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Original Article

Comparative analysis of temporomandibular joint morphology in degenerative joint disease: A cone-beam CT study in patients with and without arthralgia

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ABSTRACT

Objectives: This cross-sectional study aimed to compare, by using Cone-Beam Computed Tomography (CBCT), temporomandibular joint (TMJ) morphology among patients with degenerative joint disease (DJD) with or without arthralgia, as well as a control group. Methods: Thirty-one patients and their respective CBCT TMJ exams were assessed. These individuals were selected from an Orofacial Pain Service and classified into three groups based on the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD): group 1 (10 patients with TMJ DJD and arthralgia), group 2 (11 patients with TMJ DJD without pain), and group 3 (the control group, consisting of 10 healthy individuals without any signs or symptoms of TMD). A second examiner, who was calibrated and blinded for the patient's diagnosis, evaluated the CBCT images. Results: Group 1 showed a statistically significant association with the variables of erosion ($p = 0.003$) and osteophyte ($p = 0.04$) on the condyle surface, as well as concentric condyle position with reduced joint space ($p = 0.01$). The Kappa concordance index between the clinical diagnosis of DC/TMD and CBCT images was $k = 0.134$ ($p \leq 0.001$). Conclusion: The presence of erosion, osteophyte, and concentric condyle position with reduced joint space was statistically associated with DJD and ongoing TMJ joint pain.

1. Introduction

Degenerative Joint Disease (DJD) is a common, non-inflammatory temporomandibular joint (TMJ) disorder type. It is defined as a degenerative joint condition characterized by deterioration and abrasion of articular tissue and, most of the time, concomitant remodeling of the underlying subchondral bone due to overload of the remodeling mechanism. An imbalance of joint chondrocyte-controlled deterioration (progressive loss/destruction) and proliferation (reparative) occurs, resulting in acute phase deterioration (osteoarthritis), as well as chronic phase proliferation (osteoarthrosis).(Schiffman et al., 2014, De Leeuw and Klasser, 2018).

In the realm of Temporomandibular Disorders (TMD), Cone-Beam Computed Tomography (CBCT) examinations of TMJ are widely employed to comprehend the TMJ's bone structures and enhance the DJD's diagnostic accuracy when combined with a thorough patient history and clinical inspection.(Ahmad et al., 2009, Comert Kilic et al., 2015, Talaat et al., 2016) However, clinical data and CBCT images can result in a weak correlation between condylar changes seen on CBCT and clinical pain and/or other clinical signs of TMJ osteoarthritis.(Palconet et al., 2012, Al-Ekrish et al., 2015, Hilgenberg-Sydney et al., 2018) According to the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD),(Schiffman et al., 2014) clinical diagnosis of DJD requires the presence of crepitus during jaw movement both reported by the patient and detected by the examiner during TMJ evaluation. If misdiagnosed, DJD can lead to a limited range of motion and restriction of joint movements in the long term.(De Leeuw and Klasser, 2018) The TMJ DJD can be a silent condition.(Hilgenberg-Sydney et al., 2018).

This study aimed to compare, by using CBCT, TMJ hard tissue findings of degenerative joint disease among patients with arthralgia, without arthralgia, and a control group. Understanding the disorder's severity is beneficial for choosing an efficient treatment plan and improving the quality of life in DJD patients.

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2. Materials and Methods

This study was submitted to and approved by the local Committee on Ethics in Research under the approval protocol #3.007.331. All procedures were performed following the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Subjects were recruited from the list of patients who underwent TMJ evaluation at the Orofacial Pain Service and other Dental Clinics at the Federal University of Paraná, from November 2021 to June 2022. Informed consent was obtained from all participants, who were invited to voluntarily participate. This study is under Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm et al., 2007).

Sample size calculation was performed with G*Power 3.1.9.6 software (Düsseldorf, Germany), considering the following parameters: test power of 0.8, significance level of 0.05 %, effect size of 0.46, and Df = 2. The estimated total sample size was 46. Each TMJ was considered a unit of observation.

Brazilian women over 18 years old were included in the sample and a clinical examination was performed by a single experimented examiner (P.B.H.S.) with more than 17 years of experience and who is a specialist and TMD and Orofacial pain professor. The subjects were then allocated into three groups according to the clinical DC/TMD(Talaat et al., 2016) examination as follows: group 1, DJD and arthralgia; group 2, DJD without arthralgia/pain; and group 3, control group, without any signs and/or symptoms of TMD. TMJs with disk displacement, with or without reduction according to the DC/TMD, were not included in any group. The normal TMJs from the groups 1 and 2 were excluded and then, CBCT exams of the included TMJs from the 3 groups were evaluated (Fig. 1). The CBCTs exams were analyzed by a second examiner (F.F.Z.), blinded for clinical diagnosis, and previously calibrated (k = 0.801; p ≤ 0.001) according to the study by Iskanderani et al. (Iskanderani et al., 2020), following a two-step evaluation of the same set of 6 CBCTs, with fifteen days between sessions.

