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Evaluation of morphologic variation of the mandibular condyle in Degenerative Joint Disorders using Cone Beam Computed Tomography

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Abstract

Objectives: Knowledge about bone changes in degenerative joint disorders of Temporomandibular joint is fundamental for adequate diagnosis and treatment planning. There is a dearth of studies on morphologic alterations of Temporomandibular joint in degenerative joint disorders using Cone Beam Computed Tomography in our population. This study is intended to evaluate the role of Cone Beam Computed Tomography imaging in diagnosing degenerative changes of Temporomandibular joint in patients attending a tertiary health care center in our state.

Materials and Methods: This study was done in a total of 40 patients diagnosed with degenerative joint disorders of TMJ in the department of Oral Medicine and Radiology over a period of 1 year after obtaining ethical clearance. They were subjected to CBCT examination and morphologic changes of condyle were evaluated in two reference planes.

Results: Most common morphologic alteration on condyle was flattening followed by presence of erosions and osteophytes. Out of the 36 patients with tenderness, 30 had flattening of condyle, 25 had erosions and 11 had osteophytes. Out of the 19 patients with trismus, 18 had both flattening and erosions while 9 of them had osteophytes. Out of the 19 patients with crepitus, 13 had flattening of condyle, 15 had erosions and 8 had osteophytes.

Conclusion: The treatment and prognosis of degenerative joint disorders affecting the

Temporomandibular joint is highly dependent on the detection of osseous abnormalities of Temporomandibular joint. From the above study we have concluded that Cone Beam Computed Tomography imaging definitely has a promising future regarding the diagnosis of patients with degenerative changes of Temporomandibular joint.

Keywords: Cone-Beam Computed Tomography; Mandibular condyle; Temporomandibular Joint; Temporomandibular joint disorders.

Introduction

TMJ 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 [1]. Temporomandibular disorders (TMD) are a heterogenous group of complex disorders that affect the associated structures of TMJ and are a significant public health problem affecting approximately 5% to 12% of the population. Pain related TMD can impact the individual's daily activities, psychosocial functioning, and quality of life. Complex etiologic factors like trauma, emotional stress, orthopaedic instability, muscular hyperactivity, causes inflammatory and degenerative diseases which compromise the equilibrium of TMJ [2].

Degenerative Joint Disorders (DJD) also referred to as osteoarthrosis, osteoarthritis and degenerative arthritis, is primarily a disorder of articular cartilage and subchondral bone, with secondary inflammation of the synovial membrane. They are mostly associated with degenerative bone changes involving osseous structures of TMJ which comprises of flattening of condyle, erosions, osteophytes, subchondral bone sclerosis, pseudocysts, articular eminence pneumatisation, joint space reduction and variation in the shape and size of condyle [1].

These degenerative bone changes are challenging to be detected in the conventional radiographs of TMJ due to the anatomy of the region, superimpositions and the presence of overlapping structures. CT and MRI imaging are currently relied for diagnosing the various pathologies affecting the TMJ. But various factors like increased radiation dosage in CT imaging, cost, claustrophobia and the presence of various artefacts often limits the use of these imaging modalities.

Cone Beam Computed Tomography (CBCT) imaging has revolutionized TMJ imaging 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 improves the prognosis. There is a dearth of studies on morphologic alterations of TMJ in degenerative joint disorders using CBCT in our population. Hence this study is intended to evaluate morphological variations of mandibular condyle in patients with Degenerative Joint Disorders using CBCT and to correlate with variables like age, gender and their dentition status attending a tertiary health care center.

Materials and methods

This descriptive study was carried out in the Department of Oral Medicine and Radiology, Government Dental College, Kozhikode, Kerala, over a period of one year after obtaining Institutional ethical clearance (IEC no:135/2018/DCC, dated :30-10-2018).All the patients who presented with complaints related to the TMJ were screened as per the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications which is an evidence-based Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). The DC/TMD provides a questionnaire for the pain history in conjunction with validated clinical examination criteria for diagnosing the most common

TMD. The patients with features of degenerative joint disorders were selected and subjected to CBCT imaging for evaluation of condylar morphology. The exclusion criteria included those patients with a history of recent trauma/surgery involving TMJ or polyarthritis (rheumatoid arthritis, gouty arthritis, psoriatic arthritis) and those who were undergoing fixed orthodontic treatment. Patients with history of various neurologic, psychologic disorders, claustrophobia and pregnant patients were also excluded. All participants have read and signed the informed consent and it was documented prior to the procedure.

