Original Article

# Relationship between maxillary sinus findings, Schneiderian membrane thickness, and various skeletal malocclusions in a selected sample of ethnic Kashmiri population: A retrospective cone-beam computed tomography study


## ABSTRACT

**Objective:** There are very limited studies which have investigated the relationship between maxillary sinus findings and skeletal malocclusion based on cone-beam computed tomography (CBCT). The objectives of this study were to determine the relationship between the patients' skeletal malocclusion and the maxillary sinus findings in ethnic Kashmiri population.

**Materials and Methods:** A total of 45 CBCT scans were examined and divided into three groups according to skeletal classification. Two experienced observers reviewed the CBCT images and recorded all maxillary sinus findings. The patients' skeletal malocclusion, the thickness of the Schneiderian membrane, and the pathologic maxillary sinus findings were evaluated.

**Results:** The maxillary sinus findings were classified into five groups: 0 = no finding, 1 = mucosal thickening, 2 = polypoidal thickening, 3 = partial opacification, and 4 = total opacification. The statistical analysis showed that there was no correlation between the skeletal malocclusion and pathological maxillary sinus findings. However, there were significant differences in the Schneiderian membrane thicknesses between the groups.

**Conclusion:** The Schneiderian membrane thickness was significantly different for Class II and Class III patients ($P = 0.002$). It was lowest for Class II and highest for Class III group. The relationship between pathological maxillary sinus findings and skeletal malocclusions was statistically insignificant ($P > 0.05$).


**Keywords:** Cone-beam computed tomography, maxillary sinus, Schneiderian membrane, skeletal malocclusion

## INTRODUCTION

Cone-beam computed tomography (CBCT) is used for three-dimensional imaging in orthodontics. It provides detailed and essential data about dentomaxillofacial structures. CBCT has very low effective radiation doses (80–100 μSv) as compared to computed tomography (CT) (860–1500 μSv).[1] This advantage makes CBCT an appropriate imaging technique. Radiographs produced for orthodontic purposes contribute to the radiation burden in young adults.[2] The as low as reasonably achievable (ALARA) principle may be satisfied by selecting the ideal imaging system and the smallest field of view (FOV).

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**Received:** 01-Jul-2020 **Revised:** 14-Aug-2020
**Accepted:** 30-Nov-2020 **Published:** 19-Jan-2021

| Access this article online | |
|---|---|
| **Website:** www.orthodrehab.org | Quick Response Code |
| **DOI:** 10.4103/ijor.ijor_29_20 | |




**How to cite this article:** Akhoon AB, Mushtaq M, Akhoon ZA. Relationship between maxillary sinus findings, Schneiderian membrane thickness, and various skeletal malocclusions in a selected sample of ethnic Kashmiri population: A retrospective cone-beam computed tomography study. Int J Orthod Rehabil 2020;11:151-6.

The ALARA principle is a radiation safety principle for minimizing radiation doses. Data on the frequency of incidental findings related to maxillary sinus with CBCT imaging are limited in the orthodontic literature. Patel *et al*.[3] reported the prevalence of mucosal thickening as 27% and the prevalence of cystic lesion occurrence as 9% for maxillary sinus. Cha *et al*.[4] evaluated 500 CBCT scans and concluded that the ratio of incidental findings for orthodontic patients was 24.6%. The second highest prevalence was observed for maxillary sinuses in a study performed with magnetic resonance imaging (MRI).[3] Symptoms such as nasal congestion, nasal discharge, nasal purulence, and nasal obstruction are seen in sinus pathologies such as rhinosinusitis or sinusitis.[5] Several etiologic factors such as incorrect breathing patterns and airway obstructions may contribute to the development of malocclusions.[6] Abnormal breathing in a growing child can reveal problems with craniofacial growth, such as vertical facial pattern and skeletal Class II malocclusion as reported by Agren *et al*.[7] The retrognathic mandible induces the backward position of the tongue and hyoid bone that can lead to a reduction in the upper airway volume.[8] Signs of inflammation, obstruction, or acute infection in the maxillary sinus are relevant when a dentist or orthodontist plans orthodontic treatment or during execution of the treatment.[9] Very rarely studies have evaluated the relationship between skeletal malocclusions and maxillary sinuses on CBCT scans. Therefore, the objectives of our study were (i) to analyze the Schneiderian membrane thickness (the thickness of the lower part of the sinus membrane) and sinus pathologies and (ii) to determine whether there is a correlation between skeletal malocclusions and maxillary sinus findings.

