Original Article

Functional Occlusal Patterns and Their Relationship to Static Occlusion

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ABSTRACT

Objectives: To test the hypothesis that there is no relationship between static occlusion and dynamic occlusion.

Materials and Methods: The relationship between static and dynamic occlusion was investigated in a sample of 94 dental students (39 males and 55 females) with an age range of 21–30 years. Static occlusion was determined by intraoral examination. Dynamic occlusion was determined in regulated lateral (0.5 mm and 3 mm lateral to the intercuspal position) and protrusive movements of the mandible by intraoral examination with the aid of shimstock.

Results: At the 0.5 mm lateral excursion, 24.5% had bilateral group function and 12.7% had bilateral canine guidance. At the 3 mm positions, the guidance pattern changed to a predominantly canine guidance. Fifty percent of subjects had bilateral canine guidance, and only 8.8% had bilateral group function. In terms of the anterior guidance pattern, a predominant anterior contact with posterior disocclusion (77.5%) was noted. Examination of the relationship between static and dynamic occlusions revealed that at the 0.5 mm position, the pattern of dynamic occlusion was different in relation to various static occlusion features but without reaching a significant level. While at the 3 mm position, the pattern of dynamic occlusion was significantly affected by incisor relationship. The distribution of protrusive excursion patterns was significantly influenced by incisor, canine, and molar relationships.

Conclusions: The hypothesis is rejected. An association exists between dynamic occlusion and different aspects of static occlusion. (*Angle Orthod* 2010;80:65–71.)

KEY WORDS: Static occlusion; Functional occlusion; Lateral excursion; Anterior excursion

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INTRODUCTION

Dental treatment has the capacity to fundamentally change static and dynamic occlusal relationships, while aiming for achieving as near "ideal" occlusion as possible. Accepted criteria for the "ideal" static occlusion were established based on the work of Angle,[1] who is credited with making the profession most aware of occlusion by presenting standards whereby a malocclusion could be compared with normal occlusion, and the work of Andrews,[2] who presented six keys that gave a well-delineated prescription for an ideal intercuspation of teeth. Conversely, the features that constitute "ideal" dynamic occlusion continue to be subject to great debate and have not, to date, been conclusively established.

There are three main concepts regarding tooth contact during the lateral excursion of mandibular movement: (1) balanced occlusion, which was developed from the work of Bonwill,[3] (2) canine guidance, described by D'Amico,[4] and (3) group function, as discussed by Beyron.[5]

The relationship between static and dynamic occlusion is one of the aspects of the study of functional occlusion that has received little attention. Few studies have explored the possibility of an association but conflicting results have been reported. Scaife and Holt[6] found canine protected occlusion to be associated with Class II then Class I, and least associated with Class III, malocclusion. The above mentioned findings were confirmed by Al-Hiyasat and Abu-Alhaija[7] in a study of 447 school children, aged 14–17 years. Other studies

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Accepted: April 2009. Submitted: February 2009.

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found that most Class I Angle occlusion cases were associated with balanced occlusion.[8–10] On the other hand, Tipton and Rinchuse[11] found no significant association between static and dynamic occlusion.

A number of limitations can be noted in the above mentioned studies: No reference was made to the location of the canine in terms of its relationship to the line of the arch nor to the degree of attrition of the canine, which is of particular importance in examining the assumption that attrition could lead from one type of contact during lateral movement to another.[12] Moreover, the position at which the occlusal contact pattern was recorded (cusp to cusp) is not representative of the functional range of the lateral excursion of mandibular movement.

Another fact for consideration is that changes occurring during occlusal development could influence the occlusal contact pattern; Heikinheimo et al[13] reported an increase in occlusal interferences between the ages of 12 and 15 years in 167 Finns; other studies found a decreasing prevalence with increasing age.[14,15] Although the results of these studies are contradictory, they suggest that changes occur during occlusal development that must not be overlooked in sample selection; samples that are beyond the adolescent years would be more representative of a population as it avoids the effects of age and occlusal development on the results of research.

Based on the above mentioned facts, we thought it warranted to further investigate whether a relationship exists between static occlusion and dynamic occlusion, and, if such a relationship exists, which type of dynamic occlusion is associated with which type of static occlusion.

