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The Asymmetry of the Mandible in Patients with Unilateral Temporomandibular Joint Disc Displacement Confirmed by Magnetic Resonance Imaging

Asimetrija mandibule u pacijenata s unilateralnim pomakom diska temporomandibularnoga zgloba potvrđenog magnetskom rezonancijom

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Abstract

Objectives: The study aimed to determine the relationship between the mandibular asymmetry index according to Kjellberg between patients with painful unilateral anterior disc displacement (DD) and asymptomatic volunteers without disc displacement. Vertical measurements were performed on a panoramic single-image radiograph, and the disc status was confirmed by magnetic resonance imaging (MRI). **Material and methods:** Two groups of subjects were retrospectively selected, 40 patients (the overall mean age was 35.5 years; 75% female) with temporomandibular disorder symptoms confirmed by RDC/TMD axis I and manual functional analysis. Unilateral DD was determined by MRI. A comparative group of asymptomatic volunteers (20 dental students with a mean age of 23.4 years; 72% female) had the physiological position of the disc determined by MRI. The vertical asymmetry of the condyle was determined by the method of Kjellberg et al. The symmetry of the gonial angle of the mandible was also measured. **Results:** A comparison of the mean of the asymmetry index between patients (average 90.89±7.08%) and asymptomatic volunteers (mean 95.86±4.44%) showed a statistically significant difference (p=0.0029). There was no difference (p=0.088) in gonial angle symmetry between the patients (mean 96.48±2.96º) and the asymptomatic volunteers (mean 97.52±2.31º). The distribution of the presence of individual DD diagnoses (partial and total displacement with reduction, displacement without reduction) in patients diagnosed with asymmetry of the mandible was without statistical significance (p>0.05). **Conclusion:** This study actually points to the asymmetry of the mandible as a potential morphological risk of anterior DD.

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Introduction

Temporomandibular disorder (TMD) is an umbrella term for musculoskeletal pathological conditions that may have similar signs and symptoms, and lead to disruption of normal function of the stomatognathic system. Within the term TMD, we recognize separately a muscle disorder and

Uvod

Temporomandibularni poremećaj (TMP) skupni je naziv za muskuloskeletalna patološka stanja koja mogu imati slične znakove i simptome, a rezultiraju poremećajem normalne funkcije stomatognatnog sustava. U sklopu termina TMP prepoznajemo zasebno mišićni poremećaj te poreme-

a temporomandibular joint (TMJ) disorder. In TMJ disorders, there are diagnoses of anterior disc displacement and degenerative joint changes (osteoarthritis). An overlapping situation may occur regarding diagnoses in the same patient. The main symptoms are a pain in the preauricular region (TMJ) and/or masticatory muscles, asymmetric and limited movements of the mandible. Symptomatology often includes headaches (1-3).

Of the potential etiological factors of TMD, a group of morphological factors, including occlusion, have a predisposing and perpetual role. For example, TMJ trauma is the most common precipitating factor in the pathogenesis of TMD (4, 5).

Orthopantomography scan (OPG exam) is a common dental imaging technique, or a basic radiological diagnostic and identification document, that is used in many polyvalent and specialist procedures in dentistry. Orthopantomography is used more frequently in the differential diagnosis of orofacial pain than in the targeted TMJ diagnosis. Apart from qualitative diagnostic possibilities, metric (quantitative) methods have also been developed (6-9).

The symmetry of the craniofacial region is not only an aesthetic imperative. The asymmetry of the mandible is a potential cause of dysfunction of the mandible and TMJ as a bilateral joint. Numerous studies have explored the association of vertical asymmetry of the condyle with the risk of TMJ disc displacement (10-16).

This study aimed to determine the relationship between the mandibular asymmetry index according to Kjellberg between patients with painful unilateral anterior disc displacement and asymptomatic volunteers without disc displacement. The disc status was confirmed by magnetic resonance imaging (MRI).

Material and methods

This research was approved in 2009 by the competent Ethics Committee of the School of Dental Medicine of the University of Zagreb with decision 05-PA-30-XXIV-2. The purpose and method of diagnosing TMJ were explained to all subjects according to the reported protocol. The included subjects of both subgroups had previously signed consent on voluntary participation, including MRI and orthopantomography.

82 consecutively collected patients with painful and unilateral TMJ disorders and 25 volunteers, students of dental medicine, were retrospectively included. Based on the clinical diagnostic criteria of RDC/TMD I (17) and manual functional analysis according to Bumann and Groot Landeweer (18), an indication for MRI was set. The patients were examined at the Department of Removable Prosthodontics of the School of Dental Medicine, University of Zagreb, and at the Department of Diagnostic and Interventional Radiology of Sestre milosrdnice University Hospital Center, where the Chair of Radiology, School of Dental Medicine, University of Zagreb is located.

Patients were definitively selected by MRI, which determined displacement of the TMJ disc. 19 patients with

ćaj temporomandibularnog zgloba (TMZ). U slučaju poremećaja TMZ-a moguće su dijagnoze anteriorni pomak diska te degenerativne promjene zgloba (osteoartitis). Moguće je i preklapanje pojedinih dijagnoza u istog pacijenta. Glavni simptomi su bol u preaurikalnom području (TMZ) i/ili žvačnim mišićima te asimetrične i ograničene kretnje mandibule. Simptomatologija nerijetko obuhvaća i glavobolju (1–3).

Od potencijalnih etioloških čimbenika TMP-a grupa morfoloških čimbenika, uključujući i okluziju, ima predisponirajuću i prepetualnu ulogu. Primjerice, trauma zgloba najčešće je precipitirajući čimbenik u procesu patogeneze TMP-a (4, 5).

Ortopantomogram je osnovno radiološko dijagnostičko i identifikacijsko sredstvo koje se koristi u mnogim polivalentnim i specijalističkim postupcima u stomatologiji. Ortopantomografija se češće koristi u diferencijalnoj dijagnostici orofacijalnih bolova, nego u ciljanoj dijagnostici čeljusnih zglobova. Uz kvalitativne mogućnosti dijagnostike, postoje i metričke (kvantitativne) metode (6 – 9).

Simetrija kraniofacijalne regije nije samo estetski imperativ. Asimetrija mandibule mogući je uzrok poremećaja funkcije mandibule i TMZ-a kao bilateralnog zgloba. U brojnim studijama autori su proučavali povezanost vertikalne asimetrije kondila s rizikom od nastanka pomaka diska TMZ-a (10 – 16).

Svrha istraživanja bila je utvrditi povezanost indeksa asimetrije mandibule prema Kjellbergu između pacijenata s bolnim unilateralnim anteriornim pomakom diska i asimptomatskih dobrovoljaca bez pomaka diska. Status diska potvrđen je MR-om.

