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ORIGINAL ARTICLE

# A CBCT based study evaluating the degenerative changes in TMJs among patients with loss of posterior tooth support visiting Qassim University Dental Clinics, KSA: A retrospective observational study

**Heba A AlKhairAllah [a,*], Minu P Mohan [b], Mazen S. AlSagri [c]**

[a] *Dental Intern, College of Dentistry, Al Qassim University, Qassim-Buraydah, Saudi Arabia*
[b] *Boston Medical Center, Boston University School of Medicine, Boston, MA, USA*
[c] *Consultant Diagnostic Radiology in Radiology Department, King Fahad Specialty Hospital, Qassim- Buraydah, Saudi Arabia*

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## 1. Introduction

Loss of teeth can cause severe functional and esthetic disabilities and compromise the patient's life quality (Gupta and Gupta 2014). Deficiently supported occlusion due to multiple missing functional molars can load the temporomandibular joint (TMJ) (Mohl 1988, Ra'ed Al-Sadhan, 2008), leading to mandibular overclosure (Tallents et al., 2002), joint pain on the side corresponding to the maximum number of missing teeth, and condylar deviation to an abnormal position in the TMJ, resulting in joint dislocation (Pullinger et al., 1993).

The TMJ muscles experience greater force when there is teeth loss or joint misuse (Kreutziger and Mahan 1975, Becker 1995). Posterior teeth provide areas of occlusal support and play a significant role in the position of both arches. Molars and premolars absence in partially edentulous arches can affect the TMJ function, as a greater load is placed on the remaining teeth, which can cause faster abrasion and reduction in occlusal height. This can also cause alterations in the mandibular position as compared to the maxilla, which disrupts the TMJ biomechanics and may generate various temporomandibular disorders (TMDs) due to alterations in the spatial relation of the articular disc, fossa, and condyle mandibular (Gupta and Gupta 2014, Okeson 2019). Dr. Edward Kennedy defined these partially edentulous arches as class I, "bilateral edentulous regions positioned behind the normal teeth" and class II, "a singular edentulous region placed behind the remaining normal teeth" (Carr and Brown 2011).

TMDs are a collection of multifactorial illnesses that can influence the mastication muscles along with TMJ's osseous and soft tissue parts. They are also frequently the cause of non-dental pain in the oral and maxillofacial regions (De Leeuw and Klasser 2018). Lack of proper occlusion is also linked to TMJ osteoarthritis (OA) (Ra'ed Al-Sadhan, 2008). TMJ-OA is a deformed bone condition associated with increasing age

* Corresponding author at: Dental Intern, College of Dentistry, Al Qassim University, Qassim-Buraydah, Saudi Arabia.
E-mail address: heba.abdulkareem144@gmail.com (H.A AlKhair-Allah).

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(Ishibashi et al., 1995). As a result, degenerated proteoglycans and proteinases are released into the synovial fluid (Axelsson 1993, Mercuri 2008, Tanaka et al., 2008). Women are more commonly affected than men, and condyles are primarily affected. Degenerative changes are known to degrade with aging (dos Anjos Pontual et al., 2012). TMJ-degrading bone alterations involve osteophyte formation, uneven and dense cortical edges, condyle flattening, subchondral cysts, joint space reduction, erosions (Gynther et al., 1996, Ra'ed Al-Sadhan, 2008, Ahmad et al., 2009, Alexiou et al., 2009), and OA (Ra'ed Al-Sadhan, 2008). Articular surface flatness and subchondral sclerosis are other signs of bone remodeling (Gynther et al., 1996, Mercuri 2008, Ahmad et al., 2009, Alexiou et al., 2009).

Cone-beam computed tomography (CBCT) was introduced as a valuable radiograph for TMJ bone morphology examination in all three dimensions (3D) (Barghan et al., 2012), without deformation or superimposition. It also contains critical information for diagnosing OA (Honda et al., 2001, Tsiklakis et al., 2004, Honda et al., 2006). A study by Okeson et al. (Okeson and occulsion, 2013), who reviewed 57 epidemiological studies on the relationship between occlusion and TMDs, established that 35 cases suggested a relationship, while 22 cases suggested no relationship. However, no significant relationship has been established in the morphological and functional occlusal factors concerning the TMDs development (McNamara et al., 1995). As well, there are no original studies observing the TMDs prevalence in patients with posterior partial edentulism in Saudi populations have been published to date. Thus, this study aimed to identify the degenerative bone alterations associated with TMDs in Kennedy class I and II patients who visited the Qassim University Dentistry Clinics (QUDCs), KSA.

