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Orthodontic Treatment and Temporomandibular Joint Condylar Position Relationship with Disk Displacement (Magnetic Resonance Imaging Study)

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Abstract

Temporomandibular joint (TMJ) is a complex synovial articulation between the mandibular condyle and the glenoid fossa of temporal bone. The question of whether a relationship exists between orthodontic treatment, abnormal condyle and disk position, and temporomandibular disorders has been investigated for many years. Despite the abundance of studies, the question continues to trouble orthodontists.

This study conducted to assess the relationship between orthodontic treatments, abnormal condyle and disk position, with temporomandibular disorders, and to study the disk- condyle relationship in term of presence or absence of anterior disk displacement. By mean of Magnetic Resonance Imaging a cross sectional investigation for the condyles of temporomandibular joints (TMJs) and disk position was conducted to 50 TMJs of 25 patients between 19-30 years of age who had undergone orthodontic treatment (by upper and lower fixed orthodontic appliances with extraction of maxillary first premolar only for treatment of class II division 1 malocclusion), and 50 TMJs of 25 patients who had not yet received orthodontic treatment from the same class and matched age group.

The results of this study showed that 30% of pre-treatment group have anterior disk displacement in comparison to 26.0% of the post treatment group. The condyle position is more concentric in post treatment group than pre-treatment, and the position of the disk is not affected by orthodontic treatment. This conclude that condyle position of the TMJ may be affected by orthodontic treatment, but the disk position is not.

Key words: Temporomandibular joint, orthodontic treatment, MRI.

Introduction

In TMJ, the most common intra-articular abnormalities are internal derangement and the next most common is degenerative arthritidies [(1)]. Although disk displacement was first identified in the later part of the 19th century, the literature concerning this phenomenon up until recent times was sporadic and mainly related to indications of diskectomy [(2,3)]. There

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were few attempts made at correlating disk displacement with clinical symptoms, it was not until 1970s that renewed interest in disk displacement was stimulated by the clinical studies of ***Farrar*** who investigated TMJ symptoms in relation to disk displacement [(4)].

Patient with temporomandibular disorders (TMDs) have a cluster of joint and muscle disorders that are characterized primarily by pain, joint sounds, and irregular or deviating jaw function [(5)]. ***Bertram et al.*** stated that "in several articles, we found that the classification, diagnosis and treatment of pain and dysfunction related to TMJ were based on diagnoses of TMJ disk position". On other hand, extraction has been a controversial subject for as long as the specialty of orthodontics has existed [(6)].

Some authors believe that the extraction of premolars leads to temporomandibular disorders. This occurs, they say, because the vertical dimension collapses. Concomitantly, over-retraction and retroclination of the incisors cause the facial profile to flatten, bring about premature anterior contacts, and distally displace the mandible and mandibular condyle. Numerous correlation studies in the dental literature do not support this contention. There appears to be no higher incidence of temporomandibular disorders in patients treated with the extraction of premolars than in non-treated patients or those treated without extractions [(6,7)]. However we have limited knowledge of the changes in the TMJ of class II div 1 patients who undergo orthodontic treatment with premolar extraction. Conventional imaging systems do not lend themselves to detailed study of the TMJ structures [(8)]. Magnetic resonance imaging (MRI) has been the method of choice in recent years for simultaneous imaging of both the soft and hard tissues of TMJ [(9)]. Excentric position of the condyle in the glenoid fossa and internal derangements in the temporomandibular joint may cause pain and dysfunction [(10)]. In addition, an association has been found between posteriorly seated condyles in centric occlusion and anterior disk displacement. On the other hand, such condylar position may also be present in subjects without any signs and symptoms of disk displacement [(11)].

This study is conducted to test:

1. The hypothesis that patients, with class II div1 malocclusion treated with premolars extraction and upper and lower fixed orthodontic appliances, have more prevalence of posteriorly positioned condyle than non treated group with same class of malocclusion.
2. The condyle-fossa relationship, in studied groups, in term of anterior, posterior, superior joint spaces and joint space index in both genders and matched age group.
3. The disk- condyle relationship in term of presence or absence of anterior disk displacement.