Ispitanici i postupci

Istraživanje je 2009. godine odobrilo Etičko povjerenstvo Stomatološkog fakulteta Sveučilišta u Zagrebu rješenjem pod oznakom 05-PA-30-XXIV-2. Svim ispitanicima je, prema prijavljenom protokolu, objašnjena svrha i metoda dijagnostike TMZ-a. Uključeni ispitanici obiju podgrupa potpisali su prije toga suglasnost o dobrovoljnom sudjelovanju, uključujući MR i ortopantomogram.

Retrospektivno su obuhvaćena 82 konsekutivno odabrana pacijenta s bolnim i unilateralnim poremećajem TMZ-a i 25 dobrovoljaca, studenata stomatologije. Na temelju kliničkih dijagnostičkih kriterija RDC/TMD-a I (17) i manualne funkcijske analize prema Bumannu i Grootu Landeweeru (18) postavljena je indikacija za snimanje magnetskom rezonancijom (MR). Pacijenti su pregledani i obrađeni u Zavodu za mobilnu protetiku Stomatološkog fakulteta Sveučilišta u Zagrebu te u Zavodu za dijagnostičku i intervencijsku radiologiju KBC-a Sestre milosrdnice gdje je Katedra za radiologiju Stomatološkog fakulteta Sveučilišta u Zagrebu.

Pacijenti su odabrani poslije snimanja MR-om kada je utvrđen pomak diska TMZ-a. Iz studije je isključeno 19 pacijenata s izraženim degenerativnim promjenama (osteoartitis) s pomakom i bez pomaka diska. Od preostala 63 pacijen-

pronounced degenerative changes (osteoarthritis) with and without disc displacement were excluded from the study. Of the remaining 63 patients, 23 patients with bilateral disc displacement were excluded. The study finally included 40 patients (mean age 35.5 years; 75% female) with unilateral anterior displacement of the TMJ disc.

A comparison group of volunteers was obtained from a sample of 25 undergraduate students who were without any previous symptoms of TMD. In 5 students, an asymptomatic disc displacement was detected by MRI; hence they were excluded from the study. The remaining 20 volunteers (mean age 23.4 years; 72% female) with physiological disc positions were included in the study. Patients and asymptomatic volunteers were not undergoing orthodontic therapy, had no facial anomalies or previous treatment of facial and jaw anomalies, did not suffer from polyarthritis and rheumatic forms of arthritis, and did not undergo major oral surgery procedures.

MRI evaluation

Right and left TMJs were recorded simultaneously in closed-mouth and open-mouth positions when the patient was in a supine position. MRI recording began with fast sequences (pilots), by which the recording object was brought to the center of the magnetic field. Subsequently, its incomplete alignment concerning the midsagittal plane was corrected. The recording angle of the parasagittal sections was determined individually by the angle shown on the individually angled layers of the axial and coronal sections. The layers in the spin-echo sequences (Table 1, Figure 1) with a thickness of 3 mm were used for a parasagittal projection of the TMJ.

The normal superior position of the disc is differentiated from the anterior displacement of the disc in patients depending on the presence of pain. The criteria for asymptomatic disc displacement are identical to those of painful (symptomatic) joints. However, anamnestic and clinical disease indicators (pain, sounds) of the TMJ are absent. The criterion for the normal superior position of the disc is: the pars intermedia of the disc lies in the shortest distance between the posterior slope of the articular tubercle and the anterior edge of the head of the condyle in the closed mouth position. The pars posterior lies on the head of the condyle. Both criteria should be met for all parasagittal layers of an individual joint. When the mouth is open, the disc maintains its normal superior position. The criterion for partial disc displacement with reduction is as follows: while the mouth was closed the disc was normally positioned in some parasagittal layers and anteri-

ta isključena su 23 zato što su imali bilateralni pomak diska. U studiji je konačno sudjelovalo 40 pacijenata (prosječna dob 35,5 godina; 75 % ženskoga spola) s jednostranim anteriornim pomakom diska TMZ-a.

Usporedna skupina dobrovoljaca sastavljena je od 25 dodiplomskih studenata koji su bili bez ikakvih prethodnih simptoma TMP-a. Kod njih 5 je MR-om ustanovljen simptomatski pomak diska, pa su isključeni iz studije. Preostalih 20 dobrovoljaca (prosječna dob 23,4 godine; 72 % ženskoga spola) s fiziološkim položajem diska uključeni su u studiju.

Pacijenti i asimptomatski dobrovoljci nisu bili u tijeku ortodontske terapije, nisu imali anomalije lica ili prethodno liječenje anomalija lica i čeljusti, nisu bolovali od poliartritisa i reumatskih oblika artritisa te nisu bili podvrgnuti većim kirurškim oralnim zahvatima.

Evaulacija MR-a

Desni i lijevi TMZ snimljeni su istodobno u položaju zatvorenih i otvorenih usta dok je pacijent bio u ležećem položaju. Snimanje je počelo brzim sekvencijama (pilotima) kojima se objekt snimanja postavlja u centar magnetskoga polja te se ispravlja njegovo neprecizno namještanje u odnosu prema mediosagitalnoj ravnini. Kut snimanja parasagitalnih presjeka određen je individualno prema kutu prikazanom na individualno anguliranim slojevima aksijalnoga i koronarnoga presjeka. Korištene su slojevi u spin-eho sekvencijama (tablica 1., slika 1.) za parasagitalnu projekciju TMZ-a debljine 3 mm.

Kod pacijenata je diferenciran normalan superiorni položaj diska od anteriornoga pomaka diska, ovisno o bolovima. Kriteriji za asimptomatski pomak diska identičan je onim bolnim (simptomatskim) zglobovima, ali pritom izostaju anamnestički i klinički pokazatelji bolesti (bol, zvukovi) TMZ-a. Kriterij za normalni položaj diska je bio: *pars intermedia* diska leži u najkraćoj udaljenosti između stražnje kosine zglobne kvržice i prednjega ruba glavice kondila u položaju zatvorenih usta, a *pars posterior* leži na glavici kondila. Oba kriterija trebaju biti ispunjena za sve parasagitalne slojeve pojedinog zgloba.

