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Digital Analysis of Occlusal Contacts in Angle Class II and Class III Malocclusion

Digitalna analiza okluzijskih kontakata u slučajevima malokluzija klase II i III prema Angleu

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Abstract
Objective: To evaluate the number, interocclusal distance categories, and spatial distribution of occlusal contacts per subject in Angle Class II and Class III malocclusions using digital intraoral models. **Materials and Methods:** This exploratory, cross-sectional study evaluated 60 untreated subjects (30 Class II, 30 Class III). Digital models were obtained via the Medit i600 intraoral scanner, and contact analysis was performed using the Medit Occlusion Analyzer software. Variables represented the cumulative number of teeth per subject. Data were analyzed using median and interquartile range (IQR). Intergroup comparisons were performed using Mann–Whitney U tests $\alpha = 0.05$), with effect size estimated using rank-biserial correlation (r_B). **Results:** Premolar contacts showed no significant intergroup differences regarding interocclusal distance ($p > 0.05$). However, Class III subjects exhibited significantly more molar contacts within the 0.050–0.100 mm distance range ($p = 0.018$). Full-surface contacts were significantly more frequent in Class II patients for both premolars ($p = 0.002$) and molars ($p = 0.007$). Class II subjects also showed a highly significant complete absence of molar contacts ($p < 0.001$). Palatal distribution of premolar contacts showed a borderline difference ($p = 0.044$), interpreted as a clinical trend. **Conclusion:** Digital analysis revealed specific patterns in the interocclusal distance and distribution of occlusal contacts in Angle Class II and Class III malocclusions. Intraoral scanning provided objective geometric data that can serve as a valuable adjunct for individualized treatment planning.

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Introduction

Facial aesthetics and smile harmony are closely linked to both tooth alignment and functional occlusal relationships.[1, 2] Modern orthodontic treatment aims not only to improve dental and facial aesthetics but also to achieve functional stability and long-term occlusal balance.[3, 4] Accurate and precise evaluation of occlusal contacts is an essential component of orthodontic diagnosis and treatment planning (5, 6).

Occlusal contacts play a crucial role in the functional balance of the stomatognathic system, influencing the distribution of masticatory forces, dental arch stability, and periodontal health. Altered occlusal contact patterns are frequently associated with sagittal malocclusions, particularly Angle Class II and Class III malocclusions, where discrepancies in maxillomandibular relationships can lead to uneven force transmission and compromised intercuspation (2, 7, 8).

Traditionally, the evaluation of occlusal contacts relied on articulating paper, wax indices, and plaster models. Although these methods are widespread in clinical practice,

Uvod

Estetika lica i skladan osmijeh usko su povezani s poravnanjem zuba i funkcionalnim okluzijskim odnosima (1, 2). Suvremenom ortodontskom liječenju nije cilj samo poboljšati dentalnu i facijalnu estetiku, nego i postići funkcionalnu stabilnost i dugoročnu okluzijsku ravnotežu (3, 4). Točna i precizna procjena okluzijskih kontakata ključna je sastavnica ortodontske dijagnostike i planiranja liječenja (5, 6).

Okluzijski kontakti iznimno su važni u funkcionalnoj ravnoteži stomatognatnoga sustava i utječu na raspodjelu žvačnih sila, stabilnost zubnih lukova i zdravlje parodonta. Promijenjeni obrasci okluzijskih kontakata često su povezani sa sagitalnim malokluzijama, osobito Angleovim malokluzijama klase II i III kod kojih nerazmjeri u maksilomandibularnim odnosima mogu potaknuti neujednačeni prijenos sila i narušenu interkuspidaciju (2, 7, 8).

Tradicionalno se procjena okluzijskih kontakata temeljila na artikulacijskome papiru, voštanim registratima i gipsanim modelima. Iako su te metode česte u kliničkoj praksi, they offer limited qualitative information and are subject to subjective interpretation by the clinician (9). Furthermore, they do not allow for precise quantification of the interocclusal distance or their three-dimensional spatial localization (10-12).

Intraoral scanners represent a significant technological advancement that has transformed digital diagnostics in modern dentistry and orthodontics. These technologies enable high-precision acquisition and digital storage of dental structure data, leading to substantial improvements in diagnostic and therapeutic processes. In addition to diagnostics, the gradual transition toward fully digital workflows in orthodontic practice also enables more precise fabrication of removable retention appliances using 3D printing, aimed at maintaining the long-term stability of orthodontic treatment outcomes, although further research is still required regarding their durability under intraoral conditions (13). The precision of intraoral scanning allows for detailed three-dimensional reconstruction of tooth morphology, while specialized software platforms provide precise, reproducible, and objective analysis of occlusal relationships, thereby increasing diagnostic value (11, 14, 15). These systems enable detailed assessment of the number of occlusal contacts, interocclusal distance, and spatial distribution across different tooth surfaces (11, 16).

Despite the increasing use of digital occlusal analysis in orthodontics, data regarding the characteristics of occlusal contacts in untreated patients with Angle Class II and Class III malocclusions remain limited. Comparative analyses focusing on the interocclusal distance and spatial distribution of posterior contacts using intraoral scanning systems are rare. Therefore, the aim of this study was to perform a digital analysis of the number, interocclusal distance categories, and spatial distribution of occlusal contacts in patients with Angle Class II and Class III malocclusions, using three-dimensional intraoral models obtained via the Medit i600 scanner and analyzed using the Medit Occlusion Analyzer software.

Materials and Methods

Study Design and Participants

This exploratory, comparative, cross-sectional study included a sample of 60 untreated patients aged 15–20 years. The participants were divided into two groups according to the sagittal classification of malocclusions: Angle Class II (n = 30) and Angle Class III (n = 30). The orthodontic diagnosis and allocation of subjects into groups were established exclusively based on a detailed clinical assessment of the Angle occlusal relationship in the position of maximum intercuspation, considering the relationships of the first permanent molars and canines bilaterally.

The study was approved by the Ethics Committee at the Faculty of Dentistry, "Ss. Cyril and Methodius" University in Skopje, North Macedonia (Approval No. 2024-09-1984/2) and was conducted in accordance with the Declaration of Helsinki. The reporting of this study followed the STROBE guidelines. Prior to enrollment, written informed consent was obtained from all participants or their legal guardians.

pružaju ograničene kvalitativne informacije i podložne su subjektivnoj interpretaciji kliničara (9). Nadalje, ne omogućuju preciznu kvantifikaciju međučeljusne udaljenosti, ni njezinu trodimenzionalnu prostornu lokalizaciju (10 – 12).

