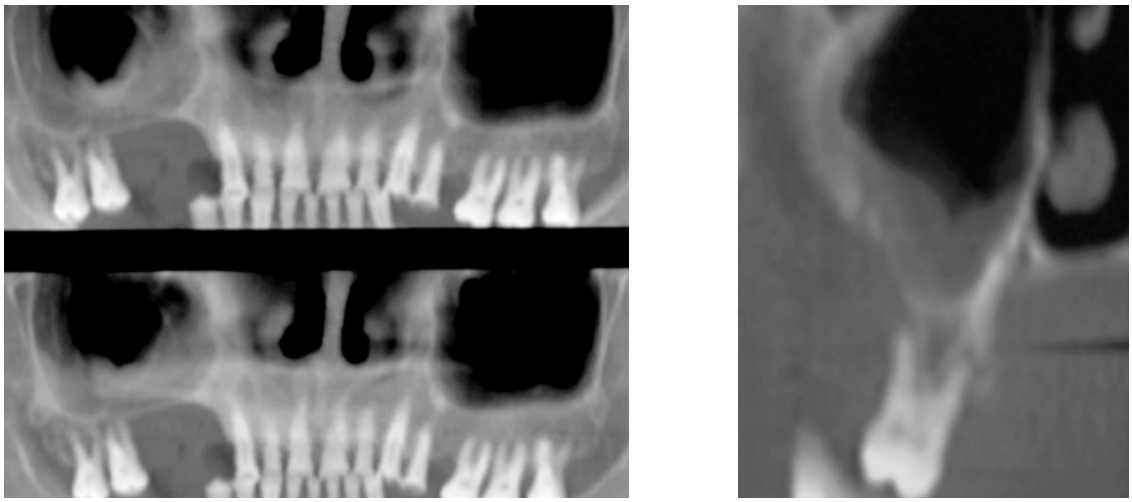

Fig. (4): Plasmacytoma on reformatted panoramic (left) and cross-sectional (right) CT showing malignant pattern of bone destruction and resorption without expansion.

The type of bone expansion was described by calculating the expansion ratio (bucco-lingual/mesio-distal dimensions) of the lesion (Fig. 5). Upper jaw lesions showed a higher expansion ratio (mean=1.12±0.54) than did lower jaw lesions (mean=0.66±0.39) (Table 5) (*t*-test significance value=0.000). A cutoff point of 0.8 was statistically significant in comparing upper and lower jaw lesions (Fig. 6). Most (77%, n: 44) of upper jaw lesions showed an expansion ratio over 0.8 compared to 32% (n: 13) of lower jaw lesions (Table 6). (*p*-value=0.000).

About 65% (n: 43) of non-neoplastic lesions resulted in an expansion ratio over 0.8 while neoplastic ones had an expansion ratio higher or lower than 0.8 in 43% (n: 14) & 57% (n: 18) of cases respectively (Table 7). (*p*-value=0.037).

Bowing of sinus/nasal wall (Fig. 7) was seen in 100% (n: 4) & 63% (n: 5) of fibro-cemento-osseous and benign neoplastic lesions of the upper jaw respectively, while it was absent in 81% (n: 25) & 83% (n: 5) of inflammatory and malignant lesions respectively (Table 8). (*p*-value=0.006).

Table (5): Expansion ratio of upper jaw versus lower jaw lesions.

	Jaw affection	N	Mean	Std. Deviation
Expansion ratio	Upper jaw	57	1.1174	.53735
	Lower jaw	41	.6558	.38714

t-test significance value = 0.000.
Upper jaw lesions showed a higher expansion ratio than lower jaw lesions.

Table (6): Expansion ratio of upper jaw versus lower jaw lesions at cutoff point (0.8).

	Upper jaw	Lower jaw	Total
Expansion ratio:			
<0.8	13	28	41
>0.8	44	13	57
Total	57	41	98

p-value (by Fischer's exact test) = 0.000.
Most upper jaw lesions showed an expansion ratio over 0.8.

Table (7): Expansion ratio of neoplastic versus non-neoplastic lesions.

	Neoplastic	Non-neoplastic	Total
Expansion ratio:			
<0.8	18	23	41
>0.8	14	43	57
Total	32	66	98

p-value (by Fischer's exact test) = 0.037.

Non-neoplastic lesions showed a higher expansion ratio than neoplastic ones.

Table (8): Bowing of sinus/nasal wall in different types of upper jaw lesions.

	Classification of upper jaw lesions					Total
	Developmental	Fibro-cemento-osseous	Inflammatory	Benign tumors	Malignant tumors	
Sino-nasal bowing:						
No	5	0	25	3	5	38
Yes	3	4	6	5	1	19
Total	8	4	31	8	6	57

p-value = 0.006.

Malignant and inflammatory lesions of the upper jaw were unlikely to bow sino-nasal walls than other types of lesions.