Kada su usta otvorena disk zadržava svoj normalni superiorni položaj. Kriterij za djelomični pomak diska s redukcijom je sljedeći: dok su usta bila zatvorena disk je bio normalno postavljen u nekim parasagitalnim slojevima i s anteriornim pomakom u drugim parasagitalnim slojevima. U položaju otvorenih usta pojavljuje se redukcija djelomič-

Table 1   Magnetic resonance imaging parameters for the parasagittal view of the temporomandibular joint in different spin-echo sequences.
Tablica 1.   Parametri snimanja magnetske rezonancije za parasagitalni prikaz čeljusnoga zgloba u različitim spin-eho sekvencijama

Imaging parameters and sequences • Parametri i sekvencije snimanja	T_1-weighted image • T_1-mjerena snimka	T_2-weighted image • T_2-mjerena snimka
Time of eho (TE) (ms) • Vrijeme eha	12	13–15
Time of repetition (TR) (ms) • Vrijeme repeticije	450	460–770
field of view (FoV) (dot/cm)	160x160	160x160
Matrix (pixsel) • Matrica (pikseli)	256x192	256x128

ms – milisecond • milisekunde; cm – centimeter • centimetar
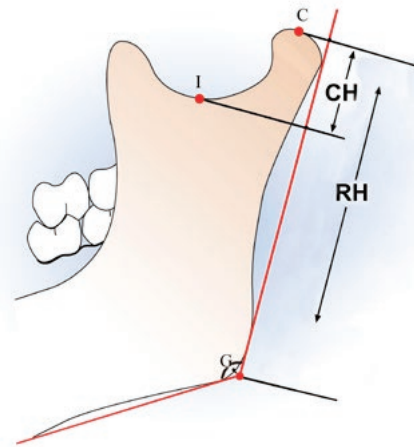
$$ SI = \frac{\left(\dfrac{CH}{RH_A}\right)}{\left(\dfrac{CH}{RH_B}\right)} \times 100 $$

Figure 1 Magnetic resonance imaging of the temporomandibular joint of a patient with anterior disc displacement (closed mouth position)
Slika 1. Snimka magnetske rezonancije temporomandibularnog zgloba pacijentice s anteriornim pomakom diska (položaj zatvorenih usta)
Figure 2 Schematic representation of asymmetry measurement using point projections on the distal edge of the ramus of the mandible. The height of the condyle (CH) is the distance between the projections of the condylar (C) and incisura (I) points. Height of the mandible (RH) between point I and point gonion (G). The gonial angle is formed by the lines RH and the tangent of the lower edge of the body of the mandible.
Slika 2. Shema mjerenja asimetrije s pomoću projekcija točaka na distalnom rubu ramusa mandibule; visina kondila (CH) distancija je između projekcija točaka *condylare* (C) i *incisura* (I); visina mandibule (RH) između točke I i točke gonijon (G); gonijalni kut čine linije RH i tangenta donjega ruba tijela mandibule.
Figure 3 Formula for calculating the percentage of symmetry of the mandible according to Kjellberg. CH is the distance of the height of the condyle, and RH is the distance of the entire ramus of the mandible. Regardless of the left or right side, the smaller value (A) is always divided by the larger value (B).
Slika 3. Formula za izračun postotka simetrije mandibule prema Kjellbergu; CH je distancija visine kondila, a RH cijelog ramusa mandibule; bez obzira na lijevu ili desnu stranu, uvijek se manja vrijednost (A) dijeli s većom vrijednošću (B)

orly displaced in other parasagittal layers. In the open mouth position, there is a reduction of partial anterior displacement, i.e. in all layers of the same joint, the disc is without displacement. In the case of complete displacement of the disc with the reduction in all parasagittal layers of the same joint, the disc is displaced anteriorly when the mouth opens completely and it is repositioned on the condyle. A complete disc displacement without reduction means that the disc is displaced in the closed-mouth position, and in the open-mouth position the anterior displacement is still not reduced.

Evaluation of mandibular asymmetry

All orthopantomographs were recorded using a standard protocol on the same X-ray orthopantomographic device Orthophos D3200 (Siemens, Erlangen, Germany) which was operated at 12 mA and 90 kV, in the X-ray room of the School of Dental Medicine, University of Zagreb. High-quality recordings were used with a standardized patient position according to the manufacturer's instructions. The patient's lips were relaxed and the head was oriented towards the Frankfort horizontal plane and the midsagittal plane using the tripod of the device in order to avoid distortion. Patients were positioned with their back and spine as straight as possible and their necks extended. The patient's antero-posterior position was achieved by placing the incisal edges of their maxillary and mandibular incisors in a notch positioning device.

All measurements (40 orthopantomographs of patients and 20 orthopantomographs of volunteer subjects) were performed by one researcher (S.V.) on orthopantomographs in

nog anteriornog pomaka, tj. u svim slojevima istoga zgloba disk je bez pomaka. U slučaju potpunoga pomaka diska s redukcijom u svim parasagitalnim slojevima istoga zgloba disk je anteriorno pomaknut, a u položaju otvorenih usta događa se njegova repozicija na kondil. Potpuni pomak diska bez redukcije znači da je disk pomaknut u položaju zatvorenih usta, a u poziciji otvorenih usta i dalje nije reduciran anteriorni pomak.

Evaulacija asimetrije mandibule

Svi ortopantomogrami snimljeni su standardnim protokolom na istome rendgenskom ortopantomografskom uređaju Orthophos D3200 (Siemens, Erlangen, Njemačka) Orthophos which was operated at 12 mA and 90 kV, u rendgenskome kabinetu Stomatološkoga fakulteta Sveučilišta u Zagrebu. Korištene su snimke visoke kvalitete sa standardiziranom pozicijom pacijenta prema uputama proizvođača. Pacijent je bio opuštenih usana, a glave usmjerene prema frankfurtskoj horizontalnoj ravnini i mediosagitalnoj ravnini s pomoću stativa uređaja kako bi se izbjegla distorzija. Pacijenti su postavljeni sa što je moguće ravnijim leđima i kralježnicom te ispruženim vratom. Anteroposteriorni položaj pacijenta postignut je postavljanjem incizalnih rubova njihovih gornjih i donjih inciziva u uređaj za pozicioniranje.

Sva mjerenja (40 ortopantomograma pacijenata i 20 ortopantomograma dobrovoljnih ispitanika) obavio je jedan istraživač (S. V.) na ortopantomogramima u digitaliziranom

digitized form using the computer program Adobe Photoshop, Adobe Systems.

The methodology of symmetry of the mandible using the method according to Kjellberg et al. (19) is focused on the vertical distances of the distal edge of the mandible (Figure 2). The reference points of the ramal tangent on the lateral edge of the ramus of the mandible are at the height of the highest point of the condyle (point C) and the mandibular notch (point I). The tangential line following the marginal edge of the body (mandibular line) forms a gonial angle with the ramal line. The intersection of the ramal and gonial lines in the area of the angle of the mandible forms point G. The calculation of the index is obtained according to the formula shown in Figure 3 as the ratio of the height of the condyle (CH) and the height of the entire ramus (MH).

