

Temporomandibular Joint Disorders: An Orthodontist's Perspective

Ranjit Manne^{1*} Krishna Prasad² Srikanth Aryasri³ E Sridhar Reddy⁴

¹Professor, Department of Orthodontics and Dentofacial Orthopedics, Panineeya Institute of Dental Sciences, Hyderabad, India.

²Reader, Department of Orthodontics and Dentofacial Orthopedics, Panineeya Institute of Dental Sciences, Hyderabad, India.

³Senior Lecturer, Department of Orthodontics and Dentofacial Orthopedics, Panineeya Institute of Dental Sciences, Hyderabad, India.

⁴Senior Lecturer, Department of Oral Pathology and Microbiology, MNR Dental College and Hospital, Sangareddy, India.

ABSTRACT

Background: Temporomandibular joint problems have always posed a challenge to orthodontists. The major goal of an orthodontist is providing patient with better esthetics as well as masticatory system. In this review we have tried to high light the major factors associated with TMJ complaints and an overview of the treatment modalities along with the perspective of how the treatment will go based on the severity of TMJ disorders and the keen role an orthodontist will play in establishing better joint functions.

Keywords: TMJ, TMD, Orthodontic treatment and TMD management.

INTRODUCTION

Orthodontists are constantly being challenged with the task of providing their patients with acceptable esthetics and masticatory function.^{1,2} So developing a sound, functional masticatory system is the primary goal of orthodontic therapy.^{3,4} The frequency of TMJ complaints has multiplied in the last few years. This may have been brought about by the increased stresses of our fast paced world, with nocturnal parafunctional activity. Dental procedures such as extractions leading to horizontal or vertical dental changes can add to distal and elevated mandibular pressure. Crowns, bridges, fillings that alter

physiologic intercuspation can create adverse functional pressure on the mandible. The craniomandibular articulation is a complex synovial system composed of temporomandibular joints together with their reticular ligaments and masticator muscles.⁵ The craniomandibular articulation presents several features that complicate diagnosis and treatment. According to "American Academy of Orofacial Pain"⁶ – Temporomandibular disorder is a collective term embracing a number of clinical problems that involve the masticatory musculature, temporomandibular joint and associated structures or both.

CLASSIFICATION

According to American Academy of Orofacial Pain -

TEMPOROMANDIBULAR JOINT DISORDERS	MASTICATORY MUSCLE DISORDERS	CONGENITAL AND DEVELOPMENTAL DISORDERS
A) Deviation in form	A) Acute	1. Condylar hyperplasia

Received: Jan. 11, 2017; Accepted: Mar. 3, 2017

*Correspondence Dr. Ranjit Manne.

Department of Orthodontics and Dentofacial Orthopedics, Panineeya Institute of Dental Sciences, Hyderabad, India.

Email: Not Disclosed

1. Articular surface defects 2. Disc thinning and perforation.	1. Myositis 2. Reflex muscle splinting 3. Muscle spasm	2. Aplasia 3. Neoplasms 4. Fractures
B) Disc displacement 1. Disc displacement with reduction 2. Disc displacement without reduction	B) Chronic 1. Myofacial pain 2. Muscle contracture 3. Hypertrophy 4. Myalgia	
C) Displacement of disc condyle complex 1. Hypermobility 2. Dislocation		
D) Inflammatory conditions 1. Capsulitis and synovitis 2. Retrodiscitis		
E) Degenerative disease 1. Osteoarthritis 2. Polyarthritis 3. Osteoarthritis		
F) Ankylosis 1. Fibrous 2. Bony		

ETIOLOGY OF TEMPOROMANDIBULAR DISORDERS

The etiology of TMD remains in controversy and is multifactorial.⁷

Predisposing factors	Initiating factors	Perpetuating factors
1. Systemic factors – Rheumatic infections, Nutritional and metabolic disorders 2. Psychologic factors- Personality and Behavior 3. Structural factors – Occlusal discrepancies, Improper dental treatment, postural abnormalities, skeletal deformation, past injuries etc. 4. Genetic factors.	1. Trauma – Microtrauma or Macrotrauma 2. Overloading of joint structures 3. Parafunctional habits etc.	1. Mechanical and Muscular stress. 2. Metabolic problems.

