Research article
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Association between the temporomandibular joint disc position on magnetic resonance imaging and the mandibular deviation on posteroanterior cephalogram: a cross-sectional study in adolescents

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Abstract

Objective. The aim of this cross-sectional research was to analyze the association between the disc position of the temporomandibular joint (TMJ) evaluated by magnetic resonance imaging (MRI) and the mandibular deviation evaluated by posteroanterior cephalometric (PA) in adolescents.

Materials and Methods. The sample was 53 adolescents aged 11-18 years. This cross-sectional study was based on the analysis of PA and bilateral TMJ MRI images retrospectively selected. The mandibular deviation was evaluated by PA and defined by the amount of menton (Me) deviation from the midsagittal reference line. The temporomandibular disc position was evaluated by MRI: normal (N), disc displacement with reduction (DDR) and disc displacement without reduction (DDNR). The DDNR was considered more severe than the DDR. The patients were classified into three groups based on the bilateral disc position: group I, the same bilateral disc position; group II, disc displacement more severe on the ipsilateral side of the menton deviation; group III, disc displacement more severe on the contralateral side of the menton deviation. ANOVA followed by post hoc Tukey's test was used to evaluate the interaction between the menton deviation and the bilateral disc position.

Results. There was an association statistically significant between the bilateral disc position and the Me deviation ($p<0.05$). There were significant differences in the mean of the menton deviation between group II (4,40 ±2,26), and group I (2,17±1,93) and III (2,10±1,70).

Conclusions. the menton deviation was significantly correlated with the disc position in the TMJ exhibit more deflection to the side more affected. ***Clin Ter 2020; 171 (6):e509-516. doi: 10.7417/CT.2020.2265***

Key words: *temporomandibular joint disc, adolescent, mandibular asymmetry*

Introduction

The temporomandibular disorders (TMD) are defined as a collective term that encompasses a series of clinical problems involving the masticatory muscles, the temporomandibular joint (TMJ) and associated structures. This disorders are a health problem, affecting adults and adolescents with a prevalence between 7% and 35%. [1,2] Pain, limitation of mandibular movements, TMJ noises and headache are the most common signs and symptoms in patients with TMD. [3]the Validation Project determined that the RDC/TMD Axis I validity was below the target sensitivity of ≥ 0.70 and specificity of ≥ 0.95. Consequently, these empirical results supported the development of revised RDC/TMD Axis I diagnostic algorithms that were subsequently demonstrated to be valid for the most common pain-related TMD and for one temporomandibular joint (TMJ The disc displacement (DD) of the TMJ are a common intra-articular disorder characterized by an abnormal relationship of the articular disc relative to the mandibular condyle and articular eminence. [3,4]the Validation Project determined that the RDC/TMD Axis I validity was below the target sensitivity of ≥ 0.70 and specificity of ≥ 0.95. Consequently, these empirical results supported the development of revised RDC/TMD Axis I diagnostic algorithms that were subsequently demonstrated to be valid for the most common pain-related TMD and for one temporomandibular joint (TMJ

The American Academy of Pediatric Dentistry recognizes that disorders of the TMJ, masticatory muscles and associated structures also occur in children and adolescents.[1] The signs and symptoms of TMD can present in children with gradual increase during adolescence.[1] The disc displacement can occur even in the growing population and is considered to be a condition that may worsen over time. [1,5]

Articular disc displacement has been related to alterations in facial morphology and growth. A high incidence of articular disc displacement, the most concerning characteristic of TMD, has been reported in patients with asymmetry affecting different genders and ages. Some researchers suggested that unilateral DD patients, and bilateral DD patients with dominance on one side, tended to demonstrate more severe mandibular asymmetry than those with equivalent status in

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bilateral sides; and the menton was likely to deviate toward the more degenerated side. [6–9]externally visible mandibular deformity and no history of previous extraarticular mandible fracture were selected for retrospective analysis. All had been investigated clinically and with radiography, tomography, and high-field surface-coil MR imaging to determine the presence or absence and extent of temporomandibular joint degeneration. Temporomandibular joint degeneration was found in either one or both joints of each patient studied. Chin deviation was always toward the smaller mandibular condyle or more diseased joint, and many patients either complained of or exhibited malocclusion, often manifested by unstable or fluctuating occlusion disturbances. Three radiologically distinct forms of degenerative vs adaptive osteocartilaginous processes--(1

