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&
Temporomandibular Disorders

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بسم الله الرحمن الرحيم

قَالُوا سُبْحَانَكَ لا عِلْمَ لَنَا إِلاَّ مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيم

صدق الله العظيم

سورة البقرة (آية ٣٢)

Dedication

To my lovely family

To the soul of my father

Mariam

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Abstract :

TMD is a collective term that embraces a number of clinical problems that involve the masticatory muscles, the TMJs and its associated structures, or both.

The aim of this review is to critically review evidence for a possible association between malocclusion, orthodontic treatment and TMD. Whether orthodontic treatment is a cause or a cure for TMD .

In order to answer this question the orthodontic treatment goals for all patients were discussed, and these goals focused on achieving that: the condyles should be in their most superoanterior position (MS) in closed mouth position , obtaining canine guidance which provide the most desirable guidance , the posterior tooth contacts should be heavier than anterior tooth contacts in the alert feeding position.

In this review , the anatomy and physiology of the jaw movement were discussed . Also how to examine and evaluate TMD patients and their proper management protocol . General orthodontic treatment possibilities have been also illustrated briefly.

Conclusion : Findings from recent studies confirm that orthodontic treatment generally does not cause or cure TMD problems. However; it is essential not to neglect such relation because usually there is a malocclusion in orthodontic patient .

Introduction

Temporomandibular joint (TMJ) disorders and related masticatory muscle pain represent the most common chronic orofacial pain condition, and are the main cause of pain of non-dental origin in the oro-facial region including head, neck and face (de Leeuw 2008). The etiology of temporomandibular disorders (TMD) is multifactorial. One of historical proposed factor was improper occlusion (Pullinger 1993).

In the late 1980s, the attention of the orthodontic community regarding TMD was awakened following litigation involving orthodontic treatment as the cause of TMD in an orthodontic patient in the US court. The orthodontist at cause lost the case only because at that time there was a lack in evidence based medicine literature (Pollack 1988).

In 1987 the Board of Trustees of the American Association of Orthodontists (AAO) passed a motion "that the AAO immediately initiate a program to conduct documented studies for the purpose of determining the relationship, or lack thereof, between orthodontic treatment and TMD." They also moved to form a new task-oriented committee, the Scientific Studies Committee, to conduct the program. Early in 1988, the committee was formed, consisting of persons with recognized knowledge in this area but with differing backgrounds: a prosthodontist, an oral pathologist, a general practitioner, and two orthodontists. Their conclusion was that orthodontic treatment generally is not a primary factor in TMD (Behrents and White 1992).

Since then many important investigations have been conducted, but still the possible association between orthodontic therapy and TMD signs and symptoms is a matter of debate among orthodontists, orthognathic surgeons, dentists and dental patients.With the development of new aesthetic orthodontic techniques (lingual orthodontics, invisalign, etc.) more adults seek orthodontic treatments, and therefore there appears to be an increased likelihood of orthodontic patients having TMD (Winocur and Emodi-Perlman 2012) .
Orthodontist should be capable to recognize the signs and symptoms of TMD already during the anamnestic appointment, to inform the patient of the finding, to point it out in the patient file, and if necessary to refer the patient to an Orofacial/TMD specialist.

The objective of this review is to discuss the effectiveness of orthodontic intervention in reducing symptoms in people with TMD and to establish if there is any evidence based data that proves that active orthodontic intervention leads

to TMD. In order to fulfill these objectives the following questions should be asked:

1. Does orthodontic treatment cause TMD?
2. Does orthodontic treatment cure or prevent TMD?

1. Temporomandibular Disorders (TMD)

TMD is a collective term that embraces a number of clinical problems that involve the masticatory muscles, the TMJs and its associated structures, or both. TMD is considered a musculo-skeletal disorder. It is the most prevalent clinical entity affecting the masticatory apparatus, and is the main cause of pain of non-dental origin in the oro-facial region (de Leeuw 2008). Therefore; in order to understand the process of examination and the evaluation of the TMD patients and their management from orthodontic point of view, a brief explanation of TMJ anatomy and physiology in different mandibular jaw movements will be discussed below:

1.1 TMJ Anatomy and Physiology with Jaw Movements

The **temporomandibular joint** (TMJ) is formed by the articulation of the mandible and the temporal bone of the cranium. It is located anteriorly to the tragus of the ear, on the lateral aspect of the face. It is composed by the following structures (Bumann *et al.* 2002):

A. Articulating Surfaces

TMJ consists of articulations between three surfaces; the mandibular fossa and articular tubercle (from the squamous part of the temporal bone), and the head of mandible. This joint has a unique mechanism; the articular surfaces of the bones never come into contact with each other; they are separated by an articular disk. The presence of such a disk splits the joint into two synovial joint cavities, each lined by a synovial membrane. The articular surfaces of the bones are covered by fibrocartilage, not hyaline cartilage, (Figure 1).

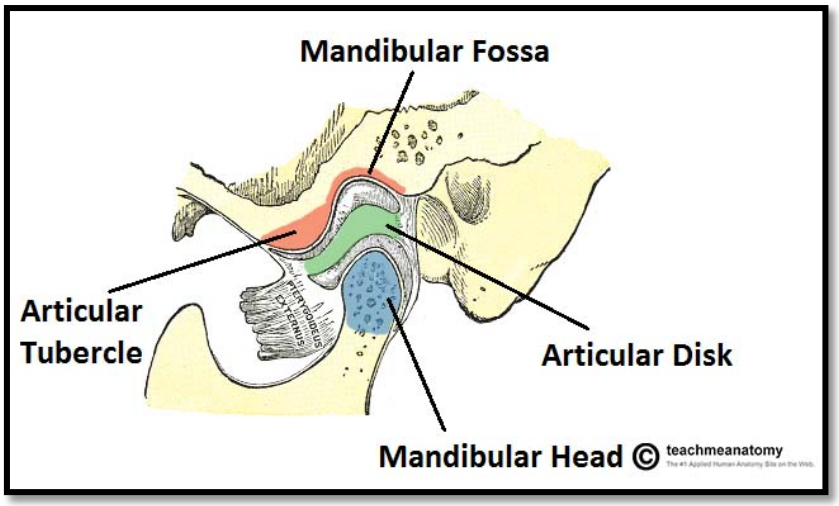

Fig.1: The osteology of the TMJ (Bumann *et al.* 2002).

B. Ligaments

There are three extracapsular ligaments. They act to stabilize the TMJ, (Figure 2):

- *Lateral ligament*: It runs from the beginning of the articular tubule to the mandibular neck. It is a thickening of the joint capsule, and acts to prevent posterior dislocation of the joint.
- *Sphenomandibular ligament*: Originates from the sphenoid spine, and attaches to the mandible.
- *Stylomandibular ligament:* A thickening of the fascia of the parotid gland. Along with the facial muscles, it supports the weight of the jaw.

