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Articular Eminence Inclination between Croatian and American Skulls

Usporedba nagiba stražnjeg zida zglobne kvrčice između hrvatskih i američkih lubanja

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Abstract

Objectives: To determine and compare articular eminence inclination (AEI) values between Croatian and American skulls. **Materials and Methods:** The study was carried out on 210 human dry skulls divided into Croatian (early medieval, late medieval and contemporary), and American (Illinois, Kentucky, contemporary African Americans and American Caucasians) groups. AEI was measured by two methods (M1 and M2) on 5 sagittal sections through virtual silicone impressions of articular eminence. The obtained results were analyzed at the significance level of $p < 0.05$. **Results:** No statistically significant differences of AEI values were obtained with regard to the group of skulls, body side, sex and age ($p > 0.05$). AEI M2 values were statistically significantly higher than AEI M1 values ($p < 0.05$). **Conclusions:** Comparing the AEI values between different group of skulls can reveal insights into TMJ morphology, and can also shed light on possible evolutionary adaptations, dietary influences, and genetic diversity across cultures. According to the results of this study, AEI values were not affected by group of skulls, body side, sex and age or at least not as much as needed for significant changes. However, a measurement method significantly influences AEI values, with higher AEI M2 values compared to AEI M1 values.

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Introduction

Temporomandibular joint (TMJ), one of the most complex joints in the human body, allows a large range of mandibular movements which are essential in the functioning of the masticatory system. The TMJ articular eminence is an important biomechanical element over which the condyle-disc complex slides during the mandibular movements (1-5). The path of condylar movement during function is determined by the inclination of the posterior wall of the articular eminence (AEI). AEI is defined as an angle formed by the posterior wall of the articular eminence and some horizontal plane e.g. Frankfurt horizontal plane (2, 3). In order to withstand the masticatory loading as well as to transmit loads on to the skull base, the articular eminence is made up of thick and dense bone (3).

Uvod

Temporomandibularni zglob (TMJ) jedan od najsloženijih zglobova u ljudskome tijelu, omogućuje širok raspon pokreta donje čeljusti esencijalno važnih za funkcioniranje žvačnog sustava. Zglobna kvrčica TMJ-a bitan je biomehanički element preko kojega se kompleks kondil-diska pomiče tijekom pokreta donje čeljusti (1 – 5). Putanja kondilarnog pokreta tijekom funkcije određena je nagibom stražnjega zida zglobne kvrčice (AEI). AEI se definira kao kut koji čini stražnji zid zglobne kvrčice i neka horizontalna ravnina, npr. frankfurtska horizontala (2, 3). Da bi izdržala žvačno opterećenje i omogućila prijenos opterećenja na bazu lubanje, zglobna kvrčica građena je od debele i guste kosti (3). Morfologija zglobne kvrčice (kao i AEI-ja) pod utjecajem je mnogih čim-

The morphology of the articular eminence (as well as AEI) is affected by many factors, and it undergoes remodeling throughout the life (6). Mastication and consequently masticatory forces are one of the most important factors affecting AEI, and they are more important than skull base morphology or genetics (2). At birth, the temporal part of the joint is quite rudimentary, with the absence of articular eminence and shallow glenoid fossa (2, 7, 8). In that case, forward and lateral mandibular movements are possible without any inferior movement (2). During development of deciduous dentition the articular eminence develops and grows very fast. The articular eminence inclination reaches half of its adult value by the age of two years. Later, the growth of the articular eminence continues but at a slower rate. According to Katsavrias (2), AEI reaches 70% to 72% of its adult value by the age of 10 years, and 90% to 94% of its adult value by the age of 20 years. Adult human TMJ comprises well defined articular eminence with deep glenoid fossa (9). During life, the articular eminence morphology could be affected by changes in dentition associated with ageing (tooth loss, attrition), tooth inclination, but also by pathological and degenerative changes of TMJ (10-14). Some authors investigated possible association of the articular eminence morphology with the body side (left and right TMJ), gender and facial morphology (10-17) but reported different results in performed studies.

Masticatory loading is an important environmental factor that affects variation in craniofacial morphology (18). Allowing the transmission of masticatory forces and loads on to the skull base, the articular eminence morphology is affected by forces generated by function (19). The amount of masticatory force changes according to the types of food consumed. In the past, teeth were often used as a tool, and the food was raw, fibrous and harder than today (20). Chewing such a food required higher masticatory forces which then required more pronounced articular eminence remodeling. In that case, the temporal fossa becomes deeper and the articular eminence higher with steeper AEI.

Differences in AEI values can influence temporomandibular joint function by altering the biomechanics of mandibular movement. The AEI plays a crucial role in guiding the mandibular condyle during jaw opening, closing, and lateral excursions, which directly affects occlusion and joint loading. Variations in AEI values may therefore influence the risk of TMJ disorders such as dysfunction, internal derangements, or degeneration, and can impact clinical outcomes in treatments such as prosthodontics. The association between AEI values and TMJ disorders has been investigated by several researchers, with some studies finding a correlation between AEI values and internal derangements, while others reported no significant association (21, 22).

Little is known about AEI values among Croatian and American group of skulls. It could be assumed that the morphology of the articular eminence as well as AEI values differ between various historic and contemporary groups of skulls. Therefore, the aim of the present study was to establish AEI values between historic and contemporary group of skulls from Croatia and North America (skulls from early medi-

benika i podliježe remodeliranju tijekom života (6). Žvakanje i posljedično žvačni tlak među prvim su čimbenicima koji utječu na AEI i važniji su od morfologije baze lubanje ili genetike (2). Pri rođenju je temporalni dio zgloba nerazvijen, bez zglobne kvržice i jamice (2, 7, 8). U tom slučaju mogući su prednji i bočni pokreti donje čeljusti bez ikakva pomaka prema dolje (2). Tijekom razvoja mliječnih zuba zglobna kvržica se razvija i brzo raste. Njezin nagib doseže polovinu svoje odrasle vrijednosti do dobi od dvije godine. Poslije se rast zglobne kvržice nastavlja, ali sporije. Prema Katsavriasu (2), AEI doseže 70 do 72 % svoje odrasle vrijednosti do 10. godine, a 90 do 94 % do 20. godine. Odrasli ljudski TMJ sastoji se od dobro definirane zglobne kvržice s dubokom zglobnom jamicom (9). Tijekom života na morfologiju zglobne kvržice mogu utjecati promjene u denticiji povezane sa starenjem (gubitak zuba, trošenje), nagib zuba, ali i patološke i degenerativne promjene TMJ-a (10 – 14). Neki autori istraživali su moguću povezanost morfologije zglobne kvržice sa stranom tijela (lijevi i desni TMJ), spolom i morfologijom lica (10 –17), ali su izvještaji o rezultatima različiti među istraživanjima.

Žvačno opterećenje važan je okolišni čimbenik koji utječe na varijaciju u kraniofacijalnoj morfologiji (18). Omogućujući prijenos žvačnih sila i opterećenja na bazu lubanje, morfologija zglobne kvržice pod utjecajem je sila koje nastaju funkcijom (19). Iznos žvačne sile mijenja se ovisno o vrsti hrane koja se konzumira. U prošlosti su zubi često korišteni kao alat, a hrana je bila sirova, vlaknasta i tvrđa nego danas (20). Takvo žvakanje zahtijevalo je veću žvačnu silu, što je potaknulo izraženije remodeliranje zglobne kvržice. U tom slučaju zglobna jamica postaje dublja, a zglobna kvržica viša sa strmijim AEI-om.