MATERIALS AND METHODS

The population for this study consisted of 94 dental students at Jordan University of Science and Technology (39 males and 55 females). The age of subjects ranged from 21–30 years, with a mean age of 23.1 (±1.44) years. Subjects who met the following criteria were selected:

- White
- No previous or current orthodontic treatment.
- The presence of fully permanent dentition except for the third molars
- No previous occlusal adjustments
- No large restorations involving the incisal edge or a cusp tip
- No crowns or bridges
- No apparent pathologic periodontal problems
- Upper and lower canines in the line of the arch
- No tooth showing attrition into the dentine

The static occlusion of each subject was assessed by intraoral examination on a dental chair under direct vision. The following static occlusal features were recorded:

- Incisor relationship classified according to the British Standard Institute[16]
- Canine relationship classified according to Houston et al[16]
- Molar relationship classified according to Angle's criteria[1]

Dynamic occlusion was determined with the aid of shimstock (Almore shimstock, 8 mm wide, 8 μm thick, Hanel, Langenau, Germany) to confirm tooth contact. The examination was carried out with subjects seated in an upright position in a dental chair with the Frankfort plane parallel to the floor. All recordings were made by the same operator in the same period of the day (morning hours) to avoid possible diurnal variation.[17]

For the lateral excursion, occlusal contacts were recorded on the working and the nonworking side at ½ mm and at 3 mm lateral to the habitual centric occlusion. To regulate each lateral position, marks were made on the maxillary central incisor with a water-resistant pencil to mark the intercuspal position at 0.5 mm and 3 mm positions for both right and left sides. Subjects were asked to perform the movements with the aid of a handheld mirror. The shimstock was placed on the occlusal surfaces of teeth from the canine backward; the subject was then asked to close his/her mandible into maximum intercuspation. Gliding movement was performed to the right or the left while the examiner maintained a constant pulling force on the shimstock; on reaching the 0.5 mm position, the teeth holding the shimstock were recorded as working side contacts. The subject was asked to repeat the movement with the shimstock placed on the opposite side to record nonworking side contact. The same procedure was carried out to record occlusal contact at 3 mm lateral to the habitual centric occlusion.

Occlusal contacts at the protrusive excursion of mandibular movement were recorded at the edge-to-edge position. The shimstock was placed on the occlusal surfaces of the anterior teeth; the subject was asked to close into maximum intercuspation and then slide to the edge-to-edge protrusive position while the examiner maintained a constant pulling pressure. Once the teeth were at the edge-to-edge position, teeth holding the shimstock were considered to be in contact and were recorded. The shimstock was then placed on the occlusal surfaces of post teeth, and the subject was asked to repeat the same movement to check for the presence of posterior teeth contact.

In the lateral excursion, the guidance pattern was considered as one of the following:

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Table 1. Distribution (%) of Dynamic Occlusion at 0.5 mm and 3 mm Lateral Excursion and Incisor Classification[a]

Occlusion	Class I		Class II/1		Class II/2		Class III		Total	
	0.5 mm	3 mm	0.5 mm	3 mm	0.5 mm	3 mm	0.5 mm	3 mm	0.5 mm	3 mm
Bilateral canine protected occlusion	12(25)	26(53)	0	7(70)	0	12(70)	0	2(11)	12(12.8)	47(50.0)
Bilateral group function occlusion	10(20)	4(8)	4(40)	0	5(29)	1(6)	4(22)	3(17)	23(24.5)	8(8.5)
Mixed canine protected and group function	6(12)	11(22)	3(30)	2(20)	4(24)	2(12)	4(22)	3(17)	17(18.1)	18(19.1)
Bilateral balanced occlusion	4(8)	0	0	0	1(6)	0	2(11)	0	7(7.4)	0
Mixed balanced and group function	3(6)	1(2)	1(20)	0	4(24)	0	4(22)	2(11)	12(12.7)	3(3.2)
Mixed group function and single tooth contact	7(14)	3(6)	1(20)	0	1(6)	0	1(11)	4(22)	10(10.6)	7(7.4)
Others	7(14)	4(8)	1(20)	1(10)	2(12)	2(12)	3(17)	4(22)	13(13.8)	11(11.7)
Total	**49**		**10**		**17**		**18**		**94**	

[a] Chi-square test, $P = .499$ for 0.5 mm lateral excursion and $P = .047$ for 3 mm lateral excursion.