Subjects and methods

This is a cross sectional study conducted in the College of Dentistry-Baghdad University, for the period from 1st of June, 2006 to the 31st of May, 2007. The study is based on the results of two groups. The first one consisted of 25 consecutively patients that had been treated for class II division 1 by upper and lower fixed orthodontic appliances, with extraction of upper first premolar. The mean post retention period is 2 years and 4 months, to be sure of stable result, and without sign and symptoms of TMJ disorders.

The second (control) group consists of 25 subjects with class II division 1 malocclusion, they are pre-treatment patient (had not yet receive orthodontic treatment), without any sign or symptoms of TMJ dysfunction.

All the subjects subjected to clinical examination to confirm the special sample criteria. No pain, clicking, cripitation, and/or locking in the TMJ. The TMJ pain was not present during palpation, no palpable jumping of either condyle over the articular eminence in late opening movements, no signs and symptoms that characterized a diagnosis of myalgia; no history of trauma, and an absence of mandibular growth disturbance. We informed the subjects about the study procedure and received informed consent from them.

Calibration of mandibular range of motion was done for each subject by examination of three types of movements:

1- Maximal opening of the mouth: This is the summation of interincisal distance on maximal mouth opening and the overbite. In open bite cases the amount of negative overbite was subtracted from the maximal interincisal distance to give the maximal opening capacity of the mouth. The interincisal distance was measured by a millimetre graded vernier. The patient was encouraged to open his mouth as wide as possible, then one end of the vernier was placed in the median plane against the incisal edge of one of the lower incisors and the distance to the incisal edge of the opposing upper incisor was measured to the nearest half of a millimetre, giving the interincisal distance on maximal opening in one vertical line. A maximal opening of less than 35mm was defined as mouth opening restriction and excluded from the sample. **The clinical over bite** was measured with a millimetre graded vernier, while the patient was in centric occlusion with his or her occlusal plane horizontal to the floor using the same incisors used for measuring the interincisal distance [12,13].

2- Maximal lateral movements: While the patient was in centric occlusion with his or her occlusal plane horizontal, a vertical line was marked with an indelible pencil in the midline from the upper incisors down to the opposing lower incisor. Then the patient was asked to move his mandible to the right as far as he or she could with the teeth slightly separated and the distance between the pencil markings on the upper and lower incisors in the horizontal plane was measured by a metric ruler or vernier to give the maximal lateral movement capacity to the right. In a similar manner, the maximal lateral movement capacity to the left was measured [14,15].

3- Maximal protrusion: It is the distance between the labial surfaces of the upper and lower central incisors on maximal protrusion of the mandible plus the over jet. The straight end of vernier was placed on the labial surface of an upper incisor and the horizontal distance to the labial surface of the lower incisor was measured to the nearest half of a millimetre, while the patient protruded his or her mandible as much as he or she could. **The clinical over jet** is the horizontal distance from the most prominent point on the incisal edge of maxillary central incisor to the most prominent point on the labial surface of the corresponding mandibular incisor. The over jet was measured while the patient was in centric occlusion with his or her occlusal plane horizontal , using the same incisors used for measuring the maximal protrusion distance [15, 16,17].

The Magnetic Resonance Imaging (MRI) examination was done at the Specialised Surgeries Hospital-Baghdad, with ***Gyroscan NT Philips scanner (Holland)*** **(Fig.1),** and a dedicated, circular polarized, transmit and receive TMJ (6.5cm) surface coils. The data were collected on a 252x256 dots-per inch matrix with a field of view of 145mm giving a pixel size of 0.06x0.57nm.