Razlike u AEI vrijednostima mogu utjecati na funkciju TMJ-a mijenjajući biomehaniku pokreta donje čeljusti. AEI je ključan u vođenju kondila donje čeljusti tijekom otvaranja, zatvaranja i bočnih pomaka, što izravno utječe na okluziju i opterećenje zgloba. Varijacije u vrijednostima AEI-ja stoga mogu utjecati na rizik od poremećaja TMJ-a poput disfunkcije, poremećaja kompleksa disk-kondila ili degeneracije te mogu utjecati na kliničke ishode u tretmanima kao što su protetičke rehabilitacije. Povezanost između AEI vrijednosti i poremećaja TMJ-a istraživali su mnogobrojni znanstvenici, pri čemu su autori nekih istraživanja dokazali povezanost između vrijednosti AEI i TMJ poremećaja, a drugi ne navode takvu povezanost (21, 22).

Malo se zna o AEI vrijednostima među hrvatskim i američkim lubanjama. Moglo bi se pretpostaviti da se morfologija zglobne kvržice, kao i AEI vrijednosti, razlikuju između različitih povijesnih i suvremenih skupina lubanja. Zato je cilj ovog istraživanja bio utvrditi AEI vrijednosti na lubanjama iz povijesnih i suvremenog perioda iz Hrvatske i Sjeverne Amerike te ih usporediti između istraživanih skupina (lubanje iz ranog srednjovjekovnog hrvatskog perioda – EMP; lubanje iz kasnog srednjovjekovnog hrvatskog perioda – LMP; hrvatske lubanje s početka 20. stoljeća – CCP; pretpovijesne američke lubanje Woodland Period Illinois – IP; američke lubanje s područja Kentuckyja – KP; lubanje američkih crnaca s početka 20. stoljeća – AAP; lubanje američkih bijelaca s početka 20. stoljeća – ACP).

eval Croatian period - EMP; skulls from late medieval Croatian period - LMP; Croatian skulls from early 20th century - CCP; prehistoric Native American skulls, Woodland Period Illinois - IP; Archaic Period Kentucky skulls - KP; African American skulls from early 20th century - AAP; American Caucasians skulls from early 20th century - ACP), and to analyze the obtained AEI values for possible differences between investigated groups of skulls.

Materials and Methods

The study was carried out on 210 human dry skulls divided into 7 groups. Each group comprised 30 adult human dry skulls. The skulls from the early medieval Croatian period (10th and 11th centuries AD) and from the late medieval Croatian period (12th to 15th centuries AD) were stored in the Anthropological Center, Croatian Academy of Sciences and Arts in Zagreb, Croatia, while the Croatian contemporary skulls from the early 20th century were stored at the Institute of Anatomy, University of Zagreb School of Medicine. Woodland Period Illinois population skulls (from 900 to 1500 AD years), Archaic Period Kentucky population skulls (from 500 BC to 500 AD years), African American skulls (first ½ of the 20th century St. Louis, Missouri) and American Caucasian skulls (first ½ of the 20th century St. Louis, Missouri) were stored at the Department of Anthropology, Smithsonian Institution, Washington DC, USA. The skulls from 20th century (Croatian and American) were generally classified as contemporary human specimens. Given the samples from different time periods and their limited number at the sites where they are stored, every effort was made to include as many specimens as possible. However, the inclusion criteria were based on the complete preservation of the skull, with no visible pathological conditions or observable taphonomic damage in the measured areas (orbit and nasal region, temporal bone—specifically the *fossa articularis* and the articular eminence, as well as the *meatus acusticus externus*). While the preservation of the entire maxilla and mandible was also desirable, this was not always fully achievable.

All seven groups of skulls had complete data on sex. Age data (age at death) was available for EMP, LMP, CCP, AAP, and ACP skulls, but not for IP and KP skulls. The skulls were grouped into three age groups: individuals 30 years of age or younger; individuals from 31 to 45 years of age, and individuals 46 years of age or older.

Using a silicone-type material (Optosil, Heraeus, Hanau, Germany), impressions of left and right side articular eminence were made for each skull. Special attention was focused on the parallelism of the silicone impression base to the Frankfurt horizontal plane (line connecting the Porion and Orbitale points). Therefore, the axio-quick face bow (SAM Präzisionstechnik GmbH, Munich, Germany) was stabilized on each skull with ear sets inserted into the *meatus acusticus externus* and the nasion extension placed on nasion anatomical point. Stabilized face bow was parallel to the skull's Frankfurt horizontal plane. To make silicone impression base parallel to the Frankfurt horizontal plane, a spe-

Materijali i metode

Istraživanje je provedeno na 210 ljudskih lubanja (odraslih ljudi) podijeljenih u 7 skupina i u svakoj ih je bilo 30. Lubanje iz ranog hrvatskog srednjovjekovnog razdoblja (10. i 11. stoljeće poslije Krista) i iz kasnog srednjovjekovnog hrvatskog razdoblja (12. do 15. stoljeće poslije Krista) pohranjene su u Antropološkom centru HAZU-a u Zagrebu, Hrvatska, a suvremene hrvatske lubanje s početka 20. stoljeća pohranjene su u Institutu za anatomiju Medicinskog fakulteta Sveučilišta u Zagrebu. Lubanje iz Woodlandskog doba (Illinois, od 900. do 1500. godine poslije Krista.), lubanje iz područja Kentuckyja (od 500. prije Krista do 500. poslije Krista), lubanje američkih crnaca (prva polovica 20. stoljeća, St. Louis, Missouri) i lubanje američkih bijelaca (prva polovica 20. stoljeća, St. Louis, Missouri) pohranjene su na Odjelu za antropologiju Instituta Smithsonian, Washington DC, SAD. Lubanje iz 20. stoljeća (hrvatske i američke) općenito su klasificirane kao suvremeni ljudski uzorci. S obzirom na uzorke iz različitih razdoblja i njihov ograničeni broj na lokacijama na kojima su pohranjene, uloženi su svi naponi kako bi se uključilo što više uzoraka. Međutim, kriteriji uključivanja temeljili su se na potpunoj očuvanosti lubanje, bez vidljivih patoloških stanja ili uočenih oštećenja na mjestima mjerenja (orbitna i nosna regija, temporalna kost, posebice zglobna kvržica i jamica te vanjski slušni hodnik). Iako je očuvanost cijele gornje i donje čeljusti također bila poželjna, to u cijelosti nije bilo moguće.

Sve skupine lubanja imale su potpune podatke o spolu. Podatci o dobi (dob u trenutku smrti) bili su dostupni za lubanje iz skupina EMP, LMP, CCP, AAP i ACP, ali ne i za one iz skupina IP i KP. Lubanje su bile podijeljene u tri dobne skupine: do 30 godina, od 31 do 45 godina i starije od 46 godina.

Korištenjem silikonskog materijala (Optosil, Heraeus, Hanau, Njemačka) izrađeni su otisci zglobne kvržice lijeve i desne strane za svaku lubanju. Posebna pozornost posvećena je paralelnosti baze silikonskog otiska s frankfurtskom horizontalom (linija koja povezuje točke *porion* i *orbitale*). U tu je svrhu obrazni luk (SAM Präzisionstechnik GmbH, München, Njemačka) bio postavljen na svakoj lubanji s pomoću nastavaka za vanjski slušni hodnik i nastavka *nasion* postavljenoga na anatomsku točku *nasion*. Tako postavljen obrazni luk bio je paralelan s frankfurtskom horizontalom lubanje. Kako bi baza silikonskog otiska bila paralelna s frankfurtskom horizontalom, na obrazni luk postavljena je posebno dizajnirana naprava s horizontalnom pločicom paralelnom s postavljenim obraznim lukom i frankfurtskom horizontalom (slika 1.). Nakon primjene silikonskog materi-

