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Research article

Centric slide in different Angle's classes of occlusion

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ABSTRACT

The purpose of this study was to test the possible differences in centric slide values between different Angle's classes of occlusion. The study included 98 participants divided into four groups: Angle's class I, Angle's class II, subdivision 1, Angle's class II, subdivision 2 and Angle's class III. All recordings were obtained using an ultrasound jaw tracking device with six degrees of freedom. The distance between the maximum intercuspation (reference position) and the centric occlusion was recorded at the condylar level. Anteroposterior, superoinferior and transversal distance of the centric slide were calculated for each participant, and the data were statistically analyzed (analysis of variance and Newman–Keuls post hoc test). No statistically significant difference was found in the anteroposterior and transversal distance of the centric slide between tested groups, while Angle's class II, subdivision 2 showed smaller vertical amount of the centric slide compared to Angle's class I and class II, subdivision 1. None of the 98 participants showed coincidence of centric occlusion and maximum intercuspation. Our results suggest that coincidence of the maximum intercuspation with the centric occlusion should not be expected. Smaller extent of the vertical distance of the centric slide could be morphological and a functional expression characteristic of the Angle's class II, subdivision 2.

1. Introduction

Centric slide is defined as a movement of the mandible while in centric relation, from the initial occlusal contact into maximum intercuspation (The Glossary of Prosthodontic Terms, 2005). Initial occlusal contact (or contacts) in centric relation is defined as centric occlusion (The Glossary of Prosthodontic Terms, 2005). Most of the textbooks state that slide from the centric occlusion to the maximum intercuspation occur at approximately 90% of people, and on average is 1 mm long (Okeson, 2008). Still, review of literature (Pullinger et al., 1987; Mohlin, 1983; Demisch et al., 1992; Abraham and Veeravalli, 2012; Weffort and de Fantini, 2010; Klar et al., 2003; Foglio-Bonda et al., 2006) reveals different results, mostly because of study methods. Different approaches have been used for measuring the centric slide: directly in the mouth (Pullinger et al., 1987; Mohlin, 1983; Demisch et al., 1992), with conventional radiography (Kydd and Sander, 1961), cone beam CT (Henriques et al., 2012), jaw tracking devices (Foglio-Bonda et al., 2006) and with articulated casts (condyle position indicator) (Abraham and Veeravalli, 2012; Weffort and de Fantini, 2010; Klar et al., 2003). Differences in obtained values for centric slide are also expected because of different reference points. For instance Pullinger et al. (1987) choose a second premolar for measuring the centric slide, while many studies used sagittal incisal point (Kydd and Sander, 1961; Demisch et al., 1992) or condyle of the articulator (condyle position indicator) (Weffort and de Fantini, 2010; Padala et al., 2012; Abraham and Veeravalli, 2012). Due to condylar rotation, centric slide can have different values at occlusal or condylar level (Foglio-Bonda et al., 2006).

Review of the literature shows different opinions about impact of malocclusion on centric slide values. Some authors (Ingervall, 1968; Wen-Ching Ko et al., 2012; Mohlin, 1983) have found differences in centric slide values between different dental classes of occlusion, while others have not (Klar et al., 2003; Foglio-Bonda et al., 2006; Karl and Foley, 1999; Utt et al., 1995). Weffort and de Fantini (2010) state that subjects with distinct facial characteristics will demonstrate smaller or larger differences between arch relationships, even in the presence of the same amount of the condylar displacement.

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Jaw tracking devices with six degrees of freedom provide complete knowledge of the three dimensional movements of the entire mandible (Naeije et al., 1999) and are standardly used for investigation of temporomandibular joint function and morphology (Cimic et al., 2014; Reicheneder et al., 2008, 2013; Tymofiyeva et al., 2007; Bernhardt et al., 1999; Nagerl et al., 1999). Obrez and Gallo (2006) state that only since the development of three dimensional tracking systems supplemented with sophisticated mathematical transformation of the obtained data has it been possible to estimate condylar movements relatively accurately.

The purpose of this investigation was to study possible differences of the centric slide between different Angle's classes using ultrasound jaw tracking device with six degrees of freedom.

