ORTHODONTIC THERAPY AND TEMPOROMANDIBULAR DISORDERS: SHOULD THE ORTHODONTIST EVEN CARE?

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ABSTRACT

It has been over 20 years since the "Michigan Case" suggested that orthodontic therapy was a risk factor for the development of a temporomandibular disorder (TMD). This chapter explores the relationships between orthodontic therapy, occlusion and TMDs. The available scientific literature is reviewed and concepts of how occlusion may affect TMD are presented. Although scientific studies do not strongly link orthodontic therapy with the development or prevention of TMD, it is difficult to imagine a specialty that routinely and significantly changes a patient's occlusal condition would not have a powerful affect on the masticatory structures and their functions. Orthodontists need to establish their treatment goals by considering both the occlusal position and the stable joint position. This chapter emphasizes the importance of establishing orthopedic stability in the masticatory through orthodontic therapy. These goals are important for maintaining a healthy masticatory system for a lifetime.

The term "temporomandibular disorder" (TMD) stirs up much interest and debate in the profession of dentistry and it has for many years. By definition, TMD is a collective term embracing a number of clinical problems that involve the masticatory musculature, the TMJ and associated structures, or both (Okeson, 1996). Therefore, TMDs are musculoskeletal pain disorders of the masticatory system. Dentistry has become interested in these disorders because the occlusion of the teeth can influence masticatory function greatly. Over the years, there has been much professional debate regarding how the dental occlusion influences jaw function and ultimately how this relationship may lead to TMD.

Many dentists feel that the occlusion of the teeth is the primary etiology of TMD symptoms, while others feel it has little effect. This debate remains an important discussion in that dentists are the only healthcare providers who alter the occlusion. Therefore, if occlusion does

play a significant role in the etiology of TMD, the dentist can and should play an important role in the management of these disorders. On the other hand, if occlusion plays no role in TMD, than any attempt by the dentist to alter the occlusal condition is misdirected and should be avoided. It is obvious that this question is very important to the dental profession.

So where does the orthodontist fit into the debate? The orthodontist, like any dentist, is brought in to the debate any time she or he changes the patient's occlusion. It is obvious that most, if not all, orthodontic therapies alter the patient's occlusion. In fact, from a prosthodontic viewpoint, the orthodontist performs a full mouth reconstruction in the natural dentition for every patient. Therefore, it is obvious that the orthodontist needs to be interested in this debate.

Orthodontists' interest in this debate was emphasized further in 1987 when a young patient sued an orthodontist for causing her TMD. The jury found in her favor for an original judgment of over one million dollars. This case caught the orthodontists' attention and brought the specialty soundly into the debate. The question that needs to be answered is whether the scientific data support such a decision. This chapter will attempt to review the science and opinions that prevail at this time.

STUDIES INVESTIGATING ORTHODONTIC THERAPY AND TMD

After the "Michigan Case," orthodontists became interested in documenting the relationship between orthodontic therapy and TMD. In fact, three significant studies (Larsson and Ronnerman, 1981; Sadowsky and Polson, 1984; Sadowsky *et al.,* 1988) already had been published but seemed to be ignored in the courtroom. Since these studies, seven more studies (Dahl *et al.,* 1988; Smith and Freer, 1989; Hirata *et al.,* 1992; Kremenak *et al.,* 1992*b*; Rendell *et al.,* 1992; Wadhwa *et al.,* 1993; Henrikson and Nilner, 2000) have attempted to investigate this relationship. These studies are highlighted in Table 1 and suggest that subjects who received orthodontic therapy have no greater incidence of developing TMD than a group of control subjects who never received orthodontic therapy.

There were some in the dental community who felt that the extraction of premolars produced risk factors that would lead to increased TMD. Five studies (Janson and Hasund, 1981; Sadowsky *et al.,* 1991;

Table 1. TMD signs and symptoms: post-ortho *vs.* controls.