## 2. Materials and method

### 2.1. Ethical regulations

The Dental Ethics Commission of the College of Dentistry, QU, approved this study (Ethical approval number F2018-3010). TMJ CBCT images taken from patients at the Oral and Craniofacial Radiology Department at QU from July 2017 to February 2020 were retrieved from the radiology archives. Once the patient opens a file at the clinic, a consenting record is taken.

### 2.2. Patient selection

TMJ radiographs from 200 patients (86 women and 114 men) with Kennedy's class I and II posterior edentulism of all ages, excluding children and teenagers, were included in the sample. The sample size was estimated using 80 percentage power and 95 percentage confidence intervals. All scans were obtained using the same equipment (Sirona Dental Systems GmbH, Bensheim, Germany) in high-resolution mode with Metal Artifact Reduction Software; 85 KvP, 25 mAs, and 14 s exposure were the scan settings, with field of view (FOV) of 15 X 15 cm and voxel sixes 0.03 mm (Ra'ed Al-Sadhan, 2008). CBCT FOV size group selection is depend on the determined diagnostic region (Pauwels et al., 2021). Small FOV CBCT (diameter < 50 mm), appropriate for small lesions as endodontic lesions. Large FOV CBCT (diameter > 16 cm), appropriate for extensive diseases, as TMDs (Dillenseger et al., 2017). Images were obtained with the mouth closed and maximum intercuspation. The dataset was recreated in 1-mm interval slices. The proprietary software (Sidexis 4) was used for the analysis.

### 2.3. Radiographic evaluation

The reconstructions of bone surface changes of the TMJ on CBCT images was assessed with the help of an expert radiologist. Two hundred TMJs were independently evaluated on either side, resulting in 400 TMJs. TMJ images were evaluated using a computer with a 21-in monitor and the iCAT Cone Beam 3D Dental Imaging System Workstation application. Sex, osseous changes, and Kennedy's classification (I or II) were recorded for each patient. Bony alterations appearing in at least two successive sliced images were considered (coronal, sagittal, and axial) (Tsiklakis et al., 2004). Osseous changes investigated in the condyles were **normal** (in the axial plane, the mandibular condyle is round; in the cross-sectional plane, it is convex, round, or flat, round condyle with an intact cortical outline in the oblique-sagittal plane) (Whaites and Drage 2013), **flattening** (a bone contour that is flat and not convex), **erosion** (a cortical bone and associated subcortical bone region with reduced density), **osteophytes** (bony outgrowths on the condyle's margins), **subchondral sclerosis** (an area of increased density of the cortical bone extending into the bone marrow) (Alexiou et al., 2009), **subchondral cysts** "pseudocysts, idiopathic bone cavity" (well-circumscribed, osteolytic surrounding subcortical bone region without cortical loss), **ankylosis** (calcified ossification connecting the condyle to the temporal bone with no joint space), and **depression** (concave bony shape). Other changes, such as **joint space reduction** (Borahan et al., 2016), **irregular and possibly thickened cortical outlines** (Barghan et al., 2012), and **thickness of the glenoid fossa roof** (increased or decreased), which is one of the temporal component (Scarfe et al., 2009, Whaites and Drage 2013, Borahan et al., 2016), were also evaluated (Fig. 1).

### 2.4. Analytical statistics

Using the IBM SPSS statistics (IBM Corp., Chicago, USA, 2013, Statistical Package for Social Sciences software version 22.0), data were expressed as a percentage of absolute and relative frequencies. The chi-square ($\chi 2$) test was used to elicit frequency differences to determine the most common TMJ degenerative changes among the means of females and males. A p-value of less than 0.050 was considered significant; otherwise, it was considered nonsignificant.

