Relationship between Disk Position and Degenerative Bone Changes in Temporomandibular Joints of Young Subjects with TMD. An MRI Study

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This study determines the frequency and relationship between disk position and degenerative bone changes in temporomandibular joints in children and adolescent patients with internal derangement. ***Study design:*** *TMJ, MRI of 88 patients were analyzed (average age: 14.7 years-old, range age: 10-18 years-old), female n=65 (73.9%) and male n=23 (26.1%). Images obtained were used to determine the frequency of disk position, joint effusion (JE) and degenerative bone changes (OA). Images were assessed by a calibrated radiologist (Kappa=0.82).* ***Results:*** *No significant association was found between disk displacement with reduction and degenerative bone changes (Chi2=9.894; OR= 0.375; p=0.0017), nor disk without displacement (Chi2=9.448; OR= 0.223; p=0.0021). A significant association was found between disk displacement without reduction and degenerative bone changes (Chi2=30.951; OR=6.304; p=0.0001).* ***Conclusions:*** *There is a significant association between disk displacement without reduction and degenerative bone changes (p=0.0001) in children and adolescent patients with TMD.*

Keywords: *TMJ, TMD, MRI, TMJ Disk, degenerative bone disease, children, internal derangement.*

INTRODUCTION

Temporomandibular Disorder (TMD) is a wide term which includes a group of musculoskeletal problems in the masticatory system, and is the main cause of non-dental originated pain in the oro-facial region which includes head, face and related structures.[1-3]

Even though the precise etiology of TMD has not been yet determined, occlusion, TMJ anatomy, psychological and functional factors may be involved.[4]

Internal derangement (ID) of TMJ is one of the most common TMD. The term refers to an abnormal position of the articular disk in relation with the mandible condyle and the articular eminence of the temporal bone. The term disk displacement has generally been accepted as a synonym. Disk displacement is subdivided into two main groups, disk displacement with reduction and disk displacement without reduction, referring to the functional disk performance. The disorder has been associated with characteristic clinical findings such as pain, clicks, articular dysfunction, and close or open locks.[5,6]

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ID is diagnosed by means of clinical examinations combined with imaging methods such as Magnetic Resonance Imaging (MRI). MRI can provide essential information about disk position, signal intensity, morphology and structure.[7]

In patients with ID, a variety of morphological changes in bone structure of mandible condyle and temporal eminence may occur, such as flattening of the condyle and temporal functional surfaces, osteophytes, erosion, idiopathic condyle resorption, subcondral cysts, and intra-articular loose bodies. A relation has been reported between ID and morphological changes of the condyle and articular eminence, associated with secondary remodeling and degenerative bone changes (OA) observed in CT scan images.[7,8]

Common ID signs and symptoms such as clicking, locking, pain tenderness, restricted ranges of mandible motion, crepitation and others, are associated with detectable structural changes that have been observed tri-dimensionally thanks to the introduction of CT and MRI.

ID frequency among studied population corresponds to 30%, mostly young adults with an average age of 35, but many recent studies have reported that ID has been found in children and adolescents.[9] The relation between ID and degenerative bone changes has already been studied, most of them using young-adult subjects.[10-14]

Clinical observations show that TMD-related symptoms are very rare in 3- and 5-year-olds. In age groups of 10- and 15-year-olds, 5-9% of the subjects reported more severe symptoms, and up to 50% show one or more TMD signs. The severity of symptoms and signs seem to increase with age. No gender differences in severity have been observed. Oral parafunctions are reported in 11-47%. In general, apart from a few variables, no statistically significant changes in the prevalence of TMD symptoms and signs

have been observed in people who have turned 20 years or more. Teeth clenching/grinding and general health factors were found to be associated with TMD symptoms and signs,[15] additionally, it has been observed that disk displacement is relatively common (34%) in asymptomatic volunteers and is highly associated with patients (86%) with TMD aged from 6 to 25.[16]

Disk displacement can be considered to be an acquired state. MRI images of children ranging from two month to five years, have consistently demonstrated their disk to be in its normal superior position, showing a minimal chance of disk displacement incidence up to the age of five. Clicking and pain in TMJ identified only one half of the patients with abnormal condyle-disk relation in juvenile population.[17]

Prevalence rate of asymptomatic disk displacement is reported to be about 6% between 8 to 15 years of age,[18] increasing by the ages of 16 and 19, reaching the same prevalence as the one found in adults.