- Bilateral canine protected occlusion
- Bilateral group function occlusion
- Mixed canine protected and group function
- Bilateral balanced occlusion
- Mixed balanced and group function
- Mixed group function and single tooth contact
- Others (this category included bilateral mediotrusive interference, mixed laterotrusive and canine, bilateral laterotrusive interference, mixed mediotrusive and group, mixed canine guidance, and laterotrusive interference)

In the protrusive excursion, the guidance pattern was considered as one of the following:

- Anterior contact with posterior disocclusion
- Anterior contact with unilateral posterior contact
- Anterior contact with bilateral posterior contact
- No anterior contact with unilateral posterior contact
- No anterior contact with bilateral posterior contact

Ten subjects were reexamined at 2 months following the initial clinical examination to determine intraexaminer reliability. The Kappa ranged from (0.8–1), indicating a reliable examination.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 11 (SPSS Inc, Chicago, Ill). The Chi-square test was used to examine the relationship between the different variables included in this study. P values less than .05 were considered statistically significant.

RESULTS

Dynamic Occlusion

In the total sample at 0.5 mm lateral guidance, 24.5% of subjects had bilateral group function and 18.1% had mixed canine guidance and group function. While at the 3 mm positions, the guidance pattern changed to a predominantly canine guidance. Fifty percent of subjects had bilateral canine guidance, and only 8.5% had bilateral group function (Table 1).

In the protrusive guidance patterns, a predominant anterior contact with posterior disocclusion (77.5%) was followed by anterior contact with unilateral posterior contact (12.7%). Anterior contact with bilateral posterior contact was found in 4% of subjects. The remaining 5.8% had no anterior contact with unilateral or bilateral posterior contact.

Static Occlusion

The incisor relationship was Class I in 49 subjects, Class II/1 in 10 subjects, Class II/2 in 17 subjects, and Class III in 18 subjects. The molar and canine relationships are reported in Tables 2 and 3.

Table 2. Distribution (%) of Dynamic Occlusion at 0.5 mm and 3 mm Lateral Excursion and Canine Classification[a]

Occlusion	Both sides Class I		One side Class I		Both sides Class II		Both sides Class III	
	0.5 mm	3 mm	0.5 mm	3 mm	0.5 mm	3 mm	0.5 mm	3 mm
Bilateral canine protected occlusion	6(14)	16(37)	6(21)	18(62)	0	12(70)	0	1(20)
Bilateral group function occlusion	9(21)	5(12)	8(28)	2(7)	6(35)	1(6)	0	0
Mixed canine protected and group function	11(30)	9(21)	5(17)	6(21)	1(6)	2(12)	0	1(20)
Bilateral balanced occlusion	3(7)	0	1(4)	0	3(18)	0	0	0
Mixed balanced and group function	4(9)	3(7)	4(14)	0	3(18)	0	1(20)	0
Mixed group function and single tooth contact	5(12)	5(12)	2(7)	1(3)	2(12)	0	1(20)	1(20)
Others	5(12)	5(12)	3(10)	2(7)	2(12)	2(12)	3(60)	2(40)
Total	**43**		**29**		**17**		**5**	

[a] Chi-square test, $P = .159$ for 0.5 mm lateral excursion and $P = .146$ for 3 mm lateral excursion.

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Table 3. Distribution (%) of Dynamic Occlusion at 0.5 mm and 3 mm Lateral Excursion and Molar Classification[a]

	Both Sides Class I		One Side Class I		Both Sides Class II		Both Sides Class III	
Occlusion	0.5 mm	3 mm	0.5 mm	3 mm	0.5 mm	3 mm	0.5 mm	3 mm
Bilateral canine protected occlusion	8(16)	25(49)	4(19)	13(62)	0	9(64)	0	0
Bilateral group function occlusion	10(20)	4(8)	8(38)	2(10)	5(36)	1(7)	0	1(13)
Mixed canine protected and group function	14(27)	11(22)	1(6)	4(19)	0	1(7)	2(25)	2(25)
Bilateral balanced occlusion	2(4)	0	1(6)	0	3(21)	0	1(13)	0
Mixed balanced and group function	5(10)	3(6)	4(19)	0	2(14)	0	1(13)	0
Mixed group function and single tooth contact	6(12)	4(8)	1(6)	1(5)	2(14)	0	1(13)	2(25)
Others	6(12)	4(8)	2(12)	1(5)	2(14)	3(22)	3(38)	3(38)
Total	**51**		**21**		**14**		**8**	

[a] Chi-square test, $P = .196$ for 0.5 mm lateral excursion and $P = .341$ for lateral excursion at 3 mm.

No statistically significant differences were found between males and females in the various aspects of static occlusion or in the guidance pattern in lateral or protrusive excursions. Therefore, male and female subjects were pooled together in the analysis.

