IS ORTHODONTIC TREATMENT PREDISPOSING FACTOR FOR TEMPEROMANDIBULAR JOINT DISORDERS: A REVIEW

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Abstract
The association between orthodontic treatment and temporomandibular disorders has always been of great interest to oral health professionals. Temporomandibular disorders have been quite prevalent in children and adolescents. Moreover, about 30 per cent of the population receive orthodontic treatment during this period. In this context, the issue of orthodontic treatment may be a predisposing factor for the occurrence of temporomandibular disorders has been raised. Lack of obvious evidence to the assumption that orthodontic treatment is associated with the occurrence of temporomandibular disorders promotes the need for extensive follow-up studies representing broader population sample and more rigorous methodology encompassing all confounding factors in relation to temporomandibular disorders.
Keywords: Temporomandibular Joint Disorders, Orthodontic Treatment, Orthodontics, Mandibular Condyle.

Introduction
The issue of relationship of temporomandibular disorders (TMD) and orthodontic treatment has been explored for many years by researchers; this association has always been of great interest to the oral professionals.[1-7] TMD has been quite a common condition, which is being prevalent in children and adolescents. Moreover, about 30 per cent of the population receive orthodontic treatment during this period. In this context, the issue of orthodontic treatment may be risk factor for occurrence of TMD has aroused.[7-11] The findings in relation to TMD may have clinical implications and can have a profound effect on health and quality of life of patients. The present literature review was undertaken with the purpose to confirm about whether the association exists between TMD and orthodontic treatment.

MATERIALS FOR REVIEW

For this systematic review, the literature search was done in Pub med, Medline and Google databases using the keywords as 'Temporomandibular joint disorders and orthodontic treatment, temporomandibular joint disorders or orthodontics' for the period 1980 to 2015, 91 articles could be retrieved, However only 38 were relevant to the theme chosen. Out of this, were 27 original articles, 9 were review and 2 were case reports. The study subjects were in the age range of 9- years including both the genders. (Table 112-19 ,Table 220-26 , Table 327-31) Previously, many reviews were conducted to estimate the possible association between TMD and orthodontic treatment which had variable interpretations about the literature.

Initially, Greene CS32, 1981, in his review work inferred that occasional clicking may be seen in orthodontically treated patients. The two assumptions that the orthodontic correction of malocclusion may reduce the likelihood of development of TMD or may be therapeutic for those who have developed TMD, were discussed in his review work. Later, Tallents RH et al., 19904 in his review dealt with etiology of the temporomandibular joint (TMJ) problems and found it quite debatable. He postulated that orthodontic therapy neither accelerates nor hinders the development of mandibular dysfunction, in turn, the TMD. McNamara JA et al33, 1995, has reviewed the literature on the interaction of functional and morphologic occlusal factors and orthodontic treatment in relation to TMD. It was concluded that the prevalence of TMJ signs and symptoms increases with age, and they occur in a population otherwise. Hence the TMD that originates during orthodontic treatment may not be associated with treatment. It was also mentioned that extractions of teeth or type of mechanics used for treatment do not elevate the risk of TMD. However, the author advised that the future research may be targeted at the complete understanding of occlusal factors to manage TMDs as although minor it needs to be explored. The systematic review of the randomized controlled trials on the role of occlusal adjustment in the temporomandibular disorders in adults inferred that the occlusal adjustments do not have the role in prevention or treatment of TMD.[9] Luther F reviewed the literature relating TMD with orthodontic treatment as well as malocclusion. It appeared to him that the treatment or malocclusion had little role in worsening or precipitating TMD. Contrarily, some longitudinal studies showed the reduction in TMD signs in orthodontically treated subjects.[10-11] They mentioned about the inadequacy of literature on long-term studies investigating a functional occlusion following orthodontic treatment.[10-12] The literature reviews mentioned that the assumption of orthodontic treatment leads to or prevents TMD appears to be ill-founded.[7,37]

