Temporomandibular Pain-Dysfunction and Occlusal Relationships

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Introduction

Not too infrequently, either during the course of orthodontic mechanotherapy or sometime after appliance removal, the orthodontic patient may complain of clicking, subluxation, dislocation and/or pain associated with the temporomandibular joints and masticatory muscles. At times these symptoms may be transitory in nature or of prolonged duration with periods of exacerbations and remissions, or limitation of opening or movement.

Dental literature cites many etiological factors that may cause dysfunction of the temporomandibular joints and associated musculature and elicit these symptoms. These factors may be a result of arthritis, tumors, congenital malformations, traumatic injury, pathological degenerative changes, neurological and muscular disease, cerebrovascular disease, and, of course, occlusal interferences.

In 1955 Laszlo Schwartz[16] described what he termed the "Temporomandibular Joint Pain-Dysfunction Syndrome." Schwartz believed that the above stated symptoms were, many times, brought about by sudden or prolonged stretch of the musculature following rapid or extensive changes in the occlusion in individuals predisposed by constitution or temperament. He considered the abnormalities of the occlusion of the teeth to be only a contributing factor. The individuals in Schwartz's study, when subjected to stress or anxiety, manifested increased muscle tension, particularly of the masticatory muscles. Based on the work of Wolff,[22] Holmes,[6] Travell and Rinzler,[21] and Bonica,[2] Schwartz concluded that sudden or prolonged stretching of tense muscle was a manner of inducing spasm.

Although Schwartz believed that the occlusion of the teeth played a secondary role in the creation of the temporomandibular joint pain-dysfunction syndrome, evidence by other investigators[3,5,8,17,18] seems to indicate that occlusal interferences are the prime etiological factors.

It is almost universally agreed that the presence of occlusal interferences during a period of emotional stress, coupled with clenching, grinding or gnashing of the teeth, will usually produce some or all of the symptoms found in the classic temporomandibular joint pain—dysfunction syndrome.

Ramfjord and Ash[13] have found that the individual tolerance level variation will determine whether or not pain-dysfunction symptoms will occur in the presence of slight or severe occlusal interferences. They have found, however, that functional occlusal therapy, if performed with a high degree of accuracy, will eliminate dysfunctional manifestations in the masticatory system despite high fusimotor activity and persistent nervous tension.

It has been demonstrated clinically, by many, that the symptoms of the temporomandibular joint pain-dysfunction syndrome can be alleviated by alteration of the occlusion by means of splints, equilibration of the occlusion, restorative dentistry and orthodontics. It has also been demonstrated that the symptoms of this syndrome can be

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created iatrogenically by the same means.

In 1925 McCollum[8] formed the Gnathological Society for the purpose of studying the relationship of the occlusion to mandibular border movements. This group produced the first instrumentation capable of accurately recording and reproducing mandibular border movements. In 1952 Posselt[12] diagrammed the border envelope of possible mandibular motion and showed that the border movements are reproducible and that all other movements occur within these borders. Many other investigators and clinicians have stated, either directly or indirectly, that the occlusion should ideally be in harmony with the closure and movement patterns that are determined and dictated by the temporomandibular articulations.[4,5,8,12,17,18,20]

This concept has become an accepted premise in dentistry. Correlating the occlusion to joint-dictated border excursions of the mandible is the basis for occlusal morphology in restorative dentistry and is the basis for most methods of occlusal equilibration. Controversy arises only in relation to the degree of correlation of the occlusion to mandibular border movement deemed necessary and to the particular occlusal scheme to be employed (e.g., bilateral balance, unilateral balance or mutual [cuspid] protection) and also the type of instrumentation to be utilized.

It is obvious that currently used orthodontic diagnostic armamentaria do not relate the dentition to joint-movement patterns on closure or during eccentric excursions. This is probably why the existence of occlusal interferences that may trigger the temporomandibular joint pain-dysfunction syndrome have gone largely unnoticed by the orthodontist.

Another reason is that patients learn to develop a neuromuscular avoidance pattern to occlusal interferences, as shown by Ramfjord.[13] The avoidance pattern is a result of the neuromuscular "feedback" mechanism mediated through the mesencephalic nucleus of the trigeminal. It has been shown quite conclusively by many investigators that a change in proprioceptive input to the periodontal proprioceptors due to a change in the occlusion elicits a change in the neuromuscular response to the lower motor neuron, which can be detected and recorded electromyographically.[7,9,10,11,13,14]

It is the neuromuscular avoidance pattern that makes it difficult, if not impossible, to locate many harmful occlusal interferences intraorally. This is particularly true in patients exhibiting symptoms of the pain-dysfunction syndrome where there is a muscle "splinting" phenomenon for joint protection or where the muscles are in spasm.

The fully adjustable articulator set accurately to a recording of the patient's border movements has allowed the prosthodontist to locate and correct occlusal interferences that are difficult to locate in the mouth. Because this approach has not been used traditionally by the orthodontist, it is in the area of orthodontics that the production or alleviation of the temporomandibular joint pain-dysfunction syndrome has remained somewhat of a mystery. This is particularly true in instances where the "well treated" orthodontic patient either develops symptoms, or where good orthodontic therapy has failed to yield relief from pain-dysfunction symptoms when other etiological factors (besides occlusion and emotional tension) have been ruled out.

