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Evaluation of Twenty Non-Metric Dental Crown Traits in Different Types of Malocclusions in a Sample from India, New Delhi Population

Procjena dvadeset nemetričkih karakteristika zubne krune u različitim vrstama malokluzija na uzorku iz Indije, populacija New Delhija

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Abstract

Background: Dental phenotype shows variation in the form of various metric and non-metric traits, primarily due to gene-environment interplay. It gives an insight into the evolutionary trends, ancestry, and food habits. Recently, it has been explored for genetic affinity with several growth anomalies and development of craniofacial skeleton which is also responsible for dental and skeletal malocclusions. **Objectives:** The current study aims to investigate the non-metric dental crown traits (NDCTs) using Arizona State University Dental Anthropology system (ASUDAS) in different types of malocclusions in Delhi, National Capital Region (NCR) population. **Materials and methods:** The study design was observational and retrospective. The total sample comprised of 240 pairs of dental casts divided into four equal groups of 60 subjects each (30 male and 30 female), based on malocclusion. The four groups of malocclusions were: Angle's Class I, Class II division 1, Class II division 2, Class III. The investigator was blinded for patient ID and sex before recording the data. The data for cast were recorded by three observers independently in a modified malocclusion- non-metric dental crown traits (M-NDCT) anthropological variants chart and statistically analyzed for association with different malocclusions and sex. **Results:** Significant differences were found in the expression of several NDCTs (both in presence and scoring) in different malocclusions. Class I malocclusion showed predominantly winging, shoveling –upper central and lateral incisor, protostylid, hypoconulid absence in lower second molar, and cusp number. Class II malocclusion showed double shoveling, interrupted groove, tuberculum dentale, canine mesial ridge, premolar accessory cusp, Carabelli's trait, lingual cusp variation, and seventh cusp in the lower left first molar. Class III malocclusion showed the absence of hypocone in upper second molar, deflecting wrinkle, distal trigonid crest, and Y groove in left lower second molar. Besides, sexual dimorphism was seen in shoveling –upper central and lateral incisor, canine mesial ridge, Carabelli's trait, 3-cusp in upper second molar, and cusp number. **Conclusions:** Significant association was found between non-metric dental traits and malocclusions (Class I, Class division 1, Class II division 2, and Class III). Significant sex-linked differences were also found. Further studies can be performed at multicenter pan-India level or across ethnicities with a standard robust protocol and a large sample.

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Introduction

Dental anthropology (DA) is a branch of physical anthropology which deals with the study of wide variations in the dental phenotype due to an interplay of genes and environment (1). These variations usually manifest in the form of various metric and nonmetric dental traits including more than 100 crown traits (NDCTs) and root traits (2, 3). The difference in dental morphogenetic proteins which release the mineral mediators, lead to phenotypic changes in the form of pits or grooves (negative) and cusp (positive) trait. These are in turn responsible for tracing the commonality in ancestry, food, history, and the biological processes associated with evolution (4).

The traits vary amongst different populations and types of dentition (permanent and deciduous dentitions). The morphological deviations can have significant applications in many dental fields including, orthodontics, prosthodontics, dental anatomy, dental anthropology, oral pathology, and forensic dentistry, which utilize them for clinical, pre-clinical, and individual identification purposes (5, 6). Various authors have tried to study the frequency, grades, and structure of individual NDCTs in different populations,(7–12) or as a part of categorized anthropological systems including "Arizona State University Dental Anthropology System" (ASUDAS).(3,4,13–17) ASUDAS is a plaque-based scoring system of non-metric dental traits (18,19) which has been used extensively in ethnicity determination worldwide (4,12,14), and also, in individual and ancestral remains of Indian origin (2,8,15,20–23). The basis of ethnicity determination by ASUDAS system is the stability of dental morphological patterns over time due to highly mineralized tooth structure unaffected by systemic diseases or evolution (15). Recently, the genetic affinity for 36 ASUDAS traits among African and global samples have been explored using single nucleotide polymorphisms (SNPs) and traced to strong geographical localization in Africa with close association of ASUDAS/SNP for dental and genetic traits (24). This implies that genetic markers or data may have non-metric ASUDAS traits as reliable proxies and can further be studied with other conditions influenced by genetics or heredity. The phenotypic aspect of these non-metric dental characteristics has been explored sufficiently in various growth deformities and syndromes including achondroplasia, osteogenesis imperfecta, chondroectodermal dysplasia, cleft lip and palate, but their genetic overlap is yet to be explored (25–27).

In addition, the genetic predisposition of particular dental traits may also influence the craniofacial growth, more specifically skeletal jaw growth and occlusal arrangements of teeth. These parameters are under strong influence of heredity, further modulated by epigenetic factors including dietary patterns or morphology in a specific geographical area (28–30). The potential implications of these variations may cause occlusal teeth derangements or craniofacial growth discrepancies leading to dental (13, 30, 31) or skeletal malocclusions (30).

The malocclusions are identified, classified, and treated by orthodontists based on positioning of teeth in three planes

Uvod

Dentalna antropologija (DA) grana je fizikalne antropologije koja se bavi proučavanjem širokih varijacija u dentalnom fenotipu zbog odnosa gena i okoliša (1). Te se varijacije obično manifestiraju u obliku različitih metričkih i nemetričkih dentalnih svojstava, uključujući više od 100 svojstava krunica (NDCT) i svojstava korijena (2, 3). Razlika u dentalnim morfogenetskim proteinima koji otpuštaju mineralne medijatore rezultira fenotipskim promjenama u obliku jamica ili utora (negativno) i kvržice (pozitivno). Oni su zauzvrat odgovorni za praćenje sličnosti kad je riječ o podrijetlu, prehrani, povijesti i biološkim procesima povezanima s evolucijom (4).

Svojstva se razlikuju među različitim populacijama i vrstama denticije (trajne i mliječne denticije). Morfološke devijacije mogu imati značajnu primjenu u mnogim područjima dentalne medicine, uključujući ortodonciju, protetiku, dentalnu anatomiju, dentalnu antropologiju, oralnu patologiju i forenzičku stomatologiju koja ih upotrebljava u kliničke, pretkliničke i individualne svrhe identifikacije (5, 6). Razni autori pokušali su proučavati učestalost, stupnjeve i strukturu pojedinačnih NDCT-ova u različitim populacijama, (7 – 12) ili kao dio kategoriziranih antropoloških sustava, uključujući sustav dentalne antropologije Državnoga sveučilišta Arizona (ASUDAS) (3, 4) (13 – 17). ASUDAS je sustav bodovanja temeljen na pločicama nemetričkih dentalnih svojstava (18, 19) koji se često koristi u određivanju etničke pripadnosti diljem svijeta (4, 12, 14), a također i u pojedinačnim i predačkim ostatcima – indijsko podrijetlo (2 , 8, 15, 20 – 23). Osnova određivanja etničke pripadnosti sustavom ASUDAS-a jest stabilnost morfoloških uzoraka zuba tijekom vremena zbog njihove visokomineralizirane strukture na koju nisu utjecale sistemske bolesti ili evolucija (15). Nedavno je istraživan genetski utjecaj za 36 svojstava ASUDAS-a među afričkim i globalnim uzorcima s pomoću polimorfizama jednog nukleotida (SNP) i praćen snažnom geografskom lokalizacijom u Africi s bliskom povezanosti ASUDAS/SNP-a za dentalna i genetska svojstva (24). To implicira da genetski markeri ili podatci mogu imati nemetrička svojstva ASUDAS-a kao pouzdane zamjene i mogu se dalje proučavati s drugim stanjima pod utjecajem genetike ili nasljeđa. Fenotipski aspekt tih nemetričkih dentalnih obilježja dovoljno je istražen na raznim deformitetima rasta i sindroma, uključujući ahondroplaziju, *osteogenesis imperfecta*, kondroektodermalnu displaziju i rascjep usne i nepca, ali njihovo genetsko preklapanje tek treba istražiti (25 – 27).

Uz to, genetska predispozicija pojedinih dentalnih svojstava također može utjecati na kraniofacijalni rast, točnije na rast skeletne čeljusti i okluzalni raspored zuba. Ti su parametri pod jakim utjecajem nasljeđa dodatno moduliranoga epigenetskim čimbenicima, uključujući načine prehrane ili morfologiju u određenom zemljopisnom području (28 – 30). Potencijalne implikacije tih varijacija mogu prouzročiti okluzalne poremećaje zuba ili kraniofacijalne razlike u rastu, što rezultira dentalnom (13, 30, 31) ili skeletnom malokluzijom (30).

Malokluzije identificiraju, klasificiraju i liječe ortodonti na temelju položaja zuba u trima ravninama (sagitalnoj,

(sagittal, vertical, and transverse) and the inter-relationships of both upper and lower arches (32). The individual variations in shape and size of teeth as categorized in NDCT, may influence the orthodontic treatment results and necessitate morphological alterations in few cases (33), yet significant importance to date has not been given to correlate the NDCT traits with malocclusion. Establishing this correlation may improve the clinical orthodontic outcome, and also aid in finding the genetic etiology or correlation with malocclusion, and individual identification for forensic purposes (34).

Keeping this literature gap in mind, we planned to establish an association of NDCTs with different classes of malocclusion in a specific ethnic population. We have already studied the frequency of NDCT in Delhi and NCR population in a previous study (3). The current study in succession is planned with the aim to assess the frequency of NDCT traits in different classes of malocclusion using ASUDAS plaques in the same population.

Materials and methods

Sample description

The study was carried out after obtaining institutional ethical clearance (8/5/234/JMI/IEC/2019). Informed consent was taken from the study participant/guardian.

The study was planned as descriptive cross-sectional retrospective pilot study. The study sample was collected from the orthodontic records of patients enrolled for orthodontic treatment in the Department of Orthodontics of a Central Govt. Dental School in India.

Study Inclusion/exclusion

The inclusion criteria for the study sample were 14-30-year-old patients residing in Delhi, NCR region from the past three generations, and their dental casts with full component of permanent teeth and minimal occlusal wear. The study casts showing regressive alterations (including severe attrition, abrasion, erosion, etc.) or patients with congenital defects were excluded from the study.

Our sample comprised of four equal groups of 60 subjects each (30 male and 30 female), based on types of malocclusion according to Angle's classification (32):

Group A: Class I
Group B: Class II division I
Group C: Class II division 2
Group 4: Class III

The description of various classes of malocclusion is diagrammatically represented in Figure 1.

Thus, the total sample size was 240 pairs of upper and lower dental casts with different malocclusions.