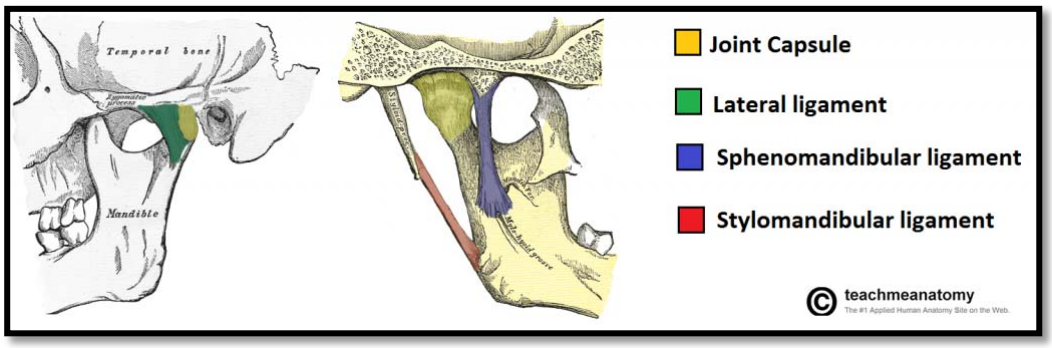

Fig. 2: The joint capsule and accessory ligaments of the TMJ. (Bumann *et al.* 2002).

C. Muscles of mastication and Jaw Movements

Movements at this joint are produced by the muscles of mastication, and the hyoid muscles. The two divisions of the TMJ have different functions.

- *Protrusion and Retraction:* The upper part of the joint allows protrusion and retraction of the mandible; the anterior and posterior movements of the jaw. The lateral pterygoid muscle is responsible for protrusion (assisted by the medial pterygoid), and the geniohyoid and digastric muscles perform retraction.
- *Elevation and Depression:* The lower part of the joint permits elevation and depression of the mandible; opening and closing the mouth. Depression is mostly caused by gravity. However, if there is resistance, the digastric, geniohyoid, and mylohyoid muscles assist. Elevation is very strong movement, caused by the contraction of the temporalis, masseter, and medial pterygoid muscles.

D. Neurovascular supply

The arterial supply to the TMJ is provided by the branches of the external carotid, principally the superficial temporal branch. Other contributing branches include the deep auricular, ascending pharyngeal and maxillary arteries. The TMJ is innervated by the auriculotemporal and masseteric branches of the mandibular nerve.

1.2 Etiology, Sign and Symptoms of TMD Patients

The main TMD symptom is pain in the masticatory muscles, preauricular area and/or TMJ. As usual in all the musculo-skeletal disorders, pain increases during masticatory function. Other common signs or symptoms are limited or altered jaw movements, joint noises (eg. clicks, crepitus, etc), earache, headache, non specific dental tooth pain, etc. (Carlsson and de Boever 1994).

The prevalence of TMD signs (e.g. abnormal jaw movements, joint noises, and tenderness on palpation) in the general population, as demonstrated by epidemiologic studies ranges up to 75% of the population. Approximately 33% of the population has at least one symptom (e.g. facial pain, joint pain) (Friction and Schiffman 1995).It is a significant finding that in all studies except one (Talaat *et al.* 1986) females are affected more than males.

It is important to state that symptoms and signs are not real muscular or articular compound TMD. A single symptom or sign from the masticatory system is not synonymous with TMD, or automatically leads to a TMD diagnosis. (de Leeuw 2008).

The etiology and the pathophysiology of TMD are poorly understood. It is generally accepted that it is a multifactorial phenomenon. Contributing factors (central, peripheral, behavioral psychological, physical, etc) may

predispose, initiate, or perpetuate TMD. Normally great physiologic and external forces are absorbed in the masticatory system with no consequence. But, if the forces exceed the individual genetic- physiologic tolerance the system may undergo detrimental changes. When the structural tolerance is exceeded breakdown will occur in the weakest structure of the system (teeth, muscles or joints) (Okeson 2003).

A developing view of TMD is linked to that of low back pain. The use of the word *psychogenic* suggests there is no known physical cause. However a bio- psychosocial model is developing as the most heuristic approach to chronic pain (Gatchel *et al.* 2007). This has been related to TMD (Suvinen *et al.* 2005), whereby the interaction of basic neuroscience processes of pain (the *bio* of biopsychosocial) with psychosocial factors or the interaction of psychological and social factors with the processing of information in the central nervous system influence health. The causation related to gender predisposition may be associated with genetic variations of pain perception, although this is yet to be defined. There is some data that link pain to the circulating hormones. One study in particular, although with a limited sample size, considered low levels of estrogen relating to highest levels of pain (although increased levels of pain may also be associated with the most rapid periods of change of estrogen levels) (LeResche *et al*. 2003).

Therefore; diagnosis of some form of TMD requires a careful process of examination and evaluation of patient's TMJs to get a robust differential diagnosis, because there are many medical and dental problems that produce orofacial pain symptoms; some of these overlap considerably with TMD symptoms. Now, if patients present with signs/symptoms of a TMD condition, so for the orthodontist to deliver a proper diagnosis and provide appropriate management strategies, the patient should be firstly examined carefully according to specific criteria as discussed below (Kandasamy *et al.* 2015).

1.3 Clinical Examination and Evaluation of TMD Patient

Since TMD symptoms are common, it is recommended that every orthodontic patient be screened for these problems, regardless of the apparent need or lack of need for treatment. Since orthodontic therapy will likely influence the patient's occlusal condition, it is important to identify any dysfunction in the masticatory system before therapy is ever begun. Knowing the functional condition of the masticatory system in advance helps prepare the patient and the orthodontist to what can be expected after the therapy has been completed (Graber *et al*. 2017).

So for accurate management of the patient, the evaluation should have the following items (Kandasamy *et al.* 2015):

1- Patient history.
2- Physical examination of the TMJ.
3- Adjunctive investigation

1- Patient History

The purpose of the screening history and examination is to identify any TMD signs and symptoms of which the patient may or may not be aware (i.e., headaches, ear pain). The screening history consists of several questions that will help alert the orthodontist to any TMD symptoms. The following questions can be used to identify functional disturbances (Okeson 2013):

1. Do you have difficulty and/or pain opening your mouth, for instance, when yawning?
2. Does your jaw get "stuck, locked, or go out"?
3. Do you have difficulty and/or pain when chewing, talking, or using your jaws?
4. Are you aware of noises in the jaw joints?
5. Do your jaws regularly feel stiff, tight, or tired?
6. Do you have pain in or about the ears, temples, or cheeks?
7. Do you have frequent headaches, neck aches, or toothaches?
8. Have you had a recent injury to your head, neck, or jaw?
9. Have you been aware of any recent changes in your bite?
10. Have you previously been treated for any unexplained facial pain or a jaw joint problem?

If a patient reports positively to any of these questions, the clinician should request additional information to clarify the condition (Graber *et al.* 2017).