AUTHORS	# PAT	# CONTROLS	YEARS	RESULTS
Sadowsky & BeGole, 1980	75	75	10	No significant differences
Sadowsky & Polson, 1984	96	103	10	No significant differences
Larsson & Ronnerman, 1981	23	HI	10	No significant differences
Dahl *et al.,* 1988	51	47	5	No significant differences (-pat)
Smith & Freer, 1989	87	28	4	No significant differences (+pat)
Rendell *et al.,* 1992	462	HI	1.5	No significant differences
Hirata *et al.,* 1992	102	41	2	No significant differences
Kremenak *et al.,* 1992	109	HI	1-6	No significant differences
Wadhwa *et al.,* 1993	31	71	4	No significant differences
Henrikson *et al.,* 2000	65	60	2	No significant differences

Dibbets and van der Weele, 1992; Kremenak *et al.,* 1992*a*; Luppanapornlarp and Johnston, 1993) investigated this concept; they are highlighted in Table 2. The data do not imply that the extraction of premolars is a significant contributor to TMD.

Another argument that has been made is that the extraction of the premolars leads to a posterior displacement of the condyles in the fossa. This has been investigated in five studies (Gianelly *et al.,* 1989; Artun *et al.,* 1992; Luecke and Johnston, 1992; O'Reilly *et al.,* 1993; Beattie *et al.,* 1994) listed in Table 3. Although some differences were reported, there was no strong evidence that the condyles assume a more posterior position in the fossa following premolar extractions and orthodontic therapy. In fact, one study found the condyles positioned more anteriorly after the completion of orthodontic therapy.

Table 2. Extraction *vs.* non-extraction and various TMD symptoms.

AUTHORS	# EX PAT	# NON-EX	YEARS	RESULTS
Janson & Hasund, 1981	30	30	5	No significant differences
Sadowsky *et al.,* 1991	87	68	3	No significant differences
Luppanapornlarp, 1993	33	29	15	No significant differences
Kremenak *et al.,* 1992	39	26	1-2	No significant differences
Dibbets *et al.,* 1992	73	38	20	No significant differences

Table 3. Extraction *vs.* non-extraction and posterior displacement of the condyle.

AUTHORS	# EX PAT	# NON-EX	RESULTS
Gianelly *et al.,* 1988	30	37	No significant differences
Luecke *et al.,* 1992	42	--	70% more forward after tx
Beattie *et al.,* 1994	33	30	No significant differences
Artun *et al.,* 1992	29	34	Mixed: right middle & lateral All other areas, no significant differences
O'Reilly *et al.,* 1993	60	60	No significant differences

These reported studies do not suggest that orthodontic therapy is a significant risk factor for the development of TMD. Although this observation has been a positive finding for many orthodontists, a reverse statement also must be recognized. Orthodontic therapy does not seem to reduce the risk of TMD. Therefore, orthodontists who tell their patients that orthodontic therapy is needed to prevent TMD have no data to support their claim.

INTERPRETING THE DATA

Most orthodontists who review these studies breathe a sigh of relief. Certainly the outcome of the "Michigan Case" was not based on scientific evidence. Perhaps, however, we need to reconsider the interpretation of the results. The concept that orthodontic therapy has nothing to do with TMD is like stating that moving the teeth anywhere will not influence how the patient functions. Certainly that is not the case in prosthodontics. Perhaps some additional factors need to be considered. For example, all these studies investigated populations in which very controlled orthodontic therapy had been performed (most in teaching environments). Can poorly completed orthodontics be a greater risk factor? If orthodontic therapy is carried out with no consideration for joint function, will this increase TMD risk factors? Clinical sense says yes but studies have not investigated this variable. Most prosthodontists would be greatly concerned with developing a permanent occlusal position with no regard to joint position.

It may be that the orthodontist has a significant advantage over the prosthodontist. Prosthodontists normally are rebuilding the mouths of mature adults who already have developed TMJ anatomy and function. Orthodontists often are working in an environment in which the structures of the TMJs are not matured fully. In many instances, the orthodontist completes treatment before full maturation of the condyles and fossa has occurred and therefore takes advantage of nature's adaptability. The concept that "form follows function" is evident in the growing young adult and may contribute to the success of orthodontic therapy and the low risk factors of developing TMD.