With the patient in supine position **(Fig.2),** MRI protocol included closed mouth (teeth in habitual occlusion), sixteen parasagittal slices were obtained of each TMJ using a turbo-spin-echo-proton-density sequence (time of reception, 2.800 millisecond; echo time, 15ms) with thin 3mm slices. MRIs were corrected to be horizontal angulations of long axis of condyle. Then each subject received a non-ferromagnetic intermaxillary device (a syringe wrapped with gauze) to wear to help him or her obtain the different mouth opening positions required for this examination. Sequential bilateral images were done with the subject's mouth closed and at the maximum mouth opening positions**.** None of the subjects was excluded on the basis of an MRI contraindication. For each joint, one representative central cut was selected for measurement on the basis of clarity and contrast of condyle and fossa. The selected MRI sections were examined by two MRI specialists in the hospital to analyze the disk-condyle relationship that depicted the disk, condyle, articular eminence and glenoid fossa. Diagnosed TMJs were categorized according to disk-condyle relationships as no disk displacement **(NDD)**; disk displacement with reduction **(DDR)**; and disk displacement without reduction **(DDNR)** [18].

MRI images were coded to allow randomization and blinding of joint space measurements. A line drawn perpendicular to the horizontal tangent line was used to divide the joint space into anterior and posterior halves. Anterior and posterior condylar tangent lines were drawn to intersect with the perpendicular line. Lines perpendicular to the condylar tangent lines were used to measure joint space width. Linear joint spaces were defined as posterior (Post), superior (Sup), and anterior (Ant)**.** Measurement of condylar position within the glenoid fossa on tracings of the parasagittal MRIs by means of the method described by ***Kamelchuk et al*** [19], and as shown in figure 3.

An Index value of "0" means a centric condylar position, a negative value means a posterior condylar position, and a positive value means an anterior condylar position**.**

To assess the validity of our measurements, intra - examiner calibration was done by retracing (computerized tracing by special soft ware programme) and re-measuring of 10 MRI sections (randomly selected) by the same operator with time elapsed of two weeks between the two examinations for all joint spaces and their measurements to exclude memory bias. The inter-examiner calibration was carried out by repeating all the tracing procedures and measurements of the same radiographs. Kappa statistics to find out the level of agreement among the above diagnostic tools, excellent agreement (>80%) was found [20]**.**

Data was entered and analyzed by Statistical Package for Social Sciences (SPSS) version 11. Analysis was done by using;

1-Descriptive statistics (frequencies and percentages)
2-Inferential statistics (student t-test & X^2-test), P-value <0.05 considered to be significant.

Results

Table 1 shows the descriptive characteristics of the study sample (the two studied groups).The differences between the two groups, regarding the age and gender, were not statistically significant.

The mean joint space index in pre-treatment group is higher than that in post-treatment group. The difference is statistically significant (p-value= 0.039). The difference is still significant regarding gender and age classifications.

Table 3 demonstrates the JSI of the right TMJs in both groups. There is also a high statistically significant difference between the two groups.

Table 4 and 5 demonstrate the superior joint space (SJS) for the right and left TMJs in both groups. There are no statistically significant differences between the two groups. Table 6 shows the differences in JSI and SJS within each group (pre-treatment or post treatment) for the left and right sides.

There are no statistically significant differences between right and left JSI in pre-treatment as well as post treatment group (P-value=0.886 and 0.858 respectively). The same finding also observed for the SJS. So all right and left TMJs of group I will be gathered together in next tables and the same for group II. Table 7 shows the association of the JSI indicated by the condyle position (anterior, concentric and posterior) in both studied groups. There is a highly significant association in between the two groups and condyle position.

It has been found that the most dominant position of the condyle in patient that where treated from class II dev 1 malocclusion, 2 years and 4 months post retention period, was centrally positioned condyle, this is found in 26 out of 50 TMJs (52 %) and the posteriorly positioned condyle (negative joint space index) were found in 14 out of 50 TMJs (28 %), while the anteriorly position condyle (positive joint space index) where found in 10 out of 50 (20 %). In comparison to group I, 60% (30 out of 50) of the subjects had anteriorly position condyle and 24% (12out of 500 had centrally positioned condyle. The association between study groups regarding the presence or absence in disk displacement found to be not statistically significant, as shown in table 8, indicating that the disk position could not be associated with orthodontic treatment.

Table 9 shows distribution of the studied groups regarding the association between JSI (condyler position) and disk displacement. The association between condyle positions, as determined by joint space index, and disk displacement was not statistically significant.

