ORIGINAL ARTICLE
ORIGINALNI RAD
DOI: https://doi.org/10.2298/SGS2303124S
UDC: 616.314.21/.22

Condylographic evaluation of propulsive and Bennett angles in patients with temporomandibular disorders

Viktor Stefanovski[1], Slobodan Gjeorgiev[1], Elena Vasilevska Gjeorgieva[1], Goran Panchevski[2], Sanja Panchevska[2]

[1]PHI Denta ES, Skopje, Republic of North Macedonia;
[2]Ss. Cyril and Methodius University, Faculty of Dentistry in Skopje, The Republic of North Macedonia

SUMMARY

Introduction Mandibular kinetics is composed of a series of complex movements regarding opening and closing and latero-lateral movements. The procedure for registration of this trajectory is condylography. This procedure represents a diagnostic method for monitoring and registering the movements of the mandibular condyles. The analysis starts from the most distal position of the condyle to the maximum propulsive point and latero-lateral maximum extensions. The aim of this examination is to compare the trajectory of movement of the mandibular condyle in patients with symptoms of TMD, in the acute phase and the trajectory after the treatment and corrections of intermaxillary relations.
Materials and methods The examination was carried out in 20 (10 men and 10 women) patients of PHO Denta Estetika Team Skopje. The patients were complaining about pain, limitation of movements and crepitations in the temporomandibular joint as well as difficult mastication. Condylographic measurements were made with the Kavo Arcus Digma digital condylograph. The registration of the movements was done in two sessions, before and after the treatment.
Results There was no statistically significant difference in temporomandibular condyle movement angles before and after the treatment in patients with TMD. There was a statistically significant difference in the value of Bennett's angle. Easier and more accurate movements of mandible were noticed in the patients after the treatment.
Keywords: condylography; condylar movement path; functional diagnostics; jaw movement; temporomandibular joint; temporomandibular joint disorders

INTRODUCTION

Mandibular movement patterns have been commonly used by clinicians to investigate dysfunction of the masticatory system. Restricted maximal opening (normal values range 45+/-5 mm) and deflections or deviations in the opening trajectory are one of the symptoms of TMD.

In everyday practice a dentist is confronted with problems such as tooth sensitivity, tooth fractures, luxating teeth, pain in the temporomandibular joints, muscles sensitive to palpation, facial pain etc. [1, 2]. Due to inappropriate angulation and design of the anatomy of dental cusps we get "inappropriate" and premature contacts that lead to persistent pain in the tooth and furthermore pain in the muscles after the fixation of the restauration. Form a therapeutic point of view we need to understand the occlusal concept of intercuspation and mastication, not doing so it may lead our treatment into a completely wrong approach. A first symptom that we notice are cracks or even complete fractures of dental structure. These are first indicators of some kind of disharmony in the patient's occlusion [3]. All of these complications can be prevented with a correct analysis of the occlusion and correct planning of the treatment [4].

Already in 1995 Dawson emphasized the importance of occlusion, but also of the act of mastication, which depends primarily on the neuromuscular connection of the masticatory muscles, the placement of the mandibular condyle and the angle of temporal fossa [5, 6].

Articulators are devices that help replicate the position and movements of the condyle in TMJ and are indispensable in the fabrication of restorations that match the movements of the condyles in all directions. The development of articulators has been followed by the development of methods for tracking and registering the trajectory of the condyle that help to study the degree of maximum movements mouth opening or closing, lateral movements, as well as to identify the best functional position [7]. With these results we can precisely replicate the jaw movement in the act of mastication.

Condylography is a diagnostic method for monitoring and registering the movements of the condyles. The measurements start from the most distal position of the condyle to the maximal propulsive point and latero-lateral maximal extension respectively [8]. Obtained registrations and angles are used to adjust the articulator with individual values, regardless of whether it is a virtual CAD-CAM or a mechanical articulator. This way, mandibular movements during mastication can be reproduced most accurately.

As an auxiliary diagnostic tool, condylography is used in the treatment of patients with neuromuscular problems related to head muscles [9]. Any disturbance in the degree

Address for correspondence: Viktor STEFANOVSKI, PHI Denta ES, Anton Popov 31, Skopje, Republic of North Macedonia;
viktorstefanovski@yahoo.com

of muscle contraction will move mandible out of its trajectory. Every registration is done in three dimensions and the smallest deviation is noted [10].

The aim of this study was to compare the trajectory of mandibular condyle during propulsion, opening and closing in patients with symptoms of TMD and after the treatment that eliminated symptoms.

MATERIALS AND METHOD

For the purposes of this study, 20 subjects (10 women and 10 men) aged from 20 to 50 years with TMD symptoms confirmed by clinical examination and a completed survey questionnaire were included. Patients who were currently undergoing orthodontic treatment, with mental disorders or neurological diseases were excluded as well as patients who had trauma in the head and neck area in the last 12 months. All patients were informed that they could cancel their participation at any time during the trial.