Study cast evaluation

Dental study casts (upper and lower) for each study subject were analyzed under good lighting conditions as used by the authors in their previous study (3). The method of examination is explained in detail as follows:

The dental casts were blinded before analysis by observer (AN) for patient ID, and sex. The casts were allocated num-

vertikalnoj i transverzalnoj) te uzajamnog odnosa gornjega i donjega luka (32). Individualne varijacije u obliku i veličini zuba kategorizirane u NDCT-u mogu utjecati na rezultate ortodontskog liječenja i zahtijevati morfološke promjene u nekoliko slučajeva (33), no do danas nije posvećena odgovarajuća pozornost povezivanju svojstava NDCT-a s malokluzijom. Uspostavljanje te korelacije može poboljšati klinički ortodontski ishod, a i pomoći u pronalaženju genetske etiologije ili korelacije s malokluzijom, te u individualnoj identifikaciji u forenzičke svrhe (34).

Imajući na umu tu prazninu u literaturi, planirali smo uspostaviti povezanost s različitim klasama malokluzije u određenoj etničkoj populaciji. Već smo u prethodnoj studiji proučavali učestalost NDCT-a u Delhiju i u NCR populaciji (3). Ova studija planirana je sa svrhom da se procijeni učestalosti NDCT svojstava u različitim klasama malokluzije korištenjem ASUDAS-ovih plakova u istoj populaciji.

Materijali i metode

Opis uzorka

Studija je provedena nakon što je dobiveno institucionalno etičko dopuštenje (8/5/234/JMI/IEC/2019). Informirani pristanak potpisali su sudionici/skrbnici. Planirana je kao deskriptivna presječna retrospektivna pilot-studija. Uzorak je prikupljen iz ortodontske dokumentacije pacijenata prijavljenih za liječenje na Odjelu za ortodonciju u Indiji.

Uključivanje/isključivanje iz studije

Kriteriji za uključivanje bili su pacijenti u dobi od 14 do 30 godina koji žive u Delhiju – regija NCR-a u posljednje tri generacije i njihovi odljevi zuba s punom komponentom trajnih zuba i minimalnim okluzalnim trošenjem. Odljevi koji pokazuju regresivne promjene (uključujući ozbiljno trošenje, abraziju, eroziju itd.) ili pacijenti s prirođenim defektima bili su isključeni iz studije.

Uzorak su činile četiri skupine od po 60 ispitanika (30 muškaraca i 30 žena) s vrstama malokluzija prema Angleovoj klasifikaciji (32): Grupa A: I klasa; Grupa B: razred II / I; Grupa C: klasa II / 2; 4. grupa: razred III.

Opis različitih klasa malokluzije dijagramski je prikazan na slici 1.

Tako je ukupan uzorak bio 240 pari gornjih i donjih zubnih odljeva s različitim malokluzijama.

Procjena studijskog kalupa

Stomatološki studijski model (gornji i donji) za svakog ispitanika analiziran je u dobrim svjetlosnim uvjetima kojima su se autori koristili u svojoj prethodnoj studiji (3). Metoda ispitivanja potanko je objašnjena kako slijedi:

Zubne odljeve zaslijepio je prije analize promatrač (A. N.) za identifikaciju pacijenta i spol. Promatračima su dodijeljeni

1

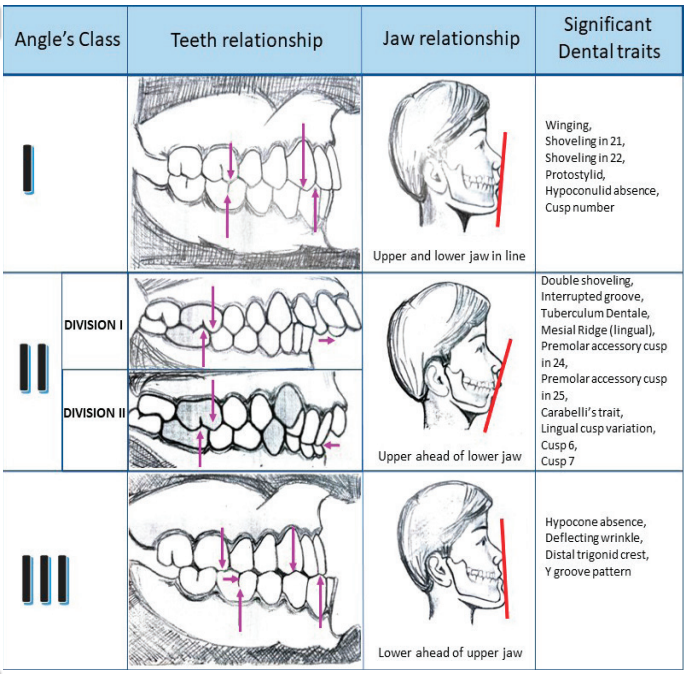


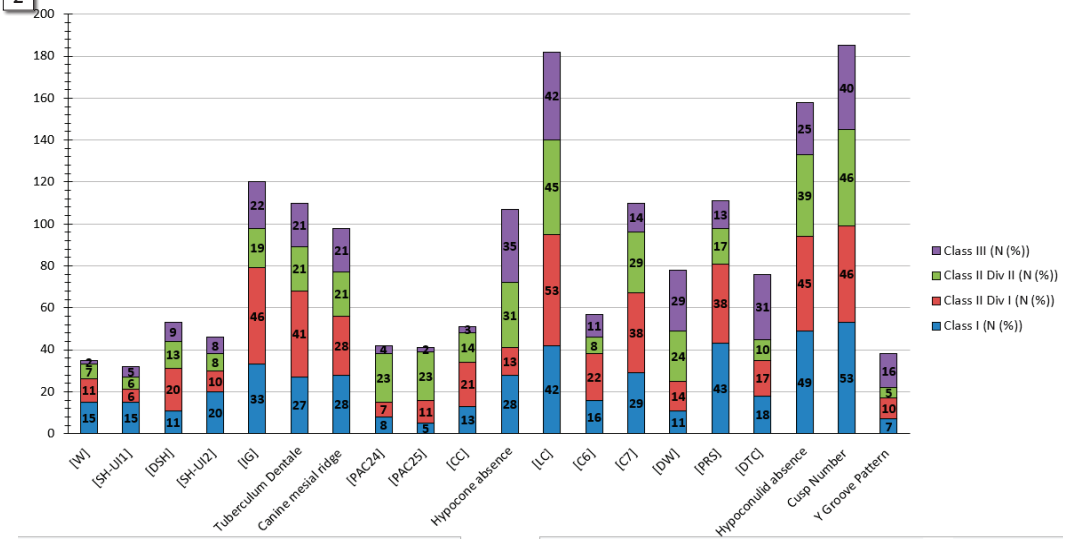
Figure 1 Diagrammatic representation of Angle's Classification of malocclusion along with significant association of dental traits.
The figure gives a diagrammatic representation of four classes of Angle's classification of malocclusion along with the dental traits which are most frequently associated with these malocclusions.

Slika 1. Dijagramski prikaz Angleove klasifikacije malokluzije uz značajnu povezanost dentalnih svojstava
Na slici je dijagramski prikaz četiriju razreda Angleove klasifikacije malokluzija s dentalnim značajkama koje su najčešće povezane s tim malokluzijama

Figure 2 Dichotomic expressions of the twenty nonmetric dental crown traits in all the four Angle's classes of malocclusion.

Slika 2. Dihotomski izrazi dvadeset nemetričkih obilježja zubne krune u svim četirima Angleoveim klasama malokluzije

2



CC-Carabelli's trait, C6-Cusp 6 in left lower first molar, C7-Cusp 7 in left lower first molar, DW-Deflecting wrinkle, DTC-Distal trigonid crest, DSH-Double shoveling, IG-Interrupted groove, LC-Lingual Cusp Variation in 35, PAC24-Premolar accessory cusp in 24, PAC-25-Premolar accessory cusp in 25, PRS-Protostylid, SH-UI1- Shoveling upper central incisor, SH-UI2- Shoveling, upper lateral incisor, W-Winging

bers maintained in a master excel sheet. The analysis was performed independently by three observers (PK, DBP, MS), and a consensus was achieved with a fourth observer (AC) in case of any discrepancies.

Each study cast was assessed and graded for expression of 20 NDCT traits as per malocclusion- non metric dental crown trait (M-NDCT) anthropological variants chart given in Table 1, which has been adapted for association with malocclusion (3). A dichotomy of expression as per ASUDAS protocol of "present" or "absent" for each trait was noted after grading the individual traits (3, 14).

The teeth selected from the left hemi-arch of each cast (as mentioned in Table 1) were examined for the expression of each trait to avoid bias and distortions due to possible asymmetries. But if there were dental anomalies or loss of tooth structure on the left side of the arch, the right quadrant of the same jaw was scored. In case recording the expression of any trait was not possible, the "null" expression was registered.

brojevi koji se vode u glavnom listu Excela. Analizu su neovisno obavila tri promatrača (P. K., D. B. P. i M. S.), a u slučaju odstupanja konsenzus je postignut s četvrtim promatračem (A. C).

Svaki dio studije procijenjen je i ocijenjen za izražavanje 20 NDCT svojstava prema grafikonu antropoloških varijanti malokluzije – nemetričke značajke zubne krune (M-NDCT) u danoj u tablici 1. koja je prilagođena za povezanost s malokluzijom (3). Dihotomija ekspresije prema ASUDAS-ovu protokolu „prisutnog" ili „odsutnog" za svaku značajku uočena je poslije ocjenjivanja pojedinačnih svojstava (3, 14).

