

## ORIGINAL PAPER

doi: 10.5455/medarh.2019.73.205-208

MED ARCH. 2019 JUN; 73(3): 205-208

RECEIVED: MAR 03, 2019 | ACCEPTED: APR 28, 2019

# Heritability of Craniofacial Characteristics in Twins - Cephalometric Study

Alisa Tiro<sup>1</sup>, Vildana Dzmidzic<sup>1</sup>, Samra Salaga-Nefic<sup>2</sup>, Ismeta Redzic<sup>3</sup>, Enita Nakas<sup>1</sup>

<sup>1</sup>Department of Orthodontics, School of Dental Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

<sup>2</sup>Private clinic, Bern, Switzerland

<sup>3</sup>Department of Public Health, Faculty of Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

**Corresponding author:** Enita Nakas, Department of Orthodontics, School of Dental Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina. Phone; ++387 33 214 249. E-mail: enakas@sf.unsa.ba, ORCID ID: <http://www.orcid.org: 0000-0003-0239-6566>

## ABSTRACT

**Introduction:** The growth and development of the craniofacial complex are under the influence of genetic and environmental factors, which determine its morphological and functional characteristics. Twin studies provide significant insight into how many genetic and environmental factors determine dental and craniofacial characteristics. **Aim:** The aim of the study was to determine the genetic influence on craniofacial complex using a twin study model. **Methods:** The study sample comprised 52 pairs of twins who were referred to the Orthodontic Department, School of Dental medicine, University of Sarajevo. Informed consent was obtained by the parents of the children included in the study. Twenty pairs of twins were diagnosed as monozygotic while 32 pairs were diagnosed as dizygotic. Zygosity was diagnosed by physical characteristics similarity. Nineteen variables were measured: 10 dental variables, 9 cephalometric. **Results:** Based on the findings of this study, t-test showed significant genetic effect on the length of cranial base ( $p = 0.03$ ), corpus of maxilla ( $p = 0.02$ ) and mandibular length ( $p = 0.03$ ), and also for B-angle ( $p = 0.04$ ). Environmental factors are more involved in determining dental traits (e.g., the inclination of the incisors). **Conclusion:** There is a significant genetic effect on the linear cephalometric variables: the length of the cranial base, maxillary length and mandibular length.

**Keywords:** Heritability, twins, cephalometric.

## 1. INTRODUCTION

The growth and development of the craniofacial complex are under the influence of genetic and environmental factors, which determine its morphological and functional characteristics. In the etiology of malocclusion, inheritance, congenital and environmental factors are equally important. However, in severe skeletal anomalies, the inheritance has a dominant role (1, 2).

It is important to accurately assess the impact of heritability on the development of craniofacial and occlusal characteristics for the planning of orthodontic therapy and prognosis because in genetically inherited anomalies, preventive action is not possible and the therapy is significantly limited (3). Research on twins presents a unique method for assessing the impact of genetic and environmental factors on the formation of an individual (4). Monozygotic twins are created by the fertilization of one oocyte, which is divided into two identical embryos at the early stage of the embryogenesis. Each embryo has the same number

and gene distribution—the genotype, which is manifested by identical morphological characteristics - phenotype. Variations in monozygotic pairs are the result of the influence of different environmental factors, as well as the interaction of genetic and environmental factors. The fertilization of two oocytes creates dizygotic twins, and from the very beginning they develop as two different embryos, which have a similar genotype, so they are phenotypically similar to other siblings, which are not twins. Variations in dizygotic twins are mostly due to differences in genetic bases (5). Observing occlusal characteristics within families, Harris and Smith have concluded that most of the examined variables are under the influence of environmental factors, which is the consequence of the same living conditions within the family (6).

Furthermore, the papers of Corruccini support the thesis of the stronger influence of environmental factors on malocclusion, which is associated with modernization in contemporary living conditions (7-

© 2019 Alisa Tiro, Vildana Demidzic, Samra Salaga-Nefic, Ismeta Redzic, Enita Nakas

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

9). The low prevalence of malocclusion in the Australian Aboriginal population supports this claim (10). Occlusal characteristics such as overbite, overjet, sagittal and the rotation of the anterior teeth do not show dominant genetic control, while the dimensions and shape of the dental arch are under the influence of the inheritance (11, 12). The results of the studies, which included size and shape of the dental arch and specific type of orthodontic irregularities as observed variables, show that the examined variables related to the maxilla are under the strong influence of the inheritance (11-13). Analyzing the craniometric and occlusal variables, similar studies concluded that the craniofacial characteristics are under a stronger genetic control compared to occlusal characteristics (14-17). Recent studies, in which scanning of the craniofacial complex was done, and where cephalometric and gnathometric analysis have been performed with sophisticated computer analyses, also confirm these conclusions (18-21).