The symmetry index was calculated by dividing the values of CH and RH regardless of whether it was on the left or right side, and the numerator had to be smaller than the value of the denominator (Figure 3). The symmetry of the gonial angle was also measured by dividing the value of the gonial angle of the left and right sides of the same person. It was done in such a manner that a higher value than one on the opposite side was put into the numerator. In order to obtain the percentage of the symmetry index of the mandible and the gonial angle, the obtained value was multiplied by 100. For the limit criterion of asymmetry, a percentage value greater than 6% was taken, i.e. if the symmetry index was ≤93 (19), then it was a true skeleton asymmetry of the mandible. The same criterion was used for the symmetry values of the gonial angle.

Statistical analysis

The collected data were encrypted and organized as a file using the Microsoft Office Excel 2003 program on a personal computer. Statistical analysis of the data was performed using the STATISTICA and SAS programs. The normality of the data distribution of the numerical variables of the symmetry index of the mandible and the gonial angle was tested with the Shapiro–Wilk normality test ($p < 0.05$). The t-test for independent samples was used to compare numerical variables between the group of patients and asymptomatic volunteers. Fisher's exact test was used within the group of students to analyze the frequency of established asymmetry depending on the diagnosed types of unilateral disc displacement: partial disc displacement with reduction, complete disc displacement with reduction, and disc displacement without reduction.

An analysis of the accuracy of the MRI reading and the concordance of the diagnosis of disc displacement was performed between two examiners (specialists in medical radiology (DZ) and dental prosthetics (TB), and by the examiner himself (TB). High reliability of the findings was determined ($\kappa = 0.8 - 1$) on the scans of 12 patients by independent analysis of disc displacement findings, whether by a single examiner (TB) or by two examiners (TB and DZ). Cohen's kappa was used for this purpose. The significant difference for statistical testing was 5% and 1% (20, 21). The Dahlberg error method (22) was used to check the reliability of the measure-

obliku u računalnom programu Adobe Photoshop, Adobe Systems.

Metodologija simetrije mandibule, metodom prema Kjellbergu i suradnicima (19), usmjerena je na vertikalne udaljenosti distalnoga ruba manidbule (slika 2.). Referentne točke ramalne tangente na lateralnom rubu ramusa mandibule u visini su najviše točke kondila (točka C) i incizure mandibule (točka I). Tangencijana linija koja prati marginalni rub korpusa (mandibularna linija) čini s ramalnom linijom gonijalni kut. Sjecište ramalne i gonijalne linije u području ugla mandibule tvori točku G. Kalkulacija indeksa dobiva se prema formuli na slici 3. kao omjer visine kondila (CH) i visine cijeloga ramusa (MH).

Indeks simetrije računa se dijeljenjem vrijednosti CH i RH, bez obzira na to je li u pitanju lijeva ili desna strana, a brojnik mora biti manji od vrijednosti nazivnika (slika 3.). Mjerena je i simetrija gonijalnog kuta tako što je podijeljena vrijednost gonijalnog kuta lijeve i desne strane iste osobe, ali je u brojnik uvijek stavljena veća vrijednost od one sa suprotne strane. Kako bi se dobio postotak indeksa simetrije mandibule i godialnoga kuta, dobivena vrijednost množena je sa 100. Za granični kriterij asimetrije uzeta je vrijednost postotka veća od 6 %, tj. ako je indeks simetrije ≤ 93 (19), tada je u pitanju prava skeletna asimetrija mandibule. Isti kriterij bio je i za vrijednosti simetrije godialnog kuta.

Statistička analiza

Prikupljeni podatci bit će šifrirani i organizirani kao datoteka u programu Microsoft Office Excel 2003. u osobnom računalu. Statistička analiza podataka obavljena je u programima STATISTICA i SAS. Normalnost distribucije podataka numeričkih varijabli indeksa simetrije mandibule i gonijalnog kuta testirana je Shapiro-Wilksovim testom normalnosti ($p < 0,05$). Za uzajamnu usporedbu numeričkih varijabli između skupine pacijenata i asimptomatskih volontera korišten je t-test za nezavisne uzorke. Unutar grupe studenata Fisherovim egzaktnim testom analizirana je frekvencija utvrđene asimetrije, ovisno o dijagnosticiranim vrstama unilateralnog pomaka diska – djelomični pomak diska s redukcijom, potpuni pomak diska s redukcijom i pomak diska bez redukcije.

Između dvaju ispitivača, specijalista medicinske radiologije (D. Z.) i stomatološke protetike (T. B.), te između samoga ispitivača (T. B.) provedena je analiza točnosti očitanja MR-a te podudarnosti dijagnoze pomaka diska. Korištenjem Cohenove kappa-statistike ustanovljena je visoka vjerodostojnost nalaza ($\kappa = 0,8 - 1$) na snimkama 12 pacijenata u neovisnom određivanju nalaza pomaka diska, bilo da je riječ o pojedinom ispitivaču (T. B) ili o dvama ispitivačima (T. B i D. Z). Značajna razlika za statističko testiranje bila je 5 % i 1 % (20, 21).

Za provjeru pouzdanosti mjerenja metričkih vrijednosti korištena je metoda pogreške prema Dahlbergu (22). Raču-

ment of metric values. The error between two independent measurements of orthopantomographs of 12 randomly selected patients was calculated. The procedure was performed on the same image in two different periods. When there is no measurement error, then the Dahlberg error (ME) is zero. The expression ME=$\sqrt{\sum d2/2n}$ is used for calculation (d – the difference between two measurements; n – the number of double-measured values on the orthopantomograph). It was shown that the repeated measurement of ME amounted to as high as 0.6 to 0.08.

nala se pogreška između dvaju neovisnih mjerenja ortopantomogramima nasumično odabranih 12 pacijenata na istoj snimci u dvama različitim razdobljima. Kad nema pogreške u mjerenju, tada je pogreška prema Dahlbergu (ME) jednaka nuli. Za izračunavanje koristi se izraz ME=$\sqrt{\sum d^2/2n}$ (d – razlika između dvaju mjerenja; n – broj dvostruko mjerenih vrijednosti na ortopantomogramu). Pokazalo se da je u ponovljenom mjerenju ME iznosio visokih 0,6 do 0,08.

Results

A comparison of the mean asymmetry index between patients (n=40, mean 90.89±7.08%, minimum-maximum 72.38%–99.92%) and asymptomatic subjects (n=20, mean 95.86±4.44 %, minimum-maximum 83%–99.98%) showed a statistically significant difference (t-test (df58)=286491, p=0.0029). The symmetry of the gonial angle was also analyzed, which for patients (mean 96.48±2.96°, minimum-maximum 97.37°-99.73°) and asymptomatic volunteers (mean 97.52±2.31°, minimum- maximum 90.99°–100°) was not statistically significant (t-test(df58)=-1.36762 with p=0.088).