In group I, 35 out of 50 TMJs were found having normally positioned disk, (where the posterior band of the disk on the top of the condyle), while 15 TMJ have disk displacement (14 with reduction and only one without reduction). While in group II, 37 out of 50 TMJ were found having normally positioned disk while 13 TMJ with disk displacement (12 with reduction and 1 without reduction).

Discussion

The orthodontic literatures are full of contradictory claims and results regarding mandibular response to orthodontic treatment and relationship between orthodontic treatment and TMJ dysfunction. It is believed that the results of this study will contribute to this discussion. The totally 100 TMJs views (left and right sides of 50 subjects) were analyzed to find the condyle position (by using joint space index), whether anterior, concentric or posterior according to Kamelchuk et al [19]. There are no statistically significant differences between right and left joint space index in pre-treatment group (p-value 0.886), and also between right and left joint space index regarding group II (p-value 0.858). Therefore the joint space indexes of right and left TMJs of each group were gathered together and the number of TMJs in each group was 50 TMJs. this is in agreement with Rabban [21] and Pullinger et al. [22].

Regarding group I, it is found that the dominate condylar position is anterior (30 out of 50 TMJs or 60%), this is in agreement with Rabban [21], who found that the mandibular condyles of (68.63 %) of class II sample were in anterior position . Also the results of this study agreed with the results of Logsdon and Chaconas [23], they found condyles to be more anteriorly positioned in class II cases. Pullinger et al. [22], Kikuchi et al. [24], and Elias and Demetrios [25], also reported a more anteriorly situated condyle in a class II sample relative to a class I sample. While the results of Cohlmia et al. [26], disagreed with ours, they found a more anterior condyle position in class III patients; while in classes I and II, the condyle is anteriorlly positioned with no difference between them. The concentric condyle position was found in 12 out of 50 TMJs (24%) of pre treatment group, while posterior condyle position in this group was 8 condyles only (16%). Our results also disagree with that of Pullinger [22] and Bean and Thomas [27].

In group II, 26 condyles out of 50 TMJs were found concentrically positioned, 14 (28%) TMJs had been posteriorly positioned. While the positions of the condyles were anteriorly only in 10 (20%) TMJs. Our results indicate that there is an increase in the frequency of concentrically and posteriorly positioned condyle more than anteriorly positioned condyle and this could mean that the TMJs of treated group tend to be more concentric in position. This finding agrees with the above studies [23,24,25,26], but it disagrees with Gianlley et al. [28], who found that there is no significant difference in condyle position between pre-treatment and treated groups, although the posteriorly positioned condyle in treated group are more than those in pre- treated group, this could not mean a cause and effect relationship with orthodontic treatment.

In the past there was a belief that a relationship between occlusal interferences and TMJ dysfunction, therefore a suggestion has even gone so far as to claim that orthodontists had the task of preventing this disease. But in recent MRI studies of the TMJ, different degrees of disk displacement have been reported in asymptomatic individuals. Tasaki et al. [29] reported a frequency of 29.8% (17.5% unilateral and 12.3% bilateral) and Ribeiro et al. [30] reported a frequency of 34%.

The hypothesis of our study whether condylar retro-position is frequently observed in the joints with disk displacement or there is no association between condylar position and disk position was evaluated, after assessment of the position of the condyle from MRI in term of concentric, anterior or posterior positioned condyles (zero, positive or negative joint space index respectively) and after assessment of disk -condyle relationship in the pre-treatment and post-treatment groups. Regarding the pre-treatment, there were 15 out of 50 (30%) TMJ with anterior disk displacement. This is located with in the normal range of disk displacement in asymptomatic TMJs and it is explained as normal variation of TMJ disk-condyle assembly relationship. In the pervious MRI studies, Westesson et al. [(31)] found 15% of their asymptomatic volunteers to have unilateral disk displacement. While in a study of evaluation of TMJ sounds in asymptomatic volunteers, Tallents et al. [(32)] found that 24% had one or two joints with disk displacement as diagnosed by MRI.