In order to be part of the study every patient gave a written consent, the analysis that will be done as well as the treatment plan that will follow. Each patient also filled out an ethical questionnaire in which he/she subjectively described their symptoms.

The position of the mandibular condyle and its trajectory was recorded with an Arcus Digma digital condylograph. Due to the protection of patient's personal data, all communication with laboratory was conducted under a coded record number (procedure for the protection of personal data ISO 9001:2012) according to the regulations of Denta Estetica Tim polyclinic.

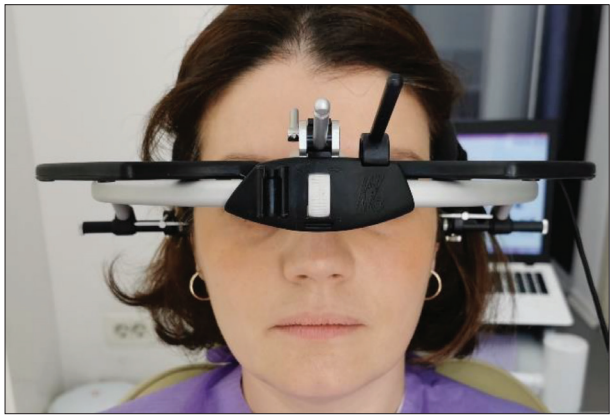

Figure 1. Anterior view of facebow with sensor
Slika 1. Obrazni luk sa senzorom sa prednje strane

Figure 2. Lateral view of face bow with sensor
Slika 2. Obrazni luk sa senzorom sa bočne strane

Procedure

Measurements and analysis

In continuation of the examination, a condylographic analysis was performed for each participant to register the trajectory of the condyle in the temporomandibular joint [11].

Measurements were made with a KAVO Arcus DIGMA condylograph.

The device consisted of:

1. Hardware part
2. Software part

The hardware part had a Face bow that was fixed on the patient's head. This part carried the receiver for the sonic emitters that emitted 40 KHz sound, with a measurement error of +/- 0.1 mm and registration frequency 50 HZ. The weight of the Face bow was 38 grams.

The placement of the facebow always followed the Camper line laterally, while the frontal placement was parallel to the bi-pupillary line. The two components for the ears rested on the external ear opening (Figures 1 and 2).

The maxillary transfer fork was fixed to the maxilla and rested on the occlusal surface of the upper dental arch. The mandibular dental arch was fixed on the buccal surface of the lower teeth, making sure that it does not hinder the movements and that there are no premature contacts on the fork.

The registration procedure started by positioning first the maxillary fork, allowing registration of the maxillary position on the virtual model as a fixed reference. The carrier was then transferred to the mandibular fork and the registration of the trajectory of the mandibular condyle started. Three sequences of propulsion left and right lateral maximal translations were recorded/ registered.

The software part of the Digma system had an algorithm for analyzing the intensity of the sonic emission, which accurately registered the position of mandible. This registration was done continuously thus registering the complete trajectory of TMJ. At the end the software provided a sketch with a schematic representation of trajectory and angles of the incisal guide and angles of the propulsive path of the condyles on the left and right side respectively. Bennet's angle and the immediate shift angle were also recorded. These parameters were important for the adjustment of the individual articulator when planning and constructing the intermaxillary relations in occlusion (Figures 3, 4, 5) [11].

Student's T-test was used to analyze the results, comparing results in the same subjects before and after occlusion

