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Reliability of *Zagreb 82 MOD* Cephalometric Assessment in Determining the Facial Growth Pattern

Pouzdanost Zagreb 82 MOD *kefalometrijske analize u određivanju obrasca rasta lica*

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Abstract

Objective: The aim of this study was to investigate accuracy and reliability of the existing cephalometric analysis Zagreb82 MOD in determining the facial growth pattern. **Materials and methods:** Of all patients aged 10-17 years without missing teeth, craniofacial anomalies and previous orthodontic medical history, who were attending Department of Orthodontics, University Hospital Centre Zagreb in years 2021 and 2022, lateral cephalograms and digital dental models were examined. Subsequently, subjects were collected and divided into two groups: eugnathic group (N=50, SNA 81°±3.5°, SNB 78.5°±3°, ANB 2.5°±2°, Wits -1±2mm, Angle class. I, overbite 1-3.5mm, overjet 1-3.5mm, dystopia<3mm, total crowding<3mm, total diastemas<3mm) and test group (N=129, overbite>4mm for deep bite and overbite<-0.1mm for open bite). In the eugnathic group, reference values were calculated for ten skeletal parameters and a corrected analysis was created. In the test group, facial growth patterns (horizontal, neutral or vertical) were determined, within the corrected and Zagreb82 MOD analysis. The T-test was used to examine the differences between the corrected and the Zagreb82 MOD analysis. The McNemar test was performed to compare the distribution of facial growth patterns between the tested parameters within and between analyses. **Results:** Differences were observed in the reference values of saddle angle, Y-axis, articular angle, mandibular angle, Björk's Sum and upper section of mandibular angle (p<.05). The distribution of facial growth patterns according to Y-axis, intermaxillary angle, mandibular angle, Bjork's Sum also differed between the two analyzes (p<.001). In the corrected analysis, there was no significant difference in the distribution of facial growth patterns between Björk's Sum, mandibular inclination, and intermaxillary angle (p>.05). **Conclusion:** The reliability of Zagreb82 MOD analysis in defining facial growth pattern should be taken with caution. Björk's Sum, intermaxillary angle and inclination of mandible are equitable parameters in determining the facial growth pattern within the corrected analysis.

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Introduction

It is not possible to determine the true nature of malocclusion without information about the underlying skeletal relationships (1). These relationships cannot be solely gained from dental casts, scans or photographs (1). Going back 100 years in time (2), 2D lateral cephalograms have still remained a fundamental assistant for evaluation of dental and/or skeletal relationships, assessment of malocclusion severity and treatment planning (3,4). In 1982, 14 cephalometric variables on 200 cephalograms of eugnathic subjects, 80 percent of whom were 10-17 years old, were processed at the School of Dental Medicine; Department of Orthodontics University of Zagreb and reference values for the

Uvod

Pravu prirodu malokluzije nije moguće odrediti bez informacija o kraniofacijalnim skeletnim odnosima (1). Ti se odnosi ne mogu dobiti samo iz dentalnih odljeva, skenova ili fotografija (1). Vraćajući se unatrag gotovo sto godina (2), 2D lateralni kefalogrami ostaju osnovni pomoćni alat za procjenu dentalnih i/ili skeletnih odnosa, procjenu težine malokluzije i planiranje liječenja (3, 4). Godine 1982. na Stomatološkom fakultetu, u Zavodu za ortodonciju Sveučilišta u Zagrebu, obrađeno je 14 kefalometrijskih varijabli na 200 kefalograma eugnatskih ispitanika od kojih je 80 posto bilo u dobi od 10 do 17 godina, te su određene referentne vrijednosti za hrvatsku populaciju (5). Analiza je nazvana *Zagreb*

Croatian population were determined (5). The analysis was named 'Zagreb 82 MOD' and has been taught since, as one of the basic instruments for orthodontic diagnosis and planning in Croatian population.

Determination of the cephalometric vertical angular parameters: inclination of mandible, intermaxillary angle, Y-axis, mandibular angle and sum of Björk's polygon angles, and determination of the facial growth pattern (neutral/straight-angle, horizontal/low-angle or vertical/high-angle), is a very important and indispensable step before deciding on the timing and choice of orthodontic treatment (6.-10).

By using the abovementioned analysis over the years in clinical practice and determining the facial growth patterns according to the reference values of the sum of Björk's polygon angles (hereafter referred to as Björk's sum), a large number of cases with high angles were found. Furthermore, high values of the Björk's sum did not match the values of intermaxillary angle, Y-axis or mandibular angle, which in these cases often indicated a straight-angle, i.e. neutral, facial growth pattern. Since the cephalograms used for determining the Zagreb 82 MOD analysis were no longer available, the accuracy of the old measurements could not be verified.

