

An evaluation of the relationship between periocular anthropometric measurements and mandibular incisor crowding

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Abstract

Aim: This study aimed to determine whether a relationship exists between the periocular anthropometric measurements (POAM), intercanine width, and Little's irregularity index (which measures the crowding of the mandibular incisors) among the Turkish population.

Methodology: Ninety-four children (49 with mandibular crowding and 45 in a control group) aged 12-18 years were included in this study. Subjects' inter-outer canthal distance (IOCD), inter-inner canthal distance (IICD), interpupillary distance (IPD), inter-canine width (ICW), and Little's irregularity index (LII) were measured from two standardized digital photographs using a public domain Java processing program (ImageJ software). Spearman's correlation coefficient and multiple linear regression tests were used to investigate the relationship between POAM, ICW, and LII.

Results: For the mandibular crowding group, the means of IICD, IOCD, IPD, and ICW were 30.6 ± 1.7 mm, 82.4 ± 2.0 mm, 59.2 ± 1.6 mm, and 23.3 ± 1.1 mm, respectively. For the control group, the means of the corresponding measurements were 32.1 ± 1.5 mm, 84.4 ± 2.4 mm, 60.1 ± 1.9 mm, and 24.6 ± 1.4 mm, respectively. Statistically significant differences were found between the groups among all variables ($p < 0.001$). A negative correlation was found between POAM and ICW with LDI. In particular, a high correlation was found between the ICW and IICD variables ($r = -0.732$, $p < 0.001$ versus $r = -0.705$, $p < 0.001$, respectively). As a result of this study's multivariate regression analysis, IICD and ICW were found to be affected by mandibular crowding negatively and significantly ($p = 0.003$ and $p = 0.026$, respectively).

Conclusion: Based on the results of our study, we concluded that IICD—which remains stable after the age of 10 years—and ICW can be used to predict irregularities of the mandibular incisors among children in the Turkish population.

Keywords: mandibular incisors, crowding, periocular anthropometric measurements, Little's irregularity index

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Received: 1 March 2021

Accepted: 18 May 2021

Access Online



DOI:

[10.5577/intdentres.2021.vol11.suppl1.31](https://doi.org/10.5577/intdentres.2021.vol11.suppl1.31)

How to cite this article: Kızıltan Eliacık B. An evaluation of the relationship between periocular anthropometric measurements and mandibular incisor crowding. Int Dent Res 2021;11(Suppl.1):216-21. <https://doi.org/10.5577/intdentres.2021.vol11.suppl1.31>

Introduction

Mandibular incisor crowding is among the most common types of malocclusion for children, and it is also one of the foremost complaints presented by many

adults referred to orthodontics (1). In the simplest terms, mandibular incisor crowding is defined as the discrepancy between the mesiodistal tooth widths of the four permanent incisors and the available space in the alveolar crest (2).

Crowding can be classified according to severity (mild, moderate, or severe) or into primary, secondary, and tertiary crowding, depending on when it appears in the dentition (3). Despite studies in the literature having reported that genetic and environmental factors affect the etiology of dental crowding, many researchers have focused on mesiodistal tooth size and dental arch discrepancies' role in crowding (4-7). Crucially, preventive orthodontic treatment plans must predict permanent incisor crowding at an early stage due to its potential effect on oral health by increasing susceptibility to dental caries and periodontal disease. Al-Zubair established a strong relationship between mandibular arch lengths and intercanine width (ICW), and Al-Joubori and Alhuwaizi reported on the effect of ICW on mandibular crowding (8, 9). Tripathi et al., on the other hand, showed a relationship between ICW and some periocular anthropometric measurements (10). A previous study of the Turkish population compared patients with a Class I facial pattern in early mixed dentition and those with anterior crowding, observing that the maxillary and mandibular lengths were shorter among patients with anterior crowding (4). Investigating the parameters that cause anterior crowding and the factors that could facilitate treatment among the Turkish population is extremely important.

In light of this information, we understood that anterior crowding may be associated with periocular anthropometric measurements (POAMs). The period for the optimum response to orthodontic treatment is known to be adolescence, and the detection and treatment of malocclusions during this period should reduce treatment lengths (11). According to the literature, the inner intercanthal distance (IICD) among POAMs remains constant after the age of 10 (12). The first examination of most children is performed by pedodontists. Therefore, the identification of crowding by a pedodontist, based on these measurements and informing patients' parents in advance, could save patients from more problematic and long-term future orthodontic treatments.

The present study aimed to reveal possible connections by examining the relationship between mandibular anterior crowding and POAMs among the Turkish population, contributing to the development of preventive orthodontic plans by predicting anterior crowding.