## 2. AIM

Starting from the assumption that genetic factors have a dominant role in the formation of craniofacial characteristics concerning their influence on occlusal and functional characteristics, the aim of the study was to determine genetic influence on craniofacial complex using twin study model.

## 3. METHODS

The study sample comprised 52 pairs of twins from the same geographical area and the same race, who were referred to the Orthodontic Department, School of dental medicine, University of Sarajevo. All referred patients were recruited as part of the project "Genetic characteristic of the craniofacial complex in the twins." The study was approved by the Ethics Committee of School of Dental Medicine, University of Sarajevo (09-225-15/05).

Zygosity was diagnosed by physical characteristics similarity, and by number of fetal membranes and placentas on birth as reported by mother. Informed consent was obtained by the parents of the children included in the study. Only healthy children without a history of head and neck trauma, surgery or orthodontic treatment were included in the study. Twenty pairs of twins were diagnosed as monozygotic (MZ) and 32 pairs were diagnosed as dizygotic (DZ). Nineteen variables were measured: 10 dental variables, 9 cephalometric (3 linear and 6 angular). Data were analyzed using Statistical Package for Social sciences (SPSS/PC). For each variable, mean value, standard deviation, intra-pair and inter-pair differences were calculated and tested by t-test, for MZ and DZ twin pairs.

### Dental characteristics

Dental variables were obtained from study models, being that as follow: mesiodistal diameter (MDD) of central and lateral maxillary and mandibular incisors, overjet and overbite. All measurements were made on the sliding caliper (Dentaurum). Teeth were selected for measurements only if they were fully erupted, not noticeably affected by attrition or caries and had not been restored.

The MDD of a tooth is obtained measuring the greatest distance between proximal surfaces of the crown.

Overjet was defined as the horizontal distance between incisors (11 and 21) and (31 and 41) and was measured directly on the models, from buccal to buccal surfaces. The overbite was defined as the vertical distance between incisors (11 and 41) and was measured directly on the models, a pencil marking indicating the upper incisor edge was made on the buccal surface of the lower incisors. In case of the open bite, the distance between incisal edges was measured.

Cephalometric points	
N (Nasion)	The most anterior point of the frontonasal suture in the midsagittal plane
S	Midpoint of sella (the center of sella turcica)
A (subnasal)	The deepest midline point on the anterior outer contour of the maxillary alveolar process
B (supramentale)	The deepest point on the outer contour of the mandible
ANS	Anterior nasal spine, the most anterior point of the tip of the anterior nasal spine in the midsagittal plane
PNS	Posterior nasal spine
Go (Gonion)	A point at the intersection of lines tangent to the posterior border of the ramus and the lower border of the mandible
Me (Menton)	The most inferior point of the outline of the symphysis in the midsagittal plane
Cephalometric linear variables	
Maxillary plane	A plane passing through ANS and PNS
Mandibular plane	Mandibular plane—a plane passing through points Me and Go
Length of maxilla	Distance between points ANS to PNS
Length of mandible	Distance between points Me to Go
L1	Lower incisal constructed between incisal tip of most anterior mandibular central incisor and its apex
U1	Upper incisor constructed between incisal tip of most anterior maxillary central incisor and its apex
Cephalometric angular variables	
SNA angle	The sagittal position of the maxilla relative to the cranial base using A-point as a cephalometric landmark
SNB angle	The sagittal position of the mandible relative to the cranial base using B-point as a cephalometric landmark
ANB angle	The sagittal relative position of the maxilla to mandible. The ANB angle can be measured or calculated from the formula: ANB = SNA – SNB
B angle	The angle between mandibular and maxillary plane
UII (Upper incisors inclination)	The angle of the long axis of a upper central incisor from a maxillary plane
LII (Lower incisors inclination)	The angle of the long axis of a lower central incisor from a mandibular plane

Table 1. Definition of cephalometric points, linear and angular variables

### Cephalometric characteristics

All cephalograms were made on the Kodak C 8000 Panorex–Ceph machine. Films of poor quality and those of which posterior teeth were not occluded, were not included in the study. Skeletal cephalometrics landmarks were identified on each radiogram. Linear and further angular measurements were taken: Cranial base length (S-N), Maxillary length (ANS-PNS), Mandibular length (Go-Me), SNA, SNB, ANB, B angle, the inclination of maxillary incisors and inclination of mandibular incisors, as shown in Figure 1 and Table 1.