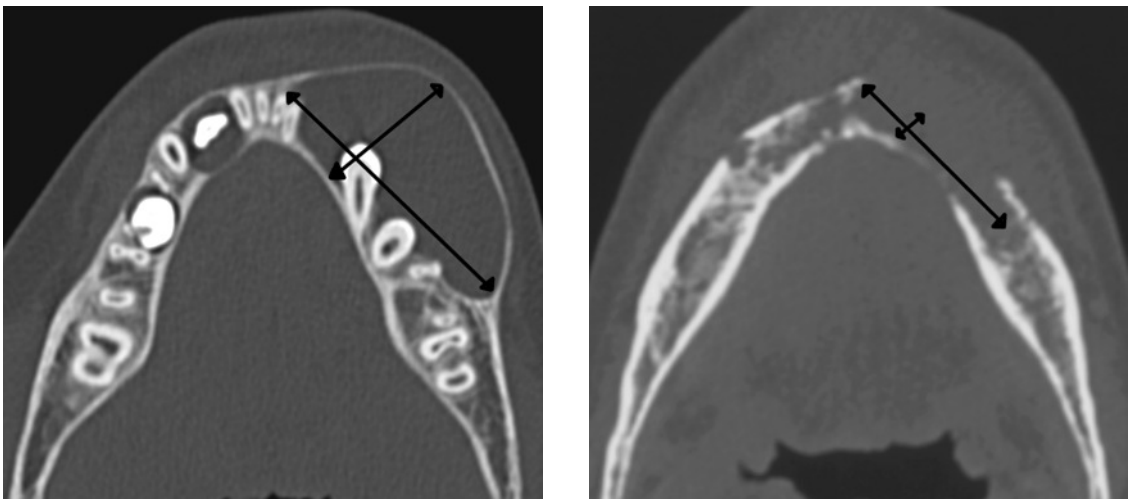

Fig. (5): Dentigerous cyst (left) versus squamous cell carcinoma (right) showing high and low expansion ratios respectively.

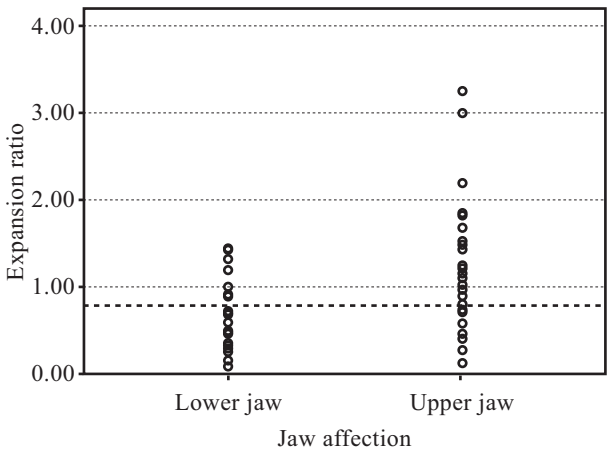

Fig. (6): Most lower jaw lesions have an expansion ratio less than (0.8) while most upper jaw lesions show the reverse.

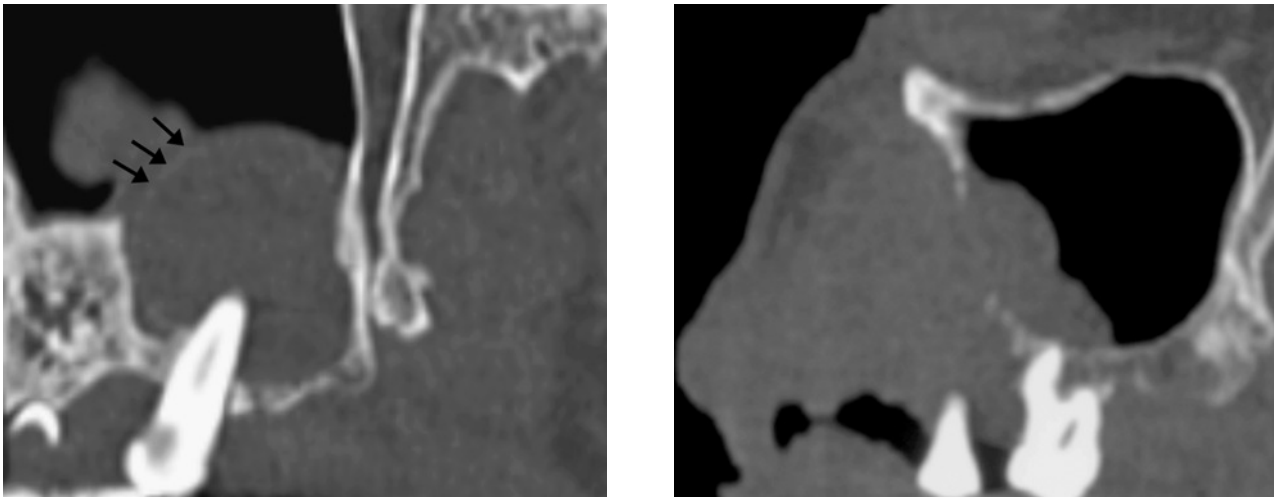

Fig. (7): Radicular cyst (left) versus squamous cell carcinoma (right) of the maxilla on reformatted cross-sectional CT showing bowing of sinus wall seen as a very thin plate of cortical bone (arrows) due to cyst expansion (left) in comparison to erosion of sinus wall due to infiltrating carcinoma (right).

