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Review Article

Biomechanics of TMJ and Its Clinical Relevance to Orthodontics: A Review

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ABSTRACT

The temporomandibular joint is one of the most complex operational systems in the human body. The problems associated with the diagnosis and management of temporomandibular disorders (TMD) has aroused interest to the orthodontist. The attention to signs and symptoms associated with TMD has modified the clinical management before, during and after orthodontic treatment. So, Knowledge of the general morphology and biomechanics makes basic examination of the TMJ region easier thereby maintaining the normal integrity of the joint to have normal form and function.

Keywords: Occlusion, Orthotics, Temporomandibular Disorders, Temporomandibular Joint.

INTRODUCTION

Orthodontists are constantly being challenged with the task of providing their patients with acceptable esthetics and masticatory function. Developing a sound, functional masticatory system is the primary goal of all orthodontic therapies. Therefore, orthodontists should know the normal masticatory function and the goals that need to be achieved to maintain normal function.

The understanding of the evolution and the comparative anatomy of the masticatory system yields important insights into normal and potentially abnormal function in humans. [1] The stomatognathic system performs various masticatory tasks such as swallowing food, speaking and esthetics. It consists of three main components, i.e. TMJ components, masticatory muscles, and dental occlusion. These components are interrelated and coordinated by the central nervous system.

The Temporo-mandibular joint is classified as a compound joint. A compound joint requires the presence of at least 3 bones, but the TMJ is made of only 2 bones i.e. mandibular bone and the temporal bone. Functionally the articular disc serves as the non-ossified bone that permit the complex movements of the joint. This articular disc functions as 3rd bone and so it is considered as a compound joint. [2] The TMJ is both ontogenetically and phylogenetically a secondary jaw joint. The primary jaw joint is between the incus and the malleus which persists for some time in the fetal period. It is then replaced by the secondary joint, while the incus and the malleus recedes into the middle ear and takes over the function of sound conduction. It is the articulation between the condyle of the mandible and the squamous portion of the temporal bone, also referred to as "**CRANIO MANDIBULAR ARTICULATION**".

TMJ problems being largely within the province of dental care, however, the therapy has concentrated mainly on the mechanical aspects, largely ignoring the importance of physiological and psychological areas. In other words, dentistry itself must broaden its diagnostic & therapeutic horizons, de-emphasize the tooth-oriented vision and mechanical procedures. TMJ problems are largely cyclic, and are often self-correcting via homeostasis, with time and advancing age. [3]

Anatomy of TMJ

The TMJs form the articulation between the mandible and the skull allowing the mandible to move with six degrees of freedom. The TMJ is unusual in that the articular surfaces are lined by fibrocartilage, not hyaline cartilage as in most other joints. This, together with the thin roof of the articular fossa, has been taken in the past to indicate that the joint is non-load bearing. However, it is now accepted that the TMJ is load bearing and that joint reaction forces are directed upwards and forwards through the articular eminence rather than vertically upwards through the floor of the fossa. [3]

The presence of fibrocartilage in the joint is explained by the evolutionary history of the TMJ. Other synovial joints are formed between endochondral-ossified bones that are pre-formed in hyaline cartilage. Most of this cartilage is converted into bone, but some persists to form the articular surfaces. In contrast, the bones of the TMJ are membranous bones and the fibrocartilaginous articular surface is derived from the periosteum. [5]

TMJ is a diarthrodial synovial paired joint. This means that the joint has to function in pairs and the joint movement will involve both joint compartments. [6] The right and left TMJ form a bicondylar articulation and ellipsoid variety of the synovial joints similar to knee articulation. [7] However, the features, that differentiates and make this joint unique is its articular surface, which is covered by fibrocartilage instead of hyaline cartilage.

