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Morphometric Description of Temporomandibular Joint (TMJ) Using Cone Beam Computed Tomography (CBCT)

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ABSTRACT
Objectives: To study the morphology of mandibular condyle by assessing parameters like size, shape, articular eminence height, superior joint space, thickness of Roof of Glenoid Fossa (RGF) and the presence of erosions and osteophytes using Cone Beam Computed Tomography (CBCT) in patients with temporomandibular disorders (TMD) and to make a comparative evaluation of these parameters in patients who do not have a history of TMD.
Methods: Thirty-six Temporomandibular joint (TMJ) CBCT volumes from archived data over a period of six months were studied in various planes. Information regarding the study variables were compared with TMJ volumes of patients clinically and radiographically diagnosed as TMD.
Results: Among the Non-TMD patients, the commonly found shape was *convex*, and among the TMD patients, the commonly found shape was *flat*. The medio-lateral condylar width was significantly reduced among the TMD patients. There was no significant difference among the values obtained for articular eminence height and thickness of RGF in both sets of patients. Erosive changes of condyle were seen in sixteen patients while osteophyte were seen only in four patients.
Conclusion: Variations in size and shape of condyle, articular eminence height, superior joint space, thickness of RGF and presence of osteophytes and erosions were identified in cases with TMD. The results of this study were promising and would definitely help in the proper diagnosis and management of TMD.

Keywords: CBCT, Degenerative Joint Diseases, TMJ

INTRODUCTION

Temporomandibular joint is a diarthrodial joint which comprises of mandibular bone, temporal bone and articular disc and is regarded as one of the most complex joints of the body. Complex etiologic factors like trauma, emotional stress, orthopedic instability, muscular hyperactivity, causes inflammatory and degenerative diseases which compromises the equilibrium of TMJ.

Temporomandibular joint disorders (TMDs) are considered a subdivision of musculoskeletal pathologies and are the main source of orofacial pain of non-dental origin. The most common clinical signs and symptoms of TMDs are joint pain, muscle pain, mouth-opening limitation, clicking and crepitation. TMDs are frequently associated with degenerative bone changes involving the bone structures of the

TMJ such as flattening, erosion, osteophytes, subchondral bone sclerosis and pseudocysts. Knowledge about these bone changes is fundamental for correctly diagnosing the dysfunctions associated with the disease and for adequate treatment planning. Anatomical knowledge of the temporomandibular joint is one of the foundations for the clinical practice that allows the understanding of pathological alterations, diagnostic evaluation and appropriate choice of therapeutic paths. It is a rather difficult region to visualize in conventional radiographs due to superimposition of adjacent anatomic structures. Digital Panoramic radiographs, also have a limited role in diagnosing bony changes of mandibular condyle in patients with chronic TMJ disorders. With the advent of CBCT, better diagnostic information on TMJ pathology can be obtained as it provides multiplanar images without superimposition of mandibular condyle, with minimal radiation exposure to the patient. This aids in better diagnosis, treatment planning and thus improve the prognosis.

MATERIALS AND METHODS

This pilot study was conducted in the Department of Oral Medicine and Radiology, Government Dental College, Kozhikode, Kerala, as a part of ongoing research work on evaluation of morphology of TMJ in patients with Degenerative Joint Disease using CBCT imaging. Institutional ethical committee clearance was obtained for the same (IEC no: 135/2018/DCC). Thirty-six archived TMJ volumes of eighteen patients who had undergone CBCT imaging, acquired over a period of six months were used for the study. CBCT scans were acquired using Planmeca Promax 3D MiD extra oral imaging system with a flat panel image detector and the DICOM files were analysed in a PC workstation running Microsoft Windows 10 using the software “Planmeca Romexis TMJ mode”. The reconstructions were assessed twice by the principal investigator. Intra examiner calibration was assessed performing test-retest exercises in 10 images of patients with intra examiner agreement of 95%. Right and Left TMJs were evaluated separately.