This transversal imaging study was aimed at establishing the frequency and possible relationship between disk position [disk without displacement (DWD), disk displacement with reduction (DDR) and disk displacement without reduction (DDWR)], and degenerative bone changes of TMJ in children and adolescent population with internal derangement before orthodontic treatment.

The hypothesis proposed herein refers to that there is a relationship between degenerative bone changes and disk displacement without reduction, in children and adolescents with internal derangement of temporomandibular joint.

MATERIALS AND METHOD

This transversal and blinded study was based on imaging observation of MRI performed to 88 consecutive patients, sent to study by TMJ imaging, of both genders being evaluated prior to orthodontic treatment. Inclusion criteria considered symptomatic patients who had been clinically diagnosed with ID in at least one TMJ during their first visit, and who had never received previous treatment for their condition. Exclusion criteria: patients over 18 years of age, patients who were under orthodontic treatment, patients with systemic diseases such as gout disease, generalized osteoarthrosis, joint hyperlaxity, congenital TMJ deformity, cysts, tumors and patients with a previous history of TMJ surgery. Information was recorded in a special form during the patient's first visit and undersigned by the children/adolescent's tutor.

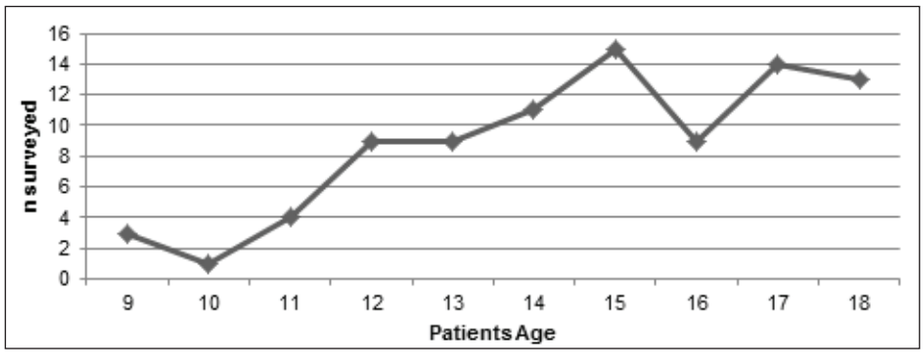
Patients were examined simultaneously in both TMJ, using bilateral MRI (Phillips Intera 1.5 T, Sense Flex S Dual Coil, Eindhoven, Nederland) in the following sequences; sagittal DP weighted (TR 1500; TE 20), T2 weighted (TR 2000; TE 100) and SPIR, coronal: PD weighted (TR 1500; TE 20) and dynamic: ECHO gradient (TR 180; TE 14), taken at close mouth at 10mm, 20mm and 40mm of interincisal distance, or maximum mouth opening according to clinical possibilities of each patients, in case of pain. Mouth opening was maintained with a disposable plastic bite block adjusted at different sizes.

Table 1. Frequency of patients age and gender

Age	Male	Female	n surveyed	Frequency
9	1	2	3	3%
10	1	0	1	1%
11	1	3	4	5%
12	3	6	9	10%
13	2	7	9	10%
14	2	9	11	13%
15	3	12	15	17%
16	5	4	9	10%
17	5	9	14	16%
18	3	10	13	15%

MRI findings were used to assess disk morphology and position, classifying them according to Sener *et al* [7] Kurita *et al* [19], and Güler *et al* [20, 21] in disk without displacement (DWD), disk displacement with reduction (DDR) and disk displacement without reduction (DDWR). Disk without displacement (DWD) morphology was described for bow-tie, biconcave, configuration and disk position, as it was located over the condyle, implying that the thin middle zone of the disk is articulated against the anterior prominence of the condyle. In disk displacement with reduction (DDR), was considered to be displaced when the posterior band is misplaced in relation to condyle functional surface at close mouth position. The disk is said to feature reduction when at open mouth the thin central portion of the disk is interposed between the temporal eminence and the condyle. Diagnosis of disk displacement without reduction was made for all those disks that were observed in a displaced position when the mouth was closed, not showing reduction at open mouth where the posterior band remained misplaced in relation to the anterior surface of the condyle.