Intra-observer method error was assessed using Pearson test of correlation. The correlation was 0.899 and tested by tracing and measuring 10 randomly selected lateral cephalograms, twice in 30 days.

## 4. RESULTS

Data were analyzed using Statistical Package for Social sciences (SPSS/PC). Mean value, standard deviation, intra-pair and inter-pair differences were calculated and tested with a t-test. The mean age of twins was 8.3 to 14.8 years. The difference in average variability between DZ and MZ twins was used as an estimate of the heritability in the etiology of malocclusion. Mean value for MDD in monozygotic twins was smaller than the dizygotic twins. There were no statistically significant differences in MDD of teeth 11, 21, 22, 31, 32 and 42 between MZ and DZ group. Measurements have shown that variability differed between a single tooth, as the upper right lateral incisor and lower left central incisor has exhibited the greatest variability,  $p = 0.04$  and  $p = 0.05$ . An overjet and overbite in the group of monozygotic twins were different as compared to the dizygotic group, but with no statistical significance ( $p=0.56$ ,  $p=0.39$ ). The relative variability in MDD of permanent incisors determined by the t-test in the MZ and DZ groups are shown in Table 2. The relative difference in cephalometric variables determined by the t-test, are shown in Table 3.

## 5. DISCUSSION

One of the major methods in genetics to estimate genetic and environmental influences is the twin method (22-24). As MZ twins possess identical genetic material,

Dental characteristics	MZ		DZ		t-test	p-value
	x	SD	x	SD		
MDD 11	0.11	0.21	0.33	0.43	-1,507	0.14
MDD 12	0.11	0.19	0.45	0.48	-2,13	0.04
MDD 21	0.11	0.21	0.39	0.45	-1.854	0.08
MDD 22	0.16	0.22	0.42	0.50	-1.594	0.14
MDD 31	0.07	0.16	0.30	0.34	-2.01	0.06
MDD 32	0.14	0.23	0.36	0.38	-1.683	0.11
MDD 41	0.07	0.16	0.33	0.38	-2.06	0.05
MDD 42	0.14	0.22	0.39	0.38	-1.855	0.08
Overjet	1.40	2.49	1.96	2.28	-0.597	0.56
Overbite	0.85	1.11	1.28	1.26	-0.866	0.39

Table 2. Comparison of dental characteristics between monozygotic and dizygotic twins. MDD–mesiodistal diameter

Cephalometric characteristics	MZ		DZ		t-test	p-value
	x	SD	x	SD		
Cranial base length	0.90	1.06	2.87	2.58	- 2.281	0.03
Maxillary length	0.97	1.51	3.44	2.81	- 2.548	0.02
Mandibular length	1.60	0.98	4.15	3.29	- 2.371	0.03
ANB angle	0.97	0.73	1.93	1.71	- 1.677	0.10
SNA angle	1.39	1.68	2.60	2.82	- 1.220	0.23
SNB angle	1.85	1.85	3.23	3.07	- 1.278	0.21
B angle	3.30	2.48	6.23	3.70	- 2.202	0.04
UII	3.79	3.57	5.66	3.31	- 1.360	0.19
LII	2.98	2.83	5.47	4.19	- 1.652	0.11

Table 3. Comparison of cephalometric characteristics between monozygotic and dizygotic twins. UII – Upper incisors inclination; LII – Lower incisors inclinations

differences between them can be attributed to environmental factors (23, 24). Our study included 52 pairs of MZ and DZ twins from the same geographical area and the same race, zygosity based on physical characteristics similarity was reliable in 95% of cases in previous researches (25, 26).

### Dental characteristics

Based on the results of this study, we could not confirm the primary role of the genetics in dental traits such as overjet and overbite, and incisor size (Table 2). The dental traits are strongly influenced by environmental factors such as food, habits (suckling, etc.) and trauma (27-30). However, the role of the genetic factors controlling tooth size and morphology has been shown in previous studies (31). It has been suggested that the peg-shaped or reduced lateral incisors may be the result of a variation in the expression of hypodontia (32), this can be the reason for the differences in the diameter of the 12 and 41 teeth, as observed in our study.

