BJOS Brazilian Journal of Oral Sciences

Original Article

Volume 21
2022
e225388

Dental arch characteristics among South Indian twins – A morphometric study

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Genetic and environmental factors are essential in occlusal variations and malocclusion and have been of considerable interest to orthodontists. Studies on twin pairs are one of the most effective methods for investigating genetically determined occlusal variables. Many studies have focused on distances between first molars or between canines but malocclusions can also occur in other regions of the dental arch. **Aim:** To evaluate the characteristics of the dental arch between pairs of Monozygotic (MZ) and Dizygotic (DZ) twins from Southern India. **Methods:** A random sample of 51 twin pairs (12–18years old) participated in this study. The zygosity of twin pairs was recorded by facial appearance. The occlusion of the first permanent molars was recorded according to Angle's classification. Study models were prepared to assess dental arch characteristics (i.e., arch form, arch perimeter, arch length; intercanine, intermolar width, and teeth size discrepancy). The obtained data was statistically analyzed using SPSS software 19.0. The student's t-test (two-tailed, independent) and Chi-square test was used to determine the significance of studied parameters. **Results:** Angle's Class I molar relation was more commonly observed followed by the Class II molar relationship among twins. The measured dental arch dimensions did not show a statistically significant difference among twin pairs. The ovoid arch form was commonly observed among Monozygotic and Dizygotic Twins. There was a similarity among MZ and DZ twins in the anterior and overall Bolton's ratio. **Conclusion:** There were similar occurrences of measured parameters among twins, which showed genetic predominance in the expression of measured dental arch traits.

Keywords: Dental arch. Twins. India.

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Editor: Altair A. Del Bel Cury

Received: April 21, 2021
Accepted: December 12, 2021

Introduction

Twin research has made important contributions to understanding normal and abnormal dentofacial development. Some researchers believed that the value of twin studies would diminish owing to the revolution in molecular biology, which has occurred over the past 10–15 years. However, the data derived from twins and their families have allowed the researchers to adopt newer models and approaches that take advantage of the unique features of twins and the twinning process and combined these with advances in genotyping and phenotyping[1].

Twins and the twinning process have been a continual source of fascination for human populations over the centuries. Building on the pioneering work of Sir Francis Galton in the 19th century, studies on twins became more common and sophisticated throughout the 20th century, which provided important insights into the relative contributions of genetic factors (nature) and environmental factors (nurture) to variation in many behavioral and physical features including some dental traits[1].

In dentistry, numerous differences in the dentofacial characteristics of individuals are seen even among family members. Some children have large teeth, high prevalence of dental caries, while only some have good occlusion and low dental caries. Therefore, the question arises as to whether the dental traits are inherited. Twin research allows establishing detectable genetic variability and study genetic environment interactions in dental development[2].

Othman et al. studied teenage twins and reported high genetic contribution to variation in dental arch dimensions[3]. Cassidy et al., suggested that arch size and shape are mainly determined by environmental effects[4]. Twin studies have demonstrated that, while genetic variance can be discerned for different occlusal variables, heritability tends to be low, which emphasizes the importance of environmental effects on occlusal variation[5]. Harris and Johnson obtained similar results in their longitudinal study on siblings[6]. The above mentioned researchers concluded that most observed variation in occlusion in permanent dentition was acquired rather than inherited[6]. Some studies have implicated hereditary contributions to tooth size, dental malalignment, occlusion, and tooth morphology[7-9]. Therefore, it is not clear whether dental arch characteristics are determined by genetic or environmental factors. Thus, the aim of the study was to evaluate the characteristics of the dental arch between pairs of Monozygotic (MZ) and Dizygotic (DZ) twins from Southern India.

Materials and Methods

Before commencing this cross-sectional study, ethical clearance was obtained from the institutional review board. (HIMS/IRC/126/20-21) The study protocol was as per the guidelines provided by the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research. The sample size calculation was done based on the previous studies[1,9,10] on the sample size chart with the power of 0.09.

Twins aged 12–18-year-old studying in the schools participated in this study. Permission from the schools was obtained, and preliminary identification of twins was done from the school admission register. Each child was given an information sheet, which explained the purpose and nature of the study. Children, who were willing to participate in the study, were given a consent form to obtain written informed consent from the parents. Only the children who obtained informed consent were included in the study. Strict confidentiality was assured for both parents and children.