To investigate the reliability of the existing cephalometric analysis in determining the facial growth pattern, the present study was designed in which a new group of skeletally eugnathic patients was collected. Reference values were calculated for the ten cephalometric angular parameters (hereinafter referred to as the corrected analysis). The test group was collected in order to determine the facial growth patterns of patients with clinical deep or anterior open bite based on the corrected and Zagreb 82 MOD analysis. Inclination of mandible (SN/GoMe), which was not considered in the previous analysis, was also included in the study to investigate its significance in determining the facial growth pattern.

The aims of the study were to calculate the inclination of the mandible (SN/GoMe angle) for both groups, to compare the reference values of the tested angular parameters between the corrected analysis and the Zagreb 82 MOD analysis, to define for each patient in the test group an appropriate facial growth pattern in relation to the reference values of the corrected and the Zagreb 82 MOD analysis and to investigate whether there is a difference between the analyses in determining the facial growth pattern, and to check within each analysis whether there is a difference in determination of the facial growth pattern between the tested parameters.

Materials and Methods

The study protocol was reviewed and approved by the Ethics Committee of the University Hospital Centre Zagreb. Of all patients aged 10-17 years without missing teeth, craniofacial anomalies and previous orthodontic health history, who visited the Department of Orthodontics University Hospital centre Zagreb in years 2021 and 2022, pretreatment lateral cephalograms and three-dimensional digital dental models were analyzed (N=961). The subjects were collected and divided into two groups according to following criteria:

82 MOD i od tada se uči kao jedan od osnovnih alata za ortodontsku dijagnostiku i planiranje terapije u hrvatskoj populaciji.

Određivanje kefalometrijskih vertikalnih kutnih parametara: inklinacije mandibule, međučeljusnoga kuta, Y-osi, mandibularnoga kuta i zbroja kutova Björkova poligona, te određivanje obrasca rasta lica (normalni, horizontalni ili vertikalni) vrlo je važno i neizostavno prije odluke o vremenu i izboru ortodontske terapije (6 – 10).

Korištenjem navedene analize tijekom godina u kliničkoj praksi i određivanjem obrazaca rasta lica prema referentnim vrijednostima zbroja kutova Björkova poligona (u daljnjem tekstu Björkova suma) uočen je velik broj slučajeva s vertikalnim obrascem rasta lica. Nadalje, visoke vrijednosti Björkove sume nisu odgovarale vrijednostima međučeljusnoga kuta, Y-osi ili mandibularnoga kuta koji su u tim slučajevima često upućivali na normalan obrazac rasta lica. Budući da kefalogrami koji su korišteni za određivanje analize *Zagreb 82 MOD* više nisu bili dostupni, nije se mogla provjeriti točnost starih mjerenja.

Kako bi se istražila pouzdanost postojeće kefalometrijske analize u određivanju obrasca rasta lica, osmišljena je studija u kojoj je prikupljena nova skupina skeletno eugnatih pacijenata kojima su izračunate referentne vrijednosti za deset ispitanih kefalometrijskih kutnih parametara (u daljnjem tekstu korigirana analiza). Testna skupina prikupljena je da bi se pacijentima s kliničkim dubokim i prednjim otvorenim zagrizom određivali obrasci rasta lica s obzirom na korigiranu analizu i analizu *Zagreb 82 MOD*. Inklinacija mandibule (SN/GoMe), koja nije bila uzeta u obzir u analizi *Zagreb 82 MOD*, također je uključena u studiju kako bi se istražilo njezin značaj u određivanju obrasca rasta lica.

Ciljevi istraživanja bili su izračunati inklinaciju mandibule (SN/GoMe kut) za obje skupine, usporediti referentne vrijednosti ispitanih kutnih parametara između korigirane analize i analize *Zagreb 82 MOD*, definirati za svakog pacijenta u testnoj skupini odgovarajući obrazac rasta lica u odnosu prema referentnim vrijednostima korigirane analize i analize *Zagreb 82 MOD* te istražiti postoji li razlika između dviju analiza u određivanju obrasca rasta lica, te unutar svake analize provjeriti postoji li razlika u određivanju obrasca rasta lica između ispitivanih parametara.