Joint effusion was assessed in T2 weighted MRI and classified as being present when an area of high signal intensity was observed in upper or lower joint spaces.[20]



Graph 1. Distribuition of patients by age and number

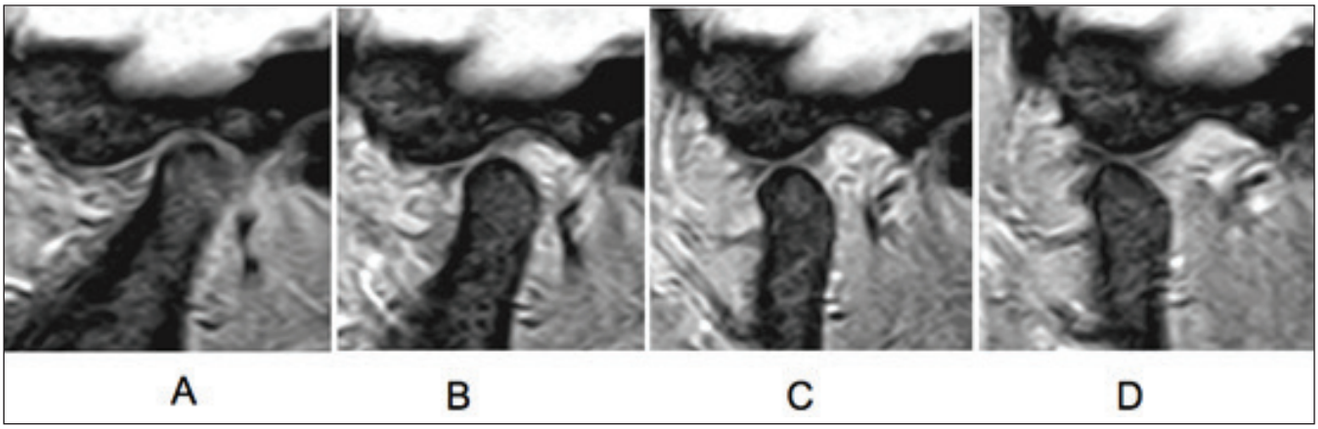


Figure 1. Sagittal MRI of a TMJ classified as "Disk displacement with reduction". The sequence shows a TMJ at close mouth (A), 10 mm (B), 20mm (C) and 40mm. of inter-incisal distance (D). In this case, the displaced disk has been recaptured at 10mm of inter-incisal opening. This image belongs to a Female 14 years old patient

Evidence of degenerative bone changes (OA) on the articular surface of the condyle and/or temporal eminence was considered to be present if erosion, concavity, flattening, osteophyte formation, osteoesclerosis, subchondral cyst and/or deformity were found.[19,22] Each MRI images were assessed twice, by one of the authors of this study (GM, Cohen's Kappa= 0.86), who was blinded to previous clinical information.

A self-assessment questionnaire designed to identify the symptoms of each patient was conducted prior to the exams that classify patients as symptomatic, those who reported pain, noises, or functional limitations in the TMJ, and asymptomatic. (CM)

All patient´s tutors signed the informed consent approved by the Ethics Committee (Dental School, Mayor University, UM-2008-02)

Statistical analyses were performed by one of the remaining authors (DC), who was blind to clinical and imaging information, using SPSS v14.0 software (Chicago, IL; 800.543.2185) and performing Chi^2 to compare group variables. These variables were gathered with a dichotomy and non continued (presence or absence) criteria.

Table 2. Distribution of Degenerative Bone Changes of the children and adolescence TMJ, expressed in quantity and percentage.

	N	Frequency	Female	Male
TMJ with degenerative bone changes	70	57.8%	54	16
Degenerative bone Changes found				
Condyle Flattening	55	45%	44	11
Erosions and Irregularities	32	26%	24	8
Temporal eminence flattening	24	20%	20	4
Subchondral Cyst	7	6%	7	0
Osteophytes	2	2%	1	1
Condyle Resorption	1	1%	1	0
Total degenerative bone changes surveyed	121	100%	97	24

RESULTS

Patient's age and gender showed higher frequency of female gender (n=65; 73.1%) over male population (n=23; 26.9%). whose average age was of 14.7 years old. Patients separated by age showed more frequency distribution in the ages of 15 (17%), 17 (15.9%) and 18 (14.8%), while the less frequent age found was 10 (1.1%). Ages of 12, 13 and 16 showed a similar frequency of 10.2%. 9 and 11 years old were found only in 3 and 4 patients (Table 1, Graph 1). All images obtained were suitable for imaging assessment (176 MRI).

