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IZVORNI ZNANSTVENI RAD
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Utjecaj načina prijenosa šarnirske osi na trodimenzionalni pomak kondila između položaja centrične relacije i maksimalne interkuspidacije

Influence of the Hinge Axis Transfer Modality on the Three-Dimensional Condylar Shift Between the Centric Relation and the Maximum Intercuspation Positions

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Sažetak

Svrha: Željelo se odrediti utječe li način registracije i prijenosa šarnirske osi (prijenos obraznim lukom spram prosječnog montiranja) s ispitanika u artikulator na trodimenzionalni pomak kondila između položaja centrične relacije (CR) i maksimalne interkuspidacije (MI). **Materijal i metode:** U istraživanju su sudjelovala 32 potpuno ozubljena ispitanika (16 muškaraca i 16 žena). Inkluzijski kriteriji studije obuhvatili su asimptomatske ispitanike s normalnim okluzijskim odnosima (Angleova klasa I) u dobi od 20 do 33 godine (prosječna dob 22,6 ± 4,7 godina). Trodimenzionalni pomak kondila (anteroposteriorni, superoinferiorni i mediolateralni) između položaja centrične relacije (CR) i maksimalne interkuspidacije (MI) bio je analiziran upotrebom indikatora položaja mandibule (MPI, SAM Prazisionstechnik GmbH, München, Njemačka). **Rezultati:** Prosječni trodimenzionalni pomak kondila iznosio je 0,13 ± 0,12 milimetara za prijenos obraznim lukom i 0,22 ± 0,23 milimetra za prosječno montiranje. Nisu zabilježene statistički značajne razlike između spolova. Rezultati Mann-Whitneyjeva testa pokazali su statistički značajne razlike za anteroposteriorni i superoinferiorni pomak kondila ($P < 0,001$). Razlika u mediolateralnom pomaku nije bila statistički značajna. **Zaključak:** S obzirom na odstupanja unutar trodimenzionalnog pomaka kondila, prijenos obraznim lukom pokazao se točnijim u odnosu prema prosječnom montiranju u poluprilagodljivi artikulator. No prosječne vrijednosti trodimenzionalnog pomaka kondila nisu odstupale od normalnih vrijednosti, pa nemaju kliničko značenje. Prema tome, pouzdanima se mogu smatrati oba načina prijenosa (prijenos obraznim lukom i prosječno montiranje) kod asimptomatskih ispitanika s normalnom okluzijom.

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Ključne riječi
artikulatori; centrična relacija; zglobna osovina; prijenos obraznim lukom

Uvod

Centrična relacija (CR) definira se kao *odnos gornje i donje čeljusti u kojemu zglobne glavice artikuliraju s najtanjim avaskularnim dijelom svojih zglobnih pločica*. Kompleks zglobnih glavica i pločica nalazi se u anterosuperiornom položaju prema stražnjim kosinama zglobnih kvržica. Ovaj položaj ne ovisi o zubnom dodiru, a određuje se vođenjem donje čeljusti u čisto rotacijskoj kretnji oko transverzalne, horizontalne (šarnirske) osi *(1).* Poluprilagodljivi i potpuno prilagodljivi artikulatori koji se koriste za obrazne lukove pokazali su se neprocjenjivima u svakodnevnoj praksi ako se obavlja opsežna dijagnostika, planiranje i liječenje okluzije i/ili žvačnog sustava. Obrazni luk bilježi položaj transverzalne šarnirske

Introduction

Centric relation (CR) is defined as the "maxillomandibular relationship in which the condyles articulate with the thinnest avascular portion of their respective discs with condyles in the anterior-superior position against the slopes of the articular eminence. This position is independent of tooth contact and is determined by manipulation of the mandible in a purely rotary movement along the transverse horizontal (hinge) axis (1)." Semi and fully adjustable dental articulators employing facebows have proven invaluable in daily practice when it comes to extended diagnostics, planning and therapy of occlusion and/or masticatory system. Facebow records the position of the transverse hinge axis that passes through

osi koja prolazi kroz zglobne glavice kada su one u položaju CR. Prema tome, preduvjet za točno određivanje šarnirske osi jest ponovljiva i pouzdana registracija položaja CR-a (1,2).

Ponovljivost je jedan od glavnih kriterija za prihvaćanje CR-a kao klinički relevantnog položaja. Preporučuju se različite kliničke metode za procjenu ponovljivosti položaja CR-a. Mnogi istraživači ispitivali su je tako da su se koristili različitim mjernim instrumentima kojima se bilježe promjene zglobnih glavica u tri ravnine prostora (vertikalnoj, horizontalnoj i transverzalnoj). Ti trodimenzionalni pomaci zglobnih glavica uzrokovani su pomakom između položaja MI-a i CR-a na razini okluzije (3). Wood i Elliot (4) koristili su se indikatorom položaja kondila (CPI) da bi ispitali ponovljivost Rothove metode određivanja CR-a (5). Autori nisu našli značajnu razliku između očitavanja na indikatoru položaja kondila te su zaključili da je Rothova metoda određivanja CR-a izrazito ponovljiva. Hobo i Iwata (6) analizirali su ponovljivost različitih kliničkih tehnika određivanja CR-a tako što su se služili elektroničkim indikatorom položaja mandibule. Tehnike CR-a korištene u studiji bile su nevođeno zatvaranje usta, vođenje bradom i bimanualna manipulacija. Istraživanje je provedeno na deset odraslih osoba i zaključeno je da su sve metode imale pomak zglobnih glavica od 0,2 do 0,3 milimetra. Autori su to povezali s filozofijom slobode u centriku i nisu ga smatrali slabom stranom upotrebe centričnih registrata. Najponovljivija metoda bila je bimanualna manipulacija. Vođenje bradom postavljalo je zglobne glavice posteriorno, inferiorno i desno lateralno. Tehnika nevođenja zatvaranjem usta pokazivala je blagi lateralni pomak u odnosu prema drugim metodama. Utt i suradnici (7) uspoređivali su položaj zglobnih glavica između CR-a i MI-a kod 107 pacijenata prije njihove ortodontske terapije. Učestalost, smjer i veličina MI-CR razlike analizirala se zbog moguće povezanosti s pacijentovom klasifikacijom prema Angleu, mjerenjem ANB kuta, dobi ili spola. MI-CR razlika bila je gotovo identična s desne i lijeve strane, a slaba povezanost bila je nađena samo između MI-CR pomaka desnih i lijevih zglobnih glavica. Zaključili su da se dob pacijenta, ANB kut i Angleova klasifikacija ne mogu upotrijebiti za predviđanje učestalosti, smjera i veličine MI-CR promjena na razini zglobnih glavica.