SYMPTOMS AND SIGNS⁷

1. PAIN:

Present as a constant or periodic dull ache over the joint, the ear and the temporal fossa. It can be of following origins-

a) **Myogenic pain:** Mechanical trauma and muscle fatigue.

b) **Articular pain:** Arises as a result of inflammation of articular and periarticular tissues caused by Overloading or trauma.

2. JOINT SOUNDS:

a) **Crepitus:** Grating or scraping noise that occurs on movement. Due to roughened, irregular articular surfaces of the joint.

b) **Clicking:** Due to uncoordinated movement of condylar head and articular disc.

3. LIMITATION OF MANDIBULAR MOVEMENT:

a) **Muscular Restriction:** It is most common reason for limitation of mandibular movement. The restriction is caused by contraction of group of muscles.

b) **Disc Displacement:** An anteriorly displaced disc may prevent the forward translation of the mandibular condyle. This results in limitation of opening of the mouth.

c) **Ligamentous Restriction:** The ligaments normally restrict the movements of the joint in all direction and operate when the muscles are unable to stop the movement and when there is a risk of dislocation of joint.

4. **DISLOCATION:** On wide opening of the mouth, patient may be unable to close the mouth as condyle cannot return into the fossa.

5. **EAR SYMPTOMS:** Subjective ear symptoms are associated such as tinnitus, itching in the ear, vertigo.

6. **RECURRENT HEADACHE:** TMD is mostly associated with temporalis muscle contraction, headache and sometimes migraine headaches.

REVIEW OF THE LITERATURE

In a comprehensive review of the literature on this subject that was published by Reynder et al⁸ divided publications into three categories: View point articles, case reports and sample studies.

The view point articles were not suitable for critical evaluation of association between two entities, however useful in identifying questions that may be worthy of scientific investigation.⁹

1) What is the prevalence of signs and symptoms of TMD in orthodontically untreated population?

Numerous epidemiologic studies have shown a significant prevalence, with an average of 32% reporting at least one symptom of TMD and an average of 55% demonstrating at least one clinical sign.^{27, 32}

2) Does orthodontic treatment lead to a greater incidence of TMD?

Two of the first major investigations sponsored by the National Institute of Health to consider relationship between orthodontics and TMD revealed no statistically significant differences between the treated and untreated groups.²²

3) Does the type of appliance (e.g. fixed functional or orthodontic v/s orthopedic) make a difference?

In the major longitudinal study conducted by Dibbets et al⁴⁸ consisting of 171 patients, 75 of whom were treated by Begg mechanotherapy, 65 were treated by activator and 30 patients were treated with chin cups, revealed that at the end of treatment, fixed appliance group had a higher percentage of objective symptoms than did the functional group, but no differences existed at the 20 year follow up evaluation.

Another prospective study conducted by Pancherz⁴⁹ examined the effects of functional mandibular advancement in patients with Class II div I malocclusion. He used bonded Herbst appliance. After an initial edge to edge bite registration, several patients reported muscles tenderness during first 3 months of treatment. However, at 12 months following treatment, the number of subjects with symptoms was the same as that before treatment.

4) Does the removal of teeth as part of an orthodontic protocol lead to a greater incidence of TMD?

Sadowsky and Coworkers²⁹ conducted a study on 160 patients and reported that joint sounds were evident before and after treatment in 87 extraction patients and 68 non extraction orthodontic patients. They reported there is no increase in the risk of development of joint sounds regardless of whether teeth were removed.

5) Can orthodontic treatment lead to a posterior displacement of the mandibular condyle?

Gianelly et al²⁸ conducted a study by collecting the tomograms to evaluate condylar position. They took the tomograms before orthodontic treatment in 37 consecutive patients aged 10 to 18 years and compared them with tomograms from 30 consecutively treated patients with fixed mechanotherapy and removal of four premolars. No differences in condylar position were noted between groups.

6) Should the occlusion of orthodontic patients be treated to specific gnathologic standards?