It would seem that the identification of occlusal interferences that trigger the temporomandibular joint pain-dysfunction syndrome, and a method of successfully eliminating these interferences, either through better tooth positioning or occlusal adjustment, would be beneficial aids to the orthodontist in his goal of attempting to attain, not only an esthetic, but a good functional occlusion as well.

It is the purpose of this preliminary investigation to shed some light on the identification of the specific types of occlusal interferences that seem to be most commonly associated with the temporomandibular joint pain-dysfunction syndrome on postorthodontic patients, and on the methods that can be employed to successfully eliminate or prevent the symptoms associated with this syndrome, not only posttreatment, but also during orthodontic mechanotherapy.

Methods and Materials

Nine subjects were selected for this preliminary investigation. All subjects had previously undergone complete, full-banded edgewise orthodontic therapy. The individuals ranged in age from fifteen to twenty-four years and had been out of treatment from six months to seven years. The entire group was comprised of cases that could be considered well-treated by current orthodontic standards. Six cases were selected from the author's practice, while three subjects were treated by other orthodontists.

Seven of the nine were selected on the basis of need of relief from their symptoms, as therapeutic need for the correction of their occlusions was indicated. The remaining two patients were selected as a control group since they were symptom-free.

All of the sample group of seven suffered from varying degrees of symptoms commonly associated with the temporomandibular joint pain-dysfunction syndrome.

Of the entire group of subjects, three were males and six were females; five were four first bicuspid extraction cases and four were treated nonextraction.

The breakdown of malocclusion types prior to orthodontic treatment was as follows: Four were Class II, Division I; three were Class I arch length deficiency; one was Class III; and one was Class II, Division 2.

Because of the complex nature of the procedure to be followed on each subject and the time involved (three to four days working time per subject) and the limitation involved in drawing from the author's private practice, a randomly selected sample was not feasible.

Since this was a preliminary investigation, quite a few characteristics for each subject were evaluated and used in the hope of finding some trends or correlations that could later be quantitated and subjected to statistical analyses in future studies.

The characteristics selected for the data were chosen by the author on the basis of his clinical experience in this area. It was felt that the characteristics would yield a good possibility of accomplishing the objectives set out in the introduction.

A true hinge-axis location, pantographic recording and centric interocclusal wax records were taken on each of the subjects (Figs. 1-4). On those subjects with the more severe symptoms and/or limitation of mandibular movement, a mandibular repositioning splint (after Dyer[3]) was used. The splint was adjusted until a stable and comfortable position of the mandible in centric relation was attained. This was done prior to obtaining the hinge-axis location, pantographic recording and centric relation records (Fig. 5).

Initially, at least two sets of accurate stone models were made of each subject's teeth. These models were transferred to a Stuart articulator that had been programmed from the panto-

Fig. 1 Subject with facebow in place after hinge axis location.

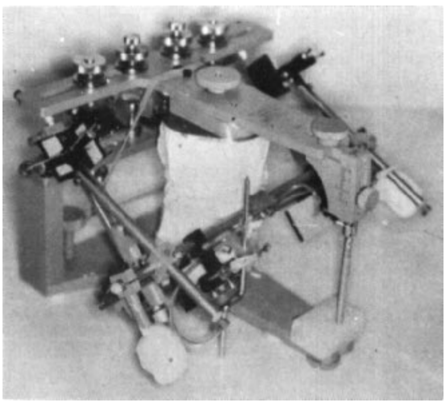

Fig. 2 Pantograph and recording transferred to the Stuart instrument.

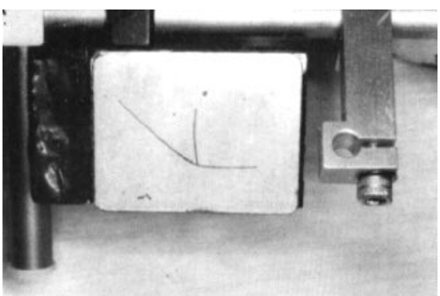

Fig. 3 Pantographic recording on the Denar pantograph (right anterior table).

graphic recording. These were transferred via a hinge axis-orbital facebow and the centric interocclusal wax records. The mandibular cast mounting was verified using at least four centric records of different thicknesses that

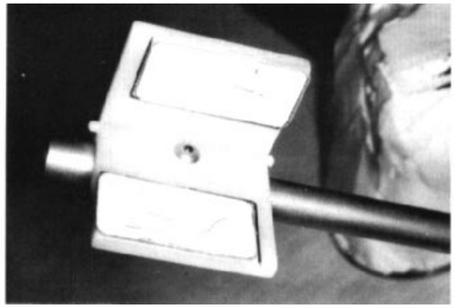

Fig. 4 Pantographic recording on the Denar pantograph (right posterior table).

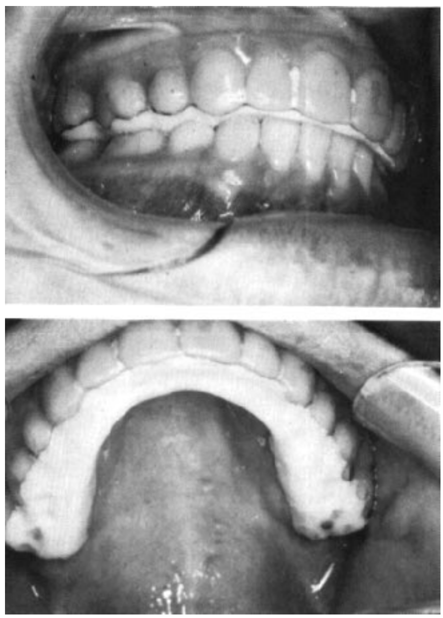

Fig. 5 Mandibular repositioning splint (after Dyer).

were checked with split-casts (after Lauritzen) (Figs. 6, 7, and 8).