Intraoralni skeneri golem su tehnološki napredak koji je promijenio digitalnu dijagnostiku u suvremenoj dentalnoj medicini i ortodonciji. Ta tehnologija omogućuje visokoprecizno prikupljanje i digitalno pohranjivanje podataka o dentalnim strukturama, što znatno poboljšava dijagnostičke i terapijske postupke. Uz dijagnostiku, postupni prijelaz prema potpuno digitalnim radnim procesima u ortodontskoj praksi omogućuje i precizniju izradu mobilnih retencijskih naprava primjenom 3D ispisa, sa svrhom održavanja dugoročne stabilnosti ishoda ortodontskog liječenja, iako su potrebna daljnja istraživanja njihove trajnosti u intraoralnim uvjetima (13). Preciznost intraoralnoga skeniranja omogućuje detaljnu trodimenzionalnu rekonstrukciju morfologije zuba, a specijalizirane softverske platforme preciznu, reproducibilnu i objektivnu analizu okluzijskih odnosa, čime se povećava dijagnostička vrijednost (11, 14, 15). Ti sustavi omogućuju detaljnu procjenu broja okluzijskih kontakata, međučeljusne udaljenosti i prostorne distribucije na različitim zubnim površinama (11, 16).

Unatoč sve češćoj primjeni digitalne okluzijske analize u ortodonciji, podatci o obilježjima okluzijskih kontakata neliječenih pacijenata s Angleovim malokluzijama klase II i III i dalje su ograničeni. Rijetke su komparativne analize usmjerene na međučeljusnu udaljenost i prostornu distribuciju stražnjih kontakata primjenom sustava za intraoralno skeniranje. Zato je svrha ovog istraživanja bila obaviti digitalnu analizu broja, kategorija međučeljusne udaljenosti i prostorne distribucije okluzijskih kontakata kod pacijenata s Angleovim malokluzijama klase II i III, primjenom trodimenzionalnih intraoralnih modela dobivenih skenerom Medit i600 i analiziranih u softveru Medit Occlusion Analyzer.

Materijali i metode

Dizajn istraživanja i ispitanici

Ovo eksplorativno, komparativno, presječno istraživanje obuhvatilo je uzorak od 60 neliječenih pacijenata u dobi od 15 do 20 godina. Ispitanici su podijeljeni u dvije skupine prema sagitalnoj klasifikaciji malokluzija: Angleova klasa II (n = 30) i Angleova klasa III (n = 30). Ortodontska dijagnoza i razvrstavanje u skupine temeljili su se isključivo na detaljnoj kliničkoj procjeni Angleova okluzijskoga odnosa u položaju maksimalne interkuspidacije, uzimajući u obzir odnose prvih trajnih kutnjaka i očnjaka obostrano.

Istraživanje je odobrilo Etičko povjerenstvo Stomatološkog fakulteta Sveučilišta Sv. Ćiril i Metod u Skoplju, Sjeverna Makedonija (broj odobrenja 2024-09-1984/2) i provedeno je u skladu s Helsinškom deklaracijom. Izvještavanje o istraživanju provedeno je prema smjernicama STROBE-a. Prije uključivanja u istraživanje svi su ispitanici, ili njihovi zakonski skrbnici, potpisali informirani pristanak.

Svi ispitanici imali su potpuno iznikle trajne zube (uz iznimku trećih kutnjaka koji su isključeni iz analize). U ovoj

All participants had fully erupted permanent teeth (with the exception of third molars, which were excluded from the analysis). In this age group (15–20 years), this typically coincides with the final stages of skeletal jaw maturation. Although skeletal age was not measured via cephalometric radiographs or hand-wrist radiographs, the age group was deliberately selected to ensure that the peak of pubertal growth had passed in the majority of subjects.

Inclusion criteria: subjects aged 15–20 years with a full permanent dentition, no history of prior orthodontic treatment, absence of craniofacial anomalies, or significant dental restorations such as extensive composite fillings or inlays that alter the morphology of the occlusal surface.

Exclusion criteria: temporomandibular disorders, extensive prosthetic restorations, missing posterior teeth, and systemic conditions affecting bone metabolism. To ensure high clinical homogeneity and eliminate factors that directly influence the anatomical position of contact points, strict additional criteria were applied: patients with transversal anomalies (posterior crossbite), vertical deviations (open bite), as well as severe primary dental crowding were eliminated from the study**.** Furthermore, patients wearing athletic mouthguards were excluded to eliminate potential transient changes in tooth position or neuromuscular adaptations that could affect the accuracy of the analysis. Finally, third molars were excluded from the analysis in all subjects due to their frequently atypical morphology and high variability in eruption timing, which could compromise the standardized occlusal measurements.

Procedures and Digital Analysis

Digital impressions of both dental arches were acquired using an intraoral scanner (Medit i600; Medit Corp., Seoul, South Korea), operated via the Medit Link software platform. To minimize operator-dependent variability, all scans were performed by a single experienced operator following the manufacturer-recommended protocol. Prior to the initiation of the study, a training and calibration protocol was conducted on 10 subjects to confirm the intraoperator consistency during scanning. Before commencing the scanning procedure, each participant was instructed on correct biting in maximum intercuspation (MIP). The accuracy of the occlusion was visually verified by the operator before and during digital recording, and the digital record was compared with the clinical presentation to ensure precision.

The obtained three-dimensional digital models were exported in STL format. Subsequently, an occlusal contact analysis was performed using the Medit Occlusion Analyzer software. The digital models were analyzed via automatic software bite registration in maximum intercuspation, and occlusal contacts were automatically detected based on interocclusal distance values. All automatically mapped contacts were additionally verified visually by a single examiner to confirm accurate software registration. For the purpose of spatial contact localization, posterior teeth (premolars and molars) were operationally defined across three anatomical surfaces: buccal (buccal cusp slopes), palatal/lingual (palatal/lingual slopes), and occlusal (central fissure and marginal ridges). The

dobnoj skupini (15 – 20 godina) to se uobičajeno podudara sa završnim fazama sazrijevanja kostura čeljusti. Iako skeletna dob nije procijenjena kefalometrijskim snimkama, ni snimkama šake i ručnoga zgloba, dobna je skupina namjerno odabrana kako bi se osiguralo da je većini ispitanika već prošao vrhunac pubertetskoga rasta.

Kriteriji za uključivanje: ispitanici u dobi od 15 do 20 godina s potpunom trajnom denticijom, bez prethodnoga ortodontskoga liječenja, bez kraniofacijalnih anomalija ili značajnih dentalnih restauracija poput opsežnih kompozitnih ispuna ili inleja koji mijenjaju morfologiju okluzijske površine.

Kriteriji za isključivanje: temporomandibularni poremećaji, opsežne protetičke restauracije, nedostatak stražnjih zuba i sustavna stanja koja utječu na metabolizam kosti. Da bi se osigurala visoka klinička homogenost i uklonili čimbenici koji izravno utječu na anatomsku poziciju kontaktnih točaka, primijenjeni su strogi dodatni kriteriji: iz istraživanja su isključeni pacijenti s transverzalnim anomalijama (stražnji križni zagriz), vertikalnim odstupanjima (otvoreni zagriz) i teškom primarnom dentalnom zbijenošću. Nadalje, pacijenti koji su nosili sportske štitnike za zube isključeni su da bi se uklonile moguće prolazne promjene u položaju zuba ili neuromuskularne prilagodbe koje bi mogle utjecati na točnost analize. Konačno, treći kutnjaci isključeni su iz analize zbog njihove često netipične morfologije i velike varijabilnosti tijekom nicanja, što bi moglo ugroziti standardizirana okluzijska mjerenja.