### Cephalometric characteristics

Based on the results of this study, the primary role of the genetics in length of the cranial base was confirmed ( $p = 0.03$ ), the corpus of the maxilla ( $p = 0.02$ ) and the mandibular length ( $p = 0.03$ ). The same findings were obtained for B-angle ( $p = 0.04$ ) (Table 3). Similar results were obtained in twin studies of the Chinese, Saudi and Iranian population (33-35). This could be the reason why orthodontic treatment is not stable in case of skeletal anomalies when compared with surgical treatment (36). Other cephalometric traits did not show a statistically significant difference between the MZ and DZ SNA angle ( $p = 0.23$ ), SNB ( $p = 0.21$ ), angle ANB ( $p = 0.10$ ), inclination of maxillary incisors ( $p = 0.19$ ) and inclination of mandibular incisors ( $p = 0.11$ ), hence the environmental factors may contribute to deter these traits. Lobb found the similar results as the results in our study (37). Based on these findings the orthodontic treatment is possible and it is possible to achieve aesthetic and functional occlusion without surgical treatment. The muscular action, which helps in performing of all functions of the orofacial region, presents a significant factor in the remodeling of the jaw bones. By performing a proper function, it is possible to prevent and make corrective actions even in severe skeletal forms of orthodontic anomalies. By

making a re-education of mimic and masticatory musculature, interceptive and curative actions are possible. Difficulties in pairing the twins in the study and in the control group is the limitation of the twin studies.

## 6. CONCLUSION

Significant genetic effect on the linear cephalometric variables including the length of the cranial base, maxillary length, and mandibular length was proven in our study. Environmental factors are more involved in determining dental traits.

- **Author's contribution:** A.T., E.N. and V.Dz. gave substantial contribution to the conception or design of the work and in the acquisition, analysis and interpretation of data for the work. A.T., E.N., V.Dz., S.S.N., I.R. had role in drafting the work and revising it critically for important intellectual content. A.T., E.N., V.Dz., S.S.N., I.R. gave final approval of the version to be published.
- **Declaration of patient consent:** The authors certify that they have obtained all appropriate patient consent forms.
- **Conflicts of interest:** There are no conflicts of interest.
- **Financial support and sponsorship:** Nil.

