2. Orofacial Examination.

a. Muscle Palpation

The muscles of mastication, including the neck, shoulders, back and intercostal muscles may be palpated to facilitate a differential diagnosis.

Foreman (1985) suggests that the purpose of muscle palpation is to identify the presence of active trigger points which may be referring pain to the TMJ and other facial structures.

Muscles which may have trigger points referring to both local and distal facial structures include superficial and deep bodies of masseter, anterior and posterior temporalis, medial and lateral pterygoids, digastric, sternocleidomastoid, trapezius, splenius capitus, and the occipital muscles. (Gelb 1977, Foreman 1985).

Figure 6 – Palpation of middle fibres of the temporalis muscle.

Figure 7 – Palpation of the body portion of the masseter muscle.


Figure 8 – Palpation of the medial pterygoid muscle intra and extra orally simultaneously.

Figure 9 - Palpation of the lateral pterygoid muscle (inferior head.)


b. **Joint Noise**

Articular sounds are variable and should be identified with a stethoscope. Klineberg (1986) differentiates them as:

i. "Soft" or popping - Such sounds may not always be present, and may not always occur in the same position in the opening-closing pathway. Klineberg (1986) suggests this may indicate a neuromuscular dysfunction resulting in a mild chronic hypermobility of the meniscus.

ii. "Hard" clicking - Such sounds are always present and usually occur in the same position in the opening-closing pathway. Klineberg (1986) feels this indicates an acute hypermobility of the meniscus.
iii. Reciprocal clicking - Refers to clicking that occurs both on opening and closing of the jaws. Weinberg (1980) and Klineberg (1986) suggest this as being due to displacement of the condyle beyond the confines of the middle of the disk during opening and closing.

iv. Crepitus - there is general agreement in the literature that this is due to degenerative changes and perforations in the disk. (Weinberg 1980, Solberg 1986c)

c. Functional Analysis of Occlusion

An assessment of TM joint dynamics is an important first step in clinical analysis of TMJ function. The degree of mobility provides a guide to the presence or otherwise of normal function.

Solberg (1986c) notes that the premise underlying this approach is that TM pain usually relates reasonably well with the demands of function and therefore functional testing will yield diagnostic rewards.

1. Range of Motion

i. Maximum jaw opening - Proffit and Ackerman (1985) state that maximum jaw opening for children is usually less than 45mm, while for adults it should be 45–65mm. In neither children nor adults should the mandible deviate laterally during opening. Solberg (1986b) suggests that a 40mm intercincisal opening is a realistic lower limit for persons from 10–70 years of age.

Proffit and Ackerman (1985) note that in children, either limitation of opening or lateral
deviation usually is the result of previous injury to one or both condyles. If scarring in the area of
the TMJ occurs, so that translation of the mandible is impeded, there will be an interference with
normal growth. If a child can only open on a hinge movement, the resulting limitation of maximum
opening may be the first sign of a potentially serious problem.

ii. Opening and Closing Pathways

Klineberg (1986) suggests that jaw deviation on opening and/or closing may also relate to
dysfunction, in the absence of an abnormality of bony origin (eg condylar fracture, ankylosis) or
soft tissue origin (eg infection, inflammation, pathology) It may indicate the presence of jaw
muscle spasm or the presence of an inter-articular derangement.

iii. Lateral jaw movement

As well as assessing movements in the sagittal plane, freedom of movement in the horizontal
plane should also be noted.

2. Occlusal Analysis

It is important to establish the path of closure of the mandible to determine whether the
maximum intercuspal position (centric occlusion) corresponds to the retruded contact position
(centric relation).

As discussed in Chapter 1, centric relation is the key position of reference that allows the
orthodontist to relate the occlusion to the joint articulation and to the correct functioning of the
neuromuscular system. On centric relation closure there should be even contacts of all the posterior teeth in centric relation to produce a stable occlusion.

Timm et al (1976) notes that centric relation should be on the same relative horizontal plane as centric occlusion for each tooth, and there should be no slide from centric relation to centric occlusion caused by deflective tooth contacts on inclined planes in centric relation closure.

The presence of supracontacts, especially on posterior teeth, has been considered to be of considerable importance in the aetiology of TMJ and MPD syndrome, as was discussed in Chapter 2.

Klineberg (1986) states that supracontacts have the potential of altering the approach and departure angle of tooth contact during jaw movement and so may vary the co-ordinated patterning and timing of jaw muscle contraction.

It is clinically apparent that supracontacts suddenly introduced as a result of treatment, such as restorative, prosthetic or orthodontic treatment, can cause the above changes, if the supracontacts are sufficiently large. Although minor irregularities may be accommodated by soft tissue resiliency (periodontal and articular), and may not cause any problems, Klineberg (1986) believes that more pronounced irregularities may cause alterations in muscle activity, which may result in regional areas of muscle hyperactivity and myofascial pain.

Gross occlusal interferences should therefore be noted, particularly if they are balancing type interferences which prevent cross arch contact on the working inclines. ( Solberg, 1986c). According to Klineberg (1986), if supracontacts are present on posterior teeth, torque forces develop around these supracontacts during parafunctional clenching that may cause condyle and disc displacement and muscle asynchrony. It is for these reasons that balancing contacts are
potentially of greatest concern in this regard.

**Parafuction**

During parafuction, the customary controls of jaw movement are absent and tooth contact is sustained. These sustained tooth contacts may result in rapid loss of tooth surface structure with the development of bruxofacets. The loss of permanent tooth structure occurring on the contact surfaces of opposing teeth is often seen in adults and may be the cardinal sign of parafunction in young people.

The aetiology of parafunctional jaw movement is complex, yet there appears to be agreement in the literature that some daytime and all nocturnal parafunctional habits are caused by an altered central drive that is usually stress related. (Yemm 1979, Ramfjord and Ash 1983, Klineberg 1986)

Klineberg (1986) notes that in this way and generally unconsciously, the individual generates sustained and heavy loads on teeth that may affect the temporomandibular joints, the jaw muscles as well as the opposing teeth.

3. **Special Tests**

   a. **Study casts**

   Solberg and Seligman (1985) believe that the mounting of study models on an articulator for all orthodontic cases is not required. Rather, it is an elective procedure to be used in the treatment...
planning of complex occlusal conditions, for the measurement of relationships during treatment and to facilitate post-treatment occlusal adjustment.

Although a great deal of information can be obtained and stored from hand held diagnostic casts, they will not provide any information about the relationship between the occlusion and the temporomandibular joints, especially with respect to excursive and retrusive interferences. These relationships can only be studied by an intraoral examination and by articular analysis.

Where a TMJ dysfunction is suspected, properly mounted study models are an important aid to diagnosis. (Gelb and Bernstein 1983, Klineberg 1986) It must be emphasized, however, that errors may be introduced during the clinical and laboratory procedures, and one must be aware of these possibilities and take steps to minimise potential errors.

Properly mounted study casts allow convenient visualization and measurement of discrepancies between centric relation and centric occlusion, and the presence and effect of balancing and working side contacts.

According to Klineberg (1986), the use of an adjustable articulator such as the Denar Mark II, also makes it possible to examine the displacement of the condylar sphere on the articulator when the casts are positioned in intercuspal position, having been articulated in centric relation.

b. **Radiographs**

It is a general rule of diagnosis that the decision to order radiographs should only be made in anticipation that they will provide some diagnostic information, not otherwise available. Bearing
this in mind, radiographs of the TMJ should be considered mostly for cases where the cause of pain
and dysfunction cannot be understood, or where conservative short term care does not alleviate the
symptoms.

Solberg (1986d) notes that it is not consistent with good patient management to subject all
patients complaining of various signs and symptoms of temporomandibular disorders to
radiographic procedures. However, to ignore the diagnostic indications for TMJ radiograms on
selected patients is equally untenable.

Various projections of the TMJ may be used to study the hard tissues of the condyle and fossa
including transcranial, transorbital and transpharyngeal. For a more specific discussion on the
technique and practical evaluation of lateral temporomandibular joint radiographs, the reader is
referred to the work done by Weinberg in this area. (Weinberg 1972a, Weinberg 1972b, Weinberg
1984)

According to a number of authors, the incidence of TMJ dysfunction syndrome with the
condyles asymmetrically placed in the fossae is greater than 90%. (Weinberg 1972b, Weinberg
1979a, Bassette et al 1974.)
Fig. 1. The superior portion of the temporomandibular fossa is usually symmetrical; AM, auditory meatus.

Fig. 2. Condylar concentricity exists when the anterior (A) and the posterior (P) joint spaces are equal.

Fig. 3. When the posterior joint space (P) is less than the anterior joint space (A), the condyle is retruded.

Fig. 4. Condylar protrusion is demonstrated when the posterior joint space (P) is larger than the anterior joint space (A).

Figure 10 - Diagrammatic representation of orientation of condyle in fossa.

Reference: Weinberg (1972b) p.520.

Tomographic techniques allow various 'cuts' to be taken through the joint, only a relatively thin section being in focus at any one time. According to Solberg (1986d), tomography has become
the standard for comprehensive evaluation of the bony components of the TMJ, because it allows visualisation of the temporal and condylar components.

Figure 11 - Linear tomogram of a patient with troublesome joint noise and discomfort taken in the frontal plane with the jaw in a protruded position.

Reference: Solberg (1986d) p.200

Note gross arthrotic changes in the lateral half of the articular eminence and condyle revealed by this projection.
Solberg (1986d) also notes that projections of the TMJ should follow standard radiological principles and be taken in two or more planes. With tomography, sagittal closed views should be taken in the medial, central and lateral parts of the joint. Most importantly, the views taken should represent maxillomandibular positions of clinical relevance.

c. **Arthrography**

Arthrography is a technique for the radiographic study of joints by the injection of a contrast medium (dye, air, or a combination) into the joint space. This technique has proven to be extremely reliable, with correlation between radiographic findings and direct observation at surgery being in the 90% range, according to Moloney (1985).

The clinician should be guided by the Report of the Presidents Conference of the American Dental Association (Griffiths 1983) which suggested that TMJ arthrography is not recommended as a routine diagnostic procedure to assess internal joint derangements.

Moloney (1985) suggests that this procedure should be used in the following situations:

i. Those patients with a strong clinical indication of internal derangements where non-surgical therapy of adequate duration has not resolved the symptoms.

ii. Persistent pain in the temporomandibular joints.

iii. All presurgical cases.

iv. Those cases where the history and physical examination suggest an acute rupture of the disc.

Although arthrography is considered useful for evaluating TMJ disc displacement, the method
is invasive and can expose the patient to relatively high levels of radiation. (Bleschke et al, 1980). It is also often painful, time consuming, and requires sophisticated equipment as well as considerable experience in the conduct of the procedure.

d. Other Techniques.

A number of highly specialized procedures such as Computer Assisted Tomography (CAT) (Blankestijn et al 1983) provides another tool for diagnosis. Moloney (1985) suggests this is particularly useful in those cases where the inferior joint space has been destroyed by adhesions between the disc and condyle and the entrance of dyes for arthrography into this potential space is not possible.

Instrumentation methods such as electromyography may be used for evaluating muscle activity in relationship to muscle contraction headache, TMJ and muscle dysfunction, and for determining the electromyographic silent period. Although electromyography has diagnostic value, the instrumentation required is used more as a research tool than for diagnosis. (Ash, 1986)

3.3 Differential Diagnosis

Establishing an accurate diagnosis is accomplished by taking a careful history, performing a thorough examination, and having a knowledge of the various other conditions that can produce signs and symptoms similar to those of TMJ and MPD syndromes.

The following tables provide a useful guide for the differentiation of those nonarticuler conditions that produce pain resembling that of MPD syndrome (Table 1), those that produce
mainly limitation of jaw opening (Table 2), and pathologic conditions of the TMJ (Table 3).

Table I. Differential diagnosis of nonarticular conditions mimicking pain of MPD syndrome

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Limitation</th>
<th>Muscle tenderness</th>
<th>Diagnostic features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulpitis</td>
<td>No</td>
<td>No</td>
<td>Mild to severe ache or throbbing; intermittent or constant; aggravated by thermal changes; eliminated by dental anesthesia; positive x-ray findings</td>
</tr>
<tr>
<td>Pericoronitis</td>
<td>Yes</td>
<td>Possible</td>
<td>Persistent mild to severe ache; difficulty swallowing; possible fever; local inflammation; relieved with dental anesthesia</td>
</tr>
<tr>
<td>Otitis media</td>
<td>No</td>
<td>No</td>
<td>Moderate to severe earache; pain constant; fever; usually history of upper respiratory infection; no relief with dental anesthesia</td>
</tr>
<tr>
<td>Parotitis</td>
<td>Yes</td>
<td>No</td>
<td>Constant aching pain, worse when eating; pressure feeling; absent salivary flow; ear lobe elevated; ductal suppuration</td>
</tr>
<tr>
<td>Sinusitis</td>
<td>No</td>
<td>No</td>
<td>Constant aching or throbbing; worse when change head position; nasal discharge; often molar pain not relieved by dental anesthesia</td>
</tr>
<tr>
<td>Trigeminal neuralgia</td>
<td>No</td>
<td>No</td>
<td>Sharp stabbing pain of short duration; trigger zone; pain follows nerve pathway; older age group; often relieved by dental anesthesia</td>
</tr>
<tr>
<td>Atypical (vascular) neuralgia</td>
<td>No</td>
<td>No</td>
<td>Diffuse throbbing or burning pain of long duration; often associated autonomic symptoms; no relief with dental anesthesia</td>
</tr>
<tr>
<td>Temporal arteritis</td>
<td>No</td>
<td>No</td>
<td>Constant throbbing preauricular pain; artery prominent and tender; low grade fever; may have visual problems; elevated sedimentation rate</td>
</tr>
<tr>
<td>Trotter’s syndrome (nasopharyngeal carcinoma)</td>
<td>Yes</td>
<td>No</td>
<td>Aching pain in ear, side of face, lower jaw; deafness; nasal obstruction; cervical lymphadenopathy</td>
</tr>
<tr>
<td>Eagle’s syndrome (elongated styloid process)</td>
<td>No</td>
<td>No</td>
<td>Mild to sharp stabbing pain in ear, throat, retromandible; provoked by swallowing, turning head, carotid compression; usually posttonsillectomy; styloid process longer than 2.5 cm</td>
</tr>
</tbody>
</table>

Table I - Differential diagnosis of non-articular conditions mimicking pain of MPD syndrome.