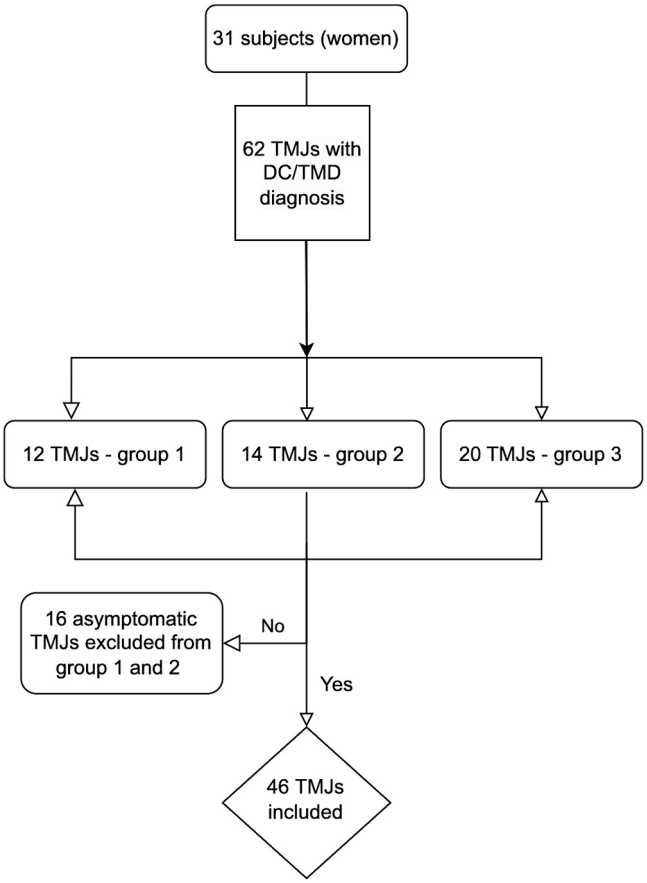

Fig. 1. Sample and methods flowchart.

Exclusion criteria were patients under 18 years old; diagnosis of rheumatoid arthritis; history of previous surgery in the TMJs; masticatory muscles myofascial pain referred to one or both TMJs, and other abnormalities that did not meet the DC/TMD (Palconet et al., 2012) for 'DJD' neither 'arthralgia'.

2.1. Cone-Beam Computed Tomography imaging

Cone Beam Computed Tomography images were obtained with an iCAT® Next Generation CBCT (Imaging Sciences International Hatfield, Pennsylvania) (Field of view 16 cm × 13 cm; resolution 0.25 voxel, 20 mA and 120 kV, 26.9 s acquisition time). Images were visualized in the iCAT Vision® software (Kavo® Dental Excellence, USA). The criteria for assessment of condylar position and hard tissue were the ones proposed by Ahmad et al., 2009.(Ahmad et al., 2009) Images were evaluated and classified as 'no osteoarthritis', 'indeterminate for osteoarthritis', or 'osteoarthritis'. When at least one of the following criteria was present, DJD was considered: subchondral cyst(s), surface erosion(s), generalized sclerosis, and/or osteophyte(s).(Ahmad et al., 2009) Flattening and/or cortical sclerosis are indeterminate signs of DJD and should be considered normal variations. The criteria 'no osteoarthritis' and 'indeterminate for osteoarthritis' were grouped and considered as 'no osteoarthritis', as suggested by previous authors.(De Leeuw and Klasser, 2018).

2.2. Statistical analysis

Age variable did not present a normal distribution so differences among groups were calculated using the Kruskal-Wallis test. Considering DJD groups, the agreement between clinical and tomographic findings for sensitivity and specificity analyses was evaluated with the kappa test.(Landis and Koch, 1977) Logistic regression analysis was applied for groups 1 and 2 to identify which anatomic variable was related to the concomitant presence of arthralgia in patients with DJD and to predict the influence of age in the presence of ongoing TMJ pain in DJD patients. Mann-Whitney test was used to evaluate the association between ongoing TMJ pain and the number of tomographic findings. Statistical Package for the Social Sciences (SPSS®, Version 21.0) and Jamovi (Version 1.6.23.0) were used for statistical analyses with a significance level of p ≤ 0.05.