Several authors considered that the presence of functional alterations of the TMJ, such as disc displacement, could be associated with disturbed facial skeleton growth, in particular with the mandibular asymmetry and mandibular deviation. The degree to which TMJ disorder can affect facial growth might depend on the time of onset and the duration of the condition. [6,7,10–14]disk displacement, and clinical symptoms of 28 patients were examined clinically and by magnetic resonance imaging (MRI The severity of the disorder and the side it involves are other important questions to consider. [7,15]it is unknown whether abnormalities of the soft tissues of the TMJ are associated with greater than normal craniofacial asymmetry. In this study, we investigated the amount of craniofacial asymmetry in female orthodontic patients with unilateral or bilateral TMJ internal derangement (TMJ ID However the causal relationship remains controversial.

The aim of this investigation was to analyze the association between TMJ disc position evaluated by MRI and the mandible deviation evaluated by PA in adolescents.

Materials and methods

Subjects

The study group was retrospectively selected from the database from adolescent patients evaluated in the clinic of Orthodontic of the Department of Oral and Maxillofacial Sciences, University Sapienza of Rome, in the period 2018-2019 and based on the availability of MRI and PA images. All imaging studies were indicated by the patients' treating physicians for completed the pre-orthodontic diagnosis (not as part of this study); the most common reason for referral were the presence of various malocclusions and TMD.

All the subjects or their parents gave their informed consent for dental evaluation and data processing. The study followed the Helsinki Declaration on medical protocol and recommendations for research in humans.

The inclusion criteria were adolescent subjects (11-18 years of age), both genders, with PA cephalogram and MRI images of TMJ. The exclusion criteria were the presence of systemic diseases that could affect the TMJ, syndromes or craniofacial malformations, previous traumas in the maxillofacial area, tumors or neoplasms of the head, previous maxillofacial surgery.

The sample was obtained from a population of 90 patients who attended the Department of Orthodontic during the period 2018-2019. It comprised 53 subjects (16 males and 37 females), aged 11–18 years (mean age 14.28 ± 2.46).

Data Acquisition

The TMJ MRIs were performed with an MRI scanner OpticaMR360® GE 1.5-Tesla model (General Electric Medical System, Milwaukee, WI) and with a bilateral 7.5 cm TMJ antenna. Scanning was obtained in maximum intercuspation and in maximum mouth opening. Based on an axial image, 3 mm thick sections were obtained in the oblique sagittal and oblique coronal planes. For each TMJ (right and left) the following sequences were obtained: oblique sagittal T1-w, oblique sagittal T2-w, oblique sagittal proton density (PD) and oblique coronal T1-w in closed-mouth position and oblique sagittal PD in opened-mouth. At the maximum opened mouth position, the subjects were instructed first to open their mouths as far as possible without discomfort. While maintaining a maximum opening, plastic blocks were placed in their mouths during the imaging process.

The PA cephalograms of subjects were placed in the head holder and asked to look straight forward with the Frankfort horizontal plane (FH) positioned parallel to the floor and with teeth in the maximum intercuspation.

The images were interpreted by two researchers (orthodontists) with experience. Images that were not clear enough were excluded. A series of parameters were investigated in MRI and PA.

Measurements

Mandibular deviation

PA cephalograms were traced manually on acetate paper and landmarks were located to determine a x–y coordinate system. The line passing through the most internal point of the zygomatic-frontal suture and lateral orbital margin, right and left (ZL/ZR) represented the horizontal plane (x-axis) and a line perpendicular to this plane passing to through the crista-galli (Cg) was used as the vertical reference plane (y-axis) and named the midfacial line.

The menton deviation (Medev) on PA, was defined as the horizontal distance from the menton (Me) to the midfacial line (y-axis) and was measured as an absolute value.[16–18-]and analyze the influence TMJ factors of the MA severity. Methods Patients aged under 20 years old with symptomatic unilateral ADD and asymptomatic volunteers with normal disc-condyle relationship diagnosed by magnetic resonance imaging (MRI (Fig 1).