Another consideration in interpreting the data is that the relationship between TMD and orthodontics is based on the fact that orthodontic therapy changes the patient's occlusion; occlusal factors, however, may not be a major contributor to TMD. If the relationship between occlusion and TMD is strong, the influence of orthodontics may be strong. If this

relationship is weak, orthodontics may play very little role in either contributing or preventing TMD symptoms. Therefore a sound appreciation of the etiology of TMD is needed to understanding the orthodontist role in TMD.

THE ETIOLOGY OF TMD

It is critical for the dentist attempting to manage a TMD patient to appreciate the major etiologic factors that may be associated with the condition. Such knowledge is essential for selecting proper and effective therapy. A review of the scientific literature reveals at least five major factors that may be associated with TMD. These factors are the occlusal condition, trauma, emotional stress, deep pain input, and parafunctional activity (Fig. 1). The importance of any of these factors may vary greatly from patient to patient. Since this chapter is discussing only the role of occlusion, the other factors will not be elaborated. During this discussion, however, the reader should be aware that the most important etiology may not be the occlusal condition. Assuming occlusion to be the major etiology for every TMD patient is common with dentists because this is our training. Automatically making this assumption, however, can lead to major treatment failures. A full description of how each of these factors may influence TMD can be found in another text (Okeson, 2008*a*).

THE ROLE OF OCCLUSION IN TMD

When evaluating the relationship between occlusal factors and TMD, the occlusal condition may need to be considered both statically and dynamically. To date, most occlusal studies only have assessed the static relationship of the teeth (*e.g.,* the Angle molar classification in the intercuspal position). Some studies do investigate slides from a certain condylar position to the intercuspal position, while others investigate eccentric tooth contacts. The findings certainly are not impressive regarding any single factor consistently being associated with a TM disorder.

Some authors have suggested that the relationship between occlusal factors and TM disorders may be appreciated better when combination of factors are investigated. Pullinger and colleagues (1993) attempted to do this by using a blinded multifactorial analysis to determine the weighted influence of each factor, acting in combination with the other factors. The interaction of 11 occlusal factors was considered in randomly collected but strictly defined diagnostic groups compared to

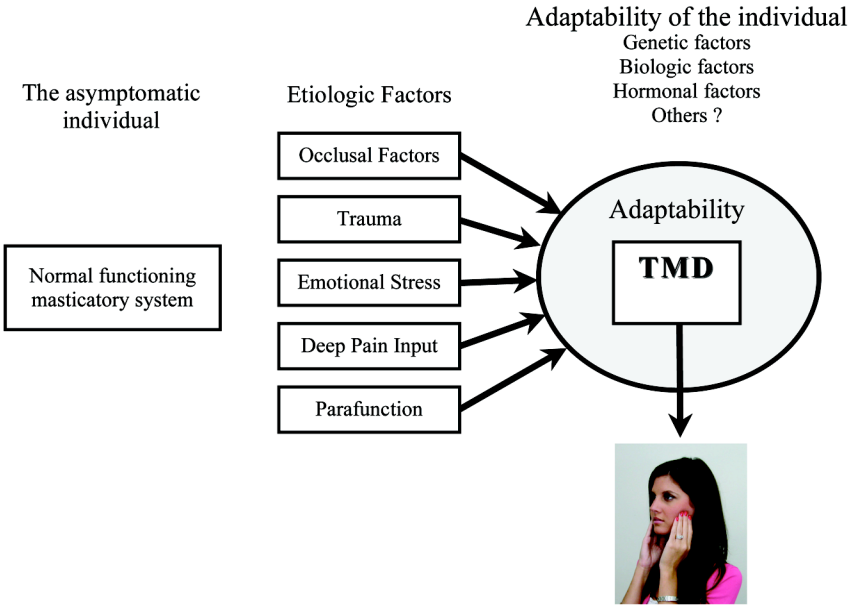

Figure 1. A model depicting etiologic factors and how they may contribute to TMD. When an asymptomatic individual is exposed to one of the five etiologic factors, the musculoskeletal system may be affected. Each individual has a certain amount of adaptability that protects him or her from developing a TMD. If one of these factors is great or if the patient's adaptability is small, a TMD may develop. It is important for the orthodontist to appreciate that occlusion is the only factor that is influenced by orthodontic therapy. If this is not the significant reason for the patient's TMD, orthodontic therapy should not be expected to help the TMD.

asymptomatic controls. These investigators concluded that no single occlusal factor was able to differentiate patients from healthy subjects. There were four occlusal features, however, that occurred mainly in TMD patients and rarely were seen in normals. These factors were: the presence of a skeletal anterior open bite; RCP-ICP slides of greater than 3 to 4 mm; overjets greater than 4 mm; and five or more missing and unreplaced posterior teeth. Unfortunately all of these signs not only are rare in healthy individuals, but also in patient populations as well, indicating limited diagnostic usefulness of these features.

