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Clinical Paper
TMJ Disorders

Correlation of gender and age with magnetic resonance imaging findings in patients with arthrogenic temporomandibular disorders: a cross-sectional study

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Abstract. The objective of this study was to analyse the correlation between the gender and age of individuals with arthrogenic temporomandibular disorders (TMDs) and magnetic resonance imaging (MRI) findings. A total of 199 patients were included in the study and were divided into four age groups: group A, ≤30 years; group B, 31–44 years; group C, 45–55 years; group D, ≥56 years. MRI scans were analysed for the presence or absence of the following conditions: morphological changes in the mandibular condyle and/or articular tubercle, disc displacement with (DDWR) and without reduction (DDWoR), bone oedema, effusion, and avascular necrosis. Statistical analyses were conducted using logistic regression models ($P < 0.05$). The mean patient age was 44.47 ± 16.39 years; 158 (79.4%) were female and 41 (20.6%) were male. Only DDWoR was more significantly found in females than in males ($P < 0.05$). Group D showed an odds ratio three times higher for the presence of morphological changes than group A (odds ratio 3.042, 95% confidence interval 1.421–6.512; $P = 0.0042$). No differences were found among groups for the other findings. Based on the results of the present study it may be concluded that MRI findings tend to differ according to age and gender.

Key words: temporomandibular disorder; magnetic resonance imaging; gender; age groups; epidemiology.

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Temporomandibular disorder (TMD) is a term used to describe a group of conditions that affect the stomatognathic system. Typical TMD symptoms are pain in the jaws, decreased mouth opening, and the production of sounds/clicks in the temporomandibular joint (TMJ).[1] TMD is considered the leading cause of orofacial pain of non-dental origin, and the reported prevalence of TMD ranges from 16% to 88% of the population worldwide.[2–4]

The diagnosis of patients with TMD involves a detailed investigation of the case history, followed by a series of intra- and extraoral physical examinations, as well as complementary examinations whenever deemed necessary. Magnetic resonance imaging (MRI), a non-invasive imaging test, is the primary imaging technique in the diagnosis of TMJ dysfunction.[5–7] MRI scans present high soft tissue contrast and great accuracy in the visualization of the anatomy of TMJ bony structures. Additionally, dynamic images may also be acquired to demonstrate joint functionality.[7–9] Thus, MRI is capable of demonstrating changes in the articular disc, where computed tomography (CT) scans and X-rays cannot.[7]

Studies have shown that females are more frequently affected by TMD than males,[3,10–13] leading to the belief that imaging findings such as disc displacement, effusion, and osteoarthritis are more common in women than in men.[14,15] With regard to age distribution, evidence seems to suggest that the presence of TMD is characterized by a Gaussian curve, i.e., peaking between 35 and 45 years, being less prevalent in the young and in the old.[2,3,16] However, the literature on this matter remains inconclusive, as peak age is not always the same for all TMD diagnoses. The presence of TMJ disc displacement is more common between the second and fifth decades of life,[2–4,11,14] while the presence of osteoarthritis is more common in the fourth and fifth decades.[2,3,13] In regard to effusion, this is expected to be more common in younger individuals,[13] while avascular necrosis is expected to be more common in older patients.[17]

Although several studies focusing on patients with TMDs have been performed, only a few have attempted to establish a correlation between patient sex and age and imaging findings. Evidence suggests that differences in diagnoses among the different age groups require further investigation.[2–4]

Therefore, the aim of this study was to evaluate the correlation of sex and age group with MRI findings in individuals diagnosed clinically with arthrogenic TMD. The null hypothesis to be tested was that the prevalence of the imaging findings in the conditions studied would not differ between the sexes or among the different age groups.

Materials and methods

This observational cross-sectional analytical study, using secondary data, was approved by the ethics committee for research involving human beings of the local institutional review board.