Relationship Between Static and Dynamic Occlusion

The type of guidance at the 0.5 mm position was not significantly associated with the incisor (Table 1), canine (Table 2), or molar classification (Table 3). However, it should be noted that at 0.5 mm lateral excursion, bilateral canine protected occlusion was observed only in subjects with Class I incisor, canine, or molar relationships

As can be seen in Table 1, 70% of subjects with Class II div 1 and Class II div 2 incisor relationships have bilateral canine protected occlusion at 3 mm lateral guidance, compared with 53% in Class I and 11% in Class III. This difference was statistically significant ($P = .047$). On the other hand, no significant association was noted between the type of lateral guidance at the 3 mm positions and the canine relationship (Table 2) or the molar relationship (Table 3).

The pattern of guidance in protrusive mandibular excursions was significantly associated with incisor classification ($P < .0001$; Table 4), canine classification ($P < .0001$; Table 5), and molar classification ($P = .031$; Table 6), with less anterior contact with posterior disocclusion observed in Class III subjects.

DISCUSSION

The criteria set for selecting subjects for this study were chosen to ensure the presence of a natural dentition. The absence of apparent pathologic periodontal problems was used as a criterion because the neuromuscular control of occlusion stability and masticatory muscles is influenced by the periodontal afferent.[18,19] The fact that the sample was composed of subjects aged 21 to 30 years was chosen because the changes occurring during occlusal development could influence the occlusal contact pattern. Cases with marked attrition were excluded based on the assumption made by McAdam[20] and Woda et al[12] that canine guidance and group function appear to correspond to two successive states of the evolving dentition under the effect of attrition.

Static occlusion was assessed by intraoral examination by direct vision with the aid of a dental mirror, as was done in previous investigations.[7,11] Ovsenik et al[21] reported that intraexaminer and inter-examiner malocclusion assessment recorded and measured intraorally is reliable and therefore is proposed as the method of choice to be used not only in epidemiologic studies and screenings, but also in clinical orthodontic assessments.

Occlusal contacts for both lateral and protrusive excursions of the mandible were determined by intraoral examination with the aid of shimstock to confirm the contact between the teeth, as was done in previous investigations.[7,22–24] Shimstock has been shown to have greater interexaminer reliability than articulating film[25] and high intraexaminer reliability.[7] The chosen thickness

Table 4. Distribution (%) of the Pattern of Guidance in Protrusive Mandibular Excursion and Incisor Classification[a]

	Class I	Class II/1	Class II/2	Class III
Anterior contact with posterior disocclusion	41(84)	8(80)	17(100)	6(33)
Anterior contact with unilateral posterior contact	3(6)	2(20)	0	7(39)
Anterior contact with bilateral posterior contact	4(8)	0	0	1(6)
No anterior contact with unilateral posterior contact	0	0	0	2(11)
No anterior contact with bilateral posterior contact	1(2)	0	0	2(11)
Total	**49**	**10**	**17**	**18**

[a] Chi-square test, $P < .0001$.

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Table 5. Distribution (%) of the Pattern of Guidance in Protrusive Mandibular Excursion and Canine Classification[a]

	Both Sides Class I	Class I and Class II	Both Sides Class II	Both Sides Class III
Anterior contact with posterior disocclusion	31(72)	24(83)	15(88)	2(40)
Anterior contact with unilateral posterior contact	7(16)	3(10)	2(12)	0
Anterior contact with bilateral posterior contact	3(7)	1(4)	0	1(20)
No anterior contact with unilateral posterior contact	0	1(4)	0	1(20)
No anterior contact with bilateral posterior contact	2(5)	0	0	1(20)
Total	**43**	**29**	**17**	**5**

[a] Chi-square test, $P < .0001$.

of the shimstock was 8 μm, which is below the range of reported thresholds for dental proprioception. This method allows identification of contacting teeth without disturbing this delicate mechanism; a system of measurement that disrupts proprioception may alter mandibular position and consequently tooth contact.[26]

For the lateral excursion of the mandible, occlusal contacts were recorded at two positions: ½ mm and 3 mm lateral to the habitual centric. These two positions were selected based on the findings of Ogawa and coworkers,[23] who conducted a study in which tooth contacts were recorded at 0.5, 1, 2, and 3 mm lateral to the maximum intercuspation. They concluded that the occlusal contact patterns during lateral movement varied greatly with mandibular position. The occlusal contact pattern in the 3 mm position predicted the presence or absence of the occlusal contact in the 1 and 2 mm positions (sensitivity $>$0.7) but not in the 0.5 mm position (sensitivity $<$0.6). Finally, they suggest that the 0.5 mm position could be used to evaluate occlusal contact in a position close to maximum intercuspation in the functional range, and that the 3 mm position could be used to assess occlusal contact in an edge-to-edge position in the parafunctional range.[24]