The Stuart instrument was selected for its accuracy and full range of adjustment capability and ability to regain centric when set to large immediate side-shift recordings.

The Denar pantograph was used according to Basta's[1] technique. This pantograph was selected because of ease of clutch construction, automatic recording styli, and the ability to trans-

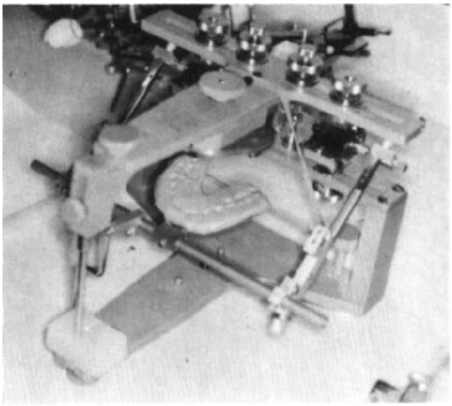

Fig. 6 Axis-orbital facebow secured to the Stuart instrument for maxillary cast mounting.

Fig. 7 Mounting of mandibular cast with centric interocclusal wax record.

fer the pantograph to the instrument without the use of a mounting stand or jig.

The stone models were utilized as a reference to the original condition and the second set was used for equilibration on the programmed instrument. The equilibration was done in accordance with Stuart's rules for equilibration[17] utilizing Basta's[1] technique. All of the occlusions were equilibrated to the "mutually protective, cuspid guided" occlusal scheme and were refined to the point that every pair of opposing teeth in the buccal segments would hold a .005″ shimstock feeler. The eccentric excursions were equilibrated prior to centric by placing grooves in the occlusal surfaces of the

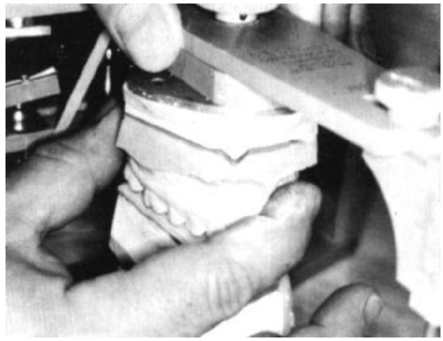

Fig. 8 Checking mandibular cast mounting with split casts.

teeth to insure proper cusp positioning and clearance on excursions while maintaining occlusal anatomy with a minimal amount of tooth surface reduction (Fig. 9).

All of the cuts were duplicated on the patient's teeth as closely as possible and then through the use of articulating ribbon and .005″ shimstock feelers, the centric stops were equalized. The occlusion was refined as closely as possible to that which was attained on the mounted models.

New models were made from new impressions in most instances and remounted on the instrument to determine the need for subsequent adjustment of the occlusion and to check the

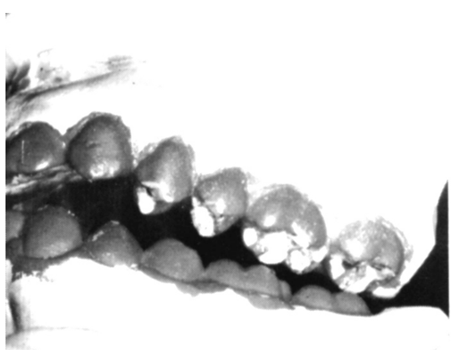

Fig. 9 Equilibration of mounted models showing grooves placed on occlusal surfaces to allow passage of opposing cusps with minimal reduction of tooth material.

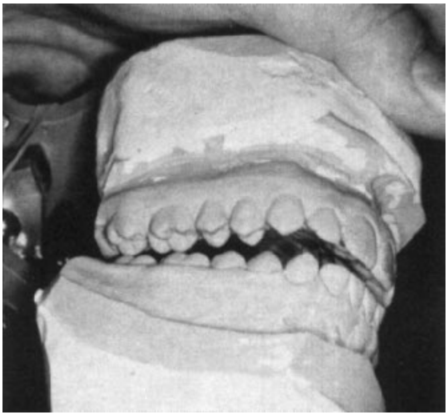

Fig. 10 Reference set of casts exhibiting original balancing interference on second molars.

Fig. 11 Equilibrated set of casts used for data in comparison with reference set of casts.

accuracy of the completed equilibration. The remount procedures and readjustment of the occlusion were done as necessary for each subject until the operator was satisfied that no better result could be attained.

The reference set of untouched models of the original occlusion and the final equilibration remount models were compared with the patient's response to treatment to comprise the data for this study (Figs 10 and 11).

The following characteristics for each subject comprised the data:

1. Symptoms — The types of symptoms and their severity were noted, as there may be some correlation between the location of occlusal interferences and the type of symptoms elicited.

2. Character of the Pantographic Recording — The recording gives the characteristics of the border movement patterns and is also an indicator of unresolved muscle or temporomandibular joint symptoms by virtue of the smoothness or irregularity of movement and the ability to reproduce the same lines on subsequent recordings. In addition, the amount of immediate and/or progressive side-shift is an indicator of the likelihood of posterior tooth interference occurring on lateral test excursions.