Study Year	Type of study/ Sample	Objective of study	Parameters	Findings
Larssonan-dRonerman, 1981	Retrospective 23, 24-28 yrs	Analyze mandibular dysfunction symptoms in treated patients	10 year follow-up	No association between extensive tooth movement & occurrence of symptoms, higher prevalence of symptoms in patients treated with fixed appliances in both jaws than only in one jaw
Tadej et al 1989	Prospective, 100, Adolescent	Study the TMJ changes due to forces applied using functional appliance	Radiographic	Major changes in condyle size during growth occurred in mediolateral dimension than anteroposterior. Condylar size in males was greater than in females
Kundinger KK, 1991	Prospective, 29, Adolescent 13-19y	Evaluate TMJ and jaw muscles after orthodontic treatment in extraction cases	Premolar. Extractions, Electromyographic	There were no significant differences between the control and experimental subjects.
Artun et al 1992	Prospective 29/F--Cl II, 34/F--Cl I, 16.6y	Study the relationship between condylar position & internal derangement of TMJ in treated patients	Radiographic & clinical follow-up, Extraction &non-extraction	%, Few patients developed clicking, Condyles were located more posteriorly in patients with clicking -No difference in extraction & non-extraction cases
Rendell JK et al, 1992	Longitudinal, 451, 18-months	Investigate relationship between orthodontic treatment & TMD	TMJ pain & dysfunction in symptomatic patients	No clear or consistent changes in levels of pain and dysfunction occurred longitudinally during the treatment period
Dib-bets&Weele, 1996	Prospective, 161, Children, 8-15	to study relationship between orthodontic treatment and TMD	20 year follow up	Although signs and symptoms of TMD increased with age. After 20 years neither orthodontic treatment showed a causal relationship with TMD
Peltola, 1993	Prospective 355/M, 613/F, 19-25	assess of condylar variations TMD	Radiographic	Treated students had condylar variations of 21.1% in males and 16.5 per cent in females. No age correlation in frequency of variations, Condylar flattening & subcortical sclerosis were common in treated subjects
Pullinger et al, 1993	logistic regression 44 young	analysis of 11 common occlusal features in controls in 5 TMD groups		The features as intercuspal position, occlusal slide asymmetry, retruded contacts, overbite, overjet, midline discrepancies, missing teeth, molar relationship did not develop TMD
Peltola, 1995	Longitudinal, 625, 4-15.9	examined panoramic radiographic characteristics in mandibular condyles in treated patients	12-year follow-up	osseous changes of the condyle were only detected in 2.2 % and associated with Class II malocclusion. Condylar findings varied greatly during follow-ups. The findings had become more severe in 49% of the subjects, F>M, Condylar findings disappeared in 28%

Table no. 1: Archiving of features of studies conducted in 1981-1995 [24-29]

Study Year	Type of study	Theme/objective	Variables/ parameters	Findings
Katzberg RW et al, 1996	Prospective 102 treated 76 control	to compare prevalence of internal derangement of TMJ	MRI	prevalence of disk displacement in 33% & 77% patients. No link between a history of prior treatment & internal derangement of TMJ
Owen AH, 1998	Retrospective 600 Adolescent	Assess female patients during fixed appliance therapy, those female Class II malocclusion	--	Patients demonstrating a severe initial overjet, overbite and moderate to severe crowding of the lower arch were most predisposed to developing TMD. Stated the importance of routine X-ray follow-up
Lagerström L1, et al	Prospective 860 19yrs	study the prevalence of signs and symptoms of TMD	questionnaire and clinical examination	Severe signs and symptoms of TMD were rare, the prevalence did not differ between 2 study groups, more common in females than in males
Henrikson T et al, 1999	Prospective 65 females with Class II Adolescent	Investigate the relationship between orthodontic treatment and symptoms and signs of TMD	fixed appliance treatment with straight-wire technique, with or without extractions	Both symptoms and signs of TMD showed considerable fluctuations over 3-year period, with general tendency towards decreasing. TMJ clicking increased slightly over 3 year period.
Yamada K et al 1999	Prospective 23 F 6 M, 18.8-6y	To explore condylar bony changes relate to craniofacial morphology radiographically	Radiographic MRI, CT	Bilateral condylar-change group showed osteophyte formation and erosion commonly, Unilateral condylar change group showed flattening of condyles. Erosion only subjects aged below 19 years. Condylar resorption may be related to a lateral mandibular shift and a retrognathic mandible
Henrikson T1, Nilner M, Kurol J, 2000	longitudinal females 65-Class II 58-unt 60 normal Adolescent	Examine signs of TMD and occlusal changes in Class II malocclusion receiving orthodontic treatment & compare with untreated	---	Temporomandibular joint clicking increased in all study groups over the 2 years, but was less common in the Normal group. The Normal group had a lower prevalence of signs of TMD than orthodontic & untreated Class II groups.
Tahima K et al, 2000,	56 Adolecent	the purpose of this study was to estimate the morphologic features of the craniofacial skeleton in treated adolescent patients with Class III malocclusion	Radiographic-cephalograms chin cup therapy for duration of 3.9 months	Upward-and-forward rotation of mandible, with the forward growth and displacement, is highly associated with unsatisfactory treatment outcomes after pubertal growth in growing Class III patients.