Each TMJ is classed as a "ginglymoarthrodial" joint since it is both a ginglymus (hinging joint) and an arthrodial (sliding) joint. The condyle of the mandible articulates with the temporal bone in the mandibular fossa. These two bones are actually separated by an articular disc, which divides the TMJ into two distinct compartments. The inferior compartment allows for rotation of the condylar head around an instantaneous axis of rotation, corresponding to the first 20mm or so of the opening of the mouth. After the mouth is open to this extent, the mouth can no longer open without the superior compartment of the TMJ becoming active. [2]

At this point, if the mouth continues to open, not only is the condylar head rotating within the lower compartment of the TMJ, but the entire apparatus (condylar head and articular disc) *translates*. Although this had traditionally been explained as a forward and downward sliding motion, on the anterior concave surface of the glenoid fossa and the posterior convex surface of the articular eminence, this translation actually amounts to a rotation around another axis. This effectively produces an evolute which can be termed the resultant axis of mandibular rotation, which lies in the vicinity of the mandibular foramen, allowing for a low-tension environment for the vasculature and innervation of the mandible. Movement is not only guided by the shape of the bones, muscles, and ligaments but also by the occlusion of the teeth, since both joints are joined by a single mandible bone and cannot move independently of each other. The resting position of the TMJ is not with the teeth biting together. Instead, the muscular balance and proprioceptive feedback allow a physiologic rest for the mandible, an interocclusal clearance or freeway space, which is 2 to 4 mm between the teeth.

Translation occurs in the upper portion of the joint, and this motion of the condyle and the meniscus is relative to the articular eminence. According to Schwartz,' the axes of mandibular movements do not shift significantly during either motion. The rotary motion causes successive regions of the condylar articulating surfaces to come into relation on a fixed point; this is arthrokinematically termed a glide. This gliding will only permit a depression of the mandible with no forward movement occurring. Because a continuance of this rotary glide will cause an impingement of structures posteriorly, the condyle must assume a translation or roll occurring almost simultaneously with rotation. This allows a resulting motion about the axis of the articular eminence as well as the condylar head. On jaw opening, the condyles are found to rotate at the very beginning of opening to about mid opening; the translator movement is then obvious, permitting the condyle to slide forward just under the eminentia'.

It is apparent that the function of the upper lateral pterygoids in drawing the meniscus anteriorly is necessary and critical in preparation for condylar rotation. The meniscus, with its irregular shape, acting to stay ahead of the condyle, provides for contour and lubrication especially at the beginning and end of motion. With these two conditions in effect, the lower lateral pterygoids will function to provide jaw protrusion (translatory condylar movement) and if required lateral deviation. Lateral deviation occurs to the opposite side of the contracting pterygoid. There has been little investigation on the exact mechanism of this deviation, nor is there agreement on the site of axis about which motion occurs. [8]

Unique features of the human temporomandibular joint

The temporomandibular joint is a load-bearing, synovial-lined articulation which permits both hinge and sliding movements. Furthermore, the TMJ is the only load-bearing articulation that is connected to its contralateral counterpart by a single bone (i.e., the mandible connects both TMJs). This unique anatomic relationship forces dependent movements of the TMJs.

The articular surfaces of the TMJ are composed of fibrocartilages that are distinct from the hyaline cartilages of articulations of the appendicular skeleton. The unique biochemical composition of these articular tissues is reflected by material properties that are also distinct from those of other load-bearing articulations.

During human embryologic development, two distinct sets of articulations form between the cranium and mandible, termed primary and secondary TMJs. The primary TMJ forms from cellular elements of Meckel's cartilage and the first branchial arch serving as a limited hinge articular until 16 weeks of postnatal life. This articulation will ultimately become the joint between the incus and the malleus. The secondary TMJ develops from condensed mesenchyme located lateral to Meckel's cartilage beginning at six weeks of development. This structure will mature to the complex articulation that is characteristic of the human TMJ.