The study group consisted of 199 consecutive patients of both sexes with evidence of arthrogenic TMD. The clinical TMD diagnosis was conducted in accordance with previously established clinical diagnostic criteria for TMD.[18] The cases were drawn from individuals referred for MRI of the TMJ because of a history of clinical signs and symptoms of TMJ dysfunction (such as mandibular deviation–deflection), and/or the presence of a limited inter-incisal opening or limited mouth opening, and/or joint noise/clicking during mouth opening and closing. All subjects underwent an MRI investigation of the TMJ in an orofacial pain and deformity centre (Cenddor) in Porto Alegre, Brazil, from January 2007 to January 2014. Patients with a clinical history of rheumatoid arthritis, agenesis, hyperplasia, hypoplasia and/or malignant neoplasms of the mandibular condyle, bone ankylosis, previous TMJ surgery, and/or any type of surgery to the face that might interfere with image analysis, were excluded from the sample.

Participating patients were divided into four age groups based on a methodology described previously,[2–4] using the percentile age intervals of the study population. As a result, patients were distributed as follows: group A, age $\leq$30 years; group B, age between 31 and 44 years; group C, age between 45 and 55 years; group D, age $\geq$56 years.

Magnetic resonance imaging

MRI examinations were performed with a 1.5-T imaging system (Signa HDxt; GE Healthcare, Milwaukee, WI, USA) with the use of dual surface coils 9 cm in diameter. Sequences were performed with T1-weighted images, employing a repetition time (TR) of 567 ms and echo time (TE) of 11.4 ms. For T2-weighted images, TR of 5200 ms and TE of 168.5 ms were used. T1-weighted data were collected on a 288 $\times$ 192 dots/cm matrix, with number of excitations (NEX) = 3, while T2-weighted data were collected on a 288 $\times$ 160 dots/cm matrix, with NEX = 4 and a field of view (FOV) of 11 cm $\times$ 11 cm.

T1- and T2-weighted images with 3-mm slices were obtained for each TMJ in the oblique sagittal plane, perpendicular to the axis of the mandibular condyle, in maximum intercuspation and maximum mouth opening. Moreover, images of the TMJ were also obtained in the oblique coronal plane, in maximum intercuspation only. In order to locate the image of the mandibular condyles (scanogram), an axial section was first performed to obtain an image parallel to the axis of the mandibular condyle. An individual non-ferromagnetic intermaxillary device was used to keep the patient relaxed, minimize movement, and maintain the maximum mouth opening previously identified in the clinical examination.

The film used was 43 cm $\times$ 35 cm, with 12-image documentation (3 $\times$ 4) and 1.5-times magnification. Each set of images was analysed by the same experienced radiologist, who was completely blind to the clinical diagnosis received by the patient. Image analyses were conducted according to the criteria defined by Larheim et al.[19] and Ahmad et al.[20]

The presence or absence of the following conditions was assessed in the images obtained from each TMJ: morphological changes in the mandibular condyle and/or articular tubercle (Fig. 1), disc displacement with reduction (DDWR) (Fig. 2), disc displacement without reduction (DDWoR) (Fig. 3), bone oedema (Fig. 4), effusion (Fig. 5), and avascular necrosis (Fig. 6).

Statistical analysis

The Hosmer and Lemeshow logistic regression test was applied to compare the different age groups concerning each type of imaging finding.[21] First, by taking the data of the entire sample (n), the frequency of the presence of all findings involved in the study was identified. Then, a sub-sample (n_i) composed only of those individuals who presented the finding in question was established for each finding. After that, each sub-sample, n_i, was divided according to the age group. Thus, the logistic regression model was performed taking the n_i of each specific finding and characterizing an independence criterion among the groups as the basis for conducting the analyses. For comparisons between the sexes, in which the individual was adopted as the observational unit, the χ^2 test and Fisher's exact test were used. All analyses were performed using R version 3.0.2 (R Foundation for