23 patients (symmetry index on average 86.32±5.95%) and 5 asymptomatic volunteers (symmetry index on average 89.63±4.62%) had less than the limiting 94% symmetry index value. Their comparison was not statistically significant (t-test (df26) =-1.16082 with p=0.1281). Furthermore, the gonial angle (subjects of both groups with a Kjellberg index <94%) was compared between patients (n=23; mean gonial angle symmetry index 96.14±3.28°) and asymptomatic volunteers (n=5; mean gonial symmetry index angle 96.30±2.21°). No statistically significant difference was found (t-test (df26) =-0.10925, with p=0.457).

Rezultati

Usporedba prosjeka indeksa asimetrije između pacijenata (n = 40, prosjek 90,89 ± 7,08 %, minimum-maksimum 72,38 % – 99,92 %) i asimptomatskih ispitanika (n = 20, prosjek 95,86 ± 4,44%, minimum-maksimum 83 % – 99,98%) pokazala je statistički značajnu razliku [t test (df58) = 286491, p = 0,0029]. Analizirana je i simetrija gonijalnog kuta koja za pacijente (prosječno 96,48 ± 2,96°, minimum-maksimum 97,37° – 99,73°) i asimptomatske volontere (prosječno 97,52 ± 2,31°, minimum-maksimum 90,99° – 100°) nije bila statistički signifikantna [t-test(df58) = -1.36762 s p = 0,088].

Manje od graničnih 94 % vrijednosti indeksa simetrije imala su 23 pacijenta (indeks simetrije prosječno 86,32 ± 5,95 %) i 5 asimptomatskih volontera (indeks simetrije prosječno 89,63 ± 4,62%). Njihova usporedba nije bila statistički značajna [t-test(df26) = -1,16082 s p = 0,1281]. Nadalje je uspoređen gonijalni kut (ispitanici obiju grupa s indeksom prema Kjellbergu < 94 %) između pacijenata (n = 23; prosjek indeksa simetrije gonijalnog kuta 96,14 ± 3,28°) i asimptomatskih volontera (n = 5; prosjek indeksa simetrije gonijalnog kuta 96,30 ± 2,21°). Nije se pokazala statistički značajna razlika [t-test(df26) = -0,10925, s p = 0,457].

Table 2   Distribution of the frequency of certain diagnoses of disc displacement within the group of patients depending on whether they have symmetry or established asymmetry of the mandible.
Tablica 2.   Raspodjela učestalosti pojedinih dijagnoza pomaka diska unutar grupe pacijenata, ovisno o tome imaju li simetriju ili je utvrđena asimetrija mandibule

Variables / subgroups of patients • Varijable / podgrupe pacijenata		Partial DDwR Djelomični pomak diska s redukcijom	Total DDwR Potpuni pomak diska s redukcijom	DDwoR Pomak diska bez redukcije	Total • Ukupno hp
n of patients – asimetry n pacijenti - asimetrija		5	5	13	23
	hp	12,5%	12,5%	32,5%	57,5%
	vp	55,56%	58,33%	31,58%	100%
n of patients – simetry n pacijenti - simetrija		4	7	6	17
	hp	10%	17,5%	15%	42,5%
	vp	44,44%	58,33%	31,5%	100%
n of patients – total n pacijenti - ukupno		9	12	19	40
	vp	22,5%	30%	47,5%	100%

Fischer's egzact test • Fischerov egzaktni test
p = 0,388
n, number of patients; DDwR, disc displacmetnt with reduction; DdwoR, disc displacmetnt without reduction; hp, the sum of the column percentages; vp, the sum of the row percentages
n – broj pacijenata; hp – zbroj postotaka stupca; vp – zbroj postotaka redova

Associations between the vertical asymmetry of the mandible and the presence of certain diagnoses of disc displacement within the group of patients with unilateral disc displacement were analyzed using Fisher's exact test (p>0.05), but without statistical significance (Table 2).

Discussion

A panoramic X-ray image of the jaws, teeth, and TMJ is used in qualitative initial dental diagnostics. In addition, the panoramic X-ray image also shows the surrounding bone structures and pathological changes in the imaging zone. Furthermore, it is used in the quantitative analysis of jaw asymmetry in orthodontics and TMD diagnostics (19, 23).

The patient's intermaxillary relation achieved through protrusive movement utilizing the bite block leads the TMJs to the position of the condyle outside the articular fossa. Therefore, panoramic imaging, in contrast to MRI, is not applicable for analyzing the basic position of the condyle behind the articular fossa in the closed mouth position. In this study, panoramic imaging was used for vertical measurement of the structure of the ramus and condyle of the mandible. MRI is the gold standard in determining disc status and it is used for the analysis of soft and hard tissues, depending on whether the mouth is closed (in bite) or maximally open, and for quantitative analysis of intra-articular structures (24-26).

There was no predominance of any form of anterior displacement and jaw asymmetry in our study. The difference in the reference positions of the mandible and TMJ in the diagnosis of MRI and panoramic radiograph did not affect the results of this study, because they are two completely different radiological methods (27-30). In this study, MRI was used to differentiate TMJ depending on the physiological and displaced disc, which is not possible with classical X-ray diagnosis, including panoramic radiography.

The issue of TMJ and mandible image distortion on orthopantomographs can have an impact on the accuracy of measurements. The validity of vertical measurements, as well as horizontal measurements that do not cross the medial line, has been proven on the same device on which our research was conducted (31, 32).

The method developed by Kjellberg et al., which was applied in this research (19), implies measuring the scale and not the actual sizes of the distances, including the magnification factor. The relationship between the relative height of the condyle and the height of the ramus of the mandible is determined separately for each joint of the same patient. The comparative method of calculating mandibular asymmetry according to Habets et al. (23) differs from the Kjelberg et.al, method. The advantage of the method according to Kjellberg et al. (19) is that only unilateral linear measurements are included in the calculation. They are not taken into account when measuring the left and right sides at the same time.

Iturriaga et al. (10) did not confirm patients' vertical condylar symmetry as a risk factor for the development of TMD, using both measurement methods (19, 23). Xie et al. (11), similar to this study, used MRI to confirm disc displacement and compared vertical measurements on the posterior-ante-

Povezanosti između vertikalne asimetrije mandibule i prisutnosti pojedine dijagnoze pomaka diska u grupi pacijenata s unilateralnim pomakom diska analizirani su Fisherovim egzaktnim testom (p > 0,05), ali bez statističke značajnosti (tablica 2.).

Rasprava

Panoramski rendgenski prikaz čeljusti, zuba i TMZ-a služi u kvalitativnoj inicijalnoj stomatološkoj dijagnostici. Uz to, panoramska rendgenska snimka prikazuje i okolne koštane strukture patološke promjene u području snimanja te pomaže u kvantitativnoj analizi asimetrije čeljusti u ortodonciji i TMP-dijagnostici (19, 23).