### Aims and objectives

The aim of the study was:

1. To find the relationship between malocclusion and the maxillary sinus
2. To know how does the malocclusion already present affect the maxillary sinus findings, namely pathological findings and Schneiderian membrane thickness.

## MATERIALS AND METHODS

The data for the study were obtained from CBCT scans taken as part of orthodontic diagnosis and treatment planning in the Department of Orthodontics and Dentofacial Orthopaedics of our college ($n$ = 75). The study protocol was approved by the Ethical Committee of the institution (No. GDC/perio/938). Data presenting cleft lip and palate were excluded from the study ($n$ = 7). In addition, poor quality scans of the mandible only or only the upper jaw without the maxillary sinuses were excluded from the study ($n$ = 23). Thus, a total of 45 CBCT scans for 45 patients were eligible for further evaluation.

### Inclusion criteria

1. No craniofacial disorders
2. No symptoms of maxillary sinus pathology
3. No history of sinusitis or allergic rhinitis
4. Patients selected for the sample were in the age range of 19–37 years.

### Exclusion criteria

1. Data presenting cleft lip and palate
2. Poor quality scans of the mandible only or only the upper jaw without the maxillary sinuses were excluded from the study
3. Patients under 18 years of age were excluded because maxillary sinus development occurs up to 18 years of age
4. Patients referred for a CBCT scan of the maxillary sinus because of sinus symptoms or suspected diseases
5. Images of low-resolution quality and those in which the presence of metallic artifacts impaired sinus visualization were excluded from the study.

The CBCT scans were divided into three groups according to the skeletal malocclusions: Classes I, II, and III. Each group consisted of 15 patients. The mean age of the patients was 28.5 ± 4.7 years. Gender classification revealed more women ($n$ = 26) than men ($n$ = 19).

All CBCT images were taken using a small FOV (8 cm × 5 cm FOV; NewTom Giano Volume Scanner, CBCT unit, at, 90 kV, and 2 mA). The data were reconstructed in 1:1 scaled slices and examined slice by slice in all three planes with the help of the New Net Technologies software (CEFLA S.C. - CEFLA DENTAL GROUP Via Bicocca 14/C 40026 Imola (BO) Italy). When needed, a magnifier and the ruler tool of the viewer were used.

Two observers reviewed all CBCT scans independently. The reviewers checked and recorded all sinus findings and determined the patients' skeletal malocclusions via CBCT scans (according to the Steiner analysis and Wits appraisal done on the lateral ceph image and the sagittal view image of the CBCT sample). The pathological findings were classified into the following categories as described by Pazera *et al*.:[10] 0 = no finding, 1 = mucosal thickening, 2 = polypoidal thickening, 3 = partial opacification, and 4 = total opacification. The two reviewers agreed in 41 of the 45 cases, which resulted in inter-rater classification agreement higher than 90%.

The Schneiderian membrane thickness was recorded at three representative positions (a, b, and c) in the coronal plane. The distance b was measured at the deepest point of the recess of the maxillary sinus. The distances a and c were measured 3 mm buccally and palatally based on line b [Figure 1].

### Statistical analysis

The significance level for all tests was $P < 0.05$. All statistical analyses were performed with software Statistical Package SPSS (version 20.0, 233 South Wacker Drive, 11th Floor Chicago, Illinois 60606-6307, U.S.A). There were significant differences between Group II and Group III for the membrane thickness [Table 1]. The relationship between pathological maxillary sinus finding and malocclusion was statistically insignificant [$P > 0.05$, Table 2]. Analysis of variance was done to compare the means of the membrane thicknesses of the three groups. It showed that there was a significant difference in the mean values of the three groups [$P = 0.002$; Table 3]. *t*-test was done to see the level of significance between two groups, i.e., between Classes I and II, between Classes II and III, and between Classes I and III [Table 4].