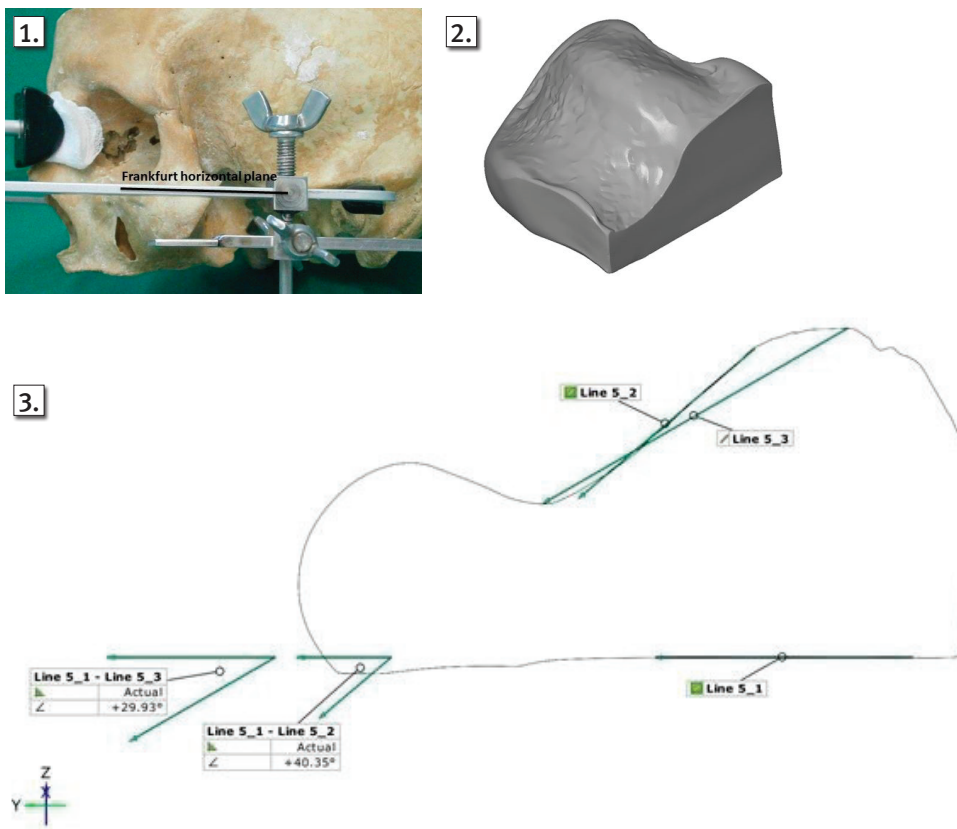


Figure 1 Face bow with specially designed device which horizontal plate is parallel to the Frankfurt horizontal plane.

Slika 1. Obrazni luk s posebno dizajniranom napravom čija je horizontalna pločica paralelna s frankfurtskom horizontalom

Figure 2 Digital impression of glenoid fossa and articular eminence.

Slika 2. Digitalni otisak zglobne kvrčice i jamice

Figure 3 Measurement of articular eminence inclination by M1 and M2 methods (Line 5_1 – line parallel to the Frankfurt horizontal plane, Line 5_2 – best fitting line to the posterior wall of articular eminence, Line 5_3 - line connecting the most superior point of the glenoid fossa and the most inferior point of the articular eminence).

Slika 3. Mjerenje nagiba stražnjega zida zglobne kvrčice primjenom M1 i M2 metode (linija 5_1 – linija paralelna s frankfurtskom horizontalom, linija 5_2 – najbolje prilagođena linija stražnjem zidu zglobne kvrčice, linija 5_3 – linija koja spaja najvišu točku zglobne jamice i najnižu točku zglobne kvrčice)

cially designed device was placed on the face bow with the horizontal plate parallel to the stabilized face bow and the Frankfurt horizontal plane (Figure 1). After a silicone like material had been applied in the area of articular eminence and glenoid fossa, the horizontal plate of the specially designed device was slightly pressed over the impression material, thus forming an impression base parallel to the Frankfurt horizontal plane.

The impressions of the articular eminence and glenoid fossa were three-dimensionally optically scanned (Figure 2) with an ATOS Core 135 device (GOMmbH, Braunschweig, Germany) and AEI measurements were performed in GOM Inspect software (GmbH, Braunschweig, Germany). The applied method of three-dimensional digitization of silicone impressions enables the simulation of five sections through impression (virtual impressions) in an anteroposterior direction (sagittal plane) where there was a distance of 4 mm between each section. The most lateral section was first, being sectioned through the most lateral top of the articular eminence. AEI was measured in relation to the Frankfurt horizontal plane by two methods (in degrees). AEI measured by first method (M1) was defined as an angle between

jala na područje zglobne kvrčice i jamice, horizontalna pločica posebno dizajnirane naprave lagano je pritisnuta na otisak materijal čime je oblikovana baza otisaka paralelna s frankfurtskom horizontalom.

Otisci zglobne kvrčice i jamice optički su trodimenzionalno skenirani (slika 2.) uređajem ATOS Core 135 (GOMmbH, Braunschweig, Njemačka), a mjerenja AEI vrijednosti obavljena su u računalnom programu GOM Inspect (GmbH, Braunschweig, Njemačka). Primijenjena metoda trodimenzionalne digitalizacije silikonskih otisaka omogućuje simulaciju pet presjeka kroz otisak (virtualni otisci) u anteroposteriornom smjeru (sagitalna ravnina), gdje je između svakog presjeka bio razmak od 4 mm. Prvi je bio najlateralniji presjek, presječen kroz najlateralniji vrh zglobne kvrčice. AEI je mjeren u odnosu na frankfurtsku horizontalu dvjema metodama (u stupnjevima). AEI izmjeren prvom metodom (M1) definiran je kao kut između frankfurtske horizontale i linije koja spaja najvišu točku zglobne jamice i najnižu točku zglobne kvrčice (slika 3.). Druga metoda mjerenja AEI-ja (M2) označava mjerenje kuta između frankfurtske horizontale i linije najbolje prilagođene stražnjem zidu zglobne kvrčice (slika 3.). Te metode dobro su opisane u literaturi i

the Frankfurt horizontal plane and the line connecting the most superior point of the glenoid fossa and the most inferior point of the articular eminence (Figure 3). The second AEI measurement method (M2) was to measure as an angle between the Frankfurt horizontal plane and the best fitting line to the posterior wall of the articular eminence (Figure 3). These methods are well described in the literature and are regularly applied in the measurement procedures of AEI values, regardless of the type of samples used in the research (5, 7, 10, 11). Consequently, they have been selected for this study. The mean value of five measured AEI values was assigned as AEI value of the corresponding articular eminence.

Data analysis was performed using SPSS 15.0 statistical software (SPSS Inc., Chicago, IL, USA) by the method of descriptive statistics, independent-sample Student's t-test, one way ANOVA, and univariate analysis. The results were considered significant at the $p < 0.05$ level.

Results

The study was performed on 109 (51.9%) male specimens and 101 (48.1%) female specimens: in the EMP group was 14 (46.7%) males and 16 (53.3%) females; the LMP group 13 (43.3%) males and 17 (56.7%) females; the CCP group 20 (66.7%) males and 10 (33.3%) females; the IP group 12 (40%) males and 18 (60%) females; the KP group 20 (66.7%) males and 10 (33.3%) females; the AAP group 15 (50%) males and 15 (50%) females; the ACP group 15 (50%) males and 15 (50%) females. The individuals in EMP, LMP, CCP, AAP and ACP groups were divided into 3 age groups (Table 1).

