Diffusion-weighted Magnetic Resonance Imaging of Sinonasal Masses: Does Bone Erosion or Destruction Alter the Apparent Diffusion Coefficient Value in Differentiating Benign from Malignant Masses?

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ABSTRACT

Objective: Detect whether bone erosion or destruction alters the ADC value while
discriminating benign from malignant sinonasal masses.

Patients and methods: Twenty five patients were investigated and operated upon in this study. Preoperative CT scans and diffusion weighted MRI imaging were done within 48 hours prior to surgery. Surgical procedures were done in the form of complete resection or biopsy taking. The ADC values were calculated for sinonasal lesions associated with bone erosion or destruction detected on CT scanning.

Results: Histopathological diagnosis revealed benign masses in 44% and malignant tumors in 56% of biopsies. No significant differences between mean ADC values of the first and second ROI in both benign (P value =0.365) and malignant masses (P value =0.07). Statistical significant difference was found between the ADCL values of benign and malignant sinonasal masses. (P value =0.044).

Conclusions:
Bone erosion or destruction does not alter the ADC value in differentiating between benign and malignant masses. ADC value does not change with bone erosion or destruction.

Introduction:

Development of the technique of MRI has led to the use of diffusion-weighted imaging in screening of various body parts and diagnosing different lesions [1-4]. A great benefit of DWI in diagnosing neoplasms is that DWI reveals the biological character of the tissue [5]. Sinonasal tumors are of low incidence. However, they typically have poor prognosis owing to their early extension to the surrounding structures, most importantly, intracranial extension [6]. A wide variety of both benign and malignant sinonasal tumors have been recorded. Differentiation between benign and malignant tumors is essential for the treatment plan. CT and conventional MRI (cMRI) are mainly used to diagnose sinonasal tumors. MRI is more useful for soft tissue characterization, whereas CT is better to assess bone involvement. Both provide useful information about tumor extension but they are lacking sensitivity and accuracy as they depend on volumetric and morphological criteria [7,8]. So, it is not always easy to differentiate between benign and

malignant lesions [9-11]. Diffusion-weighted imaging (DWI) and ADC value are used to reflect tissue cellularity. Therefore, they were found to be useful in discrimination between benign and malignant neoplasms [12-15]. Many authors reported that the mean ADC value of benign solid lesions was significantly higher than that of malignant tumors [12,16]. In sinonasal tumors, however, bone erosion and destruction are associated not only with malignant lesions but also with some benign lesions [17]. Therefore, this study was designed to identify whether bone erosion or destruction alters the ADC value while discriminating benign from malignant sinonasal masses.

Materials and Methods:

Patients:

Patients presented clinically with sinonasal tumors were scanned using low dose multidetector CT. Only patients having sinonasal mass with bone erosion or destruction were included. Therefore a total number of 25 patients (17 males and 8 females) were enrolled in this study.

CT protocol:

Patients were scanned using spiral 16 multi-detectors CT in axial section from the top of the frontal sinus till the end of the hard palate. Parameters were used: 120 KV, 40 mAs, 2.5mm collimation, 3-mm slice thickness, 1.2-mm reconstruction increment, and a pitch of 1.

MRI protocol:

Patients were scanned using 1.5 Tesla MRI scanner. They were examined in supine position with standard polarized head coil. Routine MRI was performed using the following sequences: Spin echo axial T1-weighted imaging (TE/ TR: 650/12 ms), axial and coronal T2-weighted imaging (TE/TR: 4800/98 ms) with slice thickness of 5 mm and inter-slice gap of 1.5 m. The field of view (FOV) used was 190 x 190 mm and matrix size of 320 x 320. After intravenous administration of Gadolinium -DPTA (Gd), contrast enhanced T1WI in axial and coronal planes were obtained in 21 patients. DWI was then performed on axial scans using single shot echo planner spin echo (EPI). The following parameters were used: (TE/TR: 6800/98 ms), with slice thickness of 5mm and inter-slice gap of 1.5 mm. The field of view (FOV) used was 250 x 250 mm and matrix size of 192 x 192.

Diffusion gradient encoding was performed in three orthogonal planes (X, Y, Z). Three b- factors (0-400-800) were obtained. ADC maps were then generated. In each patients, two regions of interest (ROI) were selected, the first ROI was drawn at the area of bone erosion or destruction, whereas the second was drawn at the area recorded the lowest ADC value in the lesion, away from the area of bone destruction. For each patient, the lowest ADC reading, whether that of the first or the second ROI has been selected to represent the mean ADC of the lesion (ADCL).