Disc position

The position of the articular disc was evaluated in TMJ MRIs in the maximum intercuspation and in the full open-mouth position. The combination of both positions constituted the position of the articular disc.

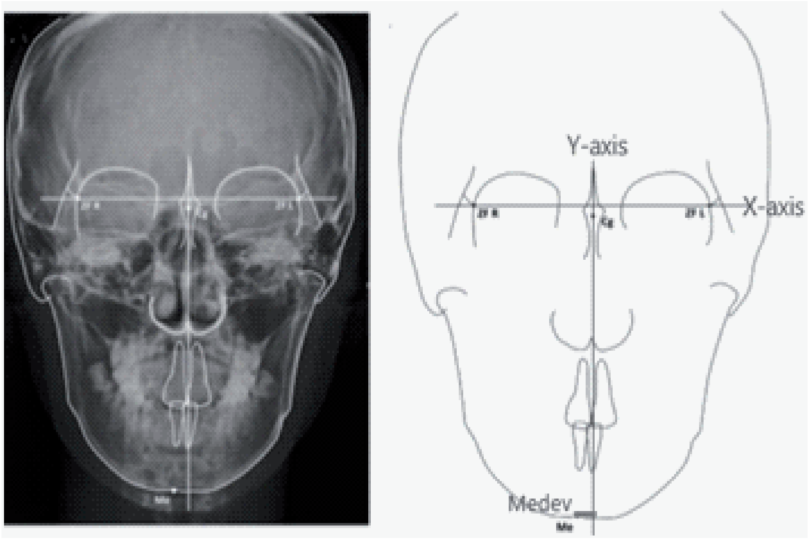

Fig.1. PA image, linear used in the cephalogram: X-axis, horizontal reference ZR-ZL, line passing through the most internal point of the zygomatic-frontal suture and lateral orbital margin, right and left; Y-axis, vertical reference, perpendicular to x-axis passing to through the crista-galli (Cg). Menton deviation (Medev): horizontal distance from the menton (Me) to the midfacial line (y-axis)

The evaluation of the disc position in closed-mouth was performed in the sagittal and coronal planes: *Normal disc position*: in the sagittal plane, relative to the superior aspect of the condyle, the border between the low signal of the disc and the high signal of the retrodiscal tissue is located between the 11:30 and 12:30 clock positions and the intermediate zone is located between the anterior-superior aspect of the condyle and the posterior-inferior aspect of the articular eminence; in the oblique coronal plane, the disc is centered between the condyle and eminence in the medial, central, and lateral parts. *Disc displacement*: when the low signal of the disc and the high signal of the retrodiscal tissue are located anterior to the 11:30 clock position relative to the superior aspect of the condyle and, the intermediate zone of the disc is located anterior to the condyle or the disc is not centered between the condyle and eminence in either the medial or the lateral parts in the axially corrected coronal plane.[3,4,19,20]the Validation Project determined that the RDC/TMD Axis I validity was below the target sensitivity of ≥ 0.70 and specificity of ≥ 0.95. Consequently, these empirical results supported the development of revised RDC/TMD Axis I diagnostic algorithms that were subsequently demonstrated to be valid for the most common pain-related TMD and for one temporomandibular joint (TMJ

The evaluation of the disc position in open-mouth may present the following positions: *Normal disc position* when the intermediate zone of the disc was between the articular eminence and the condyle articular surface or persistent *disc displacement* when the intermediate zone is located anterior to the condylar head.[3,20,21]the criterion that yielded the highest percentage of normal disk position diagnoses was the disk's intermediate zone (93.5%

The TMJ disc position was obtained from the combination of the closed-mouth and open mouth positions and a final diagnosis was formulated for each joint. It was divided into three categories according to the following criteria: 1.