Međučeljusni odnos pacijenta postignut je protruzijskom kretnjom zagrizom u blok čime se TMZ dovodi do položaja kondila izvan zglobne jamice. Zato se panoramsko snimanje, za razliku od MR-a, ne primjenjuje za analizu osnovnoga položaja kondila iza zglobne jamice u položaju zatvorenih usta. U ovom istraživanju korišteno je panoramsko snimanje za vertikalno mjerenje strukture ramusa i kondila mandibule. MR je zlatni standard u određivanju statusa diska, a koristi se za analizu mekih i tvrdih tkiva, ovisno o tome jesu li usta zatvorena (u zagrizu) ili maksimalno otvorena, te za kvantitativnu analizu intraartikularnih struktura (24 – 26).

U našem istraživanju nije bilo predominacije bilo kojeg oblika anteriornog pomaka i asimetrije čeljusti. Razlika u referentnim položajima mandibule i TMZ-a u dijagnostici MR-a i panoramske radiografije nije utjecala na rezultate u ovoj studiji jer je riječ o dvjema potpuno različitim radiološkim metodama (27 – 30). U ovoj studiji MR je korišten za razlikovanje TMZ-a, ovisno o fiziološkom pomaku i pomaku diska, što nije moguće postići klasičnom rendgenskom dijagnostikom, uključujući panoramsku radiografiju.

Pitanje distorzije prikaza TMZ-a i mandibule na ortopantomogramima može imati utjecaj na točnost mjerenja. Dokazana je validnost vertikalnih mjerenja te horizontalnih mjerenja koja ne prelaze medijalnu liniju, na istome uređaju na kojemu je provedeno i naše istraživanje (31, 32).

Metoda primijenjena u ovom istraživanju prema Kjellbergu i suradnicima (19) podrazumijeva mjerenje razmjera, a ne stvarnih veličina distancija, uključujući i čimbenik magnifikacije. Utvrđuje se odnos relativne visine kondila u odnosu prema visini ramusa mandibule posebno za svaki zglob istog pacijenta. Od komparativne metode izračunavanja asimetrije mandibule prema Habetsu i suradnicima (23), prednost metode prema Kjellbergu i suradnicima (19) jest to što se u kalkulaciju uzimaju samo unilateralna linearna mjerenja. Ne uzimaju se u razmjer mjerenja lijeve i desne strane istodobno.

Iturriaga i suradnici (10), koristeći se objema metodama mjerenja, nisu potvrdili vertikalnu kondilarnu simetriju pacijenata kao čimbenik rizika za razvoj TMP-a, (19, 23). Xie i suradnici (11), slično ovome istraživanju, koristili su se MR-om za potvrdu pomaka diska te usporedili vertikalna mjerenja na posteriorno-anteriornom kefalogramu s kontrolnim ispitanicima. Asimetrija mandibule zabilježena je u 72,12 % pacijenata i 25,64 % kontrolnih ispitanika. Kako su pacijen-

rior cephalogram with control subjects. The asymmetry of the mandible was present in 72.12% of patients and 25.64% of control subjects. Since the patients also had unilateral disc displacement, the results obtained by the aforementioned researchers are in line with ours. Mandibular asymmetry is more common in subjects with unilateral disc displacement.

Toh et al. (12) investigated patients with clinically confirmed TMD and dentofacial deformities, which was contrary to the patients in our research sample. They detected mandibular asymmetry in 61.2% of subjects. Ahmed (13) used CBCT scans to measure the correlation of the left and right condyles of subjects without a diagnosis of TMD, thus detecting the asymmetry of the mandible.

Chandhok et al. (14) took a sample of patients with myalgia and of those with myalgia and clicked in the TMJ. The control group included subjects without pain and without clicking. Although the highest index of asymmetry was in the group of patients with myalgia and clicking, there was no statistical significance: height and contour of the condyle, as well as mandibular asymmetry, cannot be a predisposing factor for clicking in the TMJ. In contrast, Piancino et al. (15) showed the results obtained in their research. They used MRI to determine the position of the disc. They stated that orthopantomography can be a screening method because they believe that condylar asymmetry increases in individuals who have disc displacement. Mendoza-García et al. (16) found on orthodontic patients that asymmetry was greater in patients with TMD, but without a statistically significant difference. Therefore, they concluded that TMD is not related to mandibular asymmetry.

Radhakrishnan et al. (33) found on the orthopantomographs of orthodontic patients, likewise in our study, that the differences in the symmetry of the gonial angle were insignificant. Habib et al. (34) did not find statistically significant differences in vertical measurements, including mandibular asymmetry index and gonial angle values in pre-orthodontic patients.

So far, the direct impact of certain etiological factors in the process of TMD formation has not been sufficiently explained. Therefore, disc displacement and/or osteoarthritis are the most common diagnoses of TMJ (35). Although the application of the measurement method did not show a correlation of mandibular asymmetry in different profiles of dental patients, patients with TMD, and control subjects, it can be concluded that there is a correlation between unilateral disc displacement and facial asymmetry, which is contrary to our results (9,36).

Conclusions: In conclusion, with proven disc status using MRI, it was shown that there was a statistically significantly higher index of mandibular asymmetry in patients with unilateral disc displacement compared to asymptomatic subjects who were proven to have a physiological disc position. The asymmetry of the mandible can be considered part of the morphological risk for the occurrence of anterior disc displacement.

ti također imali unilateralni pomak diska, njihovo istraživanje potvrđuje naše rezultate da je mandibularna asimetrija u njih češća.

Toh i suradnici (12) istraživali su pacijente s kliničkim potvrđenim TMD-om i dentofacijalnim deformitetima, suprotno pacijentima iz našeg istraživanja, te utvrdili asimetriju mandibule kod njih 61,2 %. Ahmed i suradnici (13) koristili su se CBCT skenovima za mjerenje korelacije lijevoga i desnoga kondila ispitanika bez dijagnoze TMP-a te ustanovili asimetriju mandibule.

Chandhok i suradnici (14) uzeli su za uzorak pacijenta s mijalgijom te mijalgijom i škljocanjem u TMZ-u. Kontrolna grupa bili su ispitanici bez bolova i bez škljocanja. Iako je najveći indeks asimetrije bio u grupi pacijenata s mijalgijom i škljocanjem, nije bilo statističke signifikatnosti – visina i kontura kondila i manibularna asimetrija ne mogu biti predisponirajući čimbenik za škljocanje u TMZ-u. Suprotno tomu, Piancino i suradnici (15) koristili su se i MR-om za utvrđivanje položaja diska. Iako ortopantomogram može biti *skrining*-metoda jer oni smatraju da kondilarna asimetrija predisponira pomak diska. Mendoza-García i suradnici (16) uočili su kod ortodontskih pacijenata da je asimetrija bila veća kod onih s TMP-om, ali bez statistički značajne razlike. Stoga zaključuju da TMP nije povezan s mandibularnom asimetrijom.