2. Material and methods

2.1. Subjects

Ninety-eight young adults, (26.0 ± 5.2 years), without previous orthodontic treatment participated in this study. All subjects had no history of signs and symptoms of temporomandibular dysfunction. The subjects were completely dentate (except third molar) with stability in the maximum intercuspation, and without extensive restorative therapy. Each subject gave written informed consent which was approved by the Ethical Committee of the School of Dental Medicine, University of Zagreb.

Subjects were divided into four study groups based on Angle's classification. All subjects had the same Angle's class on the left and right side. Subjects with different Angle's class on the right and left side, and subjects with an unclear classification were excluded from this study. Group 1 consisted of 58 individuals with Angle's class I, group 2 consisted of 10 individuals with Angle's class II, subdivision 1, group three consisted of 14 individuals with Angle's class II, subdivision 2 and group 4 consisted of 16 individuals with Angle's class III occlusion.

2.2. Procedure

Condylar and mandibular movements were recorded with the use of an electronic ultrasound motion capture device (ArcusDigma II, Kavo, Biberach, Germany). This ultrasound contact free measuring device has a transmitter which is attached to the lower jaw with the use of a paraocclusal tray (Fig. 1). With the facial bow, the receiver is attached to the upper jaw (measuring bow). The device measures the real-time latency period between transmitted and received ultrasound pulses. A kinematic analysis uses mathematical transformation of the obtained data which allows the three dimensional reconstruction of the trajectory of any point along the lower jaw, including those located within the condyles (Obrez and Gallo, 2006).

Fig. 1. Ultrasound jaw tracking device.

First, irreversible hydrocolloid impressions (Aroma Fine Plus, GC, Tokyo, Japan) were taken for each subject, and stone casts were made. Using the stone cast, a paraocclusal tray was made for each subject from light cured acrylic resin (Unitray, Polident, Volčja Draga, Slovenia), according to manufacturer's recommendations. At the next appointment recordings of the position analysis was performed using a jaw tracking device. Each subject was seated comfortably in a chair (upright posture). The paraocclusal tray was fixed in the lower jaw using acrylic resin for temporary restoration (Structur, Voco, Cuxhaven, Germany). The paraocclusal tray was not in contact with upper teeth in intercuspal position or eccentric movements, and was firmly fixed to the lower dental arch. After the paraocclusal tray, the lower and upper bows of the recording device were mounted (Fig. 1).

Slide between centric occlusion and maximum intercuspation (centric slide) was measured in the module "Electronic position analysis" (EPA). Module EPA measures condylar positions of the selected reference axis. Selected axis was "Kavo Transfer System", as recommended by the manufacturer. Every subject had to bite in position of maximum intercuspation, and position of the condyles in maximum intercuspation was measured (reference position). Every subject was trained to move the lower jaw to the back, and close to the first tooth contact/contacts, so the position of the condyles at the centric occlusion could be measured. There was no manipulation or investigator guidance during recording of the centric occlusion. With SD card obtained data were transferred to a personal computer. Using the device's associated software (Kavo Integrated Desktop, Kavo, Biberach, Germany), the distance between centric occlusion and maximum intercuspation was measured. With the software's option "Copy points" recorded positions were transferred to Microsoft Excel®, (Microsoft Corporation, Redmond, USA). The reference position (maximum intercuspation) was represented by zero on the Cartesian coordinate system, and the distance of the centric occlusion to the reference position was represented in three axes; antero-posterior (x), supero-inferior (y), and transversal (z). For every subject, the distance from the centric occlusion to the maximum intercuspation was calculated and used in this study: anteroposterior distance, superoinferior distance, and transversal distance. All recordings and ratings were performed by a single experienced investigator in jaw movement recording to eliminate potential problems with interexaminer reliability.

Left–right side differences were compared using the F test. For comparing Angle's class groups, one way ANOVA and Newman–Keuls post hoc test were used (Statsoft, Tulsa, USA).

3. Results

The F test showed no significant difference between left and right side ($\alpha = 0.05$), therefore were considered as one sample, as in most of the similar studies. Table 1 shows descriptive statistics for all groups for the anteroposterior, superoinferior and transversal distance from the centric occlusion to the maximum intercuspation. Centric slide ≥0.5 mm on the transversal axis for the left and/or right side was observed in six participants (6.1%); four participants were at Angle's class I group, none were at Angle's class II, subdivision 1 and class II, subdivision 2, and two participants were at Angle's class III group. Coincident maximum intercuspation and the centric occlusion showed neither one participant. Table 2 shows results of the one way ANOVA test between Angle's class groups, while Table 3 shows Newman–Keuls test for the superoinferior distance between the centric occlusion and the maximum

Table 1
Descriptive statistics for all groups for the anteroposterior (x), superoinferior (y) and transversal distance (z) of the centric slide (left and right side are one sample, millimeters).