Materials and Methods

This observational, descriptive study was conducted with approval from the Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee (10840098-772.02-E.58380) and in accordance with the Declaration of Helsinki. The study included 49 participants with mandibular anterior crowding and 45 participants without mandibular anterior crowding, aged 12 to 18 years, who had presented to our dental clinic between September 2020 and April 2021. Study participants and their parents were informed about the scope of the study, and they gave written and verbal consent to voluntarily participate prior to the study.

A pediatric dentist performed an intraoral examination on 94 patients identified in the study's initial examination to ensure that the children participating in the study had an Angle's Class I molar relationship of occlusion. Patients with missing mandibular or maxillary teeth, restorations of the anterior teeth due to caries, a history of orthodontic treatment, any syndrome that would affect POAMs, or a history of surgery or trauma were excluded from the study.

Facial photographs for the POAMs measured in this study—interpupillary distance (IPD), inner intercanthal distance (IICD), and outer intercanthal distance (OICD)—and mandibular occlusal photographs to measure Little's irregularity index (LII) and ICW were recorded with a digital camera using previously validated methods (Fig. 1 and 2) (13, 14). The images acquired were transferred to ImageJ, free image processing and analysis software (<https://imagej.nih.gov/ij/download.html>).

Anatomical positions were marked on digital images, and linear measurements were made via the software's digital caliper and recorded by a single researcher (B. K. E.). To assess intra-rater reliability, 50% of the cases were randomly selected and measured again four weeks later by the same researcher under similar lighting, using the same device and software. The case group was divided into study and control groups, according to the indication of mandibular crowding in participants' occlusal measurements.

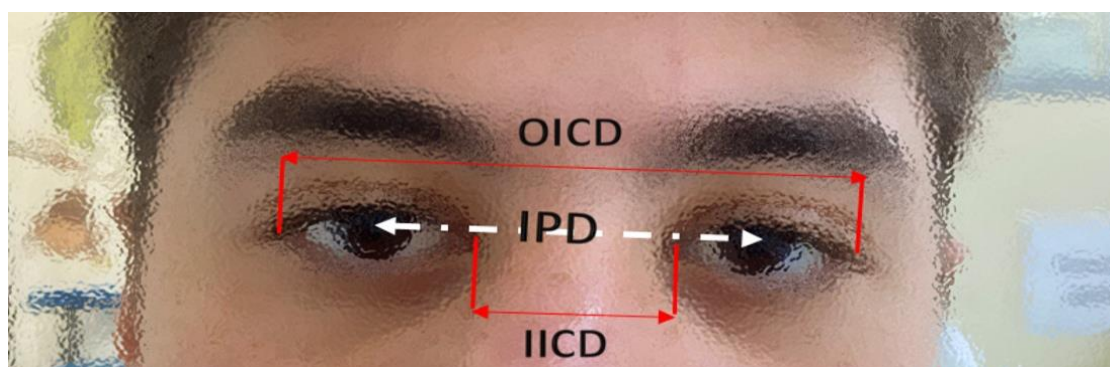


Figure 1. Periocular anthropometric measurements, IICD: Inner intercanthal distance, OICD: outer intercanthal distance, IPD: Interpupillary distance.

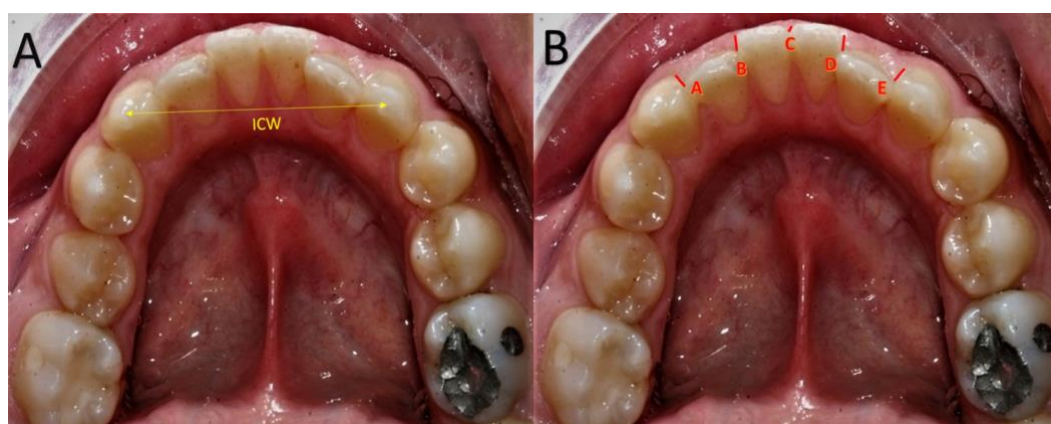


Figure 2. (A) Intercanine widths of the mandibular arch (B) Little's "Irregularity Index" of dental arch. It is the millimetric sum of five interproximal distances among the six anterior teeth: A + B + C + D + E

Statistical analysis

Data analyses were performed using SPSS software version 21.0 (IBM Corp., Armonk, NY, USA). The normal distribution of the considered variables was first evaluated using the Shapiro-Wilk test. The Mann-Whitney U-test was used for the comparison of two groups. To explore the relation of study variables Spearman's rank correlation and multivariate regression analysis were performed. A p-value of 0.05 was considered statistically significant.