Pullinger and coworkers (1993, 2000) concluded that many occlusal parameters that traditionally were believed to be influential contribute only minor amounts to the change in risk in the multiple factor analysis used in their study. They reported that although the relative odds

for disease were elevated with several occlusal variables, clear definition of disease groups was evident only in selective extreme ranges and involved only a few subjects. Thus they concluded that the occlusion cannot be considered the most important factor in the definition of TMD.

The multifactorial analysis of Pullinger and colleagues (1993, 2000) suggests that, except for a few defined occlusal conditions, there is a relatively minor relationship between occlusal factors and TMDs. It should be noted, however, that these studies report on the static relationship of the teeth as well as the contact pattern of the teeth during various eccentric movements. This represents the traditional approach to evaluating occlusion. Perhaps these static relationships can provide only limited insight into the role of occlusion and TMD.

When considering the dynamic functional relationship between the mandible and the cranium, it appears that the occlusal condition can impact on some TM disorders in at least two ways. The first relates to how the occlusal condition effects orthopedic stability of the mandible as it loads against the cranium. The second is how acute changes in the occlusal condition can influence mandibular function thus leading to TMD symptoms. Each of these conditions will be discussed separately.

The Effects of Occlusal Factors on Orthopedic Stability

Orthopedic stability in the masticatory structures exists when the stable intercuspal position of the teeth is in harmony with the musculoskeletally stable position of the condyles in the fossae (Okeson, 2008*b*). When this condition exists, functional forces can be applied to the teeth and joints without tissue injury. However, when there is a lack of harmony between the musculoskeletally stable position of the condyles and the intercuspal position of teeth, the condition is known as orthopedic instability. When this condition exists, there are opportunities for overloading and injury.

When orthopedic instability is present and the teeth are not in occlusion, the condyles are maintained in their musculoskeletally stable positions by the elevator muscles (Fig. 2*A*). However, when teeth are brought into occlusion, maximum intercuspation cannot be achieved with the condyles maintained in their stable position (Fig. 2*B*). This results in a very unstable occlusal position, even though each condyle remains in a stable joint position. The individual now has a choice either to maintain the stable joint position and only occlude on a few teeth, or bring the teeth into a more stable occlusal position, which may compromise joint

→ Figure 2. *A:* With the teeth apart, the elevator muscles maintain the condyles in their musculoskeletally stable positions (superoanterior, resting against the posterior slopes of the articular eminences). In this situation there is joint stability. *B:* When the mouth is closed, a single tooth contact does not allow the entire dental arch to gain full intercuspation. At this moment there is occlusal instability but still joint stability. Because the condyles and teeth do not fit in a stable relationship at the same time, this represents orthopedic instability. *C:* To gain the occlusal stability necessary for functional activities, the mandible is shifted and the intercuspal position is achieved. At this moment the patient achieves occlusal stability, but the condyles may no longer be orthopedically stable. This orthopedic instability may not pose a problem unless unusual loading occurs. If loading begins, the condyles will seek out stability and the unusual movement can lead to strains on the condyle/disc complex resulting in a risk factor for an intracapsular disorder. (Reprinted with permission; Okeson JP. *Management of Temporomandibular Disorders and Occlusion.* 6th ed. St Louis: Mosby Co., 2008:142.)

