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Functional occlusal relationships in a group of post-orthodontic patients: preliminary findings

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SUMMARY This study investigated features of the functional occlusion in a group of 37 patients immediately following two-arch fixed appliance treatment. Study casts were mounted in the retruded axis position on a semi-adjustable articulator and occlusal contacts were recorded with articulating paper in retruded and lateral mandibular positions. The magnitude of the slide between the retruded axis position and the intercuspal position was measured to the nearest 0.5 mm in the antero-posterior, vertical and lateral directions.

The results revealed that the majority of subjects had a unilateral contact on initial closure in the retruded axis position, and a slide between this position and the intercuspal position. Most subjects demonstrated canine guidance on the working side in lateral positions. In addition, however, most subjects had contact between the second molars on the non-working side.

Based on current concepts of functional occlusion, this group of post-orthodontic patients did not exhibit ideal occlusal relationships. The long-term implications of this finding are unclear, but may be associated with post-orthodontic instability, tooth wear and temporomandibular disorders. A long-term follow-up is planned to attempt to clarify some of these issues.

Introduction

Orthodontic treatment aims to create an occlusion that has a close resemblance to an established norm, which is based mainly on a description of arch form, tooth position and tooth contacts in the intercuspal position. This orthodontic picture of 'ideal occlusion' is largely the result of work by Angle (1900) and, more recently, Andrews (1972). Considerable emphasis is placed on this static occlusal relationship in assessing the quality of completed orthodontic treatment with less emphasis on the importance of the functional occlusion.

A number of different theories have been proposed to represent 'ideal' functional occlusion. Early workers in this field promoted the concept of balanced occlusion (Gysi, 1910; Monson, 1932), but this was ultimately replaced by two new occlusal schemes in the 1950s following the work of Beyron (1954) and D'Amico (1958). Group function occlusion occurs when there is simultaneous contact of the canine and posterior teeth on the working side during lateral mandibular excursions, and canine protected occlusion occurs when there is contact only between the working side canines during lateral excursions. The two theories have a common theme: absence of contact on the non-working side during lateral excursion, and absence of posterior occlusal contact during mandibular protrusion. It is generally agreed that both canine guidance and group function occlusion are acceptable (McAdam, 1976; Belser and Hannam, 1985). Studies by Besler and Hannam (1985) and Akören and Karaağaçliğlou (1995), however, have shown that the presence of canine guidance reduces the opportunity for generating high inter-arch forces, and it may therefore reduce normal tooth wear and parafunctional loads. Canine guidance may therefore offer some advantage over group function.

Although the ideal type of functional occlusion has not been conclusively established, it

is clear that certain types of occlusal contact may be detrimental to the masticatory system. Specific types of occlusal contact have been shown to be more likely to 'interfere' with function than others, including non-working side contact (Geering, 1974; Ingervall *et al.*, 1980; De Boever and Adriaens, 1983; Mohlin and Thilander, 1984; Nilner, 1986), unilateral contacts in the retruded contact position (RCP) (Ingervall *et al.*, 1980; Egermark-Eriksson *et al.*, 1983; Nilner, 1986), long slides (greater than 1 mm) between the RCP and the intercuspal position (ICP; Ramfjord, 1961; De Laat *et al.*, 1986; Pullinger *et al.*, 1993; Weiland, 1994), and asymmetry in the slide between RCP and ICP (Geering, 1974; Solberg *et al.*, 1979; Ingervall *et al.*, 1980; De Laat *et al.*, 1986).

Epidemiological studies have shown that the presence of occlusal interferences is widespread in all population groups and that there are more people with non-ideal functional occlusal relationships than people with signs or symptoms of functional disorders (Agerberg and Sandström, 1988: Heikinheimo *et al.*, 1990; Ingervall *et al.*, 1991). This, however, should not lead to a practice of disregarding basic functional principles during orthodontic treatment. The gradual adaptation of muscles and joints which 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 interferences, such as tooth wear and relapse of tooth position may only become apparent some time after the completion of orthodontic treatment, but may nevertheless be attributable to interferences introduced during appliance therapy.