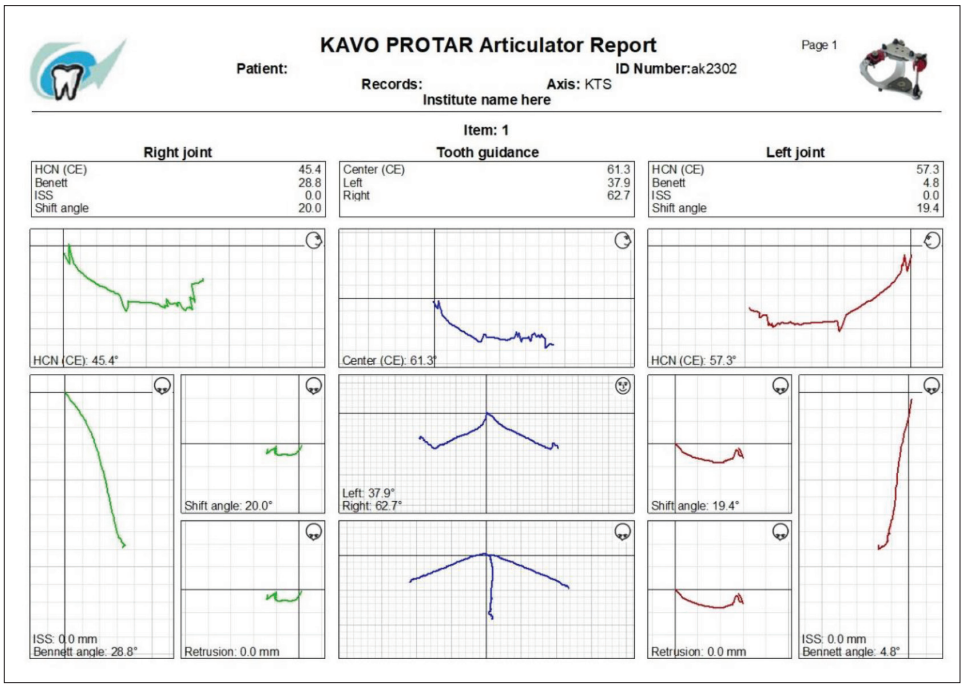

Figure 3. Scheme of condylar trajectory
Slika 3. Šema kondilarne trajektorije

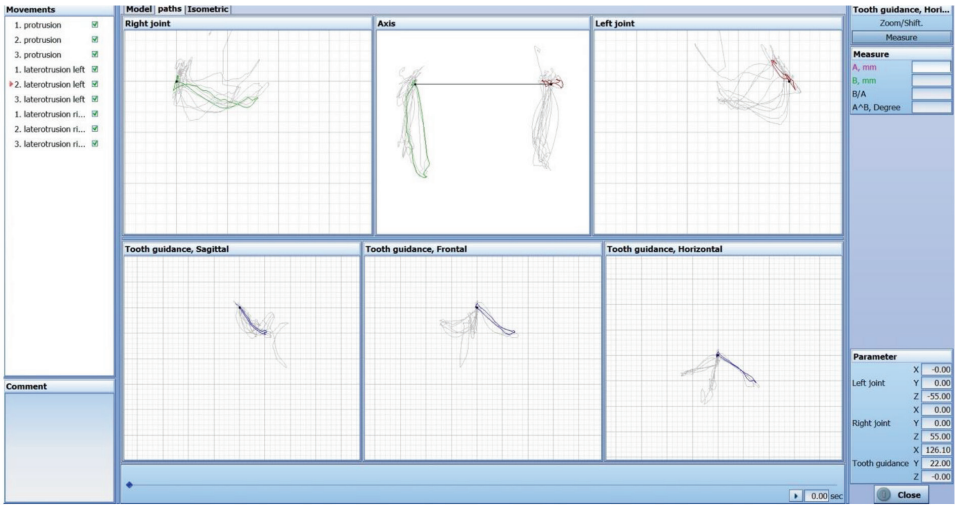

Figure 4. Graphical presentation of TMJ movement
Slika 4. Grafički prikaz pokreta TMZ

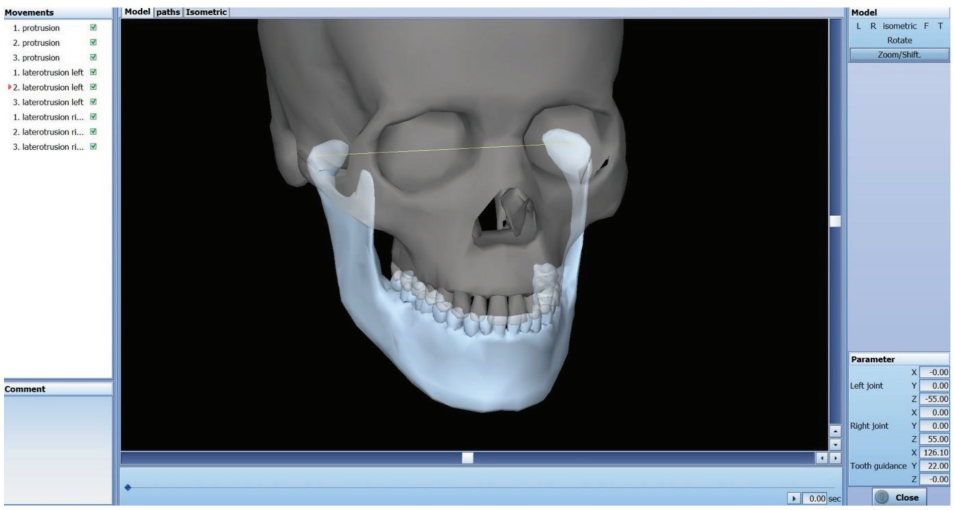

Figure 5. Virtual presentation of TMJ movement
Slika 5. Virtuelni prikaz TMZ pokreta

Table 1. Results of the analyisis before and after the treatment
Tabela 1. Rezultati analize pre i posle terapije