Relationship Between Static and Dynamic Occlusion

The orthodontic picture of "ideal occlusion" places considerable emphasis on the static occlusal relationship in assessing the quality of completed orthodontic treatment, with less emphasis on the importance of the dynamic occlusion. In fact, none of the available orthodontic indices for the assessment of treatment outcome contains any functional components! One could argue that this is caused by the absence of consensus regarding what constitutes an "ideal" dynamic occlusion. This, nonetheless, should not lead to a practice of disregarding basic functional principles during orthodontic treatment. As Clark and Evans[27] argue, the gradual adaptation of muscles and joints that occurs during the slow development of a specific occlusion during growth may not occur following the much quicker change related to orthodontic treatment. Other possible consequences of occlusal interference, such as tooth wear and relapse of tooth position, may become apparent only some time after completion of orthodontic treatment, but nevertheless may be attributable to interferences introduced during appliance therapy.

Based on all of the above, we found it particularly interesting to explore the relationship between static and dynamic occlusion. At 0.5 mm lateral excursion, canine protected occlusion was more dominant in Class I incisor, canine, and molar relationships; at 3 mm lateral excursion, canine protected occlusion was dominant in Class II occlusion. Our findings at the 3 mm position compare favorably with those of Al-Hiyasat and Abu-Alhaija,[7] who reported that canine guidance was more dominant in Class II followed by Class I; and those of Scaife and Holt,[6] who found canine protected occlusion to be associated with Class II then Class I and least associated with Class III. However, these results do not agree with other studies, in which investigators found most of Class I Angle occlusion to be associated with balanced occlusion[8–10]; neither do they agree with the findings of Tipton and Rinchuse,[11] who found no significant association between static and dynamic occlusion.

Table 6. Distribution (%) of the Pattern of Guidance in Protrusive Mandibular Excursion and Molar Classification[a]

	Both Sides Class I	Class I and Class II	Both Sides Class II	Both Sides Class III
Anterior contact with posterior disocclusion	38(75)	18(86)	12(86)	4(50)
Anterior contact with unilateral posterior contact	7(14)	2(10)	1(7)	2(25)
Anterior contact with bilateral posterior contact	4(8)	1(5)	0	0
No anterior contact with unilateral posterior contact	0	0	0	2(25)
No anterior contact with bilateral posterior contact	2(4)	0	1(7)	0
Total	**51**	**18**	**14**	**8**

[a] Chi-square test, $P = .031$.

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This lack of agreement may be attributed to the different registration materials utilized. Registration material has a significant influence on the number of contacts recorded; some materials tend to record "near contact" as actual contact resulting in differences in the occlusal contact pattern registered.[28] Diurnal difference in occlusal contacts,[17] differences in the criteria used for sample selection, and differences in the classification system are additional factors that contribute to the observed differences.

Anterior guidance with posterior distocclusion was associated with Class II div 2 incisors, followed by Class I and Class II div 1; Class II canines followed by Class I; and Class II molars followed by Class I. These associations explain the high prevalence of posterior contact in protrusion observed in Class III cases and the high prevalence of anterior contact with posterior distocclusion in Class II div 2 cases.

These observations are consistent with those of Al-Hiyasat and Abu-Alhaija,[7] who reported that anterior guidance with posterior distocclusion was associated with Class II div 2 incisors, then Class I and Class II div 1. The prevalence of posterior contact in protrusion was dominantly associated with Class III incisor and molar relationships (50% and 33%, respectively).

Although an association between static and dynamic occlusion was found, it is very difficult to establish a definitive association between them. Therefore, it is necessary to evaluate dynamic occlusion with the aspects of length and inclination of the occlusal guidance of each tooth used as functional indicators.

CONCLUSIONS

- The distribution of lateral guidance is different at the 0.5 mm and 3 mm positions.
- At 0.5 mm lateral excursion, bilateral canine protected occlusion was observed only in subjects with Class I incisor relationships or subjects with unilateral or bilateral Class I molar or canine relationships.
- At 3 mm lateral excursion, bilateral canine protected occlusion was predominant in subjects with Class II incisor, canine, and molar relationships.
- Anterior guidance with posterior disocclusion was observed most often in subjects with Class II div 2 occlusion and was least observed in subjects with Class III occlusion.

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