MRI assessment performed of this 176 TMJ, found 171 displaced disks (97.1%), with DDR frequency of 50.6% (n=89) (Figure 1) and DDWR frequency of 42.6% (n=75) (Figure 2), DWD was found on 6.8% (n=12) surveyed subjects.

Healthy TMJ bone structures (no signs of OA) were found in 106 of 176 TMJ (60.2%), degenerative bone changes were found in 70 TMJ (39.8%) of the overall subjects studied.

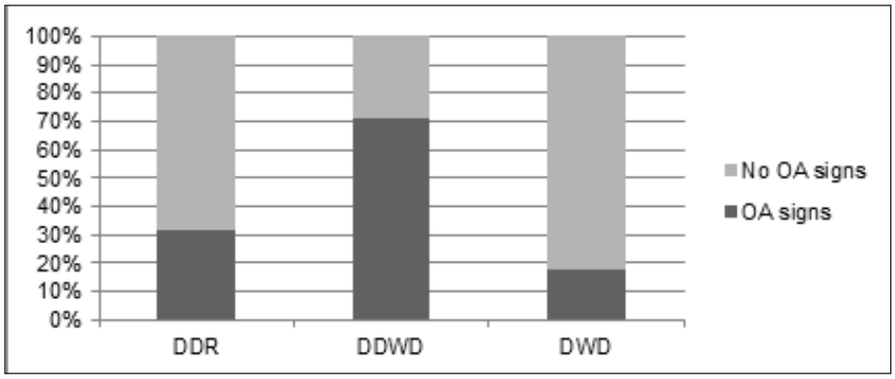
In the surveyed patients, a minor group had one diseased joint (n=9; 15%) and 25 (45%) both TMJ compromised, showing that bilateral OA was more prevalent (Figure 4). Regarding affected TMJ, a cumulative number of 121 OA signs were found. (Table 2)

The most frequent degenerative bone changes found were: flattening of condyle anterior surface (n=55), followed by joint surfaces erosion and irregularities (n=32), flattening of temporal eminence functional surface (n=36), subchondral cysts (n=7), osteophytes (n=2), and idiopathic condyle resorption (n=1), all in decreasing order (Table 2).

The different types of DD, its frequency and the presence or absence of OA signs are summarized on table 3, a statistical association was found between DDWR and the presence of OA signs (p=0.0001). No association was found between DWR or DWD and OA signs (p=0.0017 and p=0.0021). A frequency of 71% of OA signs was found when the TMJ disk was displaced without reduction (Graph 2).

Only 14 TMJ presented Joint Effusion (JE), and no association was found between them and OA signs (Chi^2= 0.037;p=0.847). (Figure 3)

Thirty-seven TMJ had two OA signs, proving to be the most frequent result. One OA sign, was less frequent n=27, three OA signs n=14, four simultaneous OA signs n=1 (Table 4). The distribution of



Graph 2. Presence of OA signs on the different types of DD

degenerative bone changes of TMJ with one or multiple OA signs are surveyed in Table 5. When three or four OA signs were found simultaneously, they were registered in Table 5 also.

DISCUSSION

The results of this study showed a strong relationship between degenerative bone changes and disk displacement without reduction ($p< 0.01$), in TMJ of young subjects with TMD, however, disk displacement with reduction was not associated with degenerative bone changes ($p< 0.01$). DWD did not present a statistical association with OA signs either ($p< 0.01$).

In general, these results may be explained considering that DDWR involves an enduring displaced disk position, where no disk tissue is positioned between the temporal eminence and the jaw condyle surface neither during functional nor resting position. It is recognized that cartilage changes, and changes in the synovial membrane, give rise to a vicious sequence of cartilage break down, together with episodes of repairing attempts. When degenerative process exceeds its repairing response, OA could progress into clinical or image detectable phases.[23-25]

This report coincides with previous researches where female adolescent patients present a higher rate of DD than male.[29-31] Nevertheless, other research (Köler *et al* 2009)[15] had observed no gender differences in children and adolescents. Those results may be explained due to the number of surveyed subjects or their clinician calibration level.