Postupci i digitalna analiza

Digitalni otisci obaju zubnih lukova dobiveni su intraoralnim skenerom (Medit i600; Medit Corp., Seul, Južna Koreja) kojim se upravljalo putem softverske platforme Medit Link. Da bi se smanjila varijabilnost ovisna o operateru, sva je skeniranja obavio jedan iskusni operater prema protokolu koji je preporučio proizvođač. Prije početka istraživanja 10 ispitanika sudjelovalo je u protokolu edukacije i kalibracije da bi se potvrdila intraoperaterska konzistentnost tijekom skeniranja. Prije početka skeniranja svakom je ispitaniku objašnjen pravilan zagriz u maksimalnoj interkuspidaciji (MIP). Operater je vizualno provjeravao točnost okluzije prije digitalnog snimanja i tijekom toga postupka, a digitalni zapis uspoređen je s kliničkom slikom kako bi se osigurala preciznost.

Dobiveni trodimenzionalni digitalni modeli preneseni su u STL formatu. Nakon toga analiza okluzijskih kontakata obavljena je u softveru Medit Occlusion Analyzer. Digitalni modeli analizirani su automatskom registracijom zagriza u maksimalnoj interkuspidaciji, a okluzijski kontakti automatski su detektirani na temelju vrijednosti međučeljusne udaljenosti. Sve automatski mapirane kontakte dodatno je vizualno provjerio jedan ispitivač da bi se potvrdila točna registracija s pomoću softvera. Za potrebe prostorne lokalizacije kontakata stražnji zubi (pretkutnjaci i kutnjaci) operativno su definirani na temelju triju anatomskih površina: bukalne (nagibi bukalnih kvržica), palatinalne/lingvalne (palatinalni/lingvalni nagibi) i okluzijske (središnja fisura i marginalni grebeni). Međučeljusna udaljenost procijenjena je ljestvicom

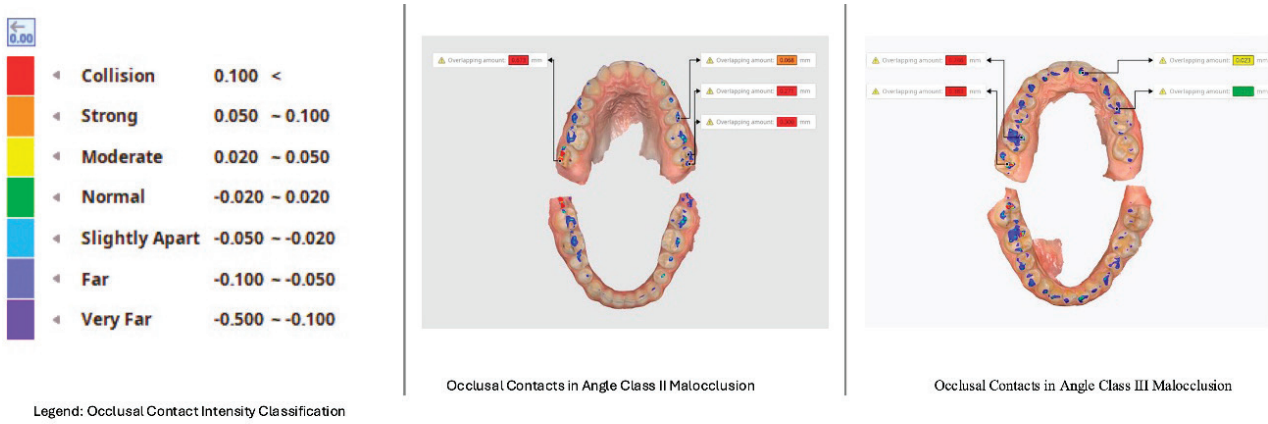

Figure 1 Classification of interocclusal distance categories. The visualization demonstrates the spatial distribution of occlusal contacts based on the color-coded distance scale (in millimeters) within the Medit Occlusion Analyzer software.
Slika 1. Klasifikacija kategorija međučeljusne udaljenosti; uočava se prostorna distribucija okluzijskih kontakata na temelju ljestvice udaljenosti označene bojama (u milimetrima) unutar softvera Medit Occlusion Analyzer

interocclusal distance was evaluated using a color-coded scale: contacts within the range of 0.050–0.100 mm, 0.020–0.050 mm, and slightly separated surfaces from -0.050 to -0.020 mm. Contacts within these geometric ranges were considered clinically relevant and the most stable parameters for differentiation between different malocclusions (Figure 1).

Statistical Analysis

Statistical analysis was performed using JASP software (version 0.95.4.0). Descriptive statistics were calculated for the interocclusal distance categories (proximity), localization, and distribution of occlusal contacts in the premolar and molar regions bilaterally. Data were presented as frequencies and percentages for categorical variables, and as medians with interquartile ranges (IQR) for continuous summary variables.

It is fundamental to emphasize that the statistical unit of analysis in this study was the patient (N = 60; 30 in Class II and 30 in Class III). For each individual subject, the primary data obtained from the Medit software were aggregated at the patient level. Because the analyzed variables represent discrete count data (number of teeth ranging from 0 to 4 within the functional pairs per subject) with a pronounced deviation from a normal distribution, which was confirmed by the Shapiro–Wilk test ($p < 0.001$), parametric methods were inappropriate.

The primary choice for intergroup comparisons between Angle Class II and Class III malocclusions was the non-parametric Mann–Whitney U test, performed exclusively on the summarized data at the patient level. To complement this analysis and quantify the magnitude of the differences, effect sizes were estimated using the rank-biserial correlation (\(r_ {B}\)). This entire procedure prevented the risk of pseudo replication, which would have occurred if individual teeth or contacts had been treated as independent observations.

Given the exploratory nature of this study and the large number of comparisons performed across different anatomical zones, contact types, and interocclusal distances, a formal statistical correction for multiple testing (such as Bonferroni) was not applied. Instead, all obtained p-values were

označenom bojama: kontakti unutar raspona od 0,050 do 0,100 mm, od 0,020 do 0,050 mm te blago odvojene površine od −0,050 do −0,020 mm. Kontakti unutar tih geometrijskih raspona smatrani su klinički relevantnima i najstabilnijim parametrima za razlikovanje različitih malokluzija (slika 1.).

Statistička analiza

Statistička analiza obavljena je u softveru JASP (verzija 0.95.4.0). Deskriptivna statistika izračunata je za kategorije međučeljusne udaljenosti (blizina), lokalizaciju i distribuciju okluzijskih kontakata u regiji kutnjaka i pretkutnjaka obostrano. Podatci su prikazani kao frekvencije i postotci za kategorijske varijable te kao medijani s interkvartilnim rasponima (IQR) za kontinuirane sažete varijable.