DISCUSSION

Many cystic lesions of the jaws are expansile. Cysts usually show fluid or semisolid contents. Developmental and inflammatory cysts grow by proliferation of the wall. As they expand, resorption of bone occurs until they attain large sizes or even perforate through the cortex. Benign odontogenic tumors are also characterized by imaging findings of expanding growth. They usually grow slowly with interaction between the tumor and surrounding bone. When the tumor grows slowly, it exerts pressure on neighboring structures resulting in displacement of cortices. The outer cortex remodels in response to pressure due to simultaneous endosteal resorption and deposition of bone along the outer cortex by periosteum **[4,5]**. The lesion may appear lobulated because of differences in the rapidity of growth at each margin **[6]**. You need also to look for buccolingual expansion of the lesion to reach the diagnosis **[7]**.

In our series, 83% of malignancies didn't demonstrate any bone expansion. This is in agreement with the patterns of cancer spread through the mandible described in the literature. Cancer causes bone destruction rather than expansion. It is well recognized that there are two patterns of tumor invasion of the mandible by oral squamous cell carcinoma **[8,9]**. In the infiltrative (also termed invasive) pattern, fingers and islands of tumor advance independently into the cancellous spaces without expansion, with little osteoclastic activity and no intervening layer of connective tissue. In the erosive (also termed arrosive) pattern, the tumor advances on a broad front with a connective tissue layer and active osteoclasts separating the tumor from the bone.

Other forms of malignancies such as odontogenic carcinoma, malignant ameloblastoma, and sarcomas may be expansile **[10]**. The only two expansile malignant lesions within our series were due to Ewing's sarcoma and neuroblastoma metastatic to the jaw.

Some lesions grew in the buccolingual direction longer than in the mesiodistal direction, while other lesions behaved oppositely. This finding was of interest to the investigators as it was also described in the literature. Yoshiura et al., presented a morphologic analysis of odontogenic cysts by CT **[6]**. The authors stated that cysts arising in the maxilla showed typical radiologic features, whereas the shape of cysts arising in the mandible was modified by the thick buccolingual cortices and, in general, the mesiodistal diameter was greater than the buccolingual diameter. In our series the pattern of expansion could be demonstrated by calculating the ratio of the buccolingual over the mesiodistal dimensions of lesions. It was defined as the expansion ratio. The expansion ratio is a new term suggested by the investigators as we didn't find any similar ratio in the literature. The ratio equals 1 when expansion is the same in each direction. In our study, upper jaw lesions showed a higher expansion ratio (mean=1.12±0.54) than did lower jaw lesions (mean=0.66±0.39), or in other terms upper jaw lesions demonstrated more expansion in the buccolingual than in the mesodistal directions, while lower jaw lesions did the opposite possibly due to thick buccal and lingual cortices

which may have stopped expansion in their direction to some extent (in agreement with the analysis of Yoshiura et al. [7]. A cutoff point of 0.8 was optimum to compare upper jaw versus lower jaw lesions and neoplastic versus non-neoplastic ones with statistical significance. The pattern of expansion, although not extensively analyzed, seems to be an interesting subject for further research.

With reformatted dental CT, bone expansion could be easily appreciated in all directions especially in the vertical plane. In the buccolingual or mesiodistal directions, axial images were enough in most occasions being only confirmed when visualized in multiplanar views.

Diverse disease entities may cause expansion of the maxilla. Malignant tumors of the maxillary sinus and benign conditions including fibroosseous diseases, mucocele, and various odontogenic cystic lesions may present with expansile maxillary masses. Cystic expansile maxillary lesions (mostly benign) usually result in bowing of their cortical boundaries including the maxillary sinus or the nasal floor [11].

In our series, all fibro-osseous lesions and 63% of benign tumors of the maxilla resulted in sinonasal bowing, while lesions that grow faster (inflammatory and malignant) didn't expand (but erode) the walls of the maxillary sinus. Again it is the rate of growth that determines how the cortical plate responds to the pressure effect of the lesion. But this finding also implies another importance of careful identification of the cortical bone plate between the lesion and the maxillary antrum which is to distinguish antral from extra-antral lesions. A maxillary mucocele or retension cyst may sometimes be diagnosed as an odontogenic cystic lesion and vice versa. Han et al., described CT findings of 28 benign expansile maxillary masses, 8 of them were odontogenic. The authors concluded that identifying the thin cortical bony plate (and the mode of expansion) between the lesion and the antrum is very important to localize the exact site of origin which helps in the differential diagnosis [12].

Conclusion:

Bone expansion was found to be a useful feature that should be evaluated by dental CT when a jaw lesion is under investigation. Malignant lesions rarely expand the jaw while benign lesions may do. The ratio of expansion is an interesting parameter that can be applied with positive impact on the diagnosis. Further research is needed to assess other forms of jaw bone expansion.

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