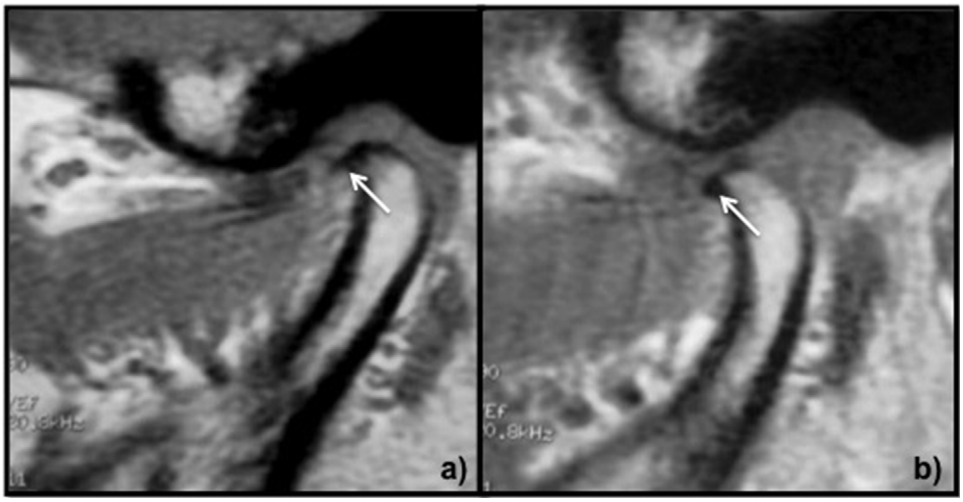

Fig. 1. T1-weighted sagittal view: (a) mouth closed; (b) mouth open. Angled exophytic bone tissue formation in the mandibular condyle (arrows), indicating the presence of osteophytes (morphological change).

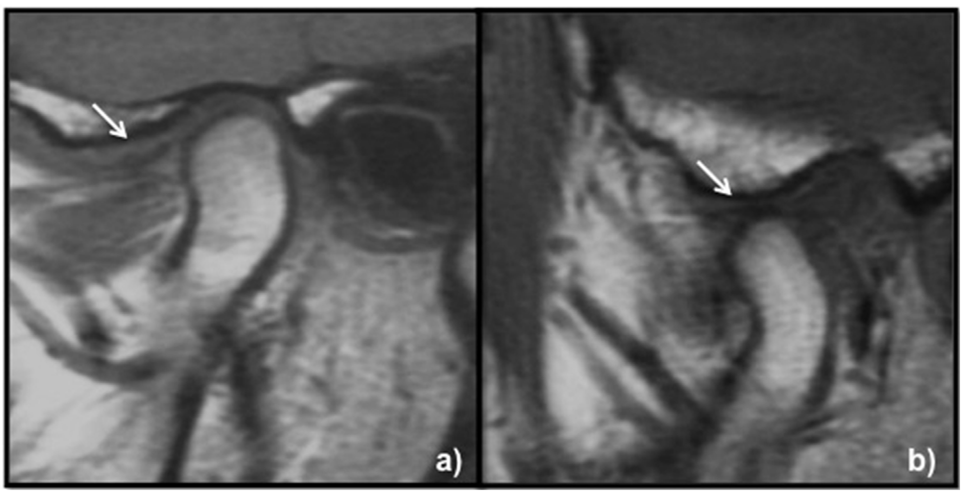

Fig. 2. T1-weighted sagittal view: (a) mouth closed – note that the articular disc (hypointense area, arrow) is in a position prior to 11:30 h in relation to the mandibular condyle; (b) mouth open – the articular disc returns to its original position, with the intermediate zone located between the mandibular condyle and the articular tubercle, characterizing disc displacement with reduction (DDWR).