The temporomandibular joint is the only load-bearing joint that is innervated by a cranial nerve (i.e., the trigeminal nerve). Using retrograde labeling methods, some investigators have provided evidence that the TMJ also receives significant innervation from neurons located in C2-C5, as well as from the superior cervical, stellate, sphenopalatine, and otic ganglia. Neuropeptides, including substance P, calcitonin gene-related peptide (CGRP), neuropeptide Y (NPY), and vasoactive intestinal polypeptide (VIP) have been identified in TMJ synovial tissues and synovial fluid obtained from symptomatic patients. Some of these neuropeptides produce inflammatory effects when released into peripheral tissues from stimulated nerve terminals (i.e., neurogenic inflammation). Neurogenic mechanisms have been proposed in some models of degenerative temporomandibular joint disease.

The temporomandibular joint possesses a remarkable remodeling capacity that may be required for adaptation to mandibular growth and changes in dentition. Dramatic examples of this capacity consisting of extensive remodeling of joint structures following subcondylar fractures of the mandible in children and young adults have been observed clinically. The molecular events that underlie temporomandibular joint remodeling and adaptation are poorly understood. [3]

Biomechanical Behaviour of the TMJ

Mandibular motions result in static and dynamic loading in the TMJ. During natural loading of the joint, combinations of compressive, tensile, and shear loading occur on the articulating surfaces. [9] The analysis of mandibular biomechanics helps to understand the interaction of form and function, mechanism of TMDs; and aids in the improvement of the design and the behavior of prosthetic devices, thus increasing their treatment efficiency. [10-12]

In-vivo assessment

In contrast to earlier studies in the English Literature which reported the TMJ to be a force-free joint, [5] demonstrated that considerable forces were exerted on the TMJ during occlusion as well as mastication. In face of these contrary reports, Breul et al (1999) [13] showed that the TMJ was subjected to pressure forces during occlusion as well as during mastication and it was slightly eccentrically loaded in all positions of occlusion. Korioth and Hannam (1994) [14] indicated that the differential static loading of the human mandibular condyle during tooth clenching was task dependent and both the medial and lateral condylar thirds were heavily loaded.

Huddleston Slater et al (1999) [15] suggested that when the condylar movement traces coincide during chewing, there is compression in the TMJ during the closing stroke. However, when the traces do not coincide, the TMJ is not or only slightly compressed during chewing.

Naeije and Hofman (2003) [16] used these observations to study the loading of the TMJ during chewing and chopping tasks. Their analysis showed that the distances traveled by the condylar kinematic centers were shorter on the ipsilateral side than on the contralateral. The kinematic centers of all contralateral joints showed a coincident movement pattern during chewing and chopping. The indication that the ipsilateral joint is less heavily loaded during chewing than the contralateral joint explained, why patients with joint pain occasionally report less pain while chewing on the painful side.

Hansdottir and Bakke (2004) [5] evaluated the effect of TMJ arthralgia on mandibular mobility, chewing, and bite force in TMD patients compared to healthy control subjects. The pressure pain threshold (PPT), maximum jaw opening, and bite force were significantly lower in the patients as compared to that in controls. The patients were also found to have longer duration of chewing cycles. The most severe TMJ tenderness and the most impeded jaw function with respect to jaw opening and bite force were found to be more severe in the patients with inflammatory disorders. [5]

In-vitro assessment - mechanical testing and finite element modeling

As the TMJ components are difficult to reach and as the applications of experimental devices inside the TMJ cause damage to its tissue, the direct methods are not used often. Indirect techniques utilized to evaluate mandibular biomechanics have had limited success due to their ability to evaluate only the surface stress of the model but not its mechanical properties (Ingawalé and Goswami, 2009).Thus, mechanical testing and finite element modeling (FEM) have been progressively used by TMJ researchers.

Excessive shear strain can cause degradation of the TMJ articular cartilage and collagen damage eventually resulting in joint destruction. [17] Tanaka et al. (2008) [17] attempted to characterize the dynamic shear properties of the articular cartilage by studying shear response of cartilage of 10 porcine mandibular condyles using an automatic dynamic viscoelastometer. The results showed that the shear behavior of the condylar cartilage is dependent on the frequency and amplitude of applied shear strain suggesting a significant role of shear strain on the interstitial fluid flow within the cartilage.