Zubi odabrani s lijeve strane zubnoga luka svakog odljeva (kao što se vidi u tablici 1.) ispitani su na izraženost svake osobine kako bi se izbjegle pristranosti i distorzije zbog mogućih asimetrija. Ali ako je bilo dentalnih anomalija ili gubitka strukture zuba na lijevoj strani luka, bodovan je desni kvadrant iste čeljusti. U slučaju da bilježenje ekspresije bilo kojeg obilježja nije bilo moguće, registrirana je „nulta" ekspresija. U

Table 1 Malocclusion- Dental Non-metric Crown Dental traits (M-NDCT) Anthropological variants chart
Tablica 1. Malokluzija – nemetričke karakteristike zubne krune (M-NDCT) Tablica antropoloških varijanti

Name of Expert	
Date	/ /
ID/File of patient	
Age/Sex:	
Cast ID with specified malocclusion	(A/B/C/D)

S.No.	Trait (abbreviation)	Target tooth FDI*	Dichotomy Expression**	Dichotomy Score (Tick the correct score observed on cast)	Dichotomy Result	
					Yes	No
1	Winging (W)	11, 21	(1A-2) / (1A-4)	1A 1B 2 3 4		
2	Shoveling upper central incisor (SH- UI1)	21	(3-6) / (0-6)	0 1 2 3 4 5 6		
3	Double shoveling (DSH)	21	(2-6) / (0-6)	0 1 2 3 4 5 6		
4	Shoveling, upper lateral incisor (SH-UI2)	22	(3-7) / (0-7)	0 1 2 3 4 5 6 7		
5	Interrupted groove (IG)	22	(M, D, MD, Med) / (0 - Med)	0 M D MD Med		
6	Tuberculum dentale	22	(1-6) / (0-6)	0 1 2 3 4 5 6 7 8 9		
7	Canine Mesial Ridge	23	(1-3) / (0-3)	0 1 2 3		
8	Premolar accessory cusp (PAC24)	24	(1)/ (0-1)	0 1		
9	Premolar accessory cusp (PAC25)	25	(1)/ (0-1)	0 1		
10	Carabelli's trait (CC)	26	(5-7) / (0-7)	0 1 2 3 4 5 6 7		
11	Hypocone absence (3-cusp UM2)	27	(0-1) / 0-5)	0 1 2 3 4 5		
12	Lingual Cusp Variation (LC)	35	(1-9) / (0-9)	0 1 2 3 4 5 6 7 8 9		
13	Cusp 6 in left lower first molar (C6)	36	(1-5) / (0-5)	0 1 2 3 4 5		
14	Cusp 7 in left lower first molar(C7)	36	(1-4) / (0-4)	0 1 2 3 4		
15	Deflecting wrinkle (DW)	36	(3) / (0 – 3)	0 1 2 3		
16	Protostylid (PRS)	36	(1-7) / (0-7)	0 1 2 3 4 5 6 7		
17	Distal trigonid crest (DTC)	36	(1)/ (0-1)	0 1		
18	Hypoconulid absence (4 cusp LM2)	37	(0) / (4-5)	0 4 5		
19	Cusp number	37	(4) / (4, 5)	4 5		
20	Y groove pattern	37	(y) / (Y, +, X)	Y + X		

*Fédération Dentaire Internationale (FDI) tooth-numbering; ** (Grades present) / (total range of grades), Malocclusion ID's : A- Angle's class I, B- Class II div 1, C- Class II div 2, D- Class III • *Svjetska stomatološka organizacija (FDI) numeriranje zuba; ** (prisutni stupnjevi) / (ukupni raspon stupnjeva), ID-ovi malokluzije: A – Angleova klasa I, B – klasa II div 1, C – klasa II div 2, D – klasa III

Table 1, column "dichotomy expression" provides the cut-off value for the presence or absence of the trait. The column "dichotomy score" records the actual grade of the trait. The column "dichotomy result" records whether the trait was present (yes), or absent (no).

The data were entered separately for each class of malocclusion into an Excel (Registered) and processed with SPSS 20.0 IBM Chicago.

Statistical analysis

The association between the NDCT and malocclusion classes was studied using the Chi square test. The sex pooled data were also analyzed using the Chi square test.

tablici 1., stupac „izraz dihotomije" daje graničnu vrijednost za prisutnost ili odsutnost svojstva. U stupcu „rezultat dihotomije" zabilježen je stvarni stupanj svojstva. U stupcu „rezultat dihotomije" zabilježeno je postoji li određeno svojstvo (da) ili ga nema (ne).

Podatci su uneseni u Excel zasebno za svaku klasu malokluzije i obrađeni u programu SPSS 20.0 IBM, Chicago.

Statistička analiza

Povezanost između NDCT-a i razreda malokluzije proučavana je s pomoću hi-kvadrat testa. Objedinjeni podatci o spolu također su analizirani tim testom.

Results

A dichotomic expression of each of the twenty NDCT traits in all the four classes of malocclusion is presented in Figure 1. The association between the NDCT and malocclusions is presented in Tables 2-4. The results have been interpreted both for the presence and scoring of NDCT traits amongst different malocclusions.

The results showed that Class I malocclusion predominantly showed the presence of traits such as winging (W) (25%), shoveling –upper central incisor (SH-UI1) (25%), shoveling –upper lateral incisor (SH-UI2) (33.3%), protostylid (PRS) (71.7%), hypoconulid absence in lower second molar (4 cups LM2) (81.7%), and cusp number (88.3%), (Table 1). Winging showed a significantly higher score 3 than score 2 in Class I malocclusion (p<0.001).

Class II malocclusion predominantly showed the traits including double shoveling (DSH) (33.9%), interrupted groove (IG) (78%), tuberculum dentale(69.5%), canine mesial ridge (47.5%), premolar accessory cusp in upper left first premolar(PAC 24), premolar accessory cusp in upper left second premolar (PAC 25), Carabelli's trait (CC) (35.6%), lingual cusp variation (LC) (89.8%), cusp 6 (C6) (37.3%), and cusp 7 (C7) (64.4%) in the lower left first molar (Table 2).

Class III malocclusion showed a predominantly hypocone absence in upper second molar (3 cusp UM2) (58.3%), deflecting wrinkle (DW) (48.3%), distal trigonid crest (DTC) (51.7%) in left lower first molar, and Y groove in left lower second molar (26.7%), (Table 4).

Difference amongst malocclusions

Shoveling in upper central incisor showed a significantly higher presence of score 3 (18.3%) in Class I malocclusion, and score 1 (40.7%) in Class II division I malocclusion (p=0.001) (Table 1).

Different malocclusions did not show any significant differences in the presence of double shoveling (DSH), but Class II division 2 showed a higher score of 3 and score 4 in 18.7% cases (p<0.001) (Table 2). Additionally, Class II division 2, compared to other malocclusions, showed higher (38%) premolar accessory cusps in 24 and 25 (p<0.001).

On collective appraisal of Tables 2-4, significant differences were found in the expression of all the NDCTs (both in presence and scoring) and the types of malocclusions but canine mesial ridge, double shoveling, and lingual cusp variation did not vary significantly. The canine mesial ridge showed no significant association between the malocclusions, in terms of overall presence (p=0.308) and scoring (p=0.488). Double shoveling was significantly associated in terms of scoring (p<0.001) but not presence (p=0.072), while lingual cusp variation was significantly associated in terms of presence (p=0.035) but not scoring (p=0.152).

Table 5 assessed sexual dimorphism of the pooled data using the Chi square test. Significant differences were observed in six morphological traits both in the presence and scoring between males and females. These traits were shoveling in upper central and lateral incisors, canine mesial ridge, Carabelli's trait, hypocone absence, and cusp number.

Rezultati

Dihotomijski izraz svakoga od dvadeset obilježja NDCT-a u svim četirima klasama malokluzija prikazan je na slici 1. Povezanost između NDCT-a i malokluzija prikazana je u tablicama od 2. do 4. Rezultati su interpretirani i za prisutnost i bodovanje NDCT obilježja među različitim malokluzijama.

Rezultati su pokazali da malokluzija klase I pretežno ima obilježja kao što su rotirani središnji sjekutići (W) (25 %), lopatasti gornji središnji sjekutić (SH-UI1) (25 %), lopatasti gornji lateralni sjekutići (SH-UI2) (33,3 %), protostilid (PRS) (71,7 %), odsutnost hipokonulida u donjemu drugom kutnjaku (4 čašice LM2) (81,7 %) i broj kvržica (88,3 %) (tablica 1). Rotacija gornjih središnjih sjekutića pokazala je značajno viši rezultat 3 nego rezultat 2 u malokluziji klase I (p < 0,001).

Klasa II malokluzije pretežno je pokazivala sljedeće značajke: dvostruke lopataste sjekutiće (DSH) (33,9 %), prekinuti žlijeb (IG) (78 %), *tuberculum dentale* (69,5 %), mezijalni greben očnjaka (47,5 %), kvržicu pomoćnog pretkutnjaka u gornjemu lijevom prvom dijelu pretkutnjaka (PAC 24), dodatnu kvržicu pretkutnjaka u gornjemu lijevom drugom pretkutnjaku (PAC 25), Carabellijevo svojstvo (CC) (35,6 %), varijaciju lingvalne kvržice (LC) (89,8 %), kvržicu 6 (C6) (37,3 %) i kvržicu 7 (C7) (64,4 %) u donjemu lijevom prvom kutnjaku (tablica 2.).

Malokluzija klase III pokazala je pretežno odsutnost hipokonusa u gornjemu drugom kutnjaku (3 kvržice UM2) (58,3 %), deflektirajuću boru (DW) (48,3 %), distalni trigonidni brijeg (DTC) (51,7 %) u lijevomu donjem prvom kutnjaku i Y-utor u lijevomu donjem drugom kutnjaku (26, 7%) (tablica 4.).

Razlika među malokluzijama

Rotacija gornjega središnjeg sjekutića pokazalo je znatno veću prisutnost rezultata 3 (18,3 %) u malokluziji klase I i ocjene 1 (40,7 %) u malokluziji klase II odjeljenja I (P = 0,001) (tablica 1.).

Različite malokluzije nisu pokazale nikakve znatne razlike u prisutnosti DSH-a, ali klasa II odjeljak 2 pokazala je viši rezultat od 3 i rezultat 4 u 18,7 % slučajeva (p < 0,001) (tablica 2.). Dodatno, klasa II odjeljak 2, u usporedbi s drugim malokluzijama, pokazao je veće (38 %) dodatne kvržice pretkutnjaka u 24 i 25 (p < 0,001).

Pri zajedničkoj procjeni tablica od 2 do 4, pronađene su znatne razlike u ekspresiji svih NDCT-ova (i u prisutnosti i bodovanju) i vrstama malokluzija, ali varijacije mezijalnog grebena očnjaka, Labijalno lopataste sjekutiće i lingvalne kvržice nisu značajno varirale. Mezijalni greben očnjaka nije pokazao znatnu povezanost između malokluzija, kad je riječ o ukupnoj prisutnosti (p = 0,308) i bodovanju (p = 0,488). Labijalno lopatasti sjekutići bili su značajno povezani u smislu bodovanja (p < 0,001), ali ne i prisutnosti (p = 0,072), a varijacija lingvalne kvržice bila je značajno povezana u smislu prisutnosti (p = 0,035), ali ne i bodovanja (p = 0,152).

U tablici 5. procijenjen je spolni dimorfizam skupnih podataka koristeći se hi-kvadrat testom. Uočene su znatne razlike u šest morfoloških svojstava u prisutnosti i bodovanju između muških i ženskih ispitanika. Te su značajke bili lopatasti gornji središnji i bočni sjekutići, mezijalni greben očnjaka, Carabellijevo svojstvo, odsutnost hipokonusa i broj kvržica.