### Table II. Differential diagnosis of nonarticular conditions producing limitation of mandibular movement

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Pain</th>
<th>Muscle tenderness</th>
<th>Diagnostic features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odontogenic infection</td>
<td>Yes</td>
<td>Yes</td>
<td>Fever; swelling; positive x-ray findings; tooth tender to percussion; pain relieved and movement improved with dental anesthesia</td>
</tr>
<tr>
<td>Nonodontogenic infection</td>
<td>Yes</td>
<td>Yes</td>
<td>Fever; swelling; negative dental findings on x-ray; dental anesthesia may not relieve pain or improve jaw movement</td>
</tr>
<tr>
<td>Myositis</td>
<td>Yes</td>
<td>Yes</td>
<td>Sudden onset; movement associated with pain; areas of muscle tenderness; usually no fever Palpable nodules seen as radio-opaque areas on x-ray; involvement of nonmasticatory muscles</td>
</tr>
<tr>
<td>Myositis ossificans</td>
<td>No</td>
<td>No</td>
<td>Palpable mass; regional nodes may be enlarged; may have paresthesia; x-ray may show bone involvement</td>
</tr>
<tr>
<td>Neoplasia</td>
<td>Possible</td>
<td>Possible</td>
<td>Palpable mass; regional nodes may be enlarged; may have paresthesia; x-ray may show bone involvement</td>
</tr>
<tr>
<td>Scleroderma</td>
<td>No</td>
<td>No</td>
<td>Skin hard and atrophic; mask-like faces; paresthesias; arthritic joint pain; widening of periodontal ligament</td>
</tr>
<tr>
<td>Hysteria</td>
<td>No</td>
<td>No</td>
<td>Sudden onset after psychological trauma; no physical findings; jaw opens easily under general anesthesia</td>
</tr>
<tr>
<td>Tetanus</td>
<td>Yes</td>
<td>No</td>
<td>Recent wound; stiffness of neck; difficulty swallowing; spasm of facial muscles; headache</td>
</tr>
<tr>
<td>Extrapyramidal reaction</td>
<td>No</td>
<td>No</td>
<td>Patient on antipsychotic drug or phenothiazine tranquilizer; hypertonic movement; lip snapping; spontaneous chewing motions</td>
</tr>
<tr>
<td>Depressed zygomatic arch</td>
<td>Possible</td>
<td>No</td>
<td>History of trauma; facial depression; positive x-ray findings</td>
</tr>
<tr>
<td>Osteochondroma coronoid process</td>
<td>No</td>
<td>No</td>
<td>Gradual limitation; jaw may deviate to unaffected side; possible clicking sound on jaw movement; positive x-ray findings</td>
</tr>
</tbody>
</table>

Table 2 - Differential diagnosis of nonarticular conditions producing limitation of mandibular movement.

### Table III. Differential diagnosis of temporomandibular joint disease

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Pain</th>
<th>Limitation</th>
<th>Diagnostic features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agenesis</td>
<td>No</td>
<td>Yes</td>
<td>Congenital; usually unilateral; mandible deviates to affected side; unaffected side long and flat; severe malocclusion; often ear abnormalities; x-ray shows condylar deficiency</td>
</tr>
<tr>
<td>Condylar hypoplasia</td>
<td>No</td>
<td>No</td>
<td>Congenital or acquired; affected side has short mandibular body and ramus, fullness of face, deviation of chin; body of mandible elongated and face flat on unaffected side; malocclusion; x-ray shows condylar deformity, antegonial notchting</td>
</tr>
<tr>
<td>Condylar hyperplasia</td>
<td>No</td>
<td>No</td>
<td>Facial asymmetry with deviation of chin to unaffected side; cross-bite malocclusion; prognathic appearance; lower border of mandible often convex on affected side; x-ray shows symmetrical enlargement of condyle</td>
</tr>
<tr>
<td>Neoplasia</td>
<td>Possible</td>
<td>Yes</td>
<td>Mandible may deviate to affected side; x-rays show enlarged, irregularly shaped condyle or bone destruction depending on type of tumor; unilateral condition</td>
</tr>
<tr>
<td>Infectious arthritis</td>
<td>Yes</td>
<td>No</td>
<td>Signs of infection; may be part of systemic disease; x-ray may be negative early, later can show bone destruction; fluctuance may be present; pus may be obtained on aspiration; usually unilateral</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>Yes</td>
<td>Yes</td>
<td>Signs of inflammation; findings in other joints (hands, wrists, feet, elbows, ankles); positive laboratory tests; retarded mandibular growth in children; anterior open bite in adults; x-ray shows bone destruction; usually bilateral</td>
</tr>
<tr>
<td>Traumatic arthritis</td>
<td>Yes</td>
<td>Yes</td>
<td>History of trauma; x-ray negative except for possible widening of joint space; local tenderness; usually unilateral</td>
</tr>
<tr>
<td>Degenerative arthritis</td>
<td>Yes</td>
<td>Yes</td>
<td>Unilateral joint tenderness; often crepitus; TMJ may be only joint involved; x-ray may be negative or show condylar flattening; lipping, spurring, or erosion</td>
</tr>
<tr>
<td>Ankylosis</td>
<td>No</td>
<td>Yes</td>
<td>Usually unilateral but can be bilateral; may be history of trauma; young patient may show retarded mandibular growth; x-rays show loss of normal joint architecture</td>
</tr>
<tr>
<td>Internal disk derangement</td>
<td>Yes</td>
<td>Yes</td>
<td>Pain exacerbated by function; clicking on opening, or opening limited to under 25 mm with no click; positive arthrographic findings; may be history of trauma; usually unilateral</td>
</tr>
</tbody>
</table>

Table 3 - Differential diagnosis of temporomandibular joint disease.

CHAPTER FOUR

POSSIBLE EFFECTS OF ORTHODONTIC TREATMENT ON THE FUNCTIONAL STABILITY OF THE
TEMPOROMANDIBULAR JOINT.

The requirement for a correctly functioning occlusion for the maintenance of oral health is
recognized in all areas of dental practice. The damaging effects of improper function of the
stomatognathic system on the integrity and health of the temporomandibular joints has been
discussed in previous chapters. The orthodontist must recognize that he must maintain a close
balance between orthodontic treatment and the functional status of the temporomandibular joint and
its related musculature, if the functional stability of the temporomandibular joint is to be
maintained.

Solberg and Seligman (1985) note that the ability of the TMJ apparatus to endure
instabilities and tolerate changing mechanics is generally good. In certain instances, however,
orthodontic therapy may be implicated in the aetiology of TMJ and MPD syndromes. This chapter
will attempt to review those factors of orthodontic treatment which could possibly be involved in
precipitating or aggravating temporomandibular joint signs or symptoms in the orthodontic patient.

The question of whether orthodontic treatment causes mandibular dysfunction remains
controversial. As early as 1956 clicking and crepitus of the temporomandibular joint was
reported in teenage retention and post-retention cases. (Thompson 1956).

According to Kalbfleisch (1985), the relationship of orthodontics to mandibular dysfunction
can be categorized according to two separate aetiological conditions:

1. Those aspects of dysfunction resulting from the orthodontically established occlusion
and the lack of co-ordination with the temporomandibular joints and muscles.

2. Those aspects of dysfunction dependent on the actual mechanical techniques of orthodontic treatment.

4.1 Orthodontically Established Occlusion – Possible Iatrogenic Causes of TMJ Problems.

4.1.1 Forced Mandibular Positioning.

Most authors recognize the fact that centric relation is an anatomically and physiologically stable, repeatable position of the mandible that can be considered the most acceptable treatment and reference position.

Weinberg (1979a) found a high incidence of TMJ symptoms in patients with condylar retrusion. In a study of 116 patients consisting of 55 with acute TMJ patients and 61 patients he described as a “general practice control”, Weinberg found radiographically, of the 55 acute TMJ dysfunction patients, 71% had condylar retrusion of which 40% were unilateral and 31% were bilaterally retruded.

In the general practice control group, the incidence of condylar retrusion was approximately one half (36%) of that which occurred in the acute TMJ patients. The proportion of unilateral to bilateral retrusion was almost identical in both groups (approximately 1.4:1).

According to Weinberg (1974, 1979a), the high incidence of condylar retrusion (71%) in the acute TMJ patients indicates that condylar displacement posteriorly is an aetiologic factor in
TMJ dysfunction. Since the proportion of unilateral to bilateral condylar displacement in both groups is almost the same (1.4:1), it would seem, on the basis of this evidence, that the occurrence of condylar retraction itself is the significant factor, rather than if it is unilateral or bilateral.

It would seem possible, therefore, that forced mandibular positioning occurring during orthodontic treatment could precipitate temporomandibular joint disorders.

Roth (1981a) notes that centric relation is only a strained position if attempts are made to forcibly retrude the mandible. According to Solberg and Seligman (1985), the deleterious effects of forced mandibular positioning are more likely to occur in females because they are subject to greater joint laxity (though he gives no evidence for this), and in those patients whose coping mechanisms involve excessive muscular tension or stress related habits.

According to Thompson (1986), many orthodontic patients later develop abnormal joint function, more often the result of continued mandibular growth rather than an effect of treatment. This is largely due to the differential growth of mandible and maxilla which is a common characteristic of pubertal growth. This may be seen in straight type faces as a traumatogenic relation of the incisors in the post-pubertal period in treated or untreated individuals alike. This situation may be anticipated to some extent by an increase in the S-N-B angle while the S-N-A angle remains the same.

Thompson (1986) suggests that in the more pronounced differential growth cases, continuing superior — posterior condylar growth may produce posterior condyle displacement if compensatory forward movement or positioning of the mandible is inhibited by the incisor relations. In this position of posterior mandibular displacement, the condyle is displaced posteriorly and the disk displaced antero-inferiorly on the eminence.
Resulting translatory movements between condyle and disk, not present normally, according to Thompson (1986), represent flaccidity of the joint structures with the resultant clinical symptoms of clicking or crepitus, irregular mandibular movement, restriction of mandibular movement, and even pain.

Perry (1969) also suggests the late pubertal growth of the mandible as being implicated in TMJ dysfunction after orthodontic treatment. If the maxillary dentition is stabilized by a Hawley retainer and there is a minimal overjet relation, latent mandibular growth will be restrained by the maxillary incisors. He believes this places a distal force on the mandible and joint, which can result in internal derangement of the joint.

Bandeen and Timm (1985) reported such a case where the patient developed a chronic temporomandibular disorder of two years duration, subsequent to routine comprehensive orthodontic treatment.

The patient was a girl aged 12 years 9 months with an Angle Class I occlusion and space deficiencies of 6 mm in the maxillary arch and 5 mm in the mandibular arch. The overjet was 2.5 mm and the overbite was 1 mm. Treatment consisted of fixed appliance therapy following the extraction of all four first premolars. A fixed mandibular canine to canine retainer and a maxillary circumferential retainer were delivered at the debanding appointment.

Three years nine months after debanding and one year after the retainers were discontinued, the patient returned to the orthodontic clinic with a chief complaint of pain and clicking in the left TMJ. The patient reported continuous pain in the left TMJ during mandibular movement of any kind.
The patient exhibited an Angle Class I occlusion, a 1 mm overjet, and a 2 mm overbite. The first contacts in the centric relation position obtainable in this symptomatic patient were on the left side, which resulted in a 1 mm vertical slide into centric occlusion. A diagnosis of TMJ disorder (subluxation of the left condyle due to occlusal prematurities) was made.

Occlusal examination revealed that the patient’s initial contacts from rest position to be on the maxillary and mandibular anterior teeth. It was thought that the patient was locked into a retruded mandibular postion. Treatment consisted of maxillary bite splint therapy followed by orthodontic re-treatment with full fixed appliances.

Superimposition of lateral cephalograms before and after initial orthodontic treatment revealed there had been a significant amount of latent mandibular growth after completion of the orthodontic treatment.

Occlusal bite splint therapy and the application of sound principles of functional occlusion resulted in a definitive diagnosis and successful orthodontic re-treatment of a patient with a chronic TMJ disorder directly related to the effect of previous orthodontic treatment.

This case demonstrates that a likely association exists between latent growth of the mandible and orthodontic retention which may produce anterior premature centric contacts causing a retruded positioning of the mandible.

The patient became asymptomatic one month after slight intrusion and changing of the axial inclination of the maxillary incisors, which provided a freedom of centric relation and allowed the condyle to seat in its correct position in the fossa.
This case was discussed in some detail as it is one of the very few cases reported in the literature where a direct relationship between orthodontic treatment and internal derangement of the temporomandibular joints has been cited.

4.1.2 Significance of Dual Bite.

Dual bite has been defined by Ingervall and Egermark-Eriksson (1979) as:

"An abnormally long anteroposterior difference between the retruded and intercuspal positions of the mandible."

The average "normal" distance is 1 mm or less in adults and children with a range of variation from 0 to 2 mm (Williamson 1976, Ramfjord and Ash 1979). If the distance is greater than 2 mm, the occlusion is classified as a dual bite (Egermark-Eriksson et al 1979). That is, the patient has two occlusal positions he finds comfortable, and in which the upper and lower teeth fit well together. The most anterior of these positions is the intercuspal position of the mandible, and the most posterior approximates the centric relation position of the mandible.

Tallgren et al (1979) conducted an electromyographic study of thirteen children with dual bite. The activity of the anterior temporal and masseter muscles was studied electromyographically during clench and light tapping in the posterior occlusal contact position and centric occlusion and in protrusive bite on the incisors.

The findings in this study indicated that the optimal muscle function during maximal clench and tapping was displayed in the posterior occlusal contact position, which in this study was on
average, 0.5 to 1 mm anterior to the centric jaw relation.

It should therefore be recommended that, in orthodontic treatment of children with dual bite, the intercuspal position (centric occlusion) should be established in the posterior occlusal relationship. This is in accordance with the opinion of a number of authors (Beyron 1969, Ingervall 1968, Roth 1973, Timm et al. 1976, Ramfjord and Ash 1983).

There are few studies in the literature concerning the prevalence or etiology of dual bite. Egermark-Eriksson et al. (1979) believe it may be of developmental origin, or it may result from unsuccessful orthodontic treatment or prosthetic treatment.

Egermark-Eriksson et al. (1979) conducted a study of twelve dual bite patients aged 11 - 60 years, with a median age of 17 years. The patients were examined clinically, radiographically and with the use of dental study casts. Three subjects had had no orthodontic treatment, three had had orthodontic treatment in the upper jaw, and six had been treated with an activator, alone or in combination with other appliances. The authors concluded that orthodontic treatment, particularly the use of an activator alone or in combination with other appliances, may result in the establishment of a dual bite situation.