3. Results

The total sample was comprised of 46 TMJs from 31 women. Median age was 48.50 (29–55) years old for group 1, 25 (23.50–30) for group 2, and 30 (21–51.25) for group 3, with no significant differences (p = 0.11).

Forty-six TMJ were included for CBCT evaluation after the clinical DC/TMD exam, being 12 TMJs evaluated in group 1, 14 TMJs in group 2, and 20 TMJs in group 3. All TMJs from group 3 were included because they were healthy joints, i.e., without clinical signs or symptoms. However, for groups 1 and 2, only those TMJ with a DC/TMD(Hilgenberg-Sydney et al., 2018) diagnosis according to inclusion criteria were evaluated, so healthy TMJs from groups 1 and 2 were not evaluated.

There was a statistically significant association of superficial erosion (p = 0.003), osteophyte (p = 0.04), and concentric condyle position with reduced joint space (p = 0.01) with group 1 (DJD and TMJ pain). Some TMJ CBCT images with DJD are shown in Fig. 2.

Fisher's exact test revealed no significant differences (p > 0.05) among the groups regarding many CBCT findings as shown in Table 1. Condyle erosion, presence of osteophytes, and 'concentric condyle with reduced joint space' were associated with the presence of ongoing pain

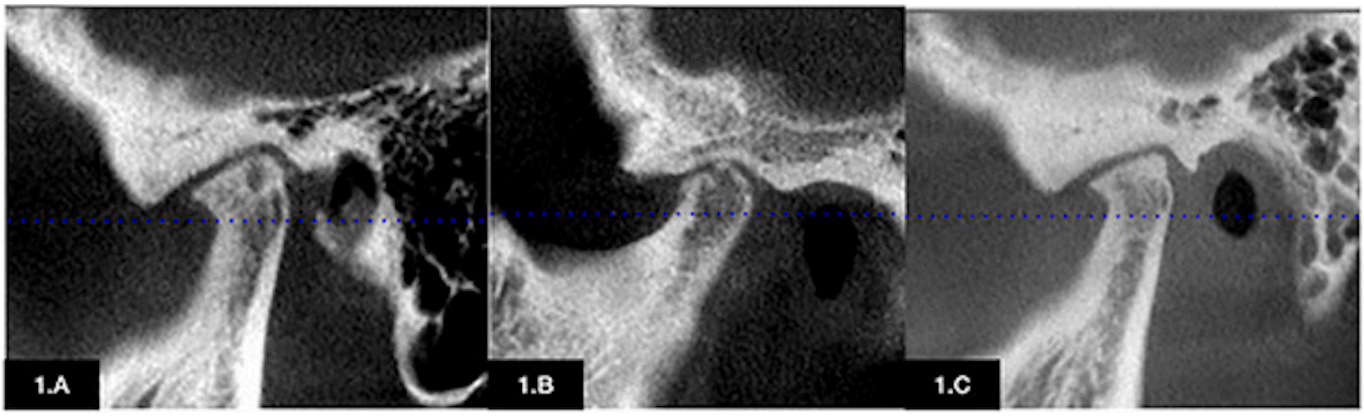

Fig. 2. CBCT findings in degenerative joint disease in temporomandibular joints. A: presence of a subcortical cyst, osteophyte, and sclerotic articular eminence; B: condyle surface erosion; C: flattening of the condyle surface and articular eminence, condylar cortical sclerosis, and osteophyte.

Table 1
Cone-Beam Computed Tomography descriptive data (n) per joint plus P value of Fisher's exact test.

	Group 1 DJD with arthralgia (n = 12)		Group 2 DJD with no arthralgia (n = 14)		Group 3 Control (n = 20)		
Findings	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	***P value***
Condylar Head							
Condylar hypoplasia	0	12	1	13	0	20	0.56
Condylar hyperplasia	0	12	0	14	2	18	0.49
Articular surface flattening	3	9	2	12	1	19	0.25
Subcortical sclerosis	2	10	2	12	2	18	0.86
Subcortical cyst	2	10	0	14	0	20	0.06
Surface erosion	6	6	5	9	2	18	***0.04****
Osteophyte	5	7	4	10	0	20	***0.003****
Generalized sclerosis	1	11	0	14	0	20	0.26
Loose joint body	1	11	0	14	0	20	0.26
Deviation in form	2	10	0	14	0	20	0.06
Bony ankylosis	0	12	0	14	0	20	n.a.
Fossa/ eminence							
Articular surface flattening	3	9	3	11	4	16	1.00
Subcortical sclerosis	2	10	0	14	1	19	0.33
Superficial erosion	2	10	2	12	1	19	0.58
Condylar position							
Concentric position with normal joint space	4	8	2	12	1	19	0.08
Concentric position with decreased joint space	4	8	2	12	0	20	***0.01****
Anterior position	3	9	3	11	1	19	0.25
Posterior position	0	12	0	14	0	20	n.a.