3. Response to Occlusal Adjustment — Alleviation of symptoms and the rapidity at which this occurs is a good indicator of the validity of the treatment procedure performed and the occlusal scheme used as a treatment goal.

4. Result of Occlusal Adjustment — There may be a trend toward correlation of the alleviation of symptoms and how closely the result approaches the idealized treatment goal.

5. Characteristics of the Centric Deviation — The forward shunting of the mandible from terminal hinge closure into acquired centric occlusion may be deflective from the arc of closure either straight forward and/or laterally. In addition, there may be a much greater anteroposterior movement rather than mere deflection. The characteristics of the centric deviation may give some clue as to the reason the centric deflection was not corrected orthodontically.

6. Incisal Pin Readings — The incisal pin readings and the difference in readings found between centric relation closure (first prematurity) and acquired centric may give some clue to the amount of subluxation of the condyles necessary to effect full closure of teeth. This may be a factor in determining the predisposition to the pain-

dysfunction syndrome. In addition, it is a measure of how much closure was established, if any, in adjusting the occlusion.

7. Location of Interferences in Test Excursions From Terminal Hinge — The teeth that were interfering contacts were charted in terminal hinge closure or centric, left lateral border movement (both working and balance), right lateral border movement (both working and balance) and protrusive. This was done to determine the type and location of tooth interferences most commonly associated with the symptoms.

8. Location of Interferences in Tooth Guided Test Excursions — Left lateral tooth guided movement (both working and balance), right lateral tooth guided movement (both working and balance) and protrusive were done to determine the type and location of tooth interferences.

In charting the various interferences the mutually protective occlusal scheme was used as the standard because of the high degree of acceptance by the profession of this particular occlusal scheme and its overwhelming degree of clinical success in restorative dentistry. Briefly, the mutually protective occlusal scheme can be described as one in which maximum interdigitation of the teeth occurs with the mandible in its rearmost, midmost, superiormost position. The occlusal stops are equally distributed among the posterior teeth on their centric cusps. The anterior teeth are not in positive contact in that they will elicit a mark with articulating paper, but a thin mylar strip will not be held by the anterior teeth when the posterior teeth are in full contact occlusion. In protrusive movement, the six maxillary anterior teeth articulate equally and evenly with the six mandibular anterior teeth and the first bicuspids (the second bicuspids, if the

Fig. 12 Mutually protected occlusion in centric closure.

Fig. 13 Mutually protected occlusion in protrusive excursion.

case happens to be a four first bicuspid extraction case) to gently separate the posterior teeth or "disclude" them. On lateral excursions the maxillary centrals, laterals and cuspids articulate with the same teeth of the mandibular arch to disclude the posterior teeth immediately on any movement out of centric. Here the cuspids serve as the main guiding inclines and the rate of cuspid rise is as gentle as possible and is in harmony with the characteristics of the lateral mandibular border excursion. This type of occlusion is illustrated in Figures 12-15 on a treated, four first bicuspid extraction case. Note that in this instance in protrusive excursion the maxillary cuspids contact the mandibular second bicuspids.

Any posterior tooth contacts on any excursion (except the mandibular first bicuspids in nonextraction cases and the mandibular second bicuspids in first

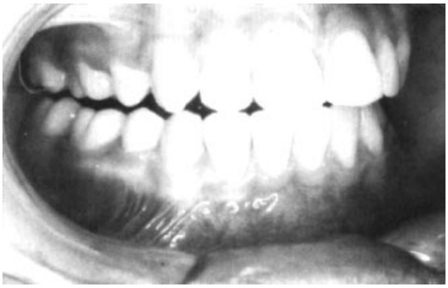

Fig. 14 Mutually protected occlusion in right lateral excursion, working side.

Fig. 15 Mutually protected occlusion in right lateral excursion, idling side.

bicuspid extraction cases on protrusive excursion) were charted as interferences.

The locations of the posterior tooth contacts on the various test excursions were identified by spraying powder on the occlusal surfaces of the teeth of the mounted models and then running them through the various excursions. In this way, where there was tooth contact, the powder was removed marking the various interferences.

Findings

All nine subjects possessed acceptable orthodontic treatment results. Two were free from any symptoms of the pain-dysfunction syndrome and seven had varying degrees of symptoms usually associated with this syndrome.

A pantographic recording of mandibular border excursions was performed on each subject and two sets of accurate stone casts were transferred in terminal hinge relationship to the Stuart articulator for each subject. One set of casts was left untouched to serve as a reference set. On the seven subjects who were suffering from pain-dysfunction symptoms, an occlusal adjustment was performed after first performing the procedure on one set of mounted casts.

In several instances, after the equilibration was performed on the subject, a new set of casts was transferred to the articulator to check the results of the occlusal equilibration.

The subjects' reactions to the equilibration and their previous symptoms were noted. In addition, various characteristics of the occlusion, pantographic recording, centric deviation, and occlusal interferences were charted so that trends, correlations, factors in common and differences could be noted.

The two asymptomatic patients were not equilibrated and served as a control group.

The first part of the findings is a qualitative evaluation of the characteristics for each subject. Several of these are included here as a sample.

The second part of the findings deals with those characteristics that are common to the experimental group as compared with the control group, and the relationship, if any, of the symptoms to the type and location of the occlusal interferences.