## 3. Results

The data of this study were collected from patients who reported to the QUDCs; 114 CBCTs were from men and 86 were from women. Table 1 presents a descriptive analysis of the study sample. Variables were distributed according to sex, Kennedy's class I or II presence, and bony changes of the condylar right and left sides.

Table 2 shows the sex-based population of individuals with condyle bone alterations. A total of 152 CBCTs scans (76 %)

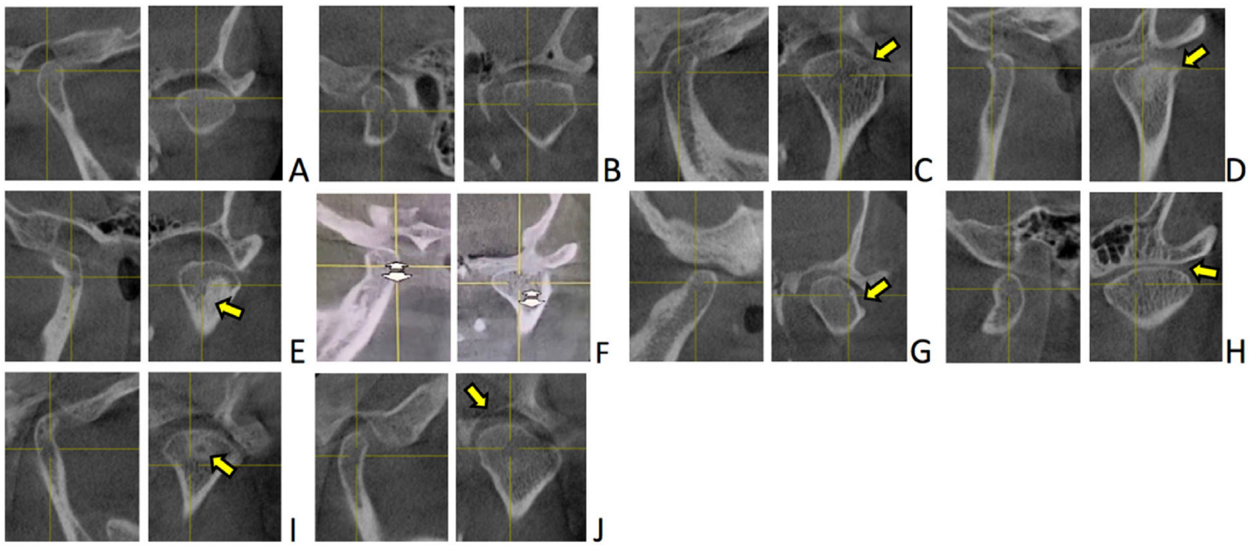


**Fig. 1** Cone-beam computed tomography CBCT sagittal and cross-sectional views of the temporomandibular joints (TMJs). Osseous changes in the condyle are (A) normal (B) flattening (C) erosion, (D) osteophyte, (E) sclerosis, (F) ankylosis, (G) depression, (H) joint space reduction, (I) subchondral cysts, (J) thickness of the glenoid fossa roof "yellow arrow" and cortical outline irregularity.

showed bony changes in the condyles, while 48 CBCTs scans (24 %) showed no bone changes in the condyles.

As shown in Table 3, there were no significant variations in Kennedy's classification I and II for right and left TMJs considering the degenerative changes ($P = 0.09$ for the right side and $P = 0.37$ for the left side). However, there were more degenerative changes for Kennedy's classification II than Kennedy's classification I for both the right and left sides. The most common degenerative change was flattening (left side: 15.5 %; right side: 14.5 %).

Further, there were no significant differences in the right and left degenerative changes for Kennedy's classes I and II based on sex (Table 4). However, Kennedy classifications I and II and degenerative changes in both the right and left sides were more common in men than in women.