The next line of questioning should be directed toward the medical, dental, and psychosocial history (Kandasamy *et al.* 2015) :

- The medical history should inquire about previous surgery, hospitalizations, trauma, illness, developmental and acquired anomalies, sleep disorders and sleep-related breathing disorders, allergies, and medication usage (including prescribed, over the counter, herbal and vitamin supplements, and illicit drug use).
- The dental history should include information regarding previous dental disease, treatment, and habit history (awake and sleep).

- The psychosocial history which includes a discussion of social, behavioral, and psychological issues; occupational, recreational, and family status; litigation, disability, or secondary gain issues

This is then followed by the history of the chief complaint which should be documented in the order of severity as expressed by the patient, which should include the following (Kandasamy *et al.* 2015):

a. The location of the pain.
b. Date of onset.
c. Event onset (spontaneous or stimulus induced).
d. Quality, frequency, duration, and intensity (based upon a numeric rating scale of: 0 = no pain to 10 = the most extreme pain, or a visual analog scale using a 10-cm line labeled at one end with “no pain” and at the other end with “most extreme pain”).
e. Questions should be asked about factors that alleviate, aggravate, or precipitate the pain.
f. If the chief complaint changes over time.
g. Previous treatment results; and any associated issues.

The history should be taken with the patient sitting upright quiet, relaxed atmosphere, ideally away from the treatment room (Bumann *et al.* 2002).

2- Screen Examination (Clinical Examination):

A screening examination should accompany the screening history (Okeson 2013). This should be relatively brief and is an attempt to identify any variation from normal anatomy and function. It begins with an inspection of the facial symmetry. Any variation from the general bilateral symmetry should raise suspicion and indicate the need for further examination. It should include (Graber *et al.* 2017):

A. Examination of facial muscle.
B. Examination of TMJs.
C. Observations of jaw movement.
D. The occlusal condition evaluated with respect to the orthopedically stable position of the joint

A. Examination Of Facial Muscles:

They are palpated for pain or tenderness to identify trigger points, which are defined as painful palpable areas of muscle that cause referred pain outside the anatomical boundaries of the affected muscle (Simons and Mense 1998). An accurate evaluation of a painful muscle is primarily made by muscle palpation

which depends upon the magnitude of the force applied, the localization, the direction of palpation, the extent of surface contact, and the examiner's knowledge of the anatomy (Widmer 1994).

The objective of palpation of the muscles of mastication is the precise localization of the muscle lesion within a single muscle or in a synergistic group of muscles (Bumann *et al.* 2002)

Palpation of the muscle is accomplished mainly by the palmer surface of the middle finger, with the index finger and forefinger testing the adjacent areas. Soft but firm pressure is applied to the designated muscles, the fingers compressing the adjacent tissues in a small circular motion. A single firm thrust of 1 or 2 seconds duration is usually better than several light thrusts. During palpation, the patient is asked whether it hurts or is just uncomfortable. For the muscle examination to be most helpful, the degree of discomfort is ascertained and recorded. This is often a difficult task. Pain is subjective and is perceived and expressed quite differently from patient to patient. Yet the degree of discomfort in the structure can be important to recognizing the patient's pain problem as well as an excellent method of evaluating treatment effects. An attempt is made, therefore, not only to identify the affected muscles, but also to classify the degree of pain in each (Figure 3, 4) (Graber *et al.* 2017).

When a muscle is palpated, the patient's response is placed in one of four categories (Okeson *et al.* 1982):

1- A zero (0) is recorded when the muscle is palpated and there is no pain or tenderness reported by the patient.
2- A number 1 is recorded if the patient responds that the palpation is uncomfortable (tenderness or soreness).
3- A number 2 is recorded if the patient experiences definite discomfort or pain.
4- A number 3 is recorded if the patient shows evasive action, eye tearing, or verbalizes a desire not to have the area palpated again.

The pain or tenderness of each muscle is recorded on an examination form, which will assist diagnosis and later be used in the evaluation and assessment of progress (Graber *et al.* 2017).

Fig. 3: Palpation of the temporalis muscle. A, palpation of the anterior portion. B, Palpation of the posterior portion (Graber *et al.* 2017).

Fig. 4: A, Palpation of the masseter muscle at the superior attachment to the zygomatic arch. B, Palpation of the masseter muscle at its attachment of the lower border of the mandible (Graber *et al.* 2017).

B. TMJ Palpation:

The TMJs are examined for any signs or symptoms associated with pain and dysfunction. Pain or tenderness of the TMJs is determined by digital palpation of the joints when the mandible is both stationary and during dynamic movement. The fingertips are placed over the lateral aspects of both joint areas simultaneously (Figure 5, *A*). If uncertainty exists regarding the proper position of the fingers, the patient is asked to open and close a few times. The fingertips should feel the lateral poles of the condyles passing downward and forward across the articular eminences, then the patient relaxes and medial force is applied to the joint areas. The patient is asked to report any symptoms and they are recorded with the same numerical code that is used for the muscles. Once the symptoms are recorded in a static position, the patient opens and closes, and any symptoms associated with this movement are recorded (Figure 5, *B*). As the patient opens maximally, the fingers should be rotated slightly posteriorly to apply force to the posterior aspect of the condyle (Figure 5, *C*) (Graber *et al.* 2017).

Fig.5: Palpation of the TMJ: A, in the closed-mouth position. B, in the opened-mouth position. C, with the mouth fully open. (Graber *et al.* 2017).

Joint sounds can be perceived by placing the fingertips over the lateral surfaces of the joint and having the patient open and close. Often they may be felt by the fingertips. A more careful examination can be performed by placing a stethoscope over the joint area. Not only should the character of any joint sounds be recorded (clicking or crepitation), but also the degree of mouth opening associated with the sound. Of equal importance is whether the sound occurs during opening or closing or can be heard during both these movements. It is not wise to examine the joint for sounds by placing the fingers in the patient's ears. It has been demonstrated that this technique can actually produce joint sounds that are not present during normal function of the joint (Hardison and Okeson 1990). It is thought that this technique forces the ear canal cartilage against the posterior aspect of the joint; either this tissue produces sounds or this force displaces the disc, which produces the additional sounds (Graber *et al.* 2017).

From these previous examinations, we may experience one of the joint sounds, which are either clicking or crepitation.

1. *A clicking* is a single sound of short duration. If it is relatively loud, it is referred to as a pop (Graber *et al.* 2017). It often will be louder on opening and softer on closing (reciprocal click) as the condyle goes beyond the posterior band of the articular disk (Kandasamy *et al.* 2015). The most common causes (70-78%) of clicking sounds in the TMJ are disk displacements of various degrees and in various directions, but predominantly anteromedial (Tasaki *et al.* 1996).

When the disc is displaced during mouth opening, an abnormal translator movement can occur between the condyle and the disc, causing a clicking sound (Graber *et al.* 2017).

Studies have shown that clicking alone is a benign condition that is found in over a third of the population, and which only rarely progresses to more

serious clinical dysfunction or disease. Furthermore, even in the presence of other TMJ symptoms, patients with clicks do not necessarily progress to more advanced TMD (Rinchuse *et al.* 1990).

2. *Crepitation is* a multiple, gravel-like sound described as “grating” and “complicated.”(Graber *et al.* 2017).