Table 2
Logistic regression analysis.

	P value	Odds Ratio	95% Confidence Interval
Condylar Head			
Condylar hypoplasia	0.995	6.92e-8	0.000 – Inf
Condylar hyperplasia	n.a.	n.a.	n.a.
Articular surface flattening	0.494	2.00	0.274–14.59
Subcortical sclerosis	0.867	1.200	0.142–10.12
Subcortical cyst	0.995	5.96e+7	0.000 – Inf
Surface erosion	0.464	1.800	0.373–8.68
Osteophyte	0.486	1.786	0.349–9.13
Generalized sclerosis	0.994	1.99e+7	0.000 – Inf
Loose joint body	0.994	1.99e+7	0.000 – Inf
Deviation in form	0.995	5.96e+7	0.000 – Inf
Bony ankylosis	n.a.	n.a.	n.a.
Fossa/eminence			
Articular surface flattening	0.830	1.222	0.197–7.59
Subcortical sclerosis	0.994	1.99e+7	0.000 – Inf
Surface erosion	0.867	1.200	0.142–10.12
Condylar position			
Concentric position with normal joint space	0.262	0.333	0.048–2.27
Concentric position with decreased joint space	0.262	3.000	0.440–20.44
Anterior position	0.830	1.222	0.197–7.59
Posterior position	n.a.	n.a.	n.a.

in the TMJ with DJD. There was no association between ongoing TMJ pain and the number of tomographic findings ($p = 0.195$).

Regarding groups 1 and 2, logistic regression analysis showed no anatomic variable impacting the presence of ongoing TMJ pain in patients with DJD (Table 2). However, it showed that age significantly impacts the probability of developing TMJ pain associated with DJD [$x^2 = 9.09$, $p = 0.003$; $R^2_N = 0.394$]. The estimated odds ratio [OR (CI 95 %): 1.11 (1.02–1.21)] allows us to affirm that for each year of age, the chance of having ongoing pain/arthralgia associated with a DJD enhances by 11 %.

Agreement of clinical and tomographic diagnosis results for group 1 showed a sensitivity of 77.8 % with the use of CBCT exams for diagnosing DJD and a specificity of 78.3 %. The Kappa concordance index between the clinical diagnosis of DC/TMD and the CBCT images for DJD with arthralgia was $k = 0.509$ ($p = 0.003$). Group 2 showed a sensitivity of 77.8 % with the use of CBCT exams for diagnosing DJD and a specificity of 72.0 %. The Kappa concordance index between the clinical diagnosis of DC/TMD and the CBCT images for DJD with no arthralgia was $k = 0.423$ ($p = 0.009$).

4. Discussion

This study aimed to understand the association of DJD osseous changes in TMJs with and without associated pain. No degenerative changes in CBCT were a predictor for TMJ arthralgia in DJD patients. On the other hand, age may be a risk factor for developing arthralgia in DJD patients. As expected, the agreement between clinical and CBCT findings was poor.

The present sample was comprised only of women, with a median age of 29 years old. It is known that DJD has the highest incidence in females,(Nah, 2012, Kim et al., 2016) especially those in the reproductive phase. The association of age with an increased frequency of DJD with associated pain is controversial in the literature. Some studies report an increase in the chance of developing osteoarthritis with age, but it is contradicted by other studies that report a similar presence of osteoarthritis at older and younger ages, suggesting that TMJ DJD may be more frequent among young people than expected.(Kim et al., 2016, De Leeuw and Klasser, 2018) An autopsy study indicated that the signs

of degenerative changes on the TMJ articular surfaces were found in 28 % of young individuals (16 to 39 years old) and 50 % of the older group (55 to 78 years old).(Pereira et al., 1994) The present study found that age may be a risk factor for developing TMJ pain associated with DJD. For each additional year of age, patients with DJD have an 11 % higher risk of developing TMJ pain. These results may suggest extra care in young patients who already have degenerative changes in CBCT images, increasing care to prevent painful symptoms in the TMJ over time. Nonetheless, clinicians should always consider the multifactorial character of TMDs.(Schiffman et al., 2014, De Leeuw and Klasser, 2018).