Several view point articles including those by Roth et al and Williamson have maintained that TMDs may result from a failure to treat orthodontic patients to gnathologic standards that include the establishment of a "mutually protected occlusion" and proper seating of the mandibular condyle within the glenoid fossa. Pullinger et al reported that small occlusal slides less than 1 mm are common in asymptomatic subjects as well as patients with TMD.

7) Does orthodontic treatment prevent TMD?

Egermark, Magnusson and Carlsson⁵⁰ found that orthodontic treatment improved TMD health. The investigators noted that clicking recorded at the first examination sometimes disappeared at subsequent examination. At the same time the clinical dysfunction index outcome was lower in those who had undergone orthodontic treatment in those who had not undergone orthodontic treatment.

TEMPOROMANDIBULAR DISORDER (TMD) Vs ORTHODONTIC TREATMENT

The potential detrimental effect of orthodontic treatment on TMJ has captured the attention of orthodontic community.¹⁰ Some of the examples of Orthodontic treatment which can lead to TMD's are:

1) Effect of headgear and/or class II elastics in correction of Class II malocclusions with deep interlocking cusps: Headgear or Class II elastics are often used in an effort to get the patient into a Class I cuspal relationship. By the headgear force, as the maxilla is moved backward, the muscles of

mastication will attempt to retract the mandible when the patient closes into maximum intercuspation. This compensating movement by the mandible can put distal pressure on the condyles and conceivably cause an anterior dislocation of the disk. To correct this problem in orthodontic treatment, a possible solution is to give a flat fixed or removable bite plane.

2) Effect of Cross elastics to correct the midline:

The cross elastics have a little effect on TMJ. As the jaw is pulled to one side, distal pressure is put only on one condyle and chances of anterior dislocation of disc. If it creates a TMJ problem then elastics should be worn only during waking hours so that the muscles can help to hold the mandible forward because of muscle tension.

3) Effect of Reverse Headgear or Class III Elastics for Correction of Class III malocclusion:

This again can put distal pressure on the mandible. If there is a developing problem, then patient is asked to wear reverse headgear or Class III elastics during waking hours as muscle tension or tone, positions the mandible forward. If then also patient cannot tolerate, then orthodontic treatment must be compromised or surgical line of treatment should be considered.

4) Effect of Lower Expansion and Upper Contraction:

In most cases, the crowded lower anterior teeth are in contact with the lingual of the upper anterior teeth. There is spacing in upper anterior. If orthodontist tries to close down the anterior spaces without opening the bite, it may create a premature contact with the lower anterior teeth and exert distal pressure on the mandible that may result in TMJ pain. In these deep bite cases one should first open the bite and carefully plan the proper interincisal anterior angulation, so that the maxillary space closure can be carried without impinging on the lower anterior teeth.

5) The Retentive Phase: According to many observers, the retentive phase of orthodontic treatment may cause more TMJ problems than any other orthodontic procedure. The majority of orthodontically treated cases mostly have dental deep bite at the beginning. So in cases of orthodontically treated deep bite malocclusions, the bite will tend to close at varying speeds, ranging from months to years. Since most of the

orthodontists give a bonded retainer on both upper and lower anterior teeth after the active treatment. These retainers prevent lower anterior teeth from crowding or collapsing and also prevent the upper anterior teeth from rotating, separating or moving forward. But at the same time the retainer cannot prevent other two adverse effects i.e. forward movement of maxilla and distal movement of mandible, which can again lead to TMJ problems. When the fixed appliances are debonded, a retainer Begg labial bow minus a bite plane should be placed on the same day. The bite is allowed to deepen with the retainer in place for 2-3 weeks. The curve of spee will begin to return to the occlusal plane. When the bite has deepened sufficiently for anterior guidance (e.g bite closure of 1-2 mm) the lingual bite plane is added to retainer. If the patient continuously wears the retainer 24 hours a day, usually the bite will not deepen dentally and there will be no distal pressure exerted on the mandible during retention unless there are major increments of upward and forward rotating mandibular growth occurring. If there is no distal pressure on the mandible by giving anterior upper bite plane, the condyles are not driven posteriorly and the articular disks would stay in place, thus TMJ problems are much less likely to occur.