Schildkraut i suradnici (8) ispitivali su kefalometrijska mjerenja koja potječu od bilježenja MI-a s konvertiranim CR mjerenjem. Statistički testovi kojima su uspoređivali kefalometrijske vrijednosti MI-a i CR-a pokazali su značajne razlike kod većine promatranih vrijednosti. No općenito nisu zabilježene razlike između skupina muškaraca i žena ili između skeletnih klasa I i II. Rezultati ove studije upućuju na to da bi se za postavljanje točne ortodontske dijagnoze donja čeljust trebala postaviti u CR prije negoli u tradicionalniji položaj MI. De Fantini i suradnici (9) procjenjivali su pomak zglobnih glavica između početnoga MI-a i CR-a zabilježen nakon nošenja deprogramirajuće nagrizne ploče u prosječnom razdoblju od 7,8 ± 2,1 mjeseci prije bilo kakvog ortodontskog liječenja. Upotreba nagriznih ploča rezultira većim prosječnim vrijednostima pomaka zglobnih glavica, posebice vertikalno između MI-a i CR-a, što je pridonijelo točnijoj ortodontskoj dijagnozi.

the condyles when they are in the CR position. Therefore, a prerequisite for precise determination of hinge axis is repeatable and reliable clinical registration of CR position (1, 2).

Repeatability is one of the main criteria for accepting a CR as a clinically relevant position. Various clinical methods for assessing the repeatability of CR position have been suggested. Many investigators have tested this repeatability by using various instrumentation devices to record condylar changes in all three planes (vertical, horizontal and transverse). These three-dimensional condylar discrepancies are caused by MI-CR displacement at the level of occlusion (3). Wood and Elliot (4) used the condylar position indicator (CPI) to examine the repeatability of Roth's centric relation method (5). The authors found no significant difference between the condylar position indicator readings, and they concluded that Roth's centric relation bite registration was highly repeatable. Hobo and Iwata (6) analyzed the repeatability of different clinical CR methods using an electronic mandibular position instrument. The CR methods used in the study were unguided closure, chin point guidance, and bimanual manipulation. The investigation on 10 adults reported that all techniques had 0.2–0.3 mm of condylar displacement. The authors related this displacement to the principle of freedom in centric and did not consider this a drawback to the use of centric records. The most repeatable technique was bimanual manipulation. Chin point guidance positioned the condyles posteriorly, inferiorly, and right laterally. The technique of unguided closure showed a slight lateral displacement in comparison to the other methods. Utt and all. (7) compared the condylar position between MI and CR for 107 patients before orthodontic treatment. The frequency, direction, and magnitude of MI-CR difference were analyzed for possible correlation to the patient's Angle classification, ANB angular measurement, age, or gender. The amount of MI-CR difference was nearly identical for right and left sides and only weak correlations were found between MI-CR displacements of right and left condyles. They concluded that patient's age, ANB angle and Angle classification cannot be used to predict frequency, direction, or magnitude of MI-CR changes at the level of the condyles. Schildkraut and all. (8) examined cephalometric measurements derived from a MI tracing with those of a converted CR tracing. Statistical tests used to compare the MI and CR cephalometric values demonstrated significant differences for the majority of the studied values. However, there were generally no differences between the groups of males and females, or between the skeletal Class I and Class II individuals. The results of this study suggest that to make a correct orthodontic diagnosis, the mandible should be placed in centric relation rather than in the more traditional maximum intercuspation. De Fantini and all. (9) assessed condylar displacement between initial maximum intercuspation and centric relation, recorded after using a deprogramming occlusal splint for an average period of 7.8 ± 2.1 months prior to any orthodontic treatment. The use of occlusal splints results in greater mean condylar displacement values, especially vertically, between MI and CR, which contributed to a more accurate orthodontic diagnosis.

Može se reći da su naprave za određivanje položaja zglobnih glavica pouzdane i jednostavne za upotrebu (10,11). Levine i suradnici (12) procjenjivali su prirodu i veličinu metode te materijalom izazvanu pogrešku razmatranjem intra- i intervarijabilnosti ispitivača upotrebom CPI instrumenta na razinama montiranja artikulatora i očitovanja pomaka zglobnih glavica. Očitovanja pomaka zglobnih glavica bila su vrlo točna i ponovljiva među ispitivačima.