	Acute phase Akutna faza		After therapy Posle terapije	
Propulsion angle Ugao propulzije	Right TMJ Desni TMZ	Left TMJ Levi TMZ	Right TMJ Desni TMZ	Left TMJ Levi TMZ
Main value Glavna vrednost	31.04	30.27	30.56	33.34
Student's t-test	Right TMJ Desni TMZ p > 0.878		Left TMJ Levi TMZ p > 0.389	

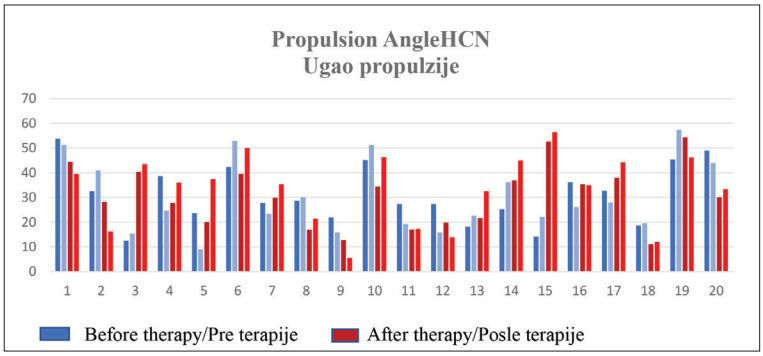

Figure 6. Graphic representation of the analysis before and after the treatment
Slika 6. Grafički prikaz analize pre i posle terapije

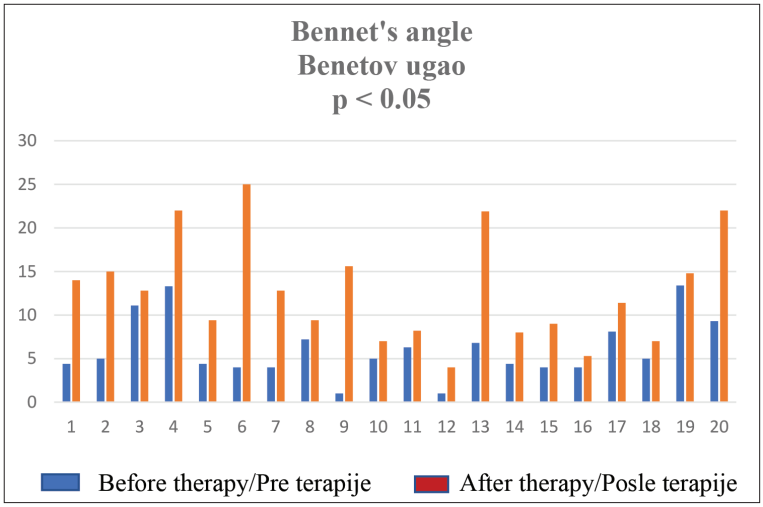

Figure 7. Graphic representation of the analysis before and after the treatment
Slika 7. Grafički prikaz analize pre i posle terapije

correction. Paired T-test analysis was used as the values were obtained in the same candidates before and after the treatment.

The mean value for the propulsive angle of the right temporomandibular joint in patients in the acute phase of TMD was 31.04^0 while that of the left temporomandibular joint was 30.27^0, the propulsive incisal guidance in the acute phase had an average value of 47.05^0. After TMD treatment and reconstruction of intermaxillary relations the measurement of the propulsive path angle of the right condyle was 30.56^o and 33.34^o for the left joint respectively. The propulsive incisal guidance angle after the treatment was 44.25^o as shown on the Table 1 and Figure 6.

Student's T-Test results showed no statistically significant difference in temporomandibular condyle movement angles before and after the treatment in patients with TMD. There was a statistically significant difference in the value of Bennett's angle. Easier and more correct and consistent movements of mandible were noticeable in the patients after the treatment (Figure 7).

DISCUSSION

This study aimed to expand our understanding of the trajectory of mandibular condyle during various movements in patients with temporomandibular disorder (TMD). Specifically, the researchers sought to compare the condylar trajectory during propulsion, opening and closing in these patients both before and after the elimination of TMD symptoms.

Previous studies conducted by Khan, Zahid Sarafas and their colleagues explored the position of the kinematic center of the condyle during opening and closing in patients without luxation. Their findings confirmed that the condyle followed the surface of the joint fossa in these individuals [12].

In 2021, Lee Won-June et al. investigated the relationship between craniofacial morphology, temporomandibular joint (TMJ) characteristics, and condylar functional movement in patients with facial asymmetry. They utilized an advanced automated real-time jaw-tracking system to analyze these factors and their correlation [13].

Another study conducted by Sojka A et al. involved the use of the Arcus Digma System to evaluate mandibular movements in healthy individuals without dental problems and TMD symptoms. The results of this study indicated that patients without TMD symptoms did not exhibit mandibular movement disorders, providing valuable insights into the normal mandibular function [14].