Egermark-Eriksson et al. (1979) found in their sample that the symptoms of mandibular dysfunction were not very common or severe, with only four patients reporting symptoms at the time of investigation. They did note, however, that the severity of both subjective and clinical symptoms tended to increase with age, which suggested to them that the presence of a dual bite resulting from orthodontic treatment, or any other cause, could involve a long term risk of development of TMJ pain and dysfunction.
An electromyographic study by Ingervall and Egermark-Eriksson (1979) of patients with dual bite, found an imbalance in the muscle activity in the anterior and posterior temporalis and masseter muscles during maximal biting activity. The duration of the muscle activity in the individual chewing cycles was longer in the subjects with dual bite than in the controls.

The authors interpreted these results as being due to instability in the occlusion. This provides further evidence of the functional importance of creating a stable occlusion in the centric relation position in all orthodontically treated cases.

4.1.3 Occlusal Interferences Following Orthodontic Treatment.

The failure of orthodontic treatment to produce occlusal harmony, especially the failure to eliminate premature contacts in centric relation and balancing contacts on mandibular excursions, has been implicated as contributing to TMJ disorders. The possible aetiological significance of these faults in occlusal stability were examined in Chapter 2.

There are a number of studies in the literature which have attempted to study functional occlusal relationships in patients after orthodontic treatment. Ahlgren and Posselt (1963) recorded the presence of balancing side contacts and functional slides from centric relation to centric occlusion in 23 orthodontically treated and 120 untreated subjects. Both fixed and removable appliances had been used to treat the 23 orthodontic subjects, while the untreated subjects had various types of Angle malocclusions. Eccentric contacts were detected by way of either occlusal indicator wax directly in the mouth or articulator mounted casts in the more complicated cases.
In this study, balancing side contacts and slides from centric occlusion to centric relation greater than 1 mm, were observed in 14 of the 23 treated subjects (61%) and in 76 of 120 untreated subjects (55%).

Cohen (1965) examined 40 orthodontically treated patients, and 36 persons with occlusions which in the author's opinion were within a normal range, for the purpose of determining whether or not there were any occlusal interferences in centric relation and centric occlusion. The time lapse between the completion of treatment and examination for prematurities in the treated patients ranged from 2 months to 6 years and 5 months, with a mean of 2.4 years. The mean age of the treated patients was 16.4 years, and that of the untreated patients was 16.1 years.

Cohen (1965) found a glide or shift of the mandible following the initial contact of the teeth in 75% of the treated patients and 80% of the untreated patients. Premature contacts in centric relation were found in 90% of the treated and 81.7% of the untreated patients. Premature contacts in centric occlusion were found in 92.5% of the treated and 94.4% of the untreated patients.

The mesio-buccal cusp as well as the disto-buccal cusp of the second molar in the treated patients had more premature contacts in centric relation than in centric occlusion. Cohen (1965) related this to the fact that in only four of the treated patients were the maxillary and mandibular second molars included in the mechanotherapy.

Gazit and Lieberman (1973) compared the occlusion of 263 male dental students divided into four groups. Group 1 consisted of 27 students treated orthodontically with the removal of four premolar teeth. Group 2 comprised 57 students treated orthodontically without extractions. Group 3 consisted of 115 untreated students with "good" occlusion, and Group 4 consisted of 64
untreated students with "poor" occlusion.

Students qualified for the first two groups on the basis of having worn fixed appliances for a period of at least a year. The total surface contact area was recorded with an impression compound bite, and tooth contacts were measured by a transillumination technique.

Approximately 30 - 35% of the students had balancing side contacts present in their molar region, with no difference between the orthodontically treated and untreated groups. Functional slides in centric relation were present in 70 - 76% of the subjects.

The untreated malocclusion group showed significantly less occlusal contact in centric occlusion than the other three groups, which indicated that the two orthodontic groups that had extraction and non-extraction treatment had occlusions similar to those of the orthodontically untreated good occlusion group.

More recently, Sadowsky and Begole (1980) compared the eccentric occlusal contacts of 75 orthodontically treated subjects aged 25 - 55 years, who had been treated with fixed edgewise appliances at least ten years previously, with 75 untreated subjects with a variety of malocclusions aged 25 - 55 years.

A mandibular slide from centric relation to centric occlusion was observed in 70 subjects in the orthodontic group and all 75 subjects in the control group. The slide was judged to be absent or minimal (less than 1 mm) in 29 orthodontic subjects, with only one subject exhibiting a slide greater than 3 mm. In the control group, 17 subjects exhibited a minimal slide and 5 subjects had a slide greater than 3 mm.
In cases exhibiting a slide, the direction of the slide was anterior in 64 subjects in the orthodontic group and lateral in 6 subjects. The direction of slide in the control group was anterior in 61 subjects and lateral in 14 subjects. Significantly, more of the orthodontic patients exhibited no slide, whereas a greater number of control subjects displayed a slide of more than 3 mm.

In the orthodontically treated group, tooth contacts during lateral excursions were present on the right balancing side in 57 subjects and on the left balancing side in 60 subjects. In the control group, tooth contacts during lateral excursions were present on the right balancing side in 58 subjects and on the left balancing side in 50 subjects. Balancing contacts on lateral excursions were present unilaterally or bilaterally in 66 subjects in the orthodontically treated group and in 58 subjects in the control group. Posterior contact on protrusion was present in 39 subjects in the orthodontically treated group and in 41 subjects in the control group.

Rinchuse and Sassouni (1982) conducted an investigation to compare the eccentric occlusal contacts, as measured from patient dictated closure, of orthodontically treated with untreated subjects.

In this study, one hundred orthodontically treated, fully banded, edgewise retention cases that were judged from their post-treatment records to have been well treated were selected. Each patient had four premolars missing as a result of orthodontic extractions. Apparently, no attempt had been made during treatment to treat any patient to any standard of functional occlusion. Rather, treatment was directed at treatment of static occlusion abnormalities. Also, none of the patients had second molars banded during treatment.

Twenty four patients were selected from the original 100 cases on the basis of their lack of relapse, and their having worn no retainers for at least three months. A similar group of
retention cases were used to select 25 subjects for a second group. The only difference to the above group was that no teeth had been extracted as part of the orthodontic therapy. The final group consisted of 27 subjects who were judged to have an “ideal” static occlusion, but had never undergone any orthodontic treatment.

Functional, working and balancing and protrusive occlusal contacts were recorded for all subjects using Citricon (Kerr Dental Products) base bite registration material. The reliability of measurements was checked by repeating the records and measurements on thirteen of the seventy six subjects. The number and location of the tooth contacts were found to be identical for all repeated measurements.

The Citricon records were examined, and the location and size of each perforation were traced onto square millimetre graph paper on which outlines of a mandibular arch had been superimposed. From this record, all data concerning the number, location, and size of each tooth contact could be easily collected and transferred to the square millimetre grid. Also recorded in this investigation was the over all functional type of occlusion (as recorded from centric occlusion), such as canine protected occlusion, group function occlusion and bilateral balanced occlusion.

In this study, Rinchuse and Sassouni (1982) found there was little difference in the number, location, and severity of balancing side contacts and protrusive contacts between forty nine university treated orthodontic patients and twenty seven untreated subjects who had an “ideal” static occlusion. Ninety seven percent of the treated and eighty five percent of the untreated patients had balancing side contacts, and according to the authors, at least within the parameters of this investigation, the eccentric occlusal contacts of orthodontically treated and comparable untreated subjects were similar.
The results of the study by Rinchuse and Sassouni (1982) were in agreement with the investigations by Ahlgren and Posselt (1963), Cohen (1965), Gazit and Lieberman (1973) and Sadowsky and BeGole (1980), which have all shown there is no statistically significant difference in the number and type of functional occlusal contacts between orthodontically treated subjects with "ideal" occlusions or in some cases, malocclusions.

The occurrence of prematurities on the balancing side is the most likely factor in the occlusion which seems to be of some aetiological significance in the development and progression of TMJ dysfunction and MPD syndromes, as has been suggested by Geering (1974) and others. In fact these prematurities probably cause more changes in the muscular contraction pattern and the mandibular reflex movements than prematurities in other jaw positions. (Scharer and Stallard 1967, Klineberg 1986).

Therefore, although the role of the occlusion in the aetiology of TMJ dysfunction and MPD syndromes remains inconclusive, occlusal prematurities can disturb function, and in this regard, balancing side interferences are the most dangerous.

The above studies by Ahlgren and Posselt (1963), Cohen (1965), Gazit and Lieberman (1973), Sadowsky and BeGole (1980) and Rinchuse and Saouni (1982), all concluded that although the occlusions which received orthodontic treatment in their studies satisfied the generally accepted objectives of treatment, all possessed varying numbers of prematurities in function.

The most striking result of the above studies is the similarity in frequency and location of occlusal prematurities between persons with normal occlusions and those with orthodontically treated occlusions. The fact is that prematurities do exist in mouths with good occlusions as well as in those with orthodontically treated occlusions.
It seems, therefore, when comparing patients with post-orthodontic occlusions to control groups of patients with normal, untreated good occlusions, or even in some cases with various types of malocclusions, that there are minimal differences in functional occlusal contacts. This information would seem to suggest that generally, the post-orthodontic occlusion in itself does not predispose a patient to mandibular dysfunction to a greater extent than already exists in the general population. (Kalbfleisch 1985.)

4.2 Mechanical Effects of Orthodontic Treatment - Possible Iatrogenic Causes of Temporomandibular Joint Problems.

Intermaxillary anchorage may be defined as a type of force application in which the teeth of one jaw are used as resistance units to move the teeth of the other jaw. (Adams et al 1972). The forces are usually applied through the use of elastic rubber bands.

The use of intermaxillary elastics in the correction of malocclusion was first described by Case (1893). The method has gained wide clinical acceptance, although its effect on the developing facial complex remains controversial. Numerous studies have been conducted over the years in an attempt to interpret the effects of intermaxillary force on structures such as the temporomandibular joint. These experiments, by necessity, have all been conducted on experimental animals.

4.2.1 Animal Experiments - Effects of Intermaxillary Forces on Temporomandibular Joints.

Meikle (1970) used three adult Macaca mulatta monkeys to study the effects of
intermaxillary elastics on the dentofacial complex. Two animals had Class II elastics and one had Class II elastics on the left and Class III on the right. The elastics were secured by means of labiobuccal splints wired to the teeth.

Forces ranging from 150 - 250 grams were used, with the experiments ranging over a period of 6 to 14 weeks. During this time the animals were confined to "chairs" to prevent dislodgment of the appliance. In vivo bone marks were produced with oxytetracycline and Procion red H8-B5 dye injected intramuscularly. Histologic controls were provided by using the heads of six previously sacrificed monkeys.

Meikle (1970) observed histologically that the areas of articular tissue in the temporomandibular joint subjected to excessive compression by external mechanical forces, in the form of intermaxillary elastics, showed metaplastic conversion to a tissue resembling hyaline cartilage, associated with localized areas of regressive remodelling of the subarticular bone. The changes did not result in any alteration in the articular surface contour. Furthermore, none of the remodelling changes were considered to be of clinical significance under the experimental conditions.

Adams et al (1972) applied Class II and Class III mechanics to four monkeys 21 - 32 months old and to three adults, more than 6 years old. The forces were applied to full upper and lower splints in order to reduce the amount of tooth movement and to cause as much craniofacial remodelling as possible. The amount of intermaxillary force was regulated at various levels between 75 and 250 grams for periods ranging from 43 to 118 days. Control data on normal craniofacial growth was obtained from previous studies on large samples of monkeys.

At the end of the experimental period, some histological changes were noted in the
temporomandibular joints. Where Class II elastics were used, condylar ossification appeared to be directed more posteriorly than normal and the shape of the condyle became less rounded.

Adams et al (1972) interpreted these findings as an alteration in the direction, but not necessarily in the amount of condylar growth. A Class II intermaxillary force applied to adult monkeys produced definite histologic changes along the articular eminence, but no increase in the amount or direction of condylar growth was evident.

The experiments by Adams et al (1972) have shown that whereas tooth migration can be induced by the use of intermaxillary force, functional adaptation (i.e. alterations in the amount and direction of growth) does not readily occur even under the influence of heavy forces.

Payne (1971) conducted cephalometric and histologic studies of the effects of Class II elastics on the temporomandibular articulation of growing Macaca mulatta monkeys using light forces. Seven monkeys were used in the experiments - five as cephalometric controls, one as a cephalometric and histologic control, and one as the experimental animal. All the animals were of a similar age, approximately 24 months, such that the dentitions corresponded to the mixed dentition stage in man.

Thin wall latex elastics delivering 20 - 30 grams of force were placed bilaterally from the molar hook on the mandibular molar bands to hooks on the maxillary arch wire. This force was apparently chosen empirically as the level at which the experimental animals gave no evidence of mesial accommodation of the mandible.

Payne (1971) found histologically, the gross appearance of the condylar head, disc and glenoid fossa in the experimental animal to be very similar in appearance to that of the histologic
control animal. There was a normal joint space in both compartments, and the thickness of the cartilaginous cap of the condyle appeared normal. There was some evidence of resorption on the anterior surface of the condyle directly beneath the attachment of the lateral pterygoid muscle, though by comparison with the control animal, this was found to be associated with normal relocation of the muscle attachment during growth.

The most significant finding in the study by Payne (1971), was the lack of pathologic change in the joint structures in the experimental animals. Histologic examination revealed no evidence of traumatic resorption or pathologic change in the articular disc or related structures resulting from the use of Class II elastic forces of 20 to 30 grams in the growing macaque monkey.

4.2.2 Skeletal and Neuromuscular Adaptation to Orthodontic Forces.

To investigate the relationship between altered muscle function and skeletal adaptation of the temporomandibular joint, McNamara (1975) conducted a study of alterations in patterns of muscle activity due to forced mandibular protrusion, in Macaca mulatta monkeys.

In one experiment, McNamara (1973b) used a total of 64 rhesus monkeys (Macaca mulatta) of various age levels. Maxillary and mandibular onlays were cemented to their teeth, producing a forced functional protrusion of the mandible. Twenty eight animals were used as the basic sample and thirty six as histologic and/or electromyographic controls. The experiment lasted for 26 weeks and this was divided into two equal segments:

1. A control period for collection of normal neuromuscular and skeletal data from all monkeys.
2. A subsequent period in which the growth data of the experimental animals and the control animals was compared.

The lateral pterygoid muscle gradually increased in activity after appliance cementation, with muscular discharges evident in functional movements and during the maintenance of the mandibular postural position. McNamara (1973b, 1975) found the frequency of tonic discharges increased in successive recordings usually reaching a maximum at four to eight weeks. After this time there was a gradual reduction in the frequency and duration of this altered lateral pterygoid activity. In many animals, a "normal" pattern of muscle function reappeared at 12 to 24 weeks after appliance cementation.