Identification of twins was done by facial appearance and history[10]. The parents of each twin was met by an investigator, and a history of medical conditions, details of chorionicity, and the number of placental cords were obtained. Twin pairs with (1) permanent occlusion including second molar teeth, (2) no history of dental extraction, prosthesis, or filling in specific contact or occlusal surfaces, (3) no history of diseases, injuries, or surgical intervention in the craniofacial region were included[9,10]. The following twin pairs were excluded[9,10]: (1) children with handicapping conditions including medically compromised individuals, (2) children on long-term medication, (3) children with not completely occluded second permanent molars, (4) children undergoing orthodontic treatment, (5) children with mixed dentition, (6) children with periodontal problems, and (7) children with developmental anomalies such as cleft lip and cleft palate, (7) missing teeth, (8) dental anomalies, (9) children with retained deciduous teeth, and (10) children with severe crowding (11) children with genetic syndromes. Thus, a total of 51 pairs of twins were included, i.e., 27 pairs of MZ and 24 pairs of DZ twins.

Pro-forma was used to record the date of birth, gender, demographic details, and oral findings. The children were seated upright on a chair and examined in adequate natural daylight to receive maximum illumination. Oral examination of children was performed by only one examiner to avoid inter-examiner variability. The kappa value for the intra-examiner agreement of the tooth status was 0.88. The examination was performed using a disposable sterile mouth mirror and probe. Recording of data was done by a single trained assistant throughout the study.

An oral examination was performed on a specific day and time scheduled as per the convenience of the children. The molar relation was recorded according to Angle's classification[11]. Then; the impression of maxillary and mandibular teeth was made using a regular-setting very high viscosity impression material (Aquasil® Soft Putty Regular set, Dentsply). The impression was analyzed for the presence of bubbles, accurate record of all teeth, and vestibular depth. Any impression lacking these characteristics was repeated. The impression was disinfected with 0.5% sodium hypochlorite. The dental cast was prepared with a die stone.The dental cast was carefully separated from the impressions, and its quality was analyzed. The dental cast with broken teeth, extended restorations to interdental contact points, broken cusp tips and incisal edges, increased number of porosity and presence of tooth wear were excluded[12]. If required a repeat cast was prepared.

Inter-molar width, inter-canine width, arch length,arch perimeter, and maxillary arch depth were measured using Vernier's caliper (calibrated with an error of ±0.01 mm) on the dental cast as described by Moyer's[11]. Arch parameters for maxillary and mandibular jaws were separately measured. The dental arch form was assessed using arch form templates (Orthoform; 3M Unitek).The template was overlaid on the dental cast, and the best template was noted. The arch form was grouped into ovoid, tapered, and square according to Chuck[13]. Bolton[14] analysis was used to determine tooth size discrepancy in maxillary and mandibular teeth.The mean was calculated for both the overall '12' ratio and anterior '6' ratio. All the dental arch measurements were recorded thrice and the mean of the three values was taken as the corresponding measurement.

The obtained data were entered into a Microsoft Excel sheet and statistically analyzed using SPSS software 19.0 (IBM Corp, Released 2010, IBM SPSS Statistics for Windows, and Version 19.0. Armonk, NY: IBM Corp.).In this study, descriptive statistical analysis was performed. Significance was assessed at the 5% level of significance. The student's t-test (two-tailed, independent) was used to determine the significance of study parameters on a continuous scale between two groups. Intergroup analysis of metric parameters and Chi-square/Fisher exact test was used to determine the significance of study parameters on a categorical scale between two or more groups. The kappa statistic for the agreement was the inter-rater agreement statistic (kappa), which was used to evaluate the agreement between two classifications on ordinal or nominal scales. The agreement is quantified by kappa (κ) or weighted kappa (κw) statistics.

Results

Two independent examiners blinded to the type of twins measured the inter-molar width, inter-canine width, arch length, arch perimeter, and maxillary arch depth. They also determined the type of dental arch form and tooth size discrepancy in maxillary and mandibular teeth. Kappa test was performed for the examiners and the score obtained was 0.87 and 0.90 for inter-examiner and intra-examiner, respectively. If there was any disagreement with the measurement, the examiners jointly reviewed and discussed and reached an agreement. If there was a disagreement between the examiners a lower measurement was considered.