The following parameters were assessed in their respective reference planes.

a) Shape of the condyle was assessed in the coronal slice and grouped as convex, round, flat and angled as described by Yale et al. [1](Fig.1a 1b 1c 1d)

b) Size of the condyle - Medio-lateral condylar width (Fig 2a) was measured as the largest linear dimension of the mandibular condyle on coronal view and antero-posterior condylar length (Fig 2b) as the largest dimension of the mandibular condyle on sagittal view. [2]

» **M** (medial condylar surface): most medial point of the mandibular condyle on the frontal view

» **L** (lateral condylar surface): most lateral point of the mandibular condyle on the frontal view

» **A** (anterior condylar surface): most anterior point of the mandibular condyle on lateral view

» **P** (posterior condylar surface): most posterior point of the mandibular condyle on lateral view

c) Articular eminence height - Measured on the sagittal view as the perpendicular distance between lowest point of articular eminence and highest point of mandibular fossa.[3](Fig 3)

The axial view on which the condylar processes were seen with the widest medio-lateral extent was chosen and the corresponding sagittal section was used to measure the height of articular eminence.

d) Superior joint space measured in the sagittal view as described by Alexiou et al is given below.[4] (Table 1)

- For the measurement of superior joint space, sagittal section passing through the center of the condyle was chosen.
- It is the distance between condylar head and mandibular fossa

e) Thickness of RGF was measured as described by Dilhan Ilguy et al.[3]

- Central equivalent region of RGF was identified among the coronal slices.
- Distance measurement tool was used to measure the thickness.
- Measurements were performed on the central sagittal slice.

f) Presence of erosions and osteophytes on the condyle.

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RESULTS

Among thirty-six TMJ volumes, twenty four were Non-TMD patients and twelve were patients with history of TMD. Age of the patients ranged between 18 and 45 years.

In the coronal section, the morphology of the condyle was categorized based on the classification given by Yale et al [1] and grouped as convex, round, flat and angled. The most commonly found shape among the Non-TMD patients was *convex*, and among the TMD patients, the most commonly found shape was *flat* followed by convex, round and angled. (Table2) (Fig4)

Size of the condyle were measured both on lateral view as well as coronal view. Medio-lateral condylar width was assessed in the coronal view and antero-posterior condylar length was assessed in the sagittal view. The range of medio-lateral condylar width and antero-posterior condylar length of Non-TMD patients and TMD patients are given below (Table 3). Medio-lateral condylar width was significantly reduced among the TMD patients.

Articular eminence height was measured as perpendicular distance between lowest point of articular eminence and highest point of mandibular fossa. Mean values of articular eminence height obtained for Non-TMD patients and TMD patients are given below (Table 4). Increased eminence height seen among the study sample was 8.4 mm (Fig 5a) and reduced articular eminence height was 4.4mm (Fig 5b). There was no significant difference among the values obtained regarding this variable.

For the measurement of superior joint space, sagittal section passing through the centre of the condyle was chosen. Superior joint space ranged from 8.4 mm to 2 mm among Non –TMD patients and between 4.4 mm to 0.8 mm among the TMD patients. Mean value of superior joint space obtained is given below (Table 5). Values obtained showed a marked reduction in superior joint space among the TMD patients.

Thickness of RGF was also assessed. Central equivalent region of RGF was identified among the coronal slices. Distance measurement tool was used to measure the thickness. Measurements were performed on the central sagittal slice. Mean values obtained are given below (Table 6). Regarding this variable also there was no significant difference in the mean values among both the groups.

Presence of erosions and osteophytes were assessed in all the thirty-six TMJ volumes. Erosive changes of condyle were seen in ten TMD patients and six Non-TMD patients of which eleven were females and five males (Fig 6a, 6b). Osteophytes were seen in three TMD patients and one Non-TMD patient of which three were females and one male (Fig 7a, 7b).