Histopathological data:

Histopathological diagnosis was obtained either by biopsy or after surgical resection.

Statistical analysis:

Data analysis was performed using SPSS statistical software package. Non-parametric Mann- Whitney U tests were used to evaluate the statistical difference between ADCL values of benign and malignant masses. Then, for each of benign and malignant masses, statistical differences between the ADC values of the selected two ROIs were calculated. P-values less than 0.05 were considered significant.

Results:

Our study populations consisted of 25 patients (17 males and 8 females). Age ranged from 13 to 58 years. On the basis of histopathological diagnosis, sinonasal masses were divided into benign masses 44% and malignant tumors 56%. The

distribution of pathology is shown in (Table 1)

For both benign and malignant lesions:
The mean ADCL value of benign sinonasal lesion was $1.14 \pm 0.41 \times 10^{-3}$ mm^2/s, whereas the mean ADC of malignant sinonasal lesion was $0.87 \pm 0.31 \times 10^{-3}$ mm^2/s. Statistically significant difference was found between the ADCL values of benign and malignant sinonasal masses. (P value =0.044) (Figure: 1).

In benign sinonasal masses:
The mean ADC value of the first ROI was $1.18 \pm 0.45 \times 10^{-3}$ mm^2/s., whereas the mean ADC of the second ROI was $1.35 \pm 0.43 \times 10^{-3}$ mm^2/s. No significant differences were found between mean ADC values of the first and second ROI (P value =0.365). (Figure: 2).

In Malignant sinonasal tumors:
The mean ADC value of the first ROI was $0.98 \pm 0.36 \times 10^{-3}$ mm^2/s, whereas the mean ADC of the second ROI was $1.22 \pm 0.35 \times 10^{-3}$ mm^2/s. No significant differences between mean ADC values of the first and second ROI were found (P value =0. 07) (Figure: 3).

Table (1): showing the final histopathological diagnosis of 25 patients.