Svrha istraživanja

Razlika između položaja CR-a i MI-a na razini zubnih lukova potiče pomak zglobnih glavica u zglobnim jamicama. Svrha ovog istraživanja bila je odrediti utječe li način prijenosa (anatomski obrazni luk spram prosječnog montiranja) s pacijenta u artikulator na trodimenzionalni pomak zglobnih glavica između MI-a i CR-a kod asimptomatskih ispitanika s normalnim okluzijskim odnosom (Angleova klasa I). Nulta hipoteza istraživanja glasi: utječu li različiti načini prenošenja šarnirske osi (prijenos obraznim lukom ili prosječno montiranje) na trodimenzionalni pomak zglobnih glavica. Na ispitivanom uzorku odredit će se spolne razlike s obzirom na promatrane varijable. Svi podatci pohranjeni su u bazi podataka (Microsoft Office Excel), a statistička analiza obavljena je licenciranim softverskim paketom Windows SPSS 12.0.

Materijali i metode

Odabir ispitanika

Uzorak se sastojao od 32 potpuno ozubljena ispitanika (16 muškaraca i 16 žena) s normalnim okluzijskim odnosom (Angleova klasa I). Sudionici su bili studenti dentalne medicine u dobi od 20 do 33 godine (muškarci 22,9 ± 5,3; žene 22,3 ± 4,1). S obzirom na inkluzijske kriterije svi su morali biti dobrog zdravlja, bez kliničkih znakova i simptoma temporomandibularnih poremećaja, bez parafunkcijskih navika te bez protetskih i ortodontskih naprava.

Veličina uzorka izračunala se s pouzdanošću od 95 posto i statističkom snagom od 80 posto. U svakoj skupini, da bi se obavila usporedba, moralo je biti najmanje 15 ispitanika.

Postupak i mjerenja

Za svakog ispitanika uzeti su alginatni otisci (ireverzibilni hidrokoloidi) obaju zubnih lukova. Zatim su isprani vodom, ispuhani zrakom i nakon 30 minuta izliveni u supertvrdoj sadri tipa IV (Elite Rock, Zhermack, Rovigo, Vêneto, Italija). Nakon trimanja modela, gornji sadreni model koristio se za izradu centričnih registrata. Za to je korišten tvrdi vosak (Beauty Pink, extra hard, Moyco Industries, Philadelphia, SAD) te vosak za registraciju zagriza (Aluwax,Aluwax Dental Products Co., Allendale, SAD) za bilježenje impresija donjega zubnog luka u lateralnim područjima. Prije određivanja položaja centrične relacije pacijent je bio *deprogramiran* tako što je pet minuta grizao pamučnu vatenu rolicu. Deprogramiranje je korišteno kako bi se pacijent lišio proprioceptivne osjetne povratne sprege i posljedično prekinuo pro-

It should be emphasized that the condylar position indicator devices have been shown to be reliable and easy to use (10,11). Levine and all. (12) assessed the nature and magnitude of method and material-induced error by studying intra- and interoperator variability using the CPI instrument at the levels of the articulator mountings and condylar displacement recordings. Condylar displacement recordings were very accurate and reproducible both among and between operators.

Aim

The difference between the position of CR and MI at level of dental arches causes a shift of articular condyles into articular fossae. The aim of this investigation was to determine whether the transfer modality (anatomic facebow vs. average mounting) from the patient to the articulator affects the three-dimensional condylar shift between the MI and the CR in asymptomatic subjects with normal occlusal relationship (Angle class I). The null hypothesis is that different ways of transferring hinge axis (facebow transfer or average mounting) does not influence on three-dimensional shift of the condyles. The gender differences with respect to the observed variables will be determined on the examined sample. All the data were saved in a data base (Microsoft Office Excel) and statistical analysis was performed using a licenced software package SPSS for Windows 12.0.

Materials and methods

Subjects selection

Study sample consisted of 32 fully dentate subjects (16 male and 16 female) with normal occlusal relations (Angle class I). Participants were dental students aged from 20 to 33 years (male 22.9 ± 5.3; female 22.3 ± 4.1). In order to meet the inclusion criteria, they had to be of good general health, with no clinical signs or symptoms of TMDs, no parafunctional habits and no prosthetic or orthodontic appliances present.

The sample size was calculated with a confidence of 95% and a statistical power of 80%. The number of subjects required in each group to make the comparisons was at least 15.

Procedure and measurement

Alginate (irreversible hydrocolloid) impressions for both dental arches were taken for each subject. The impressions were flushed clear of debris, air blown and were poured in super hard plaster type IV (Elite Rock (Zhermack, Rovigo, Vêneto, Italy)) after 30 min. After trimming the casts, the upper cast was used to prepare CR records. Hard wax was used for preparation (Beauty Pink, extra hard, Moyco Industries, Philadelphia, USA) of the CR record base as well as bite registration wax (Aluwax, Aluwax Dental Products Co., Allendale, USA) for recording impressions of the lower arch in lateral segments. Prior to the CR registration the patient was „deprogrammed“ by biting into a cotton pellet for 5 min. Deprogramming was used to deprive the patient of the proprioceptive sensory feedback and consequently disrupt the