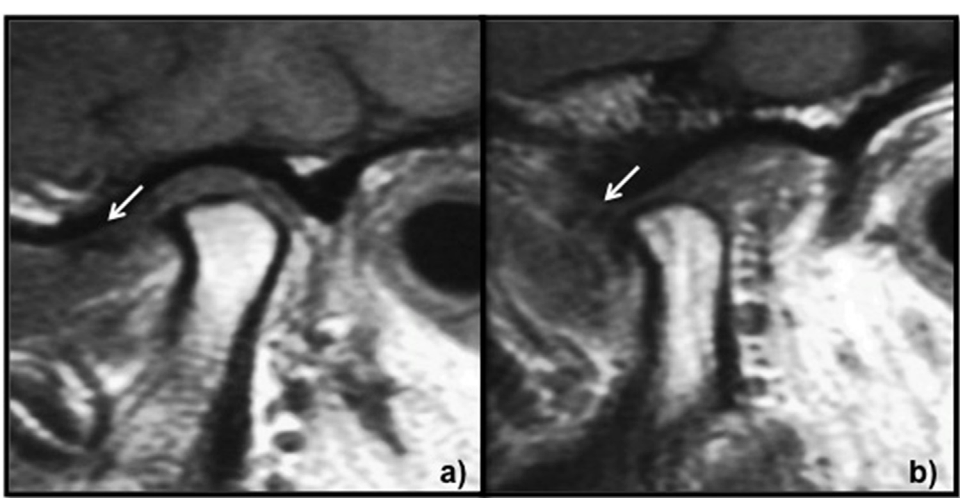

Fig. 3. T1-weighted sagittal view: (a) mouth closed – the articular disc (hypointense area, arrow) is in a position prior to 11:30 h in relation to the mandibular condyle; (b) mouth open – the articular disc remains in the displaced position, characterizing disc displacement without reduction (DDWoR).

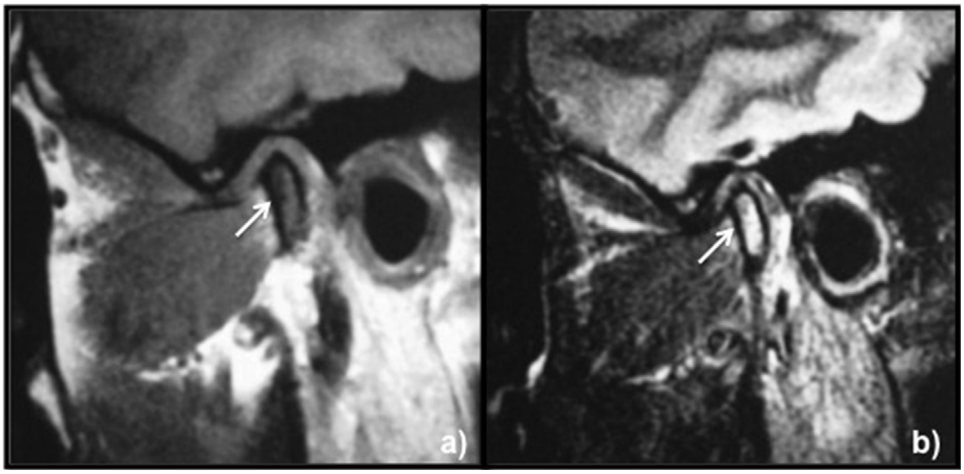

Fig. 4. Sagittal view with mouth closed: (a) T1-weighted – an extensive hypointense area in the mandibular condyle (arrow) can be observed; (b) T2-weighted – an area with hyper-signal in the mandibular condyle (arrow) is present, characterizing the presence of bone oedema.

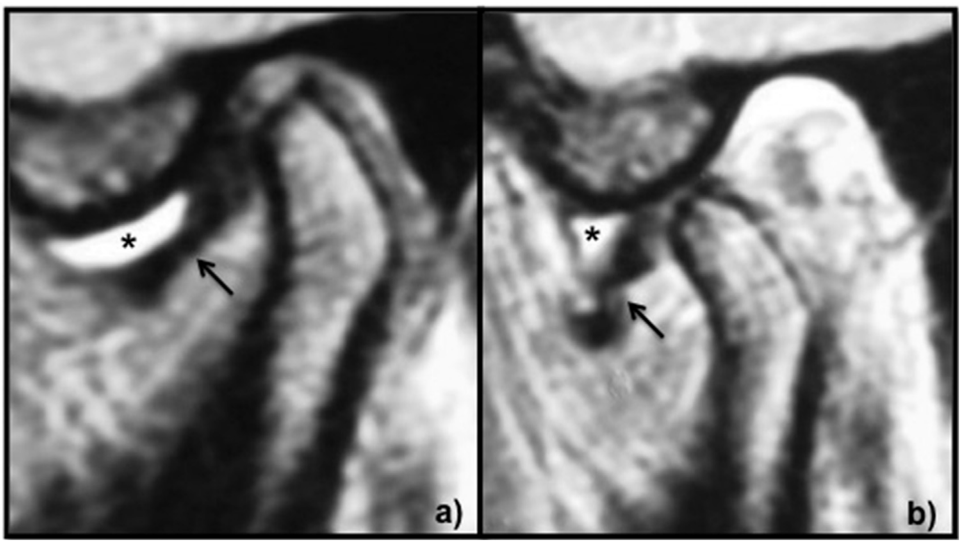

Fig. 5. T2-weighted sagittal view: (a) mouth closed – note the presence of a hyper-signal area, characterizing effusion (asterisks), while the articular disc (hypointense area, arrow) is in a position prior to 11:30 h relative to the mandibular condyle; (b) mouth open – note the presence of flow, while the disc remains in the displaced position, characterizing disc displacement without reduction (DDWoR).