A total of 51 pairs of twins participated in this study. Among 51 pairs of twins, there were 27 pairs of MZ twins (14 male pairsand13 female pairs) and 24 pairs of DZ twins (11 male pairs and 13 female pairs). Angle's Class I molar relation was observed in 88.88% of MZ twins and 95.33% of DZ twins. Angle's Class II molar relation was seen in 14.81% of MZ twins and 12.5% of DZ twins (Table1). Figures 1 to 4 shows the mean value of inter-canine, inter-molar, arch length, arch perimeter,

Table 1. Type of molar occlusal relationship among twins

Zygosity	Twin	Type of molar occlusal relationship									
		Class I				Class II				Class III	
		Right side n (%)	p value	Left side n (%)	p value	Right side n (%)	p value	Left side n (%)	p value	Right side n (%)	Left side n (%)
MZ (n=27)	Twin A	24 (88.88)	0.7	24 (88.88)	0.3	3 (11.11)	0.7	3 (11.11)	0.3	0	0
	Twin B	23 (85.18)		23 (85.18)		4 (14.81)		4 (14.81)		0	0
DZ (n=24)	Twin A	21 (87.5)	0.7	21 (87.5)	0.4	3 (12.5)	0.7	3 (12.5)	0.4	0	0
	Twin B	23 (95.33)		23 (95.33)		1 (4.16)		1 (4.16)		0	0

and arch depth of MZ and DZ twins both in maxillary and mandibular dental arches. On comparison of the mean values for all four parameters, there was no significant difference between MZ and DZ twins. The most common arch form was ovoid, which was seen in 70–81% of MZ twins and 83–91% of DZ twins. The tapered arch form was seen in 14–25% of twins. The square arch form was the least common (Table 2). The tooth size discrepancies (i.e., mean of overall and anterior ratio among MZ and DZ twins) were similar (Table 3).

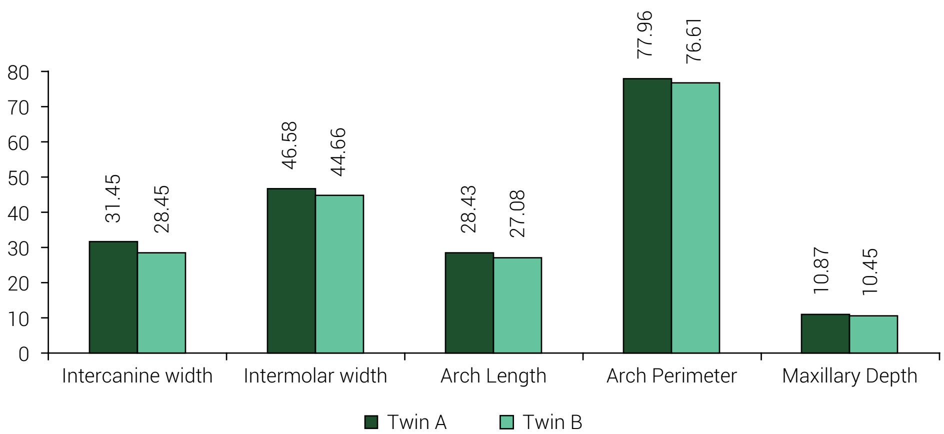

Figure 1. Maxillary dental arch characteristics among MZ twins

Table 2. Type of dental arch form among twins

Zygosity	Twin	Arch	Dental arch form		
			Ovoid n (%)	Tapered n (%)	Square n (%)
MZ (n=27)	Twin A	Maxilla	19 (70.37)	7 (25.92)	1 (3.70)
		Mandible	21 (77.77)	6 (22.22)	1(3.70)
	Twin B	Maxilla	20(74.7)	5(18.51)	2(7.4)
		Mandible	22 (81.48)	4 (14.81)	1 (3.70)
DZ (n=24)	Twin A	Maxilla	20 (83.3)	3 (12.5)	1 (4.1)
		Mandible	21 (87.5)	3 (12.5)	0
	Twin B	Maxilla	21 (87.5)	2 (8.3)	1(4.1)
		Mandible	22 (91.66)	1(4.1)	1(4.1)

Table 3. Comparison of tooth size discrepancy between MZ and DZ twins

Twin	Monozygotic Twins		Dizygotic Twins	
	Overall ratio	Anterior ratio	Overall ratio	Anterior ratio
Twin A	91.3 ± 0.14	77.26 ± 0.162	91.34 ± 0.134	77.3 ± 0.128
Twin B	91.4 ± 0.13	77.36 ± 0.173	91.27 ± 0.147	77.6 ± 0.133
p value	0.115	0.888	0.187	0.762