gramirani neuralni mehanizam koji vodi donju čeljust u CR (10 – 12). Svaki sudionik bio je podvrgnut ispitivanju četiri puta (prvi dan, sljedeći dan, za tjedan dana i za mjesec dana). Za registraciju položaja CR-a rabila se metoda bimanualne manipulacije (tzv. Dawsonov hvat) (13). Za svako od četiri mjerenja po ispitaniku, prijenos modela u artikulator bio je obavljen nasumično – dva puta prosječno montiranje i dva puta prijenos obraznim lukom. Za ovo istraživanje bila su odabrana dva načina prijenosa gornjeg modela u poluprilagodljivi artikulator – anatomski obrazni luk i prosječno montiranje s pomoću okluzijskog stolića [Occlusal Plane Indicator (SAM Prazisionstechnik GmbH, München, Njemačka)]. Anatomski obrazni luk bio je postavljen na pacijenta paralelno s osno-orbitalnom ravninom. Za prosječno montiranje okluzijski je stolić bio namješten na sljedeće vrijednosti: nagib okluzijske ravnine 7°, vertikalna visina 7,5 milimetara i horizontalna visina 5,5 milimetara. Prije ugipsavanja donjeg modela, incizalni kolčić bio je namješten na + 7 milimetara kako bi se kompenzirala debljina centričnog registrata. Indikator položaja mandibule (MPI) bio je kalibriran u skladu s preporukama proizvođača prije svakog mjerenja. Sve kliničke i laboratorijske postupke obavljali su svi ispitivači, inače iskusni kliničari.

Posebno zanimljivo u području dijagnoze čeljusnih zglobova jest određivanje prostornog pomaka kondila iz njihova fiziološkog (centričnog) početnog položaja u položaj nametnut maksimalnom interkuspidacijom zuba. Za metričko mjerenje trodimenzionalnog pomaka kondila razvijene su metode koje se temelje na registraciji terminalne (transverzalne) šarnirske osi. Pritom odabrane točke mjerenja moraju biti na transverzalnoj šarnirskoj osi. Točke mjerenja opisuju kretnje analogne translaciji kondila. Tako izmjereni pomak točaka šarnirske osi, korigiran za interkondilnu udaljenost, može se interpretirati kao pomak kondila (14).

Analiza položaja kondila, koristeći se montiranim modelima, obavljena je uporabom indikatora položaja mandibule [MPI, Mandibular Position Indicator (SAM Prazisionstechnik GmbH, München, Njemačka)] (slika 1.) (15). Ta modularna naprava sastoji se od modificiranoga gornjeg dijela SAM artikulatora. Klizne mjerne kocke bile su postavljene na osi montiranja na mjestu kondila artikulatora i analognog mjerača smještenog između kocaka. Mjerne kocke i mjerač korišteni su za mjerenje trodimenzionalnog pomaka kondila iz MI-a u CR. Anteroposteriorni (ΔX) i superoinferiorni (ΔZ) pomaci bili su izmjereni s obzirom na definirane mjerne točke na mjernim kockama. Mediolateralni pomak (ΔY) mjerio se analognim mjeračem.

Treba istaknuti da analiza položaja kondila ovisi o točnosti i kvaliteti centričnih registrata. Postupak mjerenja obavljao se za lijevu i desnu stranu kondila. To znači postavljanje artikulacijskog papira između mjernih kocaka na kojima su nalijepljene koordinatne mrežice s osima x i y i glava kondila donjega dijela artikulatora koja ostavlja markaciju za svaki položaj šarnirske osi. Maksimalna interkuspidacija smatrala se središtem kartezijskoga koordinatnog sustava i prikazivala se kao početni položaj mjerenja (vrijednost 0). Dobivena markacija može se podudarati s položajem transverzalne šarnirske osi ili označavati razliku u horizontalnim [anteroprogrammed neural mechanism that guides the mandible into CR (10-12). Each participant was subjected to four testing visits (first day, the following day, one week after and one month after). The registration of the CR position was done using bimanual manipulation method (Dawson's grasp) (13). For each of four measurements per subject, transfer of the casts to the articulator were randomly mounted twice using average mounting and twice using facebow transfer. Two modalities of transferring the upper cast to the semi-adjustable articulator have been chosen for the present investigation: anatomical facebow transfer and average mounting by means of Occlusal Plane Indicator (SAM Prazisionstechnik GmbH, Muenchen, Germany). Anatomical facebow was positioned onto the patient paralel to the axis-orbital plane. For average mounting, Occlusal Plane Indicator was set to following values: inclination of the occlusal plane 7°, vertical height 7.5 mm and horizontal height 5.5 mm. Prior to the mounting of the lower cast, incisal pin was set to + 7 mm in order to compensate the thickness of the CR record. MPI was calibrated according to manufacturer's recommendations prior to each measurement. All clinical and laboratory phases were completed by all examiners (experienced clinicians).

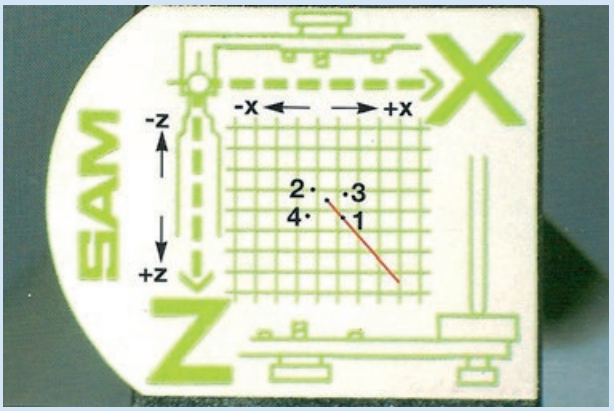
The determination of the spatial shift of the condyle from its physiological (centric) starting position into the position forced upon it by maximum intercuspation of the teeth is of special interest in the area of temporomandibular joint diagnosis. For metric recording of the condyle, a three-dimensional shift has been developed based on registration of the terminal (transverse) hinge axis. This requires that the selected measuring points lie on the transverse hinge axis. The measuring points exhibit movements analogous to the translation of the condyles. Therefore, the measured shift of the hinge axis points corrected for the intercondylar distance can be interpreted as the shift of the condyles (14).