Results

Table 1 presents the descriptive statistics for the crowding and control groups and the results of POAM and ICW comparisons between the groups. In the mandibular crowding group (n = 49), patients' mean IICD, OICD, IPD, and ICW were 30.6 ± 1.7 mm, 82.4 ± 2.0 mm, 59.2 ± 1.6 mm, and 23.3 ± 1.1 mm, respectively. In the control group (n = 45), meanwhile, the corresponding means were 32.1 ± 1.5 mm, 84.4 ± 2.4 mm, 60.1 ± 1.9 mm, and 24.6 ± 1.4 mm, respectively. When all POAMs and ICW were compared

between the groups (with and without crowding), significant differences were found for all variables ($p < 0.001$). When the correlation of POAMs and ICW with LII was analyzed for the crowding group, LII was found to be negatively correlated with all independent variables (Table 3). After correlation analysis, multivariate linear regression analysis was conducted to predict POAMs and ICW's effects on crowding. This analysis revealed a significant regression model ($F [4.44] = 11.85$, $p < 0.001$) and showed that 48% (R^2 adjusted = 0.475) of the variance in the dependent variable, crowding, was explained by the independent variables. Therefore, IICD and ICW negatively and significantly affected crowding ($B = -0.393$, $t[44] = -3.2$, $p = 0.003$, and $pr^2 = 0.18$ versus $B = -0.343$, $t[44] = -2.3$, $p = 0.026$, and $pr^2 = 0.11$). Additionally, OICD and IPD had no significant effect on LII ($p = 0.81$ and $p = 0.21$, respectively). When correlation and regression analyses were repeated for gender in the crowding group, the correlation coefficient for ICW was found to be higher among female participants than among male participants ($r = -0.572$ and $p = 0.0039$ versus $r = -0.493$ and $p = .0005$, respectively).

Table 1. Comparison of IPD, IICD, IOCD and ICW Indices among groups

Variable		Mean $\pm$ sd	Median (min, max)	p-value*
Age of Participants (years)	Crowding	14.7 ± 1.6	14(12-18)	.146
	Without Crowding	15.1 ± 1.5	15 (12-18)	
Interpupillary Distance (mm)	Crowding	59.2 ± 1.6	59 (56-63)	<.001
	Without Crowding	60.1 ± 1.9	61 (58-65)	
Inner Inter Canthal Distance (mm)	Crowding	30.6 ± 1.7	30(29-33)	<.001
	Without Crowding	32.1 ± 1.5	32(29-33)	
Outer Inter Canthal Distance (mm)	Crowding	82.4 ± 2.0	82 (79-88)	<.001
	Without Crowding	84.4 ± 2.4	84 (80-88)	
Intercanine Distance (mm)	Crowding	23.3 ± 1.1	22(21-25)	<.001
	Without Crowding	24.6 ± 1.4	24(22-27)	

*Mann-Whitney U test

Table 2. Spearman's rank correlation (rho) between the study variables

	1	2	3	4	5
1. Little's Irregularity Index	1				
2. Inter canine width	-,545**				
3. Interpupillar distance	-,301*	,460**			
4. Inner inter canthal distance	-,685**	,548**	,255		
5. Outer inter canthal distance	-,377**	,472**	,227	,358*	
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

Table 3. The result of Multivariate Regression Analysis

	Unstand. Beta	Std. Error	Stand. Beta	t	Sig.	95,0% Confidence Interval for	
						Lower Bound	Upper Bound
ICW	-,559	,243	-,343	-2,302	,026	-1,048	-,070
IPD	-,153	,121	-,149	-1,267	,212	-,397	,091
IICD	-,390	,124	-,393	-3,154	,003	-,639	-,141
OICD	-,024	,101	-,029	-,240	,812	-,228	,179
Dependent variable: Little's Irregularity Index ICW= Inter canine width IPD=Interpupillar distance IICD= Inner inter canthal distance OICD= Outer inter canthal distance							