Materijali i metode

Protokol ispitivanja pregledalo je i odobrilo Etičko povjerenstvo KBC-a Zagreb. Od svih pacijenata u dobi od 10 do 17 godina sa svim trajnim zubima, bez kraniofacijalnih anomalija i prethodne ortodontske anamneze koji su posjećivali Kliniku za ortodonciju KBC-a Zagreb 2021. i 2022. godine (N = 961), analizirani su prijeterapijski LL-kefalogrami i trodimenzionalni digitalni modeli zuba. Ispitanici su podijeljeni u dvije skupine prema sljedećim kriterijima:

1. Skupina eugnatih (eugnate skeletne sagitalne i dentalne dimenzije, N = 50, M = 19, Ž = 31): SNA 81° ± 3,5°, SNB

1. Eugnathic (eugnathic skeletal sagittal and dental dimensions, N=50, Male=19, Female=31): SNA 81°±3.5°, SNB 78.5°±3°, ANB 2.5°±2°, Wits -1±2mm, Angle class I, overbite 1-3.5mm, overjet 1-3.5mm, dystopia<3mm, total crowding<3mm, total diastema<3mm;
2. Test group (N=129, Male=63, Female=66; overbite>4mm for deep bite and overbite<-0.1mm for open bite).

All the subjects who did not meet the criteria were excluded from the study.

Patients were intraorally scanned using an iTero Element 2 (Align Technology, San Jose, California, USA) intraoral scanner, and three-dimensional dental digital models were acquired. The resulting scan images were transferred to OrthoCAD software (Align Technology, San Jose, California, USA) in which digital measurements were made for overbite, overjet, dystopia, total crowding and total diastema.

All lateral cephalograms were taken in centric occlusion with relaxed lips and natural head position using Cranex 3D (Soredex, Tuusula, Finland). The digitized cephalograms were analyzed using AudaxCeph® Ultimate software (Audax Ltd, Ljubljana, Slovenia), with automatic tracing and minor corrections done by one examiner. Fifty lateral cephalograms were randomly selected and re-analyzed by the same observer after one month.

In the eugnathic group, reference values were calculated and corrected analysis was determined for ten angular parameters: inclination of maxilla (SN/SpPm), inclination of mandible (SN/GoMe), intermaxillary angle (SpPm/GoMe), Y-axis (NSGn), Björk's polygon angles: saddle angle (NSAr), articular angle (SArGo), mandibular angle (MeGoAr) with its upper and lower segments, and Björk's sum.

For each patient in the test group, the facial growth pattern (horizontal, neutral or vertical) according to the reference values of the angles: SN/GoMe, SpPm/GoMe, NSGn, MeGoAr, upper and lower sections of MeGoAr and Björk's Sum were determined for both for the corrected and Zagreb 82 MOD analyses.

Statistical analysis

All statistical analyses were performed using the Statistica software package (TIBCO Statistica Version 14.0.0.15). Age variation between boys and girls was compared by the Mann-Whitney U test. Method error and intraexaminer reliability were measured using the Dahlberg formula and a paired T-test. The T-test was used to examine the differences between the corrected and the currently used Zagreb 82 MOD analysis. The McNemar test was performed to compare the distribution of facial growth patterns between the tested parameters within and between analyses.

Statistical significance was set at $p<.05$ for all tests.

Results

The study involved a diverse cohort of 179 participants. The gender distribution was nearly balanced, with 45.8% (n=82) for boys and 54.2% (n=97) for girls. The median age of the participants was 14 years within an interquartile range (IQR) of 13 to 15 years. This age had no significant variation

78,5° ± 3°, ANB 2,5° ± 2°, Wits -1 ± 2mm, Angleova klasa I, preklop 1 – 3,5 mm, pregriz 1 – 3,5 mm, distopija <3 mm, ukupna zbijenost < 3 mm, ukupna rastresitost < 3 mm;
2. Testna skupina (N = 129, M = 63, Ž = 66; prijeklop > 4 mm za duboki zagriz i prijeklop < -0,1 mm za otvoreni zagriz).

Svi koji nisu odgovarali kriterijima isključeni su iz istraživanja.

Pacijenti su intraoralno skenirani s pomoću intraoralnog skenera iTero Element 2 (Align Technology, San Jose, Kalifornija, SAD) i dobiveni su trodimenzionalni digitalni modeli zuba. Rezultirajući skenovi prebačeni su u softver OrthoCAD (Align Technology, San Jose, Kalifornija, SAD) u kojemu su obavljena digitalna mjerenja za prijeklop, pregriz, distopiju, ukupnu zbijenost i ukupnu rastresitost.

