An Evaluation of Functional Occlusal Interferences in Orthodontically Treated and Untreated Subjects

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Centric occlusion-initiated functional registrations demonstrate similar numbers and types of lateral and protrusive functional occlusion contacts in 49 post-orthodontic subjects and 27 non-orthodontic subjects with ideal static occlusions. Nonworking (balancing) functional occlusion contacts were present in an overwhelming percentage of both groups.

Few subjects in dentistry are as confusing or given to so many divergent interpretations and misinterpretations as "functional occlusion." There appears to be a never-ending debate over which is better—centric occlusion or centric relation occlusion, cuspid protected occlusion or group function occlusion; or whether the "Myofascial pain-dysfunction syndrome" is caused primarily by occlusal disharmonies or by psychological stress.

Part of the problem in this area is that the complex biological, physiological, and psychological factors related to mandibular movement and occlusion involve such diverse biological structures as the brain, nerves, reflexes, joints, ligaments, bone, muscle, etc. This makes research and the interpretation of findings more than a little difficult.

In the absence of definitive research findings, the dental practioner's

thoughtful skepticism is often overwhelmed by the captivating presentations of the many occlusion theorists.

The dental profession has studied mandibular movement and "functional occlusion" for decades,[1-4] and the subject is certainly of great interest to orthodontists.[5-18] Perry has stated, "No longer should the orthodontist be content with full occlusal interdigitation in the finished case, but of necessity must recognize and treat the occlusion to a functional balance."[6]

Although longitudinal research is sparse, a number of cross-sectional investigations have used orthodontic patient samples to evaluate possible relationships between functional occlusal disharmonies and/or temporomandibular joint dysfunction and orthodontic tooth movement. The findings and interpretations of these investigations have been inconclusive and sometimes inconsistent. Many uncontrolled observations have suggested a relationship between orthodontic treatment and functional occlusal disharmonies and/or TMJ dysfunction, while most controlled studies have found no relationship between those variables.

Without consideration of possible pre-treatment TMJ symptoms, Moyers[7] reported that of 150 subjects with temporomandibular joint disturbances, 40% had previous orthodontic treatment.

In another uncontrolled study, Berry and Watkinson[8] reported symptoms of TMJ dysfunction in 18 post-orthodontic patients with excessive dental overbite after Class II, division 1 malocclusions had been treated by maxillary bicuspid extractions and removable appliances.

Jarabak[9] suggested that occlusal contacts were responsible for temporal muscle spasms and temporomandibular joint clicking in seven orthodontic patients evaluated by electromyography and occlusal splint therapy.

Eggleston and Ekleberry[10] concluded that electromyographic disharmonies in 31 post-orthodontic subjects were related to mandibular centric differences between centric relation occlusion and centric occlusion.

An uncontrolled study by Jekkals,[11] using mounted casts of post-orthodontically treated subjects, found nonworking (balancing) contacts and slides from centric relation occlusion to centric occlusion in 17 of 18 subjects studied.

Roth[12] assumed that centric and nonworking (balancing) occlusal contacts were responsible for the "Myofascial pain-dysfunction syndrome" in 7 post-orthodontic subjects.

On the other hand, Ahlgren and Posselt[13] failed to find a significant difference in the number of non-working (balancing) and centric cuspal contacts between 23 post-orthodontically treated subjects and 120 non-orthodontically treated subjects that had various types of malocclusions.

Using occlusal indicator wax to record the frequency and location of premature contacts in centric relation occlusion and centric occlusion, as well as mandibular centric shifts, Cohen[14] found no difference between the functional occlusion of 36 non-orthodontically treated and 40 post-orthodontically treated subjects with "virtually" ideal static occlusions.

Using an impression compound bite, interposed dental floss and a transillumination technique to record and measure total surface contact, Gazit and Lieberman[15] reported no difference in the TMJ symptoms, frequency of centric shifts, or the location or frequency of nonworking (bal-

ancing) contacts between 179 non-orthodontically treated dental students with varied occlusions and 84 post-orthodontically treated dental students.