The purpose of the current investigation was to examine certain functional occlusal parameters in a group of post-orthodontic subjects who were considered to have a satisfactory static intercuspal occlusion and good orthodontic outcome. This is the first stage of a prospective, longitudinal study ultimately intended to identify the long-term implications of functional occlusal relationships on the dentition and masticatory system.

Subjects and methods

The sample consisted of 37 consecutively selected individuals who had undergone two-arch fixed appliance therapy (Preadjusted Edgewise-Dentaurum®, J. P. Winkelstroeter K.G., Ispringen, Germany, Andrew's prescription) at the Eastman Dental Hospital, London, and were one week post-debond, having worn no removable or fixed retainers during the week following debond. Subjects with hypodontia or restored teeth were excluded from the investigation, as were those whose orthodontic treatment had been terminated early, either following poor co-operation or at the patient's request.

A set of upper and lower impressions were taken in an alginate impression material (Alginoplast®, Bayer Coorporation, Dental Products, South Bend, IN, USA) and poured within 30 minutes in an improved stone (Silky Rock®, Whip Mix Corporation, Louisville, KY).

A facebow record was taken in the following manner: a cusp tip impression of the maxillary teeth was made using two thicknesses of softened Beauty Wax® (Moyco Industries Inc., Philadelphia, PA) on a bite fork. The subject held the bite fork firmly in place while the facebow record was taken using a Denar® transfer facebow (Figure 1; Denar Corporation, Anaheim, CA). The facebow assembly was then located onto a Denar® Mark II articulator and the maxillary study cast was orientated on the bite fork. Once in position, plaster was used to mount the maxillary cast to the upper member of the articulator. The mandibular study cast was located on the articulator using a retruded axis position (RAP) wax record. A technique described by Lucia (1964) was used to facilitate manipulation of the mandible into the retruded axis. This involved use of an acrylic jig placed over the central incisors (Figure 2) which is intended to erase existing neuromuscular control of the habitual closing movement. Each subject was instructed to bite on the occlusal jig for 10 minutes following which the wax record (Moyco extra-hard Beauty Wax®) was lightly applied to the maxillary teeth and the mandible guided into the RAP using bimanual manipulation to obtain shallow imprints of the lower teeth in the wax (Pameijer, 1995).

Figure 1 Subject supporting bite fork with Denar® facebow assembled.

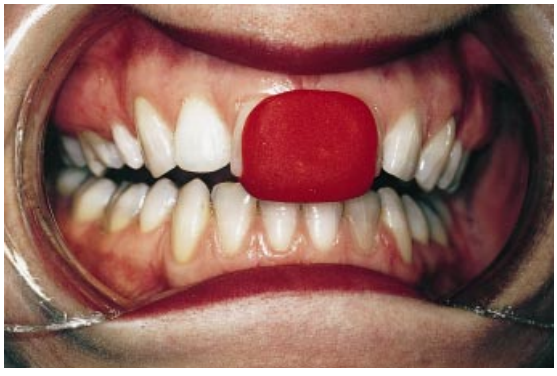

Figure 2 Subject occluding on acrylic jig prior to recording the retruded axis position.

The articulated study casts were then used to record tooth contacts with GHM® articulating paper (GHM Hanel Dental GmbH, D-72622 Nurtingen, Germany) in the RAP and in two specific lateral positions from the intercuspal position (marks were made on the upper central incisors at 1.5 and 3.0 mm from the midline to the left and right) (Figure 3). The slide between the retruded contact position (RCP) and the intercuspal position (ICP) was measured in anteroposterior, vertical and lateral directions to the nearest 0.5 mm at the incisal level.

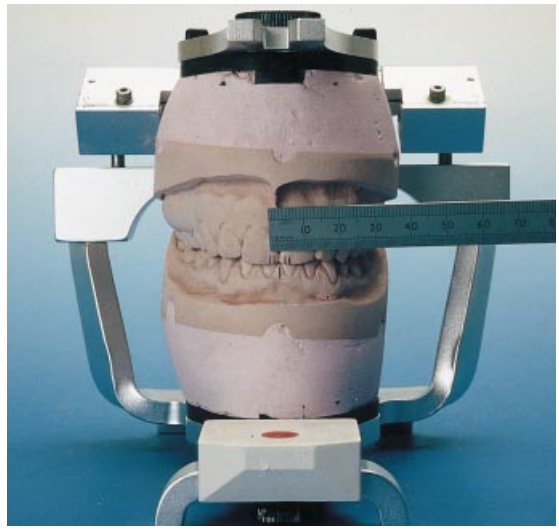

Figure 3 Articulated study casts marked at 1.5 and 3.0 mm to the right and left from the midline of the lower incisors.