CBCT scans were acquired using Planmeca Promax 3D MiD extra oral imaging system with a flat panel image detector. These images were obtained using the following CBCT acquisition protocol: • Voxel thickness: 0.20 mm • Thickness of the sagittal and coronal slice along the longitudinal axis of the mandibular condyle: 1 mm • Acquisition volume: TMJ mode. • Time: 36 s •Exposure parameters: 90 kVp and 10 mA • Field of view: 16 cm × 16 cm. The DICOM files were analysed in a PC workstation running Microsoft Windows 10 using the software Planmeca Romexis. Multiplanar reconstructions including axial, coronal, and sagittal images were obtained and evaluated independently by the investigator and a specialist, in a darkened room, on a 24-inch TFT screen. Blinding was done during image interpretation. A pilot study was carried out on 15 archived CBCT volumes of TMJ before the commencement of the present study to assess the feasibility.

Condyles were classified as convex, round, flat, angled, pointed, bifid condyle and other variations as seen in the coronal plane. Medio-lateral condylar width was measured as the largest linear dimension of the mandibular condyle on coronal section and antero-posterior condylar length as the largest dimension of the mandibular condyle on sagittal section. Flattening of condyle, sclerosis and articular eminence pneumatisation presence of erosions, osteophytes and Ely's cyst were assessed on both coronal and sagittal sections. These morphologic alterations were defined to be present if they were recorded in any one of the sections.

Statistical analysis

Qualitative variables were summarised as frequency and percentages and quantitative variables were summarised as mean and standard deviation (M [SD]). Relation between selected study variables and CBCT findings was tested using chi-square test. $P < 0.05$ was considered as statistically significant. Inter observer reliability was assessed using kappa statistics. Kappa statistics for agreement was used to assess inter examiner reliability. Kappa statistics were interpreted as <0 = poor agreement, 0.00–0.20= slight agreement, 0.21–0.40 = fair agreement, 0.41–0.60 = moderate agreement, 0.61–0.80 = substantial agreement,0.81–0.99 = almost perfect agreement, and 1.00 = perfect agreement. P value equal to or less than 0.05 was considered statistically significant.

Results

The study sample composed of 40 patients who were subjected to CBCT imaging of TMJ. Right and Left TMJ images were separately evaluated resulting in a total of 80 TMJ volumes. Study sample was grouped into two age groups, adolescents (10-19 years) and adults (above 19 years). The age of the study subjects ranged from 12 years to 57 years and mean age of the study population was 26.12 ± 11.39 years. The age and gender distribution of the patients is given in Table 1.

Table 1: Age and Gender distribution of patients.

Gender	Adolescents (0-19 years)	Adults (Above 19 years)
Male	4	8
Female	10	18

There were 13 males and 27 females, with a male to female ratio of 1:2. None of the patients were totally edentulous. Seven patients had parafunctional habits including bruxism and 8 patients gave a past history of orthodontic treatment**.** The Dentition status and the clinical signs and symptoms of the patients are summarized in Table 2.

Table 2: Dentition status and Clinical signs and symptoms of the patient.

Dentition status (Eichner)	
Class A	38
Class B	2
Class C	0
Clinical signs and symptoms	
Pain on mouth opening (VAS)	
Mild	6
Moderate	17
Severe	17
Tenderness over TMJ	
Present	36
Absent	4
Deviation/Deflection while mouth opening	
Present	34
Absent	6
Trismus	
Present	28
Absent	12
Clicking	
Present	26
Absent	14
Crepitus	
Present	19
Absent	21
Restricted mandibular movements	
Present	19
Absent	21

The shape of condyle was assessed separately on both sides condyles in the coronal sections. The most common shape in both the age groups and in males and females was the convex type. Comparison of the shape of condyle between the right and the left sides is shown in Table 3.

Table 3: Comparison of shape of condyle on right and left side.

Shape	Right (40)	Left (40)
Convex	19	14
Round	3	3
Flat	10	12
Angled	7	10
Pointed	1	0
Bifid	0	0
Other variations	0	1

The different shapes of condyle as seen on the coronal view namely convex, round, flat, angled, pointed and other variation are shown in Figures 1a, 1b, 1c, 1d, 1e and 1f respectively.