Važno je istaknuti da je statistička jedinica analize u ovom istraživanju bio pacijent (N = 60; 30 u klasi II i 30 u klasi III). Za svakoga ispitanika primarni podatci dobiveni s pomoću softvera Medit agregirani su na razinu pacijenta. Budući da su analizirane varijable diskretni podatci o brojenju (broj zuba od 0 do 4 unutar funkcionalnih parova po ispitaniku) s izraženim odstupanjem od normalne distribucije, što je potvrđeno Shapiro-Wilkovim testom ($p < 0{,}001$), parametrijske metode nisu bile primjerene.

Primarni izbor za usporedbe među skupinama između Angleovih malokluzija klase II i III bio je neparametrijski Mann–Whitneyjev U-test, proveden isključivo na sažetim podatcima na razini pacijenta. Kako bi se ta analiza dopunila i kvantificirala veličina razlika, veličina učinka procijenjena je rang-biserijalnom korelacijom (rB). Cijeli je taj postupak spriječio rizik od pseudoreplikacije koja bi se dogodila kada bi se pojedinačni zubi ili kontakti tretirali kao neovisne opažajne jedinice.

S obzirom na eksplorativnu prirodu ovoga istraživanja i velik broj usporedbi provedenih za različite anatomske zone, vrste kontakata i međučeljusne udaljenosti, nije primijenjena formalna korekcija za višestruko testiranje (poput Bonferronijeve korekcije). Umjesto toga sve dobivene p-vrijednosti interpretirane su kao eksplorativne i razmatrane su s oprezom, pri čemu je primarni fokus bio na kliničkoj relevantnosti i interpreted as exploratory and were considered with caution, focusing primarily on the clinical relevance and magnitude of the differences. The level of statistical significance for all tests was set at $p < 0.05$.

veličini razlika. Razina statističke značajnosti za sve testove postavljena je na p < 0,05.

Results

Interocclusal Distance of Occlusal Contacts

A statistically significant difference was identified in molar contacts within the distance range of 0.050–0.100 mm (U = 299.5, p = 0.018), with higher values observed in the Class III group. The effect size demonstrated a moderate difference (rank-biserial correlation r_B = 0.304. No significant differences were observed regarding the interocclusal distance of occlusal contacts between Class II and Class III subjects for premolars in any distance range, nor for molars within the 0.020–0.050 mm range (U = 449.0, p = 0.992). Occlusal contacts in both groups were predominantly located in the posterior segments, specifically in the premolar and molar regions, while minimal contact involvement was noted in the anterior teeth. This minimal anterior involvement was consistent across both malocclusion classes. (Table 1)

Rezultati

Međučeljusna udaljenost okluzijskih kontakata

Utvrđena je statistički značajna razlika u kontaktima kutnjaka unutar raspona udaljenosti od 0,050 do 0,100 mm (U = 299,5, p = 0,018), pri čemu su više vrijednosti zabilježene u skupini klase III. Veličina učinka pokazala je umjerenu razliku (rang-biserijalna korelacija rB = 0,304). Nisu ustanovljene značajne razlike u međučeljusnoj udaljenosti okluzijskih kontakata između ispitanika klase II i III za pretkutnjake ni u jednom rasponu udaljenosti, kao ni za kutnjake unutar raspona od 0,020 do 0,050 mm (U = 449,0, p = 0,992). Okluzijski kontakti u objema skupinama bili su pretežno smješteni u stražnjim segmentima, točnije u regiji kutnjaka i pretkutnjaka, a minimalna uključenost kontakata zabilježena je na prednjim zubima. Ta minimalna uključenost prednjih zuba bila je konzistentna u objema skupinama malokluzija (tablica 1.).

Table 1 Comparison of occlusal contact parameters between Angle Class II and Class III malocclusions.
Tablica 1. Usporedba parametara okluzijskih kontakata između Angleovih malokluzija klase II i III

Occlusal Variable / Parameter (Unit: Number of teeth per subject)	Class II Median (IQR) (n=30)	Class III Median (IQR) (n=30)	Mann–Whitney U	p-value	Effect Size (rB)
Interocclusal Distance Categories					
Premolars (0.020–0.050 mm)	0.000 (0.750)	0.000 (1.000)	422.0	0.608	0.096
Premolars (0.050–0.100 mm)	2.500 (2.000)	2.500 (2.000)	407.0	0.506	0.051
Molars (0.020–0.050 mm)	0.000 (0.750)	0.000 (0.000)	449.0	0.992	0.002
Molars (0.050–0.100 mm)	2.000 (4.000)	4.000 (2.000)	299.5	**0.018**	**0.304**
Spatial Surface Distribution					
Premolars — Buccal	0.000 (1.750)	0.000 (1.750)	464.5	0.807	0.016
Premolars — Palatal	0.000 (1.000)	0.000 (0.000)	558.5	**0.044**	**0.241**
Premolars — Occlusal	2.000 (2.000)	2.000 (2.000)	492.5	0.509	0.081
Molars — Buccal	0.000 (0.000)	0.000 (0.000)	429.5	0.661	0.054
Molars — Palatal	0.000 (1.000)	0.000 (0.000)	536.0	0.088	0.286
Molars — Occlusal	2.000 (1.750)	1.000 (2.000)	542.0	0.157	0.237
Distribution by Contact Points					
Premolars — 2 contact points	1.000 (2.000)	0.500 (2.000)	456.0	0.930	0.013
Premolars — Complete occlusal surface	2.000 (2.000)	0.000 (0.000)	630.0	**0.002**	**0.400**
Premolars — Without any contacts	0.000 (0.000)	0.000 (0.000)	480.5	0.453	0.109
Molars — 2 contact points	0.000 (1.750)	1.500 (2.000)	358.5	0.147	0.213
Molars — Complete occlusal surface	2.000 (1.000)	0.000 (1.000)	622.5	**0.007**	**0.383**
Molars — Without any contacts	0.000 (1.000)	0.000 (0.000)	616.5	**< 0.001**	**0.370**

Note: Data are presented as median and interquartile range (IQR). The statistical unit of analysis is the individual patient (N = 60; n = 30 per group). For each subject, primary occlusal data were aggregated at the patient level, and the analyzed variables in the rows are defined as the total cumulative number of teeth per patient (ranging from 0 to 4 within the functional pairs for the premolar and molar regions bilaterally) that meet specific occlusal criteria. U, Mann–Whitney U test statistic; p, statistical significance ($p < 0.05$). r_B, rank-biserial correlation representing the effect size for non-parametric comparisons, reported as absolute magnitude. A formal statistical correction for multiple testing was not applied due to the exploratory nature of the study; all p-values are to be interpreted as exploratory. Statistically significant differences ($p < 0.05$) are highlighted in bold. • Napomena: Podatci su prikazani kao medijan i interkvartilni raspon (IQR). Statistička jedinica analize je pojedinačni pacijent (N = 60; n = 30 po skupini). Za svakoga ispitanika primarni okluzijski podatci agregirani su na razini pacijenta, a analizirane varijable u redcima definirane su kao ukupan kumulativni broj zuba po pacijentu (u rasponu od 0 do 4 unutar funkcionalnih parova u regiji pretkutnjaka i kutnjaka obostrano) koji zadovoljavaju specifične okluzijske kriterije. Statistika Mann-Whitneyjeva U-testa; p, statistička značajnost (p < 0,05). rB, rang-biserijalna korelacija koja pokazuje veličinu učinka za neparametrijske usporedbe, prikazana je kao apsolutna vrijednost. Formalna statistička korekcija za višestruko testiranje nije primijenjena zbog eksplorativne prirode istraživanja; sve p-vrijednosti treba interpretirati kao eksplorativne. Statistički značajne razlike (p < 0,05) istaknute su podebljanim slovima.