Degenerative bone diseases of most joints are more prevalent in women than men,[32,33] the reason for this sex dimorphism is yet unclear, however, the potential role played by female reproductive hormones, particularly estrogens have been proposed in the etiology of these diseases. Additionally, sudden changes in hormone levels experienced by women during periods of menarche, menopause and pregnancy or within the same reproductive cycle, compared with the relative stability of different hormones in men and that might be associated with different disease incidence of degenerative bone changes.[34,35] Of these hormones mechanisms, it is considered that the modulation of the activities of extracellular matrix remodeling by estrogen, progesterone and relaxin are one of the key mechanisms of predisposition to suffer joint degenerative changes. Although the effects of estrogen on regeneration or replacement of tissues and tissue appears to be dose dependent, in general, enhance the expression or gene expression of matrix-degrading MMPs[36-38] in different tissues and cell types, causing loss of tissue-specific matrix as the fibrocartilage of the TMJ. The effect of estrogen on cartilage is mediated by their cytoplasmic receptors α and ER-β, and there is evidence that supports the presence of estrogen receptors (ER α) in cartilaginous tissues, but the concentration or plasma levels of them still not fully understood at all.[39] It has been shown that estrogen in the joints in vitro and in vivo, modulate immune responses, plasma extravasations, tenderness, and synthesis and matrix degradation.[40,41] In contrast the effects of estrogen and relaxin that may potentiate or enhance the expression of MMPs, progesterone has been proposed

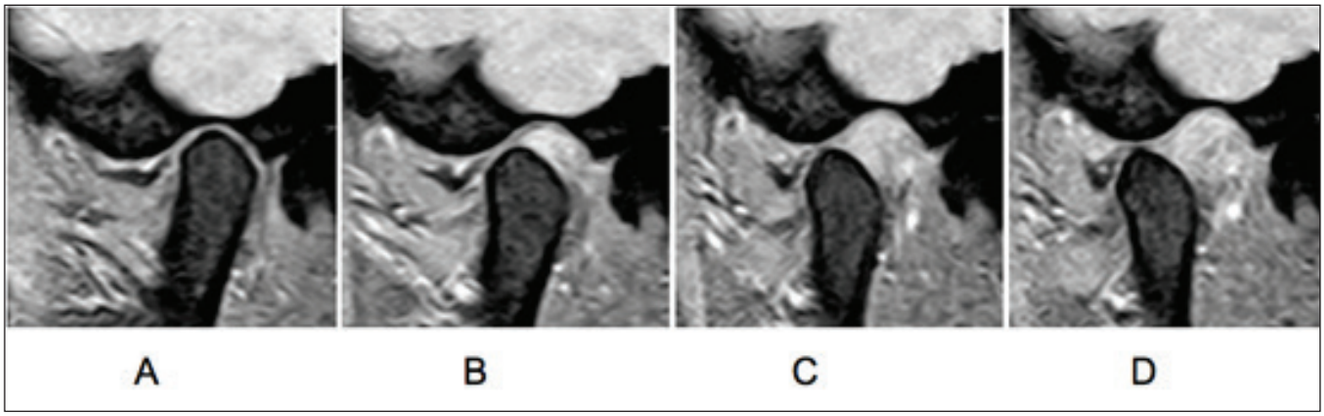


Figure 2: Sagittal MRI of a TMJ classified as “disk displacement without reduction”. The following sequence shows a TMJ at close mouth (A), 10 mm (B), 20mm (C) and 40mm of inter-incisal distance (D). The condyle is unable to recapture the articular disk in the studied dynamic position. This image belongs to a Female 18 years old patient.