MANAGEMENT OF TEMPOROMANDIBULAR DISORDERS

FIRST PHASE OF TREATMENT (COMFORT PHASE): The primary purpose is to eliminate the pain, clicking, popping, locking headaches, neckaches, backaches, which are frequently related to condyle that is improperly positioned in the fossa.¹¹ The TMJ splint repositions the mandible in such a position that the condyles are centered in the fossa and any impingement of the tissues is reduced. The treatment is usually for 6-12 months.

SECOND PHASE THERAPY

The highest priority is to maintain the condyles in the proper position, whatever it takes to maintain TMJ health. It includes the following steps:

A) TMJ Recall¹¹: If the patient feels fine with no symptoms when the splint is out and can move the mandible back to their original bite position, they can be placed on category of TMJ recall and further

no treatment is planned at that time. They can be examined once in a year.

B) TMJ Treatment (Orthopedics / Orthodontics)¹¹: If the TMJ disorder symptoms return, whenever the splint is removed and patient tries to move their lower jaw back to its pre-treatment position, this confirms the original diagnosis of TMJ disorder. The patient no longer knows where to bite and patient finds it necessary to wear splint full time.

Then following treatment methods can be carried:

1) Orthopedic / Orthodontic treatment: To rearrange the teeth to the proper condylar position. It is important to establish a new occlusion at the position that the condyles are healthy.

Orthopedic Phase: It involves the development of bones and muscles to develop arch width, length and vertical dimension.

Orthodontic Phase: To align crooked teeth as needed.

2) Crown and bridge: To build up all the teeth to correct the bite.

3) Overly partial denture: To replace the splint and any missing teeth.

4) Orthognathic Surgery: Surgery can also be carried to rearrange the jaws to the correct bite position for the temporomandibular joints. It is the best choice if there is a major skeletal imbalance or facial deformity needing correction that falls out of standard orthodontic and orthopedic treatment range.

ALTERNATIVE TO SECOND PHASE THERAPY: WALTER NEWMANN

The addition of composite to the occlusal surfaces in order to alter condyle / fossa relationships is an alternative to phase II therapy.¹² Because of the non-compliance of patients, fixed splints in the form of selective composite addition to the occlusal surfaces of teeth can be placed.

TMJ TREATMENT GUIDELINES

A) For first 2-3 days the splint can be removed for a short period of time if facial muscles get tense to

allow these muscles to adjust to new position of mandible. After the initial adjustment period, the splint must be worn full time, including eating except brushing in order for damaged ligaments and TM joint space to heal.

B) A softer diet is recommended for the few first weeks until many of the symptoms subside to reduce stress and pressure on TM joint.

DIFFERENT MODES OF TREATMENT

1. PHYSICAL THERAPIES¹² - It can be administered to break the pain spasm cycle of the craniofacial muscles. Practicing correct erect posture during walking, sitting can be of great value. Applying Pressure and massaging the muscles of mastication and oro-facial musculature produces relaxation which then permits a greater range of movement of the mandible. Vaso-coolant spray applied to the affected fatigued and painful muscles brings about muscle relaxation and result in decrease or loss of pain. Muscle pain and spasm can be controlled by regulating the electrical impulses in the affected muscles by Transcutaneous Electrical Nerve Stimulation (TENS).

2. TMJ SURGERY¹³ - TMJ Surgery should be reserved for clearly diagnosed conditions known to be amenable to surgical improvement. It is necessary in cases of degenerative bone disease, adhesions, ankylosis etc. Arthroscopic surgery and TMJ irrigation procedures may be helpful in some cases with internal joint disk mobility. The injection of corticosteroids into the TMJ may be useful in rheumatoid arthritis cases.

THE ROLE OF ORTHODONTIC THERAPY IN TMD⁴⁴

There were claims of orthodontic therapy's always causing TMD to claims of its never causing TMD. Similar claims were being made for certain types of orthodontic treatment: eg, that extraction of teeth always leads to TMD or never leads to TMD. The problem was that these concepts were based on clinical impressions and not on scientific evidence.