Svi LL-kefalogrami snimljeni su u centričnoj okluziji s opuštenim usnama i prirodnim položajem glave s pomoću Cranexa 3D (Soredex, Tuusula, Finska). Digitalizirani kefalogrami analizirani su softverom AudaxCeph® Ultimate (Audax d.o.o., Ljubljana, Slovenija), uz automatsko praćenje i manje ispravke koje je obavio jedan ispitivač. Pedeset LL-cefalograma nasumično je odabrano i ponovno ih je analizirao isti ispitivač poslije mjesec dana.

U skupini eugnatih izračunate su referentne vrijednosti i određena je korigirana analiza za deset kutnih parametara: inklinaciju maksile (SN/SpPm), inklinaciju mandibule (SN/GoMe), međučeljusni kut (SpPm/GoMe), Y-os (NSGn), kutove Björkova poligona: kut fleksije kranijalne baze (NSAr), zglobni kut (SArGo), mandibularni kut (MeGoAr) s gornjim i donjim odsječkom te Björkova suma.

Za svakog pacijenta u testnoj skupini određen je obrazac rasta lica (horizontalan, normalan ili vertikalan) prema referentnim vrijednostima kutova: SN/GoMe, SpPm/GoMe, NSGn, MeGoAr, gornji i donji odsječak MeGoAr i Björkova suma, unutar korigirane analize i analize *Zagreb 82 MOD*.

Statistička analiza

Sve statističke analize provedene su korištenjem programskog paketa Statistica (TIBCO Statistica Version 14.0.0.15). Dobna varijacija između dječaka i djevojčica uspoređena je Mann-Whitneyjevim U-testom. Pogreška metode i pouzdanost unutar ispitivača mjereni su s pomoću Dahlbergove formule i uparenoga T-testa. T-testom ispitane su razlike između korigirane i trenutačno korištene analize *Zagreb 82 MOD*. Proveden je McNemarov test da bi se usporedila distribucija obrazaca rasta lica između testiranih parametara unutar analiza i između njih.

Statistička značajnost postavljena je na $p < ,05$ za sve testove.

Rezultati

U studiji je sudjelovala raznolika kohorta od 179 ispitanika. Spolna distribucija bila je gotovo uravnotežena – 45,8 % (n = 82) dječaka i 54,2 % (n = 97) djevojčica. Prosječna dob bila je 14 godina unutar interkvartilnoga raspona (IQR) od 13 do 15 godina. Dob nije imala značajne varijacije između

Table 1 Means and standard deviations of the corrected and Zagreb82 MOD analysis. *p < .05
Tablica 1. Srednje vrijednosti i standardne devijacije korigirane analize i analize Zagreb 82 MOD *p < 0,05

Parameter	Definition	Corr. ref.values	Zagreb82 MOD	p
Inclination of maxilla	n-s:sp-pm	9.2 ± 1.7	9.5 ± 3.5	
Inclination of mandible	n-s:me-go	34.6 ± 2	/	
Y-axis	n-s-gn	67.4 ± 1.8	66.5 ± 3.5	*
Intermaxillary angle	sp-pm:me-go	25.4 ± 1.9	25 ± 5	
Saddle angle	n-s-ar	125 ± 3.9	123 ± 5	*
Articular angle	s-ar-go	143.1 ± 3.6	139.5 ± 5	*
Mandibular angle	me-go-ar	126.5 ± 2.7	127.5 ± 5	*
Björk's Sum	n-s-ar-go-me	394.6 ± 2	390 ± 5	*
Lower section of mandibular angle	n-go-me	73.2 ± 2.5	73.5 ± 3.5	
Upper section of mandibular angle	n-go-ar	53.2 ± 2.4	54.5 ± 4	*

Table 2 The proportion of diagnoses matching between the two analyses based on Björk's Sum
Tablica 2. Udio dijagnoza koje se podudaraju između dviju analiza na temelju Björkove sume

		Corrected values			Total
		Horizontal growth pattern	Neutral growth pattern	Vertical growth pattern	
Zagreb 82 MOD	Horizontal growth pattern	17	0	0	17
	Neutral growth pattern	47	10	0	57
	Vertical growth pattern	0	11	44	55
Total		64	21	44	129

Table 3 Distribution of growth pattern according to different parameters compared to the distribution according Björk's Sum, within the corrected and Zagreb 82 MOD analysis
Tablica 3. Distribucija obrasca rasta prema različitim parametrima u usporedbi s distribucijom prema Björkovu zbroju unutar korigirane analize i analize Zagreb 82 MOD