Method error

The techniques and instrumentation involved in producing accurate articulated study casts are complex and in order to minimize error two separate RAP wax records were taken for each subject and placed successively between the study casts mounted on a Denar Vericheck® (Denar Corporation, California, USA). This is an instrument which allows multiple jaw registrations to be checked for reproducibility and only those whose occlusal records were interchangable were included in the study.

Results

Table 1 records the patterns of tooth contact for each subject at the mandibular positions studied and those subjects in whom the magnitude of the slide between RCP and ICP was considered to be beyond the normal range.

Table 1 Tooth contact patterns in retruded and lateral mandibular positions to the left and right, and the presence or absence of large discrepancies between the retruded contact position and the intercuspal position.

	Unilateral RCP Contact	RCP-ICP AP>1 mm	RCP-ICP Vertical >1 mm	RCP-ICP Lateral >0 mm	1.5 mm right	3.0 mm right	1.5 mm left	3.0 mm left
Subject 1	Yes	No	No	No	CG	CG	CG	CG
Subject 2	No	No	No	No	CG	CG	CG	CG
Subject 3	No	Yes	Yes	Yes	NWS	NWS	CG/NWS	NWS
Subject 4	No	Yes	No	Yes	*	CG	CG	GF
Subject 5	No	No	No	Yes	NWS	*	NWS	NWS
Subject 6	Yes	No	No	Yes	CG	CG	CG	CG
Subject 7	No	Yes	Yes	Yes	GF/NWS	NWS	NWS	CG/NWS
Subject 8	Yes	No	No	Yes	CG/NWS	CG	CG/NWS	CG
Subject 9	No	No	No	Yes	CG/NWS	CG/NWS	NWS	NWS
Subject 10	Yes	No	No	Yes	NWS	NWS	CG/NWS	CG
Subject 11	Yes	No	No	Yes	NWS	CG/NWS	CG/NWS	CG
Subject 12	Yes	No	No	No	GF/NWS	CG/NWS	GF/NWS	CG
Subject 13	Yes	No	No	No	CG	CG	CG	CG
Subject 14	No	No	No	No	CG	CG	CG	CG
Subject 15	Yes	Yes	Yes	Yes	GF/NWS	GF/NWS	NWS	NWS
Subject 16	No	Yes	Yes	Yes	CG	CG	CG	CG
Subject 17	Yes	No	No	Yes	NWS	CG	CG	CG
Subject 18	Yes	Yes	Yes	Yes	CG	CG	GF/NWS	CG
Subject 19	No	Yes	No	Yes	*	CG	CG	CG
Subject 20	Yes	No	Yes	Yes	CG	CG	CG/NWS	CG/NWS
Subject 21	No	Yes	No	Yes	CG/NWS	CG/NWS	CG/NWS	CG
Subject 22	Yes	Yes	No	Yes	NWS	NWS	CG	CG
Subject 23	Yes	Yes	No	Yes	CG	CG	CG	CG
Subject 24	No	No	No	No	CG	CG	CG	CG
Subject 25	Yes	No	No	Yes	NWS	CG/NWS	CG	CG
Subject 26	Yes	No	No	No	GF	CG	CG	CG
Subject 27	Yes	Yes	Yes	Yes	CG	CG	NWS	CG/NWS
Subject 28	Yes	Yes	No	No	GF/NWS	*	CG	CG
Subject 29	Yes	No	Yes	Yes	CG	NWS	CG	CG
Subject 30	Yes	No	Yes	Yes	CG	CG	CG	CG
Subject 31	No	Yes	No	Yes	CG	CG	CG	CG
Subject 32	Yes	No	No	No	NWS	NWS	*	*
Subject 33	Yes	No	No	Yes	CG	CG	CG	CG
Subject 34	Yes	Yes	Yes	Yes	GF/NWS	CG/NWS	GF/NWS	CG
Subject 35	Yes	No	No	No	CG/NWS	NWS	NWS	CG/NWS
Subject 36	No	Yes	Yes	Yes	CG/NWS	CG/NWS	CG/NWS	CG/NWS
Subject 37	Yes	Yes	Yes	Yes	CG/NWS	CG/NWS	CG/NWS	CG/NWS

CG = canine guidance; GF = group function; NWS = non-working side: AP = antero-posterior.
*The tooth contact pattern did not conform to any of the specified groupings.