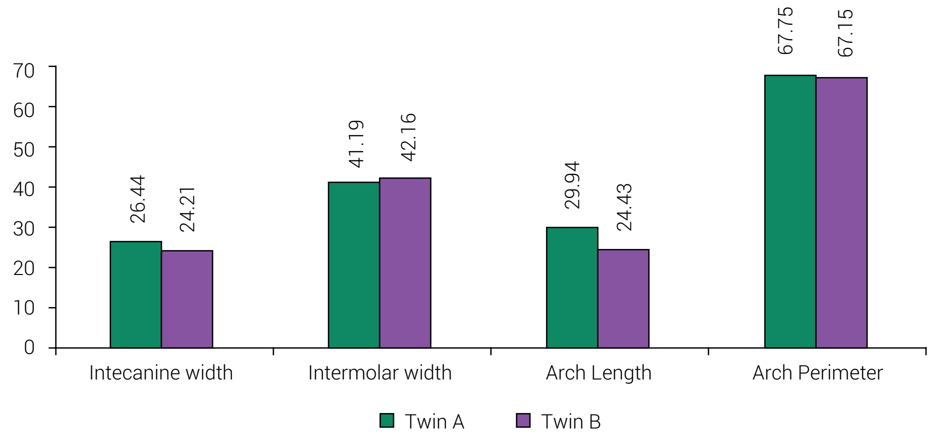

Figure 2. Mandibular dental arch characteristics among MZ twins

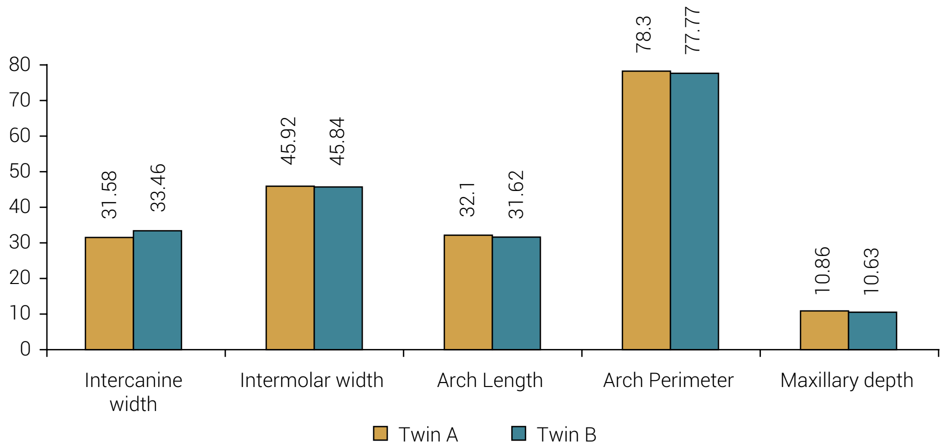

Figure 3. Maxillary dental arch characteristics among DZ twins

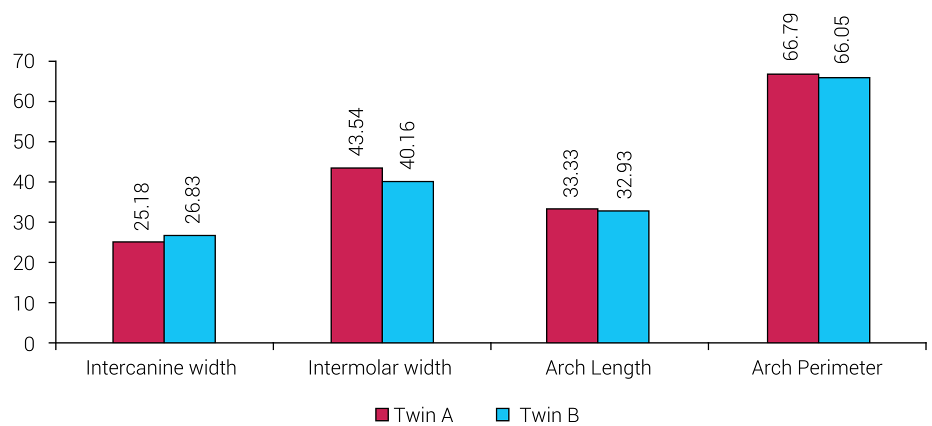

Figure 4. Mandibular dental arch characteristics among DZ twins

Discussion

Genetic and environmental factors are essential in occlusal variations and malocclusion and have been of considerable interest to dentist. Studies on twin pairs are one of the most effective methods for investigating genetically determined occlusal variables. However, studies on genetic effects on the dental arch have reported varying results[3-9].