Using kappa values, the internal consistency of the values obtained by the observer for the size of condyle, articular eminence height, superior joint space and thickness of RGF was found to be 0.90, 0.94, 0.92 and 0.95 respectively ($P < 0.05$).

DISCUSSION

The TMJ is a rather difficult area to investigate radiographically. The imaging of TMJ by CBCT provides exact quantification of condyle as well as morphometry of the TMJ which are important while providing treatment to the patients suffering from TMJ dysfunctions. Hence this study was conducted to assess the morphometry of TMJ by CBCT in the archived volumes.

- *Shape of condyle*

Only a few studies were conducted world-wide to assess the condylar morphology using three dimensional imaging. In the coronal section; the morphology of the condyle was categorized based on the classification given by Yale et al (1966)[1] as convex, round, flat and angled. The most commonly found shape among the Non-TMD patients in our study was *convex,* and among the 12 TMD patients, the most commonly found shape was flat followed by convex, round and angled. Saraswati et al in a study among south indian population, found the most common morphology in coronal section as convex 49% followed by round 23%, flat 21% and angled type 7%. However, in a study conducted by Shubasini et.al [5] the most common morphology observed was angled (37.5%) in coronal view.

- *Size of condyle*

The most recent literature states that CBCT images are reliable to evaluate the linear measurements of the condyle. According to studies by Brian Schlueter et al [2]on dry skulls, the medio-lateral condylar width ranged from 7.72 mm to 8.08 mm and the antero-

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posterior condylar length was 8.62 mm to 9.43 mm .They recommend measurements at density levels below those recommended for osseous examinations for more accurate results. Also the difference of measurements in various age groups and gender were not assessed in the above mentioned study. In our study the medio-lateral condylar width in patients without TMD ranged between 13.6 mm to 22.4 mm and antero-posterior condylar length ranged between 2 mm to 7.6 mm. Among the 12 TMD patients, medio-lateral condylar width ranged between 8 mm to 16.3 mm and antero-posterior condylar length ranged from 3.2 mm to 7.2 mm. Medio-lateral condylar width was significantly reduced among the TMD patients. The difference in the density level may account for the difference in the measurements obtained.

- *Superior joint space*

Major et al [6] and Ghristiansen et al [7] found an association between disc displacement and changes in joint space and suggested that any discrepancy between the optimal and the altered joint spaces might indirectly indicate disc displacement. **Manjula** et al [8] in a study conducted in the female population, using CBCT, provided data for the optimal condylar position, which might be a useful reference for clinical assessment of abnormal condylar position. Superior joint space was found to be 2.4 +/- 0.58 mm in their study. In the present study the mean superior joint space in Non-TMD patients was 3.16mm and in patients with TMD was 2.6 mm indicating a reduction of superior joint space in patients with TMD.

- *Articular eminence height*

The articular eminence is located in front of the glenoid fossa and its posterior surface slope varies among people. It is subjected to functional load arising from chewing forces, and the morphology of it may be affected by this. According to Dilhan Ilguy et al [3] in 2014, the articular eminence height measurements was 7.33 +/- 1.26 mm in males and 6.69 +/- 1.16 mm in females in patients without TMD and there was no significant reduction noted in patients with mild morphological alterations. In our study the articular eminence height in Non-TMD patients was about 7.43 mm and 7.18 mm in patients with TMD.

- *Roof of Glenoid Fossa*

The thickness of the RGF of the TMJ was assessed in previous studies related to gender, age, and condyle morphology. [9] [10] Tsuruta et al [11] suggested that compensative bone formation in the RGF might help to withstand the increased stress in the TMJ accompanying condylar bone change, especially erosion. Thickness of RGF was assessed by Dilhan Ilguy et al to be 1.26 +/- 0.38 mm in patients without osteoarthritis and 1.59 +/- 0.28 mm in patients with osteoarthritis. In our study the mean value obtained was 1.8mm in Non-TMD patients and 1.6 mm in patients with TMD. Further studies in a large sample size is required for assessment of RGF and articular eminence height and inclination in patients with osteoarthritis of TMJ and correlate these with age, gender, and mobility of the TMJ.