Table 2 Association of traits predominant in Angle's Class I malocclusion (Chi square test)
Tablica 2. Povezanost svojstava koja prevladavaju u Angleovoj malokluziji klase I (hi-kvadrat test)

	Categories	N	Class				Chi square	P value
			Class I (N (%))	Class II Div I (N (%))	Class II Div II (N (%))	Class III (N (%))		
Winging (W) (Presence)		35	15 (25)	11 (18.6)	7 (11.7)	2 (3.3)	12.469	**0.006**
Winging (W) (Score)	1A	15	4 (6.7)	4 (6.8)	5 (8.3)	2 (3.3)	37.117	**<0.001**
	1B	4	0 (0)	4 (6.8)	0 (0)	0 (0)		
	2	16	11(18.3)	3 (5.1)	2 (3.3)	0 (0)		
	3	196	45 (75)	45 (76.3)	52 (86.7)	54 (90)		
	4	8	0 (0)	3 (5.1)	1 (1.7)	4 (6.7)		
Shoveling upper central incisor (SH-UI1) (Presence)		32	15 (25)	6 (10.2)	6 (10)	5 (8.3)	9.419	**0.024**
Shoveling upper central incisor (SH-UI1) (Score)	0	53	13(21.7)	7 (11.9)	20 (33.3)	13 (21.7)	32.248	**0.001**
	1	64	15 (25)	24 (40.7)	14 (23.3)	11 (18.3)		
	2	90	17(28.3)	22 (37.3)	20 (33.3)	31 (51.7)		
	3	28	11(18.3)	6 (10.2)	6 (10)	5 (8.3)		
	4	4	4 (6.7)	0 (0)	0 (0)	0 (0)		
Shoveling upper lateral incisor (SH-UI2) (Presence)		46	20(33.3)	10 (16.9)	8 (13.3)	8 (13.3)	10.56	**0.014**
Shoveling upper lateral incisor (SH-UI2) (Score)	0	75	13(21.7)	10 (16.9)	17 (28.3)	35 (58.3)	56.459	**<0.001**
	1	46	18 (30)	16 (27.1)	11 (18.3)	1 (1.7)		
	2	72	9(15)	23 (39)	24 (40)	16 (26.7)		
	3	41	18(30)	7 (11.9)	8 (13.3)	8 (13.3)		
	4	5	2 (3.3)	3 (5.1)	0 (0)	0 (0)		
Protostylid (PRS) (Presence)		111	43(71.7)	38 (64.4)	17 (28.3)	13 (21.7)	45.72	<0.001
Protostylid (PRS) (Score)	0	128	17(28.3)	21 (35.6)	43 (71.7)	47 (78.3)	64.544	**<0.001**
	1	43	12 (20)	12 (20.3)	9 (15)	10 (16.7)		
	2	28	15 (25)	10 (16.9)	0 (0)	3 (5)		
	3	20	9 (15)	9 (15.3)	2 (3.3)	0 (0)		
	4	19	7 (11.7)	6 (10.2)	6 (10)	0 (0)		
	5	1	0 (0)	1 (1.7)	0 (0)	0 (0)		
Hypoconulid Absence (4 cusp LM2) (Presence)		158	49(81.7)	45 (76.3)	39 (65)	25 (41.7)	25.233	**<0.001**
Hypoconulid Absence (4 cusp LM2) (score)	0	158	49(81.7)	45 (76.3)	39 (65)	25 (41.7)	73.915	**<0. 001**
	3	8	0 (0)	0 (0)	8 (13.3)	0 (0)		
	4	53	10(16.7)	14 (23.7)	11 (18.3)	18 (30)		
	5	20	1 (1.7)	0 (0)	2 (3.3)	17 (28.3)		
Cusp Number (Presence)		185	53(88.3)	46 (78)	46 (76.7)	40 (66.7)	8.083	**0.044**
Cusp Number (Score)	4	185	53(88.3)	46 (78)	46 (76.7)	40 (66.7)	8.083	**0.044**
	5	54	7 (11.7)	13 (22)	14 (23.3)	20 (33.3)		

Table 3 Association of traits predominant in Angle's Class II Malocclusion (Chi square test)
Tablica 3. Povezanost svojstava koja prevladavaju u Angleovoj malokluziji klase II (hi-kvadrat test)

	Categories	N	Class				Chi square	P value
			Class I (N (%))	Class II Div I (N (%))	Class II Div II (N (%))	Class III (N (%))		
Double shoveling (DSH) (Presence)		53	11 (18.3)	20 (33.9)	13 (21.7)	9 (15)	7.01	0.072
Double shoveling (DSH) (Score)	0	126	27 (45)	26 (44.1)	24 (40)	49 (81.7)	71.759	**<0.001**
	1	60	22 (36.7)	13 (22)	23 (38.3)	2 (3.3)		
	2	36	5 (8.3)	9 (15.3)	13 (21.7)	9 (15)		
	3	6	0 (0)	6 (10.2)	0 (0)	0 (0)		
	4	8	3 (5)	5 (8.5)	0 (0)	0 (0)		
	5	3	3 (5)	0 (0)	0 (0)	0 (0)		
Interrupted groove (IG) (Presence)		120	33 (55)	46 (78)	19 (31.7)	22 (36.7)	31.387	**<0.001**
Interrupted groove (IG) (Score)	0	119	27 (45)	13 (22)	41 (68.3)	38 (63.3)	54.401	**<0.001**
	D	21	1 (1.7)	7 (11.9)	10 (16.7)	3 (5)		
	M	39	13 (21.7)	15 (25.4)	6 (10)	5 (8.3)		
	MD	7	2 (3.3)	5 (8.5)	0 (0)	0 (0)		
	MED	53	17 (28.3)	19 (32.2)	3 (5)	14 (23.3)		
Tuberculum Dentale (Presence)		110	27 (45)	41 (69.5)	21 (35)	21 (35)	18.976	**<0.001**
Tuberculum Dentale (Score)	0	129	33 (55)	18 (30.5)	39 (65)	39 (65)	47.9	**<0.001**
	1	53	9 (15)	15 (25.4)	11 (18.3)	18 (30)		
	2	37	8 (13.3)	17 (28.8)	9 (15)	3 (5)		
	3	13	5 (8.3)	8 (13.6)	0 (0)	0 (0)		
	4	3	2 (3.3)	0 (0)	1 (1.7)	0 (0)		
	5	4	3 (5)	1 (1.7)	0 (0)	0 (0)		
Canine Mesial Ridge (Presence)		98	28 (46.7)	28 (47.5)	21 (35)	21 (35)	3.599	0.308
Canine Mesial Ridge (Score)	0	141	32 (53.3)	31 (52.5)	39 (65)	39 (65)	5.445	0.488
	1	79	21 (35)	22 (37.3)	17 (28.3)	19 (31.7)		
	2	19	7 (11.7)	6 (10.2)	4 (6.7)	2 (3.3)		
Premolar accessory cusp (PAC)24 (Presence)		42	8 (13.3)	7 (11.9)	23 (38.3)	4 (6.7)	24.852	**<0.001**
Premolar accessory cusp (PAC)24 (Score)	0	197	52 (86.7)	52 (88.1)	37 (61.7)	56 (93.3)	24.852	**<0.001**
	1	42	8 (13.3)	7 (11.9)	23 (38.3)	4 (6.7)		
Premolar accessory cusp (PAC)25 (Presence)		41	5 (8.3)	11 (18.6)	23 (38.3)	2 (3.3)	30.379	**<0.001**
Premolar accessory cusp (PAC)25 (Score)	0	198	55 (91.7)	48 (81.4)	37 (61.7)	58 (96.7)	30.379	**<0.001**
	1	41	5 (8.3)	11 (18.6)	23 (38.3)	2 (3.3)		
Carabelli's trait (Presence)		51	13 (21.7)	21 (35.6)	14 (23.3)	3 (5)	16.83	**0.001**
Carabelli's trait (Score)	0	90	16 (26.7)	12 (20.3)	30 (50)	32 (53.3)	62.833	**<0.001**
	1	46	15 (25)	11 (18.6)	10 (16.7)	10 (16.7)		
	2	20	5 (8.3)	3 (5.1)	2 (3.3)	10 (16.7)		
	3	21	7 (11.7)	9 (15.3)	2 (3.3)	3 (5)		
	4	11	4 (6.7)	3 (5.1)	2 (3.3)	2 (3.3)		
	5	17	5 (8.3)	12 (20.3)	0 (0)	0 (0)		
	6	15	2 (3.3)	6 (10.2)	6 (10)	1 (1.7)		
	7	19	6 (10)	3 (5.1)	8 (13.3)	2 (3.3)		
Lingual Cusp Variation (LC) (Presence)		182	42 (70)	53 (89.8)	45 (75)	42 (70)	8.623	**0.035**
Lingual Cusp Variation (LC) (Score)	0	57	18 (30)	6 (10.2)	15 (25)	18 (30)	31.053	0.152
	1	22	5 (8.3)	9 (15.3)	4 (6.7)	4 (6.7)		
	2	78	15 (25)	20 (33.9)	23 (38.3)	20 (33.3)		
	3	43	11 (18.3)	12 (20.3)	11 (18.3)	9 (15)		
	4	16	2 (3.3)	6 (10.2)	3 (5)	5 (8.3)		
	5	11	5 (8.3)	4 (6.8)	2 (3.3)	0 (0)		
	6	2	2 (3.3)	0 (0)	0 (0)	0 (0)		
	8	9	2 (3.3)	1 (1.7)	2 (3.3)	4 (6.7)		
	9	1	0 (0)	1 (1.7)	0 (0)	0 (0)		
Cusp 6 in left lower first molar (C6) (Presence)		57	16 (26.7)	22 (37.3)	8 (13.3)	11 (18.3)	10.788	**0.013**
Cusp 6 in left lower first molar (C6) (Score)	0	182	44 (73.3)	37 (62.7)	52 (86.7)	49 (81.7)	30.411	**0.011**
	1	39	7 (11.7)	13 (22)	8 (13.3)	11 (18.3)		
	2	10	6 (10)	4 (6.8)	0 (0)	0 (0)		
	3	5	3 (5)	2 (3.4)	0 (0)	0 (0)		
	4	2	0 (0)	2 (3.4)	0 (0)	0 (0)		
	5	1	0 (0)	1 (1.7)	0 (0)	0 (0)		
Cusp 7 in left lower first molar(C7) (Presence)		110	29 (48.3)	38 (64.4)	29 (48.3)	14 (23.3)	20.719	**<0.001**
Cusp 7 in left lower first molar(C7) (Score)	0	129	31 (51.7)	21 (35.6)	31 (51.7)	46 (76.7)	39.363	**<0.001**
	1	55	17 (28.3)	23 (39)	13 (21.7)	2 (3.3)		
	2	26	8 (13.3)	8 (13.6)	8 (13.3)	2 (3.3)		
	3	6	0 (0)	3 (5.1)	0 (0)	3 (5)		
	4	23	4 (6.7)	4 (6.8)	8 (13.3)	7 (11.7)		

Table 4 Association of traits predominant in Angle's Class III Malocclusion (Chi square test)
Tablica 4. Povezanost svojstava koja prevladavaju u Angleovoj malokluziji klase III (hi-kvadrat test)