## 4. Discussion

Computed tomography (CT) and CBCT are frequently used to diagnose TMJ hard-tissue abnormalities. Compared to CT and other imaging modalities, CBCT images provide 3D information about TMJ degenerative changes, and the most significant pathological changes are condylar osseous deformities (Zhou et al., 2018). Additional classic features of CBCT scans include lower radiation exposure and high spatial resolution radiography of the bone tissue components (Tsiklakis et al., 2004, Koyama et al., 2007). Despite being superior to standard panoramic radiography, panoramic TMJ radiography has poor diagnostic accuracy and reliability for the detection of TMJ bone lesions (Im et al., 2018). Therefore, a CBCT was the imaging approach used in this study of QUDCs, KSA.

The occurrence of condylar bone alterations on CBCT (76 %) in the study sample was consistent with the findings of Pontual et al. (71 %) (dos Anjos Pontual et al., 2012). Degenerative bone alterations, conversely, were found in 19.6 of 461 individuals in Capurso et al. (Capurso et al., 1989). According to our study results, 57 % of patients were males and 43 % were females, unlike the study by Pontual et al. (dos Anjos Pontual et al., 2012), who found that women (78 %) develop OA more than men (22 %). The effects of estrogen and prolactin hormones on cartilage and articular bone deterioration, as well as the initiation of a series of immunological reactions in the TMJ, may explain the advanced commonness in females (Yasuoka et al., 2000, Koyama et al., 2007). Cruzoé-Rebello et al., on the other hand, found that both males and females displayed the same internal derangement features, indicating that hormonal considerations do not appear to play a part in the development of TMJ inner deficiencies (Crusoé-Rebello et al., 2003). Some of the local mechanical variables that induce potential changes in the TMJ are function overload, parafunctional behaviors, trauma, occlusion, dentofacial anatomy, joint friction increase, and disc displacement. The TMJ remodeling capability of the host is also affected by sex, age, hormonal variables, and systemic arthritis (Asakawa-Tanne et al., 2015, Bertram et al., 2018, Moncada et al., 2014, Witulski et al., 2014, Zhang et al., 2013).

Both functionally united joints coordinate the movements of the mandible, as suggested by Katzberg and Wier (Katzberg 1989) and in our research, which may explain the high degree of bilateral bone changes. According to Cruzoé-Rebello et al. (Crusoé-Rebello et al., 2003), each joint affects the other, and consequently, they cannot be studied independently, as in Nebbe et al. (Nebbe et al., 1998) and Alexious et al. (Alexiou et al., 2009) claimed. Furthermore, left-sided condyle bone changes in both men and women were more common than those on the right side in our study. It is unclear whether there is a link between TMJ dysfunction and tooth loss (Shet et al., 2013). According to Garcia et al. (Garcia et al., 2008), there is no factual connection between TMD and Kennedy class I and II partially edentulous individuals. In a study undertaken by Shet et al. (Shet et al., 2013), 250 cases (99 males and 151 women) among the ages of 35–45 were studied. The patients were partially edentulous for at least 6 months and did not use any type of prosthesis. Symptoms