Table no. 2: Archiving of features of studies conducted in 1996-2000 [30-35]

Study /Year	Type of study	Theme	Variables/ parameters	Findings
Conti A et al, 2003,	200 120/F 80/M Cross-sectional 9-20y	evaluated prevalence of TMD (TMJ & muscle palpation, mandibular motion, & joint noise) before and after orthodontic treatment	-Questionnaire -Subjects classified as per TMDs.	The 34% of sample had mild TMD, whereas 3.5% had moderate TMD, higher in females. Joint noises (15.5%) followed by headache (13%) were frequent -TMDs have not shown any relationship with orthodontic mechanics or extraction. -Positive association between TMD and parafunctional habits and emotional tension was found
Shen YH et al, 2005	Case-control 28/F	28-year-old female who underwent orthodontic treatment for 22 months	Radiographic Splint therapy	Clicking commenced 5 months prior to treatment completion along with neck-muscle and right shoulder muscle pain and condylar resorption in later stages. Splint therapy for 1 month has subsided TMD with new bone growth in right condyle
Kinzinger G et al, 2006	Prospective 20-Cl II	Study effects of orthodontic treatment with fixed functional orthopaedic appliances on the disc-condyle relationship in TMJ	Radiographic-MRI	-The treatment does not have adverse effects on initial physiological disc-condyle relationships -TMJs with initial partial or total anterior disc displacement, improved disc position can be achieved.
Cacho and Martinb, 2007	Longitudinal 27-cases-series, 11y	To analyze effect of orthodontic treatment by means of activator appliance on disc-condyle complex	Kinesiographic& sonographic records	No differences in temporomandibular joint sounds before and after treatment, orthodontic treatment with an activator in a child is not a risk factor for the development of TMD or mandibular dysfunction
Egermark&Ronnerman 2007	prospective 50 12.9	investigate development of TMD in active phase of orthodontic treatment.	TMD, headache, bruxism and occlusal interferences examined	The prevalence of TMD was high before treatment. Except for TMJ sounds, signs and symptoms of TMD and headache decreased during the treatment
Rey et al, 2008	Cohort Adolescent & Young	compare class III patients treated with headgear, class I (treated & untreated)	20 year follow-up	No difference in TMD prevalence was found between the 3 groups after 2-3 years.
MacFariane et Al 2009	Prospective Cohort 1981 n=1018 (11-12Y) 1984 n= 792 1989 n= 456 2000 n=337	Explore relationship between orthodontic treatment and TMD	--	Orthodontic treatment neither causes nor prevents TMD, participants with a history of treatment did not have higher risk of new or persistent TMD

Table No. 3: Archiving of features of studies conducted in 2001-2010

TMD and clinical

The prevalence studies on TMDs have reported that approximately 75% of the population has, at least, one sign of joint dysfunction; the signs included joint noises, abnormal jaw movement, or tenderness on palpation.[9] While approximately 33% has, at least, one symptom such as joint pain or facial pain, etc. The commonly observed signs and symptoms of TMD include joint sounds as clicking, pain, spasm of the muscles of mastication and the restricted jaw movements.[9]