Variable	Statistical parameter	Group				All participants ($N = 196$)
		Angle's class I ($N = 116$)	Angle's class II/1 ($N = 20$)	Angle's class II/2 ($N = 28$)	Angle's class III ($N = 32$)	
x	$\bar{X}$	−0.24	−0.33	−0.27	−0.22	−0.25
	SD	0.36	0.36	0.36	0.34	0.36
	Min.	−1.70	−0.80	−1.20	−0.80	−1.70
	Max.	0.70	0.40	0.40	0.60	0.70
y	$\bar{X}$	0.37	0.38	0.08	0.15	0.29
	SD	0.61	0.54	0.63	0.51	0.60
	Min.	−1.70	−0.90	−1.10	−0.90	−1.70
	Max.	2.20	1.60	1.70	1.50	2.20
z	$\bar{X}$	0.13	0.12	0.15	0.14	0.13
	SD	0.12	0.09	0.13	0.13	0.12
	Min.	0.0	0.0	0.0	0.0	0.0
	Max.	0.60	0.30	0.40	0.60	0.60

Table 2
Results of the one way ANOVA between tested groups for the anteroposterior (x), superoinferior (y) and transversal (z) distance of the centric slide (left and right side are one sample, $p < 0.05$).

Variable	F	p
x	0.40	0.880986
y	2.17	0.045048
z	0.34	0.913952

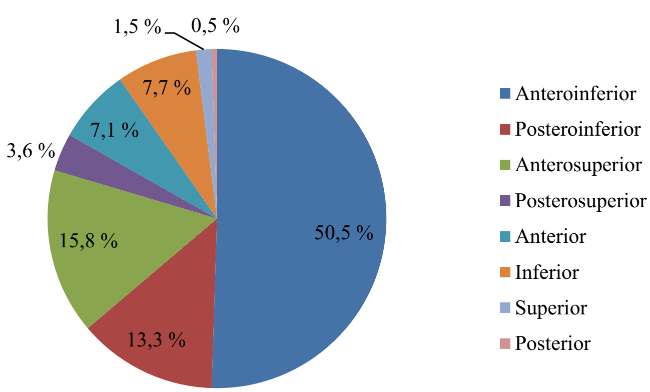

Fig. 2. Direction of the centric slide for all participants (left and right side are one sample).

intercuspation between tested groups. Fig. 2 shows direction of the condylar movement for all participants together.

4. Discussion

In this study the centric slide and its possible differences between different Angle's classes was investigated. Angle's class II, subdivision 2 showed a smaller vertical distance between centric occlusion and maximum intercuspation, compared to Angle's class I and class II, subdivision 1.

In contrast to other studies (Abraham and Veeravalli, 2012; Weffort and de Fantini, 2010; Klar et al., 2003; Utt et al., 1995; Foglio-Bonda et al., 2006), lower values of the centric slide obtained in this study (Table 1) could be explained with different material and methods. Most of the other studies included examiners guidance, while in this study participants were trained to perform retrusive movement of the lower jaw. Also, most of other studies that investigated centric slide used condyle position indicators. Considering the articulator's rigidity and proven elasticity of the lower jaw (Gates and Nicholls, 1981), differences can be expected between condyle position indicators and jaw tracking devices.

Some studies (Utt et al., 1995; Roth, 1973) related transversal distance of the centric slide <0.5 mm as clinically acceptable. Review of the literature shows different average values for the transversal distance of the centric slide; Padala et al. (2012) obtained 0.61 ± 0.38 mm, Abraham and Veeravalli (2012) −0.26 ± 0.63 mm, Weffort and de Fantini (2010) 0.23 ± 0.28 mm. Smaller amount of the transversal movement (0.13 mm, SD 0.12, Table 1) than in other studies (Abraham and Veeravalli, 2012; Weffort and de Fantini, 2010; Padala et al., 2012) could also be explained with different methodology.