Contrary to the suggestion that orthodontic tooth movement is responsible for TMJ dysfunction in some post-orthodontically treated patients, Williamson[16] reported that of 304 potential orthodontic patients between the ages of 6 and 16 years, 107 already had symptoms of incipient TMJ dysfunction.

Bucci,[17] using visual and stethoscopic examinations, found no difference in TMJ sounds (crepitis, popping, clicking and subluxation) between 115 post-orthodontic subjects and 100 non-orthodontically treated subjects equally divided between static ideal and malocclusions.

Sadowsky and BeGole[18] recently reported no significant difference in the TMJ symptoms and certain functional occlusion parameters between 75 non-orthodontically treated malocclusion subjects and 75 post-orthodontically treated subjects who had been treated with fixed Edgewise orthodontic appliances at least 10 years earlier. Mandibular centric shifts were found in 70 of the non-orthodontically treated and 75 of the post-orthodontically treated subjects. Non-working (balancing) contacts on lateral excursions were present in 58 of the non-orthodontic group and in 66 of the post-orthodontic group.

Methods and Materials

The purpose of this investigation was to compare the functional occlusion produced after full-banded Edgewise orthodontic therapy with that which naturally exists in a population with an ideal static interdigitation of the teeth.

Seventy-six (76) subjects judged to have an ideal static occlusion and no history of occlusal adjustments were selected from a population of 207 as described below. Data from this sample was also reported by the authors in another article.[28]

1. Twenty-four (24) were selected from 100 patients previously treated at the University of Pittsburgh with fully-banded Edgewise therapy and judged from their post-treatment records to have been well treated. All of this group had four bicuspids removed as a part of their orthodontic therapy. Second molars were not banded during their active treatment. No attempt had been made during or after their active therapy to achieve any specific "functional occlusion" standard. Functional occlusion as a separate entity had been ignored, with orthodontic treatment directed at correction of abnormalities of "static" occlusion.

Selection of the 24 subjects from the larger group of 100 was based on lack of relapse (no rotations, no class II return), having worn no retainers for at least three months, and availability to take part in the investigation.

2. Twenty-five (25) subjects were selected from an otherwise similar group of 80 retention patients who had been treated without the removal of teeth.

3. Twenty-seven (27) subjects were selected from among the dental students at the University on the basis of an ideal static occlusion with no history of any type of orthodontic treatment or occlusal adjustment.

Extrinsic variables such as race, missing teeth, large restorations and periodontal bone loss were neutralized by sample selection. Third molars

TABLE 1
Sample of 76 Subjects with "Ideal" Static Occlusions

Experimental Groups	*Sex*	*Mean Age in Years*	*Mean Years After Active Orthodontic Treatment*
Orthodontically Treated (with Extraction)	18 F 6 M	17.63	2.96
Orthodontically Treated (without Extraction)	16 F 9 M	16.32	2.92
Not Orthodontically Treated	27 M	23.33	
Total	76		

were unerupted or not present in the subjects used in this study.

Functional working, balancing and protrusive occlusal contacts were recorded for all subjects with a rubber-base bite-registration material. All functional records were initiated from the intercuspal (centric occlusion) position.

For working and balancing contact registrations, the bite registration material was placed over the mandibular teeth. The subjects were then instructed to close lightly on their back teeth and slide the lower jaw to the right as they had been shown previously. Buccal cusp tip contact was taken as the terminal point of the lateral record. The same procedure was repeated for the left side.

The protrusive registration was initiated in the same way, with the mandible then protruded until the anterior teeth were biting edge-to-edge.

Occlusal contacts were viewed from the mandibular side of the bite registration. Perforations were taken as indications of working, balancing or protrusive contacts. In a few instances, balancing contacts had to be differentiated from centric contacts. Contacts between the lingual slope of buccal cusps of mandibular teeth and the buccal slope of lingual cusps of maxillary teeth were recorded as balancing contacts.

Although all teeth which perforated the registration material in the protrusive position were recorded, only those posterior to the cuspids were considered to be protrusive interferences.