	Categories	N	Class				Chi square	P value
			Class I (N (%))	Class II Div I (N (%))	Class II Div II (N (%))	Class III (N (%))		
Hypocone absence (3 cusp UM2) (Presence)		107	28 (46.7)	13 (22)	31 (51.7)	35 (58.3)	18.04	**<0.001**
Hypocone absence (3 cusp UM2) (Score)	0	86	21 (35)	7 (11.9)	23 (38.3)	35 (58.3)	72.122	**<0.001**
	1	21	7 (11.7)	6 (10.2)	8 (13.3)	0 (0)		
	2	18	8 (13.3)	9 (15.3)	1 (1.7)	0 (0)		
	3	52	16 (26.7)	24 (40.7)	7 (11.7)	5 (8.3)		
	4	44	3 (5)	11 (18.6)	13 (21.7)	17 (28.3)		
	5	18	5 (8.3)	2 (3.4)	8 (13.3)	3 (5)		
Deflecting wrinkle (DW) (Presence)		78	11 (18.3)	14 (23.7)	24 (40)	29 (48.3)	15.917	**0.001**
Deflecting wrinkle (DW) (Score)	0	68	17 (28.3)	12 (20.3)	23 (38.3)	16 (26.7)	36.876	**<0.001**
	1	55	17 (28.3)	25 (42.4)	5 (8.3)	8 (13.3)		
	2	38	15 (25)	8 (13.6)	8 (13.3)	7 (11.7)		
	3	78	11 (18.3)	14 (23.7)	24 (40)	29 (48.3)		
Distal trigonid crest(DTC) (Presence)		76	18 (30)	17 (28.8)	10 (16.7)	31 (51.7)	17.588	**0.001**
Distal trigonid crest(DTC) (Score)	0	163	42 (70)	42 (71.2)	50 (83.3)	29 (48.3)	17.588	**0.001**
	1	76	18 (30)	17 (28.8)	10 (16.7)	31 (51.7)		
Y Groove Pattern (Presence)		38	7 (11.7)	10 (16.9)	5 (8.3)	16 (26.7)	8.623	**0.035**
Y Groove Pattern (Score)	+	61	0 (0)	0 (0)	19 (31.7)	42 (70)	135.111	**<0.001**
	P	111	41 (68.3)	36 (61)	32 (53.3)	2 (3.3)		
	X	29	12 (20)	13 (22)	4 (6.7)	0 (0)		
	Y	38	7 (11.7)	10 (16.9)	5 (8.3)	16 (26.7)		

Discussion

Non metric dental traits have mostly been employed to determine ethnicities, but recently the genetic-epigenetic linkage in these variations have directed the studies to consider NDCT associations with numerous conditions such as dental and skeletal malocclusions, developmental abnormalities like cleft lip and palate and other syndromes (25,27,35,36). The implications of these studies range from understanding the etiology of these variations, to clinical inferences in various domains including dental anatomy, orthodontics, anthropology, forensic odontology, and pathology (13).

The current study has explored the significance of these NDCTs with malocclusion, an area which has not been explored sufficiently in terms of dental and orthodontic treatment planning and long term stability of treatment outcomes (6). A recent study however, has explored the association of 44 NDCTs with skeletal sagittal Angle's classification of malocclusion, but these studies are sporadic, and they were performed in a different ethnic population than ours (13).

Our study analyzes 20 NDCT traits in different classes of Angle's classification and the results are broadly discussed under the following heads:

1) Presence of NDCTs in occlusion and their deviations
2) NDCTs in growth discrepancies
3) Frequency analysis
4) Sexual Dimorphism
5) Orthodontic association of NCDT's:

Rasprava

Nemetrička dentalna svojstva uglavnom su korištena za određivanje etničke pripadnosti, ali nedavno je genetsko-epigenetska veza u tim varijacijama usmjerila autore studija na razmatranje povezanosti NDCT-a s mnogobrojnim stanjima kao što su dentalne i skeletne malokluzije, razvojne abnormalnosti poput rascjepa usne i nepca te drugih sindroma (25, 27, 35, 36). Implikacije u tim studijama kreću se od razumijevanja etiologije tih varijacija do kliničkih zaključaka u različitim domenama, uključujući dentalnu anatomiju, ortodonciju, antropologiju, forenzičku odontologiju i patologiju (13).

U ovoj studiji autori su istraživali značenje tih NDCT-ova s malokluzijom, područjem koje nije dovoljno istraženo u smislu planiranja stomatološkoga i ortodontskoga liječenja i dugoročne stabilnosti ishoda liječenja (6). U prethodnoj studiji autori su istraživali povezanost 44 NDCT-a sa skeletnom sagitalnom Angleovom klasifikacijom malokluzije, ali takve su studije povremene i provedene su na etničkoj populaciji različitoj od naše (13).

U ovoj studiji analizirano je 20 NDCT svojstava u različitim klasama prema Angleu, a rezultati se opširno analiziraju pod sljedećim naslovima: 1) Prisutnost NDCT-a u okluziji i njihova odstupanja; 2) NDCT-ovi u razlikama u rastu; 3) Frekvencijska analiza; 4) Spolni dimorfizam; 5) Ortodontska asocijacija NCDT-ova.

Table 5 Sexual dimorphism in association with dental traits (Chi square test)
Tablica 5. Spolni dimorfizam u vezi s dentalnim svojstvima (hi-kvadrat test)

	Categories	N	SEX		Chi square	P value
			Female (N (%))	Male (N (%))		
Winging	Absent	204	106 (88.3)	98 (82.4)	1.71	0.191
	Present	35	14 (11.7)	21 (17.6)		
Shoveling upper central incisor	Absent	207	112 (93.3)	95 (79.8)	9.392	**0.002**
	Present	32	8 (6.7)	24 (20.2)		
Double Shoveling	Absent	186	89 (74.2)	97 (81.5)	1.868	0.172
	Present	53	31 (25.8)	22 (18.5)		
Shoveling upper lateral incisor	Absent	193	103 (85.8)	90 (75.6)	4.002	**0.045**
	Present	46	17 (14.2)	29 (24.4)		
Interrupted Groove	Absent	119	63 (52.5)	56 (47.1)	0.708	0.4
	Present	120	57 (47.5)	63 (52.9)		
Tuberculum Dentale	Absent	129	71 (59.2)	58 (48.7)	2.615	0.106
	Present	110	49 (40.8)	61 (51.3)		
Canine Mesial Ridge	Absent	141	80 (66.7)	61 (51.3)	5.862	**0.015**
	Present	98	40 (33.3)	58 (48.7)		
Premolar accessory cusp 24	Absent	197	95 (79.2)	102 (85.7)	1.768	0.184
	Present	42	25 (20.8)	17 (14.3)		
Premolar accessory cusp 25	Absent	198	95 (79.2)	103 (86.6)	2.295	0.13
	Present	41	25 (20.8)	16 (13.4)		
Carabelli's trait	Absent	188	102 (85)	86 (72.3)	5.769	**0.016**
	Present	51	18 (15)	33 (27.7)		
Hypocone Absence (3 cusp UM2)	Absent	132	57 (47.5)	75 (63)	5.824	**0.016**
	Present	107	63 (52.5)	44 (37)		
Lingual Cusp Variation	Absent	57	28 (23.3)	29 (24.4)	0.035	0.851
	Present	182	92 (76.7)	90 (75.6)		
Cusp 6 in left lower first molar (C6)	Absent	182	88 (73.3)	94 (79)	1.053	0.305
	Present	57	32 (26.7)	25 (21)		
Cusp 7 in left lower first molar (C7)	Absent	129	64 (53.3)	65 (54.6)	0.04	0.842
	Present	110	56 (46.7)	54 (45.4)		
Deflecting Wrinkle	Absent	161	80 (66.7)	81 (68.1)	0.053	0.817
	Present	78	40 (33.3)	38 (31.9)		
Protostylid	Absent	128	66 (55)	62 (52.1)	0.202	0.653
	Present	111	54 (45)	57 (47.9)		
Distal Trigonid Crest	Absent	163	78 (65)	85 (71.4)	1.139	0.286
	Present	76	42 (35)	34 (28.6)		
Hypoconulid absence (4 cusp LM2)	Absent	81	43 (35.8)	38 (31.9)	0.406	0.524
	Present	158	77 (64.2)	81 (68.1)		
Cusp Number	Absent	54	35 (29.2)	19 (16)	5.953	**0.015**
	Present	185	85 (70.8)	100 (84)		
Y Groove Pattern	Absent	201	99 (82.5)	102 (85.7)	0.462	0.497
	Present	38	21 (17.5)	17 (14.3)		

1) Presence of NDCTs in occlusion and their deviations

The contact relationship of jaws i.e., occlusion has gained relevance in odontology in the past few decades. Angle's occlusal classification is the most extensively researched, established, and practiced occlusal classification system used by orthodontists (32). Orthodontic experts, due to their footing in dental anthropology and morphology, can easily comprehend NCDT's reference systems such as ASUDAS (5, 34). Our study has identified the traits which show variations in different classes of malocclusion in terms of presence as well

1) Prisutnost NDCT-ova u okluziji i njihova odstupanja

Kontaktni odnos čeljusti, tj. okluzija, dobio je na značenju u stomatologiji u posljednjih nekoliko desetljeća. Klasifikacija okluzije prema Angleu najopsežnije je istražena, uspostavljen je i prakticiran okluzalni klasifikacijski sustav kojim se koriste ortodonti (32). Specijalisti ortodoncije, zbog svojega temelja u dentalnoj antropologiji i morfologiji, mogu lako razumjeti referentne sustave NCDT-ova kao što je ASUDAS (5, 34). U ovoj studiji identificirane su značajke koje pokazuju varijacije u različitim klasama malokluzije kad je riječ o

as scoring or severity. Our results show prominence of shoveling in upper central and lateral incisors in Class I and double shoveling in Class II. This finding is in contrast to a study by Ashoori et al, 2022 who documented presence of shoveling in central, lateral incisors, and canine in Class II. Also, premolar accessory cusp was more prominent in Class II in our study, while Ashoori et al noticed higher prominence in Class I compared to Class II. Lingual mesial ridge on canines in Class II was prominent in our study, while in their study the distal accessory ridge in canine was more prominent. The difference in these findings may be attributed to the difference in sample selection in both studies. While our study equally divided the sample into 60 dental casts for each Angle's class, the latter presented the descriptive data of 331 patients in general, which may have dissimilar division of samples for each class of malocclusion. But both studies showed similarity in the prominence of *tuberculum dentale* or talon's cusp in Class II.(37) In addition to ASUDAS traits, Ashoori et al have also studied traits such as crowding, microdontia, hyperdontia, and peg shaped laterals which were not evaluated in our study. The arch traits in association with the number and shape discrepancies of teeth have been studied previously in separate studies including a study by Dhamo B et al, who examined an association between dental development timing and aberrant non-metric traits (crowding, impaction, and hypodontia) (38).