The severity of the original symptoms for each subject was subjectively graded and the subjects were ranked in order of severity of symptoms (Chart No. 1). A summary of these findings was then charted and compared with the location and type of tooth interferences found on border excursions from terminal hinge and on tooth-dictated excursions. Along with this, the amount and direction of centric deviation was also noted (Chart No. 2). This information was com-

CHART I
EVALUATION OF SEVERITY OF SYMPTOMS

Subject No.	Ranking in Severity of Symptoms	Right TMJ Pain and/or Clicking	Left TMJ Pain and/or Clicking	Muscle Pain, Soreness, Spasm and Limitation of Movement
1	5	X	XX	XX
2	3	XXX	XXX	XXX
3	6	XX	X	0
4	2	XXX	XXX	XXXX
5	1	XXX	XXX	XXXX
6	4	XX	XXX	0
7	7	X	X	0
Control Subjects				
8	8	0	0	0
9	9	0	0	0

Key:
0 — No Symptoms
X — Mild Symptoms
XX — Moderate
XXX — Severe
XXXX — Very Severe Symptoms

pared for both experimental and control subjects for trends and correlations.

Several apparent correlations were noted as follows:

1. All experimental subjects possessed balancing interferences in border excursions from terminal hinge and in tooth-dictated excursion.

2. None of the control subjects exhibited balancing or protrusive interferences in border excursions or tooth-dictated excursions.

3. The subjects with the severest symptoms had the greatest degree of centric deviation, exhibited tooth-guided balancing and/or protrusive interferences on the first and second molar teeth.

4. There seemed to be a definite correlation between the severity and location of symptoms, and location of balancing interferences on tooth-guided excursions. The site of pain or clicking correlated with the location of balancing interferences. The farther posteriorly the location of the balancing interference, the more severe the symptoms; however, where there was a grouping of teeth in balancing interference that included one or more bicuspids, the severity of the symptoms was less.

5. The location of the balancing interference, the presence of protrusive interferences on tooth-dictated movements, and the degree of centric deviation seemed cumulative in producing severity of symptoms.

6. The interferences found on tooth guided excursions seemed better correlated to the symptoms than those found on border excursions from terminal hinge.

The most significant finding was that all subjects had complete alleviation of all symptoms after the occlusal adjustment was completed to the operator's satisfaction. Most of the subjects had relief within the first twenty-four hours. On subjects number 4 and number 5, who had the most severe and long-standing symptoms, immediate relief was obtained but some residual crepitus remained; however, this gradually diminished and is continuing to do so. None of the subjects have had a recur-

SUBJECT NO. IN ORDER OF SEVERITY OF SYMPTOMS	CLASSIFICATION OF SEVERITY OF SYMPTOMS		LOCATION AND TYPE OF INTERFERENCE ON BORDER MOVEMENTS			LOCATION AND TYPE OF INTERFERENCE ON TOOTH DICTATED MOVEMENTS		CENTRIC DEVIATION IN MM.
	RIGHT SIDE	LEFT SIDE	BALANCING	WORKING	PROTRUSIVE	BALANCING	PROTRUSIVE	
5	SEVERE	SEVERE	R7,L7	R4,7	R7, L7	R7, L5,6,7	R7,L7	4 mm.
4	SEVERE	SEVERE	R6,7 L4,5,6	R4,6 L 4	R4,5,6,7 L4,5,6	R6,7 L6	0	3 mm.
2	SEVERE	SEVERE	R6,7 L6,7	L6	0	R6,7 L6,7	0	1 mm.
6	MODERATE	SEVERE	R6,7 L6,7	R4,5,6 L6,7	R4,5,6 ↑ R5,6,7 ↓	R4 L6,7	0	1 mm. to the Right
1	MILD	MODERATE	R6,7 L4,5,6,7	R4,L4	0	L4,5,6,7	0	1 mm.
3	MODERATE	MILD	R6 L6,7	L6	0	R6,L6	0	1 mm.
7	MILD	MILD	R7 L6,7,8	R6,7 L7	R5,6,7 L5,6,7	R5,6,7 L5,6,7,8	0	3 mm.
CONTROL SUBJECTS								
8	NONE	NONE	0	R7 L6,7	0	0	0	1 mm.
9	NONE	NONE	0	0	0	0	0	0

Chart II

rence of symptoms thus far and it seems unlikely that they will.

On all subjects in the experimental group, the buccolingual axial inclinations of the maxillary molars seemed to be responsible for the presence of the balancing interferences. Even though all of the cases could be graded as acceptable by current orthodontic treatment standards, as a general observation, there was insufficient *lingual crown torque* of the maxillary first and/or second molars.

The subjects in the control group had much more acceptable buccolingual axial inclination of the maxillary molars and exhibited no balancing interferences.

Discussion

Although the literature abounds with references concerning the neuromuscular reaction to occlusal interferences in the production of temporomandibular dysfunction, there is very little information as to the location of the specific types of interferences associated with this phenomenon. Most authors refer to the importance of deviations of the mandible from centric relation due to occlusal interferences as the possible cause of dysfunction symptoms. Yet the findings in this investigation seem to indicate that, primarily, balancing or nonfunctioning side interferences have a greater correlation with the symptoms.