Table 3. Frequency and distribution of DD type and OA signs

Type of DD	Total	OA sings	Frequency	No OA sings	Frequency	Chi2	Odds Ratio	Significance
DDR	82	26	32%	56	68%	9.894	0.375	p=0.0017
DDWR	66	47	71%	19	29%	30.951	6.304	p=0.0001
DWD	28	5	18%	23	82%	9.448	0.223	p= 0.0021

as an inhibitor of several MMPs in reproductive tissues, and recently MMP-3 and 9 in the fibrocartilage of the TMJ.[42-45]

Moreover, there is consensus regarding that TMD increases with age in young subjects. In this study, 40% of the samples were patients aged 17 and 18. Additionally, patients from 15 to 16 years old correspond to a 27% of the sample and 21% of the subjects belong to the segment from 13 to 14 years old. The lowest age frequency of TMD was observed in the group from 11 to 12 years old, corresponding only to 11% of the patients. As the patient's age increases, female gender seems to also increase its frequency, while male gender remains stable (Table 1). The limited sample size could have affected the data obtained. This result clearly shows that adolescents are the highest risk group as for TMD, particularly female patients. Had been established in babies, that all TMJ presented normal superior disk positions, protecting joint surface (Paesani *et al* 1999), and additionally TMJ internal derangement prevalence seems to increase with age from 10% in children[50] to 44% in late adolescents.[51]

In the present study, in patients with clinical diagnosis of TMD, MRI images showed that 100% of disks were observed displaced in respect of their normal position. Previous reports have suggested that disk displacement is relatively common (34%) in asymptomatic volunteers and is highly associated with patients (86%) with TMD.[53]

Similar reports (Cortes, 2011) have demonstrated that in studies performed on adult patients with ID, disks without displacement were found in 6% of symptomatic subjects and no bilateral disk without displacement was found.[10]

From the 176 TMJ studied, 66 (53%) presented degenerative bone changes and 37 out of 62 subjects had bilateral compromise (60%). These patients are in their growing stages, meaning their articulations are supposed to tolerate stress due to their remodeling potential. Severity of alterations found calls the attention, since the most frequent association corresponded to two or more OA signs in the same TMJ. In the present study osteophytes, subchondral cysts, and idiopathic condylar resorption never appeared as the only imaged sign present; they were always found in concomitance with flattening of condyle anterior surface and/or temporal eminence articular surface and other types of erosion and irregularities. Same results were obtained when studying adult population previously.[10] They show chronic articular alteration, which can affect them for a lifetime.

MRI studies show reliable image information of studied structures, substituting, therefore, conventional x-ray imaging. MRI offers soft tissue contrast in order to observe the articular disk. MRI is the gold standard method to diagnose internal derangement of temporomandibular joint, as it is a useful method to determine position, configuration, and shape of TMJ disk structure. In the present study, MRI properly detected all disk shape, position and reduction if present and condyle morphology. This study is considered reliable and valid for visualizing articular soft structures with respect to osseous components.[53, 54]

The present study found 14 TMJ joint effusion, representing 11% of the sample, most of them found in female patients (12 of 14), located in the upper anterior joint space. This result is higher, by almost two times, compared with non-rheumatic children studied by Tzaribachev *et al* (2009),[35] who reported discrete synovial membrane enhancement in 3%, and small joint effusions in 3% out of 96 children (192 TMJ) with an average age of 7.8 (range 3-13 years). Among adult population, joint effusion was found in 21% of surveyed TMJ and no relationship with OA signs were found either.[10]

Idiopathic condyle resorption was the most unusual finding of the present study (1%), being one of the most dramatic tissue responses to stressors in TMJ. Its characteristics are: progressive diminishing of condyle head volume, condyle shape change and decreasing ramus height.[28, 55, 56]

Not every patient who consented to participate in this study fulfilled the inclusion criteria. Out of the initial 100 patients, 12