Crepitus, or a grinding sound, is different than the typical clicking or popping and usually represents an underlying osteoarthrosis or osteoarthritis of the TMJ. The finding of TMJ crepitus without pain or dysfunction does not mean that a patient needs immediate treatment, but the patient should be made aware of this finding and reviewed regularly. Treatment is generally not indicated when there is no joint pain or dysfunction (Kandasamy *et al.* 2015).

C.*Observations of Jaw Movements*

Jaw opening is usually measured between the incisal edges of the incisors (Hesse 1996) and to this is added the overbite (anterior vertical overlap). This is especially meaningful in patients with a "deep bite" (large vertical overlap) (Bumann *et al.* 2002). The normal range (Gea 1991) of mouth opening is between 53 and 58 mm. The patient is asked to open slowly until pain is first felt (Figure 6, *A*). At that point, the distance between the incisal edges of the maxillary and mandibular anterior teeth is measured. This is the maximum comfortable opening. The patient is next asked to open the mouth maximally. This is recorded as the maximum opening (Figure 6, *B*). In the absence of pain, the maximum comfortable opening and maximum opening are the same. A restricted mouth-opening is considered to be any distance less than 40 mm only. Less than 40 mm of mouth opening, therefore, seems to represent a reasonable point to designate restriction; however, one should always consider the patient’s age and body size (Graber *et al.* 2017).

Fig. 6: Measuring mouth opening. A, The patient is asked to open the mouth until pain is first felt. The interincisal distance is measured, which is called the maximum comfortable opening. B, The patient is then ask to open as wide as possible, even if this is painful. This measurement is called the maximum mouth opening (Graber *et al*. 2017).

Note is made of the extent of movements in millimeters and any accompanying pain and its location (right/left) (Bumann *et al.* 2002).

The patient is next instructed to move the mandible laterally. A lateral movement less than 8 mm is recorded as a restricted movement (Figure 7) (Graber *et al.* 2017). The ratio of jaw opening distance to lateral movement in a healthy system is approximately 6 : 1 (Dijkstra *et al.* 1998).

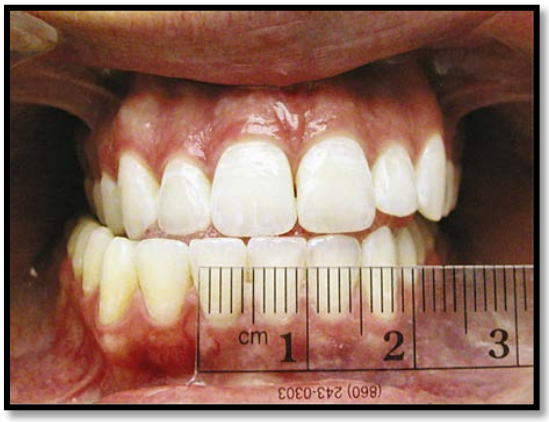

Fig. 7: Measuring the distance of lateral eccentric movement using a millimeter ruler) (Graber *et al.* 2017).

Protrusive movement is also evaluated in a similar manner (figure 8) (Graber *et al.* 2017). The extent of protrusion (i.e. condylar translation) provides important information on the mobility of the joints, and therefore reveals over how broad a surface the forces are distributed (stress = force per unit of area). The reports range from (8.8 - 9.1) mm (Hesse1996). Protrusive movements of less than 7 mm are considered to be restricted, although they are not always signs of pathology that urgently calls for treatment (Bumann *et al.* 2002).

Fig. 8: Active protrusive movement (Bumann *et al.* 2002).

D.The Occlusal Condition

The occlusal examination (Okeson 2013) begins with an observation of the occlusal contacts when the condyles are in their optimum orthopedic position (MS position which is the most superoanterior position) (Graber *et al*. 2017) .This location can be achieved by the bilateral manual-manipulation technique (Figure 9)(Okeson 2013) .When the hands are in this position, the mandible is guided by upward force placed on its lower border and angle with the fingers while at the same time the thumbs press downward and backward on the chin. The overall force on the mandible is directed so the condyles will be seated in their most superoanterior position braced against the posterior slopes of the eminences (Graber *et al*. 2017).

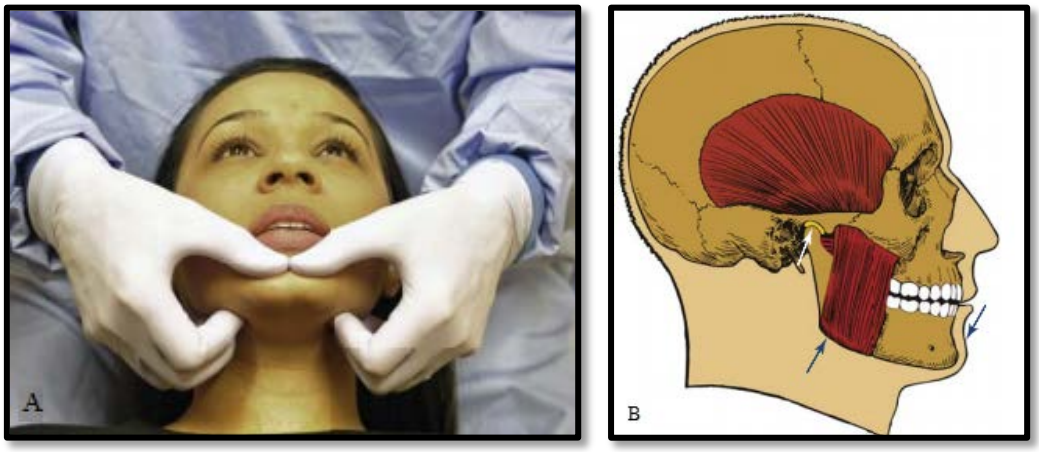

Fig. 9: bilateral manual-manipulation technique A, The thumbs meet over the symphysis of the chin. B, Downward force is applied to the chin (blue arrow) while superior force is applied to the angle of the mandible (blue arrow). The overall affect is to set the condyle superoanterior in the fossae (white arrow)(Graber *et al*. 2017).

In this position the mandible can be purely rotated, opened, and closed approximately 20 mm interincisally while the condyles remain in their MS position. Then the mandible is brought into tooth contact and the occlusal relationship of the teeth in this joint position is evaluated (Graber *et al*. 2017).

Once tooth contact is achieved, the patient is asked to hold the mandible on the first occlusal contact and the relationship of the maxillary and mandibular teeth is noted. Then the patient is requested to apply force to the teeth, and any shifting of the mandible is observed. If the occlusion is not stable in the MS position, a shifting will occur that carries the condyles away from their orthopedically stable positions to the more stable maximum-intercuspal position. This shifting represents a lack of orthopedic stability.