- *Degenerative changes*

According to Priyanka Verma et al, [12] the part of TMJ most frequently affected by arthritis was the condyle followed by articular eminence and glenoid fossa which was in agreement with our results. The degenerative changes assessed in our study were the presence of erosions and osteophytes. Erosive bony change of the condyle is defined as an area of decreased density of the cortical bone and the adjacent subcortical bone and osteophyte formation is defined as marginal bony outgrowths on the condyle. According to Seyed Hossein Hoseini Zarch et al [13] in a study which comprised of twenty eight patients at least one type of bone change was seen in 67.9% of patients of which most of the patients were females. In our study erosive changes were seen in ten TMD patients and six Non-TMD patients of which eleven were females and five males. Osteophytes were seen in three TMD patients and one Non-TMD patient of which three were females and one male. In a recent study done by Marcin Derwich et al [14] they concluded that the temporomandibular joint osteoarthritic changes occur very often, even among asymptomatic patients which was consistent with our results. A recent study done by Raweewan Arayasantiparb et al [15] confirmed that CBCT remained the imaging of choice for TMJ DJD (Degenerative Joint Disease) as they obtained the difference in levels of osseous changes between DJD and non-DJD subjects, which was confirmed in our study as well.

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CONCLUSION

Recent treatment available to TMD patients is highly dependent on the presence or absence of osseous abnormalities. Therefore, the detection and correct diagnosis of such abnormalities is paramount. Though the sample size in this pilot study is small, it can be seen that CBCT imaging in TMD and morphometric evaluation of TMJ using CBCT has a promising future in the diagnosis and management of TMDs. There is need for further studies correlating the patient characteristics like age and gender, CBCT features and clinical features in patients with and without TMD, in a larger sample for a better understanding and management of the various temporomandibular joint disorders.

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Tables

Table 1: Range of values of superior joint space

Increased	More than 4 mm
Normal	1.5 – 4 mm
Reduced	Less than 1.5 mm
Absent	0 mm

Table 2: Shape of condyle and its distribution among the TMD patients and non- TMD patients

Shape	Number (TMD)	Number (non-TMD)
Convex	3	9
Round	4	5
Flat	4	9
Angled	1	1

Table 3: Medio-lateral condylar width and Antero-posterior condylar length among the study sample.

Non –TMD (n = 24)	TMD (n = 12)
M-L width	M-L width
22.4-13.6 mm	16.3 - 8 mm
A-P length	A-P length
7.6-5.2 mm	7.2-3.2 mm