McNamara (1973b) found after 13 weeks, little histologic evidence of physiologic or pathologic responses to the induced protrusive function was evident in the sacrificed animals. He felt, therefore, that the histologic findings were consistent with past studies, such as by Stockli and Willert (1971) and Elgoyen et al (1972), which suggest that the adult temporomandibular joint was stable and resistant while the growing joint was responsive to functional changes.

The results of McNamara’s (1973b) study indicates that a chronologic correlation exists between the occurrence and disappearance of altered neuromuscular function and the re-establishment of skeletal balance. As skeletal balance was restored through specific structural adaptations, the need for compensatory muscle function was reduced.

The results of such animal experiments in relation to TMJ and MPD syndromes become clear. When the mandible is displaced by extrinsic forces applied to the animal by intermaxillary elastics or even by forced mandibular displacement as caused by various types of functional appliances, the temporomandibular joint region of the treated animals did not differ significantly from the control
animals. In other words, there seemed to be little if any effect of the intermaxillary traction on the growth of the components of the temporomandibular joints. The minor histologic changes seen did not result in an alteration in the articular surface contour.

These animal experiments would seem to suggest that intermaxillary forces, in themselves, are unlikely to cause physiologic or pathologic changes in the joint structures that could be implicated in the development of TMJ or MPD syndrome symptoms.

The animal studies by McNamara (1973b) were not designed to look for signs or symptoms of TMJ dysfunction and no direct comparison between these animal experiments and TMJ dysfunction in humans is intended. However, these experiments do provide some insight into the neuromuscular adaptations that occur in the activity of masticatory muscles, particularly lateral pterygoid muscle, in the event of forced mandibular protrusion as occurs with the use of certain functional appliances and could possibly occur under the influence of Class II elastics, and in this regard they are of some relevance.

In the human situation the question of whether such neuromuscular adaptations can be withstood by the patient, or whether they are outside the range of adaptability of a patient will depend on the individual case. The fact that not all patients subjected to forced mandibular repositioning by intermaxillary elastics do not develop TMJ or MPD syndrome symptoms is indicative of the adaptability of the masticatory system, and its capacity to maintain health and function under stress.

The conclusion to be drawn from these animal experiments on neuromuscular adaptation, is that in the "normal" individual under orthodontic treatment, any adaptations that do occur will be well within the range of adaptability of the patient and no symptoms will result. In the patient who
is predisposed by other factors to develop a temporomandibular related dysfunction, the use of intermaxillary forces may complement any other predisposing factors, such that the ability of the patient to adapt to the new stresses is exceeded. In these cases dysfunction symptoms may develop. That is not to say that all compromised patients will develop dysfunction symptoms under the effect of intermaxillary forces; clearly there will be a wide degree of variation in response.

Due to the fact that a period of neuromuscular adaptation does occur in patients undergoing mandibular displacement as a part of orthodontic treatment, it is suggested that the forces causing such displacement, in a patient predisposed to temporomandibular joint problems, may conceivably be implicated as contributing factors only, in the development of any temporomandibular joint related disorder.
CHAPTER FIVE

ORTHODONTIC TREATMENT IN RELATION TO SYMPTOMS ATTRIBUTED TO DYSFUNCTION OF THE TEMPOROMANDIBULAR JOINT—CLINICAL AND EXPERIMENTAL EVIDENCE.

It is the purpose of this chapter to investigate the evidence contained in the literature examining the question of whether orthodontic treatment may induce temporomandibular joint disorders.

Williamson (1977) conducted a survey designed to investigate the percentage of potential temporomandibular dysfunctional patients seen as adolescents prior to orthodontic treatment. 304 patients were screened for routine orthodontic treatment in the Ohio State University Orthodontic Department. Ages ranged from 6 to 16 years with a mean age of 12.9 years. There were 129 boys and 175 girls.

Sensitivity of the muscles of mastication were tested by palpation in each subject. The patient was requested to state whether pain was present and, if it was, to describe it as mild, moderate or severe. Joint noises were also assessed by having the patient open and close with the operators fingers over the temporomandibular joints. Audible and digital sensations were used by the investigator to determine the result.

In the study by Williamson (1977), of the 304 subjects screened, 107 were symptomatic. This amounted to 35.2% with pain, clicking or both, unilaterally or bilaterally. It may be postulated, according to Williamson (1977), that 35% of the potential orthodontic patients, 6 to 16 years of age, seen by a practitioner have incipient temporomandibular joint dysfunction.
Similar studies have reported equally high percentages for incipient signs of TMJ dysfunction in children and adolescents. Grosfeld and Czarnecka (1977) found musculo-skeletal disorders, such as muscle sensitivity and joint sounds in 56% of children aged 13 - 15 years.

Eriksson, Carlsson and Ingervall (1981) examined 402 children in three different age groups, 7, 11 and 15 years, and found clinical signs of dysfunction in 30% of those in the youngest group and in 60% of the oldest group.

Gazit et al (1984) in an examination of the prevalence of mandibular dysfunction in a sample of 369 Israeli schoolchildren, found 56.4% had incipient signs of mandibular dysfunction present. It increased with age from about 51% in the 10 - 13 year olds to 67.8% in the 16 - 18 year olds. The most common sign of dysfunction was joint sounds (35.8%), which increased with age from 28% in the youngest age group to 44.3% in the oldest age group. The second most common sign was joint sensitivity to palpation (30.4%), which showed a slight increase in the oldest age group. Sensitivity of the superficial muscles was recorded third, with 20%. Joint pain and restriction of mandibular movement appeared infrequently.

Although there are obvious differences apparent between these studies in factors such as racial differences, different socio-economic groups, different criteria for signs of dysfunction, and different methods and criteria for examination, certain tendencies are evident which are of critical importance to this study. It is quite clear that all studies show the presence of a high percentage of incipient symptoms of dysfunction evident in all populations of children and adolescents examined. Also, there is a general tendency to an increase in the presence of these symptoms with increasing age.

As early as 1956, clicking and crepitus of the temporomandibular joint was reported in
teenage retention and post-retention orthodontic cases. (Thompson 1956). Kalbfleisch (1985), suggests such conditions may have been caused by orthodontically established occlusion which was not in harmony with mandibular growth and/or masticatory muscle forces; problems examined in the previous chapter. However, whether TMJ problems are a direct result of orthodontic treatment remains most controversial.

Relatively few studies have been reported in which patients who have developed TMJ problems have been analysed in terms of their orthodontic background. Franks (1967), conducted a study designed to distinguish the relative importance of the various factors implicated in the aetiology of TMJ dysfunction. 100 patients who presented with symptoms of TMJ dysfunction were compared with a control group of 100 asymptomatic patients, with a similar age-sex distribution.

Franks (1967) reported 11% of the patients who presented with TMJ dysfunction symptoms had undergone orthodontic treatment, compared with 2% of the control group. However, Franks (1967) noted that the great variation in type and period of treatment reported, prevented formal analysis of these figures.

Perry (1969) found 3% of 1,146 patients with a range of malocclusions in his orthodontic practice, presented with pre-treatment symptoms of TMJ symptoms. The ages ranged from 10 to 23 years. The total sample was divided into three categories: those with symptoms before treatment, during treatment, and after orthodontic treatment.

Perry (1969) found 5.1% developed either transient or continued symptoms during active treatment. While 7.4% first noticed symptoms after treatment, during the retention period. Finally, 5.1% continued to have their problem even after retention was completed. Perry (1969) makes the important note that more than half of this latter group had originally developed their
symptoms before orthodontic treatment.

Sheppard (1977), attempted to clarify the many causative and predisposing factors implicated in the aetiology of TMJ problems. A review of the characteristics of 145 patients with temporomandibular joint and myofacial pain dysfunction syndrome was made using recorded histories and a careful clinical examination. It was found in this study that 16.6% of the patients in the study had previously undergone some form of long term orthodontic treatment (presumably with fixed appliances, though this was not specified), and 12.4% had worn intermaxillary elastics for long periods.

Sadowsky and BeGole (1980) note that much of the information regarding mandibular dysfunction in former orthodontic patients is often subjective and often anecdotal. It is usually based on studies involving patients presenting for pain or discomfort involving the TMJ or related musculature. Consequently, some of these earlier studies tended to show a high incidence of orthodontic patients among those who had ultimately presented with TMJ problems than in control groups of patients without TMJ disorders.

Kalbfleisch (1985) suggests that this relationship may have just been an indication of the frequency of patients who seek orthodontic care, rather than an aetiological factor for mandibular dysfunction. Also, the fact that the percentage of patients with TMJ symptoms may increase through orthodontic treatment as suggested by Perry (1969) may be related to the normal increase with age that occurs in the population as a whole.

Sadowsky and BeGole (1980) conducted a long term study of the status of TMJ function and functional occlusion of 75 subjects between the ages of 25 and 55 years who had been treated orthodontically with full fixed appliances at least 10 to 35 years previously, during adolescence.
The status of the temporomandibular joint function and functional occlusion was evaluated by means of a questionnaire, and a detailed clinical examination. The findings were compared with a similar group of adults with untreated malocclusions.

It was found in this study, that a history of pain or tenderness in the temporomandibular joints or related musculature was elicited in nine subjects of the sample of seventy five orthodontically treated patients many years after treatment with fixed appliances. The prevalence in the control group, of adults with untreated malocclusions, was twice that in the orthodontically treated group, namely eighteen of seventy five subjects. The prevalence of TMJ sounds was very similar in the two groups.

The study by Sadowsky and BeGole (1980), illustrated for the sample, that in patients who had undergone orthodontic treatment many years previously, the prevalence of TMJ signs and symptoms is similar to that of a control group of adults with untreated malocclusions. A positive history of pain or tenderness in the TMJ related musculature was elicited in nine subjects of the orthodontically treated group and in eighteen subjects of the control group. The authors believed that although this difference is not statistically significant, it reflected a trend which suggests that subjects who have undergone extensive fixed appliance orthodontic treatment many years previously, may possibly have a lower prevalence of TMJ problems than a similar group of adults with untreated malocclusions.

In 1981, Janson and Hasund (1981) conducted a study to investigate the effect of orthodontic treatment on the functional stability of the stomatognathic system. Their investigation was based on patients who had had treatment for Angle's Class II Division I malocclusion. The purpose of their study was to determine whether there are any differences in functional disorders between treated and untreated patients with Angle's Class II Division I malocclusion, and also whether different
methods of treatment influence these functional disorders.

In the orthodontically treated sample, different treatment methods had been used. Thirty patients were successfully treated without extractions, while in the remaining thirty cases, four first premolars were extracted. The mean age of all the patients was about 21 years, and sex distribution was approximately equal. Orthodontic treatment was undertaken by post-graduate students under the supervision of tutors at the Department of Orthodontics, University of Bergen.

In the non-extraction group, preliminary treatment was generally started in the late mixed dentition, using a combination of headgear and activator. The main treatment consisted of full fixed appliance treatment using an edgewise appliance, followed by retention with a lower fixed lingual retainer and an upper Hawley appliance.

In the four premolar extraction group, treatment was started with an edgewise appliance without any preliminary treatment. The whole treatment period, active and passive, ranged from 3 - 9 years. At the time of the study, the patients had been out of retention on average for five years (range 1 to 12 years).

Functional diagnosis for the purpose of this study by Janson and Hasund (1981), was based on the history of oral symptoms as well as on clinical examination. The material was sub-divided according to the anamnestic and clinical dysfunction indices of Helkimo (1974) (see appendix 1).

Janson and Hasund (1981) found TMJ sounds to be the most frequent symptom in all three groups. The clinical findings were given in five different groups of disorders:

1. Impaired TMJ function - comprised deviation on opening, closing and protrusion, signs
of luxation, clicking and crepitation. The treated groups were found to be slightly better in all three classes.

Figure 12 - Distribution of individuals according to symptoms of impaired TMJ function (TF).

U = untreated; PE = 4 premolar extraction; NE = non-extraction. (n=90).

No symptom free; N1 slightly disturbed; N5 severely disturbed.

2. **Pain on movement** - A significant difference was found between the four groups. All treated groups showed a larger number of patients without pain and fewer patients with severe pain. An equal number of slight disturbances was seen in the untreated group and the four premolar extraction group.

![Bar chart showing pain on movement](chart.png)

**Figure 13** - Distribution of individuals according to the pain on movement (PM).

U = untreated; PE = 4 premolar extraction; NE = non-extraction. (n = 90).

No symptom free; N1 slightly disturbed; N5 severely disturbed.


3. **Muscle pain** - Both treated groups had more patients free of symptoms than with pain. The area of attachment of the temporal muscle and the lateral pterygoid muscle exhibited the highest frequency of tenderness. Again the non-extraction group showed fewer disturbances than the other groups.
Figure 14. - Distribution of individuals according to palpation tenderness of the masticatory muscles (MP), U = untreated; PE = 4 premolar extraction. NE = non-extraction (n = 90).

No symptom free: N1 slightly disturbed: N5 severely disturbed.


4. **TMJ pain** - No patient exhibited swelling in the TMJ and very few patients presented pain when palpated laterally. The treated groups showed more undisturbed patients than the treated control group and fewer patients with slight disturbances manifest as lateral palpation pain. Only
one patient in the untreated control group displayed severe symptoms.

Figure 15. - Distribution of individuals according to the temporomandibular joint pain (TP).
U = untreated; PE = 4 premolar extraction; NE = non-extraction. (n = 90).
No symptom free; N1 slightly disturbed; N5 severely disturbed.

5. Movement capacity - This examined maximal opening of the mouth, maximum lateral movement to the right and to the left and maximal protrusion. Mean values and standard deviations
were calculated and the only differences were found on maximal opening of the mouth. The four premolar extraction group showed the smallest value and this difference was significant between the control group, the non-extraction cases and the four premolar extraction group.

Janson and Hasund (1981) make the point that comparison with other investigations must be made with caution as differences in method, dissimilarity in ethnic background and variation in the psychoemotional status may lead to different results.

The conclusion that Janson and Hasund (1981) drew from their study is that systematic orthodontic treatment is not a functional risk to patients with Angle's Class II Division 1 malocclusion.

In a similar study, Larsson and Ronnerman (1981) investigated the relationship between extensive orthodontic treatment carried out ten years earlier, and the prevalence of symptoms of temporomandibular joint dysfunction, on 23 patients aged between 24 and 28 years.