Spatial Distribution of Occlusal Contacts on Tooth Surfaces

A statistically significant difference was observed in the palatal distribution of contacts for premolars (U = 558.5, p = 0.044), with a higher number of affected teeth in the Class II group. The effect size indicated a moderate difference (rank-biserial correlation r_B = 0.241. The spatial distribution of occlusal contacts did not differ significantly between the groups for either premolars or molars in the buccal and occlusal regions (p > 0.05). (Table 1)

Distribution of Occlusal Contacts According to the Number of Contact Points

Complete occlusal-surface contacts were significantly more frequent in the Class II group for both premolars (U = 630, p = 0.002, rank-biserial correlation r_B = 0.400) and molars (U = 622.5, p = 0.007, rank-biserial correlation r_B = 0.383 (Table 1).

Additionally, a highly statistically significant difference was established regarding the complete absence of contacts in the molar region (U = 616.5, p < 0.001), with this phenomenon being significantly more prevalent among Class II subjects, demonstrating a moderate-to-strong effect size (rank-biserial correlation r_B = 0.370) No significant differences between the groups were observed only regarding two-point contacts for both premolars and molars, as well as for the absence of contacts in the premolar region (p > 0.05) (Table 1).

Discussion

Analysis of occlusal contacts is a fundamental component in evaluating occlusal function and stability, particularly in patients with sagittal malocclusions. In the present study, using an intraoral scanner facilitated an objective and reproducible assessment, successfully overcoming the inherent limitations associated with traditional qualitative methods.

Spatial Distribution of Contacts

The spatial analysis demonstrated that occlusal contacts were predominantly localized within the posterior segments of the dental arches, exhibiting the highest frequency in the molar region and lesser involvement in the premolar region, whereas the anterior teeth displayed minimal contact participation. Statistical comparisons between the groups revealed that most spatial parameters were comparable; only the palatal distribution of contacts for premolars demonstrated a statistically significant difference. However, since this finding lies at the borderline of statistical significance and given the exploratory nature of this study without formal correction for multiple comparisons, this outcome must be interpreted with caution and primarily regarded as a clinical trend requiring further validation in larger sample sizes. This subtle variation, detected through digital analysis, highlights how specific malocclusion types directly impact the interarch relationship and the resulting localization of contacts.

In comparison with established literature, the predominance of occlusal contacts within the posterior region aligns

Prostorna distribucija okluzijskih kontakata na zubnim površinama

Utvrđena je statistički značajna razlika u palatinalnoj distribuciji kontakata na pretkutnjacima (U = 558,5, p = 0,044), pri čemu je veći broj zahvaćenih zuba zabilježen u skupini klase II. Veličina učinka upućivala je na umjerenu razliku (rang-biserijalna korelacija rB = 0,241). Prostorna distribucija okluzijskih kontakata nije se značajno razlikovala između skupina ni za pretkutnjake, ni za kutnjake u bukalnim i okluzijskim regijama (p > 0,05) (tablica 1.).

Distribucija okluzijskih kontakata prema broju kontaktnih točaka

Kontakti preko cijele okluzijske površine bili su značajno češći u skupini klase II i na pretkutnjacima (U = 630, p = 0,002, rang-biserijalna korelacija rB = 0,400) i na kutnjacima (U = 622,5, p = 0,007, rang-biserijalna korelacija rB = 0,383) (tablica 1.).

Nadalje, utvrđena je statistički vrlo značajna razlika s obzirom na potpunu odsutnost kontakata u regiji kutnjaka (U = 616,5, p < 0,001), pri čemu je ta pojava bila češća među ispitanicima klase II, uz umjereno do snažno izraženu veličinu učinka (rang-biserijalna korelacija rB = 0,370). Nisu utvrđene značajne razlike između skupina samo s obzirom na kontakte u dvjema točkama za pretkutnjake i kutnjake, ni s obzirom na odsutnost kontakata u premolarnoj regiji/u regiji pretkutnjaka (p > 0,05) (tablica 1.).

Rasprava

Analiza okluzijskih kontakata temeljna je sastavnica procjene okluzijske funkcije i stabilnosti, osobito kod pacijenata sa sagitalnim malokluzijama. Uspješno prevladavajući inherentna ograničenja povezana s tradicionalnim kvalitativnim metodama, u ovom istraživanju primjena intraoralnoga skenera omogućila je objektivnu i reproducibilnu procjenu.

Prostorna distribucija kontakata

Prostorna analiza pokazala je da su okluzijski kontakti pretežno lokalizirani unutar stražnjih segmenata zubnih lukova, s najvećom učestalošću u regiji kutnjaka i manjom zastupljenošću u regiji pretkutnjaka, a prednji zubi pokazivali su minimalnu uključenost kontakata. Statističke usporedbe između skupina pokazale su da je većina prostornih parametara usporediva; samo je palatinalna distribucija kontakata na pretkutnjacima pokazala statistički značajnu razliku. No budući da je ovaj nalaz na granici statističke značajnosti i s obzirom na eksplorativnu prirodu ovog istraživanja bez formalne korekcije za višestruke usporedbe, taj ishod treba interpretirati s oprezom i ponajprije ga smatrati kliničkim trendom koji zahtijeva daljnju validaciju na većim uzorcima. Ova suptilna varijacija, otkrivena digitalnom analizom, ističe kako specifični tipovi malokluzija izravno utječu na međučeljusni odnos i posljedičnu lokalizaciju kontakata.

U usporedbi s dostupnom literaturom, prevladavanje okluzijskih kontakata u stražnjoj regiji u skladu je s poznawith the recognized biomechanical role of posterior teeth in mastication and load distribution (17- 20).

Although digital occlusal analyses utilizing the T-Scan system report that areas of close occlusal proximity are primarily localized in the posterior regions it must be explicitly emphasized that these methodologies are founded upon entirely different physical parameters (17, 21, 22).

In contrast, patients with Class II malocclusion exhibited a unique pattern of posterior occlusal contacts characterized by a distinct distribution profile (23, 24).