Table 4: Articular eminence height among the study sample

Non TMD (n=24)	TMD (n=12)
8.8 – 4.4 mm	8.4-6.2 mm
Mean-7.43 mm	Mean - 7.18 mm

Table 5: Superior joint space among study sample

Non TMD n=24	TMD n=12
8.4 - 2 mm	4.4 – 0.8 mm
Mean 3.16 mm	Mean 2.6 mm

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Figures

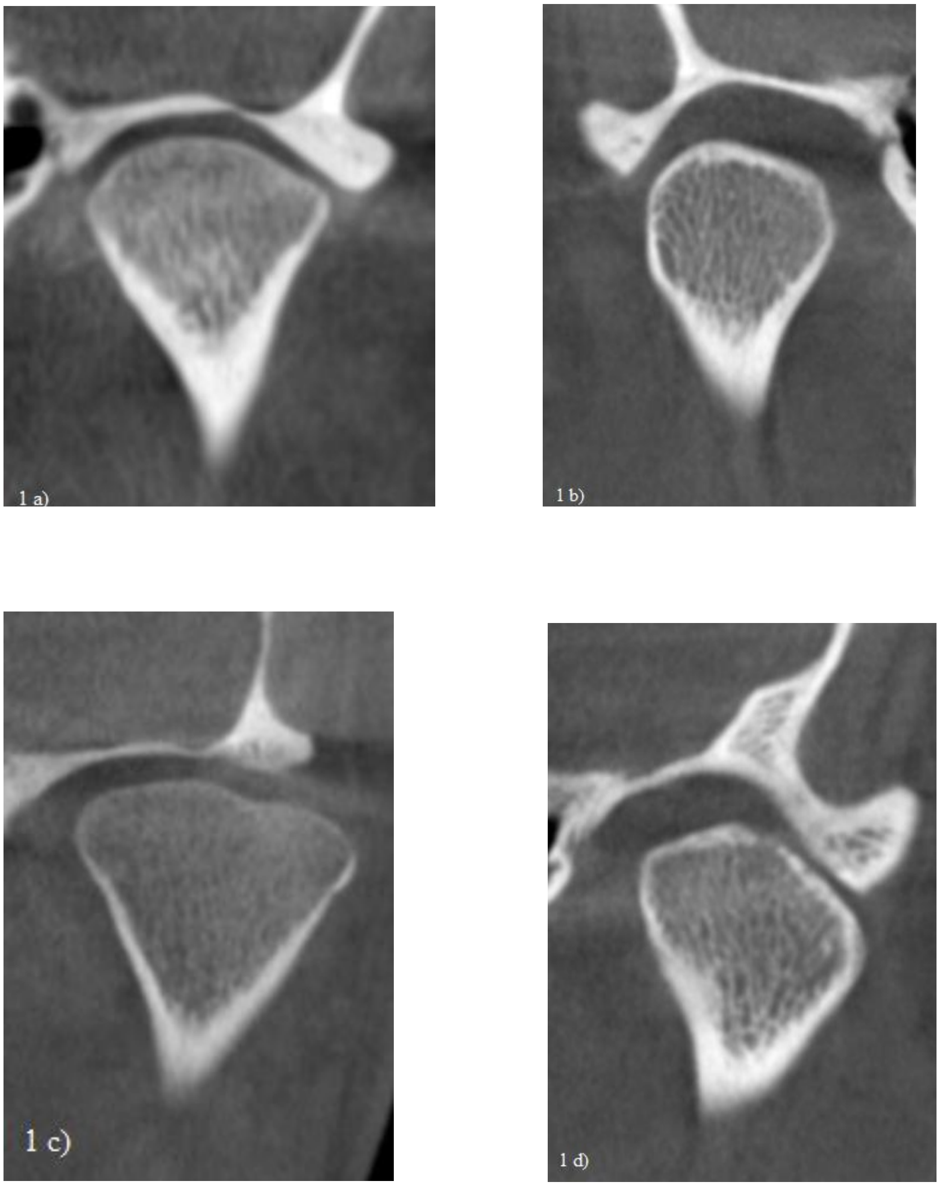

Fig 1: Showing the four morphological variations of condyle in the coronal view 1a) convex 1b) round 1c) flat 1d) angled

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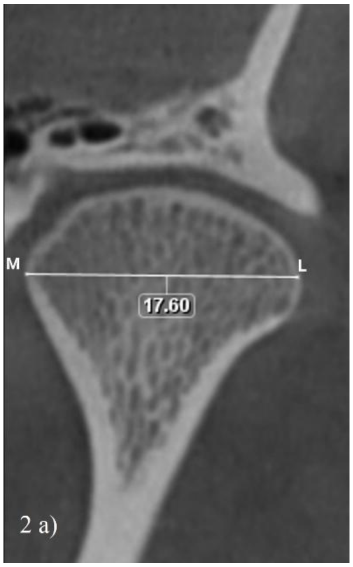