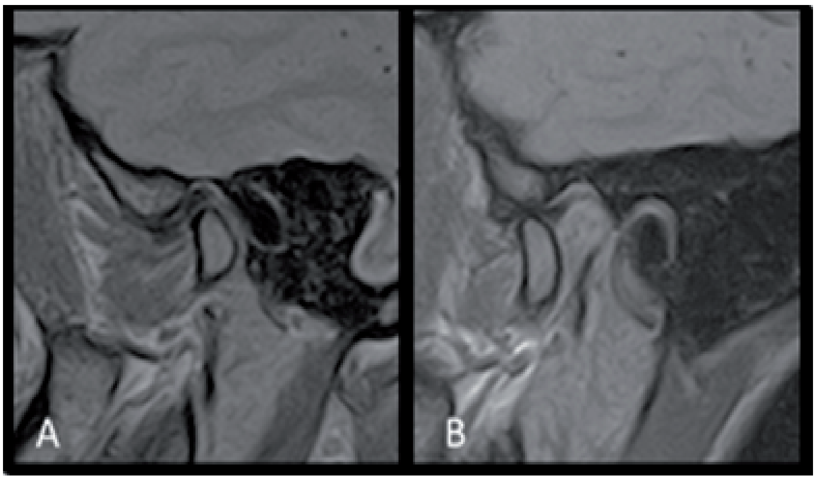

Fig.2. Sagittal images on MRI showing normal TMJ disc position: A) closed mouth; B) open mouth

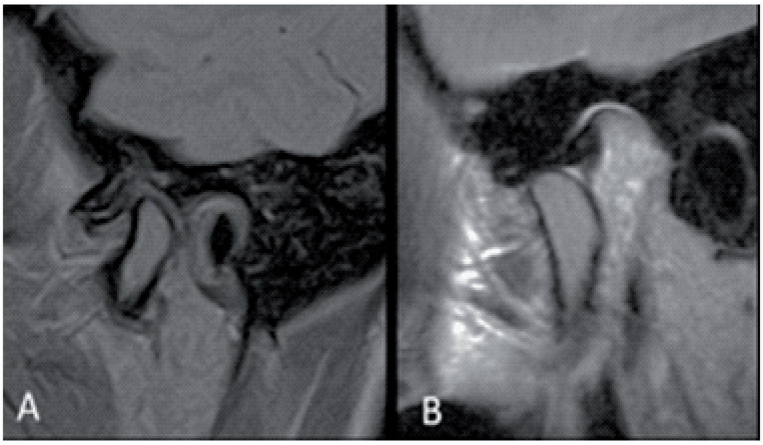

Fig. 3. Sagittal images on MRI showing TMJ disc displacement with reduction (DDR): A) closed mouth; B) open mouth

Normal (N): Disc location is normal on closed-mouth and open-mouth images (Fig 2); 2. Disc displacement with reduction (DDR): disc location is displaced on closed-mouth images but normal in open-mouth images (Fig 3); 3. Disc displacement without reduction (DDNR): Disc location is displaced on closed-mouth and open-mouth images. [3,9,20,22]the Validation Project determined that the RDC/TMD Axis I validity was below the target sensitivity of ≥ 0.70 and specificity of ≥ 0.95. Consequently, these empirical results supported the development of revised RDC/TMD Axis I diagnostic algorithms that were subsequently demonstrated to be valid for the most common pain-related TMD and for one temporomandibular joint (TMJ The DDNR was considered more severe than DDR (Fig 4).

The patients were classified into three groups based on the bilateral disc position:

– Group I: The same bilateral disc position, normal or displaced (N-N) (DDR-DDR) (DDNR-DDNR).
– Group II: Unilateral or bilateral disc displacement, but the TMJ *ipsilateral* to the Me deviation side presents a more severe type of displacement. Various combinations could be presented: N-DDR, N-DDNR, DDR-DDNR.
– Group III: Unilateral or bilateral disc displacement disc displacement but the TMJ *contralateral* to the Me deviation side presents a more severe type of displacement. Various combinations could be presented: N-DDR, N-DDNR, DDR-DDNR.