Mean AEI M1 values for all five sections through the silicone impressions of articular eminence are presented in Table 2. Mean AEI in the EMP group was 35.43° for right, and 36.58° for left side ($p > 0.05$); in the LMP group the mean was 37.91° for right, and 38.26° for left side ($p > 0.05$); in the CCP group, the mean was 34.72° for right, and 34.59° for left side ($p > 0.05$); in the IP group, the mean was 31.56° for right, and 36.62° for left side ($p < 0.05$); in the KP group the mean was 34.36° for right, and 34.54° for left side ($p > 0.05$); in the AAP group the mean was 36.48° for right, and 36.42° for left side ($p > 0.05$); and in the ACP group the mean was 36.26° for right, and 38.72° for left side ($p > 0.05$). Differences of AEI M1 values between historic groups were not statistically significant ($p > 0.05$) except statistically significantly higher right AEI M1 value measured on the LMP group compared to right AEI M1 value measured on the IP group ($p < 0.05$).

Mean AEI M2 values for all five sections through the silicone impressions of the articular eminence are presented in Table 2. Mean AEI M2 in the EMP group was 53.35° for right, and 54.35° for left side ($p > 0.05$); in the LMP group the mean was 60.13° for right, and 61.42° for left side ($p > 0.05$); in the CCP group the mean was 53.49° for right, and 54.34° for left side ($p > 0.05$); in the IP group the mean was 44.14° for right, and 52.67° for left side ($p < 0.05$); in the KP group the mean was 46.44° for right, and 50.25° for left side ($p > 0.05$); in the AAP group the mean was 50.24° for right side, and

redovito se primjenjuju u postupcima mjerenja AEI vrijednosti, bez obzira na vrstu uzoraka koji se koriste u istraživanjima (5, 7, 10, 11). Zato su i odabrane za ovo istraživanje. Srednja vrijednost od pet izmjerenih AEI vrijednosti označena je kao AEI vrijednost odgovarajuće zglobne kvržice.

Analiza podataka provedena je u statističkom programu SPSS 15.0 (SPSS Inc., Chicago, IL, SAD) metodom deskriptivne statistike, t-testa za nezavisne uzorke, jednosmjernu analizu ANOVA-om i univarijatne analize. Rezultati su smatrani značajnima na razini $p < 0,05$.

Rezultati

Istraživanje je provedeno na 109 muških uzoraka (51,9 %) i 101 (48,1 %) ženskom: u EMP skupini bilo je 14 muškaraca (46,7 %) i 16 žena (53,3 %); u LMP skupini 13 muškaraca (43,3 %) i 17 žena (56,7 %); u CCP skupini 20 muškaraca (66,7 %) i 10 žena (33,3 %); u IP skupini 12 muškaraca (40 %) i 18 žena (60 %); u KP skupini 20 muškaraca (66,7 %) i 10 žena (33,3 %); u AAP skupini 15 muškaraca (50 %) i 15 žena (50%); u ACP skupini 15 muškaraca (50 %) i 15 žena (50 %). Lubanje u skupinama EMP, LMP, CCP, AAP i ACP bile su podijeljene u tri dobne skupine (tablica 1.).

Srednje AEI M1 vrijednosti za svih pet rezova kroz sili-konske otiske zglobne kvržice prikazane su u tablici 2. Srednja AEI vrijednost u EMP skupini bila je $35,43^\circ$ za desnu stranu i $36,58^\circ$ za lijevu ($p > 0,05$); u LMP skupini $37,91^\circ$ za desnu stranu i $38,26^\circ$ za lijevu ($p > 0,05$); u CCP skupini $34,72^\circ$ za desnu stranu i $34,59^\circ$ za lijevu ($p > 0,05$); u IP skupini $31,56^\circ$ za desnu stranu i $36,62^\circ$ za lijevu ($p < 0,05$); u KP skupini $34,36^\circ$ za desnu stranu i $34,54^\circ$ za lijevu ($p > 0,05$); u AAP skupini $36,48^\circ$ za desnu stranu i $36,42^\circ$ za lijevu ($p > 0,05$); a u ACP skupini srednja vrijednost bila je $36,26^\circ$ za desnu stranu i $38,72^\circ$ za lijevu ($p > 0,05$). Razlike u AEI M1 vrijednostima između povijesnih populacija nisu bile statistički značajne ($p > 0,05$), osim značajno viših desnih AEI M1 vrijednosti izmjerenih u LMP skupini u usporedbi s desnim AEI M1 vrijednostima izmjerenima u IP skupini ($p < 0,05$).

Srednje AEI M2 vrijednosti za svih pet rezova kroz sili-konske otiske zglobne kvržice prikazane su u tablici 2. Srednja AEI M2 vrijednost u EMP skupini bila je $53,35^\circ$ za desnu stranu i $54,35^\circ$ za lijevu ($p > 0,05$); u LMP skupini $60,13^\circ$ za desnu stranu i $61,42^\circ$ za lijevu ($p > 0,05$); u CCP skupini $53,49^\circ$ za desnu stranu i $54,34^\circ$ za lijevu ($p > 0,05$); u IP skupini $44,14^\circ$ za desnu stranu i $52,67^\circ$ za lijevu ($p < 0,05$); u KP skupini $46,44^\circ$ za desnu stranu i $50,25^\circ$ za lijevu ($p > 0,05$); u AAP skupini $50,24^\circ$ za desnu stranu i $52,50^\circ$ za lijevu ($p > 0,05$); a u ACP skupini srednja vrijednost bila je $52,85^\circ$ za desnu stranu i $58,37^\circ$ za lijevu ($p > 0,05$). Vrijednosti AEI M2 razlikovale su se među povijesnim populacijama, no u veći-

Table 1 Distribution of samples according to the age groups.
Tablica 1. Raspodjela uzoraka prema dobnim skupinama

Age groups • Dobne skupine	EMP	LMP	CCP	AAP	ACP	ALL • SVI
≤ 30 years • ≤ 30 godina	4 (13.3%)	13 (43.3%)	17 (56.7%)	10 (33.3%)	6 (20.0%)	50 (33.3%)
from 31 to 45 years • od 31 do 45 godina	17 (56.7%)	14 (46.7%)	9 (30.0%)	10 (33.3%)	14 (46.7%)	64 (42.7%)
≥ 46 years • ≥ 46 godina	9 (30.0%)	3 (10.0%)	4 (13.3%)	10 (33.3%)	10 (33.3%)	36 (24.0%)
ALL • SVI	30 (100%)	30 (100%)	30 (100%)	30 (100%)	30 (100%)	150 (100%)

EMP – skulls from early medieval Croatian period; LMP – skulls from late medieval Croatian period; CCP – Croatian skulls from early 20th century; AAP – African American skulls from early 20th century; ACP – American Caucasians skulls from early 20th century • EMP – lubanje iz ranog srednjovjekovnog hrvatskog perioda; LMP – lubanje iz kasnog srednjovjekovnog hrvatskog razdoblja; CCP – hrvatske lubanje s početka 20. stoljeća; AAP – lubanje američkih crnaca s početka 20. stoljeća; ACP – lubanje američkih bijelaca s početka 20. stoljeća

Table 2 Articular eminence inclination values for different groups of skulls.