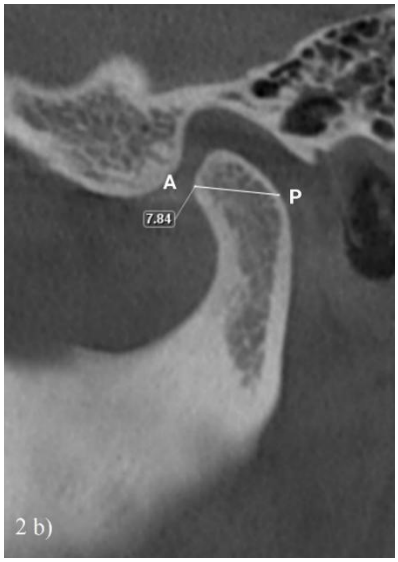

Fig 2a: Medio-lateral width of condyle *Fig 2b: Antero-posterior length of condyle*

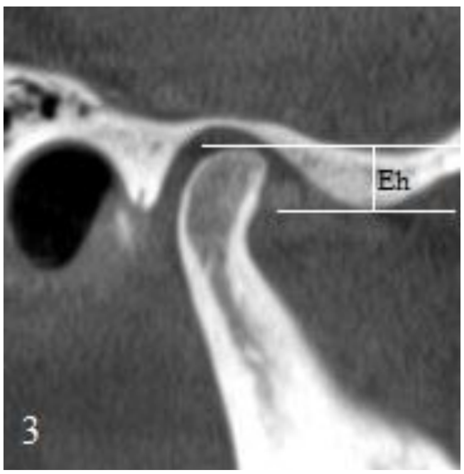

Fig 3: Method of measurement of articular eminence height

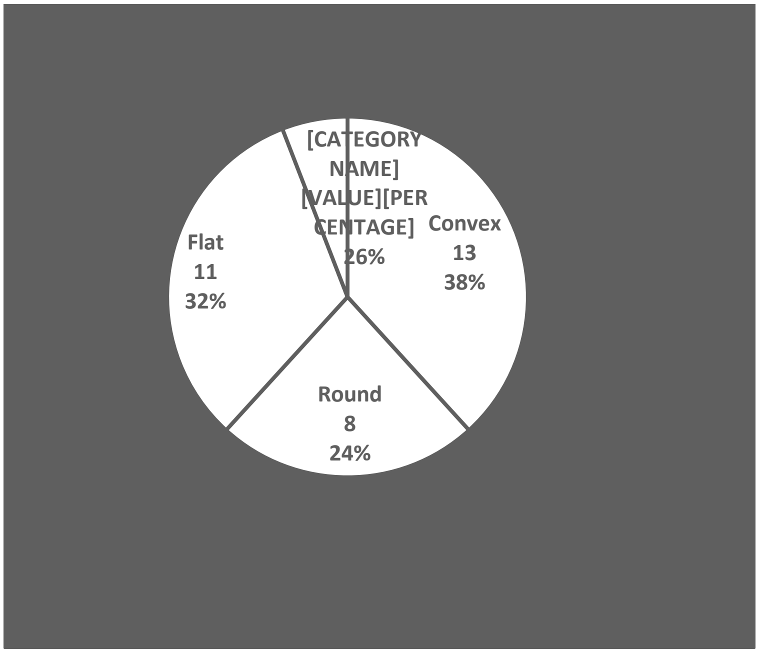

Figure 4 : Shape of condyle and its distribution among the study sample

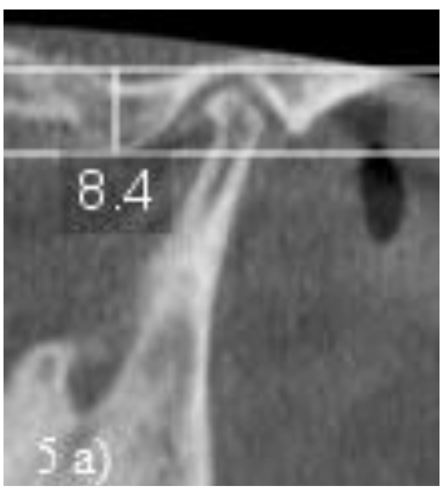