The study was carried out on 23 consecutively treated orthodontic patient, 11 boys and 12 girls, with all treatment being conducted by one of the authors. The orthodontic treatment was started during 1966 and 1967 and the investigation into mandibular dysfunction symptoms was carried out in late 1978/ early 1979, about 10 years after the completion of the active orthodontic treatment.

Table 4 provides the breakdown on the patients used in this investigation. The patients in group A were treated with activators. In 3 of the 5 patients in this group an upper expansion plate was used before the activator was inserted. No extractions were performed in group A, whereas premolars were extracted in both jaws in groups B and D, and in the upper jaw in group C. For
treatment with fixed appliances a standardised edgewise technique was used. Headgear was used in 13 cases, including all patients in group C.

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<tr>
<th>Group</th>
<th>n</th>
<th>Diagnosis</th>
<th>Treatment and appliance</th>
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<tr>
<td>A</td>
<td>5</td>
<td>Class II Division 1</td>
<td>Activator</td>
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<td></td>
<td>8</td>
<td>Class II Division 1</td>
<td>Extraction in upper and lower jaws.</td>
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<tr>
<td>B</td>
<td>9</td>
<td>Class II Division 1</td>
<td>Extraction in upper and lower jaws.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Class II Division 2</td>
<td>Full banded in upper and lower jaws.</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>Class II Division 1</td>
<td>Extraction in upper jaw. Full banded in upper jaw.</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>Class I bimaxillary crowding</td>
<td>Extraction in upper and lower jaws. Full banded in upper and lower jaws.</td>
</tr>
</tbody>
</table>

Table 4 - Diagnosis, treatment and type of appliances used in 23 orthodontically treated patients.


The total duration of treatment in group A averaged 34 months. In groups B, C, and D the treatment time varied between 17 and 23 months, and the retention time between 11 and 15 months in the different groups.

Questions concerning the functional status of the masticatory system were asked of each subject in order to obtain information for an anamnestic dysfunction index after Helkimo
(1974)(see appendix 1). The function of the masticatory system was examined clinically using routine methods. This examination comprised measurement of the range of movement of the mandible, evaluation of the function of the patients for pain at rest, and pain on movement of the mandible.

Larsson and Ronnerman (1981) found 65% of the patients exhibited no clinical symptoms. In 31% mild dysfunction was registered, and one patient had severe disturbances. Clicking was found to be the most common dysfunction symptom.

On clinical examination it was found three patients exhibited impaired mandibular mobility and one patient had tenderness on palpation of the muscles of mastication. No patient exhibited pain on movement or palpation of the temporomandibular joint. Symptoms were registered in two out of five patients in group A, three out of nine in group B, and three out of four in group D. All patients in group C were symptomless.

27% of the patients reported mild symptoms according to the anamnestic index after Helkimo (1974). The patients in group A and C were symptomless, whereas three out of nine in group B, and three out of four in group D reported having had mild symptoms of dysfunction.

Of the patients included in the study by Larsson and Ronnerman (1981), 65% had no clinical dysfunction symptoms, 31% had mild symptoms and one patient (4%) had severe symptoms. Epidemiological investigations have consistently shown a high prevalence of temporomandibular dysfunction symptoms in the investigated populations. More than 50% of individuals seem to have temporomandibular dysfunction symptoms according to Helkimo (1979). These figures reported in this study by Larsson and Ronnerman (1981) are definitely lower than those reported by Helkimo.
One of the reasons suggested by Larsson and Ronnerman (1981) for the lower incidence of temporomandibular dysfunction symptoms among patients who had previously undergone orthodontic treatment, is the unusually good dental status of the patients included in their study. No teeth had been extracted because of caries and no untreated cavities were observed at the examination. The authors suggested this was probably partly due to the orthodontic treatment having made the patients more aware of their dental health, and more anxious to keep their teeth in good condition. The educational and socio-economic level of the group was apparently above average, and the 23 patients gave the impression of being very well adjusted to society, and therefore not under inordinate degrees of stress.

It was the conclusion of Larsson and Ronnerman (1981), that extensive orthodontic treatment can be carried out without fear of complications in the form of post-therapeutic temporomandibular dysfunction symptoms.

Considering the association between malocclusion and temporomandibular dysfunction symptoms reported by Ingervall and Thilander (1975), Ingervall (1978), Mohlin and Kopp (1978), and Mohlin et al (1980, Larsson and Ronnerman (1981) felt that in view of the severe malocclusions which all of the patients in their study had previously exhibited, the low prevalence of functional disturbances suggested to them that orthodontic treatment prevents rather than causes such functional disturbances.

In a state-of-the-art workshop in 1977, according to Sadowsky and Polson (1984), it was recognized that little data existed on the long term effects of orthodontic treatment on periodontal health, and the temporomandibular joint. (Enlow et al 1977). Research grants were subsequently made to the University of Illinois and the Eastman Dental Centre in New York, to study the periodontal condition, functional occlusion, and TMJ function in a large group of orthodontic patients
who were treated at least 10 years previously as adolescents. The orthodontically treated group was to be compared to a similar group of adults with untreated malocclusions. Even though the general aims of the two studies were the same, the two research groups conducted the studies independently and without collaboration.

In both the Illinois and the Eastman studies, two groups of subjects were identified. The orthodontic groups consisted of former patients who received comprehensive fixed appliance treatment as adolescents a minimum of ten years previously. There were 96 former orthodontic patients in the Illinois study and 111 in the Eastman study. (Sadowsky and Polson 1984).

In the Illinois sample, 66% of the orthodontic group had Class II malocclusions and 34% had Class I malocclusions prior to treatment. Extractions as part of orthodontic treatment were performed on 30% of the patients.

In the Eastman sample, 64% of the orthodontic group had Class I malocclusions, 30% had Class II malocclusions, and 6% had Class III malocclusions. Extractions as part of the orthodontic treatment was performed on 36% of the patients.

The orthodontic groups were compared to similar groups of adults with untreated malocclusions. In both studies, the untreated malocclusion groups were similar to the orthodontic groups with regard to race, socio-economic level and dental awareness. In the untreated group of subjects in the Illinois study, 45% had Class I and 55% had Class II malocclusions. In the Eastman untreated group, 65% had Class I and 35% had Class II malocclusions. (Sadowsky and Polson 1984).

Results were obtained in both these studies by questionnaire, in which subjects were
questioned as to the presence of discomfort, tenderness, or pain in the region of the TMJ or related musculature. Joint sounds were identified by palpation over the TMJ.

When subjects in the Illinois study were questioned as to the presence of discomfort, tenderness, or pain in the TMJ region or related musculature, either at the time of examination, or previously, there were positive findings in 14.6% of the orthodontic subjects as compared to 21.4% of the untreated subjects. According to Sadowsky and Polson (1984), there was no statistical significance between these percentages.

Similarly, in the Eastman study there were positive findings in 16.2% of the orthodontic subjects as compared to 15.3% of the untreated subjects, a difference also of no statistical significance.

In the Illinois study, TMJ clicking was found in 34.4% of the orthodontic subjects, and 41.8% of the untreated subjects. In the corresponding groups in the Eastman study 32.4% and 28.8% of the subjects respectively, had TMJ clicking.

<table>
<thead>
<tr>
<th></th>
<th>Illinois</th>
<th>Eastman</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Orthodontic</td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td>( n = 96 )</td>
<td>( n = 103 )</td>
</tr>
<tr>
<td>Pain/tenderness/</td>
<td>14.6%</td>
<td>21.4% (NS)</td>
</tr>
<tr>
<td>discomfort.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TMJ sounds.</td>
<td>34.4%</td>
<td>41.8% (NS)</td>
</tr>
</tbody>
</table>

NS = Not statistically significant \( p > 0.05 \).

Table 5 - TMJ signs and symptoms of subjects in Illinois and Eastman studies.

The Illinois and Eastman studies, which were conducted independently, provide further evidence that no greater incidence of temporomandibular disorders occur in orthodontically treated populations. Sadowsky and Polson (1984) concluded that comprehensive fixed appliance orthodontic treatment performed during adolescence, does not generally increase or decrease the risk of developing temporomandibular joint disorders in later life.

Dibbets and van der Weele (1987) conducted a 10 year longitudinal investigation of symptoms attributed to temporomandibular joint dysfunction in orthodontically treated subjects. The stated aim of this study was to test the prevailing assumption that orthodontic therapy is an aetiological factor in inducing TMJ dysfunction.

In this investigation it was assumed that a "temporomandibular joint dysfunction" was present in children who evidenced the following symptoms:

1. Subjective symptoms - Data provided by the participant describing clicking, snapping or noises of one or both temporomandibular joints, following a structured interrogation.
2. Objective symptoms - Observations of clicking, snapping, or crepitation made by an examiner when palpating the temporomandibular joints.
3. Radiographic findings - Deformations of the condylar projection seen on the infracranial radiograph, sometimes accompanied by radiolucency below the articular contour, a defect in this contour, or hypertrophy and lipping, were referred to as X-ray findings.

Two analytic procedures were used in the investigation:

1. Comparison of symptom frequencies in the sample before and after treatment.
2. Analyses of the data after matching for age.
Figure 16.—Relationship to age of the three symptom categories before the start of orthodox treatment. The symptom frequencies for the three categories (sub, ob, x) are expressed in percentages. Rather spiky progressions with unexpected decreases are evident.


Figure 16 represents a graphic representation of the relationship to age of the various symptom categories studies as modified from previous publications from the same authors. (Dibbets 1977, van der Weele, Boering 1985; Dibbets, van der Weele, Uildriks 1985). It depicts the symptom frequencies in successive age classes and is constructed from the records of all participants in the present study by Dibbets and van der Weele (1987), before the start of treatment. The overall tendency indicates an increase in symptom percentages in the older age groups.
Figure 17 - Relationship with treatment time of the three symptom categories. On the x axis, 0 to 4 indicates the number of years after the start of treatment; S + 10 is the 10 year follow up. The symptom frequencies for the three categories (sub, ob, x) are expressed in percentages. The number of subjects at each time point is indicated. There is an overall tendency for frequencies to increase.


The question at issue, however, is whether the increasing frequencies of symptoms are totally accounted for by orthodontic treatment, or whether these children developed symptoms as a normal result of growing older.

To explore this problem, Dibbets and van der Weele (1987) compared 63 children treated with functional appliances (Andresen type activators) and 72 children treated with Begg appliances.
The Begg Class I and Class II treatments consisted mostly of four first premolar extractions. Both groups were made up of 55% girls and 45% boys. Active treatment in 75% of the cases lasted two years; while nearly all procedures were completed within three years.

The participant data were documented before initiating orthodontic treatment, then subsequently for 3 or 4 consecutive years at intervals of 12 months, and finally 10 years after the start of this longitudinal study. The documentation included frontal and lateral cephalograms, panoramic radiographs, specific temporomandibular joint radiographs, facial photographs, dental casts, a case history, and clinical findings and measurements.

<table>
<thead>
<tr>
<th></th>
<th>Subjective</th>
<th></th>
<th>Objective</th>
<th></th>
<th>X ray findings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Activator</td>
<td>Begg</td>
<td>Activator</td>
<td>Begg</td>
<td>Activator</td>
<td>Begg</td>
</tr>
<tr>
<td>t = 0</td>
<td>16%</td>
<td>32%</td>
<td>22%</td>
<td>29%</td>
<td>8%</td>
<td>25%</td>
</tr>
<tr>
<td>t = 4</td>
<td>28%</td>
<td>39%</td>
<td>18%</td>
<td>46%</td>
<td>18%</td>
<td>27%</td>
</tr>
<tr>
<td>t = S+10</td>
<td>47%</td>
<td>52%</td>
<td>48%</td>
<td>44%</td>
<td>24%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Table 6 - Frequency of symptom categories for treatment procedures.


The conclusion from Table 6 is obvious: Begg and activator treatments display differing symptom frequencies. To determine the effect of Begg treatment on TMJ symptoms, it is necessary to derive estimates of symptom frequencies for specific age classes. This may be achieved by matching, within one treatment group, the age distribution of the children studied, using the sample before treatment as a control as demonstrated in Figure 20.
The "before treatment" symptom assessments are to be considered as estimates of symptom frequencies for specific untreated age classes. Participants who were 15 years old after treatment, at \( t = 4 \) years, may then be compared with other participants of the same age (15 years) after treatment. Table 7 presents the raw data on this comparison of symptom frequencies in the Begg 15 – 17 year age group.

![Diagram showing age matching before and after treatment](image)

**Figure 18** – Schematic representation of age matching. Four years after the beginning of treatment the children, now 4 years older, were compared with the same age before treatment. The children before treatment were used as estimates for symptom frequencies at a specific age.


<table>
<thead>
<tr>
<th></th>
<th>( t = 0 )</th>
<th>( t = 4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Symptom</td>
</tr>
<tr>
<td>Subjective</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Objective</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>X-ray</td>
<td>13</td>
<td>4</td>
</tr>
</tbody>
</table>

**Table 7** – Comparison of symptom frequencies in the Begg 15 – 17 year age group at time points \( t = 0 \) and \( t = 4 \).

It is evident from Table 7 that only the objective group shows a significantly higher frequency after Begg treatment. It is also evident there is no decrease in frequency of symptoms because of treatment. Also, from Table 6 it is evident that after a 10 year duration, a difference in symptom frequencies between activator and fixed appliance children is no longer evident.

Considering the inherent limitations of this study in terms of the selected orthodontic sample, the necessary age matching of the subjects, treatment philosophies, and the grouping of symptoms into "subjective", "objective", and "X ray" categories, Dibbets and van der Weele (1987) drew the following conclusions from their data:

1. Registration of symptoms during orthodontic treatment most probably should be attributed to age changes rather than to treatment procedures.
2. Begg Class I and Class II treatments do not reduce the percentages of symptoms registered.
3. Begg Class I and Class II treatments do not affect the incidence of subjective symptoms.
4. Begg Class I and Class II treatments do not affect the incidence of X ray findings.
5. Begg Class I and Class II treatments create higher percentages of objective symptoms after retention, but not in the long run (10 years).
6. Ten years after the start of treatment, initial differences in symptomatology between activator and Begg children no longer exist.

Although there are differences in criteria and method between the acknowledged studies, the consistent conclusion drawn from the more recent investigations by Sadowsky and BeGole (1980), Larsson and Ronnerman (1981), Janson and Hasund (1981), Sadowsky and Polson (1984) and Dibbets and van der Weele (1987), is that patients who undergo orthodontic treatment during
adolescence are in no greater danger of developing TMJ dysfunction as a result of their treatment, than individuals who have not received orthodontic treatment.
CHAPTER SIX
ASSESSING THE RISK, AND REDUCING THE IATROGENIC EFFECTS OF ORTHODONTIC TREATMENT ON
THE TEMPOROMANDIBULAR JOINTS

Orthodontic treatment procedures are directed toward the specific goals of improvement of oral health, improvement of dental-facial aesthetics, improvement of dental stability, and improvement of stomatognathic function. What many orthodontists can tend to overlook is the functional integrity of the temporomandibular joints, subjective and objective symptoms of occlusal dysfunction before and during active treatment, and the similar symptoms during retention.