Statistical analysis

A pilot study was conducted to determine the reliability of the data collection procedure. Ten subjects randomly selected were evaluated in a time interval of 1 week. To determine intra-observer and inter-observer reliability, the Cohen's Kappa coefficient was calculated for qualitative data (disc position) and the inter-class correlation coefficient (ICC) for quantitative data (menton deviation). The intra-examiner reliability was k= 0.85 and 0.89 (very good level) and ICC=0.918 and 0.923 (excellent level) for each examiner respectively. The reliability between examiners was k=0.87 (very good level) and ICC=0.832 (very good level). Consequently, all measurements were considered suitable for usage in the study.

SPSS software program version 21.0 (SPSS Inc., Chicago, IL, USA) was used for data management and statistical analyses. A descriptive analysis of the sample was performed through statistical absolute and relative frequencies for qualitative variables, for continuous variables parameters

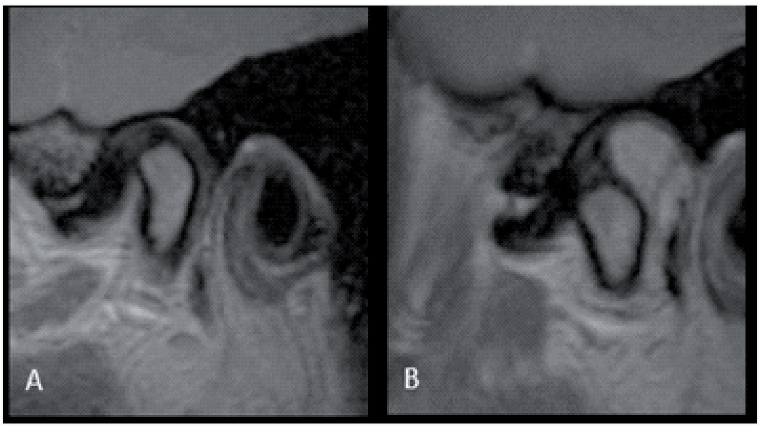

Fig. 4. Sagittal images on MRI Fig. 2: Sagittal images on MRI showing TMJ disc displacement without reduction (DDNR): A) closed mouth; B) open mouth

were expressed as mean ± SD (standard deviation). The Chi^2 test was used to evaluate the statistical association between the position disc and the genders. ANOVA followed by post hoc Tukey's test was used to make the statistical comparison between TMJ disc position and age, and the association with the menton position. For all statistical analysis, the significance level was $p < 0.05$.

Results

Fifty-three adolescents (37 females and 16 males, mean age 14.28 ± 2.46 years) and 106 TMJs were analyzed.

The frequency observed of the bilateral TMJ disc position was: Group I, the same bilateral disc position, composed of 23 subjects (43%), 9 with normal disc bilateral, 10 with bilateral disc displacement with reduction (DDR-DDR) and 4 subjects with bilateral disc displacement without reduction (DDNR-DDNR); Group II, disc displacement more severe on the ipsilateral side of the Medev composed of 17 subjects (32%); Group III, disc displacement more severe on the contralateral side of the Me deviation composed of 13 subjects (25%). The most frequent was group I followed for group II. The mean value of the menton deviation in the data was 2.87 ± 1.57 mm. For each group the mean value was: group I, 2.17± 1.93, group II, 4.4 ± 2.26 mm and group III, 2.10 ± 1.70 mm. ANOVA test were used to assess the statistical association between bilateral TMJ disc position observing significant differences between the lateral menton deviation and groups of disc position (*p=0.01*). The post hoc Tukey's test for multiple comparisons demonstrated differences statistically significant between the mean of the group II (4.4 ± 2.2) with groups I and III (*p=0.016* and *p=0.036* respectively), with a greater menton deviation with respect to the rest of groups. There was no statistical difference (p>0,05) in the mean of menton deviation between group I (2.17± 1.93) and group III (2.10 ± 1.70). (Table 1).

Using Chi^2 test, a statistical association between disc displacements and gender was observed *(p = 0.002*), with more frequent disc displacements in females (63,3%). Using one-way ANOVA, there was no significand difference in mean value of the age among the three groups (p>0,05), with the mean age for each group of 14.06 ± 2.35 (group I), 14.47 ± 2.39 (group II) and 15.04 ± 2.21 (group III).