However, the comparative findings of our study highlighted the importance of shoveling of incisors in identifying malocclusion. Shoveling is known to be a polygenic trait, with a predilection towards Mongoloid ancestry (39), and it also shows its presence in Indian population (8). Thus, it can be an important aid in racial identification. Furthermore, shoveling encompasses prominent lingual marginal ridges and an accentuated lingual fossa. This is supposed to influence the dental arch dimensions and has shown the association with increased anterior upper arch depth, and varying grades of anterior upper and/or lower crowding (39).

Another trait, Carabelli's trait (CC) or "tuberculum anomale of Georg Carabelli" (10) which is an accessory nonfunctional cusp usually seen on the mesiolingual cusp of primary maxillary second molar and permanent maxillary first, second and third molars, is seen to show predominant presence in Class II (40). It shows hereditary linkage with association to genes PAX and MSX, and may vary in size and shape (8). Its presence along with shoveling has been used to differentiate between Mongoloids and Caucasoids, and thus it has forensic and anthropological applications (39). Due to the genetic linkage, it also shows association to Class II malocclusion in our study, which is known to have polygenic inheritance with partial penetrance and inconsistent expressivity (41). Besides, it also has many clinical implications including improper adaptation of orthodontic bands during banding (12), and susceptibility to caries (odds ratio of 4.7) (40). The prevalence of Carabelli's trait in our study is highest in Class II malocclusion, and lowest in Class III, in contrast to a study by Ashoori et al, where the highest prevalence was seen in Class I and lowest in Class III (13). The difference may be attributed to the difference in percentage of subjects

prisutnosti, te bodovanju ili ozbiljnosti. Rezultati pokazuju izraženost lopatastih gornjih središnjih i bočnih sjekutića u klasi I i labijalno lopataste sjekutiće u klasi II. Taj je nalaz u suprotnosti sa studijom Ashoorija i suradnika (2022.) koji su dokumentirali prisutnost lopatastih središnjih, bočnih sjekutića i očnjacima u klasi II. Dodatna kvržica pretkutnjaka također je bila istaknutija u klasi II u ovoj studiji, a Ashoori i suradnici zabilježili su veću istaknutost u klasi I u usporedbi s klasom II. Lingvalni mezijalni greben na očnjacima u klasi II bio je istaknut u ovom istraživanju, a u njihovoj je studiji distalni akcesorni greben u očnjaku bio istaknutiji. Razlika u tim nalazima može se pripisati razlici u odabiru uzorka u objema studijama. Dok je u ovoj studiji uzorak podjednako podijeljen u 60 zubnih odljeva za svaku klasu prema Angleu, u drugoj su predstavljeni opisni podatci 331 pacijenta koji mogu imati različitu podjelu uzoraka za svaku klasu malokluzije. Ali u objema je studijama naglašena sličnost u istaknutosti *tuberculum dentale* ili kvržice talona u klasi II. (37) Uz ASUDAS-ova svojstva, Ashoori i suradnici također su proučavali svojstva kao što su zbijenost, mikrodoncija, hiperdoncija i bočne strane u obliku klina koje nisu procijenjene u ovoj studiji. Značajke zubnog luka povezane s brojem i razlikama u obliku zuba već su proučavane u odvojenim studijama, uključujući onu Dhamoa i suradnika koji su ispitivali povezanost između razdoblja razvoja zuba i nenormalnih nemetričkih obilježja (napučenost, impakcija i hipodoncija) (38).

No usporedni nalazi u ovoj studiji istaknuli su važnost uklanjanja sjekutića u prepoznavanju malokluzije. Poznato je da su lopatasti sjekutići poligenska značajka, sa sklonošću prema mongoloidnom podrijetlu (39), a također pokazuju prisutnost u indijanskoj populaciji (8). Zato može biti važna pomoć u rasnoj identifikaciji. Nadalje, lopataste sjekutiće obilježavaju istaknuti jezični rubni grebeni i istaknuta jezična jama. To bi trebalo utjecati na dimenzije zubnog luka i pokazati povezanost s povećanom dubinom prednjega gornjeg luka i različitim stupnjevima kompresije prednjega gornjeg i/ili donjeg zubnog niza (39).

Još jedno obilježje, Carabellijevo svojstvo (CC) ili *tuberculum anomale* Georga Carabellija (10) koje je dodatna nefunkcionalna kvržica koja se obično vidi na meziopalatinalnoj kvržici primarnoga gornjega drugog kutnjaka i trajnoga maksilarnog prvoga, drugoga i trećega kutnjaka, pokazuje prevladavajuću prisutnost u klasi II (40). Pokazuje nasljednu povezanost s genima *PAX* i *MSX*, a može varirati u veličini i obliku (8). Njegova prisutnost zajedno s lopatastim sjekutićima korištena je za razlikovanje mongoloida i kavkazoida, pa ima forenzičku i antropološku primjenu (39). Zbog genetske povezanosti također pokazuje povezanost s malokluzijom klase II u ovoj studiji za koju je poznato da ima poligensko nasljeđe s djelomičnom penetrantnošću i nedosljednom ekspresivnošću (41). Uz to, to ima mnoge kliničke implikacije, uključujući nepravilnu prilagodbu ortodontskih traka tijekom vezivanja (12) i osjetljivost na karijes (omjer izgleda 4,7) (40). Prevalencija Carabellijeva svojstva u ovoj studiji najveća je u malokluziji klase II, a najniža u klasi III, za razliku od studije Ashoorija i suradnika u kojoj je najveća prevalencija uočena u klasi I, a najniža u klasi III (13). Razlika se može

with Class I and Class II malocclusions. However, the prevalence of Carabelli's trait is least in our study and Ashoori's study. In craniofacial anomalies such as cleft, no significant association of Carabelli's trait is seen with clefting, with the argument that these teeth are present away from the location of clefting (42).

Winging (W) is a well-recognized clinical finding, which has distal margins of incisor rotated in labial (called as winging) or lingual direction (counter winging) (43). Several factors are thought to be of importance in the production of winging of incisors, namely the tooth dimensions, alignment of incisors, dental arch size shape and sizes (44). In the current study, winging was seen predominantly in Angle's class 1 which may be the cause of anterior malalignment with a Class I molar relationship. Centric (around long axis/ true rotation) and eccentric (rotation away from centre i.e. tipping) winging (45) were not checked in the current study, as the scoring was based only on the degree on winging and counter-winging as per ASUDAS system. This could be considered in future studies since it may have significant clinical implications and applications in clinical orthodontics, aesthetic dentistry, and anthropology (9).

2) NDCTs in growth abnormalities

Craniofacial syndromes or growth abnormalities usually involve morphological and developmental deviations of cranial tissue components arising from a known or an unknown genotype. In the latter, it is required to establish significant associations with other traits including non-metric dental traits which show genetic predisposition (46). The dental approach is required to diagnose and understand the pathogenesis of the affected developmental craniofacial field and the secondary alterations affecting the growth abnormalities or syndromes (46). In accordance with this concept, the current study has evaluated the association of the abnormal relation of upper and lower jaws due to growth discrepancies in Class II and Class III malocclusions with the dental traits. We have found significant associations of traits such as double shoveling in Class II, and hypocone absence (3 cusp UM2) in Class III, among many others. All literature reviews introduce the topic and define some key terms such as craniofacial syndromes predominantly associated with aberrations in tooth number, tooth agenesis, eruption delay, resorption, etc.. These include cleidocranial dysostosis, Down' syndrome, Klinefelter's, oro-facial cleft, etc. but they have not been studied specifically for association with dental morphological traits (47). Besides, winging has also been reported in cleft lip and palate patient with Bloch Sulzberger syndrome. Further studies are needed for association with other growth abnormalities (48). Our study identified the difference in dental morphological traits in mandibular retrognathism (Class II) or mandibular prognathism (Class III), which are also commonly seen in craniofacial syndromes. Hence, it provides insights into future study areas related to dental morphology and phenotype in syndromes using ASUDAS system.

pripisati razlici u postotku ispitanika s malokluzijama klase I i klase II. Međutim, prevalencija Carabellijeva svojstva najmanja je u ovoj i Ashoorijevoj studiji. Kod kraniofacijalnih anomalija kao što je rascjep, nema značajne povezanosti Carabellijeva svojstva s rascjepom, uz argument da su ti zubi dalje od mjesta rascjepa (42).

Kriljenje (W) je dobro poznat klinički nalaz, to su distalni rubovi sjekutića rotirani u labijalnome (naziva se krilo) ili lingvalnome smjeru (kontrakrilo) (43). Nekoliko se čimbenika smatra važnima u stvaranju krila sjekutića, a to su dimenzije zuba, poravnanje sjekutića, te oblik i veličine zubnog luka (44). U ovoj studiji krilce je uočeno pretežno u Angleovoj klasi 1, što može biti uzrok prednjeg neporavnavanja s molarnim odnosom klase I. Centrična (oko duge osi/prava rotacija) i ekscentrična (rotacija od središta, tj. prevrtanje) krila (45) nisu provjerena u ovoj studiji zato što se bodovanje temeljilo samo na stupnju krila i kontrakrila prema sustavu ASUDAS. To bi se moglo razmotriti u budućim studijama jer bi moglo imati značajne kliničke implikacije i primjene u kliničkoj ortodonciji, estetskoj stomatologiji i antropologiji (9).

2) NDCT kod abnormalnosti rasta

Kraniofacijalni sindromi ili abnormalnosti rasta obično obuhvaćaju morfološka i razvojna odstupanja komponenti kranijalnog tkiva koja proizlaze iz poznatoga ili nepoznatoga genotipa. U tom je slučaju potrebno uspostaviti značajnu povezanost s drugim osobinama, uključujući nemetričke dentalne osobine koje pokazuju genetsku predispoziciju (46). Stomatološki pristup potreban je za dijagnosticiranje i razumijevanje patogeneze zahvaćenoga razvojnog kraniofacijalnog polja i sekundarnih promjena koje utječu na abnormalnosti rasta ili sindrome (46). U skladu s tim konceptom, autori ove studije procijenili su povezanost abnormalnoga odnosa gornje i donje čeljusti zbog razlika u rastu malokluzija klase II i klase III s karakteristikama zuba. Pronašli su, među mnogima drugima, značajne povezanosti kao što su dvostruki lopatasti sjekutići u klasi II i odsutnost hipokonusa (UM2) u klasi III. Svi pregledi literature uvode temu i definiraju neke ključne pojmove kao što su kraniofacijalni sindromi pretežno povezani s aberacijama u broju zuba, agenezom zuba, kašnjenjem nicanja, resorpcijom itd. To uključuje kleidokranijalnu disostozu, Downov sindrom, Klinefelterov sindrom, orofacijalni rascjep itd., ali nisu posebno proučavani zbog povezanosti s morfološkim značajkama zuba (47). Uz to, rotacija gornjih sjekutića je također zabilježena kod ispitanika s rascjepom usne i nepca s Bloch-Sulzbergerovim sindromom. Potrebne su daljnje studije o povezanosti s drugim abnormalnostima rasta (48). U ovoj studiji identificirana je razlika u morfološkim značajkama zuba u mandibularnom retrognatizmu (klasa II) ili mandibularnom prognatizmu (klasa III) koji se također često pojavljuju u kraniofacijalnim sindromima. Zato pruža uvid u buduća područja proučavanja koja se odnose na dentalnu morfologiju i fenotip u sindromima korištenjem sustava ASUDAS.