	Growth pattern	Zagreb82 MOD	p	Corr. analysis	p
Björk 's Sum	Horizontal (%)	13.20%		49.60%	
	Neutral (%)	44.20%		16.30%	
	Vertical (%)	42.60%		34.10%	
Intermaxillary angle	Horizontal (%)	32.50%		51.20%	
	Neutral (%)	45.00%	<.001	14.70%	0.748
	Vertical (%)	22.50%		34.10%	
Mandibular angle	Horizontal (%)	40.30%		47.30%	
	Neutral (%)	46.50%	<.001	28.70%	0.044
	Vertical (%)	13.20%		24.00%	
	Horizotal(%)	2.30%		17.10%	
Upper section of mandibular angle	Neutral(%)	70.50%		53.50%	
	Vertical(%)	27.10%	0.031	29.50%	0.03
	Horizontal(%)	41.10%		45.70%	
Lower section of mandibular angle	Neutral(%)	34.90%		27.10%	
	Vertical(%)	24.00%	<.001	27.10%	<.001
Y-axis	Horizontal (%)	14.70%		34.90%	
	Neutral (%)	55.00%	<.001	27.10%	0.003
	Vertical (%)	30.20%		38.00%	
Inclination of mandible	Horizontal (%)			49.60%	
	Neutral (%)	/		16.30%	1
	Vertical (%)			34.10%	

between boys and girls in all groups (p=.192), thus indicating a homogenous age distribution across sexes.

The average Dahlberg error across all parameters was 0.027, with a standard deviation of 0.024. This indicates a relatively low variability of the measurement error and underlines the precision of the cephalometric analysis performed. No statistically significant difference was found between the two measurement series.

A comparison of the reference values between the corrected analysis and the Zagreb 82 MOD analysis is shown in Table 1. All parameters of the corrected analysis showed a lower standard deviation than those of the Zagreb 82 MOD analysis. Statistically significant differences were found in the reference values of the Y-axis, saddle angle, articular angle, mandibular angle, Björk's Sum and the upper section of the mandibular angle.

The distribution of facial growth patterns according to Y-axis, intermaxillary angle, mandibular angle and Björk's sum differed significantly between the two analyses (p<.001). Table 2. illustrates the proportion of diagnoses matching between the two analyses based on Björk's Sum.

In the Zagreb 82 MOD analysis, the distribution of facial growth patterns differed significantly according to all tested parameters compared to Björk's sum, while the distribution of facial growth patterns in the corrected analysis showed no significant differences among Björk's sum, SpPm/MeGo and SN/MeGo angles (Table 3).

Discussion

Understanding the facial growth pattern in orthodontics is frequently highlighted in the literature (1, 11, 12), with the cephalometric vertical angular variables being the key parameters for determining it (6.-10.). Their reference values should correctly reflect the attributes of the average patient with a normal facial growth direction, since upper deviations mostly indicate a vertical facial growth pattern, and lower deviations indicate a horizontal facial growth pattern. This significantly affects timing, type and plan of orthodontic therapy. The inclination of mandible to the SN line has not been part of the existing Zagreb 82 MOD analysis so far, but it was introduced in this study because it is often used in the literature as an independent parameter for defining the facial growth pattern (13-15). The mean values of inclination of mandible obtained in this study (34.6°) coincide with the values obtained in other existing analyses and research (13, 16-19). While studies may differently define the mandibular base line, (GoMe or GoGn), these definitions do not have a significant impact in a clinical setting (16).

In this study, all examined parameters, apart from the inclination of maxilla, the intermaxillary angle and the lower segment of the mandibular angle, were significantly different between the corrected and the Zagreb 82 MOD analysis. The largest deviation was found in the mean values of the articular angle (3.60°) and the Björk's sum (4.60°). The reason for such a large difference may firstly lie in the methodology of cephalometric analysis. The Zagreb 82 MOD analysis was created 40 years ago by manually tracing the cephalograms,

dječaka i djevojčica u svim skupinama (p = ,192), što upućuje na homogenu dobnu distribuciju prema spolovima.

Prosječna Dahlbergova pogreška u svim parametrima bila je 0,027, sa standardnom devijacijom od 0,024. To upućuje na razmjerno malu varijabilnost pogreške u mjerenju i ističe preciznost provedene kefalometrijske analize. Nije pronađena statistički značajna razlika između dviju serija mjerenja.