Sadowsky, Rendell, Dibbets, Hernikson, Ergmark did not suggest that orthodontic therapy was a significant risk factor for the development of symptoms of TMD. TMD in some patients, it would seem logical that orthodontists should develop

occlusal conditions that will minimize any risk factors that might be associated with TMD. However, developing a sound occlusal relationship does not mean that the patient will always be free of TMD. Bevilaqua-Grossi et al suggested that a way to identify patients who really need TMD treatment would be to determine the frequency and intensity of signs and symptoms of TMD. They suggested using the questionnaire proposed by Fonseca and a clinical examination assessing the range of mouth opening and the tenderness of masticatory muscles and TMJ to palpation.⁴⁵

Fonseca questionnaire for anamnesis of temporomandibular disorder⁴⁵

1	Do you have difficulty to open your mouth
2	Do you feel difficulty to move your jaw sideways? To the right? To the left? To both sides?
3	Do you have muscle fatigue or pain when chewing?
4	Do you often have headaches?
5	Do you feel pain in the neck or torticollis?
6	Do you have ear ache or in the temporomandibular joints region (TMJ)?
7	Have you noticed if you have TMJ sounds when chewing or when you open your mouth?
8	Have you noticed if you have any habits like pushing and/or grinding teeth, chewing gum, biting lip or pencil, nail biting?
9	Do you feel that your teeth do not fit together well?
10	Do you consider yourself a tense or nervous person?

Orthodontic treatment cannot be justified as an effective means of preventing TMD. The development of TMD cannot be predicted and no method of TMD prevention has been demonstrated. However, orthodontic treatment may be indicated to reduce existing signs and symptoms of TMD in certain carefully selected cases or to provide a morphologically and functionally optimum occlusal environment following successful management of TMD. According to existing literature, the

relationship of the TMD to occlusion and orthodontic treatment is minor.⁴⁶

Orthodontists were introduced to the field of TMD following the theorising of Thompson who believed that malocclusion caused the posterior and superior displacement of the condyle. Hence, there was the need to bring downward and forward the condyle by freeing up the trapped mandible.⁴⁷ Since then, various malocclusions have been associated with TMD signs or symptoms. In 1988, Greene and Laskin published a list of 10 myths in this field that, surprisingly after 20 years, are still a matter of debate among orthodontists:⁴⁶

1. People with certain types of untreated malocclusion (for example, Class II Division 2, deep overbite, crossbite) are more likely to develop TM disorders.
2. People with excessive incisal guidance, or people totally lacking incisal guidance (open bite), are more likely to develop TM disorders.
3. People with gross maxillo-mandibular disharmonies are more likely to develop TM disorders.
4. Pre-treatment radiographs of both TMJs should be taken before starting orthodontic treatment. The position of each condyle in its fossa should be assessed, and orthodontic treatment should be directed at producing a good relationship at the end. ('Good' position usually was defined as being a concentric placement of the condyle in the fossa).
5. Orthodontic treatment, when properly done, reduces the likelihood of subsequently developing TM disorders.
6. Finishing orthodontic cases according to specific functional occlusion guidelines (e.g. gnathologic principles) reduces the likelihood of subsequently developing TM disorders.
7. The use of certain traditional orthodontic procedures and / or appliances may increase the likelihood of subsequently developing TM disorders.
8. Adult patients who have some type of occlusal 'disharmony' along with the presence of TMD symptoms will probably require some form of occlusal correction to get well and stay well.
9. Retrusion of the mandible because of natural causes or after treatment procedures is a major factor in the aetiology of TM disorders.
10. When the mandible is distalized, the articular disc may slip off the front of the condyle.