Figure 5a: Increased articular eminence height

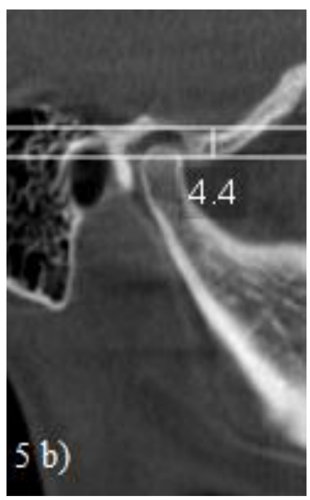

Figure 5b: Reduced articular eminence height

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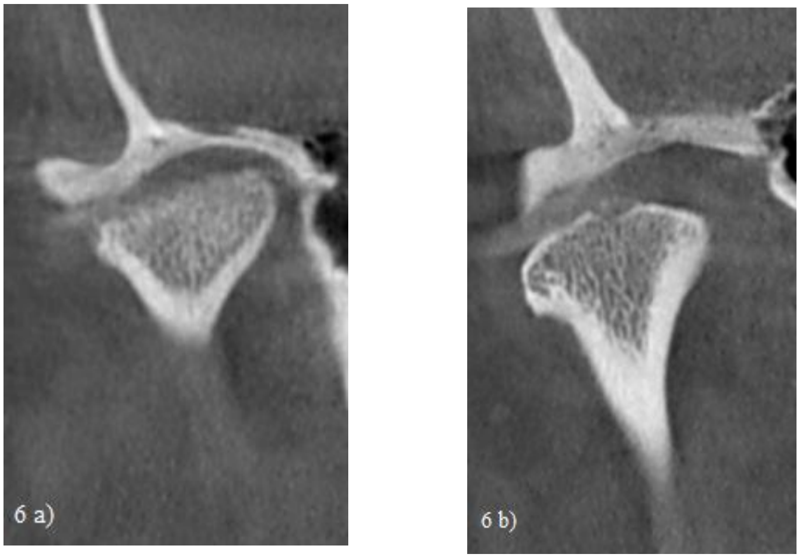

Figure 6a and 6b showing erosive changes of condyle

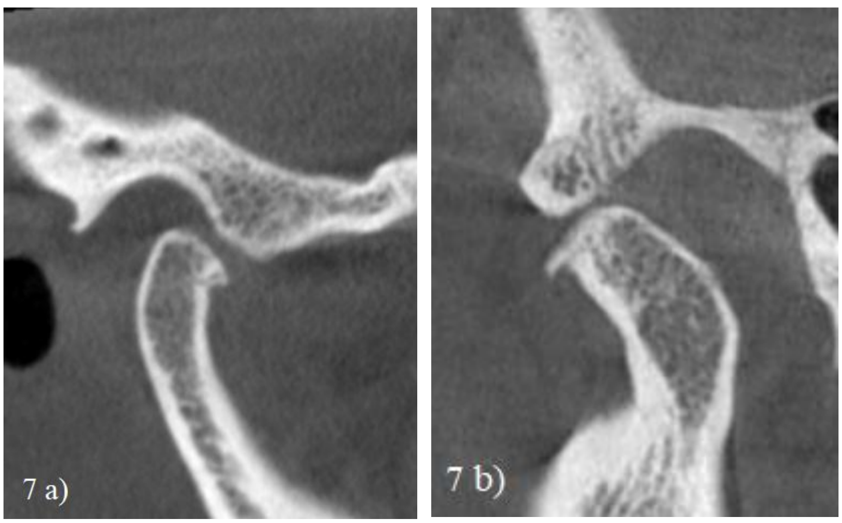

Figure 7a and 7b showing osteophytes on condyle