Radhakrishnan i suradnici (33) utvrdili su na ortopantomogramima ortodontskih pacijenata, kao i u našem istraživanju, da su razlike u simetričnosti gonijalnog kuta bile insignifikantne. Habib i suradnici (34) nisu našli statistički značajne razlike vertikalnih mjera, uključujući i indeks asimetrije mandibule te vrijednosti gonijalnog kuta u preortodontskih pacijenata.

Još uvijek nije nedovoljno objašnjen izravan utjecaj pojedinih etioloških čimbenika u procesu nastanka TMP-a, a prevalencija pomaka diska i osteoartirtisa najčešća je dijagnoza TMZ-a (35). Iako primjena metode mjerenja nije pokazala korelaciju asimetrije mandibule u različitim profilima stomatoloških pacijenata, pacijenata s TMP-om i kontrolnih ispitanika, može se reći da postoji korelacija između unilateralnog pomaka diska i asimetrije lica, što je suprotno našim rezultatima (9, 36).

U zaključku, s dokazanim statusom diska s pomoću MR-a pokazalo se da postoji statistički značajno veći indeks asimetrije mandibule kod pacijenata s unilateralnim pomakom diska nego kod asimptomatskih ispitanika kojima je dokazan fiziološki položaj diska. Asimetrija mandibule može se smatrati dijelom morfološkog rizika za nastanak anterionoga pomaka diska.

Conflict of interest

The authors declare no conflicts of interest.

Author contribution: T.B. – research design concept, writing of the text, analysis of MR images and orthopantomograms, figure preparation; **S.V.** – hypothesis setting, research design, conducting research, data collection and analysis, writing of the text; **D.B.** - consultations on study design, statistical analysis, and results preparation; **D.Z.** - analysis of MR images and orthopantomograms, data analysis, consultations on study writing; **S.A.M.** – metric analysis of orthopantomograms, data collection, and analysis; **M.S.B.** - conducting research, data collection and analysis, writing of the text; **M.P.** - metric analysis of orthopantomograms, writing of the text, literature search; **I.S.P.** – results preparation, supervising the final version of the text, literature search.

Sukob interesa

Autori nisu bili u sukobu interesa.

Doprinos autora: T. B. – koncepcija dizajna studije, pisanje teksta, analiza snimki MR-a i ortopantomograma, priprema slika; **S. V.** – postavljanje hipoteze, dizajn studije, provedba istraživanja, prikupljanje i analiza podataka, pisanje teksta; **D. B.** – konzultacija o izradi studije, statistička analiza, priprema rezultata; **D. Z.** – analiza snimki MR-a i ortopantomograma, analiza podataka, konzultacija u vezi s pisanjem rada; **S. A. M.** – metrička analiza ortopantomograma, prikupljanje i analiza podataka ; **M. S. B.** – provedba istraživanja, prikupljanje i analiza podataka, pisanje teksta; **M. P.** – metrička analiza ortopantomograma, pisanje teksta, pretraživanje literature; **I. S. P.** – priprema rezultata, nadzor definitivne verzije teksta, pretraživanje literature.

Sažetak

Svrha istraživanja: Cilj istraživanja bio je utvrditi povezanost indeksa asimetrije mandibule prema Kjellbergu između pacijenata s bolnim unilateralnim anteriornim pomakom diska i asimptomatskih dobrovoljaca bez pomaka diska. Vertikalna mjerenja obavljena su na ortopatomogramima, a status diska potvrđen je magnetskom rezonancijom. **Materijal i metode:** Retrospektivno su odabrane dvije skupine ispitanika od 40 pacijenata (prosječna dob 35,5 godina; 75 % ženskoga spola) sa simptomima temporomandibularnog poremećaja potvrđenima RDC/TMD-om os I i manualnom funkcijskom analizom. Unilateralni pomak diska ustanovljen je magnetskom rezonancijom. Usporednoj skupini asimptomatskih dobrovoljaca (20 studenata stomatologije prosječne dobi 23,4 godine; 72 % ženskoga spola) utvrđen je fiziološki položaj diska magnetskom rezonancijom. Vertikalna asimetrija kondila određena je metodom prema Kjellbergu i suradnicima. Mjerena je i simetrija gonijalnog kuta mandibule. **Rezultati:** Usporedba prosjeka indeksa asimetrije između pacijenata (prosjek 90,89 ± 7,08 %) i asimptomatskih dobrovoljaca (prosjek 95,86 ± 4,44 %) pokazala je statistički značajnu razliku (p = 0,0029). Nije bilo razlike (p = 0,088) u simetriji gonijalnog kuta između pacijenata (prosječno 96,48 ± 2,96°) i asimptomatskih dobrovoljaca (prosječno 97,52 ± 2,31°). Bez statističke značajnosti (p > 0,05) bila je distribucija prisutnosti pojedinih dijagnoza pomaka diska (djelomični i potpuni pomak s redukcijom, pomak bez redukcije) kod pacijenata kojima je utvrđena asimetrije mandibule. **Zaključak:** Ova studija dopušta povezivati asimetriju manidbule kao potencijalni morfološki rizik za nastanak anteriornoga pomaka diska.

References

1 Valesan LF, Da-Cas CD, Réus JC, Denardin ACS, Garanhani RR, Bonotto D, Januzzi E, de Souza BDM. Prevalence of temporomandibular joint disorders: a systematic review and meta-analysis. Clin Oral Investig. 2021; 25:441-53.

2 Vrbanović E, Dešković K, Zlendić M, Alajbeg IZ. Profiling of Patients with Temporomandibular Disorders: Experience of One Tertiary Care Center. Acta Stomatol Croat. 2021; 55:147-58.

3 Klarić I, Badel T, Bašić Kes V, Čimić S, Zadravec D. Temporomandibular joint disorder and headache – one-year-follow-up. Periodicum Biol. 2015; 117:261-66.

4 Ananthan S, Pertes RA, Bender SD. Biomechanics and Derangements of the Temporomandibular Joint. Dent Clin North Am. 2023;67:243-257.

5 Badel T, Savić Pavičin I, Kocijan Lovko S, Zadravec D, Anić Milošević S, Carek A. Alcohol Abuse in the Dental Patient and Temporomandibular Disorder Caused by Trauma. Psychiatr Danub. 2021;33(Suppl 4):649-55.

6 Różyło-Kalinowska, I. Panoramic radiography in dentistry. Clin Dent Rev 2021; 5:26.

7 Savić Pavičin I, Dumančić J, Jukić T, Badel T. The relationship between periodontal disease, tooth loss and decreased skeletal bone mineral density in aging women. Gerodontology. 2017; 34:441-5.