Condylar position analysis using mounted casts was done by using MPI - Mandibular Position Indicator (SAM Prazisionstechnik GmbH, Muenchen, Germany) (Figure 1) (15). This modular device consists of a modified upper member of the SAM articulator. Sliding measuring cubes were placed on the mounting axis in place of the articulator condyles and an analogue gauge lies in between. Measuring cubes and gauge were used for evaluation of the three-dimensional condylar shift from the MI to the CR. Anteroposterior (ΔX) and superoinferior (ΔZ) shifts were measured relative to defined measuring points on the measuring cubes. Mediolateral shift (ΔY) was evaluated on the analogue gauge.

It should be emphasized that the analysis of the condyle position was dependent on the accuracy and quality of centric records.

The measuring procedure was completed for both left and right condyle. It implied placing the articulating paper between the measuring cube equipped with adhesive grids with x,y coordinates and the condyle head of the lower member of the articulator leaving a mark for each hinge axis position. Maximum intercuspation was considered the center of a Cartesian coordinate system and was represented as the starting position of the measurement (set to 0). The obtained marking can match the transverse hinge axis position or de-

Slika 1. Indikator položaja mandibule (SAM Prazisionstechnik GmbH, München, Njemačka)
Figure 1 Mandibular Position Indicator (SAM Prazisionstechnik GmbH, Muenchen, Germany)



Slika 2. Mjerenje pomaka kondila u vertikalnoj (ΔZ) i horizontalnoj (ΔX) ravnini
Figure 2 Measurement of the condylar shift in vertical (ΔZ) and horizontal plane (ΔX)

posteriornim (ΔX)] i vertikalnim [superoinferiornim (ΔZ)] dimenzijama između MI-a i CR-a. Za svako mjerenje markacije artikulacijski papir bio je u drugoj boji. Pomaci kondila između MI-a i CR-a mogu biti smješteni anteriorno (1), posteriorno (2), superiorno (3) i inferiorno (4), te prikazuju pozitivne i negativne vrijednosti (slika 2.). Udaljenost između svake markacije MI-a i CR-a na grafičkom papiru bila je izmjerena u milimetrima na razini točnosti od 0,5 milimetara.

Na stražnjoj strani MPI naprave nalazi se analogni mjerač koji bilježi mediolateralni pomak kondila. Uređaj ima dvobojnu milimetarsku ljestvicu – crveni dio pokazuje pomak kondila udesno (negativne vrijednosti), a crni pomak ulijevo (pozitivne vrijednosti). Pomaci kondila u mediolateralnom smjerovima bili su mjereni u milimetrima na razini točnosti od 0,1 milimetar. Sva mjerenja na MPI napravi obavio je samo jedan ispitivač (RĆ).

Rezultati

Na tablici 1. je deskriptivna statistička analiza (učestalost i standardna devijacija) testiranih kliničkih varijabli za pomak kondila donje čeljusti izazvan razlikom između položaja MI i CR. Prosječni trodimenzionalni pomak kondila [anteroposteriorni (ΔX), superoinferiorni (ΔZ) i mediolateralni (ΔY)] iznosio je 0,13 ± 0,12 milimetara za prijenos obraznim lukom i 0,22 ± 0,23 milimetra za prosječno montiranje. Kolmogorov-Smirnovljev test pokazao je da su ispitivane varijable normalno distribuirane (P > 0,05). Iz tog se razloga za testiranje utjecaja pomaka trodimenzionalnog kondila, s obzirom na način prijenosa u poluprilagodljivi artikulator, rabio neparametrijski statistički test (Mann-Whitneyjev). Trodimenzionalni pomak kondila nije pokazivao statističku značajnost s obzirom na spol (P > 0,05) (tablica 2.).

Uspoređujući načine prijenosa šarnirske osi (prijenos obraznim likom ili prosječno montiranje) u poluprilagodljivi artikulator, rezultati Mann-Whitneyjeva testa pokazali su statistički značajne razlike za anteroposteriorni i superoinferiorni pomak kondila (P < 0,001). Ipak, razlike u mediolateralnom pomaku nisu bile statistički značajne (tablica 3.).

note a difference in horizontal (anteroposterior, (ΔX)) and vertical (superoinferior, ΔZ)) dimensions between MI and CR. For every measuring, markings were made in different color of the articulating paper. Condylar displacements between MI and CR can be placed anteriorly (1), posteriorly (2), superiorly (3) and inferiorly (4) presenting positive and negative values (Figure 2). The distance between each MI and each of the CR dots on the graph paper was measured, in millimeters, to an accuracy of 0.5 mm.

At the back of the MPI instrument there is an analogue gauge that registers mediolateral condylar shift. The gauge has a bicolor millimeter scale, red part of the scale representing condylar shift to the right (negative values) and black part representing shift to the left (positive values). Condylar shifts in mediolateral directions were measured, in millimeters, to an accuracy of 0.1 mm. All measurements on the MPI instrument were done by one examiner (RĆ).

Results

Table 1 presents descriptive statistical analysis (frequency and standard deviation) of the tested clinical variables for the condylar shift of the mandible caused by the difference between the MI and CR position. The average three-dimensional condylar shift (anteroposterior (ΔX), superoinferior (ΔZ) and mediolateral (ΔY)) was 0.13 ± 0.12 mm for facebow transfer and 0.22 ± 0.23 mm for average mounting. Kolmogorov-Smirnov test showed that the examined variables were normally distributed (P > 0.05). For this reason, to test the influence of three-dimensional shift of the condyle with respect to the mode of transferring in the semi adjustable articulator, a nonparametric statistical test (Mann-Whitney test) was used. The three-dimensional condylar shift showed no statistical significance with respect to gender (P > 0.05) (Table 2).