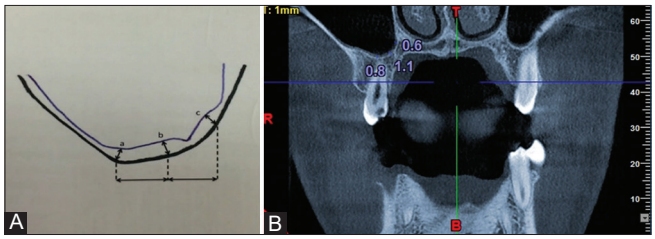


**Figure 1: (A) Measurement of the thickness of the Schneiderian membrane at three locations on a schematic coronal view of the maxillary sinus: 3mm to the facial and palatal side(a and c), the deepest point of the recess of the maxillary sinus(b). (B) Figure showing the three measurements at the three locations**

**Table 1: Schneiderian membrane thickness for various groups**

| Group | *n* | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| I | 15 | 0.967 | 0.32 | 0.47 | 1.63 |
| II | 15 | 0.778 | 0.28 | 0.40 | 1.43 |
| III | 15 | 1.33 | 0.56 | 0.47 | 2.47 |

SD: Standard deviation

## RESULTS

The mean membrane thickness was calculated for each patient, and the mean overall membrane thickness was calculated for each group [Table 1 and Figure 2]. There were significant differences between Group II and Group III. The lowest value of membrane thickness was found in Group II (mean = 0.778) and the highest value was in Group III (mean = 1.33), and for Group I, it was within average (mean = 0. 967).

Table 2 shows the prevalence of pathological findings in the various groups. In all groups, only partial opacification had the highest percentage. The highest percentages of mucosal thickening and partial opacification were in Group III. The highest percentage of polypoidal thickening was seen in Group II, which may be attributed to the upper airway impairments mostly associated with Class II malocclusions. The relationship between pathological maxillary sinus finding and malocclusion was statistically insignificant ($P > 0.05$).

## DISCUSSION

The aim of this study was to determine the relation between skeletal malocclusion and maxillary sinus findings. Four types of pathological maxillary sinus findings were observed: flat mucosal thickening, polypoid mucosal thickening, partial

**Table 2: Pathological finding percentages in maxillary sinuses in the various groups**

| | Group I (*n*=15) | Group II (*n*=15) | Group III (*n*=15) | Total (*n*=45) | *P** |
|---|---|---|---|---|---|
| No finding | 0 | 1 (6.7) | 1 (6.7) | 2 (4.4) | 1.000 |
| Mucosal thickening | 11 (73.3) | 9 (60.0) | 13 (86.7) | 33 (73.3) | 0.316 |
| Polypoidal thickening | 1 (6.7) | 5 (33.3) | 4 (26.7) | 10 (22.2) | 0.280 |
| Partial opacification | 13 (86.7) | 12 (80.0) | 13 (86.7) | 38 (84.4) | 1.000 |
| Total opacification | 4 (26.7) | 2 (13.3) | 0 (0.0) | 6 (13.3) | 0.141 |

*Statistically insignificant ($P>0.05$)

**Table 3: ANOVA test for comparing the means of the membrane thicknesses of the three groups**

| Source of variance | Degrees of freedom (df) | Sum of square deviations SS | Means square MSS | $F_{calculated}$ $f_{cal}$ | $F_{table}$ $f_{tab}$ (from the f-ratio table) | Significant |
|---|---|---|---|---|---|---|
| Between groups | $df_B$=(k-1) =3-1 =2 | $SS_B$=($SS_T$− $SS_W$)=(9.376-7.016)=2.36 | $MSS_B$=$SS_B$/ $df_B$=2.36/2=1.18 | $f_{cal}$=$MSS_B$/$MSS_W$ =1.18/0.167 =7.066 | $f_{tab}$=$df_B$ (x-axis)/$df_W$ (y-axis) =2/42 (intersect) =3.22 | 0.002* |
| Within groups | $df_W$=(N-k) =45-3 = 42 | $SS_W$=7.016 | $MSS_W$=$SS_W$/ $df_W$=7.016/42=0.167 | | | |