Additionally, Musa, Mazen conducted a study focused on exploring the quantitative and qualitative changes in the condyle following stabilization splint therapy. The study investigated various aspects such as condylar position, morphology, and bone mineral density in subjects diagnosed with temporomandibular disorders (TMD) [15]. These studies contribute to our understanding of the mandibular condyle trajectory, its correlation with craniofacial morphology and TMJ characteristics, and the effects of TMD symptoms and treatment on the condylar structure and function.

CONCLUSION

Mandibular movements are triggered by muscle contractions, controlled by the nervous system. Limited by fixed anatomical structures, the condyle-disc complex restricts translations. Muscle diseases or temporomandibular

disorders often impact mandibular movement speed and trajectory. TMD treatment has minimal effect on the condyle's trajectory during opening and closing, with only facilitated latero-lateral movements. Obtained data from condylography aids in precise adjustment of mechanical and virtual articulators, enhancing control and reliability in prosthetic rehabilitation.

REFERENCES

1. Stasiak G, Maracci LM, de Oliveira Chami V, Pereira DD, Tomazoni F, Bernardon Silva T, et al. TMD diagnosis: Sensitivity and specificity of the Fonseca Anamnestic Index. Cranio. 2023;41(3):199–203. [DOI: 10.1080/08869634.2020.1839724] [PMID: 33108257]
2. Osiewicz M, Manfredini D, Biesiada G, Czepiel J, Garlicki A, Aarab G, et al. Prevalence of Function-Dependent Temporomandibular Joint and Masticatory Muscle Pain, and Predictors of Temporomandibular Disorders among Patients with Lyme Disease. J Clin Med. 2019;8(7):929. [DOI: 10.3390/jcm8070929] [PMID: 31261623]
3. Jinal B, Kamath V, Patil K, Meshramkar R. A Clinical Investigation onto the Effect of Occlusal Interferences & Cognitive Behavioural Therapy in Temporomandibular Disorder Patients. Ind J Pub Health Res Develop. 2019;10(9):509. [DOI: 10.5958/0976-5506.2019.02754.2]
1. Ramachandran A, Jose R, Tunkiwala A, Varma RB, Shanmugham AM, Nair PK, et al. Effect of deprogramming splint and occlusal equilibration on condylar position of TMD patients – A CBCT assessment. Cranio. 2021;39(4):294–302. [DOI: 10.1080/08869634.2019.1650216] [PMID: 31451061]
2. Dawson PE. A classification system for occlusions that relates maximal intercuspation to the position and condition of the temporomandibular joints. J Prosthet Dent. 1996;75(1):60–6. [DOI: 10.1016/S0022-3913(96)90419-9] [PMID: 8850454]
3. Dawson PE. New definition for relating occlusion to varying conditions of the temporomandibular joint. J Prosthet Dent. 1995;74(6):619–27. [DOI: 10.1016/S0022-3913(05)80315-4] [PMID: 8778387]
4. Zhang L, Shen L, Zhang L, Zhang C, Wang H. Dynamic 3D images fusion of the temporomandibular joints: A novel technique. J Dent. 2022;126:104286. [DOI: 10.1016/j.jdent.2022.104286] [PMID: 36096297]
5. Banerjee A, Roy Chowdhury A, Majumder S. Temporomandibular joint disorder and biomechanical simulation of the replacement: a literature review on various surgical and nonsurgical Methods, and development of the finite element method approach in the treatment. J Eng Sci Med Diagn Therapy. 2022;5(2):021005. [DOI: 10.1115/1.4054095]
6. Wang YC, Shih TT, Yu CW, Chen YJ. Kinematic magnetic resonance imaging for the evaluation of active motion of the mandibular condyle in patients with temporomandibular joint disorders. J Formos Med Assoc. 2023;122(5):411–8. [DOI: 10.1016/j.jfma.2022.12.009] [PMID: 36588052]
7. Chen CC, Lin CC, Hsieh HP, Fu YC, Chen YJ, Lu TW. In vivo three-dimensional mandibular kinematics and functional point trajectories during temporomandibular activities using 3d fluoroscopy. Dentomaxillofac Radiol. 2021;50(2):20190464. [DOI: 10.1259/dmfr.20190464] [PMID: 32783637]
8. Park C. ARCUS digma I, II system 을 활용한 전악수복 증례 Application of ARCUS digma I, II systems for full mouth reconstruction: a case report. J Dent Rehabil Appl Sci. 2016;32(4):345–50. [DOI: 10.14368/jdras.2016.32.4.345]
9. Khan ZS, Shah SG, Humayun A, Khan ZU, Ali W, Iqbal M, et al. Association Between Kinematic Center and Anatomy, The Function of Temporomandibular Joint. Pakistan J Med Health Sci. 2022;16(06):806. [DOI: 10.53350/pjmhs22166806]
10. Lee WJ, Park KH, Kang YG, Kim SJ. Automated Real-Time Evaluation of Condylar Movement in Relation to Three-Dimensional Craniofacial and Temporomandibular Morphometry in Patients with Facial Asymmetry. Sensors. 2021;21(8):2591. [DOI: 10.3390/s21082591] [PMID: 33917213]
11. Sójka A, Huber J, Kaczmarek E, Hędzelek W. Evaluation of mandibular movement functions using instrumental ultrasound system. J Prosthod. 2017;26(2):123–8. [DOI: 10.1111/jopr.12389] [PMID: 26488230]
12. Musa M, Zhang Q, Awad R, Wang W, Ahmed MMS, Zhao Y, et al. Quantitative and qualitative condylar changes following stabilization splint therapy in patients with temporomandibular joint disorders. Clin Oral Investig. 2023;27(5):2299–310. [DOI: 10.1007/s00784-023-04963-x] [PMID: 37039959]