**Table 1** Characteristics of the study subjects.

| Variables | Groups | N | % |
|---|---|---|---|
| Sex | Male | 114 | 57 % |
| | Female | 86 | 43 % |
| Kennedy classification | I | 102 | 51 % |
| | II | 98 | 49 % |
| Degenerative change (RT) | No | 79 | 39.5 % |
| | Yes | 121 | 60.5 % |
| Degenerative change (LT) | No | 84 | 42 % |
| | Yes | 116 | 58 % |
| Rt degenerative change | Normal | 79 | 39.5 % |
| | Sclerosis | 14 | 7 % |
| | Flattening | 29 | 14.5 % |
| | Depression | 5 | 2.5 % |
| | Erosion | 5 | 2.5 % |
| | Subchondral cysts | 8 | 4 % |
| | Osteophyte formation | 2 | 1 % |
| | Flattening and erosion | 0 | 0 % |
| | Ankylosis and depression | 0 | 0 % |
| | Depression and sclerosis | 1 | 0.5 % |
| | Sclerosis and subchondral cysts | 1 | 0.5 % |
| | Joint space reduction | 20 | 10 % |
| | Joint space reduction and irregular and possibly thickened cortical outlines | 1 | 0.5 % |
| | Thickness of the glenoid fossa roof | 3 | 1.5 % |
| | Thickness of the glenoid fossa roof and joint space reduction | 2 | 1 % |
| | Thickness of the glenoid fossa roof, sclerosis, and joint space reduction | 0 | 0 % |
| | Irregular and possibly thickened cortical outlines | 20 | 10 % |
| | Irregular and possibly thickened cortical outlines and depression | 0 | 0 % |
| | Flattening and thickness of glenoid fossa roof | 0 | 0 % |
| | Flattening and joint space reduction | 1 | 0.5 % |
| | Flattening, sclerosis, and joint space reduction | 1 | 0.5 % |
| | Flattening and irregular and possibly thickened cortical outlines | 2 | 1 % |
| | Erosion, depression, and osteophyte formation | 1 | 0.5 % |
| | Sclerosis and joint space reduction | 2 | 1 % |
| | Sclerosis and irregular and possibly thickened cortical outlines | 0 | 0 % |
| | Sclerosis, erosion, osteophyte formation, and joint space reduction | 1 | 0.5 % |
| | Depression, flattening, sclerosis, and ankylosis | 0 | 0 % |
| | Subchondral cysts and joint space reduction | 2 | 1 % |
| Lt degenerative change | Normal | 84 | 42 % |
| | Sclerosis | 12 | 6 % |
| | Flattening | 31 | 15.5 % |
| | Depression | 1 | 0.5 % |
| | Erosion | 9 | 4.5 % |
| | Subchondral cysts | 6 | 3 % |
| | Osteophyte formation | 1 | 0.5 % |
| | Flattening and erosion | 1 | 0.5 % |
| | Ankylosis and depression | 1 | 0.5 % |
| | Depression and sclerosis | 0 | 0 % |
| | Sclerosis and subchondral cysts | 0 | 0 % |
| | Joint space reduction | 23 | 11.5 % |
| | Joint space reduction and irregular and possibly thickened cortical outlines | 0 | 0 % |
| | Thickness of the glenoid fossa roof | 4 | 2 % |
| | Thickness of the glenoid fossa roof and joint space reduction | 1 | 0.5 % |
| | Thickness of the glenoid fossa roof, sclerosis, and joint space reduction | 1 | 0.5 % |
| | Irregular and possibly thickened cortical outlines | 16 | 8 % |
| | Irregular and possibly thickened cortical outlines and depression | 1 | 0.5 % |
| | Flattening and thickness of the glenoid fossa roof | 1 | 0.5 % |
| | Flattening and joint space reduction | 1 | 0.5 % |
| | Flattening, sclerosis, and joint space reduction | 0 | 0 % |
| | Flattening and irregular and possibly thickened cortical outlines | 0 | 0 % |
| | Erosion, depression, and osteophyte formation | 0 | 0 % |
| | Sclerosis and joint space reduction | 1 | 0.5 % |
| | Sclerosis and irregular and possibly thickened cortical outlines | 1 | 0.5 % |
| | Sclerosis, erosion, osteophyte formation, and joint space reduction | 0 | 0 % |

(*continued on next page*)

**Table 1** (*continued*)

| Variables | Groups | N | % |
|---|---|---|---|
| | Depression, flattening, sclerosis, and ankylosis | 2 | 1 % |
| | Subchondral cysts and joint space reduction | 2 | 1 % |
| Sample Total | | 200 | 100 % |

**Note: Lt and Rt = left and right sides, N = number of patients**.

**Table 2** Patients' sex distribution based on the degenerative bone abnormalities in the condyles.

| Sex | With bone changes | | Without bone changes | |
|---|---|---|---|---|
| | N | % | N | % |
| Female | 64 | 32 | 22 | 11 |
| Male | 88 | 44 | 26 | 13 |
| Total | 152 | 76 | 48 | 24 |

**Table 3** Distribution of patients with Kennedy classification based on degenerative bone changes.

| Side | Kennedy classification | Prevalence % | Count | P-value |
|---|---|---|---|---|
| Rt | I Normal | 45.1 % | 46 | 0.098 |
| | I Changed | 54.9 % | 56 | |
| | II Normal | 33.7 % | 33 | |
| | II Changed | 66.3 % | 65 | |
| Lt | I Normal | 45.1 % | 46 | 0.365 |
| | I Changed | 54.9 % | 56 | |
| | II Normal | 38.8 % | 38 | |
| | II Changed | 61.2 % | 60 | |