Usporedba referentnih vrijednosti ispitanih kutnih parametara između korigirane analize i analize *Zagreb 82 MOD* prikazana je u tablici 1. Svi parametri korigirane analize pokazali su nižu standardnu devijaciju od onih u analizi *Zagreb 82 MOD*. Statistički značajne razlike utvrđene su u referentnim vrijednostima Y-osi, kutu fleksije kranijalne baze, zglobnome kutu, mandibularnome kutu, Björkovoj sumi i gornjemu odsječku mandibularnoga kuta.

Distribucija obrazaca rasta lica prema Y-osi, međučeljusnome kutu, mandibularnome kutu i Björkovoj sumi značajno se razlikovala između dviju analiza (p < ,001). Tablica 2. ilustrira udio dijagnoza koje se podudaraju između dviju analiza na temelju Björkove sume.

U analizi *Zagreb 82 MOD* distribucija obrazaca rasta lica značajno se razlikovala prema svim ispitivanim parametrima u usporedbi s Björkovom sumom, a distribucija obrazaca rasta lica u korigiranoj analizi nije pokazala značajne razlike između Björkove sume, SpPm/MeGo-a i SN/MeGo kutova (tablica 3.).

Rasprava

Razumijevanje obrasca rasta lica u ortodonciji često se ističe u literaturi (1, 11, 12), pri čemu su kefalometrijske vertikalne kutne varijable ključni parametri za njegovo određivanje (6 – 10). Budući da gornje devijacije uglavnom označavaju vertikalni obrazac rasta lica, a donje horizontalni, njihove referentne vrijednosti trebale bi ispravno odražavati atribute prosječnog pacijenta s normalnim smjerom rasta lica. To znatno utječe na vrijeme, vrstu i plan ortodontske terapije. Inklinacija mandibule prema SN liniji do sada nije bila dio postojeće analize *Zagreb 82 MOD*, ali je uvedena u ovu studiju jer se u literaturi često koristi kao samostalni parametar za definiranje obrasca rasta lica (13 – 15). Srednje vrijednosti inklinacije mandibule dobivene u ovoj studiji (34,6°) podudaraju se s vrijednostima u drugim postojećim analizama i istraživanjima (13, 16, 17). Iako se studije mogu razlikovati u načinu na koji definiraju baznu liniju mandibule (GoMe ili GoGn), te varijacije nemaju značajan klinički utjecaj (16).

U ovoj studiji svi ispitivani parametri, osim inklinacije maksile, međučeljusnoga kuta i donjega odsječka mandibularnoga kuta, značajno su se razlikovali između korigirane analize i analize *Zagreb 82 MOD*. Najveće odstupanje ustanovljeno je u srednjim vrijednostima zglobnoga kuta (3,60°) i Björkove sume (4,60°). Razlog tako velikoj razlici prije svega može biti u metodologiji kefalometrijske analize. Analiza *Zagreb 82 MOD* nastala je prije 40 godina ručnim precrtavanjem kefalograma, označavanjem kefalometrijskih točaka i mjerenjem kutomjerom. Danas su kefalogrami kvalitetniji,

marking the cephalometric points and measuring with an angle gauge. Today, cephalograms are of better quality. They are digital and can be enlarged, sharpened and analyzed using specialized software. Therefore, it is not surprising to find a deviation in the reference values of the corrected and Zagreb 82 MOD analysis, particularly in the Björk's sum, the value of which is the total of three angular measurements. The second explanation for the large difference between the mean values of certain skeletal parameters may be found in the presence of a general positive secular trend, which also refers to the increase in height of children with age (18, 19). Whether the increase in height affects the increase in craniofacial angular values is certainly a topic that should be addressed in more detail in the future. There are studies that have already confirmed the influence of secular trends on the growth of certain cephalometric variables (20), but recently there have been no studies that deal with the influence on vertical angular parameters.

The noticeable distinction in the corrected values of the analyzed parameters compared to the Zagreb 82 MOD analysis is further influenced by the findings related to the comparison of facial growth pattern distributions between the two analyses. When classifying patients by facial growth pattern according to the reference values of the tested parameters between the corrected and Zagreb82 MOD analyses, there was a statistically significant difference for Y-axis, intermaxillary angle, mandibular angle and Björk's sum. For the Björk's sum, that served the best for presentation (Table 2.), 20% of all patients, identified with the vertical facial growth pattern based on the Zagreb82 MOD analysis, fell within the normal facial growth category according to corrected values, while 80% of all patients who fit Zagreb82's definition of a normal facial growth pattern fell into the horizontal facial growth pattern, according to the corrected analysis. From this, it can be concluded that concerns raised in *Introduction* were justified, since the reference values of the Björk's sum from the Zagreb 82 MOD analysis determine the patient's facial growth pattern to be more vertical than the actual state of affair.