It was also observed that the patients occasionally developed TMD or clicking in TMJ during orthodontic treatment which is seen more in an adult population. This was attributed to effects of exceeding adaptive capacity of muscles and joints.[13] The orthodontically treated patients with clicking had more posteriorly placed condyles suggesting the internal arrangements of TMJ.[15] Cacho and Martinb, 200710, evaluated a case-series of 27 symptom-free patients treated using activator. The sonographic study showed no differences in

temporomandibular joint sounds before and after treatment. Henrikson T et al23, 1999 examined 65 patientsduring and post-treatment for TMD, except for TMJ clicking which has increased over a period, there was great fluctuation in symptoms and signs of TMD over the three-year period. The studies evaluated orthodontically treated patients and observed that 34% had mild TMD, and 3.5% had moderate TMD, the joint noises and headache were the most frequent complaints and had female predilection.[25-27]Egermark and Ronnerman11, 2007 investigated the presence of muscle tenderness, headache, bruxism, and occlusal interferences in 50 patients (mean age 12.9 years) before, during and immediately after orthodontic treatment. Except for TMJ sounds, other signs, and symptoms of TMD decreased during the treatment. Although there was a high prevalence of occlusal interferences during treatment, they seemed to have little importance for the development of TMD. Shen YH et al28, 2005 mentioned regarding the case of 28-year-old female who developed clicking sound 5 months prior to completion of 22 months orthodontic treatment. Additionally, she had neck-muscle and right shoulder muscle pain; radiograph revealed right mandibular condylar resorption. The orthodontic treatment was terminated, and the patient was treated with splint therapy, one month subsequent to which the symptoms were subsided, and new bone growth in the right condyle was observed. Accordingly, it is recommended to closely monitor the patient when TMD is noted during active orthodontic treatment. Also, splint therapy may be utilized to treat TMD and any associated bone remodelling.

Peltola et al[5,18] investigated the hypothesis that radiographic condylar findings in treated patients are associated with clinical TMD. The frequency of temporomandibular joint crepitation was higher in treated (27%) subjects than controls (8%). It was suggested that crepitation may be due to osteoarthrosis in the present subjects. Further, 12-year follow-up study showed that although radiographic findings worsen with duration, the subjective symptoms and signs did not seem to cause any significant clinical problems to the patients. Rendell JK et al[16,] 1992, had 2 observations as the asymptomatic patients who underwent orthodontic treatment showed no evidence of signs and symptoms of TMD during treatment. The patients who had signs and symptoms of TMD at the time of their entry showed no consistent and reliable clinical parameters of pain and dysfunction during the treatment. Twenty-year follow-up studies for orthodontically treated patients showed no causal relationship with signs and symptoms of TMD.[15,16]

The observations by Katzberg RW et al[20], 1996 could not show the significant correlation between the internal derangement of the TMJ and the orthodontic treatment. It was inferred in a study that orthodontic treatment performed during adolescence has no significant effect on the initiation and precipitation of TMD later in the patient's life.[17] However, the patients having severe initial overjet, overbite and moderate to severe crowding of the lower arch showed the higher predilection towards developing TMD subsequent to orthodontic treatment; it was observed more in female patients.[18]

TMD and appliance

Larsson and Ronnerman12, 1981, studied the Mandibular dysfunction symptoms in 23 orthodontically treated patients by fixed appliances aged between 24 and 28 years with 10-year follow-up. The patients with fixed appliances in both jaws had a tendency towards higher prevalence of symptoms than having appliance only in the upper jaw. In general, there was no evidence of increased occurrence of mandibular dysfunction symptoms; however, it is advocated to be cautious dealing with the patients given the torque on the molars to avoid mediotrusive interferences. Dibbets and Van der Weele17, 1992, compared TMD in children treated with different orthodontic procedures. Patients were monitored for a 20-year period after the start of orthodontic treatment. Although signs and symptoms of TMD increased with age, after 20 years neither orthodontic treatment showed a causal relationship with signs and symptoms of TMD.