Beek et al. (2001) [18] performed sinusoidal indentation experiments and reported that the dynamic mechanical behavior of disc was nonlinear and time-dependent. Beek et al. (2003) [19] simulated these experiments using axisymmetric finite element model and showed that a poroelastic material model can describe the dynamic behavior of the TMJ disc.

Tanaka et al. (2006) [20] carried out a series of measurements of frictional coefficients on 10 porcine TMJs using a pendulum-type friction tester. The results showed that the presence of the disc reduces the friction in the TMJ by reducing the incongruity between the articular surfaces and by increasing synovial fluid lubrication. This study highlighted the importance of preserving the disc through alternatives to discectomy to treat internal derangement and osteoarthritis of the TMJ.

The finite element modeling (FEM) has been used widely in biomechanical studies due to its ability to simulate the geometry, forces, stresses and mechanical behavior of the TMJ components and implants during simulated function. Chen et al (1998) [21] performed stress analysis of human TMJ using a two-dimensional FE model developed from magnetic resonance imaging (MRI). Due to convex nature of the condyle, the compressive stresses were dominant in the condylar region whereas the tensile stresses were dominant in the fossa-eminence complex owing to its concave nature.

Nagahara et al (1999) [22] developed a 3D linear FE model and analyzed the biomechanical reactions in the mandible and in the TMJ during clenching under various restraint conditions. All these FE simulations considered symmetrical movements of mandible, and the models developed only considered one side of the joint. Hart et al. (1992) [23] generated 3D FE models of a partially edentulated human mandible to calculate the mechanical response to simulated isometric biting and mastication loads.

Tanaka et al (2001, 2004) [24,25] developed a 3D model to investigate the stress distribution in the TMJ during jaw opening, analyzing the differences in the stress distribution of the disc between subjects with and without internal derangement. Tanaka et al. suggested that increase of the frictional coefficient between articular surfaces may be a major cause for the onset of disc displacement.

In 2005, Koolstra and van Eijden developed a combination of rigid-body model with a FE model of both discs and the articulating cartilaginous surfaces to simulate the opening movement of the jaw. Using the same model, Koolstra and van Eijden (2006) [26] performed FEA to study the load-bearing and maintenance capacity of the TMJ. The results indicated that the construction of the TMJ permitted its cartilaginous structures to regulate their mechanical properties effectively by imbibitions, exudation and redistribution of fluid.

Perez-Palomar and Doblare (2006) [27] used more realistic FE models of both TMJs and soft components to study clenching of mandible by developing a 3D FE model that included both discs ligaments and the three body contact between all elements of the joints, and analyzed biomechanical behavior of the soft components during a nonsymmetrical lateral excursion of the mandible to investigate possible consequences of bruxism. This study suggested that a continuous lateral movement of the jaw may lead to perforations in the lateral part of both discs, conforming to the indications by Tanaka et al. [24,25]

Whiplash injury is considered as a significant TMD risk factor and has been proposed to produce internal derangements of the TMJ. [28-30] However, this topic is still subject to debate. In 2008, Perez del Palomar and Doblare, [29] published the results of finite element simulations of the dynamic response of TMJ in rear-end and frontal impacts to predict the internal forces and deformations of the joint tissues. The results, similar to suggested by Kasch et al. (2002), [28] indicated that neither a rear-end impact at low-velocity nor a frontal impact would produce damage to the soft tissues of the joint suggesting that whiplash actions are not directly related with TMDs. However; since this study has its own limitations such as analysis of only one model, for low-velocity impacts, without any restrictions like contact with some component of the vehicle; there is a need for more reliable finite element simulations to obtain more accurate numerical results. A theoretical model developed by Gallo et al. (2000) [31] for estimating the mechanical work produced by mediolateral stress-field translation in the TMJ disc during jaw opening/closing suggested that long-term exposure of the TMJ disc to high work may result in fatigue failure of the disc. In 2001, Gross et al. proposed a predictive model of occlusal loading of the facial skeleton while May et al. (2001) [32] developed a mathematical model of the TMJ to study the compressive loading during clenching. Effect of mandibular activity on mechanical work in the TMJ, which produces fatigue, may influence the pathomechanics of degenerative disease of the TMJ, was studied by Gallo et al. (2006). [33]