IMPLICATIONS IN ORTHODONTICS

Of the all systematic reviews about TMD, many seems to have the greatest implications for orthodontics: (1) Orthodontics and the cause of TMD, (2) "Occlusal adjustment for treating and preventing temporomandibular joint disorders,"¹⁴ (3) "Occlusal treatments in temporomandibular disorders: a qualitative systematic review of randomized controlled trials,"¹⁵ (4) "Association of malocclusion and functional occlusion with temporomandibular disorders (TMD) in adults: a systematic review of population-based studies,"¹⁶ and (5) "Orthodontics and temporomandibular disorders: a metaanalysis."¹⁷ All above reviews in some way deal with the role of occlusion in the etiology and treatment of TMD. Although the EMG biofeedback review supporting its efficacy in treatment of TMD does not directly appear to address occlusion, one could logically argue that, if a psychological treatment modality such as EMG biofeedback can treat TMD, then structural factors such as occlusion would play a lesser role in etiology of TMD. Nonetheless, the salient point that can be gleaned from all reviews is that occlusion generally plays a secondary role in the etiology and treatment of TMD. This does not mean that occlusion (or condyle position) has no relevance to TMD or that orthodontists should ignore it.¹⁸ What can be derived from the evidence based information is that occlusion is no longer considered a primary factor in the multifactorial nature of TMD.¹⁷⁻³⁴ And, isn't this the modern-day and evidence - based view of occlusion and its relationship with TMD? Recall, however, that occlusion was once thought of as the primary, and perhaps sole, cause of TMD.

Furthermore, TMD, once known as the TMJ pain dysfunction syndrome, was considered a single disorder. TMD is now considered to include some half dozen subclasses that involve masticatory muscles, joints, and associated structures, with the TMJ in some instances not even involved or affected. However, as orthodontists, we are perhaps perceived as the brightest and best in dentistry and therefore should be the most knowledgeable about areas of dentistry, such as TMD, that can impact our specialty. Our correspondence and interaction with our colleagues in general dental practice, as well as other dental specialties and medicine, should reflect positively about our knowledge of TMD. With this in mind, the information obtained from evaluating the TMD systematic reviews pertaining to diagnostic TMJ imaging, TMJ hypermobility, hyaluronic acid and treatment should help us better communicate with other dental and health professionals.³⁶⁻⁴¹

CONCLUSION

As a consequence of the multifactorial etiology, multidisciplinary non-invasive therapy is generally suggested, with reversible treatments for TMD problems. With regard to TMJ dysfunction, the treatment goals should be to reduce pain and to improve function. Signs and symptoms of TMD increase with age, particularly during adolescence, until menopause, and therefore TMDs that originate during orthodontic treatment may not be related to the treatment. Orthodontic treatment with fixed appliance either with or without tooth extractions did not increase the prevalence of symptoms and signs, or worsen preexisting symptoms and signs of TMD. Although a stable occlusion is a reasonable orthodontic treatment goal, not achieving a specific gnathologic ideal occlusion does not result in signs and symptoms of TMD. The reversible therapies commonly used for the management of TMJ dysfunction include physiotherapy (to improve movements and function), pharmacotherapy (anti-inflammatory, antidepressants etc.), occlusal therapy (occlusal appliances) and psychological therapy (cognitive behavioural therapy). It must be stressed that for the vast majority of patients with TMD, the prognosis is favourable. Therefore, it is important to develop a tailored treatment protocol aiming to manage pain and function. Unsuccessfully treated patients with TMD are frequently highly

disabled by the pain and should be included in a comprehensive pain management protocol.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Brodie AG. Differential diagnosis of joint conditions in orthodontia. *Angle Orthod.* 1934; 4: 160-170.
2. Brodie AG. The temporomandibular joint. *III Dent J.* 1939; 8: 2-12.
3. Thompson JR, Brodie AG. Factors in the position of the mandible. *J Am Dent Asso.* 1942; 29: 925-941.
4. Ricketts RM. Variations of the temporomandibular joint as revealed by cephalometric laminagraphy. *Am J Orthod.* 1950; 36: 877-898.
5. Daniel M. Laskin, Charles S. Greene, William L. Hylander. *TMD's An Evidence Based Approach to Diagnosis and Treatment.* 2006, Quintessence Publishers.
6. Weldon E. Bell, Quintessence Pub. Co., 2005. *Orofacial pain: Guidelines for assessment, diagnosis, and management: The American academy of orofacial pain. Temporomandibular disorder, classification, diagnosis and management.*
7. Jeffrey P. Okeson, Mosby. 1985. *Fundamentals of occlusion and Temporomandibular disorders.*
8. Reint M. Reynders *Orthodontics and temporomandibular disorders: A review of the literature (1966-1988).* *Am J Orthod.* 1990; 97: 463- 471.
9. James A. McNamara, Jr., *Orthodontic treatment and temporomandibular disorders.* *Am J Orthod Dentofac Orthop.* 1997; 83: 107-117.
10. William E. Wyatt. Preventing adverse effects on TMJ through orthodontic treatment. *Am J Orthod.* 1987; 91: 493- 499.