Although the general opinion is that centric slide occurs approximately at 90% of the people, while other 10% have coincidence of the maximum intercuspation and the centric occlusion (Okeson, 2008), results of the novel studies failed to confirm it. In the investigations done by Fantini et al. (2005), Foglio-Bonda et al. (2006) and Klar et al. (2003), as well as in this study, not one participant demonstrated coincidence between the positions of maximum intercuspation and centric occlusion.

Inferior condylar movement was determined in most participants (71.5%, Fig. 2) during centric slide, which was in agreement with previous studies (Wood and Elliott, 1994; Klar et al., 2003; Weffort and de Fantini, 2010). Every second participant had anteroinferior movement, while posterior movement was shown in 17% of the participants. Wood and Elliott (1994) explained posterior condylar movement during centric slide. The first tooth contact in the centric relation acts as a fulcrum while the rest of the teeth are discluded. To get in the maximum intercuspation, the condyles are distracted inferiorly and posteriorly in the glenoid fossa while the mandibular teeth shift forward, as seen in the mouth clinically. Superior condylar movement (21% of participants, Fig. 2) can be

Table 3
Results of the Newman–Keuls test for the superoinferior distance of the centric slide between tested groups (left and right side are one sample, $p < 0.05$).

	Angle's class I	Angle's class II/1	Angle's class II/2	Angle's class III
Angle's class I		0.999166	0.043374	0.348477
Angle's class II/1	0.999166		0.049359	0.536603
Angle's class II/2	0.043374	0.049359		0.609707
Angle's class III	0.348477	0.536603	0.609707	

found at individuals with healthy temporomandibular joints (Utt et al., 1995; Rosner, 1982). Findings of the maximum intercuspation located superior to the centric relation position Utt et al. (1995) explained by occurrence of internal derangement of the temporomandibular joint. According to authors (Utt et al., 1995) the internal joint derangement could allow the condyles to become positioned more superior to the centric relation position. Superior condylar position during maximum intercuspation could be explained also with measurement error. Authors believe that the observed condylar reference point could show superior position during the centric slide, due to a condylar rotation at some individuals.

Studies (Krisjane et al., 2009; Arieta-Miranda et al., 2013; Katsavrias and Halazonetis, 2005; Wohlberg et al., 2012; Nakajima and Osato, 2013) showed differences between examined parameters of the temporomandibular joint at different Angle's classes. Krisjane et al. (2009) used 3D CT in investigation of condyle positions in glenoid fossa at skeletal class II and III. All measurements showed differences between the study groups. Arieta-Miranda et al. (2013) concluded that different skeletal classes have different relationships between the condyle and the glenoid fossa. Still, most of the studies that investigated the centric slide have not found differences in size or direction between different classes of occlusion (Klar et al., 2003; Foglio-Bonda et al., 2006; Karl and Foley, 1999; Utt et al., 1995), which is partly congruent to this study results (Angle's class I, Angle's class II, subdivision 1, and Angle's class III). Determined smaller amount of vertical movement in Angle's class II, subdivision 2 (Tables 2 and 3) is contradictory to most of other studies of the centric slide (Klar et al., 2003; Foglio-Bonda et al., 2006; Karl and Foley, 1999; Utt et al., 1995), but nevertheless in agreement with some morphological studies of the temporomandibular joint (Zhou et al., 1999; Katsavrias and Halazonetis, 2005). Zhou et al. (1999) investigated relationships between the glenoid fossa and the position of the condyles in patients with various skeletal and dental malocclusions. Authors (Zhou et al., 1999) concluded that skeletal class III and II, subdivision 1 have normal structure and function of the joint, while Angle's class II, subdivision 2 have posterior condylar position. In a study of the condyle and fossa shape, authors Katsavrias and Halazonetis (2005) also found posterior position of the condyles in class II, subdivision 2 group. Some authors (Anders et al., 2000) suggest dominant locked occlusion as characteristics of Angle's class II, subdivision 2 patients, due to a deep bite and a steeper condylar path. With this assumption is associated posterior position of the mandible and the condyles at class II, subdivision 2 patients. Posterior condylar position is caused during functional closing of the lower jaw because of retruded upper incisors (Thompson, 1986). The smaller amount of vertical movement (Tables 2 and 3) obtained during centric slide and posterior condylar position (Zhou et al., 1999; Katsavrias and Halazonetis, 2005) could be related to the expression of the anatomy and function in individuals with Angle's class II, subdivision 2.

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