Received: 5.6.2023 • Accepted: 2.9.2023

Kondilografska evaluacija propulzivnog i Benetovog ugla kod pacijenata sa temporomandibularnim oboljenjima

Viktor Stefanovski[1], Slobodan Gjeorgiev[1], Elena Vasilevska Gjeorgieva[1], Goran Pančevski[2], Sanja Pančevska[2]

[1]PHI Denta ES, Skoplje, Republika Severna Makedonija;
[2]Univezitet „Sveti Ćirilo i Medodije", Stomatološki fakultet u Skoplju, Republika Severna Makedonija

KRATAK SADRŽAJ

Uvod Mandibularna kinetika se sastoji od niza složenih pokreta u pogledu otvaranja i zatvaranja i latero-lateralnih pokreta. Procedura za registraciju ove trajektorije je kondilografija. Ova procedura predstavlja dijagnostičku metodu za praćenje i registrovanje kretanja kondila donje vilice.

Analize počinju od najudaljenijeg položaja kondila do tačke maksimalne propulzije i maksimalne latero-lateralne ekstenzije.

Cilj ovog ispitivanja je uporediti putanju kretanja mandibularnog kondila kod pacijenata sa simptomima temporomandibularnih poremećaja (TMD), u akutnoj fazi, kako i putanju nakon terapije i korekcije intermaksilarnih odnosa.

Materijali i metode Ispitivanje je sprovedeno na 20 pacijenata (10 muškaraca i 10 žena) iz poliklinike „Denta estetika tim" u Skoplju. Pacijenti su se žalili na bol, ograničenje pokreta, krepitacije u temporomandibularnom zglobu, kao i na otežano žvakanje. Kondilografska merenja vršena su pomoću digitalnog kondilografa Kavo Arcus Digma. Registrovanje pokreta je izvršeno u dve sesije, pre i posle tretmana.

Rezultati Rezultati Studentovog t-testa nisu pokazali statistički značajnu razliku u uglovima kretanja temporomandibularnog kondila pre i posle terapije kod pacijenata sa TMD-om. Međutim, primećena je stastistički značajna razlika u vrednosti Benetovog ugla. Uočeni su lakši i precizniji pokreti vilice kod pacijenta posle terapije.

Ključne reči: kondilografija; putanja kretanja kondila; funkcionalna dijagnostika; pokret vilice; temporomandibularni zglob; poremećaj temporomandibularnog zgloba

UVOD

Obrasci pokreta mandibule su često korišćeni od strane kliničara za istraživanje disfunkcije mastikatornog sistema. Ograničeno maksimalno otvaranje (normalne vrednosti se kreću u rasponu 45+/-5 mm) i devijacije ili odstupanja u putanji otvaranja su jedan od simptoma TMD-a.

U svakodnevnoj praksi stomatolog se susreće sa problemima kao što su osetljivost zuba, frakture zuba, luksacija zuba, bol u temporomandibularnim zglobovima, mišići osetljivi na pipanje, licevna bol itd. [1, 2].

Zbog neodgovarajućeg ugla i dizajna okluzalne morfologije i anatomije dobijamo „neodgovarajuće" i prerane kontakte koji dovode do upornih bolova u zubu, a dalje i bola u mišićima nakon fiksacije restauracije. Sa terapijskog stanovišta moramo razumeti okluzalni koncept interkuspacije i mastikacije, a ne čineći to možemo našu terapiju odvesti u potpuno pogrešnom pravcu. Prvi simptom koji primećujemo su pukotine ili čak potpuni prelomi zubne strukture. Ovo su prvi pokazatelji neke vrste disharmonije u okluziji pacijenta [3]. Sve ove komplikacije mogu se sprečiti ispravnom analizom okluzije i ispravnim planiranjem lečenja [4].