Pathology	Number	
Inflammatory polyps	4	
Inverted papilloma	2	
Mucocele	3	**Benign**
Juvenile psammomatoid ossifying fibroma	1	
Juveniles angiofibroma	1	
Squamous cell carcinoma	9	
Non – Hodgkin lymphoma	3	
Olfactory neuroblastoma	1	**Malignant**
Adenocarcinoma	1	
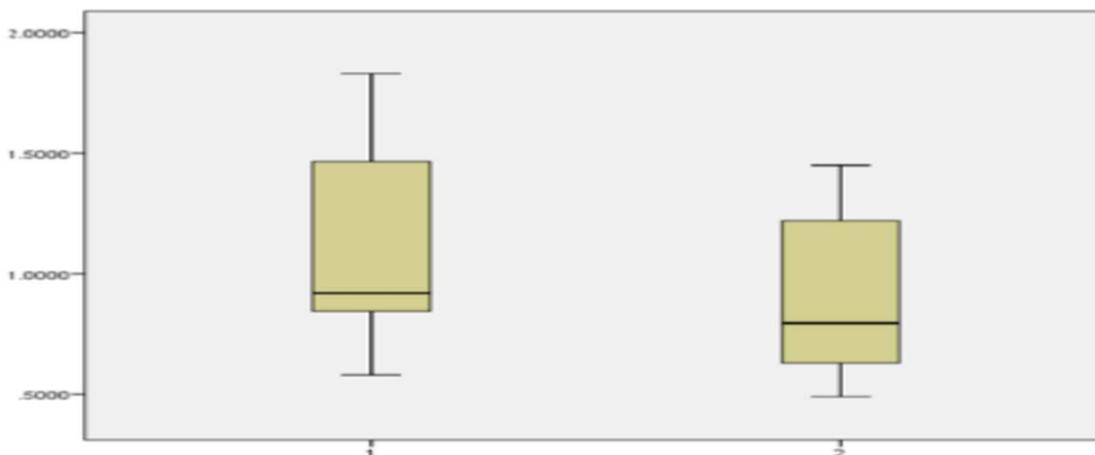
Fig. 1: Box plots comparing the mean ADCL values of 1) benign and 2) malignant sinonasal tumors. The horizontal thick line is the median, and the vertical lines show the full range of values in the data. ADCL of malignant neoplasm was significantly lower than that of benign lesions. (P value =0.044).
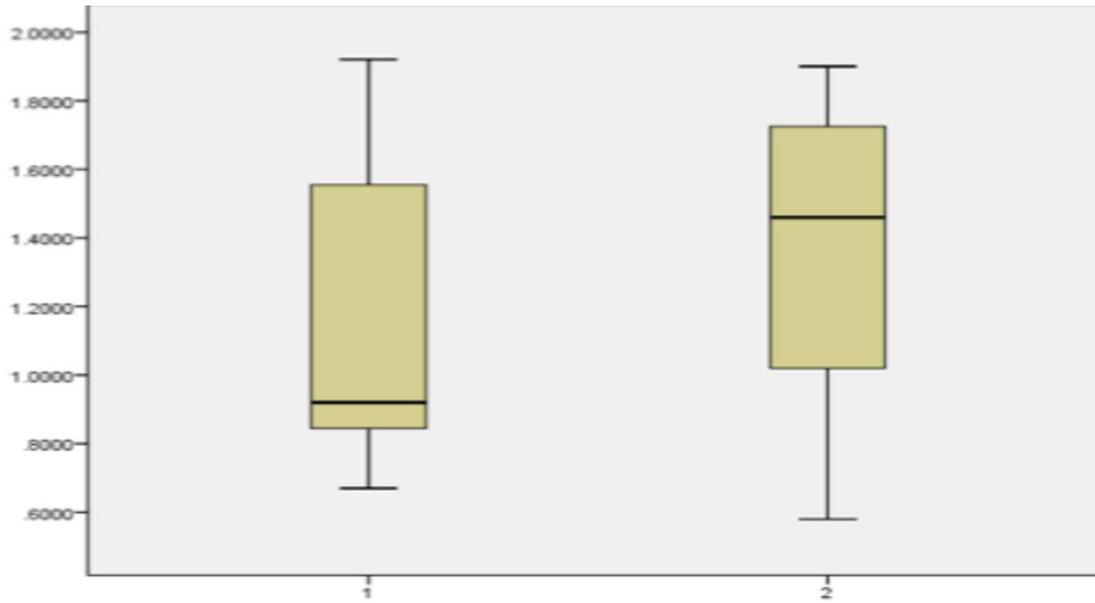
Fig. 2: Box plots comparing the mean ADC values of 1) the first ROI and 2) the second ROI of benign sinonasal tumors. The horizontal thick line is the median, and the vertical lines show the full range of values in the data. No significant difference was found between the ADC values of the two ROIs.
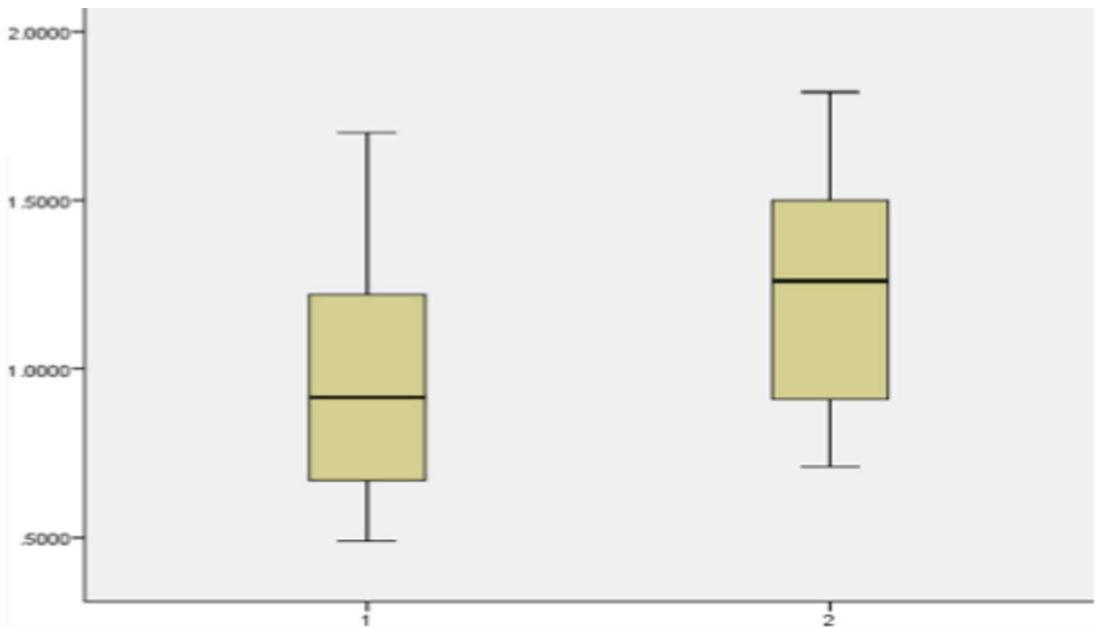