All three of the bite records were examined, and the location and size of each perforation was traced onto millimetric graph paper on which outlines of a mandibular arch had been superimposed. This method allowed easy data collection of the number, location and size of each tooth contact. Right and left working, right and left balancing, and protrusive tooth contacts were transferred from the functional registrations to the recording grid, using a color code system to distinguish between the different types of contacts.

Mesial and distal contacts of the first and second molars were recorded separately because their surface area and number of cusps represented approximately twice the surface area and number of cusps as the other teeth. Since four bicuspids were missing in the extraction subjects, these teeth were not included in the final data recordings.

The overall functional occlusion type was noted as recorded from centric occlusion. These types included cuspid protected occlusion, group functional occlusion, unilateral balanced occlusion and bilateral balanced occlusion.

To test the reliability of the functional bite registration technique, repeat functional recordings were made on 13 randomly selected subjects from the overall sample.

To qualitatively substantiate that this functional bite method was sufficiently accurate to record overall functional occlusion types, it was compared against the use of a semi-adjustable Hanau articulator. Data from 10 subjects from the present investigation that were also used by Ismail and Guevara[19] were compared, even though those recordings were made with centric relation occlusion records and the present investigation involved centric occlusion-generated records.

A Chi-square test[20] for possible statistical differences among and within the three experimental groups, and a non-parametric statistic (the Kruskal-Wallis one-way analysis of variance by ranks)[21] to test whether there was a difference in the severity of the balancing contacts among experimental groups were applied. A probability of 0.05 was adopted to delimit the level of significance. Because of the limited frequency of occurrence of protrusive contacts, only descriptive statistics were used for that data.

Results

Reliability and Accuracy of Measurements

The functional bite registration method proved to be reliable when repeat measurements were performed on 13 of the 76 subjects. The number and location of tooth contacts were identical for all repeated measurements. The area of the 154 measurements was the same for 78.5% of the recordings.

Overall functional occlusion type determinations made by this method using centric occlusion-generated records were identical to those made with centric relation occlusion records and an articulator for the thirteen subjects tested.

Number of Balancing Contacts

Although there was a slight difference in the number of balancing contacts among the three experimental groups, this was not statistically significant at $P < .05$ as revealed by the Chi-Square Test (Table 2). There was also no significant difference in the number of balancing contacts among experimental groups or between individual teeth.

There were, however, statistically significant differences between specific teeth. When experimental groups were considered separately or collectively, the number of balancing contacts for the distal of the second molar was significantly greater than for the other teeth.

Severity of Balancing Contacts

There was no statistically significant difference in the severity of the balancing contacts among experimental groups as tested by the Kruskal-Wallis one-way analysis of variance by ranks (Table 3).

Number and Severity of Protrusive Interferences

Protrusive contacts were of little consequence in this study. Only 24 contacts were recorded, and they were evenly distributed throughout all three experimental groups.

Type of Functional Occlusion

Group functional occlusion and cuspid protected occlusion were not pres-

TABLE 2
Group Totals of Nonworking (Balancing) Contacts for mandibular teeth.

Experimental Group	*Central Incisor*	*Lateral Incisor*	*Cuspid*	*Second Bicuspid*	*First Molar (Mesial)*	*First Molar (Distal)*	*Second Molar (Mesial)*	*Second Molar (Distal)*	*Total*	*Mean*	*S.D.*
Orthodontically Treated (Extraction)	13	15	8	7	3	18	7	25	96	4.0	± 2.7
Orthodontically Treated (Non-Extraction)	7	7	4	13	6	18	17	32	104	4.2	± 2.7
Not Orthodontically Treated	11	7	6	4	7	11	14	30	90	3.3	± 2.7
Total	31	29	18	24	16	47	38	87	290		

TABLE 3
Total Area of Nonworking (Balancing) Contact Perforations in Bite Registrations for Each Experimental Group (square mm).