While T-Scan registers dynamic occlusal force, our research is based on a static geometric analysis of clearances; therefore, any comparisons regarding contact "proximity" or "clearance ranges" are strictly descriptive and refer to the spatial coincidence of surfaces rather than actual force transmission.

The posterior segments frequently displayed altered or absent contacts, while occasional compensatory contacts were noted in the anterior region. These findings can be attributed to the retruded position of the mandible characteristic of Class II malocclusion, which restricts optimal intercuspation and compromises functional load distribution (25).

Previous studies have similarly reported reduced stability of posterior contacts and increased asymmetry in Class II malocclusions (26).

Interocclusal Distance of Contacts

Regarding the proximity categories of the contacts, our findings indicate, that while most contacts in both groups fell within a physiologically acceptable range (closer distances), significant differences emerged within the narrow spatial spectrum. No statistically significant intergroup differences were observed for either premolars or molars within the 0.020–0.050 mm range. However, molars within the 0.050–0.100 mm range demonstrated a significantly higher cumulative tooth involvement in Class III subjects. In this context, it is critical to clarify that the concept of contact "proximity" in our study is strictly defined as a software-generated distance category (interocclusal clearance in millimeters) rather than a metric for actual occlusal load or bite force. This tendency toward a greater number of posterior contacts in the larger clearance category among Class III subjects may reflect anatomical adaptive mechanisms aimed at achieving adequate intercuspation in the presence of sagittal discrepancies (18, 27, 28).

These adaptive patterns and spatial tooth alignments are also strongly influenced by the underlying skeletal characteristics and individual facial rotation patterns inherent to skeletal Class III subjects (29).

This aligns with previous literature reporting that the anterior position of the mandible in Class III malocclusions facilitates a wider and more extensive intercuspal relationship as a compensatory mechanism (18, 27, 28, 30).

Number and Type of Contact Points

Analysis of the contact types revealed that the pattern of intercuspal engagement differs substantially between the two groups. A key finding of this study is that full-surface

tom biomehaničkom ulogom stražnjih zuba u mastikaciji i raspodjeli opterećenja (17 – 20).

Iako se u digitalnim okluzijskim analizama koje primjenjuju sustav T-Scan navodi da su područja bliske okluzijske blizine primarno lokalizirana u stražnjim regijama, potrebno je izričito istaknuti da se te metodologije temelje na potpuno različitim fizikalnim parametrima (17, 21, 22).

Suprotno tomu, pacijenti s malokluzijom klase II pokazali su jedinstveni obrazac stražnjih okluzijskih kontakata karakteriziran specifičnim profilom distribucije (23, 24).

Dok T-Scan registrira dinamičku okluzijsku silu, naše se istraživanje temelji na statičkoj geometrijskoj analizi razmaka; stoga su sve usporedbe koje se odnose na *blizinu* kontakata ili *raspone razmaka* isključivo deskriptivne i odnose se na prostorno podudaranje površina, a ne na stvarni prijenos sila.

U stražnjim segmentima česti su bili promijenjeni ili odsutni kontakti, a povremeni kompenzacijski kontakti zabilježeni su u prednjoj regiji. Ti se nalazi mogu pripisati retrudiranom položaju mandibule karakterističnom za malokluziju klase II koji ograničava optimalnu interkuspidaciju i narušava funkcionalnu raspodjelu opterećenja (25).

U dosadašnjim istraživanjima također se ističe smanjena stabilnost stražnjih kontakata i povećana asimetrija u slučaju malokluzija klase II (26).

Međučeljusna udaljenost kontakata

Kad je riječ o kategorijama blizine kontakata, naši nalazi pokazuju da su, iako je većina kontakata u objema skupinama bila unutar fiziološki prihvatljivoga raspona (manje udaljenosti), značajne razlike zabilježene unutar uskoga prostornoga spektra. Nisu utvrđene statistički značajne razlike između skupina ni za pretkutnjake, ni za kutnjake unutar raspona od 0,020 do 0,050 mm. No kutnjaci unutar raspona od 0,050 do 0,100 mm pokazali su značajno veći kumulativni broj zahvaćenih zuba kod ispitanika klase III. U tom je smislu ključno objasniti da je pojam *blizine* kontakta u našem istraživanju strogo definiran kao softverski generirana kategorija udaljenosti (međučeljusni razmak u milimetrima), a ne kao mjera stvarnoga okluzijskog opterećenja ili sile zagriza. Ta tendencija većeg broja stražnjih kontakata u kategoriji većeg razmaka među ispitanicima klase III može odražavati anatomske adaptivne mehanizme usmjerene na postizanje odgovarajuće interkuspidacije u prisutnosti sagitalnih nerazmjera (18, 27, 28).

Na te adaptivne obrasce i prostorni raspored zuba također snažno utječu temeljna skeletna obilježja i individualni načini rotacije lica svojstveni ispitanicima sa skeletnom klasom III (29).

To je u skladu s dosadašnjom literaturom u kojoj se navodi da anteriorni položaj mandibule u slučaju malokluzija klase III olakšava širi i opsežniji interkuspalni odnos kao kompenzacijski mehanizam (18, 27, 28, 30).

Broj i vrsta kontaktnih točaka

Analiza vrsta kontakata pokazala je da se obrazac interkuspalnoga kontakta značajno razlikuje između dviju skupina. Ključni nalaz ovog istraživanja jest da su kontakti precontacts were significantly more frequent in Class II patients across both the premolar and molar regions. Conversely, the complete absence of occlusal contacts for molars was a phenomenon highly characteristic of the Class II group.

These results align with previous literature reporting that Class II malocclusions are frequently associated with a reduced number of posterior contacts and increased occlusal asymmetry (17, 23, 31).

Such a reduction in posterior stability may directly contribute to an uneven and compromised transmission of occlusal forces (25, 26).

Clinical Significance and Methodological Advantages

Inadequate or poorly localized occlusal loading, such as that seen in the larger clearance range categories among Class III subjects or the significant lack of posterior support in Class II patients, could theoretically be associated with functional complications. Although this study did not directly evaluate functional outcomes, the literature suggests that prolonged or excessive posterior contact involvement can be discussed as potential contributing factors to the development of temporomandibular disorders (TMD), myofascial pain, and fremitus (4, 12).

Furthermore, chronic occlusal trauma and excessive loading can induce pathological changes in the supporting periodontal structures (32- 35).

However, given that our research was primarily focused on static digital analysis and did not include a clinical evaluation of TMD symptoms or acute myofascial pain, these relationships in the context of our results must be interpreted with caution. The differences in occlusal patterns between Class II and Class III groups suggest a specific morphological adaptation of the stomatognathic system to sagittal discrepancies, but the functional implications of these specificities remain within the domain of hypotheses that require further long-term clinical investigations.