It is the purpose of this chapter to examine the importance placed by most authors on the critical value of assessing patients at all stages before, during and after treatment, as potential candidates for TMJ dysfunction. An examination of suggested methods to reduce any iatrogenic risk of causing symptoms of dysfunction, by establishing a suitable occlusion with fixed orthodontic treatment will also be given.

6.1 Assessing the Risk.

The actual techniques for examining and diagnosing a patient suspected of suffering from TMJ dysfunction were reviewed in Chapter 3. In assessing the risk, the orthodontist must review the TMJ data and evaluate their relationship to the proposed orthodontic treatment. The orthodontist should note anything that might affect postural maxillomandibular relationships, such as anxiety, psychosocial problems, parafunction, unbalanced occlusions, improper anterior guidance, and relapse. (Solberg and Seligman 1985)
Solberg and Seligman (1985) also note that the orthodontist must also take into account indications of an intracapsular condition that could progress with time such as certain growth patterns (for example micrognathia), complaints specific to internal derangements (clicking and locking), and older patients with crepitus or dysfunctions. The prognosis will be affected by indications of excessive joint laxity possibly associated with a history of trauma, benign hypermobility, or acute open dislocation.

The most important point to be learned from this survey is the need for thorough diagnosis and an awareness by the orthodontist of potential temporomandibular joint dysfunction prior to the initiation of orthodontic treatment.

Williamson (1977) warns that the incipient joint problem at the ages of 6 to 16 years will likely be the one overtly seen at the age of 30 years, whether orthodontic treatment has been rendered or not. It is the responsibility of the orthodontist to be alert and to realize which of his patients may have the tendency.

In support of this is the comment by Roth (1981a), that many of the postorthodontic TMJ cases he has treated, have led him to the conclusion that many of the problems associated with such cases could have been avoided, or at the very least, minimised, had the tendency to TMJ dysfunction been recognized as a problem before treatment began. According to Roth, the emphasis today is still being placed, by many clinicians on what to do "after the fact."

In addition to the diagnostic procedures reviewed in Chapter 3, Chiappone (1976) suggests additional diagnostic information may be gained in some TMJ dysfunction risk patients by:

1. **Stress evaluation** - Stress increases the severity of symptoms associated with occlusal
problems. The adult patient, especially the female adult patient with TMJ signs and symptoms should be evaluated regarding her exposure to stress and her handling of stress. A useful technique is to ask the patient to keep a stress diary, recording each day how they are feeling, when they have headaches, when they feel tense, and to try to identify the events which may have caused the stress to occur. By identifying the stress, the patient is able to cope with them in some way, either by trying to avoid the situation altogether or at least being prepared for the particular stressful situation.

2. Diet evaluation - It may be most useful with "high risk" TMJ-orthodontic patients, to take a diet evaluation. According to Chiappone (1976), patients who are tender in their chewing muscles or whose teeth hurt, are more likely to become hypoglycaemic during the daytime, because they are more likely to be eating softer foods which are normally higher in refined carbohydrates. The body reaction to the initial hyperglycaemia produces hypoglycaemia. If the patient is in a hypoglycaemic valley, it is likely that their symptoms are going to be much more severe than if they were at a normal blood level.

3. Conferences with allied practitioners - If there is extreme wear on the teeth or missing teeth that may need replacement, it may be very helpful to seek the opinion of other specialists, such as prosthodontists prior to beginning the case. Knowing the prosthetic limitations and problems sometimes helps to decide whether to close spaces caused by missing teeth or to leave spaces caused by missing teeth open for future bridgework.

The orthodontist should be on the alert for warning signs of TMJ problems. According to Wyatt (1987), the following are the most important:

a. Head, neck, and shoulder pain, including headaches. Tender and sore muscles, and
trismus in the joint area are related problems of patients suffering from TMJ disorders.

b. Hearing impairment, frequently accompanied by tinnitus or ringing in the ears.

c. Joint sounds (monitored with or without a stethoscope), which would include crepitus, must be evaluated. A sound may occur on one or both sides of the face. If it is unilateral, the midline of the jaw will shift toward the affected side.

d. "Closed lock" condition, or an inability to fully open the jaw could indicate a major problem. Visually, this is easily recognized as a sign of acute TMJ distress and indicates that the disk is usually dislocated anteriorly or anteromedially and will not reposition itself on the condyle. (Isberg et al. 1985)

Before active orthodontic treatment, it is often possible to identify certain features of a patient’s jaw relation or facial structure that alert one to future occlusion-related TMJ problems. Perry (1973) suggests some of the following pre-treatment signs:

1. Deep overbite with supra-erupted mandibular incisors in Class II Division 2 (Angle) malocclusion.

2. Skeletal open bite with occlusal contact in only the posterior buccal segment.


4. Ankylosed mandibular second deciduous molars with mesial tipping of mandibular first permanent molars.

5. Early loss of second deciduous molars and severe tipping of permanent first molars.

6. Extensive loss of tooth material and supraeruption of antagonistic teeth or an antagonistic tooth.

7. Extraction of deciduous or permanent teeth without space maintenance, resulting in tipping, supraeruption, and drifting of adjacent and opposing units.

8. Evidence of mandibular trauma, that is, scars on the chin, lower lips, fractured
maxillary or mandibular incisors, avulsed and missing teeth.

9. Past or present history of joint noises.

10. Limitation or deviation in opening.

11. Attritional facets on labial incisal surfaces of mandibular incisors or on lingual incisal surface of maxillary incisors.

It is important to note that Perry (1973) gives no evidence in support of these factors, other than his own clinical experience, and indeed as was seen in Chapter 2, the evidence implicating factors such as openbite, Angle's malocclusion type, and crossbites, in TMJ dysfunction is inconclusive and conflicting.

It must be remembered that temporomandibular joint symptoms can occur in all age groups and that signs and symptoms are prominent in the 15 to 30 year old age group, as was discussed in Chapter 5. Patients with TMJ afflictions will require more frequent and longer observation into and beyond the retention period. The stability of the results of treatment will be markedly affected by the degree of symptomatology, and the prognosis for success must be equated with the anticipated life history of temporomandibular disorders. (Rasmussen 1981a, 1981b)

6.2 Reducing the Iatrogenic Effects of Orthodontic Treatment on the Temporomandibular Joints.

The goal of all who deliver orthodontic services should be not only to produce an ideal occlusion, but also to produce an occlusion that is harmonious with the supporting jaw mechanism and free from occlusal disharmony. To achieve these goals, it is imperative to finish each case in centric occlusion as discussed in Chapters 1 and 4.
Throughout active orthodontic treatment, the homeostasis of the masticatory system, especially in extraction mechanics, is continually under challenge. Orthodontists alter the vertical, anteroposterior, and lateral relation of the teeth and jaws. This movement of teeth into new positions incites an endless series of neuromuscular adaptations. It is possible that the ability of the teeth, muscles and joints to adapt sometimes is exceeded, creating dysfunction and consequent pain. (Perry 1973)

Perry (1973) has suggested from his clinical experience, some of the possible factors of orthodontic treatment which can result in TMJ flare-up during treatment are:

1. Excessive tooth tipping into the vertical dimension of the freeway space.
2. Cuspal interferences with brackets, bands, tubes or wires.
3. Cuspal interferences resulting in bite opening associated with buccal cross bite reduction.
4. Excessive vertical collapse in extraction mechanics.

Throughout the period of retention, Perry (1973) warns against the following factors which could be implicated in occlusion related TMJ flare-ups:

1. Supra-erupted mandibular third molars after the extraction of maxillary third molars.
2. Postpubertal mandibular growth spurts (as discussed in Chapter 4).
3. Vertical collapse.
4. Cuspal interference with retainer wire.
5. Extreme forces on Hawley labial wire.
6. Closure of anterior maxillary space with anterior elastic in absence of overjet.
7. Tooth positioner depression of all teeth except second and third molars.
8. Long term poorly controlled wear of Hawley retainer.
9. Distorted and bent mandibular retainers.
10. Trauma associated with extraction of the mandibular third molars.

It is apparent from the discussion so far, that the degree of responsibility for many of the above factors in causing TMJ dysfunction has not been established. However, it is also obvious, that an avoidance of the above factors during orthodontic treatment can only lead to a physiologically more desirable environment which must minimise any effect these factors may play in the aetiology of TMJ dysfunction.

6.2.1 Clinical Application of Functional Concepts – Posterior Relationships

The need to correctly establish and treat to centric relation has been discussed at length in Chapters 1 and 4. The potential risk and effect of occlusal interferences has been examined and stressed throughout this treatise.

Roth (1981a), notes that although ideally centric relation and centric occlusion should be co-incidental, he queries whether it is realistic to expect such co-incidence in the treated orthodontic case. A realistic objective in Roth's opinion, is to be able to treat the orthodontic case close enough that there is not a discernible discrepancy between centric relation and centric occlusion clinically.

Wasson (1986) has suggested some of the causes of centric slide that are of importance in fixed orthodontic treatment:
1. Lack of co-ordination in the widths of the dental arches. This is very common in patients with Class II malocclusions who have a short, narrow mandible. The mandible is forced forward to intercuspate with the maxilla. In treatment, the maxillary arch must be constricted and the mandibular arch must be expanded slightly to allow proper centric relation closure.

2. An extruded tooth due to improper bracket placement or unsupported elastic wear. If the cause is improper bracket placement, either a change in the band position, or an offset in the archwire will correct the problem. If extrusion is due to the forces exerted from the interarch elastics, discontinuation of the elastics may solve the problem, provided the tooth is cut free from the archwire and given a chance to settle back into place.

3. Extruded cusp due to improper torque. The buccolingual inclination of the posterior teeth must be correct to have proper cuspal relationships.

The most common aspect of the problem is a lack of sufficient lingual crown torque in the maxillary molars, which makes the lingual cusp hang down too far, creating centric or working side interferences.

The next most common error is too much lingual crown torque on the lower molars which makes them roll into the lingual area and create interferences of their buccal cusps. These tendencies are quite strong and must be counteracted throughout treatment with active torque force in the archwires. Wasson (1986), suggests that techniques using only round wire may lack the necessary control in this area of treatment.

4. Improper angulation in a mesiodistal direction (tip) may cause cuspal interferences. All teeth should have the roots angled in a slightly distal direction, with the long axis of the teeth
roughly parallel to each other. Teeth that are not upright may cause interferences, because the occlusal surfaces may be at the wrong angle to properly occlude with their antagonists.

5. Rotation of posterior teeth will cause the malpositioned cusps to offer centric interferences. Lateral interferences will likely occur also because of incorrect ridge and groove directions. All the teeth in the arch should form a continuous line along the labial and buccal cutting edges. Also, the central developmental groove of the posterior teeth should follow a continuous line posteriorly through each tooth.

6. Posterior position of the mandibular arch due to a short mandible will also cause a centric slide. This is a most difficult situation to correct in a short time because basically it is a skeletal problem. Bodily en masse movement of the teeth in both arches can be accomplished, but it takes time and there is a limit to the extent this can be done before teeth are tipped precariously off basal bone.

7. Anterior position of the maxillary arch due to loss of anchorage, resulting from poor patient co-operation, can be one of the most frustrating causes of centric slide.

8. Anterior openbite tendencies can cause the patient to subluxate the condyles and rotate the mandible over molar fulcrums to bring the anterior teeth together. This should not go undetected before treatment is completed because of the harmful consequences that are likely to accompany condylar subluxation.

A common cause of posterior cuspal interferences arises through failure to include the second permanent molar in fixed appliance orthodontic treatment. The second molar usually erupts after the second premolar and before the third molar. This relatively late eruption creates a problem in
orthodontic therapy because the orthodontist may be "finished" with the patient before the second molar has erupted completely or at all.

Two problems may arise through failure to include the second permanent molars in treatment, according to Andreasen (1986):

1. An occlusal step may be produced between the first permanent molar and the second permanent molar. Debonding such an occlusion after active treatment would leave the teeth in another malocclusion in the first and second permanent molar region.

2. An intermolar width discrepancy between the permanent first and second molars may occur. During treatment with the first permanent molars banded, the intermolar width usually increases. Bringing the second molars into the arch requires banding or bonding them, and aligning them buccal-lingually to the correct arch form.

According to Andreasen (1986), the only reasonable solution to these problems is to bend or bond second permanent molars whenever possible, to align, level, and obtain complete occlusal contacts in the complete permanent dentition. Andreasen, does not believe it is necessary to extend this concept to the third molars.

Other authors who have stressed the need to include permanent second molars in fixed orthodontic treatment to avoid iatrogenic interferences, particularly balancing side interferences include Roth (1973), Perry (1976), Watson (1981) and Kalbfleisch (1985).
6.2.2 Clinical Application of Functional Concepts - Anterior relationships

The ideal anterior guidance will provide the gentlest possible lift from the anterior teeth with the cuspids as the main guiding inclines in all border excursions, as described in Chapter 1. Anterior tooth positions should provide proper anterior guidance with no interference with condylar movement.

Wasson (1986) suggests that the vertical overbite should be sufficient to provide a clearance of 1 mm in the posterior teeth when the anterior teeth reach an edge to edge position. Thurow (1977) recommends limiting vertical canine overbite in finishing, so that posttreatment settling will allow the canines to adjust to the optimum functional pattern for the individual. Aubrey (1978), believes that some cases can be treated to an edge to edge relationship, to allow settling and the establishment of a normal overbite; however, a few do not.

In most cases the interincisal angle should be from 125 to 135 degrees to provide the correct angle of disclusion. If this angle is too high, its steepness can restrict mandibular movement, as well as encourage a deepening of the overbite. (Wasson 1986).

The importance of sufficient anterior root torque is demonstrated in Figure 21. This illustrates the effect on the occlusion, and the tendency to create posterior interferences, due to inadequate anterior root torque.

This brief overview of occlusal objectives required to provide an occlusion that is as free as possible from interferences both in closure and during mandibular movement, is intended to stress the point that occlusal stability and health of the stomatognathic system is to a large extent dependent upon occlusal dynamics.
For a more detailed review of occlusal objectives in orthodontic treatment, the reader is referred to Andrews (1976), Roth (1976), Aubrey (1978), Wasson (1986), Roth (1981c).