Comparing the ways of transferring the hinge axis (facebow transfer or average mounting) to the semiadjustable articulator, the results of the Mann-Whitney test showed statistically significant differences for anteroposterior and superoinferior condylar shift (P < 0.001). However, the differences in the mediolateral shift were not statistically significant (Table 3).

Tablica 1. Deskriptivna svojstva testiranih trodimenzionalnih pomaka kondila između prijenosa obraznim lukom i prosječnog montiranja
Table 1 Descriptive characteristics of the tested three-dimensional condylar shifts between the facebow transfer and average mounting.

	Prijenos obraznim lukom • Facebow transfer		Prosječno montiranje • Average mounting	
	Prosjek • Mean	SD	Prosjek • Mean	SD
Δ Yd • Δ Yr	0.16	0.11	0.18	0.12
Δ Yl • Δ Yl	0.07	0.14	0.19	0.15
Δ Xdn • Δ Xrf	0.11	0.11	0.10	0.16
Δ Xds • Δ Xrb	0.12	0.16	0.32	0.33
Δ Zdd • Δ Zrd	0.22	0.16	0.19	0.24
Δ Zdg • Δ Zru	0.02	0.05	0.39	0.38
Δ Xln • Δ Xlf	0.32	0.10	0.16	0.19
Δ Xls • Δ Xlb	0.02	0.04	0.31	0.37
Δ Zld • Δ Zld	0.19	0.34	0.26	0.23
Δ Zlg • Δ Zlu	0.12	0.14	0.13	0.16
Total	**0.134**	**0.124**	**0.223**	**0.232**

ΔYd – mediolateralni pomak desno; ΔYl – mediolateralni pomak lijevo; ΔXdn – anteroposteriorni pomak desno naprijed; ΔXds – anteroposteriorni pomak desno straga (-); Δ Zdd – superoinferiorni pomak desno dolje; Δ Zdg – superoinferiorni pomak desno gore (-); ΔXln – anteroposteriorni pomak lijevo naprijed; ΔXls – anteroposteriorni pomak lijevo straga (-); Δ Zld – superoinferiornipomak lijevo dolje; Δ Zlg – superoinferiorni pomak lijevo gore (-), SD – standardnadevijacija
ΔYr – mediolateral shift to the right; ΔYl – mediolateral shift to the left; ΔXrf – anteroposterior shift right forwards; ΔXrb – anteroposterior shift right backwards (-); Δ Zrd – superoinferior shift right downwards; Δ Zru – superoinferior shift right upwards (-); ΔXlf – anteroposterior shift left forwards; ΔXlb – anteroposterior shift left backwards (-); Δ Zld – superoinferior shift left downwards; Δ Zlu – superoinferior shift left upwards (-), SD – standard deviation.

Tablica 2. Rezultati Mann-Whitneyjeva testa za trodimenzionalni pomak kondila s obzirom na spol (obrazni luk spram prosječnog montiranja)
Table 2 The results of the Mann-Whitney test for three-dimensional condylar shift with respect to gender (facebow vs. average mounting)

	ΔYd • Δ Yr	ΔYl	ΔXds • Δ Xrf	ΔXdn • Δ Xrb	ΔZdd • Δ Zrd	ΔZdg • Δ Zru	ΔXls • Δ Xlb	ΔXln • Δ Xlf	ΔZld • Δ Zld	ΔZlg • Δ Zlu
Mann-Whitney U	17513	17053	17453	17588	18344	16596	17587	18363	17745	17835
Wilcoxon W	36549	35581	35981	36116	36872	35124	36115	36891	36273	36363
Z	-0.89	-1.49	-1.18	-0.95	-0.10	-2.17	-0.89	-0.09	-0.80	-0.69
Značajnost • Significance	0.372	0.135	0.236	0.343	0.918	0.130	0.373	0.929	0.423	0.486

ΔYd – mediolateralni pomak desno; ΔYl – mediolateranil pomak lijevo; ΔXdn – anteroposteriorni pomak desno naprijed; ΔXds – anteroposteriorni pomak desno straga (-); Δ Zdd – superoinferiorni pomak desno dolje; Δ Zdg – superoinferiorni pomak desno gore (-); ΔXln – anteroposteriorni pomak lijevo naprijed; ΔXls – anteroposteriorni pomak lijevo straga (-); Δ Zld – superoinferiorni pomak lijevo dolje; Δ Zlg – superoinferiorni pomak lijevo gore (-)
ΔYr – mediolateral shift to the right; ΔYl – mediolateral shift to the left; ΔXrf – anteroposterior shift right forwards; ΔXrb – anteroposterior shift right backwards (-); Δ Zrd – superoinferior shift right downwards; Δ Zru – superoinferior shift right upwards (-); ΔXlf – anteroposterior shift left forwards; ΔXlb – anteroposterior shift left backwards (-); Δ Zld – superoinferior shift left downwards; Δ Zlu – superoinferior shift left upwards (-).