Tablica 2. Vrijednosti nagiba stražnjega zida zglobne kvrčice za različite skupine lubanja

Samples • Uzorci		AEI M1 (°)					AEI M2 (°)				M1/M2
		N	Min	Max	X	SD	Min	Max	X	SD	p
EMP	R	30	20.58	51.94	35.43	5.85	25.28	76.72	53.35 ^b	9.80	< 0.05
	L	30	25.64	49.00	36.58	5.37	28.16	74.24	54.35	10.90	< 0.05
LMP	R	30	26.04	44.44	37.91 ^a	4.37	40.62	75.14	60.13 ^{cde}	7.15	< 0.05
	L	30	28.38	47.34	38.26	4.34	46.16	83.42	61.42 ^f	9.11	< 0.05
CCP	R	30	22.50	50.24	34.72	6.23	27.88	83.82	53.49 ^g	13.22	< 0.05
	L	30	21.00	49.88	34.59	6.05	29.30	81.00	54.34	12.79	< 0.05
IP	R	30	21.32	40.28	31.56 ^{1a}	4.75	30.74	55.60	44.14 ^{2beg}	6.84	< 0.05
	L	30	25.14	42.78	36.62 ¹	4.36	37.98	63.46	52.67 ²	6.62	< 0.05
KP	R	30	23.96	43.52	34.36	4.59	31.42	60.16	46.44 ^d	7.72	< 0.05
	L	30	20.66	44.34	34.54	5.75	28.16	68.54	50.25 ^f	10.12	< 0.05
AAP	R	30	22.16	45.36	36.48	5.68	28.16	68.26	50.24 ^e	9.77	< 0.05
	L	30	24.72	45.84	36.42	5.65	33.60	74.82	52.50	10.29	< 0.05
ACP	R	30	23.96	47.64	36.26	6.42	31.18	73.42	52.85	12.06	< 0.05
	L	30	26.64	49.46	38.72	5.57	33.44	79.62	58.37	10.37	< 0.05

EMP – skulls from early medieval Croatian period; LMP – skulls from late medieval Croatian period; CCP – Croatian skulls from early 20th century; IP – prehistoric Native American skulls, Woodland Period Illinois; KP – Archaic Period Kentucky skulls; AAP – African American skulls from early 20th century; ACP – American Caucasians skulls from early 20th century; AEI M1 – articular eminence inclination measured by M1 method; AEI M2 – articular eminence inclination measured by M2 method; N – number of specimens; Min – minimal value; Max – maximal value; X – mean value; SD – standard deviation; R – right; L – left; ^{1,2} – statistically significant difference (p<0.05) between right and left side values; ^{a,b,c,d,e,f,g} – statistically significant difference (p<0.05) between population groups; p – p value for differences between AEI M1 and AEI M2 values • EMP – lubanje iz ranog srednjovjekovnog hrvatskog razdoblja; LMP – lubanje iz kasnog srednjovjekovnog hrvatskog razdoblja; CCP – hrvatske lubanje s početka 20. stoljeća; IP – pretpovijesne američke lubanje Woodland Period Illinois; KP – američke lubanje s područja Kentuckija; AAP – lubanje američkih crnaca s početka 20. stoljeća; ACP – lubanje američkih bijelaca s početka 20. stoljeća; AEI M1 – nagib stražnjega zida zglobne kvrčice mjereno prema M1 metodi; AEI M2 – nagib stražnjega zida zglobne kvrčice mjereno prema M2 metodi; N – broj uzoraka; Min. – minimalna vrijednost; Max. – maksimalna vrijednost; X – srednja vrijednost; SD – standardna devijacija; R – desna strana; L – lijeva strana; ^{1,2} – statistički značajna razlika (p < 0,05) između vrijednosti na desnoj i lijevoj strani; ^{a,b,c,d,e,f,g} – statistički značajna razlika (p < 0,05) između populacijskih skupina; p – p vrijednost za razlike između AEI M1 i AEI M2 vrijednosti

52.50° for left side (p>0.05); and in the ACP group the mean was 52.85° for right, and 58.37° for left side (p>0.05). AEI M2 values differed between the historic groups but in most cases without statistical significance (p>0.05). Statistically significant difference (p<0.05) in right AEI M2 values were obtained between EMP and IP, LMP and AAP, LMP and KP, LMP and IP, CCP and IP, and for left side between LMP and KP groups.

In all cases AEI values measured by the M2 method were statistically significantly (p<0.05) higher than AEI values measured by M1 method (Table 2).

Sex differences in AEI M1 and AEI M2 values were observed, but in most of cases they were not statistically significant (p>0.05) (Table 3). Also, an univariate analysis was per-

ni slučajeva bez statističke značajnosti (p > 0,05). Statistički značajna razlika (p < 0,05) u desnim AEI M2 vrijednostima dobivena je između skupina EMP i IP, LMP i AAP, LMP i KP, LMP i IP, CCP i IP, te za lijevu stranu između LMP i KP skupina.

U svim slučajevima AEI vrijednosti izmjerene metodom M2 bile su statistički značajno (p < 0,05) veće nego AEI vrijednosti izmjerene metodom M1 (tablica 2.).

S obzirom na spol razlike između AEI M1 i AEI M2 vrijednosti uočene su, no u većini slučajeva nisu bile statistički značajne (p > 0,05) (tablica 3.). Također je provedena univarijantna analiza koja nije dala statistički značajne rezultate za AEI M1 i AEI M2 vrijednosti kada se kombiniraju različite skupine lubanja i spol (p > 0,05).

Table 3 Articular eminence inclination values according to the sex.
Tablica 3. Vrijednosti nagiba stražnjega zida zglobne kvrčice s obzirom na spol

Samples • Uzorci		AEI M1 (°)						p	AEI M2 (°)				p
		Male • Muški spol			Female • Ženski spol				Male • Muški spol		Female • Ženski spol		
		N	X	SD	N	X	SD		X	SD	X	SD	
EMP	R	14	36.43	5.93	16	34.56	5.82	>0.05	55.37	9.33	51.59	10.15	>0.05
	L	14	37.49	5.47	16	35.78	5.33	>0.05	57.04	10.93	52.00	10.65	>0.05
LMP	R	13	39.55	3.32	17	36.65	4.74	>0.05	62.85 ^{bc}	5.54	58.06 ^f	7.68	>0.05
	L	13	39.49	3.69	17	37.32	4.66	>0.05	62.24 ^d	9.72	60.79	8.86	>0.05
CCP	R	20	34.26	6.68	10	35.65	5.42	>0.05	52.51	13.98	55.47	12.00	>0.05
	L	20	34.48	6.15	10	34.81	6.18	>0.05	54.92	13.33	53.18	12.25	>0.05
IP	R	12	32.74	2.79	18	31.18	5.58	>0.05	43.41 ^b	4.50	44.63 ^f	8.13	>0.05
	L	12	37.74	3.55	18	35.88	4.77	>0.05	54.04	5.70	51.76	7.18	>0.05
KP	R	20	33.87	5.12	10	35.35	3.33	>0.05	44.99 ^c	8.17	49.36	6.09	>0.05
	L	20	33.94 ^a	6.11	10	35.74	5.04	>0.05	47.87 ^{de}	10.19	55.00	8.56	>0.05
AAP	R	15	37.83	6.43	15	35.13	4.63	>0.05	53.20	10.77	47.28	7.94	>0.05
	L	15	37.79	5.55	15	35.04	5.60	>0.05	56.38	10.04	48.62	9.29	<0.05
ACP	R	15	38.68	5.73	15	33.84	6.33	<0.05	56.98	11.06	48.72	11.93	>0.05
	L	15	40.59 ^a	5.09	15	36.85	5.56	>0.05	61.11 ^e	9.08	55.63	11.15	>0.05

EMP – skulls from early medieval Croatian period; LMP – skulls from late medieval Croatian period; CCP – Croatian skulls from early 20th century; IP – prehistoric Native American skulls, Woodland Period Illinois; KP – Archaic Period Kentucky skulls; AAP – African American skulls from early 20th century; ACP – American Caucasians skulls from early 20th century; AEI M1 – articular eminence inclination measured by M1 method; AEI M2 – articular eminence inclination measured by M2 method; N – number of specimens; X – mean value; SD – standard deviation; R – right; L – left; ^{a,b,c,d,e,f} - statistically significant difference ($p < 0.05$) between population groups for males and for females; p – p value for differences in AEI values between males and females in certain population • EMP – lubanje iz ranog srednjovjekovnog hrvatskog perioda; LMP – lubanje iz kasnog srednjovjekovnog hrvatskog perioda; CCP – hrvatske lubanje s početka 20. stoljeća; IP – pretpovijesne američke lubanje Woodland Period Illinois; KP – američke lubanje s područja Kentuckyja; AAP – lubanje američkih crnaca s početka 20. stoljeća; ACP – lubanje američkih bijelaca s početka 20. stoljeća; AEI M1 – nagib stražnjega zida zglobne kvrčice mjereno prema M1 metodi; AEI M2 – nagib stražnjega zida zglobne kvrčice mjereno prema M2 metodi; N – broj uzoraka; X – srednja vrijednost; SD – standardna devijacija; R – desna strana; L – lijeva strana; ^{a,b,c,d,e,f} – statistički značajna razlika ($p < 0,05$) između populacijskih skupina za muški i za ženski spol; p – p-vrijednost za razlike u AEI vrijednostima između muškaraca i žena u određenoj populaciji

formed and no statistically significant results were obtained for AEI M1 and AEI M2 values according to combination of different groups of skulls and sex ($p > 0.05$).