Several functional and morphological occlusal relationships have been investigated, and a small number of them have been reported to cause people to develop TMD (McNamara *et al.* 1995, Michelotti and Iodice 2010) Some of the occlusal factors are open bite, overbite, overjet greater than 7 mm, centric slides (greater than 4 mm), unilateral posterior crossbites with and without lateral functional mandibular displacement, and missing posterior teeth. Current understanding and evidence-based literature fail to demonstrate a *causal* relationship between these occlusal factors and TMD signs and symptoms; thus, the relationship is only an association (McNamara *et al.* 1995, Michelotti and Iodice 2010).

3- Adjunctive investigation

TMJ imaging is indicated when the history or examination, or both, are indicative of a recent or progressive pathological joint condition; significant dysfunction or alteration in range of mandibular movements; and often sudden changes in occlusion (anterior open bite, posterior open bite, and mandibular shift). This may be required if the yield from these examination would enhance the ability of the orthodontist to develop a definitive diagnosis and/ or provide appropriate management (Kandasamy *et al.* 2015).

The standard radiographs usually taken as part of a routine orthodontic examination include a panoramic and a lateral cephalometric radiograph. With regard to the TMJs, these two dimensional plain-film or digital radiographs can be used as a screening tool to only crudely assess basic “bony” elements such as mandibular and condylar asymmetries, developmental skeletal anomalies, and fractures. Today, there are more sophisticated imaging techniques available, such as Magnetic resonance imaging (MRI), computed tomography (CT), and cone beam CT (CBCT) scans. MRI is a non-invasive soft tissue imaging technique capable of providing excellent high contrast ratios and diagnostic information of the soft tissues of the TMJs and disc-condyle relationship (figure 10). CT is excellent tools for the three- dimensional imaging of hard tissues (Kandasamy *et al.* 2015). It considered primarily as an expanded diagnostic tool for fractures, advanced arthritis, ankylosis, and tumors (Brooks *et al*. 1997). Because of its high resolution, it is especially suited for diagnosing bony abnormalities (Manzione *et al.* 1984). Although CT can reveal the disk, MRI is preferred for a more specific evaluation of the disk (Larheim 1995) because the disk is often confused with the tendon of the lateral pterygoid muscle (Bumann *et al.* 2002).

Cone beam CT (CBCTs) provide excellent osseous detail of the TMJs that is impossible to achieve with conventional radiographs (figure 11) (Kandasamy *et al.* 2015). One of the most prevalent degenerative changes seen on CBCT is that of the osteoarthritis of the TMJ which is an age-related degenerative disease seen in almost 40% of patients above the age of 40 years. It causes bony changes in the TMJ like flattening, sclerosis, formation of osteophytes, erosion, resorption of the condylar head, erosion of the mandibular fossa and reduced joint space. According to (Alkhader *et al*. 2010) who performed a comparative study, CBCT is better than MRI in detecting changes in shape (flattening, osteophyte formation or erosion) rather than changes in size. They concluded that this was probably because MRI had limited spatial resolution and increased slice thickness (>3mm) in clinical use. Also other problems like presence of fibrous tissues inside the TMJ, proximity of lateral pterygoid muscle to the articular surface of the condyle and presence of air spaces in the temporal bone can impede the accuracy in the interpretation of MRI (Krishnamoorthy *et al.* 2013).

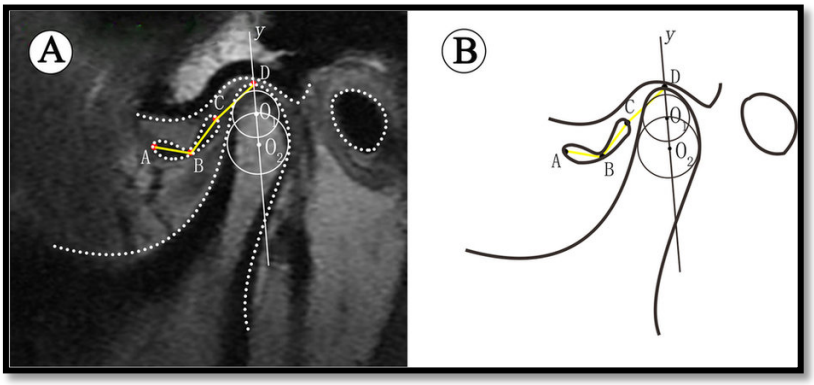

Fig. 10: Measurement of disc length and displacement distance on MRI. A, In TMJ MRI image, B, Schematic diagram (Hu YK. 2016)

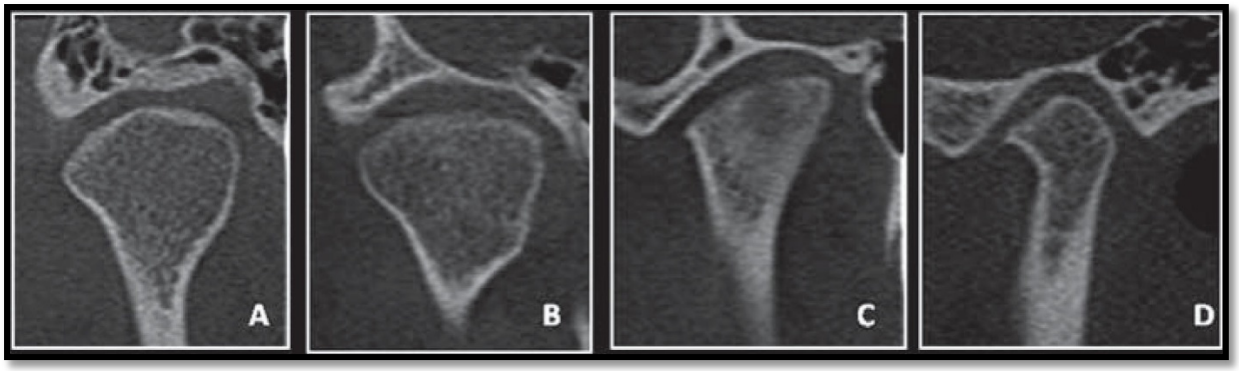

Fig. 11: Cone-beam computed tomography images of temporomandibular joint showing morphological variation of the mandibular condyle. A- Normal (coronal view); B- Flattening (coronal view); C- Erosion (coronal view); and, D- Osteophyte (sagittal view) (Valladares-Neto J. 2014).

2. Orthodontics treatment & Temporomandibular disorders

There are two main goals of orthodontic therapy that must be achieved with all types of orthodontic treatment (i.e: removable appliance, fuctional appliance, fixed appliance and even with the orthognathic sugery). The first, and often the most important to the patient, is improving aesthetics. Although aesthetics may be the primary goal of the patient (and parent), it is certainly not the most important goal. The second goal, which is achieving sound masticatory function, is actually the most important treatment goal of orthodontic therapy. Developing a healthy, orthopedically stable masticatory system enables sound function, which is essential for the lifetime of the patient (Graber *et al*. 2017).

In order to know the effectiveness of orthodontic treatment and if these treatments have any relation with TMD problems, types of orthodontic treatment are listed below:

A. *Removable orthodontic appliances:*

These are orthodontic devices that can be taken out of the mouth by the patient for cleaning, having a limited role in modern orthodontics. They may be active or passive. Active appliances are chiefly confined to use in the mixed dentition, producing simple tipping tooth movements about the apical third of the root using wire springs or bows, screws, elastics or the acrylic baseplate. Passive appliances are designed to maintain teeth in their present position (e.g. space maintainers or retainers). These devices are most efficient and are best tolerated in the upper dental arch.