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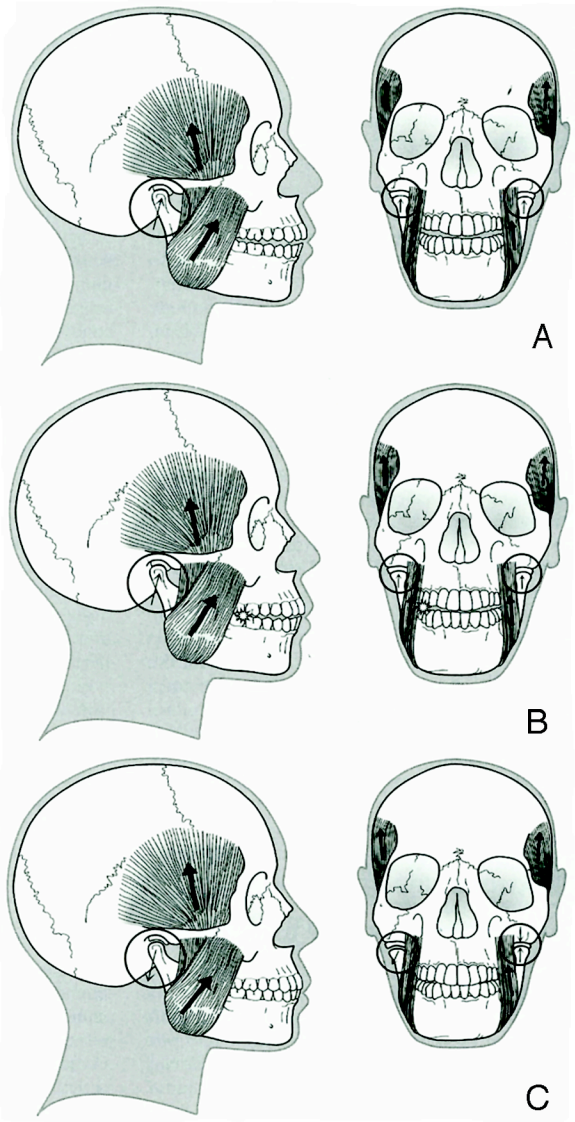
stability. In that occlusal stability is basic to function (chewing, swallowing and speaking), the priority is to achieve occlusal stability and the mandible is shifted to a position that maximizes occlusal contacts (the intercuspal position). When this occurs, this shift can force one or both condyles from its musculoskeletally stable position, resulting in orthopedic instability (Fig. 2*C*). What this means is that when the teeth are in a stable position for loading, the condyles are not, or *vice versa*.

When orthopedic instability exists, however, merely bringing the teeth into occlusion may not create a problem because loading forces are minimal. Problems arise when such an orthopedically unstable condition is loaded by the elevator muscles or by extrinsic forces (trauma). Since the intercuspal position represents the most stable position for the teeth, loading is accepted by the teeth without consequence. If the condyles also are in a stable relationship in the fossae, loading occurs with no adverse effect to the joints structures. If, however, loading occurs when a joint is not in a stable relationship with the disc and fossa, unusual movement can occur in an attempt to gain stability. This movement, although small, often is a translatory shift between disc and condyle. Movement such as this can lead to strain to the discal ligaments and eventually elongation of the discal ligaments and thinning of the disc. These changes can lead to an intracapsular TMD.

It should be remembered that there are two factors that determine whether an intracapsular disorder will develop: the degree of orthopedic



instability; and the amount of loading. Orthopedic instabilities with discrepancies of 1 or 2 mm are not likely significant enough to create a problem. However, as the discrepancy between the musculoskeletally stable position of the condyles and the maximum intercuspation of the teeth becomes greater, the risk of intracapsular disorders increases (Pullinger and Seligman, 1993, 2000).

The second factor that determines whether the patient will develop a TMD is the amount of loading. Bruxing patients with orthopedic instability, therefore, represent a greater risk for developing problems then non-bruxers with the same orthopedic instability. Also, forceful unilateral chewing can provide the mechanics that lead to sudden intracapsular disorders. These variables may help explain why patients with similar occlusal conditions may not develop similar disorders. In fact, when the static occlusal relationships of two patients are compared, the patient with the more significant malocclusion may not always be the patient who develops the disorder. Considering the dynamic functional aspect of the occlusion as it relates to the joint position is likely to provide more important information regarding the relative risk of developing a TMD.