However, one cannot divorce balancing interferences from those interferences that cause centric deviations because the same cusps are involved in the production of both of these types of interferences. Balancing interferences occur between buccal mandibular cusps and lingual maxillary cusps. These same cusps are also centric cusps and, therefore, the tooth inclinations necessary to produce severe balancing interferences will also produce centric cusp contacts that will cause a centric deviation. It would be very rare that a centric deviation would not be found in the presence of severe balancing interferences that could be detected on tooth-guided lateral excursions. However, since other types of interferences exist that could be responsible for causing centric deviation in the absence of balancing interferences, it could then be explained why all individuals who exhibit a centric deviation do not necessarily develop a temporomandibular joint pain-dysfunction syndrome, as was the case in subject number 8 of the study. This subject had a centric deviation of one mm, but exhibited no balancing interferences.

A closer look at the occlusions of subjects numbers 2, 4, and 5, who exhibited the most severe symptoms, may give some insight as to the reasons why their symptoms were so severe.

Subject number 5 had a four mm deviation from centric relation (forward). He also had bilateral balancing interferences involving the second molars and protrusive interferences involving the second molars. The effect of all of these factors appeared to be somewhat cumulative in producing the severest symptoms of the group. In moving the mounted casts of the original preequilibration models, it becomes readily apparent the amount of adaptation forced upon this individual by his occlusion is tremendous. To fit the teeth into occlusion the mandible had to be brought forward considerably, and to move in either right or left lateral excursions or to incise, the condyles must be dropped from the fossae or subluxated a considerable amount. If one were to consider mandibular movement in functional occlusion, it is apparent that to by-pass interferences and noxious tooth contact the mandible has to be lowered considerably and approximation of the teeth into occlusion must be approached by dodging interferences and elevating the entire mandible at once. It is virtually impossible for this individual to execute smooth gliding contacts of the teeth or chew by exhibiting lateral movements. All of the muscles of mastication must operate well beyond their optimum lengths, while the supra- and infrahyoids must carry an additional burden of carrying the mandible low just to avoid tooth collisions.

The same situation exists for subject number 4 with the exception that no protrusive interferences exist. But again, the lateral excursions are blocked and in this subject, as with subject number 5, it is virtually impossible for her to perform functional movements with the condyles working from the fossae onto the slopes of the emenentiae. The condyles must be subluxated considerably in both functional movements and closure into occlusion, thus making it necessary for the musculature to work well beyond its intended length.

Subject number 2 exhibited severe balancing interferences on the second molars, but no protrusive interferences, and only a one mm deviation in centric deflection. The teeth could be placed into full occlusion without the need for too much subluxation of the condyles, but lateral excursions had to be very carefully executed to avoid the balancing interferences. Here, lateral excursions were not impossible, but quite restricted requiring a fair degree of subluxation of the condyles in lateral functional movements.

As the symptoms decreased in severity there was less need to subluxate the condyles and carry the mandible low in order to make functional lateral excursions or to incise. The control group could execute all excursions without the need to subluxate the condyles and were symptom free.

The only exception to this was subject number 7. Although this patient did have balancing interferences, there was almost a group contact of the balancing interferences as in a bilaterally balanced occlusal scheme. It is difficult to say if this could account for the mildness of his symptoms. It is more likely they were just beginning. Three months prior to the time that his symptoms were noted, he appeared to be free of dysfunction symptoms; however, there was some wear and faceting of teeth.

The close correlation of the severity of symptoms with the location of the balancing interferences would seem to indicate that, in the temporomandibular joint pain-dysfunction syndrome, elimination of these interferences would be indicated. In adjusting the occlusion of all symptomatic subjects, these and all other interferences were eliminated. The occlusion was adjusted to the mutually protected occlusal scheme and the teeth were reshaped to allow maximum interdigitation in centric relation in the terminal hinge position. This achieved alleviation of the symptoms for all subjects. Immediate relief of the most severe symptoms was obtained in all instances within a matter of hours and, in some cases, within a matter of minutes.

Essentially, the occlusal adjustment eliminated the need for the individual to subluxate the condyles on functional movements and on closure into occlusion. Therefore, as a generalization, one might hypothesize that, in instances of *occlusally-induced* temporomandibular dysfunction, subluxation of the condyles in closure into occlusion and on functional excursions caused by tooth interferences may well be the major factor in production of muscular and joint symptoms. One might further state that the severity of the symptoms is proportional to the amount of subluxation required and the number of movements requiring it.

This would explain the cumulative effect of the degree of centric deviation and protrusive interferences on symptom severity and the effect of greater severity of symptoms where the balancing interferences occur more posteriorly.

Since this investigation is of preliminary nature, the above statements can only be regarded as hypotheses to be tested in properly designed statistical experimentation.

These hypotheses may not be too far-fetched. Subluxation of condyles causes a stretching of the elevator muscles of the mandible thus elongating the muscle spindles, the proprioceptive organs of the muscles. This, in turn, stimulates motoneurons in the spinal cord or brainstem causing impulses to be carried to the motor-end-plates of the muscle fibers that are stretched resulting in contraction of these muscle fibers.

Ramfjord and Ash suggest that increased muscle tension due to high fusimotor activity shortens the muscles and the muscle spindles, thus causing the muscles to be more prone to develop "splinting" for joint protection when the musculature is under increased stretch. They also believe that normal function is impossible in the face of an objectionable occlusal change unless a neuromuscular avoidance pattern is possible and learned. Then functional movements become automatic. However, functional disturbances may occur in other components of the masticatory system which cannot adapt to the avoidance pattern.