Fig. 3: Box plots comparing the mean ADC values of 1) the first ROI and 2) the second ROI of malignant sinonasal tumors. The horizontal thick line is the median, and the vertical lines show the full range of values in the data. No significant difference was found between the ADC values of the two ROIs.
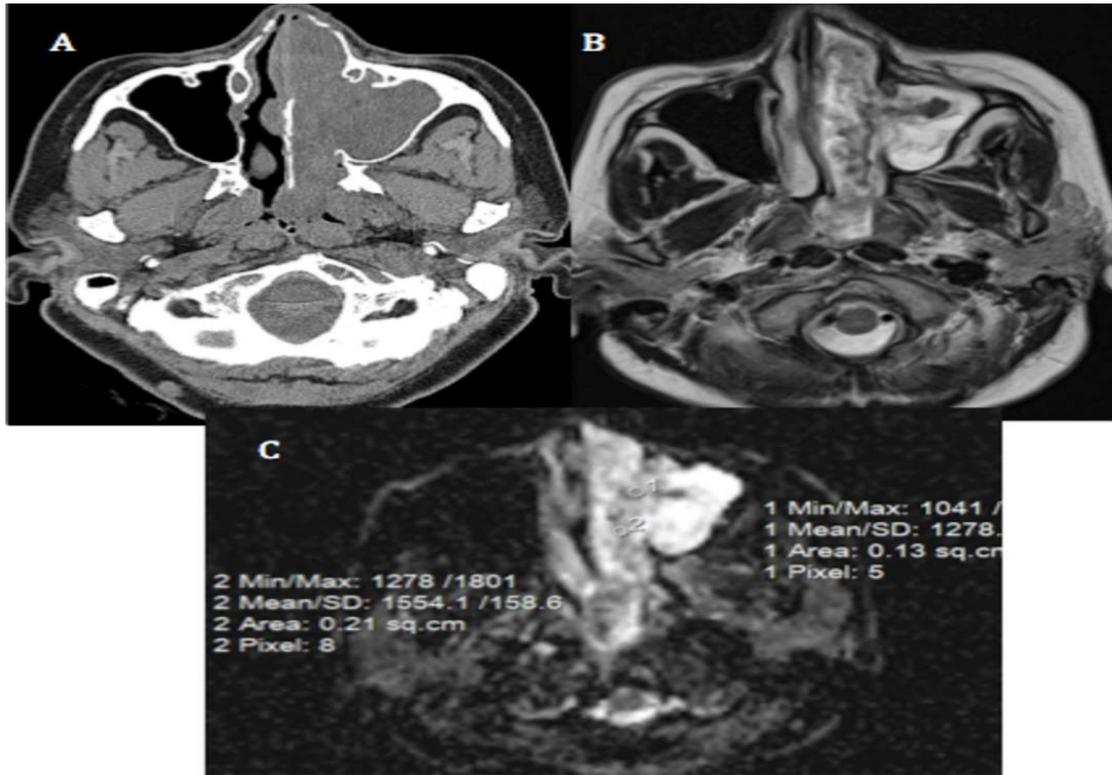
Fig. 4: Inflammatory polyp. A) Axial CT shows polypoidal thickening involving the left nasal cavity and left maxillary sinus associated with bone remolding of the upper nasal septum and left maxillary sinus. B) Axial T2WI shows polypoidal thickening in the left nasal cavity extending to the left maxillary sinus with retained maxillary secretion, eliciting high SI. C) Axial ADC map shows the ADC value of the first ROI (at the area of bone remolding) =1.2x10-3 mm2/s, whereas the mean ADC value of the second ROI =1.5 10-3 mm2/s.
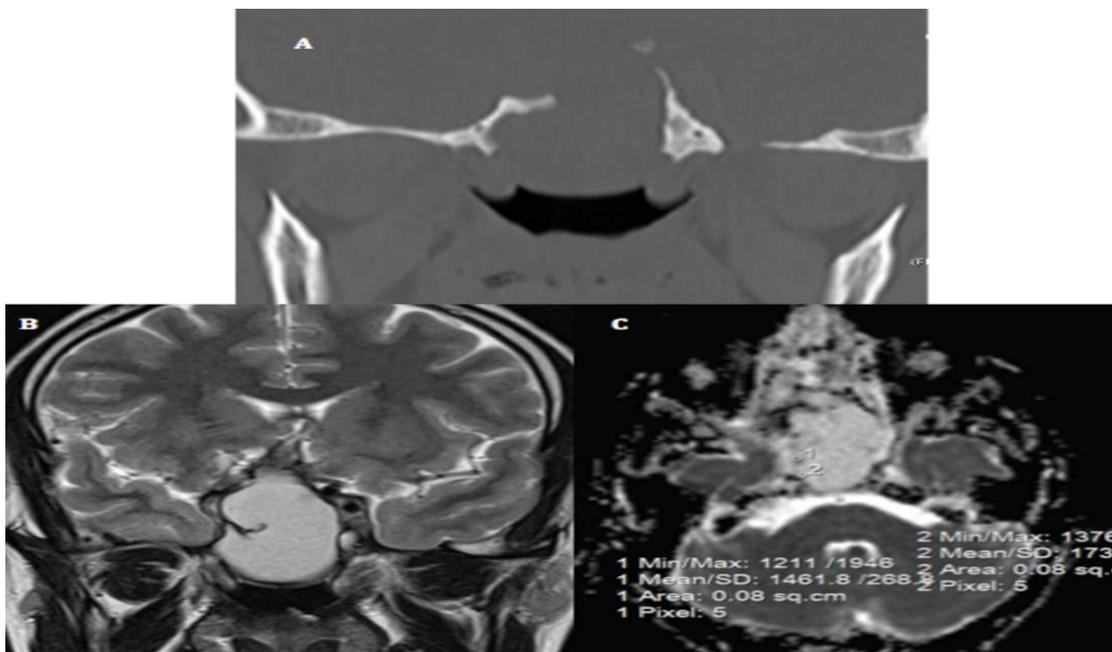
Fig. 5: Sphenoid sinus mucocele. A) Coronal CT and B) Coronal T2WI show large mucocele filling and expanding the sphenoid sinus associated with destruction of the sphenoidal sinus wall. C) Axial ADC map shows the mean ADC value of the first ROI =1.4x10-3 mm2/s, whereas the mean ADC value of the second ROI =1.7 10^{-3} mm^2/s.