Discussion

The relationship between TMJs disc displacement and mandibular asymmetry has been reported by many authors. The DD in adolescents has been associated with facial growth restrictions and the development of mandibular asymmetry. [6,7,9,10,17,23–26]externally visible mandibular deformity and no history of previous extraarticular mandible fracture were selected for retrospective analysis. All had been investigated clinically and with radiography, tomography, and high-field surface-coil MR imaging to determine the presence or absence and extent of temporomandibular joint degeneration. Temporomandibular joint degeneration was found in either one or both joints of each patient studied. Chin deviation was always toward the smaller mandibular condyle or more diseased joint, and many patients either complained of or exhibited malocclusion, often manifested by unstable or fluctuating occlusion disturbances. Three radiologically distinct forms of degenerative vs adaptive osteocartilaginous processes--(1 However it has also been proposed that changes in the mandibular position in response to occlusal abnormalities may develop articular dysfunction. [27,28] Because the menton deviation has been an easily identified characteristic of mandibular asymmetry, in the present study we evaluated the association between menton deviation and the bilateral disc position in MRI in a group of adolescent patients. The results obtained in this study are based on the analysis of MRI methods reported as gold standards for the evaluation of the structures of the TMJ and of PA cephalogram widely used in orthodontic in diagnostic of mandibular asymmetry. [19,25,28,29]whereas partial disk displacement occurred in 26 (22.6% [28]

Recently, studies have reported the presence of TMD in growing individuals, and the most frequent diagnoses found in adolescents are intra-articular disorders. [1,30,31] In our study 8 of each 10 adolescents had TMJ disc displace-

Table 1. Association between bilateral disc position and the menton deviation

Bilateral disc position	N (%)	Medev Mean ± SD	Associated groups	p-valor
Group I: Same disc position bilateral	43% (23)	2,17 ±1,93	Group II: DD more severe ipsilateral	0,016
			Group III: DD more severe controlateral	1,000
Group II: DD more severe ipsilateral	32% (17)	4,40 ±2,26	Group I: Same disc position bilateral	0,016
			Group III: DD more severe controlateral	0,036
Group III: DD more severe controlateral	25% (13)	2,10±1,70	Group I: Same disc position bilateral	1,000
			Group II: DD more severe ipsilateral	0,036

ANOVA post-hoc Tukeys'test, p-value <0.05 indicated statistical differences.
DD: disc displacement; Medev: menton deviation; SD: Standard deviation

ment, unilateral or bilateral, and only 17 % (N=9) of the data showed a normal bilateral position of the articular disc. These findings coincided with the results proposed by other investigations, which establish that the displacement of the TMJ disc is common in the adolescent population with TMD. [30,32,33]119 girls MRI imaging studies have reported a prevalence of non-reducing TMJ disc displacement amounting to approximately 4% in asymptomatic and about 60% in symptomatic children and adolescents. Bilateral disc displacement is common and reported in 50% of these groups. [34] In the present study was not possible to perform the clinical evaluation of the adolescent patients, due to the retrospective collection of the images, and the clinical data found in the reports were incomplete and therefore were not incorporated in the analysis. The evaluation of the disc position showed that 17% of adolescent presented normal disc bilateral, 26 % showed the same disc displacement in both joints (19% DDR-DDR, 7% DDNR-DDNR) and the remaining 57% of the sample showed a different disc displacement between both joints, unilateral or bilateral but with a more severe disc displacement of one side with respect to the other.

The present study coincides with others in terms of higher prevalence of disc displacements in females. [30–32]119 girls The TMJ disc displacement can occur during puberty in both sexes but there is a four time higher incidence among girls.[35] More than 10% of the girls in a general pre-orthodontic population had non-reducing disk displacement verified with MR-imaging.[32]119 girls

To describe the influence of disc displacement on facial asymmetry, our investigation showed that displacement of the TMJ disc has significant consequences on mandibular deviation, with difference between the bilateral cases of DD. The relationship between the degree of menton deviation and the disc position was found ($p<0,005$): patients with an unilateral or bilateral TMJs disc displaced, where one side is more severe than another, tended to exhibit more menton deflection to the side more affected. This was evidenced in group II, which presented a mean deviation of the menton of 4,40 ±2,26mm. (Table 1)

Similar to our findings, previous studies demonstrated that the presence of DD has a negative effect on mandibular deviation evaluated on PA. The study by Nakagawa et al.[17], demonstrated that completed and partial DD was related to mandibular displacement in adolescent females and the disc positions were categorized as normal disc position, functional disc displacement (partial-DDR) and functional disc dislocation (complete-DDNR) unilateral or bilateral, but different to our study, they not categorized the data on the presence of more severe disc position on side respect another.