Statistical Computing, Vienna, Austria) and SAS version 3.9 software (SAS Institute Inc., Cary, NC, USA), with the significance level set at 5%.

Results

Of the 199 participating patients (mean age 44.47 ± 16.39 years), 158 (79.4%) were female (mean age 44.45 ± 16.28 years) and 41 (20.6%) were male (mean age 44.54 ± 17 years).

The frequency distribution of the imaging findings for the entire sample is displayed in Table 1. The most frequent finding was DDWR (85.9%), followed by morphological changes (36.7%), DDWoR (35.7%), and effusion (30.7%).

When males and females were compared, DDWR was the most common finding for both females (85.4%) and males (87.8%). DDWoR was the only finding to be statistically different between the sexes ($P = 0.001595$), being more frequent in females (41.1%) than in males (14.6%) (Table 2).

The frequency distribution of the imaging findings according to the age groups is displayed in Fig. 7. Group A consisted of 50 participants, of whom 38 (76%) were female and 12 (24%) were male. The most frequent finding in this group was DDWR, observed in 46 patients (92%), followed by DDWoR in 18 (36%) and effusion in 17 (34%). Morphological changes were present in 13 patients (26%), bone oedema in three (6%), and avascular necrosis was not found in any of the cases (0%).

Table 1. Frequency distribution (%) of the MRI findings in the total study sample ($n = 199$).

MRI findings	Unilateral, *n* (%)	Bilateral, *n* (%)	Total
Morphological changes	47 (23.6%)	26 (13.1%)	73 (36.7%)
DDWR	58 (29.1%)	113 (56.8%)	171 (85.9%)
DDWoR	49 (24.6%)	22 (11.1%)	71 (35.7%)
Bone oedema	10 (5.0%)	1 (0.5%)	11 (5.5%)
Effusion	39 (19.6%)	22 (11.1%)	61 (30.7%)
Avascular necrosis	7 (3.5%)	0 (0%)	7 (3.5%)

MRI, magnetic resonance imaging; DDWR, disc displacement with reduction; DDWoR, disc displacement without reduction.

Fig. 6. T1-weighted sagittal view with the mouth open: a hypointense area is observed (arrow) circumscribed by a hyper-signal, characterizing the presence of avascular necrosis.

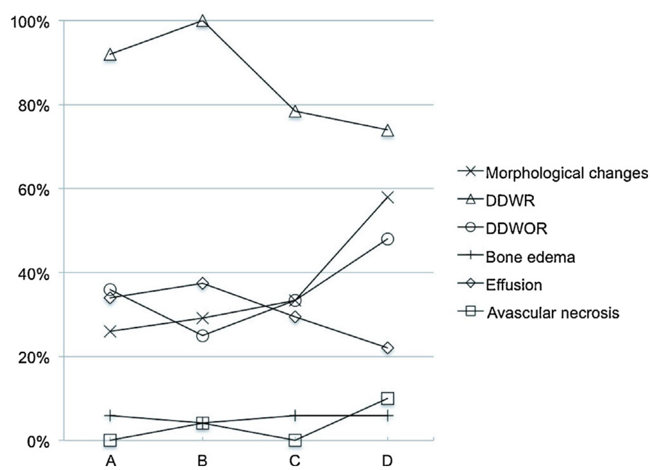

Fig. 7. Frequency distribution (%) of MRI findings in the four different age groups.

Group B consisted of 48 subjects, 39 (81.3%) females and nine (18.7%) males. DDWR was observed in all patients (100%), effusion in 18 (37.5%), and morphological changes in 14 (29.2%). DDWoR was present in 12 subjects (25%), bone oedema in two (4.2%), and avascular necrosis in two (4.2%).