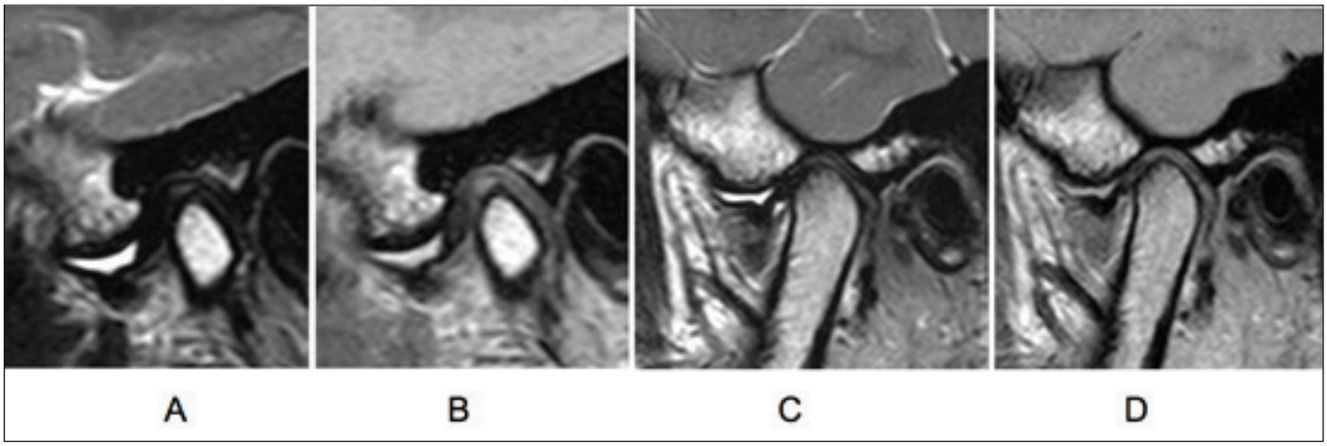


Figure 3. Joint Effusion on T2 (A-C) and PD (B-D) weighted Magnetic Resonance Imaging. Figure shows presence of Joint effusion in upper anterior disk space at close mouth. Image correspond to a left TMJ of a 14 years old, female patients.

Table 4. Frequency of two OA signs found on surveyed TMJ

	Condyle	Temporal	Erosions	Cysts	Osteophytes	Resorption
Condyle	18					
Temporal	13	1				
Erosion	11	1	8			
Osteophytes	1	0	1	0		
Cysts	4	2	2	0	0	
Resorption	1	1	0	0	0	0

Condyle = Flattening of condyle articular surface.
Temporal = Flattening of articular Temporal eminence.
Erosions = Erosion and irregularities of articular surfaces.
Cyst = Subchondral Cysts.
Osteophytes = Osteophytes.
Resorption = Idiopathic condyle resorption.

patients met the criteria for exclusion. One excluded subject had the articular disk fixed to the temporal eminence and one patient had unilateral trifid mandibular condyle. This condition is extremely rare and only a few reports have been found in literature.[46,47,48]

In an attempt to establish TMD etiology in children, many authors have reported an influence of clenching/grinding of teeth,[15] cross bite,[26] female gender,[27,31] malocclusion,[30] mouth breathin,[30] psychological variables[31] and cerebral palsy.[30] Michelotti and Iodice[1] reviewed the association between orthodontic treatment and TMD, where occlusal factors may cause or cure TMD. Pereira *et al* [31] studied 12-year-old adolescents, and concluded that psychological variables; depression, somatization characteristic of pain intensity, and female gender are important risk indicators related to TMD incidence in adolescents.

Pediatric dentists and orthodontists may be the first health practitioners to examine children's craniofacial characteristics and, if a child is under treatment, the professional will be present on most of child's growing stages. On a pilot study, Nebbe *et al* [49] establishes that the TMJ disk status influences the craniofacial growth, specifically the ramus high. Furthermore, Flores C *et al* 2006, presented a report where an association between TMJ disk abnormality and reduced forward growth of the maxillary and mandible bodies was found.[52] The prevalence of TMD averages 30% in children[10] showing the importance of TMD assessment when morphological changes associated to growth and craniofacial development prevail. Thus, a joint diagnosis is an important key to reach an early identification of TMD. Research diagnostic criteria for TMD represent a standardized protocol for research and guidelines for assessment and management of patients with TMD, it is necessary to develop a simplified protocol for specialist and for general dentists in order to get an early identification of TMD in children and adolescents.[57]

Orthodontic treatment is a long-term process; orthodontic patients may complain about TMD during or after treatment, and orthodontists may be blamed for causing TMD in unsatisfied patients. Considerations must be taken to avoid medico-legal inconveniences.[1, 58]

In summary, this study observed a strong relationship between degenerative bone changes and disk displacement without reduction ($p< 0.01$), and no relation between degenerative bone changes and disk displacement with reduction ($p< 0.01$) or disk without displacement ($p< 0.01$). Additionally, adolescents presented the highest risk group for TMD, in that regard we suggest further research shall be focused on this group.