In a study by Ahn et al. [9] were analyzed patients over 17 aged, females and skeletal class I, and studied implies that the disc displacement might have on the degree of mandibular asymmetry secondary to the change of the size of the mandibular condyle and ramus. They indicated that more vertical asymmetry can be found in patients with the more degenerate TMJ on the unilateral side compared with the contralateral TMJ and similar to our study the menton tended to deviate toward side of the more degenerated TMJ. This study didn't have the group with unilateral DDNR, while our study presented group with this characteristic.

In coincidence with our study, Sakar et al [25] demonstrated that the menton deviated toward the disc displacement side in the unilateral group (DDR or DDNR), but didn't establish the difference between the severity of the sides and included only adult, female and symptomatic patients. Xie et al.[16]and analyze the influence TMJ factors of the MA severity. Methods Patients aged under 20 years old with symptomatic unilateral ADD and asymptomatic volunteers with normal disc-condyle relationship diagnosed by magnetic resonance imaging (MRI correlated the mandibular asymmetry with DD and condylar height, classified groups into the stage of degree of menton deviation and demonstrated that mandibular asymmetry was more common and more severe in the adolescent patients with unilateral DD.

In some studies, subjects were classified according to the presence of TMJ DD, without consideration of subgroups unilateral or bilateral DD, with or without reduction. The actual study examined bilateral TMJ disc position and categorized in groups clearly defined and was focused on the presence of more severe disc in each TMJ in order to determine the menton deviated on the TMJ side more affected.

Another important aspect to highlight in the mandibular asymmetry has been the relationship between the DD and the condylar size.[11,22] Patients with unilateral DDNR showed differences in the mandibular ramus and condylar height significantly more than reference subjects. [9,26] This implies that DD might have an effect on the degree of mandibular asymmetry secondary to the change of the size of the mandibular condyle. [7,9,16,28,36]

This finding has also been demonstrated in studies in experimental animals, in which it was observed that the displacement of the TMJ disc could induce a reduction in the height and length of the mandibular condylar head, which alters the growth of the mandible.[13,37,38] Kurita et al. [39] showed that the condylar size progressively decreased with the advancement of the disc displacement. Cai et al.[40] established that a displaced articular disc untreated will continue to move and deform, accompanying important anatomical changes in the mandibular condylar head. The study of the Xie et al.[16]and analyze the influence TMJ factors of the MA severity. Methods Patients aged under 20 years old with symptomatic unilateral ADD and asymptomatic volunteers with normal disc-condyle relationship diagnosed by magnetic resonance imaging (MRI also showed correlations between mandibular asymmetry severity and TMJ status; the more the disc is displaced and deformed, the more the condylar height is shortened and the mandible has deviated.

The current findings cannot establish a cause and effect relationship due to study design. The abnormal position of the discs could contribute to the abnormal position of the mandible, but the mandibular deviation could have contributed to the abnormal position of the disc. A limitation of the present study was not to include the occlusal characteristics of the subjects (absence of teeth, posterior crossbite, etc.), that have been associated with functional mandibular deviation and possible association with disc displacement. [41–43]

Future studies are necessary with the inclusion of various factors involved in the mandibular deviation, in order to understand the relationship between the TMJ disc position and the mandibular asymmetry. In this sense is important the early detection of intra-articular TMD in growing patients for the close relationship with the lateral mandibular deviation and possible alterations in facial morphology.

Conclusion

This study suggests that the menton deviation was related to unilateral or bilateral cases TMJs disc displacement. The menton tended to exhibit more deflection to the side more affected.

Disclosure statement

No potential conflict of interest was reported by the authors.

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