The main components of a removable appliance are as follows, (Figure 12): Active component, Retention (fixation), Anchorage and Baseplate (Jones and Oliver 2000).

Fig. 12: Removable orthodontic appliance (Proffit *et al*. 2015).

B. Functional appliances:

These appliances utilize, eliminate, or guide the forces of muscle function, tooth eruption and growth to correct a malocclusion. It aims to modify growth to improve skeletal pattern in growing patients, and are most effective in patients with current active growth (Figure 13) (Mitchell 2007)

Fig. 13: Functional Orthodontic appliance. (Proffit *et al*. 2015).

C. ***Fixed Orthodontic Appliance****:* is an orthodontic device where attachments are fixed to the teeth. Forces are applied to the teeth via the action of arch wires or auxiliaries through these attachments. This allows precise three-dimensional control over the nature and direction of the forces applied. The components of fixed appliances are: Attachments (brackets, tubes, etc.), Archwires and Auxiliaries (springs or elastics)(Figure 14) (Jones and Oliver 2000).

Fig. 14: Fixed Orthodontic appliance. (Proffit *et al*. 2013).

D. ***Orthognathic surgery:*** is aimed at treating patients with congenital, developmental, or acquired dentofacial deformities that require orthodontic alignment of the teeth as well as surgical movement of one or both jaws to

achieve proper position and function of the maxilla, mandible, and dentition (Figure 15) (Bishara 2001) .It involves a combination of both fixed appliances and surgery to the jaws. By such means large discrepancies of the jaws may be corrected in suitable patients when growth has largely ceased (Jones and Oliver 2000).

Fig. 15: Adult patient with skeletal CL III malocclusion treated by orthognathic surgery (Faber J. 2010)

2.1 Is Orthodontic Treatment a Cure or a Cause of TMD Problems?

In order to answer this question with all of the above mentioned treatments possibilities, the orthodontic treatment goals for all patients are to achieve the following conditions that provide optimum orthopedic stability in the masticatory system. This represents, (Graber *et al.* 2017):

1) When the mouth closes, the condyles should be in their most superoanterior position (MS), resting on the posterior slopes of the articular eminences with the discs properly interposed. In this position, there should be even and simultaneous contact of all posterior teeth. The anterior teeth may also contact, but more lightly than the posterior teeth.
2) When the mandible moves into laterotrusive positions, there should be adequate tooth-guided contacts on the laterotrusive (working) side to immediately disocclude the mediotrusive (nonworking) side. The canines (canine guidance) provide the most desirable guidance.

3) When the mandible moves into a protrusive position, there should be adequate tooth-guided contacts on the anterior teeth to immediately disocclude all posterior teeth.
4) When the patient sits upright (in the alert feeding position) (Mohl 1976) and is asked to bring the posterior teeth into contact, the posterior tooth contacts should be heavier than anterior tooth contacts.

An article by (McNamara *et al.* 1995) represents the evolution of a solicited manuscript first presented at the International Workshop on the TMDs and Related Pain Conditions, sponsored by the National Institute of Health (Hunt Valley, Md. 1994).Its conclusions were:

(1) Signs and symptoms of TMD may occur in healthy persons.
(2)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.
(3) In general, orthodontic treatment performed during adolescence does not increase or decrease the chances of development of TMD later in life.
(4) The extraction of teeth as part of an orthodontic treatment plan does not increase the risk of TMD.
(5) There is no increased risk of TMD associated with any particular type of orthodontic mechanics.
(6) Although a stable occlusion is a reasonable orthodontic treatment goal, not achieving a specific gnathologically ideal occlusion does not result in signs and symptoms of TMD; and
(7) There is little evidence that orthodontic treatment prevents TMD, although the role of unilateral posterior crossbite correction in children may warrant further investigation. (McNamara *et al.* 1995, McNamara and Turp 1997).

2.2 Management of TMD Patients in Orthodontic Practice

The two major clinical features of most TMD are pain and dysfunction (Murray and Peck 2007), the dysfunction usually is a consequence of the pain rather than its cause, so primary therapeutic attention should be directed at the pain. When pain is relieved, improved function can be anticipated. The clinician has also to make a decision about whether the positive findings from an individual patient are minor or major in significance. Complaints of minor transient jaw fatigue, pain episodes, and painful joint following a minor trauma, or limited opening after a dental appointment should not be classified as clinically significant. On the objective side, phenomena like painless TMJ

clicking or crepitus, deviated opening, tenderness in certain areas, or non progressive limited jaw opening cannot be resolved in most cases by any reasonable treatment; therefore, they should simply be regarded as imperfections that do not reach the threshold of being significant clinical problems. On the other hand, major TMD symptomatology that is either discovered in screening or reported by the patient should be dealt with before embarking on any orthodontic evaluation , this done either by the appropriate referral to specialist or treated by the orthodontist (Kandasamy *et al.* 2015).

When actual TMD problems do arise, that group of patients is often in their mid to late teens or they are young or middle-aged adults rather than children and the elderly. Prevalence of TMDs in women is twice more common than in men(de Leeuw R and Klasser 2013).It is important to understand that TMDs are generally cyclic in nature, so symptoms often gradually progress from mild to moderate to severe, and then they can move toward a downward phase which ends up as mild to no symptoms. Therefore, practitioners may provide some form of treatment during the downward side of the cycle and get symptom relief. The practitioner may then incorrectly assume that the treatment rendered was responsible for this symptom improvement, but in fact it is possible that the patient was getting better on his or her own due to the cyclic nature of TMD (Garefis *et al*. 1994).

So in orthodontic practice, in general, we can find the following three situations (Kandasamy *et al*. 2015):

1- Before starting orthodontic treatment:

It is advisable to perform always a screening examination for the presence of TMD. For medico-legal reasons, any findings, including TMJ sounds, deviation during mandibular movements or pain, should be recorded and updated at 6-month intervals, and informed consent should be signed by the patient (Machen 1991).If the patient presents signs or symptoms of TMD before starting orthodontic treatment, *the first step* is to make the diagnosis. When the patient's chief complaint is pain, it is important to make a differential diagnosis to determine whether the pain is because of TMD, i.e. musculoskeletal condition, or to another disease. *The second step* is to resolve the pain by following a conservative treatment protocol (Michelotti *et al.* 2005) including pharmacotherapy, counseling, behavioral therapy, home exercises, physical therapy and ⁄ or occlusal appliances. (Michelotti and Iodice 2010).

- **Pharmacotherapy:** mild analgesic be used for 5 to 7 days to reduce the pain A non steroidal anti-inflammatory drug (NSAID) such as ibuprofen should be

instructed to take 400 to 600 mg three times a day with meals for 5 to 6 days For many acute TMD symptoms (Graber *et al*. 2017).