Yet another issue was found within the Zagreb82 MOD analysis itself, and it relates to the discrepancy between the Björk's sum and other parameters in determining the facial growth pattern. Table 3 shows that the distribution of the facial growth pattern according to other parameters differs significantly compared to the distribution according to the Björk's sum. This implies that in the Zagreb 82 MOD analysis there are no equivalent parameters for determining the facial growth pattern, therefore, for the same patient, their values may indicate different facial growth patterns. In the corrected analysis, there is no disparity in the distribution of the facial growth pattern according to SpPm/MeGo and SN/MeGo angles compared to Björk's sum, confirming that they are equivalent parameters for assessing the facial growth pattern, and that they should all indicate the same facial growth pattern within a single patient. This finding is expected considering that the value of the inclination of mandible is related by mathematical operations to the values of the inclination of maxilla and the intermaxillary angle (SN/

digitalni su i mogu se povećavati, izoštravati i analizirati specijaliziranim softverom. Zato ne čudi odstupanje u referentnim vrijednostima između korigirane analize i analize *Zagreb 82 MOD*, posebice u Björkovoj sumi čija je vrijednost zbroj triju kutnih mjerenja. Drugo objašnjenje za veliku razliku između srednjih vrijednosti pojedinih skeletnih parametara može se pronaći u postojanju općega pozitivnog sekularnog trenda koji se također odnosi na porast visine djece s dobi (18, 19). Utječe li povećanje visine tijela na povećanje vrijednosti kraniofacijalnih kutnih vrijednosti svakako je tema kojom bi se u budućnosti moglo detaljnije pozabaviti. Postoje istraživanja koja su već potvrdila utjecaj sekularnih trendova na rast pojedinih kefalometrijskih varijabli (20), no u novije vrijeme nema istraživanja koja se bave utjecajem na vertikalne kutne parametre.

Primjetnu razliku u korigiranim vrijednostima analiziranih parametara u usporedbi s analizom *Zagreb 82 MOD* potvrđuju i nalazi vezani za usporedbu distribucija obrazaca rasta lica između dviju analiza. Klasificirajući pacijente po obrascu rasta prema referentnim vrijednostima ispitivanih parametara između korigirane analize i analize *Zagreb 82 MOD*, utvrđena je statistički značajna razlika za Y-os, međučeljusni kut, mandibularni kut i Björkovu sumu. Za Björkovu sumu, koja najbolje služi prezentaciji (tablica 2.), 20 % svih pacijenata identificiranih s vertikalnim obrascem rasta lica na temelju analize *Zagreb 82 MOD* pripada kategoriji normalnoga rasta lica prema korigiranim vrijednostima, a 80 % svih pacijenata koji odgovaraju *Zagreb 82 MOD* definiciji normalnoga obrasca rasta lica imaju horizontalni obrazac rasta lica prema korigiranoj analizi. Iz ovoga se može zaključiti da su zabrinutosti iznesene u uvodu bile opravdane zato što referentne vrijednosti Björkove sume iz analize *Zagreb 82 MOD* određuju pacijentov obrazac rasta vertikalnijim nego što zapravo jest.

Drugi problem pronađen je u samoj analizi *Zagreb 82 MOD*, a odnosi se na nepodudaranje u određivanju obrasca rasta lica između Björkove sume i ostalih parametara. Tablica 3. pokazuje da se distribucija obrasca rasta lica prema ostalim parametrima značajno razlikuje od distribucije prema Björkovoj sumi. To implicira da u analizi *Zagreb 82 MOD* ne postoje ekvivalentni parametri za određivanje obrasca rasta lica, stoga za istog pacijenta njihove vrijednosti mogu upućivati na različite obrasce rasta lica. U korigiranoj analizi nema razlike u distribuciji obrasca rasta lica prema kutovima SpPm/MeGo i SN/MeGo u usporedbi s Björkovom sumom, što potvrđuje da su to jednakovrijedni parametri za procjenu obrasca rasta lica i da bi svi trebali upućivati na isti obrazac rasta lica unutar jednog pacijenta. Ovaj nalaz je očekivan s obzirom na to da je vrijednost inklinacije mandibule matematičkim operacijama povezana s vrijednostima inklinacije maksile i međučeljusnoga kuta (SN/MeGo = SN/SpPm + SpPm/MeGo) te vrijednostima Björkove sume (SN/MeGo = Björkova suma – 360°). Taj se odnos može provjeriti jednostavnim računanjem za korigiranu analizu, ali ne i za postojeću.