Although all the patients included in the study groups were asymptomatic, fourteen (28%) TMJs were having disk displacement with reduction, this type of disk displacement in asymptomatic subjects can be explained that the disk is not enough displaced to create clicking on opening or closing cycle of the joint, therefore the patient still asymptomatic. Regarding the post-treatment group, 26 % of the patients were having anterior disk displacement; this is also fall within the range of normal population with disk displacement in the study of Kircos et al. [(33)] but little higher than the results of study of Katzberg et al. [(34)], and Tasaki et al. [(29)]. There is no significant difference between pre-treatment and post-treatment groups regarding the disk position, this could be explained that patient undergone orthodontic treatment have nearly the same prevalence of disk displacement and indicating that orthodontic treatment does not effect the disk position, this is in agreement with Gianly et al [(35)] and Pullinger et al [(36)]. But our result disagrees with Blascke et al [(37)], who stated that there is an association has been found between posteriorly seated condyles in centric occlusion and anterior disk displacement.

Conclusions

From this study we can conclude the followings:

1. Condyle position (as measured by JSI) may be affected by orthodontic treatment as it was more concentric in treated group than pre-treatment which has dominantly anteriorly positioned condyle.
2. Superior joint space is not significantly different in pre-treatment and post treatment group.
3. Disk position may be not affected by orthodontic treatment.
4. The MRI is a modality of choice for diagnosis of TMJ disk displacement as warranted and supplementary method to clinical examination for confirming the presence or absence of TMJ disk displacement.

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Table 1: Descriptive statistics of the study sample regarding their age and gender.

Character		Group I (Pre-treatment)	Group II (Post-treatment)	Total	p-value
Age (Years)	Mean	23.640	23.900	23.770	0.21
	SD	3.610	3.468	3.539	
	Min	19.000	19.000	19.000	
	Max	29.600	30.000	29.800	
Gender	Male	19	18	37	0.747
	Female	6	7	14	
	Total	25	25	50	

Table 2: The distribution of the studied groups regarding the measurement of the left joint space index

Joint Space Index Left		Group I (Pre-treatment)	Group II (Post-treatment)	P-value
Total sample		0.349 (0.188)	-0.110(0.098)	0.039
In Male	Number	19	18	
	JSI Mean (SD)	0.340 (0.076)	-0.170 (0.010)	0.026
In Female	Number	6	7	
	JSI Mean (SD)	0.339 (0.080)	0.126 (0.090)	0.049
In age groups (Years)				
19-24	Number	12	14	
	JSI Mean (SD)	0346 (0.060)	0.182 (0.018)	0.0418
25-30	Number	13	11	
	JSI Mean (SD)	0.357 (0.098)	0.285 (0.590)	0.0353

Table 3: The distribution of the studied groups regarding the measurement of the joint space index in right TMJ.

Joint Space Index Right		Group I (Pre-treatment)	Group II (Post-treatment)	P-value
Total sample		0.365 (0.196)	-0.198 (0.105)	0.047
In Male	Number	19	18	0.026*
	JSI Mean (SD)	0.340 (0.086)	-0.170 (0.010)	
In Female	Number	6	7	
	JSI Mean (SD)	0.390 (0.092)	-0.226 (0.090)	0.049
In age groups (Years)				
19-24	Number	12	14	
	JSI Mean (SD)	0345 (0.070)	-0.182 (0.028)	0.035
25-30	Number	13	11	
	JSI Mean (SD)	0.385 (0.088)	-0.214 (5.900)	0.046

Table 4: The distribution of the studied groups regarding the right superior joint space

Sup. joint space Right		Group I (Pre-treatment)	Group II (Post-treatment)	P-value
Total sample	Mean (SD)	0.380 (0.192)	0.355 (0.096)	0.410
In Male	Number	19	18	
	SJS Mean (SD)	0.385 (0.173)	0.355 (0.087)	0.482
In Female	Number	6	7	
	SJS Mean (SD)	0.375 (0.950)	0.320 (0.148)	0.680
In age groups (Years)				
19-24	Number	13	14	
	SJS Mean (SD)	0.365 (0.176)	0.360 (0.138)	0.462
25-30	Number	12	11	
	SJS Mean (SD)	0.395 (0.166)	0.350 (0.260)	0.483