Zygosity can be determined using physical features, examining the placenta, or DNA testing using cells from inside the cheek. In this study, twins were initially segregated as MZ (identical) and DZ (non-identical) based on general facial appearance. This method of zygosity recording is easier, non-invasive, and requires little cooperation from the twin pairs. Comparison of facial appearance is a reasonably accurate approach for distinguishing between MZ and DZ twin pairs[15-17]. Using this method, determination of zygosity is straight forward if the children are of different sexes (i.e., DZ). Among twins of the same sex, by the time the children are approximately two years old, their zygosity may be clear from their physical features. Color of hair and eyes, the shape of ears, teeth eruption and formation, the shape of hands and feet, and pattern of growth provide a good indication as to whether or not the twins are identical[18].

Genetic and environmental factors affect the occlusion and dental arch parameters. There is indisputable evidence for significant influence by many dental and occlusal variables[19]. In this study, most MZ and DZ twins showed Angle's Class I molar relation followed by Class II molar relation, and none of them had Class III molar relation. There was concordance among MZ and DZ twin pairs in the first molar relation. Similarly, Lundstrom reported Angle's Class I molar relationship in most of the studied twins followed by Class II molar relation[20]. Among Indian twins, the molar relation was highly significant within MZ twin pairs and had a 100% concordance rate. However, there was a decrease in the correlation rate for MZ twins compared to DZ twins, which suggested that the environment also affected the development of malocclusion[10]. Significant genetic variance of occlusal parameters (e.g., arch size and shape, overjet, overbite, and rotated teeth) have been reported[9]. However, an increased environmental component of variance in occlusion has also been reported[21]. Eguchi et al.[2] stated that occlusal variables are associated with low estimates of hereditability. Corrruccini and Potter[21] and Townsend et al.[5] also noted that heritabilities for occlusal variables (e.g., overbite and overjet) were relatively low.

Orthodontists need to know how much the dental arch dimensions depend on genetics and how much on the environment because larger effects of genetics suggest less effective orthodontic treatment outcomes. The stability of such outcomes depends on a certain balance between genetic and environmental factors[22]. In this study, the measured dental arch parameters (i.e., intercanine width, intermolar width, arch length,arch perimeter, and maxillary depth) were not significantly different between MZ or DZ twin pairs. The similarities in MZ twin pairs suggest a high genetic predisposition. A high intra pair concordance for dental size traits among Indian MZ twins has been reported, which suggests a significant genetic influence[23]. Boraas et al.[24] reported that arch width is under significant genetic influence. Othman et al.[3] observed a high genetic contribution in dental arch dimensions. Among Lithuanian twins, the largest genetic effect was observed on the upper dental arch breadth between lateral incisors[9]. A similar but lower heritability was inherent for canines and first premolars of the upper jaw and first premolars of the lower jaw. Among twins, the arch breadths between posterior teeth showed lower heritability estimates than between anterior teeth on both jaws. The dental arch in the upper jaw has a more expressed genetic component than that in the lower jaw[9]. Data among Australian twins revealed that arch length was mainly determined by genetics than arch breadth parameters[2]. The same study also determined that in the upper jaw, the breadths had increasing heritability with increasing distality of teeth, while in the lower jaw this was less expressed[2]. Dempsey et al.[25] studied the width of teeth and revealed that genetic factors affected all incisors. Townsend et al.[26] stated that the heritability of lower arch length in Australian twins can be as high as 0.92 and is mainly determined by genetics than arch breadth (0.82). Less consistent differences between upper and lower arch parameters were also observed by Eguchi et al.[2], with more prevailing heritability in the upper jaw than in the lower jaw. Shapiro[27] reported that genetic factors more strongly contributed to variation in palatal height than either arch breadth or length. Similarly, Eguchi et al.[2] reported that variation in the vertical dimension (height) of the maxillary dental arch is under considerable genetic control. A preliminary comparison of arch dimensions among Australian twins failed to disclose any significant differences[2]. Among them, both in maxilla and mandible, males exhibited a significant difference in arch dimensions than females but there was no significant difference in arch length and palatal heights displayed the greatest variation[2]. Authors from India reported a considerable resemblance in mandibular irregularity, maxillary intercanine distance, mandibular intercanine distance, and open bite among twins and concluded that there is a significant genetic predisposition for the studied dental parameters[10]. All the above mentioned studies suggest that dental arch parameters are mainly determined by genetics.