Group C was composed of 51 individuals, 42 (82.4%) females and nine (17.6%) males. The most frequent findings in this age group were DDWR, present in 40 subjects (78.4%), followed by DDWoR in 17 (33.3%) and morphological alterations in 17 (33.3%). Avascular necrosis was absent (0%) in this group, while effusion was observed in 15 patients (29.4%) and bone oedema in three (5.9%).

Group D comprised 50 patients, 39 (78%) females and 11 (22%) males. DDWR was present in 37 cases (74%), followed by morphological changes in 29 (58%), DDWoR in 24 (48%), and effusion in 11 (22%). Avascular necrosis was identified in five patients (10%), while bone oedema was found in three (6%).

Logistic regression analysis was performed by taking the youngest group (group A) as reference. When group A was compared to the other groups, the only statistically significant difference related to morphological changes ($\chi^2 = 0.0096$). As shown in Table 3, this difference occurred between groups A and D (odds ratio 3.042, 95% confidence interval 1.421–6.512; $P = 0.0042$).

Table 2. Comparison of the MRI findings between males and females.

MRI findings	Female, *n* (%)	Male, *n* (%)	*P*-value
Morphological changes	61 (38.6%)	12 (29.3%)	0.2689
DDWR	135 (85.4%)	36 (87.8%)	0.8056
DDWoR	65 (41.1%)	6 (14.6%)	0.001595*
Bone oedema	9 (5.7%)	2 (4.9%)	1
Effusion	50 (31.6%)	11 (26.8%)	0.5512
Avascular necrosis	5 (3.2%)	2 (4.9%)	0.6348

MRI, magnetic resonance imaging; DDWR, disc displacement with reduction; DDWoR, disc displacement without reduction.

* Statistically significant difference ($P < 0.05$).

Discussion

TMDs are a heterogeneous group of conditions that can affect the TMJ and/or muscles of mastication. A better understanding of the epidemiology of TMDs at different ages could be useful in the development of future research focused on these disorders. This study assessed the frequency of different MRI findings found in TMD patients in respect to age, by splitting the sample into different age groups. The strengths of the present study are the size of the patient pool and the detailed statistical analysis.

The descriptive data show that the mean age (44.47 ± 16.39 years) and female to male ratio (3.85:1) of the sample in the present study are consistent with those of previous studies, which have reported peak ages for patients with TMD ranging from 35 to 45 years[2,3,15] and female to male ratios ranging from 2.3:1 to 7.3:1.[2,3,10,12,13,16]

Several different factors have been suggested for the predominance of females among TMD patients. One of the main reasons concerns differences in the threshold of pain, which is lower in women than in men, driving them to seek care in greater numbers.[15,22] The presence of increased intra-articular pressure in females, particularly concerning the presence of disc displacement, may also explain the higher frequency of TMDs in females.[23] Hormonal factors also seem to be responsible for constitutional differences such as increased ligament laxity and the greater fragility of the female TMJ.[16,24–27] Additionally, the greater amount of type III collagen fibres in the retrodiscal tissue in females may also play a role in the

Table 3. Logistic regression performed on the MRI findings of morphological changes ($\chi^2 = 0.0096$).

Age group[a]	OR	95% CI	*P*-value
Group A vs. group B	1.095	0.475–2.527	0.8312
Group A vs. group C	1.401	0.624–3.146	0.4137
Group A vs. group D	3.042	1.421–6.512	0.0042*

MRI, magnetic resonance imaging; OR, odds ratio; CI, confidence interval.
[a] Group A, ≤30 years; group B, 31–44 years; group C, 45–55 years; group D, ≥56 years.
* Statistically significant difference ($P < 0.05$).

higher prevalence of disc displacement in women.[25]

Morphological changes in the TMJ are more frequently observed with increasing age in both TMDs and musculoskeletal disorders.[28] This was confirmed by a series of three recent studies performed to verify age distribution patterns of different RDC/TMD (Research Diagnostic Criteria for Temporomandibular Disorders) diagnoses. All three studies demonstrated that disc displacement was more commonly found in the younger age groups, while arthralgia, osteoarthritis, and/or osteoarthrosis were more common in the older age groups.[2–4] The results found in the present study seem to confirm this assumption. While DDWR was more common in the younger age groups (groups A and B), morphological changes in the mandibular condyle and/or the articular tubercle were more prevalent in the older age groups (groups C and D). Indeed, evidence suggests that the presence of disc displacement, especially DDWoR,[29] acts as a causative factor in the degenerative changes of TMJ components.[30] This seems to explain the presence of such internal derangement in younger individuals and the degenerative changes found in older individuals. However, the existence of such a relationship has yet to be established in the scientific literature, requiring prospective studies with long follow-up periods.