Discussion:

It is possible to observe similar radiological findings for benign and malignant sinonasal lesions as some benign tumors extend into surrounding structures while some malignant tumors are slowly growing. Therefore; their distinction may be difficult and unreliable as their appearance using CT and cMRI of these lesions is not pathognomonic and distinction is necessary for detecting prognosis and planning treatment [6,9,10 & 18-22].

Magnetic resonance imaging is a fundamental tool in the diagnosis of sinonasal lesions as it distinguishes normal and inflamed soft tissues and differentiates between these tissues and tumor better than computed tomography. MRI is often used in combination with CT to precisely delineate the extent of these neoplasms [23]. Involvement of the skull base, the orbits, the intracranial compartment, and potential perineural spread of tumor can influence treatment options. For this reason, Magnetic resonance is essential to evaluate these tumors as they are often advanced and difficult to treat at the time of diagnosis because of the complex anatomy of the sinonasal region and its proximity to the previously mentioned critical structures [24].

The biophysical mechanism of DWI is based on the microscopic random translational motion of water molecules in biological tissues. The magnitude of this motion is characterized by its apparent diffusion coefficient (ADC) values. Variation in ADC values reflects the alteration and redistribution of water molecules between intracellular and extracellular compartments of a tissue [25]

In the current study, the mean ADC value of malignant sinonasal lesions was significantly lower than that of benign lesions (P= 0.04). The lower ADC value of the malignant tumors is mainly due to high tumor cellularity and reduced water content in the interstitial space [12,15,26]. In agreement with our results, Razek et al. [11] reported a significant difference between mean ADC values of benign and malignant paranasal masses. They further found a significant difference between ADC values of different grades of malignant tumors.

Malignant lesions of the nasal cavity are rare, but the similar clinical features of the benign and malignant lesions in the beginning may delay the diagnosis. [27]. In sinonasal imaging, the general rules are that benign tumours cause remodelling and thickening of adjacent bone, while malignant tumours destroy the bone [28]. Inflammatory diseases could cause destruction and erosions of the organ that resemble that caused by malignant lesions and may be misdiagnosed. [27,29].

On the other hand, some malignant tumours remodel bones rather than destroy it; e.g. sinonasal sarcomas, minor salivary gland carcinomas, extramedullary plasmacytomas, large cell lymphomas, olfactory neuroblastomas and hemangiopericytomas [28].

Our study revealed that, bone erosion or destruction does not alter the ADC value in differentiating between benign and malignant masses. As there were no significant difference between the mean ADC values between the first and the second ROI in both benign and malignant masses.

Conclusion

ADC value is a useful quantitative parameter to differentiate between benign and malignant sinonasal masses and its value does not change with bone erosion or destruction.

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