Tablica 3. Rezultati Mann-Whitneyjeva testa za trodimenzionalni pomak kondila s obzirom na način prijenosa (obrazni luk spram prosječnog montiranja)
Table 3 The results of the Mann-Whitney test for three-dimensional condylar shift in order to the transfer modality (facebow vs. average mounting)

	ΔYd • Δ Yr	ΔYl	ΔXds • Δ Xrf	ΔXdn • Δ Xrb	ΔZdd • Δ Zrd	ΔZdg • Δ Zru	ΔXls • Δ Xlb	ΔXln • Δ Xlf	ΔZld • Δ Zld	ΔZlg • Δ Zlu
Mann-Whitney U	17568	16693	16095	11979	16125	14596	14026	12432	17829	15821
Wilcoxon W	36096	35221	34623	30507	34653	33124	32554	30960	36357	34349
Z	-0.84	-1.88	-2.83	-7.28	-2.70	-4.54	-4.65	-7.83	-0.70	-3.05
Značajnost • Significance	0.401	0.059	**0.005**	**0.000**	**0.007**	**0.000**	**0.000**	**0.000**	0.483	**0.002**

ΔYd – mediolateralni pomak desno; ΔYl – mediolateranil pomak lijevo; ΔXdn – anteroposteriorni pomak desno naprijed; ΔXds – anteroposteriorni pomak desno straga (-); Δ Zdd – superoinferiorni pomak desno dolje; Δ Zdg – superoinferiorni pomak desno gore (-); ΔXln – anteroposteriorni pomak lijevo naprijed; ΔXls – anteroposteriorni pomak lijevo straga (-); Δ Zld – superoinferiorni pomak lijevo dolje; Δ Zlg – superoinferiorni pomak lijevo gore (-)
ΔYr – mediolateral shift to the right; ΔYl – mediolateral shift to the left; ΔXrf – anteroposterior shift right forwards; ΔXrb – anteroposterior shift right backwards (-); Δ Zrd – superoinferior shift right downwards; Δ Zru – superoinferior shift right upwards (-); ΔXlf – anteroposterior shift left forwards; ΔXlb – anteroposterior shift left backwards (-); Δ Zld – superoinferior shift left downwards; Δ Zlu – superoinferior shift left upwards (-).

Rasprava

U studiji je korištena bimanualna manipulacija kao metoda određivanja položaja centrične relacije. Kao što pokazuju podatci iz znanstvene literature (4 – 12) to je jedan od najpouzdanijih i najponovljivijih načina određivanja CR-a u stomatologiji, bilo da se radi o asimptomatskim ispitanicima, ortodontskim pacijentima ili onima s temporomandibularnim poremećajima. Prema tome, metoda određivanja CR-a u ovoj studiji nije utjecala na trodimenzionalni pomak kondila jer je njezina pouzdanost bila dokazana (13).

U osnovi postoje dvije metode prijenosa odnosa gornjega i donjeg zubnog luka prema bazi lubanje u artikulator – obraznim lukom i prosječnim montiranjem. Može se postaviti pitanje utječu li ovi modaliteti na točnost određivanja centrične relacije. S kliničkog stajališta, upotreba bilo kojeg tipa obraznoga luka trebala bi biti mnogo točnija od prosječnog montiranja. U ovoj studiji, nulta hipoteza je odbačena jer je jasno da kod asimptomatskih ispitanika različiti načini prijenosa šarnirske osi utječu na trodimenzionalni pomak kondila. Osim toga, trodimenzionalni pomaci kondila nisu pokazali statistički značajnu razliku s obzirom na spol. Prijenos obraznim lukom imao je manje vrijednosti trodimenzionalnih pomaka kondila (anteroposteriorni i superoinferiorni) u odnosu prema prosječnom montiranju. Ovaj zaključak rezultat je statističke analize. Drugim riječima, statističke razlike u ovoj studiji nemaju značajni utjecaj na svakodnevnu upotrebu poluprilagodljivih artikulatora. Ove razlike prosječnih trodimenzionalnih pomaka kondila između prijenosa obraznim lukom i prosječnog montiranja bile su na razini od 0,1 do 0,2 milimetra te se mogu smatrati fiziološkom varijacijom pomaka kondila normalnih čeljusnih zglobova kod asimptomatskih ispitanika s normalnom okluzijom.

U literaturi se mogu naći mnogobrojne studije sa suprotnim zaključcima s obzirom na upotrebu/neupotrebu obraznoga luka i dentalnih artikulatora (14 – 17). U onima koje podupiru upotrebu obraznoga luka, glavni je kriterij prijenos šarnirske osi u artikulator. Tuppy i suradnici (18) testirali su položaj i translaciju šarnirske osi upotrebom elektroničkog indikatora položaja mandibule kod 15 simptomatskih pacijenata. U skladu s njihovim rezultatima postoji velika ponovljivost u položajima šarnirske osi. Morneburg i Pröschel (19, 20) potvrdili su važnost bilježenja prosječne ili kinematske šarnirske osi i njezinu upotrebu u protetici. Predlažu prijenos obraznim lukom kako bi se smanjile okluzijske pogreške, posebice kada je potrebno mijenjati vertikalnu dimenziju za više od 4 milimetra. Padala i suradnici (21) istaknuli su da su vertikalni i horizontalni pomaci kondila bili veći kod pacijenata s temporomandibularnim poremećajem u odnosu prema asimptomatskim ispitanicima. Zaključili su da su diskrepancije u pomaku kondila važne u etiopatogenezi temporomandibularnog poremećaja. Nadalje, istaknuli su važnost instrumentalno-funkcijske analize tj. raščlambe trodimenzionalnog pomaka kondila i njezine primjene u dijagnostici temporomandibularnog poremećaja. S druge strane, u nekim studijama dovodi se u pitanje korisnost i pouzdanost prijenosa obraznim lukom. Skandinavsko protetsko društvo i njegovi članovi tvrde da, *iako je teoretski uvjerljivo, nema*

Discussion

In the study, the bimanual manipulation was used as a method of determining the centric relation. As shown by data from the scientific literature (4-12), it is one of the most reliable and reproducible methods of determining CR in dentistry in spite of the fact that they are asymptomatic subjects, orthodontic patients or patients with temporomandibular disorders. Accordingly, the method of determining the CR in this study did not affect the three-dimensional shift of the condyle since its reliability has been demonstrated (13).