## REFERENCES

1. Lundstrom A. An investigation of 202 pairs of twins regarding fundamental factors in the etiology of malocclusion. *Eur J Orthod.* 2007; 29: 51-57.
2. Townsend G, Hughes T, Bockmann M, Smith R, Brook A. How studies of twins can inform our understanding of dental morphology. *Front Oral Biol.* 2009; 13: 136-141.
3. Proffit WR. *Contemporary Orthodontic.* Mosby, St.Louis; 2018.
4. Townsend G, Hughes T, Luciano M, Bockmann M, Brook A. Genetic and environmental influences on human dental variation: a critical evaluation of studies involving twins. *Arch Oral Biol.* 2009; 54 Suppl 1: S45-51.
5. Cohen-Levy J, Kamoun-Goldrat AS, Simon Y, Lautrou A. Twins and the heritability of dentofacial phenotype. *Orthod Fr.* 2007; 78(1): 69-77.
6. Harris EF, Smith RJ. Occlusion and arch size in families. A principal component analysis. *Angle Orthod.* 1982; 52(2): 135-142.
7. Corruccini RS. An epidemiologic transition in dental occlusion in world populations. *Am J Orthod.* 1984; 86(5): 419-426.
8. Corruccini RS, Pacciani E. "Orthodontistry" and dental occlusion in Etruscans. *Angle Orthod.* 1989; 59(1): 61-64.
9. Corruccini RS, Townsend GC, Richards LC, Brown T. Genetic and environmental determinants of dental occlusal variation in twins of different nations. *Hum Biol.* 1990; 62(3): 353-367.
10. Hillson S. *Dental Anthropology.* University Press Cambridge; 1996.
11. Lapter V, Slaj M, Muretić Z, Weber D. Orthodontic anomalies and differences in gnathometric variables in twins. *Acta Stomatol Croat.* 1991; 25(1): 25-31.
12. Carels C, Van Cauwenberghe N, Savoye I, Willems G, Loos R, Derom C et al. A quantitative genetic study of cephalometric variables in twins. *Clin Orthod Res.* 2001; 4(3): 130-140.
13. Eguchi S, Townsend GC, Richards LC, Hughes T, Kasai K. Genetic contribution to dental arch size variation in Australian twins. *Arch Oral Bio.* 2004; 49(12): 1015-1024.
14. Hunter WS. A study of the inheritance of craniofacial characteristics as seen in lateral cephalograms of 72 like-sexed twins. *Rep Congr Eur Orthod Soc.* 1965; 41: 59-70.
15. Hu JR, Nakasima A, Takahama Y. Heritability of dental arch dimensions in humans. *J Craniofac Genet Dev Biol.* 1991; 11: 165-169.
16. King L, Harris EF, Tolley EA Heritability of cephalometric and occlusal variables as assessed from siblings with overt malocclusions. *Am J Orthod Dentofacial Orthop.* 1993; 104(2): 121-131.
17. Harris E, Johnson M. Heritability of craniometric and occlusal variables: a longitudinal sib analysis. *Am J Orthod Dentofacial Orthop.* 1991; 99(3):258-268.
18. Naini F, Moss J. Three-dimensional assessment of the relative contribution of genetics and environment to various facial parameters with the twin method. *Am J Orthod Dentofacial Orthop* 2004; 126 (6): 655-665.
19. Kau CH, Zhurov A, Bibb R, Hunter L, Richmond S. The investigation of the changing facial appearance of identical twins employing a three-dimensional laser imaging system. *Orthod Craniofacial Res.* 2005; 8: 85-90.
20. Weinberg SM, Parsons TE, Marazita ML, Maher BS Heritability of Face Shape in Twins: A Preliminary Study using 3D Stereophotogrammetry and Geometric Morphometrics. *Dent* 2000; 1(1): pii: 14.
21. Djordjevic J, Jadallah M, Zhurov AI, Toma AM, Richmond S. Three-dimensional analysis of facial shape and symmetry in twins using laser surface scanning. *Orthod Craniofac Res.* 2013; 16(3): 146-160.
22. Burke PH. Intrapair facial differences in twins. *Acta Genet Med Gemellol (Roma).* 1989; 38: 37-47.
23. Townsend G, Richards L, Hughes T, Pinkerton S, Schwerdt W. The value of twins in dental research. *Aust Dent J.* 2003; 48(2): 82-88.
24. Perinetti G. StaTips Part IV: Selection, interpretation and reporting of the intraclass correlation coefficient. *South Eur J Orthod Dentofac Res.* 2018; 5(1): 3-5.
25. Reed T, Plassman BL, Tanner CM, Dick DM, Rinehart SA, Nichols WC. Verification of self-report of zygosity determined via DNA testing in a subset of the NAS-NRC twin registry 40 years later. *Twin Research and Human Genetics.* 2005; 8: 362-367.
26. Spitz E, Moutier R, Reed T, Bushnel MC, Marchaland C, Roubertoux PL, Carlier M. Comparative diagnoses of twin zygosity by SSLP variant analysis, questionnaire, and dermatoglyphic analysis. *Behavior Genetics.* 1996; 26: 55-63.
27. Hughes T, Thomas C, Richards L, Townsend G. A study of occlusal variation in the primary dentition of Australian twins and singletons. *Arch Oral Biol.* 2001; 46(9): 857-864.
28. Sharma, K. Sex Differences in Genetic Determinants of Craniofacial Variations - A Study Based on Twin Kinships. *Acta Geneticae Medicae et Gemellologiae: Twin Research.* 1998; 47(1): 31-41.
29. Townsend G, Richards L, Hughes T, Pinkerton S, Schwerdt W. Epigenetic influences may explain dental differences in monozygotic twin pairs. *Aust Dent J.* 2005; 50(2): 95-100.
30. Baydas B, Oktay H, Metin Dagsuyu I. The effect of heritability on Bolton tooth-size discrepancy. *Eur J Orthod.* 2005; 27(1): 98-102.
31. Lundstrom A. Tooth morphology as a basis for distinguishing monozygotic and dizygotic twins. *Am J Hum Genet.* 1963; 15(1): 34-43.
32. Arte S, Nieminen P, Apajalahti S, Haavikko K, Thesleff I, Pirinen S. Characteristics of Incisor-Premolar Hypodontia in Families. *Journal of Dental Research.* 2001; 80(5): 1445-1450.
33. Peng J, Deng H, Cao C, Ishikawa M. Craniofacial morphology in Chinese female twins: a semi-longitudinal cephalometric study. *Eur J Orthod.* 2005; 27: 556-561.
34. Amini F, Borzabadi-Farhani A. Heritability of dental and skeletal cephalometric variables in monozygous and dizygous Iranian twins. *Orthodontic waves.* 2009; 68: 72-79.
35. Al Khudhairia TD, AlKofideb EA. Cephalometric craniofacial features in Saudi parents and their offspring. *Angle Orthod.* 2010; 80: 1010-1017.
36. Leelasinjaroen P, Godfrey K, Manosudprasit M, et al. Surgery first orthognathic approach for skeletal Class III malocclusion Corrections-a literature review. *J Med Assoc Thai.* 2012; Nov; 95 Suppl 11: S172-80.
37. Lobb WK. Craniofacial morphology and occlusal variation in monozygotic and dizygotic twins. *Angle Orthodont.* 1987; 57: 219-233.