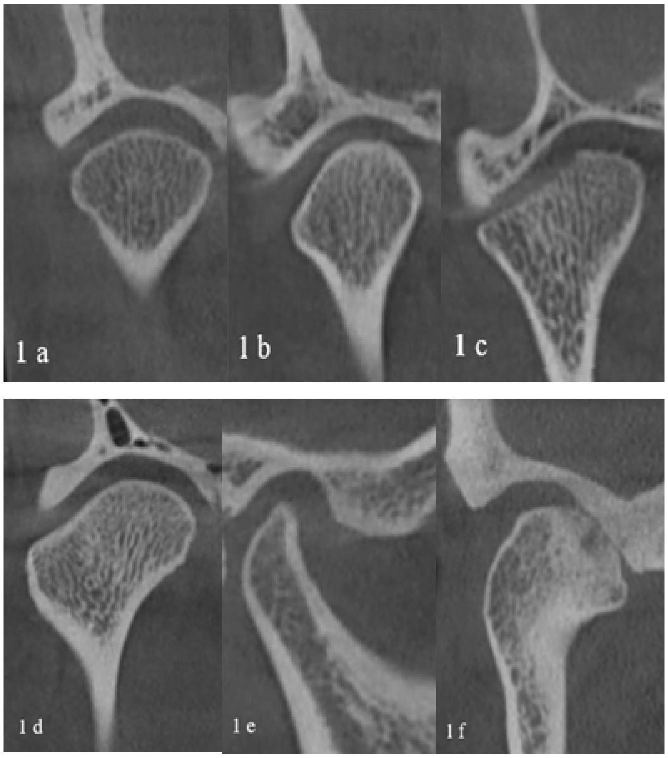
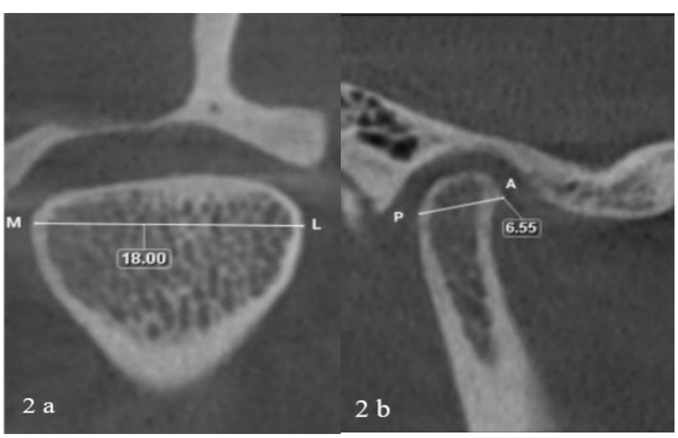


Figure 1 a – 1 f: Shows shape of condyle. 1 a = Convex, 1 b = Round, 1 c = Flat, 1d = Angled, 1 e = Pointed, 1 f = Bifid

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

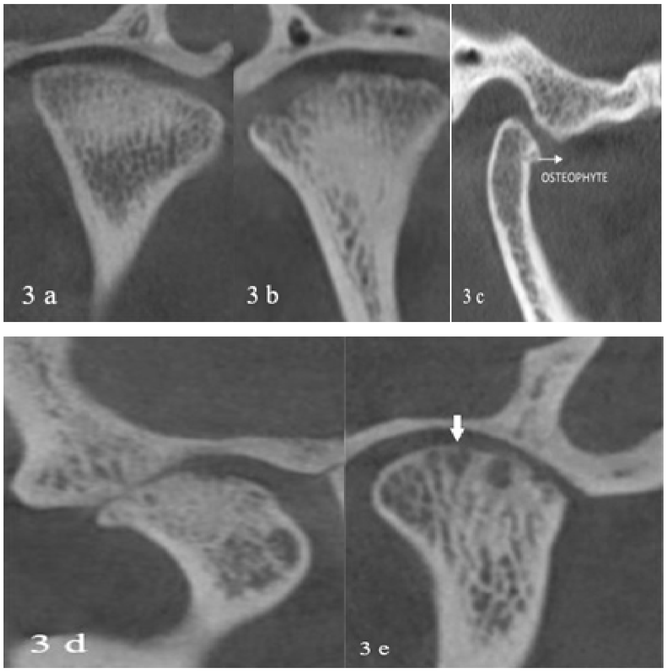


Figures 2a and 2b: Size of condyle. 2 a = Mediolateral condylar width, 2 b = Anteroposterior condylar length.