Nickel et al. (2002) [34] validated numerical model predictions of TMJ eminence morphology and muscle forces, and demonstrated that the mechanics of the craniomandibular system are affected by the orthodontic treatments. Using this validated numerical model to calculate ipsilateral and contralateral TMJ loads for a range of biting positions and angles, Iwasaki et al. (2009) [35] demonstrated that TMJ loads during static biting are larger in subjects with TMJ disc displacement compared to subjects with normal disc position. [11]

Summary of TMJ biomechanics during various mandibular movements

The mechanism by which the disc is maintained with the translating condyle is dependent on the morphology of the disc and the interarticular pressure. In the presence of a normally shaped articular disc, the articulating surface of the condyle rests on the intermediate zone, between the two thicker portions. As the interarticular pressure is increased, the discal space narrows, which more positively seats the condyle on the intermediate zone.

During translation the combination of disc morphology and interarticular pressure maintains the condyle on the intermediate zone and the disc is forced to translate forward with the condyle. The morphology of the disc therefore is extremely important in maintaining proper position during function.

Only when the morphology of the disc is greatly altered, the filamentous attachment of the disc will affect joint function. When this occurs the biomechanics of the joint is altered and dysfunctional signs begin. As with most muscles, the superior lateral pterygoid is constantly maintained in a mild state of contraction, which exerts a slight anterior and medial force on the disc. In the resting closed joint position, this anterior and medial force will normally exceed the posterior elastic retraction force provided by the non-stretched superior retrodiscal lamina. Therefore, in the resting closed joint position, when the interarticular pressure is low and the disc space widened, the disc will occupy the most anterior rotary position on the condyle. In other words, at rest with the mouth closed, the condyle will be positioned in contact with the intermediate and posterior zones of the disc.

This disc relationship is maintained during minor passive rotational and translator mandibular movements. As soon as the condyle is moved forward enough to cause the retractive force of the superior retrodiscal lamina to be greater than the muscle force of the superior lateral pterygoid, the disc is rotated posteriorly to the extent permitted by the width of the articular disc space. When the condyle is returned to the resting closed joint position, once again the tonus of the superior lateral pterygoid becomes the predominant force and the disc is repositioned forward as far as the disc space will permit.

The importance of the function of the superior lateral pterygoid during the power stroke becomes apparent when the mechanics of chewing is observed. When resistance is met during mandibular closure, such as when biting on hard food, the interarticular pressure on the biting side is decreased. This occurs because the force of closure is not applied to the joint but is instead applied to the food. The jaw is fulcrumed around the hard food, causing an increase in interarticular pressure in the contra lateral joint and a sudden decrease in interarticular pressure in the ipsilateral (same side) joint. This can lead to separation of the articular surfaces, resulting in dislocation. To avoid this, the superior lateral pterygoid becomes active during the power stroke, rotating the disc forward on the condyle so the thicker posterior border of the disc maintains articular contact. Therefore, joint stability is maintained during the power stroke of chewing. As the teeth pass through the food and approach intercuspation, the interarticular pressure is increased. As the pressure is increased, the disc space is decreased and the disc is mechanically rotated posteriorly so the thinner intermediate zone fills the space. When the force of closure is discontinued, the resting closed joint position is once again assumed.

Understanding these basic concepts in TMJ function is essential to the understanding of joint dysfunction, their evaluation and management.