An analysis of the age groups showed no statistically significant differences ($p > 0.05$) in AEI M1 and AEI M2 values between different populations. By univariate analysis, no statistically significant ($p > 0.05$) results were obtained for AEI values according to the combination of different group of skulls and age groups.

Discussion

The results of this study have shown a high variability in measured AEI values. AEI measurements were performed using computer software on digital sagittal sections of silicone impressions of the articular eminence. The reference plane for measurement was the Frankfurt horizontal; the silicone impression base was parallel to the Frankfurt horizontal plane. Variation in the AEI values in the two different measurement methods showed: the first method (AEI M1 value) was more affected by the eminence height and location of the articular eminence top relative to the roof of the glenoid fossa, while the second method (AEI M2 value) was more affected by real inclination of the posterior wall of the articular eminence and therefore represented an actual and simplified condylar path (2, 7, 10, 11). In all cases (regardless

S obzirom na dobne skupine nisu dobivene statistički značajne razlike ($p > 0,05$) u AEI M1 i AEI M2 vrijednostima između različitih populacija. Univarijatnom analizom nisu dobiveni statistički značajni rezultati ($p > 0,05$) za AEI vrijednosti kada se kombiniraju različite skupine lubanja i dobne skupine.

Rasprava

Rezultati ovog istraživanja pokazuju visoku varijabilnost u izmjenjenim AEI vrijednostima. Mjerenja tih vrijednosti obavljena su s pomoću računalnog programa na digitalnim sagitalnim presjecima silikonskih otisaka zglobne kvrčice. Referentna ravnina za mjerenje bila je frankfurtska horizontala; baza silikonskog otiska bila je paralelna s frankfurtskom horizontalom. Varijacija u AEI vrijednostima dviju različitih metoda mjerenja pokazala je sljedeće: prva metoda (AEI M1 vrijednost) bila je više pod utjecajem visine zglobne kvrčice i položaja vrha zglobne kvrčice u odnosu prema krovu zglobne jamice, a druga metoda (AEI M2 vrijednost) bila je više pod utjecajem stvarnoga nagiba stražnjega zida zglobne kvrčice te je zato predstavljala stvarnu i pojednostavljenu putanju kondila (2, 7, 10, 11). U svim slučajevima (neovisno o skupini lu-

of the group of skulls) AEI M2 the values were statistically significantly higher compared to AEI M1 values. The AEI M1 values are closer to the average values of the condylar path inclination used for articulator adjustment in prosthodontics, which suggests that they may be more clinically relevant. Therefore, it is of great importance to state which method of measurement was performed when expressing the AEI data - which is often not indicated in the published literature. In addition, a comparison of the obtained results with the results from the literature is more difficult due to the various materials used for AEI measurements. Richards (23) performed measurements using a profile gauge placed along the articular eminence and glenoid fossa. Žabarović et al. (12) performed measurement by direct craniometrics method. Katsavrias (2) used silicone impressions of articular eminence. Gilboa et al. (24) measured AEI values on radiographic images. Kranjčić et al. (10) used (in previous study) digital photography of a skull's lateral views, Cohlmiya et al. (25) used tomograms, Wu et al. (17) used CT scans, while Koppe et al. (9) examined TMJ morphology by digital three-dimensional photography. All the above mentioned authors (2, 10, 12, 17, 23, 24) performed AEI measurement in relation to the Frankfurt horizontal plane except Cohlmiya et al. (25) who performed a study on tomograms and as reference plane used the superior border of tomographic film.

Although there is a wealth of literature on the TMJ morphology, little is known about AEI values on human historic samples. The present study included seven different group of skulls in order to measure AEI values, and to compare the obtained AEI values between these groups. The investigated groups of skulls originated from different periods of time (lived within the span of 2500) and from different geographical locations. People from the IP sample lived between 900 to 1500 AD years alongside the Mississippi Illinois River, whereas the people from the KP sample lived in a period from 500 BC to 500 AD years alongside the Green River (26, 27). People from the EMP (10th and 11th centuries AD) and LMP (12th to 15th centuries AD) samples lived on the east Adriatic coast (middle Adriatic, Croatia) (20). Contemporary groups of skulls represent people living in the first half of the 20th century: AAP and ACP skulls (American contemporary skulls) represent the people living in or around St. Louis, Missouri and are part of the Robert J. Terry Anatomical Collection (28) while the CCP skulls (Croatian contemporary skulls) represent people living in or around Zagreb. Croatian samples (EMP, LMP, and CCP) were considered to be ethnically homogeneous. American samples (IP, KP, AAP, and ACP) were not ethnically homogeneous as well as ethnically different from Croatian samples. Among historic groups of skulls included in this study, people were usually engaged in hunting, gathering, fishing, and indigenous agriculture. Therefore, consumed food between investigated historic skulls was relatively similar but the way of food preparation was different between the historic and contemporary samples. In the past, food was generally raw, fibrous, harder or tougher or prepared on an open hearth compared to the softer, less tough and more processed food of today (18). Masticatory loading associated with toughness, hardness, and

banja) AEI M2 vrijednosti bile su statistički značajno veće u odnosu na AEI M1 vrijednosti. AEI M1 vrijednosti bliže su prosječnim vrijednostima nagiba kondilne staze koja se koristi za podešavanje artikulatora u stomatološkoj protetici, što sugerira da bi mogle biti klinički relevantnije. Zato je veoma važno navesti koja je metoda mjerenja primijenjena pri iskazivanju AEI vrijednosti – što često nije naznačeno u objavljenoj literaturi. Uz to, usporedba dobivenih rezultata s rezultatima iz literature otežana je zbog različitih materijala koji su korišteni za mjerenje AEI-ja. Richards (23) je provodio mjerenja koristeći se profilnom mjerkom postavljenom uz zglobnu kvrčicu i jamicu, Žabarović i suradnici (12) primijenili su izravnu kranimetrijsku metodu, Katsavrias (2) se koristio silikonskim otiscima zglobne kvrčice, Gilboa i suradnici (24) mjerili su AEI vrijednosti na radiografskoj snimci, Kranjčić i suradnici (10) upotrijebili su (u prethodnom istraživanju) digitalnu fotografiju lubanja, Cohlmiya i suradnici (25) koristili su se tomografom, Wu i suradnici (17) CT skenovima, a Koppe i suradnici (9) ispitivali TMJ morfologiju s pomoću digitalnih trodimenzionalnih snimaka. Svi spomenuti autori (2, 10, 12, 17, 23, 24) proveli su mjerenje AEI-ja u odnosu prema frankfurtskoj horizontali, a Cohlmiya i suradnici (25) proveli su istraživanje na tomogramima gdje je kao referentna ravnina za mjerenje služila gornja granica tomografske snimke.