The female patients having Class II malocclusion with significant crowding, overbite and severe overjet at entry showed more susceptibility to develop TMD on fixed orthodontic treatment.12 Henrikson T et al, 1999 treated 65 adolescent girls with Class II malocclusion with fixed appliance using the straight-wire technique. The subjects with pre-treatment signs of TMD of muscular origin were benefited functionally from orthodontic treatment over 3 year period.[19] The 65 patients treated using fixed straight wire appliances were evaluated for the period of 2 years and it was showed that orthodontic treatment does not increase the risk of TMD.25 In a study conducted for 200 patients previously, the extraction protocols and the mechanics used for orthodontic treatment did not show any relationship with occurrence of TMD.[21]

In a study conducted in wistar rats to show the change in the calcified tissues of mandibular condyle caused by abnormal muscle function. To achieve the lateral shift of mandible, the maxillary occlusal splint was fabricated. The study showed that both the mandible and the condyle modified their shape and size as well as the trabecular pattern, during shifting of the mandible to one side as it closed.[38]

The studies verified 11 common occlusal features in 5 temporomandibular disorder groups using different orthodontic techniques (functional appliances class I/II elastics, chin-cup, headgear, activator, fixed or removable appliances), the assumptions that these can be etiological factors for TMD appears to be ill-founded.[10,19,30] While in another study, where the patients were treated using chincup therapy, the patients with the upward-and-forward rotation of the mandible in combination with forward growth are highly susceptible to unsatisfactory outcomes and TMD.[26] Tadej G et al[13], 1989, evaluated 100 cases for TMJ changes due to forces applied using functional appliance. The major changes in condyle size during growth occurred in mediolateral than the anteroposterior dimension.13Kinzinger G et al[29], 2006 and Cacho and Martinb[10], 2007 studied the effects on the disc-condyle relationship of TMJ using fixed myofunctional mechanotherapy in patients with class II malocclusion and observed that the treatment does not have adverse effects on TMJs, rather in patients with anterior disc displacement, the disc position was improved. While Rey et al[30], 2008 studied effects in class III patients treated with cervical headgear, class I orthodontically treated and untreated subjects. No difference in TMD prevalence was found between the 3 groups after 2-3 years.

TMD and extraction

An evaluation of 29 orthodontically treated patients with maxillary and mandibular premolar extractions showed no significant differences in TMD signs and symptoms.[14] In a study by Artun J et al[15] 1992, on 29 female patients treated for Class II, Division 1 malocclusion it was observed that the mean condylar position was more posterior at right central and medial tomographic sections in patients treated with maxillary first premolar extraction.

In a study involving 65 females, it was inferred that the orthodontic

treatment with or without tooth extractions did not increase the risk for TMD or worsen pre-treatment signs of TMD.[23]

Conclusion

Overall, the literature review suggests the lack of clear evidence about the association of orthodontic intervention and TMD. The prevalence of symptoms and signs are shown to be varied according to the criteria used and the methods of data collection. Longitudinal studies showed the increased in occurrence of prevalence of the signs of TMD with age as compared to the symptoms. Owing to the greater prevalence of TMD in children and adolescents, also the higher number of patients in this age group undergo orthodontic treatment, it may appear that orthodontic intervention may be a risk factor for TMD. The various studies have mentioned about the development of signs and symptoms of TMD during and after treatment in the patients who were asymptomatic at the entry. In addition, there is no reliable data to correlate TMD with the type of mechanics used, associated tooth extraction and type of malocclusion in treated patients or whether the severity and prevalence of TMD are influenced by orthodontic treatment. The lack of universal diagnostic criteria for TMD, methodologic shortcomings and variability hampers that any conclusion can be drawn about this association.

On the whole, orthodontic intervention has been cited either detrimental or beneficial factor in regard to the occurrence of TMD. Lack of obvious evidence to the assumption that orthodontic treatment is associated with the occurrence of TMD promotes the need for longitudinal studies with broader representation and more rigorous methodology encompassing all relevant variables or confounding factors in relation to TMD.

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