11. Richard A. Perter, Sheldon G. Currntte. Quintessence Pub. Co.1996.Clinical management of Temperomandibular disorders and oro-facial.
12. Jefferey P. Okeson. 6th Edition, Elsevier Mosby, 2005.Management of temperomandibular Disorders and Occlusion.
13. Fonesca. 1994. Tempero-Mandibular disorders.
14. Koh H, Robinson PG. Occlusal adjustment for treating and preventing temporomandibular joint disorders. Cochrane Database Syst Rev 2003; (1).
15. Forssell H, Kalso E, Koskela P, Vehmanen R, Puukka P, Alanen P. Occlusal treatments in temporomandibular disorders: a qualitative systematic review of randomized controlled trials. Pain. 1999; 83: 549-560.
16. Gesch D, Bernhardt O, Kirbschus A. Association of malocclusion and functional occlusion with temporomandibular disorders (TMD) in adults: a systematic review of population-based studies. Quintessence Int. 2004; 35: 211-221.
17. Crider A, Glaros A. A meta-analysis of EMG biofeedback treatment of temporomandibular disorders. J Orofac Pain. 1999; 13: 29-37.
18. Rinchuse DJ, Rinchuse DJ, Kandasamy S. Evidence-based versus experience-based views on occlusion and TMD. Am J Orthod Dentofacial Orthop. 2005; 127: 249-254.
19. Rinchuse DJ, Rinchuse. The impact of the American Dental Association's guidelines for the management of temporomandibular disorders on orthodontic practice. Am J Orthod. 1983; 83: 518-522.
20. Griffiths RH. Guidelines for the examination, diagnosis and management of temporomandibular disorders. J Am Dent Assoc. 1983; 106: 75-77.
21. McNeil C, Mohl ND, Rugh JD, Tanaka TT. Temporomandibular disorders: diagnosis, management, education, and research. J Am Dent Assoc.1990; 120: 253-260.
22. National Institutes of Health Technology Assessment Conference Statement. Management of temporomandibular disorders. J Am Dent Assoc.1996; 127: 1595-1606.
23. McNamara JA, Seligman DA, Okeson JA. Occlusion, orthodontic treatment, temporomandibular disorders: a review. J Orofac Pain. 1995; 9: 73-90.
24. Rinchuse DJ, Sweitzer EM, Rinchuse DJ, Rinchuse DL. Understanding science and evidence-based decision making in orthodontics. Am J Orthod Dentofacial Orthop. 2005; 127: 618-624.
25. Rinchuse DJ. Counterpoint: a three-dimensional comparison of condylar position changes between centric relation and centric occlusion using the mandibular position indicator. Am J Orthod Dentofacial Orthop.1995; 107: 319-328.
26. Rinchuse DJ. Counterpoint: prevention of adverse effects on the TMJ through orthodontic treatment. Am J Orthod.1987; 91: 500-506.
27. Mohl ND. Temporomandibular disorders: the role of occlusion, TMJ imaging, and electronic devices, a diagnostic update. J Am Coll Dent. 1991; 58: 4-10.
28. Gianelly AA, Hughes HM, Wohlgemuth P, Gildea C. Condylar position and extraction treatment. Am J Orthod Dentofacial Orthop. 1988; 93: 201-205.
29. Sadowsky C, BeGole EA. Long-term status of temporomandibular joint and functional occlusion after orthodontic treatment. Am J Orthod. 1980; 78: 201-212.
30. Sadowsky C, Polson AM. Temporomandibular disorders and functional occlusion after orthodontic treatment: results of twoterm studies. Am J Orthod. 1984; 86: 386-390.