Mediolateral condylar width on right side ranged from 10 mm - 22.4 mm and on the left side it ranged between 8 mm - 22.4 mm with a mean value of 16 mm on both sides. Antero posterior condylar length on right side ranged from 3.2 mm – 8.94 mm and on left side it ranged from 6.5 mm – 14.27 mm with a mean value of 6.4 mm on right side and 6.5 mm on left side. Bilateral degenerative changes were noted in 27 patients and unilateral changes in 9 patients. No degenerative changes could be identified in 4 patients. 15 patients showed combination of two or more degenerative changes. Flattening and erosion was the most commonly observed combination (n-6). Table 4 summarizes the degenerative changes observed on bilateral condyles and the images of degenerative changes namely flattening, erosions, osteophytes, sclerosis and Ely's cyst are shown in Figures 3a, 3b, 3c, 3d, 3e respectively.

Table 4: Degenerative changes of condyle noted on coronal and sagittal sections

Side	Degenerative change	Coronal	Sagittal
RIGHT SIDE	a. Flattening	23	21
	b. Sclerosis	1	1
	c. Articular eminence pneumatisation	0	2
	d. Erosions	17	18
	e. Osteophyes	4	8
	f. Ely's cyst	3	2
LEFT SIDE	a. Flattening	24	24
	b. Sclerosis	2	1
	c. Articular eminence pneumatisation	0	2
	d. Erosions	21	23
	e. Osteophytes	6	8
	f. Ely's cyst	2	2



Figures 3 a - 3 e: Shows degenerative changes of condyle. 3 a = Flattening, 3 b = erosions, 3 c = osteophyte, 3 d = Other variation, 3 e = Ely's cyst (marked by arrow)

Erosion was the most common degenerative change noted in the adolescents, while flattening of condyles was noted among the adult population. Flattening of condyles and erosion were the prominent degenerative changes noted in both genders. However, no statistically significant association could be obtained between the age, gender, dentition status and the degenerative changes observed**.** Degenerative changes among the various age groups and gender are summarized in Table 5.

Table 5: Association between age, gender, dentition status and degenerative changes of condyle.

Degenerative changes	Age	Gender	Dentition status
Flattening	0.234	0.120	0.434
Sclerosis	1	1	0.816
Articular eminence pneumatisation	0.117	1	0.739

Erosions	1	0.154	0.342
Osteophytes	0.157	0.271	0.527
Ely's cyst	0.640	1	1

The common clinical signs elicited in the patients were tenderness of TMJ, trismus and crepitus and the common degenerative findings observed in patients presented with these signs were flattening of condyle, erosions and osteophytes. However, no significant correlation was obtained between the clinical signs and degenerative changes which is summarised in Table 6.

Table 6: Correlation between clinical signs and degenerative changes

Clinical findings	Flattening	Erosions	Osteophytes
Tenderness	0.419	NA	NA
Trismus	NA	0.404	0.251
Crepitus	NA	0.186	0.251

NA = Not applicable.

Table 7 shows inter observer reliability assessed using kappa statistics. Kappa statistics were interpreted as <0 = poor agreement, 0.00–0.20 = slight agreement, 0.21 0.40 = fair agreement, 0.41–0.60 = moderate agreement, 0.61–0.80 = substantial agreement, 0.81–0.99 = almost perfect agreement, and 1.00 = perfect agreement. *P* value equal to or less than 0.05 was considered statistically significant.

Table 7: Inter observer reliability using kappa statistics.

Radiographic findings	Inter-class coefficients
Flattening	0.84
Sclerosis	0.90
Articular eminence pneumatisation	0.94
Erosions	0.90
Osteophytes	0.87
Ely's cyst	1

Discussion

This study was conducted in the Department of Oral Medicine and Radiology, Govt. Dental College Kozhikode for a period of one year. Forty patients with features suggestive of degenerative joint disorders of TMJ were selected according to RDC/TMD Axis 1 protocol and subjected to CBCT examination after getting a consent. A large number of similar studies have been published in recent years as CBCT has inspired research in TMJ imaging. CBCT images have been reported to provide superior reliability and greater accuracy than TMJ panoramic projections in detection of condylar degenerative changes according to the study by Oana Bida Honey et al [3]. CBCT also provides a relatively low-dose and cost-effective imaging option, and provides high quality 3D images for diagnostic evaluation of osseous abnormalities of the TMJ.