The digital occlusal workflow facilitated by the analysis software offers substantial advantages over conventional methods, such as articulating paper and plaster models, which are inherently limited by subjectivity and a lack of quantitative assessment. Intraoral scanning systems enable enhanced three-dimensional visualization, high reproducibility, and objective measurement of clearances, thereby significantly improving precision in occlusal contact detection (36, 37).

Furthermore, with the ongoing advancement of technology, artificial intelligence (AI) can be integrated into the analysis of dental crown morphological variations in different types of malocclusions for automated assessments, which could further reduce subjective confounding variables in clinical evaluations (38).

Previous studies have demonstrated a high level of agreement between digital models and conventional methods, further supporting their clinical applicability in contemporary practice (35, 36).

It is well-established in the scientific literature that certain sophisticated digital systems allow for detailed quantitative and temporal assessment of occlusal forces, representing

ko cijele površine bili značajno češći kod pacijenata klase II i u premolarnoj i u molarnoj regiji. Suprotno tomu, potpuna odsutnost okluzijskih kontakata na kutnjacima bila je pojava izrazito karakteristična za skupinu klase II.

Ti su rezultati u skladu s onima u dosadašnjoj literaturi u kojoj se navodi da su malokluzije klase II često povezane sa smanjenim brojem stražnjih kontakata i povećanom okluzijskom asimetrijom (17, 23, 31).

Takvo smanjenje stražnje stabilnosti može izravno pridonijeti neujednačenom i narušenom prijenosu okluzijskih sila (25, 26).

Kliničko značenje i metodološke prednosti

Neodgovarajuće ili nepravilno lokalizirano okluzijsko opterećenje, poput onoga zabilježenog u kategorijama većeg razmaka među ispitanicima klase III ili značajnog nedostatka stražnje potpore kod pacijenata klase II, teoretski bi moglo biti povezano s funkcionalnim komplikacijama. Iako se u ovom istraživanju nije izravno procjenjivalo funkcionalne ishode, literatura upućuje na to da se produljena ili prekomjerna uključenost stražnjih kontakata može razmatrati kao potencijalni čimbenik koji pridonosi razvoju temporomandibularnih poremećaja (TMD), miofascijalne boli i fremitusa (4, 12).

Nadalje, kronična okluzijska trauma i prekomjerno opterećenje mogu izazvati patološke promjene potpornih parodontnih struktura (32 – 35).

No s obzirom na to da je naše istraživanje uglavnom bilo usmjereno na statičku digitalnu analizu i nije uključivalo kliničku procjenu simptoma TMD-a, ni akutne miofascijalne boli, odnose u kontekstu naših rezultata treba interpretirati s oprezom. Razlike u obrascima okluzije između skupina klase II i III upućuju na specifičnu morfološku prilagodbu stomatognatnoga sustava na sagitalne nerazmjere, ali funkcionalne implikacije tih specifičnosti ostaju u domeni hipoteza koje zahtijevaju daljnja dugoročna klinička istraživanja.

Digitalni okluzijski radni proces koji omogućuje softver za analizu pruža značajne prednosti u usporedbi s konvencionalnim metodama, poput artikulacijskoga papira i gipsanih modela, koje su inherentno ograničene subjektivnošću i nedostatkom kvantitativne procjene. Sustavi za intraoralno skeniranje omogućuju poboljšanu trodimenzionalnu vizualizaciju, visoku reproducibilnost i objektivno mjerenje razmaka, čime se značajno poboljšava preciznost detekcije okluzijskih kontakata (36, 37).

Nadalje, s kontinuiranim napretkom tehnologije, umjetna inteligencija (AI) može se integrirati u analizu varijacija morfologije dentalnih kruna kod različitih tipova malokluzija radi automatizirane procjene, što bi moglo dodatno smanjiti subjektivne čimbenike koji su izvor pristranosti u kliničkim procjenama (38).

Prethodna istraživanja pokazala su visok stupanj podudarnosti između digitalnih modela i konvencionalnih metoda, što dodatno podupire njihovu kliničku primjenjivost u suvremenoj praksi (35, 36).

U znanstvenoj literaturi dobro je utvrđeno da određeni sofisticirani digitalni sustavi omogućuju detaljnu kvantitativnu i vremensku procjenu okluzijskih sila, što je značajan a major advancement in orthodontic diagnostics compared to traditional qualitative approaches (39-43). However, it must be clearly differentiated that the method applied in this study (Medit Occlusion Analyzer) focuses exclusively on static spatial registration of clearances rather than direct dynamic force quantification.

Recent systematic reviews confirm that intraoral scanners possess high reproducibility in identifying occlusal contacts, although caution should be exercised when interpreting the contact proximity categories themselves, treating these digital findings as a valuable clinical adjunct in the diagnostic process (44).

These factors underscore the importance of achieving a balanced occlusion during orthodontic treatment. Digital occlusal analysis offers clear advantages over conventional methods due to its objectivity and capacity for quantitative evaluation.

Limitations of the Study

Before definitive conclusions can be drawn, several important limitations of this study must be considered. First, the research did not include a control group with normal occlusion (Angle Class I), nor did it incorporate an evaluation of muscle status or long-term functional effects. This limits the ability to determine whether the registered patterns in Class II and Class III subjects represent pathological deviations or merely variations within a broad physiological spectrum. Second, this is a cross-sectional study utilizing static digital models, which allows solely for a geometric assessment of interocclusal clearance.

Conclusion

Based on the digital analysis of occlusal contact parameters in patients with Angle Class II and Class III malocclusions, the following conclusions can be drawn:

Intraoral digital scanning combined with specialized occlusal analysis software provides a reliable, objective, and clinically applicable method for evaluating occlusal parameters, effectively overcoming the inherent subjectivity and limitations of conventional qualitative approaches.

Significant differences exist regarding the interocclusal distance of contacts in the molar region, with Class III subjects demonstrating a higher involvement of contacts within the closer clearance ranges. This suggests specific compensatory mechanisms of structural adaptations in the presence of sagittal discrepancies.

The pattern of intercuspal engagement differs substantially between the groups; full-surface contacts across both the premolar and molar regions are significantly more prevalent in Class II patients, whereas the complete absence of molar contacts is also more pronounced within the same group.

The spatial distribution of contacts reveals subtle variations in the premolar region that should primarily be interpreted as a clinical trend, reflecting the direct influence of the specific malocclusion type on interarch relationships.

Digital analysis successfully identified distinctive features in the proximity and distribution of occlusal contacts between Angle Class II and Class III malocclusions. Intra-

napredak u ortodontskoj dijagnostici u usporedbi s tradicionalnim kvalitativnim pristupim (39 – 43). Međutim, potrebno je jasno razlikovati da se metoda primijenjena u ovom istraživanju (Medit Occlusion Analyzer) usredotočuje isključivo na statičku prostornu registraciju razmaka, a ne na izravnu dinamičku kvantifikaciju sila.

Nedavni sustavni pregledi literature potvrđuju da intraoralni skeneri posjeduju visoku reproducibilnost u identificiranju okluzijskih kontakata, iako je pri interpretaciji samih kategorija blizine kontakata potreban oprez, pri čemu se ovi digitalni nalazi trebaju smatrati vrijednim dodatkom kliničkom dijagnostičkom procesu (44).