- **Counseling and Behavioral Therapy:** one of the most important things the orthodontist can do for the patient is to provide education. The patient needs to know that TMD symptoms are common and benign. The nature course of most TMD is to experience fluctuations of symptoms, often resolving with little to no significant treatment. Therefore, informing the patient of these can be very therapeutic. Since emotional stress can be an etiologic factor of TMD, often worrying about the problem makes the situation even worse. Education is also important in such cases, it can be used to actively bring the patient into the treatment that can help them the most. Some simple behavioral interventions such as reduce jaw use to within painless limits , eat softer foods, smaller bites and slower chewing goes a long way in symptom reduction (Graber *et al.* 2017).
- **Home exercises:** Patient self-directed care for TMD includes actions that the patient can take to limit jaw function and parafunctional activities. Patients should limit or stop such activities as chewing gum, yawning, yelling, singing, cheerleading, and so on. They can support their mandible to limit opening when yawning, and they should avoid unnecessary clicking maneuvers. Depending on their signs and symptoms, they can be advised to temporarily change their diet as follows: eat soft foods; avoid hard or chewy foods; avoid wide opening during meals; and grind or finely chop meats and other tough foods. Also, TMD patients should be advised to relax their jaws and keep the teeth apart. Because stress and tension often are associated with musculoskeletal pain, patients should be informed about this connection, and instructed about relaxation procedures that can be practiced at home. Home physical therapy procedures can be taught, such as using ice for acute pain and heat for more chronic pain. Self- massage and jaw manipulation (controlled exercises) can be encouraged (Kandasamy *et al*. 2015).
- **Physical therapy and ⁄or occlusal appliances:** If in 10 days the symptoms have not adequately resolved, additional steps may be needed by which most orthodontists feel very comfortable about using splints for the management of both bruxism and TMD patients. However, they may not all realize that splints are capable of being both the best treatment modality and the worst thing ever to appear in the TMD field (Kandasamy *et al.* 2015).

Unfortunately, the potential for serious negative outcomes is very high for splints, because they can produce irreversible occlusal and jaw position

changes, altered vertical dimension, major dentoalveolar discrepancies, and extreme dependency. This occurs when they are either designed improperly or worn full time for extended periods or both .On the other hand these splints are desirable because they correct “wrong” jaw/occlusal relationships” acting as a deprogrammer, or a centric splint, or a neuromuscular splint, the supporters of such devices expect to obtain a more ideal jaw position by utilizing splint therapy. A large number of studies have shown that this mechanistic approach to TMD therapy (which obviously is quite invasive, expensive, and irreversible) is also generally unnecessary, because patients simply can get well without it. Therefore, most modern authorities recommend splint therapy as a temporary orthopedic modality, with the therapeutic goals being relaxation of muscles, reduction of oral habits, altering joint loading, and general relief of symptoms (Figure 16) (Schmitter *et al.* 2005, Fricton *et al.* 2010)

Fig. 16 : occlusal splint inserted in patient mouth before orthodontic treatment (Bumann *et al.* 2002)

Even if prolonged splint wear is required (e.g., to control nocturnal bruxism or to treat recurrent symptoms), so avoiding any protocols involving 24-hour wearing of splints, so that no irreversible occlusal changes or alterations of TMJ relationships should occur. So the proper protocol for an oral appliance is night time usage only, so that normal occlusal relationships can be maintained in the daytime (Kandasamy *et al.* 2015).

Another appliance that may be considered is the anterior bite plane (Okeson 2013) This appliance provides only anterior tooth contact and can be useful in reducing symptoms. Since the posterior teeth do not occlude, it may be easier to fabricate and adjust. As soon as the symptoms have resolved, the appliance can be removed and active orthodontic therapy can be initiated. Orthodontic therapy should not be initiated until the TMD symptoms have been

properly managed (Graber *et al*. 2017). As a rule, orthodontic treatment should not be initiated as long as a patient suffers from facial pain. *Then the third step*: once the pain has been resolved and the condition is stable over a reasonable amount of time, initiation of orthodontic therapy may be considered. The treatment plan should always be tailored according to the problem list of the patient, to evidence based dentistry principles and to common sense considering the characteristics of the single patient and taking into account why the patient is seeking treatment. Patients with generalized musculoskeletal pain, such as fibromyalgia, or patients with a systemic inflammatory disease, such as rheumatoid arthritis, should be managed by an interdisciplinary team. (Figure 17) (Michelotti and Iodice 2010).

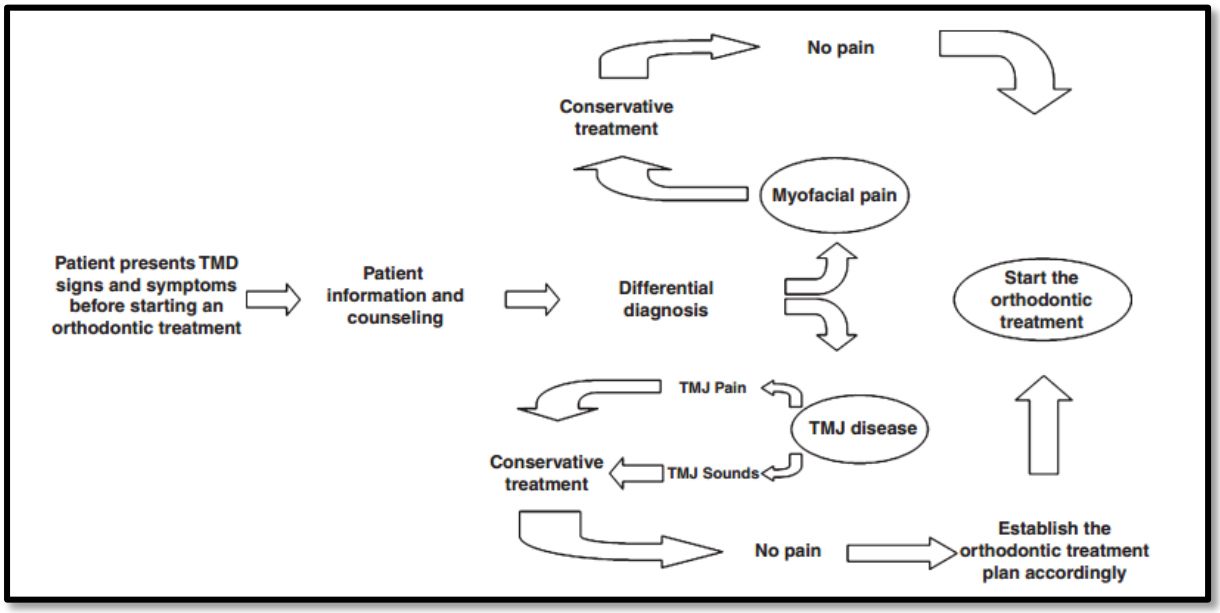

Fig. 17: TMD signs occurring before starting an orthodontic treatment (Michelotti and Iodice 2010).