Već 1995. godine Doson naglašava važnost okluzije, ali i čina žvakanja, koji zavisi pre svega od neuromišićne veze mastikatornih mišića, položaja mandibularnog kondila i ugla temporalne jame [5, 6]. Artikulatori su uređaji koji pomažu u replikaciji položaja i pokreta kondila u temporomandibularnom zglobu i neophodni su pri izradi restauracija koje odgovaraju pokretima kondila u svim pravcima. Razvoj artikulatora pratio je razvoj metoda za praćenje i registrovanje putanje kondila koje pomažu u izučavanju stepena maksimalnih pokreta otvaranja ili zatvaranja usta, lateralnih pokreta, kao i utvrđivanju najboljeg funkcionalnog položaja [7]. Sa ovim rezultatima možemo precizno replicirati kretanje vilice pri činu žvakanja.

Kondilografija je dijagnostički metoda za praćenje i registrovanje kretanja kondila. Merenja počinju od najudaljenijeg položaja kondila do tačke maksimalne propulzije i latero-lateralne maksimalne ekstenzije [8].

Dobijene registracije i uglovi se koriste se za podešavanje artikulatora sa individualnim vrednostima, bez obzira na to da li se radi o virtuelnom CAD-CAM ili mehaničkom artikulatoru. Na taj način, pokreti mandibule pri mastikaciji se mogu najtačnije reprodukovati.

Kao pomoćno dijagnostičko sredstvo, kondilografija se koristi u lečenju pacijenata sa neuromuskularnim problemima u vezi sa mišićima glave [9]. Svaki poremećaj u stepenu mišićne kontrakcije će izmestiti mandibulu iz svoje putanje. Svaka registracija se vrši u tri dimenzije i beleži se i najmanje odstupanje [10].

Cilj ovog istraživanja je uporediti putanju mandibularnog kondila pri propulziji, otvaranju i zatvaranju kod pacijenata sa simptomima TMD-a i posle tretmana koji je eliminisao simptome.

MATERIJAL I METOD

Za potrebe ovog istraživanja uključeno je 20 ispitanika (10 žena i 10 muškaraca) uzrasta od 20 do 50 godina sa potvrđenim simptomima TMD-a na osnovu kliničkog pregleda i popunjenog upitnika.

Isključeni su pacijenti koji su trenutno na ortodontskoj terapiji, pacijenti sa mentalnim poremećajima ili neurološkim bolestima, kao i pacijenti koji su imali traume u predelu glave i vrata u poslednjih 12 meseci. Svim pacijentima je objašnjeno da mogu otkazati učešće u istraživanju u bilo kom trenutku tokom trajanja ispitivanja.

Za učešće u studiji svaki pacijent je dao pisani pristanak za učešće u ispitivanju, analizama koje se moraju izvršiti, kao i planu terapije koji će slediti. Svaki pacijent takođe mora popuniti etički upitnik u kome subjektivno opisuje simptome koje ima.

Položaj mandibularnog kondila i njegova putanja registruju se pomoću digitalnog kondilografa Arcus Digma. Zbog zaštite ličnih podataka pacijenata, sva komunikacija sa laboratorijom

se vrši pod šifrovanim brojem zapisa (postupak za zaštitu ličnih podataka ISO 9001: 2012) u skladu sa propisima poliklinike „Denta estetika tim".

Procedura

Merenja i analize

U nastavku pregleda, za svakog učesnika izvršena je kondilografska analiza kako bi se registrovala putanja kondila temporomandibularnog zgloba [15].

Merenja su izvršena pomoću kondilografa KAVO Arcus DIGMA.

Uređaj se sastoji od:

1. Hardverskog dela
2. Softverskog dela

Hardverski deo ima uređaj za fiksiranje na glavu pacijenta, poznat kao obrazni luk (*face bow*). Ovaj deo nosi prijemnik za zvučne emitere koji ispuštaju zvuk od 40 KHz, sa greškom merenja od +/- 0,1 mm i frekvencijom registracije 50 HZ. Težina *face bow*-a je 38 grama.

Postavljanje *face bow*-a uvek prati lateralnu Kamperovu liniju, dok je frontalno postavljanje paralelno sa bipupilarnom linijom. Obe komponente za uši trebalo bi da leže na spoljnom otvoru uha (slike 1 i 2).

Maksilarna viljuška za trasfer je fiksirana za maksilu i postavlja se na okluzalnoj površini gornjeg zubnog niza. Mandibularni zubni niz je fiksiran na bukalnu površinu donjih zuba, vodeći računa da ne ometa kretanje i da ne postoje prevremeni kontakti na viljušci.

Procedura registracije počinje pozicioniranjem prvo maksilarne viljuške, dozvoljavajući registraciju maksilarne pozicije na virtuelnom modelu kao fiksnu referencu. Zatim se nosač prenosi na mandibularnu viljušku i počinje se sa registracijom putanje mandibularnih kondila. Zapisuju/registruju se tri sekvence propulzivnih levih i desnih bočnih maksimalnih translacija.