Ti čimbenici ističu važnost postizanja uravnotežene okluzije tijekom ortodontskog liječenja. Digitalna okluzijska analiza ima jasne prednosti u odnosu prema konvencionalnim metodama zbog svoje objektivnosti i mogućnosti kvantitativne procjene.

Ograničenja istraživanja

Prije konačnih zaključaka potrebno je razmotriti nekoliko važnih ograničenja u ovom istraživanju. Prvo, istraživanje nije uključivalo kontrolnu skupinu s normalnom okluzijom (Angleova klasa I), niti je obuhvaćalo procjenu statusa mišića ili dugoročnih funkcionalnih učinaka. To ograničava mogućnost utvrđivanja jesu li registrirani obrasci kod ispitanika klase II i III patološka odstupanja ili samo varijacije unutar širokoga fiziološkog spektra. Drugo, riječ je o presječnom istraživanju u kojemu se koriste statički digitalni modeli, što omogućuje isključivo geometrijsku procjenu međučeljusnoga razmaka.

Zaključak

Na temelju digitalne analize parametara okluzijskih kontakata kod pacijenata s Angleovim malokluzijama klase II i III može se zaključiti sljedeće: digitalno intraoralno skeniranje u kombinaciji sa specijaliziranim softverom za okluzijsku analizu pruža pouzdanu, objektivnu i klinički primjenjivu metodu za procjenu okluzijskih parametara i učinkovito prevladava inherentnu subjektivnost i ograničenja konvencionalnih kvalitativnih pristupa; postoje značajne razlike u međučeljusnoj udaljenosti kontakata u regiji kutnjaka, pri čemu ispitanici klase III pokazuju veću uključenost kontakata unutar raspona manjeg razmaka; to upućuje na specifične kompenzacijske mehanizme strukturne prilagodbe u prisutnosti sagitalnih nerazmjera; obrazac interkuspalnoga kontakta značajno se razlikuje između skupina; kontakti preko cijele površine, i u regiji pretkutnjaka i kutnjaka, značajno su češći kod pacijenata klase II, a potpuna odsutnost kontakata kutnjaka također je izraženija u toj skupini

– prostorna distribucija kontakata otkriva suptilne varijacije u premolarnoj regiji koje uglavnom treba interpretirati kao klinički trend koji odražava izravan utjecaj specifičnog tipa malokluzije na međučeljusne odnose.
– digitalna analiza uspješno je identificirala karakteristična obilježja blizine i distribucije okluzijskih kontakata između Angleovih malokluzija klase II i III; intraoralno skeniranje omogućuje dobivanje objektivnih geometrijskih podataka koji su vrijedan dodatak statičkoj okluzijskoj

oral scanning delivers objective geometric data that serve as a valuable clinical adjunct in static occlusal evaluation, enabling a precise description of the morphological characteristics unique to each malocclusion type.

evaluaciji jer omogućuju precizan opis morfoloških obilježja kontakata jedinstvenih za te specifične tipove malokluzija.

Conflict of interest: The authors declare that there is no conflict of interest regarding the publication of this article. No financial or personal relationships with people or organizations have inappropriately influenced the content of this work.

Ethical Approval: This study was approved by the Ethics Committee of the Faculty of Dentistry, Ss. Cyril and Methodius University in Skopje, North Macedonia (Approval No. 2024-09-1984/2) and was conducted in accordance with the Declaration of Helsinki. The study was reported following the STROBE guidelines. Written informed consent was obtained from all participants or their legal guardians prior to inclusion.

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Data Availability Statement: The raw dataset supporting the findings of this study is publicly available in the Zenodo repository at: https://doi.org/10.5281/zenodo.18877500. The dataset includes the original measurements of occlusal contact distribution used for statistical analysis and generation of the figures presented in this manuscript.

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Doprinos autora: **I. B.** i **I. G.** jednako su pridonijeli osmišljavanju i dizajnu istraživanja te prikupljanju, analizi i interpretaciji podataka. Oba autora sudjelovala su u pisanju teksta i njegovoj kritičkoj reviziji s obzirom na važan intelektualni sadržaj. Također su se složili s konačnim odobrenjem verzije predviđene za objavljivanje i prihvaćaju odgovornost za sve aspekte rada, uključujući osiguravanje odgovarajućega istraživanja i rješavanja pitanja povezanih s točnošću ili integritetom bilo kojega dijela rada.

Izjava o dostupnosti podataka: Sirovi skup podataka koji podupire nalaze ovog istraživanja javno je dostupan u repozitoriju Zenodo na adresi: https://doi.org/10.5281/zenodo.18877500. Skup podataka obuhvaća izvorna mjerenja distribucije okluzijskih kontakata korištena za statističku analizu i izradu slika prikazanih u ovom radu.

Sažetak

Cilj: Procjenjivali su se, primjenom digitalnih intraoralnih modela, broj, kategorije međučeljusne udaljenosti i prostorna distribucija okluzijskih kontakata ispitanika s Angleovim malokluzijama klase II i III. **Materijali i metode:** U ovom eksplorativnom presječnom istraživanju sudjelovalo je 60 neliječenih ispitanika (30 klase II, 30 klase III). Digitalni modeli dobiveni su intraoralnim skenerom Medit i600, a analiza kontakata obavljena je u softveru Medit Occlusion Analyzer. Varijable su označavale kumulativni broj zuba po ispitaniku. Podatci su analizirani primjenom medijana i interkvartilnoga raspona (IQR). Usporedbe između skupina obavljene su Mann-Whitneyjevim U-testom ($\alpha = 0{,}05$), uz procjenu veličine učinka s pomoću rang-biserijalne korelacije (rB). **Rezultati:** Kontakti pretkutnjaka (premolara) nisu pokazali značajne razlike između skupina s obzirom na međučeljusnu udaljenost ($p > 0{,}05$). No ispitanici klase III imali su znatno više molarnih kontakata unutar raspona udaljenosti od 0,050 do 0,100 mm ($p = 0{,}018$). Kontakti preko cijele površine bili su značajno češći kod ispitanika klase II i na pretkutnjacima ($p = 0{,}002$) i na kutnjacima ($p = 0{,}007$). Ispitanici klase II također su pokazali vrlo značajnu potpunu odsutnost molarnih kontakata ($p < 0{,}001$). Palatinalna distribucija kontakata pretkutnjaka pokazala je graničnu razliku ($p = 0{,}044$) koja je interpretirana kao klinički trend. **Zaključak:** Digitalna analiza otkriva specifične modele međučeljusne udaljenosti i distribucije okluzijskih kontakata u slučaju Angleovih malokluzija klase II i III. Intraoralno skeniranje omogućuje dobivanje objektivnih geometrijskih podataka koji su vrijedan dodatak individualiziranom planiranju liječenja.

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