$f_{cal} > f_{tab}$ at $\alpha$=0.05 level of significance, thus indicating at least one difference among the mean values of the three groups. *Statistically significant ($P<0.05$). MSS: Mean square slope

**Table 4: *t*-test**

| Class | *n* | Mean | SD | SEM | Significant |
|---|---|---|---|---|---|
| 1 | 15 | 0.967 | 0.32 | 0.082 | 0.09 |
| 2 | 15 | 0.778 | 0.28 | 0.073 | |
| 2 | 15 | 0.778 | 0.28 | 0.073 | 0.002* |
| 3 | 15 | 1.33 | 0.56 | 0.145 | |
| 1 | 15 | 0.967 | 0.32 | 0.082 | 0.038* |
| 3 | 15 | 1.33 | 0.56 | 0.145 | |

*Statistically significant ($P<0.05$). SD: Standard deviation, SEM: Standard error of mean

opacification, and total opacification [Figures 3 and 4]. The season during which the CBCT scans were performed may have affected the development of maxillary sinus pathologies. One may expect to find higher frequencies in winter or autumn. However, according to Pazera *et al*.,[10] seasons do not affect the frequency of maxillary sinus pathologies. The researchers also reported that maxillary sinus findings are not related to gender.

Researchers who performed CT imaging confirmed the high prevalence of incidental findings without clinical symptoms. Havas *et al*.[11] reported that a radiologic abnormality in paranasal sinuses occurred in up to 42.5% of CT scans of asymptomatic patients. Another study reported that patients presenting with symptomatic sinus are more likely to have positive sinus CT findings compared with asymptomatic patients.[12] In our study, we did not consider the clinical history of the scanned patients because it has been previously revealed that there is a weak correlation between radiologic airway findings and clinical symptoms.

Studies using CT and MRI revealed that the coronal view is appropriate for evaluating the mucosal thickness in the maxillary sinus. The measurements were always performed perpendicular to the underlying bone.[13,14] Two millimeters is an applicable threshold for pathological swellings.[15] Our results confirmed the great interindividual variability related to the Schneiderian membrane thickness, with values ranging from 0.40 to 2.47.

No signs of osteomyelitis or bone malignancy were observed in our study. However, these kinds of pathologies with a low incidence rate can be present in a patient group. A case of Ewing's sarcoma in a young female patient was revealed by Bornstein *et al*.[16] whose CBCT examination showed the proliferation of soft tissue in the maxillary sinus.

There was a significant difference in the membrane thickness between the Class II and Class III groups in our study, meaning that the malocclusion might trigger changes in the maxillary sinus membrane thickness. The lowest value for the membrane thickness was recorded in the Class II malocclusion