31. Dimiroulis G. Fortnightly review: temporomandibular disorders: a clinical update. *Br Med J*. 1998; 317: 190-194.
32. Greene CS. The etiology of temporomandibular disorders: implications for treatment. *J Orofac Pain*. 2001; 15: 93-105.
33. Luther F. Orthodontics and the temporomandibular joint: where are we now? Part 1. Orthodontics and temporomandibular disorders. *Angle Orthod*. 1998; 68: 295-304.
34. Luther F. Orthodontics and the temporomandibular joint: where are we now? Part 2. Functional occlusion, malocclusion, and TMD. *Angle Orthod*. 1998; 68: 305-318.
35. Adibi SS, Ogbureke EI, Minavi BB, Ogbureke KU. Why use oral splints for temporomandibular disorders (TMDs)? *Tex Dent J*. 2014; 131(6): 450-455.
36. Abrahamsson C. Masticatory function and temporomandibular disorders in patients with dentofacial deformities. *Swed Dent J Suppl*. 2013; 231: 9-85.
37. Leite RA, Rodrigues JF, Sakima MT, Sakima T. Relationship between temporomandibular disorders and orthodontic treatment: a literature review. *Dental Press J Orthod*. 2013; 18(1):150-7.
38. Iodice G, Danzi G, Cimino R, Paduano S, Michelotti A. Association between posterior crossbite, masticatory muscle pain, and disc displacement: a systematic review. *Eur J Orthod*. 2013; 35(6): 737-744.
39. Owtad P, Park JH, Shen G, Potres Z, Darendeliler MA. The biology of TMJ growth modification: a review. *J Dent Res*. 2013; 92(4): 315-321.
40. Abrahamsson C, Henrikson T, Nilner M, Sunzel B, Bondemark L, Ekberg EC. TMD before and after correction of dentofacial deformities by orthodontic and orthognathic treatment. *Int J Oral Maxillofac Surg*. 2013; 42(6):752-758.
41. Zonnenberg AJ, Mulder J. The efficacy of a specific stabilization splint. *Cranio*. 2014; 32(1):68-74.
42. Christidis N, Doepel M, Ekberg E, Ernberg M, Le Bell Y, Nilner M. Effectiveness of a prefabricated occlusal appliance in patients with temporomandibular joint pain: a randomized controlled multicenter study. *J Oral Facial Pain Headache*. 2014; 28(2): 128-137.
43. Jeffrey P. Okeson. Evolution of occlusion and temporomandibular disorder in orthodontics: Past, present, and future. *Am J Orthod Dentofacial Orthop*. 2015; 147: S2 16-32.
44. Ronaldo Antônio Leite, Joacir Ferreira Rodrigues, Maurício Tatsuei Sakima, Tatsuko Sakima. Relationship between temporomandibular disorders and orthodontic treatment: A literature review. *Dental Press J Orthod*. 2013 Jan-Feb; 18(1):150-7.
45. Stjepan Špalj , Martina Šlaj , Athanasios E. Athanasiou , Irena Žak , Martina Šimunović and Mladen Šlaj. Temporomandibular Disorders and Orthodontic Treatment Need in Orthodontically Untreated Children and Adolescents. *Coll. Antropol*. 39 (2015) 1:151-158.
46. A. Michelotti, G. Iodice. The role of orthodontics in temporomandibular disorders. *Journal of Oral Rehabilitation* 2010 37; 411-429.
47. Manfredini, Stellini, Gracco, Lombardo, Nardini, Siciliani. Orthodontics is temporomandibular disorder-neutral. *Angle Orthod*. 2016 (online early).
48. Dibbets and van der Weele. Extraction, Orthodontic treatment and Craniomandibular dysfunction. *Am J Orthod Dentofac Orthop*. 1991; 99: 210-19.
49. Pancherz, Wusten and Ruf. Temporomandibular Joint Effects of Activator Treatment: A Prospective Longitudinal Magnetic Resonance Imaging and Clinical Study. *Angle Orthod*. 2002; 72; 572-40.

50. Egermark, Carlsson and Magnusson. A Prospective Long-Term Study of Signs and Symptoms of Temporomandibular Disorders

in Patients Who Received Orthodontic Treatment in Childhood. Angle ORTHOD. 2005; 75: 645-50.