It can readily be seen that in subjects numbers 2, 4, and 5, an avoidance movement pattern, although not impossible, is extremely complex while the musculature is undergoing stretch. It would seem only logical that any increase in muscle tension due to increased fusimotor activity from emotional stress would tend to trigger splinting of the musculature and the start of dysfunction of the mandibular musculature. Therefore, occlusal interferences of this magnitude would tend to predispose the individual to the likelihood of developing pain-dysfunction symptoms even if he were not too predisposed to emotional upset or stress.

Schwartz, Chayes and Brod contend that the pain-dysfunction syndrome is a direct result of physical and emotional stress. It would seem that the findings in our investigation would indicate that the role of occlusion in the production of muscle tension has been grossly underestimated.

The gross alteration of the occlusion done on the subjects in this study and the almost immediate relief of symptoms in each instance would lead this author to believe that only in rare instances pain-dysfunction symptoms of the temporomandibular apparatus could be elicited in the absence of occlusal interferences, regardless of the psychological state. It is not likely that the alleviation of the severe symptoms that occurred within several hours or minutes of the occlusal adjustment on each subject was due to a change in the physical or psychological stress factors in each and every instance. This was not just a transitory relief of symptoms, for there has been no return of pain-dysfunction symptoms on any of the subjects.

There is no doubt that psychological stress-factors may predispose an individual to increased muscle tension. In all probability occlusal interferences of great enough magnitude to cause significant subluxation of the condyles upon closure and on various functional movements, also cause an increase in muscle tension and, therefore, predispose the individual through increased muscle tension to pain-dysfunction symptoms.

In instances where the occlusal

scheme is such that bruxing is not easily achievable and no interferences exist, it would be logical to assume that even if increased muscle tension were to occur from increased central nervous system fusimotor activity due to psychological or emotional stress, there would be no need for muscle splinting to occur to protect the joints from trauma. In the absence of conflicting impulses to opposing muscle groups and splinting of muscle, it would seem highly unlikely that pain-dysfunction symptoms would occur.

There are several reasons why we believe that more emphasis has not been placed on the role of occlusion, as perhaps the more important contributor to pain-dysfunction symptoms. These deal with the difficulty encountered in altering the occlusion to coincide with an idealized concept when reshaping natural teeth.

First of all, it is virtually impossible to ideally alter the occlusion on patients exhibiting any degree of severity of pain-dysfunction symptoms until those symptoms have been nearly alleviated by the use of reversible means, such as the mandibular repositioning splint. The muscle splinting reaction of the patient will simply not allow the operator to ascertain the true jaw relationship. As a result, attempts to alter the occlusion permanently under these circumstances usually result in temporary alleviation of symptoms which shortly return. The use of reversible means, such as the repositioning splint, will not only allow the operator to obtain true maxillomandibular relationships on the patient, but also will act as a means of determining if the occlusion is one of the etiological factors.

Secondly, one must be able to examine the occlusion without the influence of the individual's neuromuscular response to his occlusion in the form of neuromuscular avoidance patterns. Presently, this requires specialized training in instrumentation and technique.

Thirdly, one must be able to properly alter the occlusion to achieve a result that is very close to ideal and then deliver this result to the patient with ability to double check, or triple check the result accurately.

Most methods currently employed in occlusal adjustment fall far short of meeting these requirements. Therefore, the results usually obtained, particularly in those individuals psychologically predisposed to increased muscle tension, more often than not result in failure.

One might question why elimination of only the gross balancing interferences exhibited on tooth-guided excursions cannot be removed to achieve elimination of the symptoms of the pain-dysfunction syndrome. The problem, of course, is not that simple. However, occasionally this will seem to yield results. But, more often than not, elimination of these interferences will result in the creation of new interferences, either by allowing the mandible to close more posteriorly and contact new interferences, or by allowing the next interference to be contacted. In addition to this, since balancing interferences occur on centric supporting cusps, the improper removal of balancing interferences will cause the loss of the occlusal stops. The involved teeth will then tend to erupt into occlusal contact and thus, reestablish the balancing interference.

The most consistent degree of clinical success seems to be derived by first eliminating dysfunction symptoms with some form of mandibular repositioning splint, then using the technique described in this paper to adjust and double check the occlusal result until the most idealized occlusal scheme possible is achieved.

It has been pointed out in this investigation that balancing interferences involving the first and second molars are closely associated with the site of pain-dysfunction symptoms and their severity. It is believed that the possible connection involves the amount of subluxation of the condyles necessary to avoid these interferences in functional movements and that subluxation of the condyles causes stretch of the musculature, thereby increasing muscle tension and causing the individual to be more predisposed to pain-dysfunction symptoms. Increased muscle tension and associated shortening of the muscles, coupled with a complex avoidance pattern of movement, seems to lead to muscle splinting for joint protection and the start of pain-dysfunction symptoms, particularly if aggravated by emotional stress.

In the presence of balancing interference, protrusive interferences and a large anteroposterior centric deviation tend to cause even greater subluxation and add to the severity of symptoms.

Fig. 16 Posttreatment orthodontic case showing insufficient lingual crown torque of the maxillary molars.