3) Frequency Analysis

Although this study was not performed primarily to evaluate the prevalence of NDCTs in Delhi and NCR population, it was possible to conduct a frequency analysis of individual traits and sum up their prevalence in different malocclusions to find the total prevalence. Additionally, a comparative analysis was also presented. According to Figure 1, the highest prevalence was seen in two traits, that is, cusp number and lingual cusp variation (LC). The results are in accordance with a previous study by the same authors, where NCDT frequency distribution in various populations including Ajnala (Amritsar, India), Western Eurasians, Sub- Saharan Africans and Northeast Asian populations also found unique cusp number and lingual cusp variation to be the most common NDCTs (3). The results may vary as per different ethnic populations, as a Brazilian study found hypoconulid absence (4 cusp LM2)(83%) to be the most common NCDT (14) which may be further influenced by dietary and geographic variations. Alternatively, there was a difference noted in our results regarding a previous Indian study by Kirthiga et al 2016 who found frequency of Carabelli's trait, and shoveling of upper central incisor to be 40.5% and 68.2% respectively (49), whereas our study found the frequencies of Carabelli's trait, and shoveling of upper central incisor of 25.5% and 16%, respectively. This may be explained based on collection of the sample in the above mentioned study from Bangalore, Karnataka population while our study was conducted in Delhi, NCR population. A similar study comparing ASUDAS traits in different ethnic populations showed a dramatic difference in 18 out of 21 traits between Eskimo-Aleuts, and American Indians with the Europeans, suggesting a genetic drift. Also, traits such as shoveling and cusp number were indirectly associated to natural selection influenced by EDAR V370A allele, which may be a focus of future studies (50). Nevertheless, the importance of dental traits in establishing ethnicity or historical significance in archeological remains has been studied (51) in addition to association with skeletal and dental malocclusions using anthropometric analyses (8).

4) Sexual Dimorphism

Dental morphologic features expressed in crown of teeth are believed to be sexually dimorphic but the studies till now show low significant association with some traits. The current study has shown significant association for the presence of traits such as shoveling of upper central and lateral incisors, cusp number show different degrees of sexual dimorphism. There are ASUDAS based studies supporting the fact that NCDT's have low sexual dimorphism (3, 52). Conversely, a Brazilian study found Carabelli's trait, hypocone absence, and Cusp 6 to be sexually dimorphic (14). The current study also found sexual dimorphism with respect to canine mesial ridge, and shoveling of upper central and lateral incisors. In few studies, Carabelli's trait shows a stronger association in males compared to females, favorably in bigger molars (53). Accordingly, our study found Carabelli's trait to be more frequent in males (33 i.e., 27.7 %) compared to females (18 i.e., 15%). In contrast, few studies also report the frequency of Carabelli's trait to be higher in females compared to males

3) Analiza učestalosti

Iako ova studija nije provedena da bi se procjenjivala prevalencija NDCT-a u populaciji Delhija i NCR-a, bilo je moguće analizirati učestalost pojedinačnih svojstava i sumirati njihovu prevalenciju u različitim malokluzijama kako bi se utvrdila ukupna prevalencija. Dodatno je obavljena i komparativna analiza. Prema slici 1. najveća prevalencija zabilježena je u dvama svojstvima – u broju kvržica i varijaciji jezičnih kvržica (LC). Rezultati su u skladu sa studijama nekih autora, gdje je distribucija učestalosti NCDT-a u različitim populacijama, uključujući Ajnale (Amritsar, Indija), stanovnike zapadne Euroazije, supsaharske Afrike i populaciju sjeveroistočne Azije, također otkrila jedinstveni broj kvržica i varijaciju jezične kvržice (3). Rezultati mogu varirati ovisno o različitim etničkim populacijama, pa je tako u brazilskoj studiji istaknuto da je odsutnost hipokonulida (LM2) (83 %) najčešći NCDT (14), na što mogu dodatno utjecati prehrambene i geografske različitosti. Alternativno, uočena je razlika u rezultatima u ovoj studiji u odnosu na prethodnu indijsku studiju koju su proveli Kirthiga i suradnici 2016. godine te utvrdili da je učestalost Carabellijeva svojstva i guljenja gornjega središnjeg sjekutića 40,5 %, odnosno 68,2 % (49), dok je u ovoj studiji otkrivena učestalost od 25,5 %, odnosno 16 %. To se može objasniti na temelju prikupljenih uzoraka u navedenoj studiji iz Bangalorea, (u populaciji Karnataka), a ovo je istraživanje provedeno u Delhiju na NCR populaciji. Slična studija koja je uspoređivala svojstva ASUDAS-a u različitim etničkim populacijama pokazala je drastičnu razliku u 18 od 21 svojstva između Eskima-Aleuta i američkih Indijanaca s Europljanima, što upućuje na genetski pomak. Također su svojstva poput lopatastih sjekutića i broja kvržica bila neizravno povezana s prirodnom selekcijom pod utjecajem alela EDAR V370A, što bi mogao biti fokus budućih studija (50). Unatoč tomu, proučavana je važnost dentalnih svojstava u utvrđivanju etničke pripadnosti ili povijesnog značenja u arheološkim ostatcima (51), uz povezanost sa skeletnim i dentalnim malokluzijama s pomoću antropometrijskih analiza (8).

4) Spolni dimorfizam

Vjeruje se da su morfološke značajke zuba izražene u njihovoj kruni spolno dimorfne, ali autori studija do sada ističu nisku značajnu povezanost s nekim osobinama. U ovoj studiji pokazana je znatna povezanost značajki kao što su lopatasti gornji središnji i bočni sjekutići, a broj kvržica pokazuju različite stupnjeve spolnog dimorfizma. Postoje studije temeljene na ASUDAS-u koje podupiru činjenicu da NCDT-ovi imaju nizak spolni dimorfizam (3, 52). Nasuprot tomu, u brazilskoj studiji ističe se da su Carabellijevo svojstvo, odsutnost hipokonusa i kvržica 6 spolno dimorfni (14). U ovoj studiji također je otkriven spolni dimorfizam s obzirom na mezijalni greben očnjaka i lopatu gornjih središnjih i bočnih sjekutića. U nekoliko studija Carabellijevo svojstvo pokazuje jaču povezanost kod muškaraca u usporedbi sa ženama, posebno kad je riječ o većim kutnjacima (53). Sukladno tomu, u ovom je istraživanju istaknuto da je Carabellijevo svojstvo češće kod muškaraca (33, tj. 27,7 %) u usporedbi s ženama (18, tj. 15 %). Nasuprot tomu, u nekoliko studija također je istaknuto

(54, 55). Additionally, significant sexual dimorphism with a probability of 0.01 was also reported for shoveling, double-shoveling, metacone, hypocone, tuberculum dentale, and the middle trigonid crest in previous studies (56, 57). In concordance, Ashoori et al. also reported the occurrence of distal trogonid crest and talon cusp to be more present in men, while accessory cusps and microdontia were more present in women (13). It is believed that sexual dimorphism in these dental traits is caused by the variation in sex chromosomes and should be studied further using a genetic approach for genetic linkages with other anomalies or conditions.

5) Orthodontic association of NCDT's

There are few traits which have shown specific mention with respect to diagnosis and treatment in orthodontics. Craniofacial growth has been associated change in the morphology of teeth as well as intra-arch traits of crowding and ectopic eruption of teeth (58). Besides, ASUDAS traits of winging and counter winging have been found in association with crowded and non-crowded arches and also in syndrome with cleft lip and palate. It is thus proposed that linkage of ASUDAS traits with single nucleotide polymorphisms (SNPs) be studied further for association with other anomalies of tooth number, morphology or shape, where they may serve as genetic proxies for early diagnosis of related conditions (24). In the treatment aspect, winging has been managed using sectional edgewise mechanics, cross-elastics as well as recent aligner systems. Yet they are recommended to be followed for a longer retention period (48, 59). Carabelli's traits are expressed in varying degree in different ethnicities, but their presence can be a deterrent to proper adaptation of orthodontic bands in conventional orthodontic mechanics, which may further lead to dental caries or periodontal inflammation on collection of food debris in that area (54). Thus, these traits are important for formulating orthodontic management and retention protocols.

Limitations and road ahead:

To our knowledge, the current study is the first study to investigate 20 traits of ASUDAS anthropology system with different classes of orthodontic malocclusions in Indian population which makes comparison with world-wide data. However, this study has a few limitations. Since it is a single center study, it does not involve data of traits from pan-India orthodontic population, thus may have introduced some geographical bias. Further studies should enroll patients from multiple centers across the country with a standard protocol and analysis, and a centralized monitoring system. Artificial intelligence can be incorporated in the malocclusion-non metric dental crown trait (M-NDCT) anthropological variants chart for automated assessments, which can reduce confounding variables. Intra-oral photographs can be standardized for NDCT analysis and machine learning algorithms can be formulated for mass usage. NDCTs can be further studied for genetic linkages with other growth aberrations and syndromes, which may be useful to aid early diagnosis of these

da je učestalost Carabellijeva svojstva češća kod žena u usporedbi s muškarcima (54, 55). Dodatno, u dosadašnjim je studijama također prijavljen značajan spolni dimorfizam s vjerojatnošću od 0,01 za lopataste sjekutiće, dvostruke lopataste sjekutiće, metakonus, hipokonus, *tuberculum dentale* i srednji trigonidni brijeg (56, 57). U skladu s tim, Ashoori i suradnici također su izvijestili o pojavi distalne trogonidne kreste i kvržice talona koja je bila češća kod muškaraca, a akcesorne kvržice i mikrodoncija bile su prisutnije kod žena (13). Pretpostavlja se da je spolni dimorfizam u tim dentalnim svojstvima prouzročen varijacijama u spolnim kromosomima i da bi ga trebalo dalje proučavati koristeći se genetskim pristupom za genetske veze s drugim anomalijama ili stanjima.