The age of the 40 patients in our study ranged from 12 years to 57 years with a mean age of 26.12 years indicating that DJD is more common in adolescents and young adults which is in agreement with the findings of Comert kilic [4]. We found that radiographic TMJ osteoarthritic changes were most common in adolescents and adults younger than 30 years of age. On the contrary some recent studies by Priyanka Verma and Nagihan concluded that degenerative changes of condyle were mostly seen among older age [5,6]. Alexiou in their study concluded that progression and severity of degenerative changes of mandibular fossa and condylar head increases with age although some researchers namely Isberg and Crusoe have found no correlation between increasing age and degenerative bone changes [7-9].

Most of our patients were females with female to male ratio of 2:1. Various studies have reported that women are at increased risk of TMD [4]. The presence of more frequent degenerative joint disease in females than males is proposed mainly due to hormonal differences between women and men. According to literature, this hormonal distinction may exacerbate the degeneration of cartilage and articular bone in the TMJ and explains the higher proportion of females with TMJ-DJD. A potential role of the sex hormones oestrogen and prolactin in the development of osteoarthritis has been suggested [10]. In our study also the dentition status was classified using Eichner classification. However, the association between dentition status and degenerative changes of condyle were not statistically significant which was in agreement with the study done by Singh et al in 2020[11].

Right and left sides showed no significant difference in terms of shape as well as condylar dimensions in both males and females in the present study. In both genders, we observed that the most common shape of the condyle on the coronal section was convex, followed by flat and angled shaped ones. In the present study medio-lateral width of condyle ranged between 8 mm - 22.4 mm and antero-posterior length of condyle ranged between 6.5 mm - 14.27mm and there was no significant difference between these values on comparing right and left condyles. A study done by May Al-koshab concluded that condylar size can be an indicator of degenerative joint disorder of TMJ [12]. Kurita in 2003 studied the relationship between the horizontal condyle size and osteoarthritic change of condylar surface and found that the condyle has a reduced dimension with the presence of arthritis [13]. They concluded that the condyle shrinks in horizontal size with advancement of degenerative diseases by mechanisms that have an adverse effect on the growth of the whole condyle. Hence the assessment of the bony contours and dimensions of TMJ has an important role in the diagnosis of temporomandibular joint disorders and guiding the clinician for selecting a proper treatment modality. Even though conventional

CT imaging is accepted as the gold standard in the diagnosis of degenerative bony changes, CBCT is an alternate cheaper method of cross-section imaging, with a comparatively less radiation exposure.

Degenerative changes of mandibular condyle were assessed in coronal and sagittal sections. There was no significant difference between right and left sides regarding the presence of degenerative bone changes. Our result was similar to the result obtained by Anjos Pontual were they found that degenerative bone alteration in TMJs were more frequent in women and mostly located in the condyle and that there was no significant difference between the right and left sides and in condylar mobility with regard to the presence of degenerative bone changes [14]. Most common degenerative changes noted in our study sample was flattening of condyle, erosions and osteophytes in both age groups and gender. All the patients except four had degenerative changes on condyles either unilaterally or bilaterally. Our results were similar to the results obtained in various studies worldwide. Seyed Hossein Hoseini Zarch in their study found that flattening was the most common change and the lowest was Ely's cyst [15]. In the study done by SunMee Bae, "Erosion and Flattening" was the most common combination of the bony changes [16]. In the present study also we observed the predominance of the same combination. Future research is warranted to understand more about this pattern of occurrence of degenerative changes. The prevalence of osteophyte, erosion, and pseudocyst increased with age and flattening was the most common radiographic finding in all age groups. In the study done by Comert kilic a high rate of condylar erosion, followed by flattening, osteophytes, and sclerosis were reported [4]. These rates were relatively consistent with those reported from the TMJ-OA studies performed by Alexiou and dos Anjos Pontual [7,14]