Discussion

Anthropometric studies based on facial measurements in different ethnic and age groups report various results(15-20). However, unlike soft tissue references, POAMs are either not or minimally affected by gender and changes in age(21, 22). Two previous studies from Turkey found these measurements, and IICD in particular, not to vary by gender and age(12, 23). The study by Evereklioglu et al. evaluated POAMs of 3448 subjects aged 7 to 40 years and reported that IICD did not show any change after 10 years of age(12). Since the repeatability and consistency of the studies based on these stable measurements are high, these measurements are used by studies, especially in orthodontic and prosthetic dentistry. The in vivo study by Bangar et al., which was conducted to select artificial teeth for patients with missing anterior teeth via extraoral facial anthropometric measurements, established a high degree of positive correlation between IPD, intercanthal distances (ICDs), and ICW, which was observed for both sexes(24). In support of these findings, Tripathi et al. also found ICD and IPD to be correlated with ICW(10). In another study in which this relationship was proven, Shivhare et al. examined the role of ICW in detecting IPD and ICD for two-dimensional facial reconstruction and established a

correlation between ICW and these measurements(25). The present study also found that IPD, OICD, and IICD had a statistically significant relationship and a positive correlation with ICW, while the highest degree of correlation was between IICD and ICW ($r = .561$, $p < 0.01$).

Dental crowding is among the causes of malocclusion. Arch form and dimensions are two important factors in the assessment, diagnosis and treatment planning of orthodontic cases. Previous research on mandibular arch lengths has shown that long and short arches have an effect on diastema and crowding. For instance, Faruqui et al. investigated the effect of maxillary and mandibular arch lengths on crowding and reported that all mandibular and maxillary arches were shorter in cases with crowding than in those without crowding (26). The study by McKeown on 65 dental casts collected from individuals aged 18 to 25 years reported that arch width and crowding were strongly associated, and a narrow arch would lead to crowded teeth(27). The investigation by Howe et al. compared crowded and non-crowded groups using study models and concluded that arch dimensions had a greater contribution to dental crowding than the tooth size(28). In a similar age group, Al-Joubori and Alhuwaizi showed that individuals with crowding had narrower mandibular ICW than those without crowding among Angle's Class I

cases(8). Zigante et al. followed up 68 cases aged 12 to 21 years at three-year intervals and showed that the crowding decreased by 74% with the increase of ICW, especially in this age range(29). The present study obtained similar results to the abovementioned studies and determined that ICW was shorter in individuals with dental crowding. Furthermore, there was a negative correlation between ICW and LII. In addition, the degree of the correlation of IICD with ICW and LII was higher in female cases. In another study supporting the results of the present study, Ghaib et al. indicated that the prevalence of dental crowding was higher in females among Angle's Class I cases, which was attributed to the earlier skeletal maturity in females, leading to an earlier finalization of the final mandibular arch, compared to males(30).

The limitations of the study included a limited number of cases in a certain region and the assessment of only ICW among mandibular arch measurements. Future studies that will include larger cohorts and involve anthropometric facial measurements, both the ones used in the present study and others, will assist in the detection of possible connections between facial measurements and dental crowding in both jaws while supporting the existing ones. Although it is not possible to generalize the results of this study for all populations due to ethnic differences, the genetic diversity of the Turkish population due to the geographical location and historical background has created the possibility of various dental and facial patterns in the population. The results of the comparison of POAMs and ICW that reflects the clinical significance of crowding, and LII that has been used in many clinical studies before, revealed that the crowding would be more severe in cases with a narrower ICW. This finding is considered to be important. It is considered that the findings on the relationship between extraoral measurements and dental structure measurements could provide an insight to the pedodontists who will perform the first examinations of these children for the detection of possible crowding cases in advance and to the orthodontists for treatment planning prior to starting treatment for crowded teeth.

Conclusions

The present study established that IICD and mandibular ICW highly correlate with LII among patients aged 12 to 18 years during the permanent dentition stage, who most need orthodontic treatment. Therefore, we concluded that IICD—which does not change after the age of 10—may be appropriate as a clinical criterion in the treatment of dental crowding.

Acknowledgments: This study was presented as a full-text oral presentation at the 1st International Dental Research and Health Sciences Congress held between 20-22 May 2021.

Ethical Approval: Ethics committee approval was received for this study from Istanbul Medipol University in accordance the World

Medical Association Declaration of Helsinki, with the approval number: 10840098-772.02-E.58380

Peer-review: Externally peer-reviewed.

Author Contributions: Conception - B.K.E.; Design -B.K.E.; Supervision - B.K.E.; Materials - B.K.E.; Data Collection and/or Processing - B.K.E.; Analysis and/or Interpretation - B.K.E.; Literature Review - B.K.E.; Writer - B.K.E.; Critical Review - B.K.E.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

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