Basically, there are two methods of transferring the relation between the upper and lower dental arch to the base of the skull into the articulator- facebow transfer and average mounting. One can question whether those modalities have an influence on the precision of centric relation registration. From a clinical viewpoint, usage of any facebow type should be more precise than the average mounting. In the present study, the null hypothesis is rejected, indicating that different ways of transferring hinge axis does influence the three-dimensional shift of the condyles among asymptomatic subjects. Besides, the three-dimensional condylar shifts showed no statistically significant difference with respect to gender. The facebow transfer displayed lower values of three-dimensional shifts of the condyle (anteroposterior and superoinferior) compared to the average mounting. This conclusion is the result of the statistical analysis. In other words, the statistically significant differences found in this study do not have significant impact on everyday clinical use of semi-adjustable articulators. These differences of the average three-dimensional condylar shifts between facebow transfer and average mounting were at the level of 0.1 – 0.2 mm that they can be considered a physiological variation of condylar shift of normal temporomandibular joints among asymptomatic subjects with normal occlusion.

In the literature, there are numerous studies with controversial conclusions regarding the use/disuse of the facebow and dental articulators (14-17). In the ones which support the use of facebow, the main criterion is the transfer of hinge axis into articulator. Tuppy et al. (18) tested the position and translation of the hinge axis using an electronic mandibular positioning indicator in 15 symptomatic patients. According to their results, there is great repeatability in the hinge axis positions. Morneburg and Pröschel (19, 20) confirmed the importance of the average or kinematic hinge axis registration as well as its use in prosthetic dentistry. They recommend facebow transfer in order to minimize occlusal mistakes especially for cases that require altering the vertical dimension of the occlusion for more than 4 mm. Padala et al. (21) found that vertical and horizontal condylar shifts were greater for patients with TMD than for asymptomatic subjects. They concluded that discrepancies in condylar shift play a role in the etiopathogenesis of the TMD. Furthermore, they stressed the importance of instrumental-functional analysis, i.e. three-dimensional condylar shift analysis and its use in TMD diagnostics.

On the other hand, some studies have questioned the benefit and reliability of the facebow transfer modality. Scan-

snažnoga znanstvenog dokaza koji potvrđuje da prijenos obraznim lukom poboljšava kliničku kvalitetu protetskih radova u usporedbi s prosječnim montiranjem u artikulator (22, 23).

Zaključak

U ovoj studiji su odstupanja u trodimenzionalnim pomacima kondila bila veća pri prosječnom montiranju negoli pri prijenosu obraznim lukom. Unatoč činjenici da su nađene statistički značajne razlike, s kliničkog stajališta one nisu presudne u svakodnevnom radu. To implicira da su oba postupka klinički pouzdana – i upotreba obraznoga luka i/ili prosječno montiranje pri prijenosu odnosa gornjih i donjih čeljusti u dentalni artikulator kod asimptomatskih ispitanika s normalnom okluzijom.

Etičko odobrenje

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Autori izjavljuju da nisu u sukobu interesa.

dinavian Prosthodontic Association and its members claim that "although theoretically convincing, there is no strong scientific evidence that proves facebow transfer improves clinical quality of prosthetic restorations in comparison to the average mounting into the articulator " (22, 23).

Conclusion

In the present study, discrepancies in three-dimensional condylar shifts were greater for average mounting than for facebow transfer. In spite of the fact that there were statistically significant differences, from a clinical viewpoint, these differences are not so crucial in everyday practice. This implies that the use of the facebow and/or average mounting are equally reliable clinical procedures to transfer the relationship between upper and lower jaws into dental articulator in asymptomatic subjects with normal occlusion.

Ethics approval and conflict of interest

The study was approved by Ethics Committee of School of Dental Medicine, University of Zagreb, Croatia. We are grateful to the Dental clinic at the Clinical Hospital Center Zagreb for the financial and material support. The authors declare no conflicts of interest.

Abstract

Purpose. The purpose of the study was to determine whether the hinge axis registration and the transfer modality (facebow transfer vs. average mounting) from the subject to the articulator affect the three-dimensional condylar shift between the centric relation (CR) and the maximum intercuspation (MI) position. **Material and Methods.** The study was comprised of 32 fully dentate subjects (16 male and 16 female). Only the asymptomatic participants with normal occlusal relations (Angle class I) aged 20 - 33 (mean age 22.6 ± 4.7) met the inclusion criteria. Three-dimensional condylar shift (anteroposterior, superoinferior and mediolateral shift) between the centric relation position (CR) and the maximum intercuspation (MI) position was analyzed by means of Mandibular Position Indicator (SAM Prazisionstechnik GmbH, Muenchen, Germany). **Results.** The average three-dimensional condylar shift was 0.13 ± 0.12 mm for facebow transfer and 0.22 ± 0.23 mm for average mounting. There were no statistically significant differences noted between genders. The results of the Mann-Whitney test showed statistically significant differences for anteroposterior and superoinferior condylar shift ($P < 0.001$). However, the difference in the mediolateral shift was not statistically significant. **Conclusions.** In order to find discrepancies within the three-dimensional condylar shift, facebow transfer proved to be more accurate than the average mounting in the semi-adjustable articulator. However, the average value of three-dimensional shifts of the condyle did not differ from normal values and they did not have clinical significance. Thus, both ways of transfer modalities (facebow transfer and average mounting) in asymptomatic subjects with normal occlusion can be considered reliable.

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Dental Articulators; Centric Relation; Hinge axis; facebow transfer

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