Table 5: The distribution of the studied groups regarding the measurement of the superior left joint space

Sup. joint space Left		Group I (Pre-treatment)	Group II (Post-treatment)	P-value
Total sample	Mean (SD)	0.369 (0.188)	0.320 (0.098)	0.450
In Male	Number	19	18	
	SJS Mean (SD)	0.380 (0.163)	0.309 (0.077)	0.482
In Female	Number	6	7	
	SJS Mean (SD)	0.320 (0.205)	0.320 (0.148)	0.680
In age groups (Years)				
19-24	Number	13	14	
	SJS Mean (SD)	0.335 (0.166)	0.310 (0.135)	0.462
25-30	Number	12	11	
	SJS Mean (SD)	0.370 (0.166)	0.310 (0.260)	0.483

Table 6: The difference with each group for left and right side regarding joint space index and superior joint space

Groups	JSI (Mean±SD) Rt	JSI (Mean±SD) Lt	P-value	SJS (Mean±SD) Rt	SJS (Mean±SD) Lt	P- value
I	0.365 (0.196)	0.349 (0.188)	0.886	0.380 (0.192)	0.369 (0.188)	0.750
II	-0.198 (0.105)	-0.110 (0.098)	0.858	0.355 (0.096)	0.320 (0.089)	0.856

Table 7: The distribution of the studied groups regarding to condyle position as determined by joint space index

Groups	JSI Post.	JSI Central	JSI Ant.	Total
Group I	8	12	30	50
Group II	14	26	10	50
Total	22	38	40	100
X^2= 16.794	df = 2	P-Value = 0.00001		

Table 8: The distribution of the studied groups regarding the presence or absence of disk displacement

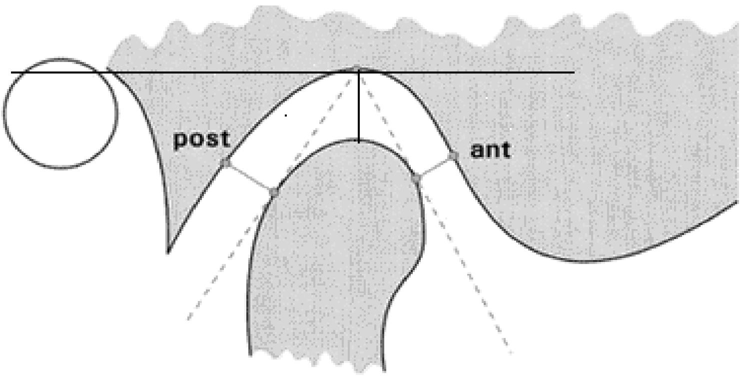
Groups	Disk displacement Absent	Disk displacement Present	Total
Group I	35	15	50
Group II	37	13	50
X^2=0.198	df = 1	P-Value = 0.656	

Table 9: The distribution of the studied groups regarding to condyle position as determined by joint space index and disk displacement

Groups	JSI	No Disk Displacement No.	No Disk Displacement %	Disc Displacement DDR No.	DDR %	DDNR No.	DDNR %	Total	P-Value
Group I	Post.	5	14.2	2	14.2	1	100	8	0.836
	Central	9	25.8	3	21.5	0	0	12	
	Ant.	21	60.0	9	64.3	0	0	30	
	Total	35	100	14	100	1	100	50	
Group II	Post.	10	27.03	4	33.3	0	100	14	0.884
	Central	20	54.05	6	50.0	0	0	26	
	Ant.	7	18.92	2	16.7	1	0	10	
	Total	37	100	12	100	1	100	50	

Fig.1: 1.5 Tesla closed system MRI unit.

Fig.2: Patient in supine position inside the MRI unit.



$$\text{Index} = \frac{\text{post} - \text{ant}}{\text{post} + \text{ant}} \cdot 100$$

Fig 3: Analysis of condylar position according to the Joint Space Index