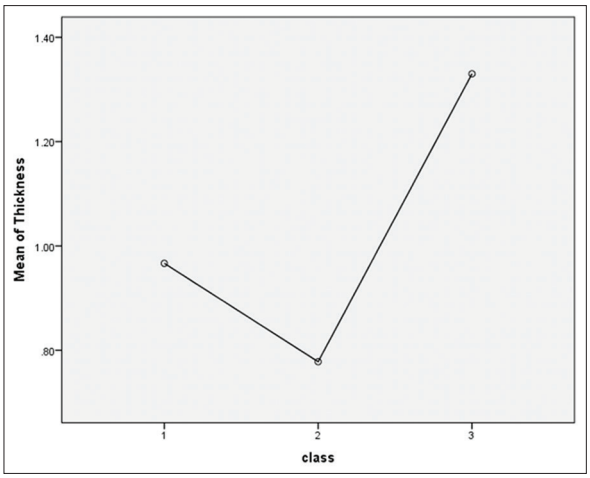


**Figure 2: Mean membrane thickness for the different malocclusion groups**

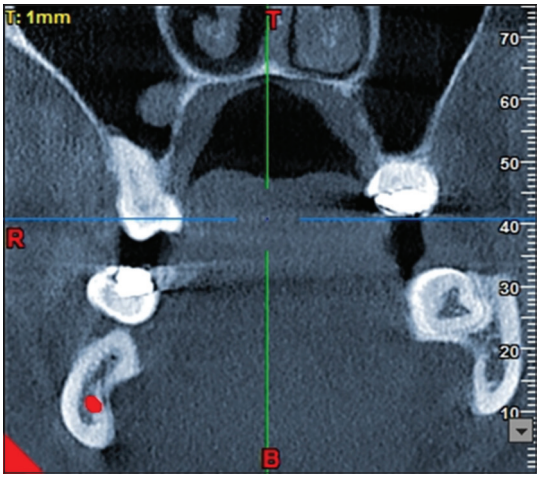


**Figure 3: An example of polypoidal mucosal thickening**

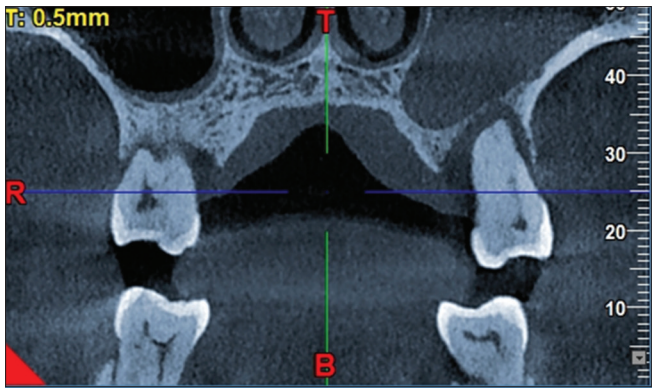


**Figure 4: Complete opacification of the left maxillary sinus and partial opacification of the right sinus**

group. These patients may present more respiratory problems caused by the backward mandibular position. Nunes and Di Francesco[17] stated that adenoid and tonsil enlargements are more often seen with Class II malocclusion; this causes less passage of air through the nasal cavity, less functioning of the nasopharynx, and results in less development of the maxillary

sinus with decreased membrane thickness.[18] Class II patients have increased craniofacial angle, are usually dolicofacial with weak musculature and low masticatory forces, and have narrow palate. The low masticatory forces result in thin maxillary bone with less development of maxillary sinus and decreased membrane thickness. Class III patients have decreased craniofacial angle, are usually brachyfacial with high masticatory forces and greater development of maxillary sinus, and have increased membrane thickness.[19]

Aksakalli *et al*.[20] did a study to investigate the relationship between maxillary sinus findings and skeletal malocclusion based on CBCT. The objectives of this study were to determine the relationship between the frequency of sinus findings and patients' skeletal malocclusion classification. A total of 105 CBCT scans were examined and divided into three groups according to skeletal classification. Two experienced observers reviewed the CBCT images and recorded all maxillary sinus findings. The patients' skeletal malocclusion, the thickness of the Schneiderian membrane, and the pathologic sinus findings were evaluated.

The sinus findings were classified into four groups: 0 = no finding, 1 = mucosal thickening, 2 = partial opacification with liquid accumulation, and 3 = total opacification. The statistical analysis showed that there was no correlation between the skeletal malocclusion and pathological sinus findings. However, there were significant differences in the Schneiderian membrane thicknesses between the groups. The Schneiderian membrane thickness was significantly different for Class II and Class III patients. There was no relationship between pathological sinus findings and skeletal malocclusions.

Al-Ghurabi[21] did a study to shade light on the role of CBCT diagnosis of the maxillary sinus anatomical variation and pathological finding among smokers and nonsmokers before maxillary sinus lift techniques. The study concluded that CBCT was the most useful technique to diagnose maxillary sinus before maxillary sinus augmentation. An evaluation of CBCT scans before implant surgery or sinus augmentation procedures has extreme clinical importance in evaluation of anatomic structures, such as thickening of the Schneiderian membrane and presence of pathological lesion such as adenoid polyp.

## CONCLUSION

Within the limitations of this study, it can be concluded that there is no relation between the pathological maxillary sinus findings and skeletal malocclusion. The Schneiderian membrane thickness recorded between the three malocclusion groups was different, and the difference in their means was statistically significant. Therefore, a relationship was found between skeletal malocclusion and incidental maxillary sinus findings, and it can be concluded that malocclusion triggers changes in the maxillary sinus membrane thickness and does not affect the prevalence of incidental pathological sinus findings.

### Financial support and sponsorship

Self.

### Conflicts of interest

There are no conflicts of interest.

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