Figure 19

A. Improperly inclined anterior crowns result in all upper contacts being mesial, leading to improper occlusion.

B. Demonstration, on overlay that when the anterior crowns are properly inclined the contact points move distally, allowing for normal occlusion.

6.3 **Occlusal Adjustment**

Occlusal equilibration is a very controversial subject at present. The timing, technique and indications are quite varied depending on the author referred to.

Occlusal adjustment therapy is a procedure of selective coronal tooth modification performed on one or more teeth. The goal of such a procedure is to achieve a stable, non-traumatic occlusal contact relationship between the maxillary and mandibular teeth in centric occlusion and in all functional excursive contact positions. Another requirement of the adjustment procedure is that the temporomandibular joint be stable in the position of centric occlusion. (Clark and Adler, 1985).

Perry (1973) sees occlusal grinding as a means of preventing occlusion-related TMJ disturbances by the selective and judicious use of occlusal adjustment before, during, and after orthodontic treatment. Perry suggests that not every patient needs such therapy at all or in part; however, in his opinion, many patients do benefit from a thorough occlusal examination for premature and initial contacting teeth in centric and eccentric mandibular relation.

In a later article, Perry (1976) relates his timing for performing such occlusal equilibration. This is done within four to six weeks of retention and is directed primarily to the presence of artificial (filling) tooth material which may have an altered vertical relation in the corrected malocclusion. Later, in retention and after all retention, Perry (1976) will do eccentric checks with wax and either improve group function patterns or canine guidance function dependent on his original musculature pattern.

Perry (1976) makes the important point that occlusal equilibration per se does not
eliminate, circumvent or avoid dysfunction and in no way should it be employed to compensate for mechanical treatment objectives.

Roth (1976) believes post-orthodontic equilibration should not be performed until growth has been completed. Otherwise, changes that occur in the occlusal relationship with growth, are sufficient to alter the results of an equilibration so that an equilibration performed during the growth period will not remain stable.

According to Roth (1976) the following are indications for occlusal equilibration:

1. To eliminate centric and excursive prematurities and interferences in the presence of symptoms of occlusal disharmony.
2. To alleviate TMJ dysfunction syndrome.
3. To eliminate occlusal wear.
4. To better distribute stress to the periodontium in the presence of symptomatology of periodontal disease.
5. To alleviate tooth sensitivity due to occlusal interferences.
6. To eliminate jiggling of teeth and unstable tooth positions due to occlusal interferences.
7. To eliminate adaptive tongue thrust if the cause is occlusal interferences.

This list of indications strongly suggests that occlusal equilibration should only be performed for some reason other than simply that the occlusion does not meet the concept of an ideal. (Roth 1976)

Chiappone (1976) lists his criteria for good occlusal adjustment as:

1. Conservation of tooth enamel.
2. Adjustment of tooth enamel without going through into dentine.

3. A high degree of stability in centric relation, without a recurrence of any mandibular slide.

According to Chiappone (1976), while an intraoral adjustment will meet these criteria, he believes that occlusal adjustment performed using an adjustable articulator as a guide, will produce the highest degree of stability in most cases.

Williams (1971) proposes that gross occlusal discrepancies should be eliminated while the orthodontic appliance is still in place. The discrepancies between centric relation and centric occlusion, and anterior prematurities, indicated by movement of one or more of the upper anterior teeth, should be eliminated. No other support for this idea, of occlusal equilibration while appliances were in place could be found, however.

A more typical application for occlusal equilibration after orthodontic treatment is outlined by Aubrey (1978). In his opinion, there exists the need to refine the occlusion, after it has been properly treated to centric relation, to eliminate any occlusal prematurities that are potentially destructive.

Aubrey (1978) believes it is not possible to consistently produce an occlusion that is free of these potentially destructive influences without a post-treatment equilibration. If the case has been treated to centric relation, this procedure is simple, merely consisting of elimination of the non-working side interferences and evening the contacts on the working inclines.

There is no need to mount a completed orthodontic case on an articulator if the case is treated to centric relation. If it is not in centric relation and has a slide of 0.5 mm or more, then the case
should be mounted, to allow for more accurate diagnosis and equilibration, according to Aubrey (1978).

Following a review of the literature concerning occlusal adjustment procedures, (Clark and Adler 1985) concluded that occlusal adjustment therapy has a place in the therapeutic regimen for individuals being treated for problems associated with the masticatory system, but only when the criteria for providing an occlusal adjustment are based on actual pathologic, clinical and periodontal findings directly relating to the traumatic occlusal condition.

According to Clark and Adler (1985), muscle and even joint pain symptoms that have developed immediately after iatrogenic interferences are placed can reasonably be expected to be relieved with an occlusal adjustment that removes the iatrogenic interferences if the adjustment is done before long term adaptation to the abnormal occlusal scheme has occurred.

In the light of the changes the occlusion is constantly undergoing through the years, especially if it has been treated orthodontically, the suggestion by Aubrey (1978) to review the occlusion for a period of at least two years after completion of orthodontic treatment seems most reasonable. Those cases that develop a minor slide after treatment is completed may then be brought back to balance and harmony, hopefully with destructive occlusal interferences minimised, with a minor occlusal equilibration.

6.4 Orthodontic Treatment Considerations for the Patient With Temporomandibular Joint Dysfunction Symptoms.

It is beyond the scope of this treatise to conduct a detailed investigation of treatment
alternatives for the patient suffering from TMJ dysfunction or MPD syndromes. However, a brief outline of the considerations to be taken when a patient suffering from such conditions presents for orthodontic treatment is appropriate to conclude this survey.

If a patient presents for routine orthodontic treatment with incidental mild clicking without pain or other symptoms, the potential for possible future intracapsular injury should be explained to the patient or his parents before proceeding with routine diagnosis and treatment of the malocclusion. (Williamson 1983.) If, however, the patient presents with a chief complaint of clicking but no pain, efforts should be made to reduce the meniscal dislocation, using a repositioning splint for this purpose. (Williamson 1983, 1985).

If treatment of the occlusion is required, the least invasive approach is indicated. The therapeutic choices might be the following: no further treatment, equilibration, orthodontic intervention, restorative dentistry, surgery, or a combination of these therapeutic modalities. (Williamson 1985)

It is very important that the patient be asymptomatic before irreversible treatment is commenced. Once the patient is in remission, the occlusion may be diagnosed and treated by the least invasive therapy. (Griffiths 1983)

Ingervall (1978) discussed the possibilities of orthodontic treatment for some adults with temporomandibular dysfunction symptoms. A great advantage of orthodontics for the elimination of cuspal interferences in adult patients with functional disturbances in the masticatory system is that in many cases no tooth substance needs to be removed. According to Ingervall (1978), orthodontics may therefore be the method of choice when grinding would have aesthetic or functional drawbacks, for example in anterior crossbites, arch width discrepancies, buccal crossbites and tipped molar
situations.

In developing a treatment plan for any patient, the accuracy of the final occlusion can only be achieved with any degree of precision if an accurate centric relation can be obtained. Patients exhibiting a functional slide from centric occlusion to centric relation may have utilized their neuromuscular avoidance pattern to guide the mandible into centric occlusion for so long, that a muscle splint may have developed. Anyone with these symptoms cannot be relied on to give an accurate centric relation record until the musculature has relaxed. (Wasson 1979).

To ensure the accurate recording of the true centric relation in patients with signs of temporomandibular joint sounds, limitation of opening or movement, or myofacial pain, Roth (1981b), Klineberg (1986), Williamson (1983), Williamson (1985), (Griffiths 1983) among others, recommend the use of an occlusal repositioning splint to allow relaxation of the muscles of mastication.

Klineberg (1986) lists the functions of occlusal splints as:

1. To provide the possibility for spatial change in jaw position to a more harmonious jaw relationship, with respect to temporomandibular joints and jaw muscles.
2. To allow jaw muscles to re-establish a co-ordinated pattern of activity in the absence of the influence of tooth guidance.
3. To encourage appropriate condyle-interarticular disc function.
4. To allow manual jaw guidance to be carried out more easily and so provide the opportunity for jaw registration to be made more accurately.
5. To allow resolution of muscle hyperactivity and spasm and so promote the re-establishment of adequate blood flow and a return to aerobic muscle metabolism.
The splint is constructed in clear heat cured acrylic resin that covers the lingual and occlusal surfaces of the teeth and 2 – 3 mm of the labial and buccal surfaces. The splint should be constructed so there is flat plane contact with opposing cusp tips at retruded jaw position to provide bilateral simultaneous contacts on posterior teeth, and the canines and incisors make light contact and separate the posterior teeth immediately upon any eccentric movement. (Williamson 1985)(Klineberg 1986)

The main purpose of the repositioning splint, according to Roth (1981c) is to enable the operator to find “true” centric (which is stable and comfortable), by relaxing the mandibular musculature; to test the patient’s response to change in the occlusion, prior to embarking upon a complex course of occlusal therapy; and finally to see if the mandibular centric relation position can be stabilized. The splint may therefore be used whenever a patient is symptomatic and/or when the mandible is difficult to manipulate.

The advantage of a correctly designed occlusal splint according to Klineberg (1986) is that with short term use it has no irreversible effects on jaw muscles, temporomandibular joints or teeth.

If the patient presents with a chief complaint of masticatory muscle pain, Williamson (1985) suggests non-invasive therapies such as counseling, biofeedback and possibly a repositioning splint. In any event, it is important that the patient be asymptomatic before irreversible treatment, such as equilibration, restorative dentistry, orthodontics or oral surgery are instituted. Once the patient is in remission, the occlusion may be diagnosed and treated by the least invasive form of therapy.

In treatment, the goal must always be to achieve a static and dynamic occlusion that gives the
patient the ideal skeletal and muscular function, and yet minimizes muscle contraction during parafunctional cyclic jaw movements. This would seem to offer the best probability for optimal oral health of all components of the stomatognathic system, including the temporomandibular joints.
CHAPTER SEVEN

SUMMARY AND DISCUSSION

It soon becomes apparent in a study of the literature that there is very little agreement among the various specialties and interest groups in dentistry about the nature and causes of TMJ dysfunction. Despite a comparatively simple anatomic configuration and physiologic design, there exists an almost complete lack of correlation between TMJ pain, functional variables, habits, subjective symptoms, and signs of popular concern. (Shapiro 1983)

The purpose of this review has been to examine the role of fixed orthodontic treatment as a possible factor in the etiology of TMJ dysfunction. One of the fundamental areas of disagreements among the various specialty groups demonstrates that dentistry is confronted by a dilemma concerning occlusion and the health of the temporomandibular joint. Consequently a large part of the discussion has revolved around the question of just what is an ideal occlusion, and as far as orthodontics is concerned, how can we achieve such an occlusion, and if we cannot achieve an ideal occlusion, what are the possible consequences.

The basis for discussion of an ideal occlusion and its effect on the temporomandibular joint was based on the definition proposed by Ash and Ramfjord (1982) for an acceptable functional occlusion which is:

“A state of the occlusion conducive to function with the following characteristics:

1. In which the occlusal surfaces are free of interferences to smooth gliding movements of the mandible.
2. There is freedom for the mandible to close or to be guided into maximum intercuspation
In centric occlusion and centric relation.

3. In which the occlusal contact relations contribute to occlusal stability.

It was apparent that controversy still continues involving centric relation, not only in its definition, but also as to whether it can be regarded as merely a reference point for treatment procedures, or whether it exists as a functional position. Electromyographic evidence would suggest that centric relation is not just a repeatable point, but also a functional entity. Indeed, most reports in the literature would agree that it is the optimal physiologic position from which the functional movements of the stomatognathic system occur.

Following an evaluation of the morphologic and electromyographic evidence to be found in the literature, the features of an ideal occlusion required after any form of occlusal alteration to maintain health of the stomatognathic system were summarised by Williamson (1985) as:

1. A static (centric) occlusion in which the mandibular condyles are seated on the posterior slope of the articular eminence with the meniscus properly interposed.
2. A dynamic occlusion in which the cuspids and incisors disclude the posterior teeth in any eccentric movement.
3. A minimum level of muscular contraction during function.

In summary, a static and dynamic occlusion in harmony with the skeletal pattern and muscular function would seem to offer the best probability for optimum health of all components of the stomatognathic system, including the temporomandibular joints.

There appears to be consensus that TMJ dysfunction syndrome comprises three prime symptoms:
1. Pain and tenderness of the muscles of mastication and temporomandibular joint.
2. Sounds during condylar movements.
3. Limitation of mandibular movements.

Other symptoms such as ear ache, tinnitus, dizziness may be apparent in conjunction with the above prime symptoms, but are not considered necessary for the diagnosis of TMJ dysfunction syndrome.

It becomes apparent from a review of the literature that the prevalence of specific symptoms associated with TMJ dysfunction in various populations is surprisingly high. Although widely different population samples are used and experiment criteria and research design make the studies difficult to compare directly with one another or with subsequent studies, the inescapable fact remains that a large proportion of the general population will demonstrate one or more symptoms associated with TMJ dysfunction. Most studies are in agreement that joint sounds are the most frequent symptom to be seen. It is also generally noted that there is an increase in the incidence of symptoms with increasing age.

A large number of theories have been proposed to account for the constellation of symptoms observed in TMJ dysfunction syndrome. Generally, these theories fall into two groups:

1. Theories suggesting pathology involving the temporomandibular joint as the causal factor.
2. Theories based on muscular hyperactivity as the primary originating factor.

A functional circle has been suggested involving the periodontal tissues, the central nervous system and the musculature in the aetiology of TMJ dysfunction. According to this idea any
disturbance of this circle could possibly lead to a dysfunctional state. The orthodontic implication of this concept is that alterations to the occlusion, through the afferent impulses from the periodontal receptors to the central nervous system, could under certain circumstances lead to a dysfunctional state.

Many studies have attempted to identify morphologic components of malocclusion which in themselves are potentially dangerous to the health of the stomatognathic system, and the integrity of the temporomandibular joints in particular. Characteristics such as Angle's type of malocclusion, anterior and posterior crossbites, both unilateral and bilateral, open bite, depth of overbite have all been implicated as contributory causal factors in the aetiology of TMJ dysfunction.

Although correlations have been reported for these characteristics, the reports in the literature are conflicting and contradictory. No positive correlations have been established for any of these characteristics.

A large amount of research has been undertaken to establish a relationship between muscle hyperactivity and TMJ dysfunction syndrome. Unfortunately, many of the articles dealing with this subject have dealt almost entirely with the subjective symptoms and have failed to provide a satisfactory explanation of the objective signs. The practice of establishing conclusions from patients subjective responses to questions, some would argue, is inconclusive because these are highly variable and in many instances arbitrary.