Nah found the most frequent condylar bony changes to be sclerosis and erosion [17]. Cevidanes observed 60% condylar flattening and 40% erosion and osteophytes in a group with TMJ-OA and concluded that these conflicting findings may result from differences in imaging techniques, the diagnostic criteria for osteoarthritis, age groups or ethnic diversity [18]. In a recent study, Talaat performed a CBCT analysis of the bony changes associated with TMD and found that osteoarthritic joints had significantly more condylar irregularities, osteophytes and condylar flattening than non-TMD joints [19]. According to Merete Bakke, the most frequent type of bony deviation was flattening, which is typical of remodelling processes [20]. They came to a conclusion that asymptomatic adult TMJ's also show degenerative bony alterations and hence such findings should be used with care and only as a supplement to clinical assessment. Since all our patients were symptomatic subjects, this discrepancy was not elicited.

Out of the total study sample (40 patients), 36 patients presented with a complaint of tenderness over TMJ region and 19 had complaint of trismus. Crepitus was also elicited in 19 patients. In our study, correlation between the clinical signs of TMD and degenerative changes of the TMJ was performed. No significant correlation was obtained between the degenerative changes and the clinical signs in our study. Our results were in agreement with the results of previous studies done by Letıcia Angelo Walewski and Marcin Derwich [21,22]. Palconet reported that there was a poor correlation between condylar changes (as observed on CBCT images), pain, and other clinical signs and symptoms in TMJ osteoarthritis[23]. Comert kilic obtained a positive correlation between general pain complaints and condylar flattening[4]. Kurita et al reported a significant relationship between pain on lateral palpation of the TMJ and radiographic evidence of bone changes at the articular surface [13]. Wiese et al reported pain-related variables not to be associated with an increased risk of degenerative findings in TMJ tomograms of cases with TMJ-OA [24]. P Verma in their study observed that there was no statistically significant difference in the presence of radiographic osseous changes in symptomatic and asymptomatic joints and concluded that radiographic findings may not truly reflect the clinical signs and symptoms [13]. According to the study done by Mahrokh Imani Moghaddam in 2017, condylar flattening, sclerosis, resorption, and erosion were not significantly associated with joint/masticatory muscle pain or crepitus while condylar osteophyte was significantly associated with pain in masticatory muscles and crepitus [25]. Comert kilic found a statistically significant negative correlation between masticatory efficiency with both condylar flattening and sclerosis [4]. Increased condylar sclerosis was also associated with reduced lateral movements of the jaw. Some experimental studies have shown that altered functional TMJ loading leads to a loss of the condylar cartilage and a transient loss in density of the mandibular condylar subchondral bone. In this respect, bony changes of the condyle due to altered TMJ loading can result in reduced masticatory efficiency and less food intake. According to Honda pathological bone changes including erosion, osteophyte formation and deformity are associated with joint sounds with a higher frequency [26].

Conclusions

The following were the conclusions of our study. Most of the patients belonged to the younger age group. Tenderness over TMJ, trismus and crepitus were elicited as the main clinical features. Shape of the condyle could be better assessed using CBCT volumes and the most commonly observed shape was convex followed by flat shape. Using CBCT imaging, various morphologic alterations of the condyle could be detected. Most commonly seen morphologic alteration among the 80 TMJ volumes was flattening followed by erosions and osteophytes. Most of the patients had bilateral degenerative changes of the TMJ.

A smaller sample size was the main limitation of the study. Similar study needs to be done in a larger sample size so as to get a better correlation between CBCT findings in degenerative joint disorders of TMJ and variables like age, gender and dentition status of patients. Also the morphology of "temporal component" of TMJ namely the articular eminence and the glenoid fossa were also not assessed.

The complex anatomy of the TMJ region demands for an accurate imaging of the region for better patient management. The development and rapid commercialization of CBCT technology has undoubtedly increased its use, as it is capable of providing accurate, submillimeter resolution images, enabling 3D visualization of the complexity of the maxillofacial region. This imaging modality is superior to conventional radiographic methods, as well as MRI, in the assessment of osseous TMJ abnormalities. There is a lack of knowledge about the impact of CBCT examinations on patient outcome and thus an obvious need for research in this area. This study clearly indicates that CBCT imaging has a promising future regarding the diagnosis, treatment planning and prognosis of degenerative joint disorders of TMJ.

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