2- <u>If the patient presents signs or symptoms of TMD during active orthodontic treatment:</u>

The first step is always to make the diagnosis. *The second step* is to stop active orthodontic treatment temporarily to avoid exacerbating factors. Activating orthodontic appliances applies forces to teeth that can cause transient discomfort or pain. Indeed, orthodontic pain induced by means of separators resulted in a transient reduction in the pressure pain thresholds of the masseter and temporalis muscles (Michelotti *et al.* 1999). These reductions can probably be ascribed to neuroplastic changes involving the brainstem second order neurons, which receive extensive convergent inputs from trigeminal afferents. *The third*

step is to resolve the pain by following the same conservative treatment protocol as suggested above (i.e. pharmacotherapy, counseling, behavioral therapy, home exercises, physical therapy). If required, an occlusal appliance can also be used to evaluate the interference-free position of the mandible (Figure 18). Afterwards, when the patient is pain-free, orthodontic treatment can be continued as previously planned or, if necessary, modified according to the patient's condition (Figure 19)(Michelotti and Iodice 2010).

Fig. 18: occlusal splint during orthodontic treatment (Bumann *et al.* 2002)

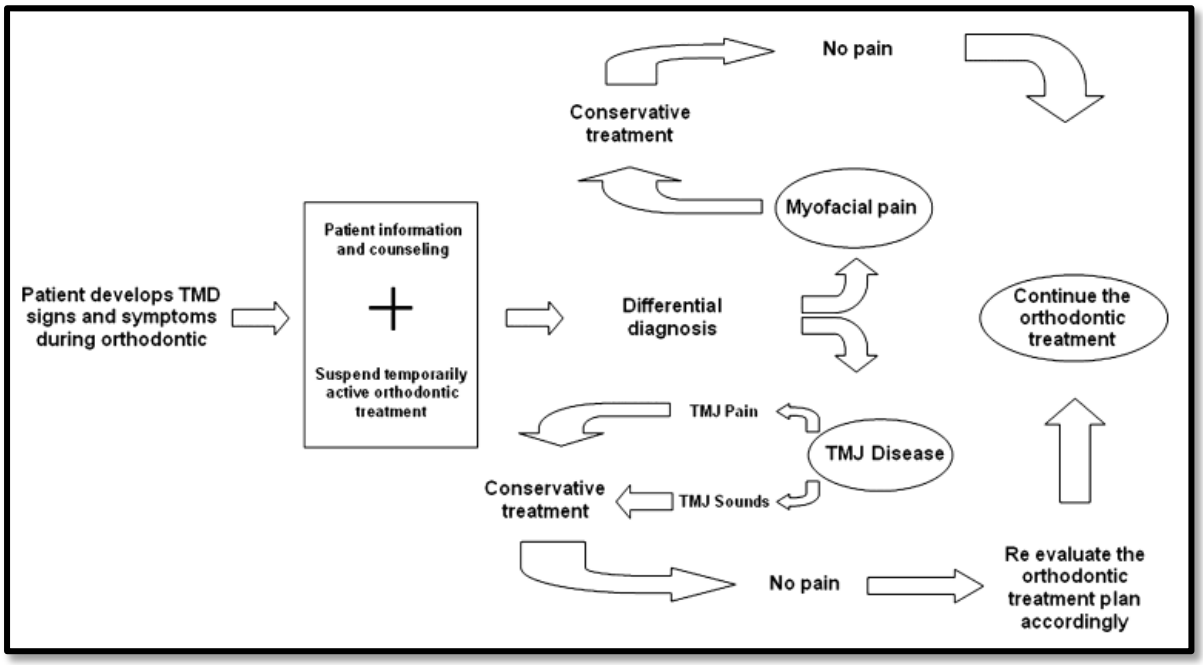

Fig. 19: TMD signs occurring during orthodontic treatment (Michelotti and Iodice 2010).

3- If Patient Develops TMD after Orthodontic Treatment

Assuming that the orthodontic treatment protocol for the patient was within normal standards of practice, and the final result was within those parameters, the literature on orthodontic-TMD relationships is very clear: orthodontic treatment generally does not cause or cure TMD problems, so the random development of symptoms cannot be attributed to that treatment (McNamara *et al*. 1995, Michelotti and Iodice 2010, Leite *et al*. 2013).

3. Conclusions

The main conclusions are the following:

1. TMD is a collective term embracing a number of clinical problems that involve the masticatory muscles and the TMJs.
2. The pathogenesis of TMD is not dental – related but rather is a part of a wider family of orofacial pain disorders which account for the need to consider neurologic, endocrine and psychosocial factors during the diagnostic process. Occlusion, condyle position, and lack of canine guidance are not the primary causes of TMD (Manfrendini and Nardini 2010).
3. TMD treatments are no longer dental, but are based on biopsychosocial approach (Rinchuse and Kandasamy 2009). Treatment options are: patient education, cognitive behavior therapy (CBT) (Turk 1997), bio feedback, physiotherapy (Stholer 1999), acupuncture(List *et al*. 1993), transcutaneous nerve stimulation (TENS), low intensity laser , splint therapy (List and Axelsson 2010), drug therapy, surgical intervention (Al-Riyami *et al*. 2009), but not occlusal definitive.
4. TMD signs and symptoms are often resolved by conservative and reversible therapies.
5. No scientific evidence exists that orthodontic treatment will prevent or mitigate the development of future TMD, or cure an existing disorder.
6. Orthodontic treatment performed during adolescence does not increase or decrease the risk of developing TMD in later life.

4. Clinical Recommendations

The main clinical recommendations are the following:

1. An attentive orthodontist should always identify and document findings of the TMJ and related structures. TMD signs and symptoms may occur before, during and after orthodontic treatment even though these findings may not necessarily lead to treatment.
2. Inform the patient of his/her temporomandibular situation and discuss the prognosis.
3. Inform the patient that his/her occlusion will undergo changes and that it is essential to avoid parafunctional, constant auto-checking of the bite in order to prevent the possible development of occlusal dysesthesia.
4. If the patient presents TMD symptoms BEFORE treatment:

a. Insignificant symptoms such as painless clicking or movement limitation or deviations in opening closing pattern should not delay the beginning of orthodontic treatment.

b. If pain and severe dysfunction are present the patient should be referred to a TMD specialist before orthodontic therapy is initiated.

5. If the patient develops symptoms DURING treatment:

a. Temporarily stop active orthodontics treatment.

b. Perform basic pain management and supportive therapy in order to reduce the symptoms, after which orthodontic treatment may continue.

c. If the symptoms persist, the treatment plan should be reconsidered because the patient might become hypervigilant and of poor adaptation capability. An alternative treatment plan should be considered.

6. If the patient develops symptoms AFTER treatment:

a. If the patient was informed before treatment about a possible development of TMD, there should not be a problem explaining that TMD was probably not a result of the orthodontics.

b. As TMD sign and symptoms tend to be observed between 20 to 30 years old (Mohlin *et al.* 2004) there is a possibility of an orthodontic patient developing symptoms after treatment based only on his/her age.

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