Retruded tooth contacts

Twenty-four subjects (65 per cent) had a unilateral contact on initial closure on the retruded axis. Figure 4 shows the pattern of distribution of RCP contacts on the maxillary teeth and Figure 5 demonstrates the corresponding pattern on the mandibular teeth.

Lateral tooth contacts

The tooth contact patterns in the lateral mandibular positions are shown in Figure 6. At 1.5 mm of lateral movement to the right, 21 subjects (57 per cent) had canine guidance and six (16 per cent) had group function on the working side; 19 (51 per cent) had non-working side contacts.

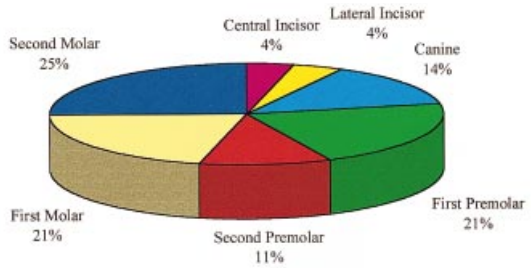

Figure 4 Site of unilateral RCP contacts (maxillary teeth).

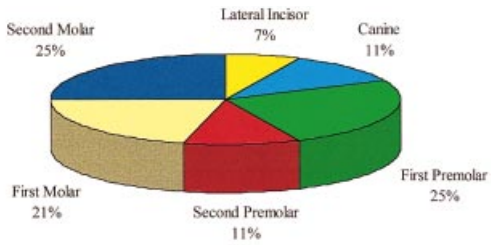

Figure 5 Site of unilateral RCP contacts (mandibular teeth).

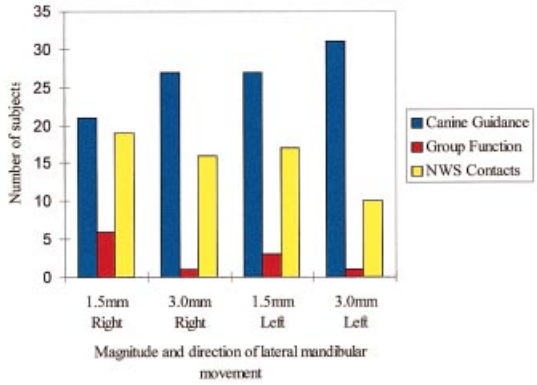

Figure 6 Tooth contact patterns at different lateral mandibular positions.

When the lateral movement increased to 3.0 mm, 27 (73 per cent) subjects had canine guidance, one (3 per cent) had group function, and 16 (43 per cent) had non-working side contacts. In left lateral excursion to 1.5 mm, 27 (73 per cent) subjects had canine guidance, three (8 per cent) had group function, and 17 (46 per cent) had non-working side contacts. At 3.0 mm of lateral excursion to the left 31 (84 per cent) had canine guidance, one (3 per cent) had group function, and 10 (27 per cent) had non-working side contacts. All of the non-working side contacts were located on the second molars.

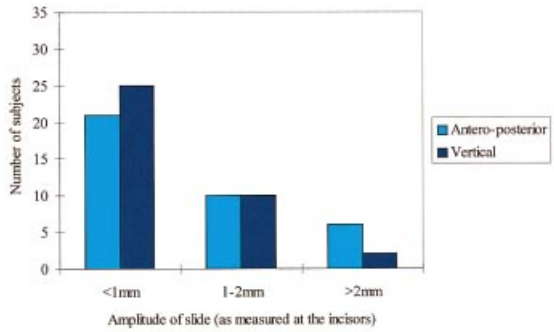

Figure 7 Magnitude of the antero-posterior and vertical components of the RCP-ICP slide.