Clinical Relevance of TMJ to Orthodontics

The relationship between orthodontic treatment and temporomandibular disorders (TMDs) has long been of interest to the practicing orthodontist. During the past decade a significant number of clinical studies have been conducted to investigate this association. This interest was prompted in the late 1980s, after the alleged litigation that orthodontic treatment was the proximal cause of TMDs in orthodontic patients. This resulted in an increased need for methodologically sound clinical studies. The findings by McNamara to investigate the relation of orthodontic treatment and TMD were as follows: Signs and symptoms of TMD may occur in healthy persons, and increase with age, particularly during adolescence, until menopause. Thus, TMDs that originate during orthodontic treatment may not be related to the treatment. They concluded that Orthodontic treatment performed during adolescence, any particular type of orthodontic mechanics, or the extraction of teeth as part of an orthodontic treatment plan does not increase or decrease the chances of development of TMD later in life. They observed no evidence that orthodontic treatment prevents TMD.

Moreover, Temporomandibular joint disorder is a common complaint from patients in dental, orthodontic and chiropractic offices. Usually a complaint of TMD or one of its side effects in a dental office will result in a referral to an orthodontist. This is the topic of concern, if the orthodontic treatment is actually helping or harming the patient with the use of appliances on the teeth.

The appliance, appliances or treatment which directly affects the bite plane of the patient, also affects all of the muscles and joints surrounding the jaws. This cosmetic correction can lead to stress being put on the different joints to accommodate for the changes. This stress can be considered to help the joints reposition if they were affected before the appliance or to harm the joint if no problem existed. Moreover, TMD can lead to mild tenderness and discomfort to several serious health problems such as migraine headaches and severe neck pain. Because of the adverse results that TMD can cause, researching the affects of orthodontic appliances and their use in treatments is a true concern.

The treatments of TMD are numerous and range from conservative care to exploratory surgery.

Kremenak et al [36] in his study of 109 patients reported that TMD status of majority (90%) of orthodontic patients treated stays the same or improves after completion of treatment.

Sadowsky et al (1991) [37] in his study of 13 patients demonstrated joint sounds after treatment even though there were no sounds present at the beginning of treatment. The sounds were head during late opening and middle closing, as determined by an audiovisual system. Joint sounds may be result of a decreased synovial fluid viscosity, irregularities of joint surfaces, sudden ligament and tissue movements, anterior condylar displacement relative to disk and anterior disk displacement. He concluded that orthodontic treatment did not pose an increased risk for developing temporomandibular joint sounds.

Thompson, an early pioneer orthodontist, observed that patients with disturbances in the vertical dimension appeared to be more prone to TMJ problems.

Grabber cited prevalence of signs and symptoms of TMD in a general orthodontically treated population observed that 32% have at least one symptom and 55% demonstrate at least one clinical sign. According to Greene CS, in adults the numbers range between 40% and 75% with at least one sign and 33% with atleast one symptom of TMD. According to Montegi E et al, in children and teenagers the prevalence is lower i.e. about 12% to 20%. The most common symptom noted was the joint sounds. Egermark I and Ronnerman A in their study of 50 patients between the ages of 7 to 16 years who had either fixed or removable appliances reported that prevalence of the symptoms of TMD in the patient group decreased from 20% to 14% during the treatment while there was no difference in occurrence of TMJ sounds. During the active phase of the orthodontic treatment and at the time of retention there was a reduction of signs and symptoms of TMD. It was concluded that the signs and symptoms were fewer at the end of treatment that before.

Sadowsky reviewed various studies from 1966 to 1988, and concluded that orthodontic treatment performed during adolescence did not generally increase or decrease the risk of developing TMD in later life. Also the studies reviewed after 1988 concluded that the emergence of symptoms associated with TMD have little or nothing to do with orthodontic therapy.