As the diagnosis of DJDs depends on radiographic images, in addition to clinical criteria, a lot is questioned about the relationship of specific TMJ tomographic findings that could be conclusive to osteoarthritis diagnosis.(Wiese et al., 2008, Palconet et al., 2012, Al-Ekrish et al., 2015, Hilgenberg-Sydney et al., 2018, Bianchi et al., 2021) The present findings do not suggest any morphologic change as a risk factor for painful DJD. Also, Hilgenberg-Sydney et al.(Hilgenberg-Sydney et al., 2022) found that abnormal tomographic findings had no significant difference in the diagnosis of TMJ osteoarthritis. Their study showed 'fair' sensitivity and specificity values of 61.5 % and 75 % respectively, for the use of CBCT as a diagnostic exam for TMJ DJD. The interexaminer reliability for tomographic findings was strong, however, the agreement between clinical and tomographic findings was reasonable.(Hilgenberg-Sydney et al., 2022) The present results have also shown that even clinically healthy patients may present some degenerative bone changes, such as condylar erosion, which is certainly not expected for asymptomatic individuals.(Schiffman et al., 2014, Hilgenberg-Sydney et al., 2018) The use of CBCT images of DJD patients, with and without TMJ pain, as a diagnostic tool should be used with additional precaution, as already suggested by previous studies.(Hilgenberg-Sydney et al., 2018).

A study by Cevidanes et al.(Cevidanes et al., 2010) found a statistically significant difference between the condylar morphology of the condyles with osteoarthritis and the asymptomatic condyles. The present study aimed to include the presence or absence of ongoing TMJ pain in the sample groups to better understand the pain relation to CBCT findings in DJD diagnosis. The results showed a statistically significant association for group 1 (DJD with arthralgia) with the variables "presence of condyle erosion", "osteophyte", and "concentric condyle with reduced joint space". Therefore, these CBCT degenerative findings may be related to pain. In addition, some authors(Comert Kilic et al., 2015) affirm that pain during mandibular function might be related to degenerative changes on the TMJ articular surface. On the other hand, joint pain during palpation may be the result of pathological changes in the lateral and posterior parts of the condyle. The present results are in accordance with previous authors, as condyle erosion and the presence of osteophyte are two of the degenerative changes most found in TMJ images to confirm DJD diagnosis.(Ahmad et al., 2009, Schiffman et al., 2014).

Condyle erosion was identified in 50 % of patients in group 1, 35.7 % in group 2, and 10 % in group 3, demonstrating a high frequency of condyle erosion in group 1. These results agree with a study from 2012, (Nah, 2012) in which the tomographic finding of condylar erosion is present in 65.9 % of the joints with associated pain. Regarding the presence of osteophytes, group 1 had a statistically significant higher frequency (41.7 %) of this finding than group 2 (28.6 %). Ahmad et al. (Ahmad et al., 2009) associate osteophytes with joint pain since it is indicative of cartilage degradation and may be an indicator of osteoarthritis progression. Condylar erosion, flattening, osteophytes, pain, joint sounds, reduced jaw movements, and worsening of mastication were common findings in Cömert Kiliç et al.(Comert Kilic et al., 2015) study, but also poor correlations were found between CBCT findings and clinical signs and symptoms of TMJ osteoarthritis.

As a result of the present study, a statistically significant difference was observed in the frequency of concentric condyle with reduced joint space among the groups. The positioning of the condyle is cited in the literature as a reference for the resorption of the lateral pole of the condylar surface, associating it with the initial phase of degenerative joint disease (DJD).(Cevidanes et al., 2014) TMJ disk displacement may also be linked to reduced joint space, a factor that should be considered. However, as outlined in the methods section, individuals with any other temporomandibular disorder (TMD) diagnosis according to the DC/TMD, aside from DJD with or without arthralgia or controls, were not included in the present sample.

Encouraging studies that advocate the association of DJD morphologic characteristics in TMJ with ongoing pain should be reinforced, as there is a scientific gap in this specific topic in the literature. As this was not a prospective study, some caution should be taken when interpreting results. It would be interesting to perform a longitudinal case-control study to evaluate DJD morphologic changes evolution. The evaluations were performed by only one clinical examiner and one CBCT imaging examiner. Despite both being calibrated and experimented in the field, future studies should have more examiners for the clinical and imaging exams.

The presence of erosion, osteophyte, and concentric condyle position with reduced joint space were statistically associated with DJD and ongoing TMJ joint pain. For each additional year of age, patients with DJD have an 11 % higher risk of developing TMJ pain. There was poor agreement between the clinical diagnosis of DC/TMD and the CBCT images.

CRediT authorship contribution statement

Priscila Brenner Hilgenberg-Sydney: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Fernanda Farago Zanlorenzi:** Conceptualization, Methodology, Investigation, Writing – original draft. **Carolina Ortigosa Cunha:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing.

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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