In considering the relationship between occlusion and TMD, another factor needs to be considered. The term "dental malocclusion" refers to the specific relationship of the teeth to each other, but does not necessarily reflect any risk factors for the development of functional disturbances in the masticatory system (TMD). Dentists have recognized and described dental malocclusions such as open bites and Angle Class II molar relationships for years. The literature, however, does not convincingly relate these dental malocclusions to TMD. These dental malocclusions are important only when viewed in relationship to the joint position. Therefore, merely looking in the mouth or viewing hand held study casts does not provide insight as to the relative risk factor for TMD.

Only by observing the occlusal relationship with respect to the stable joint position can one appreciate the degree of orthopedic instability that is present. Orthopedic instability is the critical factor that needs to be considered when accessing relative risk factors for TMD. Also remember, a small discrepancy of 1 to 3 mm is normal epidemiologically and apparently not a risk factor. Small discrepancies appear to be well within the individual's ability to physiologically adapt. Shifts of greater than 3 to 4 mm present more significant risk factors for TMD (Nilner, 1986; Seligman and Pullinger, 1989, 1991, 2000; Wanman and Agerberg, 1991; Pullinger *et al.,* 1993; McNamara *et al.,* 1995).

An Acute Change in the Occlusal Condition

A second manner by which the occlusal condition can affect TMD symptoms is through a sudden or acute change. The occlusal contact patterns of the teeth can influence the activity of masticatory muscles

significantly (Williamson and Lundquist, 1983; Miralles *et al.,* 1988, 1989; Manns *et al.,* 1989). It also has been demonstrated that introducing a slightly high contact between the teeth can induce masticatory muscle pain in some individuals (Ingervall and Carlsson, 1982; Rugh *et al.,* 1984; Sheikholeslam *et al.,* 1993). An acute change in the occlusal condition such as a high crown often will precipitate a protective response of the muscle known as *protective co-contraction*. This protective response may produce muscle symptoms. Most dentists will recognize this acute disruption in normal occlusion and quickly adjust the crown to fit, resolving the symptoms.

If the crown is not adjusted, the chronic occlusal interference may affect muscle activity in one of two ways. The most common is to alter muscle engrams so as to avoid the potentially damaging contact and get on with the task of function. This is an example of adaptation of the masticatory system and likely the most common response the body to accommodate to the altered sensory input. Another form of adaptation relates to tooth movement to accommodate the heavy loading. Dentists should be thankful that most patients can adapt to change and do not show prolonged signs of dysfunction. If the masticatory system cannot adapt sufficiently, however, continued muscle co-contraction can lead to a more significant masticatory muscle disorder that needs to be recognized and managed (Fig. 1).

HOW OCCLUSION RELATES TO TMDs

In summary, the occlusal condition can affect TMDs by way of two mechanisms. One mechanism relates to the introduction of acute changes in the occlusal condition. Although acute changes can create a protective muscle co-contraction response leading to a muscle pain condition, most often new muscle engrams are developed and the patient adapts with little consequence. The second manner in which the occlusal condition can affect TMDs is in the presence of orthopedic instability. The degree of orthopedic instability must be considerable and it must be combined with significant loading forces.

A simple way to remember these relationships is as follows: *problems with bringing the teeth into occlusion are answered by the muscles. However, once the teeth are in occlusion, problems with loading the masticatory structures are answered in the joints.* These relation-

ships are, in fact, how dentistry relates to TMD. Therefore, if one of these two conditions exists, dental therapy may be indicated. Conversely, if neither of these conditions exists, dental therapy is contraindicated.

CONCLUSIONS

Scientific studies do not link orthodontic therapy with the development or prevention of TMDs. However, it is difficult to imagine a specialty that routinely and significantly changes a patient's occlusal condition would not have a powerful affect on the masticatory structures and their functions. Perhaps the relationship between orthodontics and TMD is not great because orthodontic therapy only influences one of at least five different etiologic factors that are linked to TMD. Perhaps orthodontists are fortunate to be carrying out their therapies on young healthy populations that routinely have the ability to adapt to the treatment changes. To think that orthodontic therapy could never create risk factors for TMD is a naïve clinical thought. Orthodontists need to establish their treatment goals by considering both the occlusal position and the stable joint position. Establishing orthopedic stability in the masticatory is an important concept for maintaining a healthy masticatory system for a lifetime.

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