**Table 4** Distribution of degenerative changes and Kennedy's classification based on sex.

| Variables | Sex | Prevalence % | Count | P-value |
|---|---|---|---|---|
| Kennedy classification I | Male | 59.8 % | 61 | 0.414 |
| | Female | 40.2 % | 41 | |
| Kennedy classification II | Male | 54.1 % | 53 | |
| | Female | 45.9 % | 45 | |
| Rt degenerative change | Male | 58.2 % | 46 | 0.777 |
| | Female | 41.8 % | 33 | |
| Lt degenerative change | Male | 56.2 % | 68 | |
| | Female | 43.8 % | 53 | |

of TMJ dysfunction were substantially more common in women than in men. Our study found that TMDs were more significant in men with partial edentulous Kennedy class I and II on both the right and left sides. There were no significant changes in the Kennedy classification based on the degree of degeneration ($P \geq 0.05$). However, Kennedy classification II has a higher prevalence of degenerative changes than Kennedy classification I.

Osteophyte development, subchondral cysts, erosion, sclerosis, joint space reduction, and flattening characterize condylar bone alterations, which are radiographic features of OA. In comparison to Alexious et al. (Alexiou et al., 2009), who used CBCT in patients, and Güler et al. (Guler et al., 2003), who used MRI, discovered osteophytes, flattening, and erosion were the most frequent radiological features of the condyle, whereas Campos et al. (Campos et al., 2008) (MRI) and Pontual et al. (dos Anjos Pontual et al., 2012) (CBCT) revealed erosion and osteophytes to be more frequent in their studies. In our study, flattening was the most prevalent degenerative alteration (count right = 29, left = 31) on CBCT, especially with Kennedy class II, followed by joint space reduction. The idea that this bone modification represents an adaptive change could explain the high degree of flatness. Flattening is a degenerative change that occurs when the TMJ is overloaded (dos Anjos Pontual et al., 2012). In terms of bone alterations in combination, subchondral cysts with joint space reduction were more common in our study, contrary to the findings of the previous studies mentioned above, which revealed only a combination of erosion and sclerosis with osteophytes. Our study observed only 0.5 % of condyles with osteophytes, erosion, and flattening, which is similar to osteophytes, erosion, sclerosis, and joint space reduction.

### *4.1. The study's pro and cons*

This study has certain possible limitations, despite the fact that it is the first original research examining the frequency of TMDs with posterior partial edentulism from this region. Firstly, in terms of data analysis and interpretation, was the misinterpretation of the bone changes that were discovered. We have overcome this by going over it with the radiologist doctors again and evaluating each alteration in two sliced images as described in the material and method section. Secondly, during the COVID-19 period, sample review was interrupted, delaying our examination of the remaining samples. Lastly, is the lack of a control group, which means we cannot exclude other risk factors, including aging, trauma, inflammatory diseases, and infections that might lead to degenerative changes in the TMJ. Therefore, I recommend conducting further statics to rule out other risk variables.

## 5. Conclusions

Within this research limitation, we determined that patients with Kennedy's class I and II partially edentulous arches had a higher degree of degenerative bone alterations.

Men had a greater tendency for TMJ degenerative bone than women. The left condyles of both men and women showed a higher prevalence of degenerative changes than the right condyle. Kennedy class II partial edentulism showed more degenerative changes than class I, and the most prevalent type of degenerative bone change is flattening, which is the most common type in both females and males. As a recommendation, further studies considering age groups, sex, OA clinical examination, and period of partial edentulism without prosthetic replacement should be conducted to explain the increase in TMJ degenerative bone changes.

## 6. Data accessibility

On request, the data used to confirm the study's findings can be released from the principal investigator.

## Ethical Statement

This study was performed in strict conformity with the standards and principles of the Qassim University's local human subjects' monitoring committee, KSA (Ethical approval number F2018-3010).

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sdentj.2022.09.002.

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