Softverski deo sistema Digma ima algoritam za analizu jačine zvučnog emitera, koji precizno registruje položaj mandibule. Ova registracija se vrši kontinuirano, čime se registruje kompletna putanja temporomandibularnog zgloba. Na kraju softver prikazuje skicu sa šematskim prikazom trajektorije i uglova trajektorije, uglova propulzivnog puta kondila na levoj i desnoj strani. Takođe se registruju i Benetov ugao i ugao instantne promene. Ovi parametri su važni za prilagođavanje individualnog artikulatora pri planiranju i rekonstrukciji međumaksilarnih odnosa u okluziji [11] (slike 3, 4 i 5).

Studentov T-test je korišćen za analizu rezultata, upoređujući rezultate kod istih ispitanika pre i posle korekcije okluzije i međuviličnih relacija. Korišćena je uparena T-test analiza, tj. analizirane su vrednosti dobijene kod istih kandidata pre i posle terapije.

Srednja vrednost propulzivnog ugla desnog temporomandibularnog zgloba kod pacijenata u akutnoj fazi TMD-a bila je $31,04^0$, dok je za levi temporomandibularni zglob iznosila $30,27^0$. Ugao vodilje propulzivnog puta u akutnoj fazi imao je prosečnu vrednost od $47,05^0$. Nakon terapije TMD-a i rekonstrukcije međumaksilarnih odnosa, merenje ugla propulzivnog puta desnog kondila bilo je $30,56^o$, a za levi zglob $33,34^o$. Ugao vodilje propulzivnog puta nakon terapije iznosio je $44,25^o$, kako je prikazano na Tabeli 1 i Slici 6.

Rezultati Studentovog t-testa su pokazali da nema statistički značajne razlike u uglovima kretanja temporomandibularnog kondila pre i posle terapije kod pacijenata sa TMD-om. Postojala je statistički značajna razlika u vrednosti Benetovog ugla. Nakon terapije, kod pacijenata su zabeležena lakša, ispravnija i konzistentnija kretanja mandibule (Slika 7).

DISKUSIJA

Ovo istraživanje imalo je za cilj da proširi naše razumevanje putanje mandibularnih kondila tokom različitih pokreta kod pacijenata sa TMD-om. Konkretno, istraživači su želeli da uporede putanju kondila tokom propulzivnih pokretanja, otvaranja i zatvaranja kod ovih pacijenata pre i posle uklanjanja simptoma TMD-a.

Prethodna istraživanja koja su izvršili Khan, Zahid Sarafas i saradnici bavila su se položajem kinematičkog centra kondila tokom otvaranja i zatvaranja kod pacijenata bez luksacije. Njihovi nalazi potvrđuju da kondil sledi površinu zglobne jame kod ovih osoba [12].

U 2021. godini, Lee Won-June i saradnici istraživali su odnos između morfologije kraniofacijalne regije, karakteristika temporomandibularnog zgloba i funkcionalnog pokretanja kondila kod pacijenata sa asimetrijom lica. Koristili su napredni automatizovani sistem za praćenje kondila u realnom vremenu kako bi analizirali ove faktore i njihovu korelaciju [13].

Još jedno istraživanje koje su sproveli Sojka A. i saradnici uključuje korišćenje sistema Arcus Digma za procenu mandibularnih pokreta kod zdravih osoba bez stomatoloških problema i simptoma TMD-a. Rezultati ovog istraživanja pokazali su da pacijenti bez simptoma TMD-a nisu pokazivali poremećaje mandibularnih pokreta, pružajući vredne uvide u normalnu funkciju mandibule [14].

U nastavku, Musa, Mazen i saradnici sproveli su studiju sa fokusom na istraživanje kvantitativnih i kvalitativnih promena na kondilu nakon terapije stabilizacionom pločicom. Studija je istraživala različite aspekte, kao što su položaj kondila, morfologija i mineralna gustina kosti kod osoba sa dijagnozom TMD [15].

Gledano u celini, ova istraživanja doprinose našem razumevanju putanje mandibularnih kondila, njegove korelacije sa kraniofacijalnom morfologijom i karakteristikama temporomandibularnog zgloba, kao i efekta simptoma i terapije TMD-a na strukturu i funkciju kondila.

ZAKLJUČAK

Mandibularna pokretanja nastaju kontrahovanjem mišića, koje kontroliše nervni sistem. Ograničen fiksnim anatomskim strukturama, kompleks kondila i diska ograničava te translacije. Bolesti mišića ili temporomandibularni poremećaji često utiču na brzinu i putanju mandibularnih pokreta.

Terapija TMD-a ima minimalan uticaj na putanju kondila tokom otvaranja i zatvaranja, sa postizanjem samo olakšanih lateralnih pokretanja. Podaci dobijeni kondilografijom pomažu u preciznom prilagođavanju mehaničkih i virtuelnih artikulatora, što poboljšava kontrolu i pouzdanost u protetskoj rehabilitaciji.