Electromyographic studies by contrast, provide objective evidence for a relationship existing between various causes of masticatory muscle hyperactivity and masticatory muscle pain, which may or may not be associated with other signs and symptoms of TMJ dysfunction syndrome.
The most controversial local factor proposed as a causal factor of muscle hyperactivity is occlusal interferences. There is general agreement in the literature that balancing side interferences are potentially the most dangerous. It is generally seen that the majority of patients with disturbances of the masticatory system present with some form of occlusal disharmony. However, not everyone with occlusal disharmony experiences pain, or shows evidence of trauma resulting from a less than ideal occlusion, such as masticatory muscle hyperactivity or TMJ dysfunction.

An area gaining increasing significance as a potential factor in the aetiology of TMJ dysfunction is the effect of psychological and/or physical stress. It is suggested that the disruption of an individual's normal response to stress, may result in a breakdown of homeostatic processes, which by response specificity, may in certain individuals present as symptoms of TMJ dysfunction.

Despite a considerable amount of research data concerning the temporomandibular joint, its function, and pathology to be found in the literature, the cause of the syndrome remains obscure. Quite possibly, several of the reviewed aetiological theories may be correct for certain portions of the patient population.

This dilemma has led to the conclusion by most authors that TMJ dysfunction is best viewed as the result of a number of interlocking factors of neurophysiological, psychological and possibly morphological (including occlusal) origin. A multifactorial view of aetiology at this time would seem to be the most useful and reasonable approach.

Orthodontic treatment procedures should be directed towards the goals of improvement of oral health, improvement of dental-facial aesthetics, improvement of dental stability, and improvement of stomatognathic function. However, throughout active orthodontic treatment, the homeostasis of
the masticatory system is continually being challenged. It has been suggested by some, that the ability of the teeth, muscles and joints to adapt to such challenges is sometimes exceeded, and in some individuals, this results in TMJ dysfunction.

Kalbfleisch (1985) has divided the possible ways in which orthodontic treatment may be categorized as a potential aetiological factor in the development of TMJ dysfunction:

1. Those aspects of dysfunction resulting from the orthodontically established occlusion and the lack of co-ordination with the temporomandibular joints.
2. Those aspects of dysfunction dependent on the actual mechanical techniques of orthodontic treatment.

There is general agreement on the need to accurately identify, and treat all orthodontic patients to their true centric relation position. There is enough evidence in the literature to confirm that forced mandibular positioning not co-incident with centric relation as a result of fixed orthodontic treatment, may in certain individuals, precipitate temporomandibular joint disorders.

However, the literature also suggests that many orthodontic patients later develop abnormal joint function, more often the result of continued mandibular growth, rather than as an effect of treatment. The need to identify pre-treatment individuals where this could occur, is therefore emphasised, for obvious preventive reasons.

The studies carried out on dual bite show clinical and electromyographic evidence of the potentially damaging effect of such an occlusal discrepancy on the functional stability of the temporomandibular joints. As orthodontic treatment has been implicated as an aetiological factor in the development of dual bite, this provides further evidence of the functional importance of
establishing and treating to, the true centric relation position in all orthodontically treated cases.

As the possible effect of occlusal interferences, particularly balancing side interferences, has been emphasised as a potential damaging factor on the functional stability of the temporomandibular joints, it is interesting to review the studies designed to compare functional occlusal relationships in patients after orthodontic treatment, with similar untreated samples.

Almost without exception such studies show very great similarities between treated and untreated samples. There is a striking similarity in frequency and location of occlusal prematurities between persons with untreated occlusions and those with orthodontically treated occlusions. The inescapable fact is, that occlusal interferences do exist in patients with "good" occlusions, as well as in those with orthodontically treated occlusions.

Indeed, a number of studies such as by Sadowsky and BeGole (1980) would suggest that less occlusal interferences occur in orthodontically treated cases than in untreated cases. However, the most important point raised by these studies is the close similarity between post-orthodontic occlusions and control groups with normal, untreated occlusions.

The clear implication of such studies in relation to this survey, is that generally, the post-orthodontic occlusion in itself should not predispose a patient to TMJ dysfunction to a greater extent than already exists in the general population.

It is very difficult to experimentally relate mechanical effects of treatment to effects on the temporomandibular joints. All such experiments have been performed on animal models.

Under the influence of heavy and tight elastic forces, some histologic changes have been noted
in the temporomandibular joints. However, it is usually found that the macroscopic appearance of the condylar head, disc and glenoid fossa in the experimental animals is very similar in appearance to that of the histologic control. Payne (1971) found histologically, no evidence of traumatic changes in the articular disc or related structures resulting from the use of Class II elastic forces of 20 to 30 grams in the growing macaque monkey. The minor histologic changes that did occur, did not result in any alteration of the articular surface contour.

Extensive work by McNamara (1973b, 1975) and others, has investigated the neuromuscular adaptations that follow forced mandibular positioning, in monkeys. These experiments certainly show that changes do occur in the electromyographic activity of the masticatory muscles, particularly lateral pterygoid muscle.

It is apparent clinically, that not all patients treated with intermaxillary elastics develop TMJ dysfunction. Obviously, in most patients, therefore, any neuromuscular modifications that do occur will be within the range of healthy adaptability of the patient. It is suggested that the forces used in orthodontic treatment that could cause mandibular repositioning during treatment, may in a patient predisposed by other factors to develop a temporomandibular related dysfunction, complement such factors to the extent that the ability of the patient to adapt to the new stresses is exceeded.

In such a situation, orthodontic treatment should be seen as a contributing factor only in the establishment of a TMJ dysfunction. The need to identify prior to treatment a patient who may be predisposed to developing TMJ dysfunction by other factors such as stress, is critical if the mechanical effects of orthodontic treatment are to be minimised on such an already compromised patient.
In terms of the vast amount of articles written on all aspects of the temporomandibular joint and the aetiology of TMJ dysfunction, there have been surprisingly few studies designed to determine whether orthodontic treatment may be implicated in the aetiology of TMJ dysfunction. Although it has been speculated since the 1950's that orthodontic treatment may be a possible factor in the aetiology of TMJ dysfunction, most studies aimed at testing such a relationship, have been performed in the last ten years.

Of greatest interest are the number of studies that have attempted to establish the percentages of potential TMJ dysfunctional patients seen as adolescents prior to orthodontic treatment. This is usually done by screening samples of young patients, in the range of 6 to 16 years of age, and trying to identify the percentages in whom symptoms and signs such as joint noises, sensitivity of muscles of mastication, and joint and related muscle pain, are present.

Similar studies have reported percentages for incipient signs of TMJ dysfunction in children and adolescents ranging from 30 - 60%. Although there are obvious differences apparent between these studies in terms of racial differences, different socio-economic groups, criteria and methods for examination and so on, it is evident from these studies that a surprisingly high percentage of incipient symptoms of TMJ dysfunction are present in all populations of patients of an age in which orthodontic treatment would normally be carried out. There is also a clear trend in these studies that demonstrates a general tendency to an increase in the presence of these symptoms with increasing age.

Recent long term studies, notably by Sadowsky and BeGole (1980), Larsson and Ronnerman (1981), Janson and Hasund (1981), Sadowsky and Polson (1984), compared the functional state of the masticatory system up to ten years after the completion of orthodontic treatment with that of control groups who had not received orthodontic care. The prevalence of mandibular dysfunction
symptoms was found to be similar in both groups. Therefore, it would appear that orthodontic treatment alone does not predispose a patient to TMJ dysfunction.

Orthodontics may be accused of causing TMJ dysfunction through procedures which produce chronic traumatic insult, such as by failing to treat to the true centric relation position, or through inattention to final occlusal finishing. The most obvious method of preventing such a situation, yet the most easily overlooked detail, is to identify those patients who present for orthodontic treatment with a predisposition to developing TMJ dysfunction.

The most critical point to be learned from this survey is the need for thorough diagnosis and an awareness by the orthodontist of the need to identify potential temporomandibular joint dysfunction patients prior to the initiation of orthodontic treatment.

The American Dental Associations 1983 Conference on the Examination, Diagnosis and Management of Temporomandibular Disorders (Griffiths 1983), suggested a preliminary screening history should be a part of the routine health history asked of all patients. Should the screening history and examination reveal positive findings, a second more thorough comprehensive assessment specifically related to the evaluation of TMJ disorders can be completed.

A standard comprehensive history designed to investigate the patients chief complaints, their full medical and dental history, and a thorough orofacial examination involving muscle palpation, examination of the TM joints, and a careful functional analysis of the occlusion is the first step in diagnosis. Radiographs and other special tests may be required to provide sufficient information upon which a differential diagnosis may be made. Additional information including stress evaluation, diet evaluation and discussion with specialists in other areas, may also be required to assist in diagnosis.
It is imperative to realize that incipient joint problems are common in patients aged 6 to 16 years, whether orthodontic treatment has been given or not. It is the orthodontist's responsibility to identify such potential problems, and modify his treatment objectives and methods accordingly, so that overt TMJ problems as a result of orthodontic treatment may be minimised.

The strict treatment of all patients to their true centric relation position, the minimization of chronic traumatic insults during and after active treatment, and the closest attention to satisfactory occlusal detailing at the conclusion of treatment will assist in achieving this objective.
CHAPTER EIGHT

CONCLUSION

1. A static and dynamic occlusion that gives the patient the ideal skeletal and muscular
function and yet minimizes muscle contraction during parafunctional cyclic jaw movements, should
provide the optimal environment to maintain the health and stability of all components of the
stomatognathic system, particularly the temporomandibular joints.

2. Controversy still surrounds the actual definition of centric relation. Electromyographic evidence suggests that it is not only a reference point for treatment, but also a
location with great functional significance. There is general concensus that it is the optimal
physiologic position towards which all orthodontic treatment should be directed.

3. The symptoms held to comprise TMJ dysfunction syndrome are:

a. Pain and tenderness of the muscles of mastication and the temporomandibular
   joint.
b. Sounds during condylar movements.
c. Limitation of mandibular movements.

Although other symptoms may appear in various combinations as well, the above symptoms
are considered necessary for the diagnosis of TMJ dysfunction syndrome.

4. A large proportion of the population will demonstrate one or more symptoms associated
with TMJ dysfunction. There is general agreement that there is an increase in incidence of
symptoms with increasing age.

5. In our present state of knowledge, TMJ dysfunction syndrome is best viewed as the result of interrelated factors of neurophysiological, psychological, occlusal, and pathological origin. The degree of importance of skeletal and dental malocclusion is still contradictory and lacking conclusive documentation.

6. The importance of performing a thorough history and examination on all orthodontic patients and identifying patients with incipient TMJ dysfunction symptoms, is stressed.

7. It seems when comparing patients with post-orthodontic occlusions to a control group of patients with normal, untreated, good occlusions, there are minimal differences. This would seem to suggest that generally, post-orthodontic occlusion in itself does not predispose a patient to TMJ dysfunction syndrome.

8. Long term studies comparing the functional state of the masticatory system up to 10 years after the completion of orthodontic treatment with that of control groups who had not received treatment, show the prevalence of TMJ dysfunction is similar in both groups. Therefore, it can be concluded that in most cases orthodontic treatment does not predispose a patient to TMJ dysfunction during or after treatment.

9. The hypothesis proposed at the commencement of this treatise has been examined. It has been seen that in some instances fixed orthodontic treatment may be a contributing factor in the aetiology of TMJ dysfunction. If a patient is predisposed by other factors to develop TMJ dysfunction, then orthodontic treatment may contribute to TMJ dysfunction where that orthodontic treatment is sub-standard in its objectives, method, and final functional occlusal result. It should
be remembered, however, that such a person may have developed TMJ dysfunction whether orthodontic treatment was provided or not.

10. Although it has been possible to identify some aetiological factors responsible for initiating TMJ dysfunction, the multifactorial view of aetiology taken by most authors, makes it impossible to quantify the individual responsibility of each factor in the aetiology of TMJ dysfunction syndrome.

11. The clinical and statistical evidence studied would suggest that where the orthodontic objectives, treatment methods and final occlusal result is in harmony with the concepts of an ideal functional occlusion, then it can be concluded that fixed orthodontic treatment does not predispose a patient to TMJ dysfunction either during or after treatment, to a greater extent than already occurs in the general population.
APPENDIX A

1. **Anamnestic Dysfunction Index** (Information supplied by patient).

   **Ai0** Denotes complete absence of subjective symptoms of dysfunction of the masticatory system (i.e. symptoms mentioned under AiI and AiII).

   **AiI** Denotes mild symptoms such as temporomandibular joint sounds such as clicking and crepitus, feeling of stiffness or fatigue of the jaws.

   **AiII** Denotes severe symptoms of dysfunction. One or more of the following symptoms were reported in the anamnesis: difficulty in opening the mouth wide, locking, luxations, pain on movement, facial and jaw pain.


   **A. Symptom:** Impaired range of movement/mobility index

   **Criteria:**
   - Normal range of movement 0
   - Slightly impaired mobility 1
   - Severely impaired mobility 5

   **B. Symptom:** Impaired TM joint function

   **Criteria:** Smooth movement without TM joint sounds and deviation on opening or closing movements
   - <2mm 0
   - ≥2mm on opening or closing movements 1
   - Locking and/or luxation of the TM joint 5

   **C. Symptom:** Muscle pain

   **Criteria:**
   - No tenderness to palpation in masticatory muscles 0
   - Tenderness to palpation in 1 – 3 palpation sites 1
   - Tenderness to palpation in 4 or more palpation sites 5

   **D. Symptom:** Temporomandibular joint pain

   **Criteria:**
   - No tenderness to palpation 0
   - Tenderness to palpation laterally 1
   - Tenderness to palpation posteriorly 5
E. **Symptom:** Pain on movement of the mandible

**Criteria:**
- No pain on movement: 0
- Pain on 1 movement: 1
- Pain on 2 or more movements: 5

F. **Sum** \( A + B + C + D + E \) = **dysfunction score** (0 - 25 points)

G. **Dysfunction group** 0 - 5, according to score.

H. **Clinical dysfunction index**, D1, according to code

**Code:**
- 0 point = Dysfunction group 0 = clinically symptom free = D10
- 1 - 4 points = Dysfunction group 1 = mild dysfunction = D1I
- 5 - 9 points = Dysfunction group 2 = moderate dysfunction = D1II
- 10 - 13 points = Dysfunction group 3 =
- 15 - 17 points = Dysfunction group 4 = severe dysfunction = D1III
- 20 - 25 points = Dysfunction group 5 =
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