Iako postoji dosta literature o morfologiji TMJ-a, malo se zna o AEI vrijednostima u ljudskim povijesnim populacijama. Ovo istraživanje obuhvatilo je lubanje iz sedam različitih skupina s ciljem da se izmjere AEI vrijednosti i međusobno usporede. Istraživane skupine lubanja potjecale su iz različitih razdoblja (raspon je 2500 godina) i živjele su na različitim geografskim lokacijama. Ljudi iz IP uzorka živjeli su između 900. i 1500. godine poslije Krista uz rijeku Mississippi u Illinoisu, a ljudi iz KP uzorka od 500. prije Krista do 500. poslije Krista uz rijeku Green (26,27). Ljudi iz uzorka EMP (10. i 11. stoljeće poslije Krista) i LMP (12. do 15. stoljeće poslije Krista) živjeli su na istočnoj obali Jadranskoga mora (srednji Jadran, Hrvatska) (20). Lubanje iz suvremenog doba predstavljaju ljude koji su živjeli u prvoj polovici 20. stoljeća: AAP i ACP lubanje (američke lubanje iz suvremenog doba) predstavljaju ljude koji su živjeli u St. Louisu (Missouri) ili oko njega i dio su anatomske zbirke Roberta J. Terryja (28), a lubanje CCP (hrvatske lubanje iz suvremenog doba) predstavljaju ljude koji su živjeli u Zagrebu ili njegovoj okolini. Hrvatski uzorci (EMP, LMP i CCP) smatraju su etnički homogenima. Američki uzorci (IP, KP, AAP i ACP) nisu bile etnički homogeni, niti su bili etnički slični hrvatskim uzorcima. Među povijesnim uzorcima uključenima u ovo istraživanje ljudi su se obično bavili lovom, skupljanjem plodova, ribolovom i autohtonom poljoprivredom. Zato je konzumirana hrana među istraživanim povijesnim skupinama lubanja bila razmjerno slična, ali su se metode pripreme razlikovale među povijesnim i suvremenim skupinama lubanja. U prošlosti je hrana bila uglavnom sirova, vlaknasta, tvrda ili žilavija i pripremljena uglavnom na otvorenoj vatri, u usporedbi sa suvremenom hranom koja je mekša, manje žilava i obrađenija (18). Žvačno opterećenje povezano s tvrdoćom, žilavošću i veličinom čestica u prehrani moglo je posebno

particle size in diet could particularly affect the morphology of the articular eminence. Hard, tough, and/or unprocessed food generally leads to an increase in size of the skull, as well as of the TMJ size (18). Therefore, it was assumed that the mean AEI values differ between investigated groups of skulls with steeper and higher AEI values among the historic skulls. The results obtained from the present study show differences in AEI values between investigated skulls, but most of them were not statistically significant (differences in AEI values between Croatian samples, between American samples, and between Croatian and American samples). Mean measured AEI M1 values were in a range from 31° to 40°, and mean AEI M2 values in a range from 43° to 61° (regardless of the group of skulls). Considering the variability of AEI values regarding the group of skulls, body side and sex with statistically not significant differences in most of cases, it is not possible to make the conclusion which of investigated groups of skulls had the highest or the smallest AEI values. Only a few statistically significant differences in mean AEI values between investigated samples were obtained with higher AEI M2 values (AEI M1 just in one case) measured on Croatian historic samples compared to American historic samples. Measured AEI values correspond to the reported range of AEI values of 21° to 64° from the literature (20). Similar AEI values to those in our study have been reported by other authors, both for historical (5, 10, 11, 27-30) and contemporary skulls (5, 15, 22, 24, 31). The type of consumed food among investigated samples was relatively similar, but food preparation methods between the samples were different. However, the food preparation method ("unprocessed - hard" or "processed - soft" food) and consequently different masticatory forces related to the hardness of consumed food did not affect remodeling of the articular eminence and AEI values or at least not as much as needed for significant changes in AEI values. The possible genetic influence on the joint morphology between investigated group of skulls may be the main factor, and it would be suggested that other craniometric values should be investigated in the future to see if some of the cranial shapes are correlated to TMJ morphology. However, scientific contribution of performed research is in new, so far unexplored AEI M1 and AEI M2 data of Croatian and American historic and contemporary skulls. Contrary to this study, some researchers (9, 32) found differences in size and shape of TMJ components (AEI was not measured) between several populations. Koppe et al. (9) measured sagittal length of temporal articular surface and mediolateral width of the glenoid fossa among populations from Lithuania (lived from 5th to 6th century, and from 14th to 17th century) and from Germany (5000 BC to 1000 BC), with significantly higher values of sagittal length on Neolithic skulls from Germany. According to (32), greater TMJ dimensions were observed among aboriginal human groups than among recent people. Hinton (32) concluded that differences in TMJ morphology between populations are, apart from the possible influence of genetic factors, at least partly attributable to differences in oral function.

The AEI values obtained in this study, which were previously unknown for different groups of skulls, are something

utjecati na morfologiju zglobne kvržice. Konzumiranje tvrde, žilave i/ili neprerađene hrane općenito se dovodi u vezu s nešto većim lubanjama i veličinom TMJ-a (18). Zato se pretpostavljalo da srednje AEI vrijednosti variraju među istraživanim skupinama lubanja, s izraženijim i višim AEI vrijednostima među povijesnim skupinama lubanja.

Rezultati ovog istraživanja pokazuju razlike u AEI vrijednostima među istraživanim skupinama lubanja, ali većina njih nije bila statistički značajna (razlike u AEI vrijednostima između hrvatskih lubanja, između američkih lubanja i između hrvatskih i američkih lubanja).

Srednje izmjerene AEI M1 vrijednosti bile su u rasponu od 31° do 40°, a srednje AEI M2 vrijednosti u rasponu od 43° do 61° (neovisno o populacijskoj skupini). S obzirom na varijabilnost AEI vrijednosti u odnosu prema različitim skupinama lubanja, strani tijela i spolu te sa statistički neznačajnim razlikama u većini slučajeva, nije moguće zaključiti koja od istraživanih skupina lubanja ima najviše ili najmanje AEI vrijednosti. Samo nekoliko statistički značajnih razlika u srednjim AEI vrijednostima između istraživanih skupina lubanja bilo je dobiveno s višim AEI M2 vrijednostima (AEI M1 samo u jednom slučaju) izmjerenima na hrvatskim povijesnim uzorcima u odnosu prema američkima. Izmjerene AEI vrijednosti odgovaraju rasponu AEI vrijednosti od 21° do 64° iz literature (20). Slične AEI vrijednosti kao u našem istraživanju izmjerili su i drugi autori, kako za povijesne (5, 10, 11, 27 – 30) tako i za suvremene uzorke (5, 15, 22, 24, 31). Vrsta konzumirane hrane među istraživanim uzorcima bila je razmjerno slična, ali su se metode pripreme razlikovale. Međutim, metoda pripreme hrane („neprerađena – tvrda“ ili „prerađena – mekana“ hrana) i posljedično različite žvačane sile povezane s tvrdoćom konzumirane hrane nisu utjecale na remodeliranje zglobne kvržice i AEI vrijednosti, ili barem ne u tolikoj mjeri da bi se dogodile značajne promjene u AEI vrijednostima. Mogući genetski utjecaj na morfologiju zgloba između istraživanih skupina lubanja može biti glavni čimbenik te bi trebalo preporučiti da se u budućnosti istraže i druge kranimetrijske vrijednosti da bi se vidjelo je li neki od oblika lubanje povezan s TMJ morfologijom. Međutim, znanstveni doprinos provedenog istraživanja nalazi se u novim, do sada neistraženim AEI M1 i AEI M2 vrijednostima hrvatskih i američkih povijesnih i suvremenih skupina lubanja. Suprotno ovom istraživanju, neki su istraživači (9, 32) pronašli razlike u veličini i obliku TMJ komponenti (AEI nije bio mjereno) između nekoliko populacija. Koppe i suradnici (9) mjerili su sagitalnu duljinu temporalne artikularne površine i mediolateralnu širinu zglobne jamice među populacijama iz Litve (živjele od 5. do 6. stoljeća i od 14. do 17. stoljeća) i iz Njemačke (5000 godina prije Krista do 1000 godina prije Krista), sa značajno višim vrijednostima sagitalne duljine na neolitskim lubanjama iz Njemačke. S obzirom na veće TMJ dimenzije među Aboridžinima u odnosu na suvremene ljude, Hinton (32) je zaključio da su razlike u TMJ morfologiji između populacija, osim mogućega utjecaja genetskih čimbenika, barem djelomično posljedica razlika u žvačnoj funkciji.