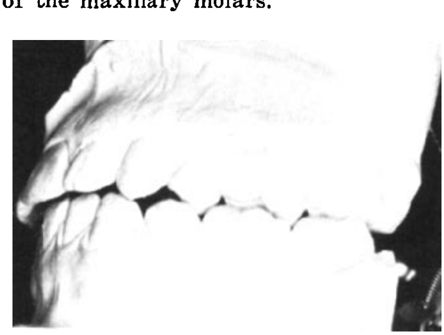

Fig. 17 Posttreatment orthodontic case showing failure to achieve true anteroposterior correction of maxillary to mandibular teeth in centric relation.

Fig. 18 Posttreatment orthodontic case showing arch width incoordination in centric relation.

On this basis it would seem prudent to take steps to avoid creating these types of interferences orthodontically.

Examination of the pre-equilibration casts of the subjects in this study revealed that, in most instances, the balancing interferences were caused by several factors. These are: 1) insufficient lingual crown torque of the maxillary molars (Fig. 16), 2) failure to truly establish a correction of the maxillomandibular relationship (Fig. 17), 3) arch width incoordination or arch form incoordination (Fig. 18), and 4) too much lingual crown torque of the mandibular molars (Fig. 19).

Assuming that one prerequisite necessary to eliminate posterior interferences is the establishment of sufficient anterior overlap to disclude the posterior teeth on eccentric excursions, let us discuss means that can be employed to eliminate balancing interferences of the molar teeth during orthodontic mechanotherapy.

To eliminate balancing interferences and centric deviations of any great magnitude, a true anteroposterior correction of maxilla to mandible must be obtained. In the subjects with the severest symptoms in this study (sub-

Fig. 19 Posttreatment orthodontic case showing too much lingual crown torque of the mandibular second molars.

Fig. 20 Mounted models exhibiting the type of balancing interference found on temporomandibular joint pain-dysfunction syndrome subjects. Neuromuscular avoidance pattern to this type of interference requires excessive subluxation of the orbiting condyle during right lateral movements.

jects numbers 4 and 5) a true correction was not obtained. In addition, subject number 5 had the mandibular plane opened considerably by the use of incorrect directional headgear force. It is a well-accepted fact in orthodontics that extrusive headgear force to the maxillary molars, particularly in the steeper mandibular plane angle cases, will hinge the mandible downward and back thus making Class II correction more difficult, if not impossible. Aside from the effect on facial esthetics, if the maxillary molars are extruded into the freeway space, subluxation of the condyles may occur so that it will be possible for the individual to fit his teeth into occlusion. This, incidently, is not evident on headfilms. If either one of these phenomena occurs, balancing interferences will be created. Failure to correct the Class II jaw relation completely leaves a sizable centric deviation, anteroposteriorly, in which from terminal hinge position to lateral excursions the molar cusps will be in interference rather than passing between each other, particularly on the balancing side. In the second instance the extrusion of the maxillary molars causes the individual to subluxate the orbiting condyles on lateral movement to avoid balancing interferences (Fig. 20).

Therefore, it is strongly advocated that the high-pull directional force be employed to the maxillary molars, particularly in the higher mandibular plane angle Class II cases, if for no other reason than to avoid creating balancing interferences.

Closer attention must be paid to detailing the molar buccolingual axial inclinations, particularly of the maxillary molars. On almost all symptomatic subjects in this study there was insufficient lingual crown torque of one or both maxillary molars on each side of the arch. If the patient is checked in terminal hinge relation and a centric deviation is present due to contact in the molar area, the cause is due to either incoordinated arch width and/or incorrect buccolingual axial inclinations of the molars, usually the maxillary molars. Where severe balancing interferences existed due to insufficient lingual crown torque of the maxillary second molars, the cause was usually because they were not banded.

Conclusions

1. There appears to be a very close association between the severity and location of temporomandibular joint pain-dysfunction symptoms and the location of balancing interferences on tooth-guided excursions.

2. In the presence of balancing interferences on tooth-guided excursions, the addition of protrusive interferences and/or a large centric deviation seems to have a cumulative effect upon the severity of pain-dysfunction symptoms.
3. The hypothesis was set forth that occlusal interferences that cause extreme subluxation of the condyles in lateral excursions and/or protrusive and/or closure into maximum interdigitation results in stretching of the musculature, which in turn would lead to increased muscle tension and muscle splinting to avoid joint trauma, thus making the individual predisposed toward developing pain-dysfunction symptoms.
4. A very effective method of occlusal adjustment for the relief of temporomandibular joint pain-dysfunction symptoms was described. This method proved effective for *all* symptomatic subjects in this study.
5. Sudden occlusal (proprioceptive) changes, if of the correct nature, will alleviate, rather than aggravate, temporomandibular joint pain-dysfunction.
6. Occlusion may play a more important role in the production of the temporomandibular joint pain-dysfunction syndrome than heretofore ascribed to it. On the basis of the findings in this study it would appear extremely rare to find pain-dysfunction where no occlusal interferences existed.
7. The presence of occlusal interferences commonly associated with temporomandibular joint pain-dysfunction on postorthodontic cases seems to be due to:
   A. Failure to achieve a true anteroposterior correction of jaw relation.
   B. Insufficient lingual crown torque of maxillary first and second molars.
   C. Too much lingual crown torque of mandibular molars.
   D. Incoordination of arch widths and arch form in terminal-hinge relation.
8. The centrically related, mutually protective, occlusal scheme, when accomplished with a high degree of accuracy, is an effective means for correction of the occlusally induced temporomandibular joint pain-dysfunction syndrome.

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