This study also demonstrated correlations between age and osteoarthritis and age and effusion, in agreement with a previous study.[13] In that study, which evaluated 144 individuals diagnosed with a TMD, the authors found that the mean age of subjects with osteoarthritis in the right TMJ was 45.67 years and in the left TMJ was 46.03 years, indicating that the development of osteoarthritic changes requires a considerable amount of time.[13] Moreover, the same study showed that patients with effusion in the right and left TMJ had a mean age of 30.81 years and 29.54 years, respectively, demonstrating that effusion is more commonly found in younger TMJs.[13]

Although the difference found in the present study was not statistically significant, avascular necrosis was more frequently found in patients in the oldest age group (group D), which is in agreement with previous results in the literature.[17] In order to explore a possible correlation between patient age and the incidence of bone oedema and avascular necrosis, Sano et al. evaluated 35 joints of 35 patients with bone marrow abnormalities of the mandibular condyle.[17] Bone oedema was found in 13 patients with a mean age of 25.7 years and avascular necrosis in 22 patients with a mean age of 45.3 years. Thus, the first variable was more frequently observed in younger subjects, while the second was more frequent in older individuals.[17] Since studies suggest that bone oedema is a precursor of avascular necrosis,[17,19] this condition may be expected to primarily affect older individuals.

The only variable to present a statistically significant difference among the groups investigated in this study was morphological changes. The oldest age group (group D) showed an odds ratio 3.042 times higher for the presence of morphological changes when compared with the youngest age group (group A). Indeed, considering all 73 individuals who presented morphological changes in the mandibular condyle and/or articular tubercle in their MRI scans, 29 (39.7%) were aged over 56 years. Unfortunately, no direct comparison of these results with those of other studies in the literature is possible, because none of the studies that served as a support for the development of the methodology used in the present study conducted statistical comparisons among groups.[2–4] Nonetheless, the results obtained in the present study reinforce the evidence arising from the literature, which shows that morphological changes are more frequently present in older TMD patients.[2,3,13,23]

Although the results of the present study confirm some important trends in the distribution of different TMD conditions, they should be interpreted with caution. One important limitation of the present study was the difficulty in finding an appropriate statistical test to answer all the questions of interest. The results obtained with the regression model used here are very specific and punctual, always comparing group A with the other age groups. Comparisons between groups B and C, for example, were not performed. Furthermore the low prevalence of bone oedema and avascular necrosis in the individuals participating in this study may also raise questions from a statistical point of view. The very low or total lack of frequency of these findings in some of the age groups directly affected the statistical analysis, preventing the identification of statistical differences between groups, particularly between groups A and D. Further studies with a larger number of individuals presenting these spinal changes, in particular, could better clarify their correlation with age.

Another important limitation was the absence of a normal group of patients without TMD. The presence of such a group would allow the effective assessment of, for example, whether the frequency of morphological changes found in the present study is related to age or TMD. Due to this limitation the results cannot be generalized, as they may not represent what actually happens in the population in general nor in individual TMD patients.

Despite the limitations mentioned above, this study demonstrated that the prevalence of the imaging findings of the conditions studied varied between the sexes and also among the different age groups, supporting the rejection of the null hypothesis. It was also found that an individual aged over 56 years presents an odds ratio three times greater of presenting morphological changes than an individual aged ≤30 years. Moreover, DDWoR was more prevalent in female than in male subjects.

Funding

None.

Competing interests

None.

Ethical approval

This retrospective observational cross-sectional analytical study, using secondary data, was approved by the Ethics Committee for Research Involving Human Beings of the State University of Maringá, Brazil (No. 727 595).

Patient consent

Not applicable.

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