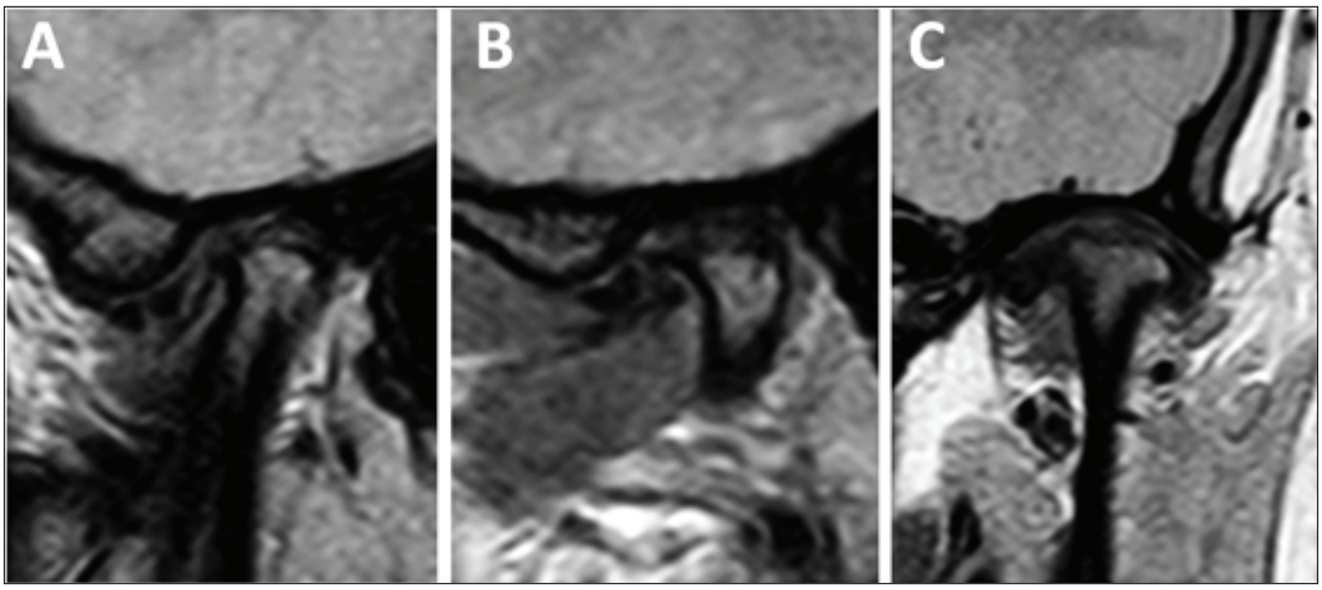


Figure 4. Sagittal (A-B) and Coronal (C), classified as "Presence of degenerative bone changes". Figures show bone irregularities, loss of shape and significant diminished condyle volume. Anterior disk displacement at closed mouth, This image corresponds to left TMJ of a 13 years-old female patient.

Table 5. Frequency of one or multiple OA signs

One OA Sign	27
Two OA Signs	30
Three OA Signs	14
Four OA Signs	1
Presence of three and four OA signs simultaneously	
Three OA Signs	
Condyle + temporal + Erosions	8
Condyle + temporal + Cysts	1
Condyle + erosions + Osteophytes	1
Condyle + erosions + Cysts	2
Condyle + temporal + Resorption	1
Erosions + osteophytes + cysts	1
Presence of Four OA Signs simultaneously	
Condylar + temporal + erosions + cysts	1

Observations in this study identify the importance of an early diagnosis, supporting a prompt treatment in young patients with internal derangement in order to prevent an increase of a pathological TMJ condition. Treatment should be aimed at avoiding disk displacement with reduction to develop into disk displacement without reduction, due to a significant probability of an early bone damage rising.

CONCLUSIONS

There is a significant association between disk displacement without reduction and degenerative bone changes, in children and adolescent patients with temporomandibular disorders. No association was found between degenerative bone changes and disk displacement with reduction or disk without displacement. No association was found between joint effusion and degenerative bone changes (p=0.847). Most patients were female (73.1%) and presented TMJ bilateral TMD. 15 year-olds showed the highest frequency of TMD (17%). Flattening of mandible condyle active surface was the most frequent degenerative bone change (45%). Disk displacement with reduction was the most frequent (46.5%) disk status assessed with MRI in children and adolescents with internal derangement.

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