Experimental Group	*Central Incisor*	*Lateral Incisor*	*Cuspid*	*Second Bicuspid*	*First Molar (Mesial)*	*First Molar (Distal)*	*Second Molar (Mesial)*	*Second Molar (Distal)*	*Total*	*Mean*	*S.D.*
Orthodontically Treated (With Extraction)	22.5	24.8	8.5	6.8	1.3	24.3	12.8	56.0	156.8	6.5	± 5.5
Orthodontically Treated (Without Extraction)	8.0	11.8	4.8	16.8	7.8	19.8	17.0	45.3	131.0	5.2	± 3.9
Not Orthodontically Treated	10.5	7.3	5.3	2.3	6.8	11.3	13.5	41.8	98.8	3.7	± 3.7
Total	41.0	43.8	18.5	35.8	15.8	55.3	43.3	143.0	386.5		

TABLE 4
Total Number and Percent of Each Functional Occlusion Type.

Experimental Group	*Group Occlusion*		*Cuspid Occlusion*		*Balanced (One Side)*		*Bilateral Balanced (Both Sides)*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Orthodontically Treated (With Extraction)	0	0	0	0	9	37.5	15	62.5
Orthodontically Treated (Without Extraction)	1	4.0	1	4.0	3	12.0	20	80.0
Not Orthodontically Treated	4	14.8	0	0	6	22.2	17	62.9
Total	5	6.6	1	1.3	18	23.7	52	68.4

ent to any appreciable extent in any of three experimental groups (Table 4). Unilateral and bilateral balanced occlusion predominated in all three experimental groups.

Discussion

Ahlgren and Posselt,[13] Cohen,[14] Gazit and Lieberman,[15] and Sadowsky and BeGole[18] have all reported no difference in the number or type of functional cuspal contacts between a total of 222 post-orthodontically treated subjects and 410 non-orthodontically treated subjects. Most subjects had nonworking (balancing) side contacts as recorded by varying methods that used records initiated from either centric relation occlusion[14,15] or centric occlusion.[13,18]

This investigation also indicates that nonworking (balancing) side functional contacts were abundant and approximately evenly distributed among 49 post-orthodontically treated and 27 non-orthodontically treated subjects with ideal static occlusions.

Although the presence of balancing contacts in the post-orthodontic sample was somewhat expected, the occurrence of an equivalent number, location and severity of nonworking (balancing) side contacts in the non-orthodontic ideal static occlusion group may be surprising to some. D'Amico,[22] Beyron,[23] Ismail and Guevara,[19] and Scaife and Holt[24] all found a relative lack of tooth contact on the nonworking (balancing) side in the populations that they studied. Weinberg[25,26] did find nonworking (balancing) side contacts in many subjects in his sample.

It must be pointed out that those studies all used populations with static malocclusions, not normal or ideal occlusions. It may be possible that nonworking (balancing) side contacts can predominate only in a population with ideal static interdigitation of the teeth, free of the many other interferences of malocclusion. For instance, Ingerval[27] found nonworking (balancing) side contacts on at least one side in 88% of 50 children and in 84% of 50 adults with ideal static occlusions.

Since there is often a direct relationship between cuspid wear and balancing side contacts, it is possible that ideal static occlusion is also related to more even distribution of tooth contacts and attrition than Class II malocclusion, where cuspids make minimal contact during functional excursions.

The occurrence of the majority of the balancing contacts on the distal of the mandibular second molar in all three experimental groups may be due to several factors. Location near the ascending ramus of the mandible, the natural Curve of Spee, and eruption timing could all contribute to the higher occurrence of balancing contacts of this tooth.

The low incidence of protrusive functional contacts in all experimental groups was probably due to the normal overbite of the subjects in the study. This could provide enough anterior guidance to disclude the posterior teeth.

Summary and Conclusion

Centric occlusion-generated functional bite registrations failed to show a difference in the number, location or severity of nonworking (balancing) or protrusive functional occlusion contacts between 49 post-orthodontically treated subjects and 27 non-orthodontically treated subjects with ideal static occlusion. Nonworking (bal-

ancing) side functional occlusion contacts were present in 85% of the non-orthodontic subjects and 97% of the post-orthodontic subjects.

At least within the parameters of this investigation, the lateral and protrusive occlusions of post-orthodontic subjects and comparable non-orthodontic subjects were equivalent.

It is important to note that this is a study of incidence. It does not address the meaning or importance of such contacts.

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