5) Ortodontska povezanost NCDT-a

Nekoliko je značajki koje su posebno spomenute kad je riječ o dijagnozi i liječenju u ortodonciji. Kraniofacijalni rast povezan je s promjenom morfologije zuba i značajkama zbijenosti te ektopičnog nicanja zuba unutar luka (58). Uz to, ASUDAS-ova svojstva krila i kontrakrila pronađena su u vezi sa zbijenim i nenatrpanim lukovima te također u sindromu s rascjepom usne i nepca. Zato se predlaže daljnje proučavanje povezanosti svojstava ASUDAS-a s polimorfizmima jednog nukleotida (SNP) radi povezanosti s drugim anomalijama broja zuba, morfologije ili oblika gdje mogu poslužiti kao genetski proksi za ranu dijagnozu povezanih stanja (24). U aspektu tretmana rotiranih gornjih sjekutića upravljalo se korištenjem sekcijske rubne mehanike, ukrižene elastike i novijih sustava poravnanja. Ipak, preporučuje se njihovo praćenje tijekom duljeg razdoblja zadržavanja (48, 59). Carabellijeva svojstva izražena su u različitim stupnjevima u različitim etničkim skupinama, ali ona mogu biti prepreka pravilnoj prilagodbi ortodontskih traka u konvencionalnoj ortodontskoj mehanici, što može potaknuti zubni karijes ili parodontnu upalu zbog skupljanja ostataka hrane u tom području (54). Zato su te značajke važne za formuliranje ortodontskog planiranja i retencijskih protokola.

Ograničenja i put pred nama

Prema našim spoznajama ovo je prva studija koja istražuje 20 karakteristika antropološkog sustava ASUDAS-a s različitim klasama ortodontskih malokluzija u indijskoj populaciji te se uspoređuje s podatcima iz cijelog svijeta. No studija ima nekoliko ograničenja. Budući da je riječ o studiji s jednim središtem, ne obuhvaća podatke o karakteristikama panindijske ortodontske populacije i zato je možda unijela određenu geografsku pristranost. U buduće studije trebalo bi uključiti pacijente iz više središta diljem zemlje sa standardnim protokolom i analizom te centraliziranim sustavom praćenja. Umjetna inteligencija može se ugraditi u tablicu antropoloških varijanti malokluzije – nemetričke zubne krune za automatizirane procjene, što može smanjiti zbunjujuće varijable. Intraoralne fotografije mogu se standardizirati za NDCT analizu, a algoritmi strojnog učenja mogu se formulirati za masovnu upotrebu. NDCT-ovi se mogu dalje proučavati zbog genetskih veza s drugim aberacijama i sindromima rasta, što može biti korisno u ranoj dijagnozi tih stanja. Pro-

conditions. The orthodontic diagnosis and management protocols based on these NDCTs should be devised and implemented in standard orthodontic textbooks and clinical practices.

Conclusions

Class I malocclusion showed predominant presence of winging (25%), shoveling – upper central (25%) and lateral incisor (33.3%), protostylid (71.7%), hypoconulid absence in lower second molar (81.7%), and cusp number (88.3%). Class II malocclusion predominantly showed presence of double shoveling (33.9%), interrupted groove(78%), *tuberculum dentale*, canine mesial ridge (47.5%), premolar accessory cusp in the upper left first and second premolar, Carabelli's trait (35.6%), lingual cusp variation (89.8%), and seventh cusp (64.4%) in the lower left first molar. Class III malocclusion showed predominantly the absence of hypocone in upper second molar (58.3%), deflecting wrinkle (48.3%), distal trigonid crest (51.7%), and Y groove in left lower second molar (26.7%). Sex-pooled data showed a significant difference in shoveling – upper central and lateral incisor, canine mesial ridge, Carabelli's trait, 3-cusp in upper second molar, and cusp number.

Conflict of interest

The authors have no conflicts of interest to declare.

Author's contributions: **P.K.** - Substantial contributions to the conception or design of the work, acquisition, analysis, and interpretation of data, drafting the work and reviewing it critically for important intellectual content, final approval of the version to be published, accountability for all aspects of the work for accuracy and integrity of any part of the work; **D.B.P.** - Data acquisition, analysis, and interpretation, drafting the work and reviewing it critically for important intellectual content, final approval of the version to be published, accountability for all aspects of the work for accuracy and integrity of any part of the work; **M.S.** - Data acquisition, analysis, and interpretation of data, drafting the work and reviewing it critically for important intellectual content, final approval of the version to be published; **A.N.** - Data acquisition, analysis, and interpretation of data, drafting the work and reviewing it critically for important intellectual content, final approval of the version to be published; **S.N.** - Data acquisition, analysis, and interpretation of data, drafting the work and reviewing it critically for important intellectual content, final approval of the version to be published, statistical analysis accuracy; **A.C.** - Substantial contributions to the conception or design of the work, acquisition, analysis, and interpretation of data, drafting the work and reviewing it critically for important intellectual content, final approval of the version to be published.

tokoli ortodontske dijagnoze i liječenja koji se temelje na tim NDCT-ovima trebaju biti osmišljeni i uvršteni u standardne ortodontske udžbenike i kliničku praksu.

Zaključci

Klasa I malokluzije pokazala je dominantnu prisutnost rotiranih gornjih sjekutića (25 %), lopataste gornje središnje (25 %) i lateralne sjekutiće (33,3 %), protostilid (71,7 %), odsutnost hipokonulida u donjemu drugom kutnjaku (81,7 %) i broj kvržica (88,3 %). Klasa II malokluzije pretežno pokazuje prisutnost dvostrukih lopatastih sjekutića (33,9 %), isprekidanog žlijeba (78 %), *tuberculum dentale*, mezijalnog grebena očnjaka (47,5 %), dodatnu kvržicu pretkutnjaka u gornjemu lijevom prvom i drugom pretkutnjaku, Carabellijevo svojstvo (35,6 %), varijaciju lingvalne kvržice (89,8 %) i sedme kvržice (64,4 %) u donjemu lijevom prvom kutnjaku. Klasa III malokluzije pokazala je pretežno odsutnost hipokonusa u gornjemu drugom molaru (58,3 %), deflektirajuću boru (48,3 %), distalni brijeg trigonida (51,7 %) i Y-utor u lijevomu donjem drugom kutnjaku (26,7 %). Podatci prikupljeni prema spolu pokazali su znatnu razliku u lopatastim gornjim središnjim i lateralnim sjekutićima, mezijalnom grebenu očnjaka, Carabellijevu svojstvu, trima kvržicama u gornjem drugom kutnjaku i broju kvržica.

Sukob interesa

Autori nisu bili u sukobu interesa.

Doprinos autora: **P. K.** – velik doprinos koncepciji ili dizajnu djela, prikupljanje, analiza i tumačenje podataka, izrada nacrta teksta i kritički pregled za važan intelektualni sadržaj, konačno odobrenje verzije koja će se objaviti, odgovornost za sve aspekte rada za točnost i cjelovitost bilo kojeg dijela rada; **D. B. P.** – prikupljanje podataka, analiza i tumačenje, izrada nacrta teskta i njegovo kritičko preispitivanje važnog intelektualnog sadržaja, konačno odobrenje verzije koja će se objaviti, odgovornost za sve aspekte rada za točnost i integritet bilo kojeg dijela rada; **M. S.** – prikupljanje podataka, analiza i interpretacija podataka, izrada nacrta teskta i kritički pregled za važan intelektualni sadržaj, konačno odobrenje verzije koja će biti objavljena; **A. N.** – prikupljanje podataka, analiza i interpretacija podataka, izrada nacrta teksta i kritički pregled za važan intelektualni sadržaj, konačno odobrenje verzije koja će biti objavljena; **S. N.** – prikupljanje podataka, analiza i interpretacija podataka, izrada nacrta teksta i njegovo kritičko preispitivanje važnog intelektualnog sadržaja, konačno odobrenje verzije koja će se objaviti, točnost statističke analize **A. C.** – velik doprinos koncepciji ili dizajnu djela, prikupljanje, analiza i interpretacija podataka, izrada nacrta teksta i kritički pregled za važan intelektualni sadržaj, konačno odobrenje verzije koja će biti objavljena.

Sažetak

Uvod: Dentalni fenotip pokazuje varijacije u obliku različitih metričkih i nemetričkih svojstava, uglavnom zbog međudjelovanja gena i okoline. Daje uvid u evolucijske trendove, podrijetlo i prehrambene navike. Nedavno je istražen njegov genetski afinitet s nekoliko anomalija rasta i razvoja kraniofacijalnog kostura koji je također odgovoran za dentalne i skeletne malokluzije. **Ciljevi:** U ovoj studiji autori istražuju nemetričke značajke zubne krune (NDCTs) korištenjem sustava dentalne antropologije Državnoga sveučilišta u Arizoni (ASUDAS) u različitim vrstama malokluzija u populaciji Delhija (regija glavnoga grada – NCR). **Materijali i metode:** Dizajn studije bio je promatrački i retrospektivan. Ukupni uzorak činilo je 240 pari gipsanih modela podijeljenih u četiri jednake skupine od po 60 ispitanika (30 muškaraca i 30 žena) na temelju malokluzije. Četiri skupine malokluzija bile su: Angleova klasa I, klasa II / 1, klasa II / 2 i klasa III. Istraživaču su bili nepoznati ID-i pacijenta i spol prije snimanja podataka. Podatke za gipsane modele očitala su tri neovisna promatrača u modificiranoj tablici antropoloških varijanti malokluzije – nemetričke značajke zubne krune (M-NDCT) radi povezanosti s različitim malokluzijama i spolom. **Rezultati:** Pronađene su znatne razlike u ekspresiji nekoliko NDCT-a (i u prisutnosti i u bodovanju) kod različitih malokluzija. Nepravilna okluzija klase I pokazala je pretežno rotirane gornje središnje sjekutiće, lopataste sjekutiće – gornji središnji i lateralni inciziv, protostilid, odsutnost hipokonulida u donjem drugom kutnjaku i broj kvržica. Klasa II malokluzije pokazala je dvostruki lopatasti sjekutić, isprekidanu brazdu, *tuberculum dentale*, mezijalni greben očnjaka, dodatnu kvržicu pretkutnjaka, Carabellijevo svojstvo, varijaciju lingvalne kvržice i sedmu kvržicu u donjemu lijevom prvom kutnjaku. Malokluzija klase III pokazala je odsutnost hipokonusa u gornjemu drugom kutnjaku, deflektirajuću boru, distalnu *crista trigonida* i Y-utor u lijevomu donjem drugom kutnjaku (26,7 %). Uz to, spolni dimorfizam uočen je u lopatastim sjekutićima – gornji središnji i lateralni sjekutić, mezijalni greben očnjaka, Carabellijevo svojstvo, tri kvržice u gornjemu drugom kutnjaku i broj kvržice. **Zaključci:** Pronađena je značajna povezanost između nemetričkih karakteristika zuba i malokluzija (klasa I, klasa 2/ 1, klasa II /2 i klasa III). Također su pronađene značajne spolno povezane razlike. Buduće studije mogu se provesti na multicentričnoj sveindijskoj razini sa standardnim robusnim protokolom i velikim uzorkom.

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