8 Shaikh AH, Ahmed S, Ahmed AR, Das G, Taqi M, Nisar S, Khan O. Assessment of radiographic morphology of mandibular condyles: a radiographic study. Folia Morphol (Warsz). 2022; 81:481-6.

9 Alqhtani N, Alshammery D, AlOtaibi N, AlZamil F, Allaboon A, Al-Tuwaijri D, Baseer MA. Correlations Between Mandibular Asymmetries and Temporomandibular Disorders: A Systematic Review. J Int Soc Prev Community Dent. 2021; 11:481-489.

10 Iturriaga V, Navarro P, Cantin M, Fuentes R. Prevalence of vertical condylar asymmetry of the temporomandibular joint in patients

11 with signs and symptoms of temporomandibular disorders. Int J Morphol. 2012; 30:315-21.

11 Xie Q, Yang C, He D, Cai X, Ma Z. Is mandibular asymmetry more frequent and severe with unilateral disc displacement? J Craniomaxillofac Surg. 2015; 43:81-6.

12 Toh AQJ, Chan JLH, Leung YY. Mandibular asymmetry as a possible etiopathologic factor in temporomandibular disorder: a prospective cohort of 134 patients. Clin Oral Investig. 2021; 25:4445-50.

13 Ahmed NF. Temporomandibular joint asymmetry in asymptomatic skeletal class I patients. Egyptian Dent J. 2021; 67:2121-32.

14 Chandhok A, Hegde C, Shetty M, Shetty G. Evaluation of the influence of mandibular condylar contour, height, and asymmetry in subjects with myalgia presenting with or without clicking among south coastal Karnataka population - A descriptive cross-sectional study. J Indian Prosthodont Soc. 2021; 21:81-7.

15 Piancino MG, Tepedino M, Cavarra E, Bramanti E, Laganà, Chimenti C, Cirillo S. Condylar long axis and articular eminence in MRI in patients with temporomandibular disorders. Cranio. 2020; 38:342-50.

16 Mendoza-García LV, Espinosa de Santillana IA, Hernández Vidal V. Temporomandibular disorders and mandibular vertical asymmetry. Cranio. 2019; 37:290-5.

17 Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: Review, criteria, examinations and specifications, critique. J Craniomandib Disord Facial Oral Pain 1992; 6:301-55.

18 Bumann A, Lotzmann U. TMJ Disorders and orofacial pain: The role of dentistry in a multidisciplinary diagnostic approach. Stuttgart-New York: Thieme; 2002.

19 Kjellberg H, Ekestubbe A, Kiliaridis S, Thilander B. Condylar height on panoramic radiographs. A methodologic study with a clinical application. Acta Odontol Scand. 1994; 52:43-50.

20 Badel T, Marotti M, Savić Pavičin I, Dulčić N, Zadravec D, Kern J. Temporomandibular disorders – the validity of clinical diagnostics compared to magnetic resonance imaging. Period Biol 2011;113;207-12.

21 Kern J. Medicinsko-informatičke metode. Zagreb: Medicinska naklada, 2004.

22 Springate SD. The effect of sample size and bias on the reliability of estimates of error: a comparative study of Dahlberg's formula. Eur J Orthod. 2012; 34:158-63.

23 Habets LL, Bezuur JN, Naeiji M, Hansson TL. The Orthopantomogram, an aid in the diagnosis of temporomandibular joint problems. II. The vertical symmetry. J Oral Rehabil. 1988; 15:465-71.

24 Daiem HAMA, Abdeldayem MAM, Eldin OAG. Added value of dynamic 3T-MRI to conventional static MRI in evaluation of internal derangement of temporomandibular joint. Clin Imaging. 2022; 91:105-10.

25 Zadravec D, Badel T, Smoljan M, Čimić S, Katavić N, Savić Pavičin I. Zygomatic air cell defect – magnetic resonance imaging of the temporomandibular joint compared with panoramic radiographs. Acta Clin Croat 2018; 57:227-34.

26 Smoljan Basuga M, Marelić M, Badel T, Škrinjar I, Lončar Brzak B, Klemenčić A, Flegarić Bradić M, Prenc M, Zadravec D. Significance of Calcifications in Projection of Carotid Arteries on Orthopantomography for Detection of Carotid Artery Stenosis. Acta Stomatol Croat. 2022; 56:257-66.

27 Selmanagić A, Ajanović M, Kamber-Ćesir A, Redžepagić-Vražalica L, Jelešković A, Nakaš E. Radiological Evaluation of Dental Age Assessment Based on the Development of Third Molars in Population of Bosnia and Herzegovina. Acta Stomatol Croat. 2020; 54:161-7.

28 Drenski Balija N, Aurer B, Meštrović S, Lapter Varga M. Prevalence of Dental Anomalies in Orthodontic Patients. Acta Stomatol Croat. 2022; 56:61-8.

29 Latić-Hodžić L, Stunja M, Anić Milošević S, Meštrović S. Dental and Skeletal Age in Patients with Palatally Displaced Canines. Acta Stomatol Croat. 2022; 56:69-76.

30 Savić Pavičin I, Dumančić J, Jukić T, Badel T, Badanjak A. Digital orthopantomograms in osteoporosis detection: mandibular density and mandibular radiographic indices as skeletal BMD predictors. Dentomaxillofac Radiol. 2014; 43:20130366.

31 Ćatić A, Čelebić A, Valentić-Peruzović M, Ćatović A, Kuna T. Dimensional measurements on the human dental panoramic radiographs. Coll Antropol. 1998;22(Suppl):139-45.

32 Ćatić A, Čelebić A, Valentić-Peruzović M, Ćatović A, Jerolimov V, Muretić I. Evaluation of the precision of dimensional measurements of the mandible on panoramic radiographs. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998; 86:242-8.

33 Radhakrishnan PD, Sapna Varma NK, Ajith VV. Dilemma of gonial angle measurement: Panoramic radiograph or lateral cephalogram. Imaging Sci Dent. 2017; 47:93-7.

34 Habib M, Ahsan T, Majeed O, Faheem F. Vertical growth pattern as a determinant of mandibular asymmetry. Pak J Med Sci. 2022; 38:1304-9.

35 Badel T, Zadravec D, Bašić Kes V, Smoljan M, Kocijan Lovko S, Zavoreo I, Krapac L, Anić Milošević S. Orofacial pain – diagnostic and therapeutic challenges. Acta Clin Croat. 2019;58(Suppl.1):82-9.

36 Marques FBC, de Lima LS, Oliveira PLE, Magno MB, Ferreira DM-TP, de Castro ACR, Maciel JVB, Ruellas ACO, Maia LC. Are temporomandibular disorders associated with facial asymmetry? A systematic review and meta-analysis. Orthod Craniofac Res. 2021;24:1-16.