AEI vrijednosti dobivene u ovom istraživanju, koje su prije bile nepoznate za istraživane populacije, ono su što ovo istraživanje čini značajnim. Iako nije bilo namjere raspravlja-

that makes this research significant. Although there was no intention to discuss temporomandibular disorders, a link between anatomy and potential disorders may sometimes be drawn. Conflicting results have been reported regarding the association between TMJ degenerative changes and the depth of the glenoid fossa as well as AEI values. Additionally, shallower glenoid fossae and lower AEI values may be associated with tooth loss and arthritic changes. Some studies also report steeper AEI values in patients with derangements and disk displacements. It could be stated that remodeling of the glenoid fossa is a complex process, ultimately influenced by a variety of variables (16, 33, 34). In order to establish a correlation between the anatomical characteristics of the temporomandibular joint and the occurrence of certain disorders, further studies are needed.

Differences in AEI values between males and females mainly were not statistically significant regardless of different groups of skulls. Similar results were obtained by Richards (23) who compared AEI M1 values of two Australian Aboriginal populations but without statistically significant difference between males and females. Cohlma et al. (25) found significantly higher left AEI M2 values in males than in females, but not statistically significant difference in AEI M2 values on the right side. Wu et al. (17) concluded that sex had great influence on AEI values with significantly steeper AEI values in males. Differences between left and right side AEI values existed, but without statistical significance. Similar results were reported by Wu et al. (17). However left-right differences occur everywhere in nature and craniofacial asymmetry is present in normal individuals (32), with a possible difference up to 30° in AEI values between left and right TMJ (12). Differences in left-right AEI values could be caused by predominant chewing of food by one side of dental arches with consequently different distribution of forces and remodeling in left and right TMJ (9, 12).

Conclusions

Articular eminence inclination values can remarkably vary depending on the method of measurement. Values are higher when measured by M2 method.

Body side and sex did not significantly affect articular eminence inclination values.

There are no differences in articular eminence inclination values between historic and contemporary groups of skulls. Differences in food preparation methods among historic ("unprocessed", hard food) and contemporary ("processed", soft food) samples with consequently different masticatory forces needed for chewing such a food were not significant factors affecting the articular eminence morphology and articular eminence inclination values.

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ti o temporomandibularnim poremećajima, povezanost između anatomije i potencijalnih poremećaja karkad može biti naznačena. Oprečne rezultate objavljuju istraživači s obzirom na povezanost između degenerativnih promjena TMJ-a i dubine zglobne jamice, te AEI vrijednosti. Plitke zglobne jamiče i niže AEI vrijednosti mogu biti povezane i s gubitkom zuba te artritnim promjenama. Autori nekih istraživanja također opisuju strmije AEI vrijednosti kod pacijenata s pomakom diska. Može se reći da je remodeliranje zglobne jamiče složen proces na koji na kraju utječe niz varijabli (16, 33, 34). Kako bi se ispitala korelacija između anatomskih karakteristika temporomandibularnoga zgloba i pojave određenih poremećaja, svakako su potrebna daljnja istraživanja.

Razlike u AEI vrijednostima između muškaraca i žena uglavnom nisu bile statistički značajne, neovisno o skupini lubanja. Slične rezultate dobio je Richards (23) koji je usporedio AEI M1 vrijednosti dviju australskih aboridžinskih populacija, ali bez statistički značajne razlike između muškaraca i žena. Cohlma i suradnici (25) našli su statistički značajno veće AEI M2 vrijednosti lijeve strane kod muškaraca u odnosu prema ženama, ali nisu pronašli statistički značajnu razliku u AEI M2 vrijednostima na desnoj strani. Wu i suradnici (17) zaključili su da spol ima velik utjecaj na AEI vrijednosti sa značajno strmijim AEI vrijednostima kod muškaraca. Razlike između lijeve i desne strane AEI vrijednosti postoje, ali bez statističke značajnosti. Sličan rezultat dobio je Wu sa suradnicima (17). No razlike između lijeve i desne strane normalno postoje u prirodi, a kraniofacijalna asimetrija također je normalna (32), s mogućom razlikom do 30° u AEI vrijednostima između TMJ-a lijeve i desne strane (12). Razlike u lijevo-desnim AEI vrijednostima mogle bi biti prouzročene pretežitim žvakanjem hrane uglavnom jednom stranom zubnih lukova, čime se posljedično različito raspoređuju sile i remodeliraju lijevi i desni TMJ (9, 12).

Zaključak

Vrijednosti nagiba stražnjeg zida zglobne kvrčice mogu značajno varirati ovisno o metodi mjerenja. Veće vrijednosti dobivaju se M2 metodom.

Strana tijela i spol ne utječu značajno na vrijednosti nagiba stražnjeg zida zglobne kvrčice.

Nema razliku u vrijednostima nagiba stražnjeg zida zglobne kvrčice između povijesnih i suvremenih skupina lubanja. Razlike u metodama pripreme hrane među povijesnim ("neprerađeno", tvrda hrana) i suvremenim ("prerađeno", meka hrana) uzorcima, s posljedično različitim žvačnim silama potrebnima za usitnjavanje takve hrane, nisu bile značajan čimbenik koji bi utjecao na morfologiju zglobne kvrčice i vrijednosti nagiba stražnjeg zida zglobne kvrčice.

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Sažetak

Svrha: Odrediti i usporediti vrijednosti nagiba stražnjega zida zglobne kvržice (AEI) između hrvatskih i američkih lubanja. **Materijali i metode:** Istraživanje je provedeno na 210 ljudskih lubanja podijeljenih u hrvatske (rani srednji vijek, kasni srednji vijek i suvremeno doba) i američke skupine (Illinois, Kentucky, suvremeni američki crnci i bijelci). AEI je mjereno dvjema metodama (M1 i M2) na pet sagitalnih presjeka kroz virtualne silikonske otiske zglobne kvržice. Rezultati su analizirani na razini značajnosti $p < 0,05$. **Rezultati:** Nisu dobivene statistički značajne razlike u AEI vrijednostima s obzirom na različite skupine lubanja, stranu tijela, spol i dob ($p > 0,05$). Vrijednosti AEI M2 bile su statistički značajno veće od vrijednosti AEI M1 ($p < 0,05$). **Zaključci:** Usporedba AEI vrijednosti između različitih skupina lubanja može pružiti uvid u morfologiju temporomandibularnoga zgloba, a također istaknuti moguće evolucijske prilagodbe, utjecaj prehrane i genetsku raznolikost među kulturama. Prema rezultatima ovog istraživanja, AEI vrijednosti nisu bile različite među skupinama lubanja niti pod utjecajem strane tijela, spola i dobi, barem ne u mjeri koja bi rezultirala značajnim promjenama. No primijenjena metoda mjerenja znatno utječe na AEI vrijednosti, pri čemu su AEI M2 vrijednosti bile veće u usporedbi s AEI M1 vrijednostima.

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