RCP-ICP slide

Figure 7 shows the distribution of the magnitude of the slide between RCP and ICP in the antero-posterior and vertical planes. In the antero-posterior dimension 21 (57 per cent) subjects had slides measuring less than 1 mm, 10 (27 per cent) had slides measuring 1–2 mm, and six (16 per cent) had slides greater than 2 mm. In the vertical direction 25 (68 per cent) subjects had slides of less than 1 mm, 10 (27 per cent) had slides of between 1 and 2 mm, and two (5 per cent) had slides greater than 2 mm. The distribution of the lateral component of the RCP-ICP slide is shown in Figure 8. Ten (27 per cent) subjects had no detectable lateral slide, 19 (51 per cent) had a lateral slide of less than 0.5 mm, and eight (22 per cent) had slides greater than 0.5 mm.

Discussion

A number of previous studies have assessed functional occlusal relationships in patients following

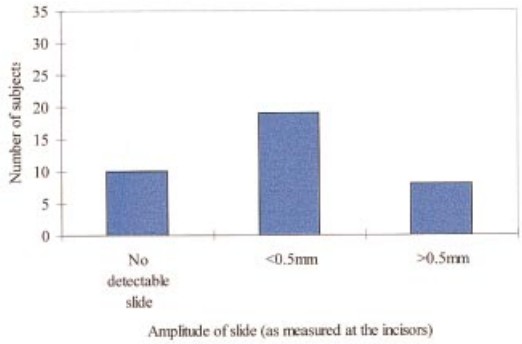

Figure 8 Magnitude of the lateral component of the RCP-ICP slide.

orthodontic treatment (Cohen, 1965; Ahlgren and Posselt, 1963; Sadowsky and BeGole, 1980; Rinchuse and Sassouni, 1982; Sadowsky and Polson, 1984). Each has chosen different aspects of the occlusion to examine and various clinical techniques have been used. The difficulty in comparing the results obtained in these various clinical studies is highlighted by Takai *et al.* (1993) who demonstrated that the number of recorded tooth contacts varies with the material used to record the registrations. To date there have been no comprehensive studies examining post-orthodontic functional occlusion using articulated study casts. If the post-treatment changes in functional occlusion are to be accurately recorded by successive operators, it is essential that a valid and reproducible method of occlusal diagnosis is developed. Wise (1995) affirms that tooth contacts on a semi-adjustable articulator, such as the Denar® Mark II, used with the average facebow should correspond closely to those in the mouth, provided that the decrease in vertical dimension on removal of the wax registration is small. In a pilot study carried out prior to this investigation, the pattern of occlusal contacts recorded from articulated study casts was found to be highly reproducible and greater than that recorded from intra-oral clinical examination. It was therefore felt that this technique of occlusal diagnosis represented an accurate picture of post-orthodontic occlusion and provided a permanent record which could be used by different operators in subsequent studies.

Andrews (1976) postulated that achieving an excellent result in terms of static occlusion was likely to lead to attainment of functional occlusal goals. This investigation, however, demonstrates a group of patients whose static occlusion was good and yet whose functional occlusal contact patterns were not ideal. In malocclusions where there is a normal relationship of the maxilla to mandible, and no tooth-size discrepancies, treatment which is planned by considering only static tooth relationships may achieve an occlusion that would be functionally acceptable purely by coincidence. However, where skeletal disproportion and tooth-size discrepancies exist, achievement of an excellent functional occlusion may be more difficult or even impossible. In particular, where skeletal disproportion exists difficulty can be encountered in achieving a Class I molar relationship at or close to the RAP; and in eliminating posterior contacts during mandibular excursions. The criteria which are thought to denote an 'ideal' functional occlusion may therefore represent an onerous task for the orthodontist to achieve.

At present, the vast majority of individuals undergoing orthodontic treatment are adolescents, most of whom have considerable remaining growth potential at the end of active treatment. In addition, following removal of appliances, small tooth movements occur in a process described as 'settling'. It is likely that these two factors will alter functional occlusal relationships with time, although there are currently no data to support this. Whether the unfavourable occlusal contacts demonstrated in this study are relevant in the long-term depends on exactly how the dentition changes following debond. It is hoped that as this population is followed with time, the long-term effects of unfavourable functional occlusal contacts, and the manner in which the occlusion 'settles' following debond, can be determined.

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