Rezultati ovog istraživanja podupiru korištenje korigiranih referentnih vrijednosti te uvođenje inklinacije mandibule kao značajnog parametra za kefalometrijsku analizu ortodontskih pacijenata.

MeGo=SN/SpPm+SpPm/MeGo), and the values of Björk's sum (SN/MeGo= Björk's sum-360°). This relationship can be verified through basic calculations for the corrected analysis, but not for the existing one.

The results of this study support the use of corrected reference values, as well as the introduction of the inclination of mandible as a notable parameter for the cephalometric analysis of orthodontic patients.

Conclusion

Within the limitations of this study, the results and discussion suggest that the corrected values are reliable in determining facial growth patterns.

Intermaxillary angle, Björk's sum, and inclination of the mandible are equally valid parameters in determining facial growth patterns within the corrected analysis.

Inclination of the mandible can be an integral part of conventional cephalometric analysis.

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Author's contribution: Conceptualization, Methodology, Formal Analysis, Writing – Review & Editing **I.P.A, L.Š., M.L.V.**; Investigation, Data Curation,. **I.P.A, L.Š**; Writing – Original Draft Preparation, **I.P.A.**; Supervision, **M.L.V**; All authors have read and agreed with the published version of the manuscript.

Zaključak

Unutar ograničenja ove studije, rezultati i rasprava sugeriraju da su korigirane vrijednosti pouzdane u određivanju obrazaca rasta lica.

Međučeljusni kut, Björkova suma i inklinacija mandibule jednako su valjani parametri u određivanju obrazaca rasta lica unutar korigirane analize.

Inklinacija mandibule može biti sastavni dio konvencionalne kefalometrijske analize.

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Sažetak

Cilj: Ispitivala se točnost i pouzdanost postojeće kefalometrijske analize *Zagreb 82 MOD* u određivanju obrasca rasta lica. **Materijali i metode:** Svim pacijentima u dobi od 10 do 17 godina sa svim trajnim zubima i bez kraniofacijalnih anomalija i prethodne ortodontske anamneze koji su posjećivali Kliniku za ortodonciju KBC-a Zagreb 2021. i 2022. godine, pregledani su LL-kefalogrami i digitalni dentalni model. Ispitanici su podijeljeni u dvije skupine s obzirom na sljedeće kriterije: u skupinu eugnatih (N = 50, SNA 81° ± 3,5°, SNB 78,5° ± 3°, ANB 2,5° ± 2°, Wits -1 ± 2 mm, Angleova klasa I, prijeklop 1 – 3,5 mm, pregriz 1 – 3,5 mm, distopija < 3 mm, ukupna zbijenost < 3 mm, ukupna rastresitost < 3 mm) i u testnu skupinu (N = 129, prijeklop > 4mm za duboki zagriz i prijeklop < -0,1 mm za otvoreni zagriz).U skupini eugnatih izračunate su referentne vrijednosti za deset ispitanih skeletnih parametara i stvorena je korigirana analiza. U testnoj skupini pacijentima su utvrđeni obrasci rasta lica (horizontalni, normalni ili vertikalni) prema korigiranoj i *Zagreb 82 MOD* analizi. Za ispitane parametre T-testom su provjerene razlike između korigirane analize i analize *Zagreb 82 MOD*. McNemarov test proveden je da bi se usporedila distribucija obrazaca rasta lica između ispitanih parametara unutar i između dviju analiza. **Rezultati:** Uočene su razlike u referentnim vrijednostima kuta fleksije kranijalne baze, Y-osi, zglobnoga kuta, mandibularnoga kuta, Björkove sume i gornjeg segmenta mandibularnoga kuta ($p < ,05$). Distribucija obrazaca rasta lica prema Y-osi, međučeljusnom kutu, mandibularnom kutu i Björkovoj sumi također se razlikovala između dviju analiza ($p < ,001$). Unutar korigirane analize nije bilo značajne razlike u distribuciji obrazaca rasta lica između Björkove sume, inklinacije mandibule i međučeljusnoga kuta ($p > ,05$). **Zaključak:** Pouzdanost analize *Zagreb 82 MOD* u definiranju obrasca rasta lica treba uzeti s dozom opreza. Björkova suma, međučeljusni kut i inklinacija mandibule jednakovrijedni su parametri u određivanju obrasca rasta lica unutar korigirane analize.

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