However, other researchers concluded that arch size is mainly determined by environmental than heredity factors; however, these researchers also stated that arch widths has the highest heritability estimates in adolescents[4]. They also suggested that arch length and width growth factors were mainly independent. Harris and Johnson[6] studied the arch breadth and length in 4–20-year-old subjects and reported that heritability estimates of traits related to tooth position gradually decreased, whereas the heritability estimates of craniofacial variables increased with age. Further, they highlighted the dynamic nature of the masticatory system and associated habitual activities and indicated that the relative contribution of genetic and environmental factors to occlusal variation was likely to change over time and also differed in different regions of dental arches[6]. Kawamura et al.[28] have proposed that dental arch breadth is related to buccolingual tooth inclination and, in turn, is affected by masticatory function, and tooth size is related to arch length. They stated that the three arch dimensions (i.e., arch length, breadth, and height, each occurring in a different plane) appeared to be independent of one another[28]. Šidlauskas[29] stated that total mandibular and corpus lengths are more heritable than maxillary. This result suggest that the effect of heritability on total jaw parameters does not apply to dental arch indicators. The difference in obtained results may be due to differences in the studied population, specific sample differences, or methodology that was used for the determination of zygosity.

The dental arch form has a wide individual variation in humans. The establishment of dental arch form aids manufacturers in designing arch wires. The most common arch form observed among both MZ and DZ was the ovoid followed by tapered and square arch form. Similar observations was reported in population of Saudi Arabian, Iran, Caucasia, Malaysia and India, but among singletons[3,12,30-32]. Sahoo et al. observed a narrow arch form to be most common among Indians than among Bhutanese[33]. Kook et al.[34] observed the square and tapered form of the dental arch were most common among the Korean and United States population, respectively.

To ensure proper inter-digitations, overbite, and overjet specific dimensional relationships must exist between maxillary and mandibular teeth. Proportionality of the size of maxillary and mandibular teeth affects the establishment of good stable functional occlusion. In this study, MZ and DZ twins showed values that were similar to those in Bolton's analysis for both anterior and overall ratios. There was concordance among MZ and DZ twins when anterior and overall ratios were compared. Studies on singletons conducted by Smith et al. using Bolton's inter-arch ratios in three populations (i.e., Black, Hispanic, and White) identified significantly different relationships between lower and upper teeth[35]. These authors have also observed sexual dimorphism in tooth dimensions and the ratio of upper and lower arch tooth sizes[35,36]. Lavelle reported that Blacks have larger overall and anterior ratios than Whites and Asians[36]. Stifter[37] replicated Bolton's study in non-twins with Class I dentitions and reported similar results, which match the results of our study.

The results of our study shows a genetic predominance in determining dental arch characteristics among twins. However, because the data on the genetic component may be country or region-specific or have an ethnic or racial background, it is essential to estimate the genetics across different populations and countries. It is also necessary to analyze environmental factors because they are essential for the development and determining the shape of dental structures.

The determination of twins using facial photographs and history. The cross-sectional nature and small sample size may have impacted the results of this study. Future longitudinal studies involving a larger sample size and determining zygosity using DNA of buccal cells should be performed to further validate our results. Multidisciplinary studies of twins with input from dentists, molecular geneticists, and twin researchers need to be performed to clarify the role of genetic factors in contributing to dental characteristics.

In conclusion, the similar occurrence of measured characteristics of dental arch between pairs of Monozygotic (MZ) and Dizygotic (DZ) twins suggest that there is genetic predominance in the expression of dental arch traits.

Acknowledgment

The authors report that we do not have a financial affiliation or any conflicts of interest for this paper.

Conflict of Interest

None.

Funding Agency

None.

Author contribution

Dr Girish Babu KL: Conceived the idea, Concept and Research design, literature search, data analysis and preparation of manuscript

Dr Geeta Maruti Doddamani: Conceived the idea, Concept and Research design, collected the data; conducted the Experiment

Dr Kavyashree G: Conceived the idea, Concept and Research design, literature search, data analysis and preparation of manuscript

All authors actively participated in the discussion of the manuscript's findings, and have revised and approved the final version of the manuscript.

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