In Contrast to all studies, Albert H. Owen believed that orthodontic treatment could be an etiology in TMD. They supported the theory that posterior condylar position predisposes the joint to internal derangement and studied 600 patients for development of any TMD signs or symptoms. They observed that most patients with TMJ problems had posterior condyle movement. The study found that female patients with excessive overjet and overbite and moderate to severe crowding of the lower arch were more predisposed to developing TMJ problems. In general, females develop more TMJ problems with orthodontics than men. Also, individuals with severe crowding have a tendency to develop temporomandibular problems.

Interocclusal orthopedic appliances of varied design and application have been employed in the treatment of temporomandibular joint disorders (TMD). These appliances provide the practitioner with a non-invasive, reversible form of intervention to manage the patient's symptoms. Sufficient credible literature exists to help provide an understanding of and a treatment protocol for the use of splints for temporomandibular disorders and bruxism problems.

Occlusal Splint/ Occlusal Device/ Orthotics: “Any removable artificial occlusal surface used for diagnosis or therapy and affecting the relationship of the mandible to the maxillae. It may be used for occlusal stabilization, for treatment of TMJ disorders, or to prevent wear of the dentition.” An occlusal appliance /a splint is a removable device, usually made of hard acrylic, that fits over the occlusal and incisal surfaces of teeth in one arch, creating precise occlusal contact with the teeth of opposing arch. It is commonly referred to as bite guards, night guard, inter occlusal appliances, intra-oral orthotic, or even orthopaedic device. These are extensively used in management of TMJ disorders.

Most occlusal splints have one primary function: to alter an occlusion so they do not interfere with complete seating of the condyles in centric relation. Intra-oral appliances when used in the management plan accurately, can contribute to the relief of TMD symptoms. [38] The purpose of the occlusal splint is to influence the lower jaw to function freely and without pain. It is used to keep the teeth, from contacting during chewing and to allow the lower jaw to return to a comfortable hinge position without interference and guidance from the teeth.

CONCLUSION

The temporomandibular joint is one of the most complicated working assemblies in the human body. No orthodontic procedure can be performed in isolation without considering its possible effect on the temporomandibular joint. Therefore, the following recommendations are made for diagnosis and treatment planning:

Etiologic factors that might cause upward and backward pressures on the mandible should be reduced as much as possible.

Mechanotherapy that may cause upward and backward pressures on the condyles is not recommended. Correction of dental abnormalities should always consider optimal temporomandibular health and function.

Retention procedures should be planned to provide a proper path of closure to minimize or prevent possible retrogressive post-treatment changes. [39]

The orthodontic treatment, regardless of the technique used and whether or not the extraction of premolars during treatment, does not increase the signs and symptoms of TMD and therefore it is not a risk factor for its development. The orthodontic treatment does not appear to be a valuable resource for treating or preventing the onset of signs and symptoms of TMD. [40]

In the individuals, symptoms and signs of TMD fluctuates substantially over time with no predictable pattern. The type of occlusion may play a role as a contributing factor for the development of symptoms and signs of TMD, although this influence is difficult to quantify and predict.

The recent thoughts about occlusion and the shift in functional appliance philosophy may need to be revisited prior to acceptance as axiomatic. It is recommended that the functional aspect of the teeth be viewed as a possible controlling factor in TMJ ontogeny, which in cases may influence a clinician toward early treatment. It is quite possible that there is a genetic basis for the occlusal variation seen with TMD which is exacerbated by our contemporary diet and the associated lack of "normal" attrition. Botox treatments may also be of some value to control facial somatotypes and guide TMJ development. The understanding of genetic factors would create research opportunities to create a test for genetic haplotype for TMD.

The correct occlusal relationship as a result of orthodontic treatment is not obtained at the expense of non-physiological positioning of both the condyle and the articular disc. Thus, when orthodontics is used correctly, does not cause adverse effects in the TMJ. The application of forces during certain orthodontic mechanics, especially orthopedic situations, can cause alterations in condylar growth and bone structures of the TMJ. Thus, the mechanics application should be performed properly and the professional must have knowledge of these impacts. [41]

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