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Original Research Article

Comparison of Dental Arch Dimensions Among Dentoalveolar Class I, Class II, and Class III Malocclusions in Male and Female Patients: A Retrospective 3D Model-Based Study

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Abstract:

Background: Malocclusion is associated with variations in dental arch morphology, which may differ according to malocclusion type and sex. Three-dimensional digital models permit detailed and reproducible assessment of dental arch dimensions.

Aim: To compare dental arch dimensions among dentoalveolar Class I, Class II, and Class III malocclusions and to evaluate gender-related differences.

Methodology: This retrospective comparative 3D model-based study included 80 dental casts (40 males and 40 females) from patients with Class I (n=27), Class II (n=27), and Class III (n=26) malocclusions. Maxillary and mandibular interincisor, intercanine, interpremolar, and intermolar widths, arch depths, and width-to-depth ratios were measured on digitized three-dimensional models. Data were analyzed using IBM SPSS Statistics version 27.0, with $p<0.05$ considered statistically significant.

Results: Significant differences were observed in maxillary intercanine, first and second interpremolar widths ($p<0.001$, $p=0.006$, and $p=0.018$, respectively). Mandibular intercanine, first interpremolar, and intermolar widths also differed significantly ($p=0.038$, $p=0.042$, and $p=0.041$). Maxillary molar depth and width-to-depth ratios showed significant intergroup differences. Males demonstrated significantly greater selected maxillary and mandibular transverse dimensions than females.

Conclusion: Dental arch morphology varied according to malocclusion type and sex, particularly in transverse dimensions. Three-dimensional model assessment may support individualized orthodontic diagnosis and treatment planning.

Keywords: Dental arch dimensions; Malocclusion; Class I; Class II; Class III; Three-dimensional digital models; Gender; Orthodontics.

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Introduction

Dental malocclusion refers to the abnormal relationship of the teeth, dental arches or supporting dentoalveolar structures [1]. It can have an unwanted impact on chewing, speech, oral hygiene care, periodontal health, temporomandibular joint function, facial aesthetics and quality of life. Genetic, skeletal, dental and environmental factors affect the development of malocclusion. One of the most widely used classification systems for malocclusion based on the relationship of the anteroposterior relationship of the first permanent molars is developed by Angle, and broadly classifies relationships as Class I, Class II or Class III malocclusion [2]. Some patients may have very different dental arch forms within the same sagittal classification, however, suggesting that sagittal classification alone is not enough to define the dental characteristics of malocclusion completely.

The dimensions of dental arches play a significant role in the diagnosis of orthodontic problems, affecting tooth alignment, tooth crowding or spacing, intercuspation and occlusal stability [3]. Intercanine width, intermolar width, arch length, arch depth, and arch perimeter are all commonly measured parameters. Changes in these dimensions may have an impact on the space available for the arrangement of teeth, and can play a role in the development of malocclusion or its severity. The knowledge of dental arch dimensions is thus of great value for the quantitative assessment of the morphology of the maxillary and mandibular arches and may contribute in

elucidating the differences between various malocclusion patterns.

Typically, the molar relationship (anteroposterior) is relatively normal, though some cases with crowding, spacing, rotation, cross bite, or other irregularities may occur. The second type of malocclusion is Class II malocclusion that can be seen by the distal relationship of the lower dentition to the upper dentition, and can also have a change in the dimensions of the dental arches [4]. Class III malocclusion involves a mesial relationship of the mandibular dentition and may be associated with anterior cross bite, minimal/no overjet and unique maxillary and mandibular arch morphology. The sagittal malocclusion categories could then be clinically reflected by the differences in the size of the dental arches.

Other orthodontic research work has reported the differences in width, length and perimeter of the arches between the different groups of malocclusion [5]. Class II subjects have been reported to show differences in the dimensions of the maxilla and mandible when compared to Class I subjects while Class III subjects may have distinctive characteristics of the mandible and transverse relationships. The morphology of dental arches is however multi-factorial and can also be influenced by tooth size, skeletal pattern, age, ethnicity, growth status and sex. The dimensions of the arches should therefore not be compared across the malocclusion groups without taking these possible sources of variation into consideration.

Studies on dental arch morphology are especially relevant with regard to sex related differences. In general, the absolute size of dental arch measurements of males is larger than those of females, especially the transverse measurements and the arch perimeter, but the differences in the magnitude of these measurements vary from population to population and from one measurement to another [6]. When males and females are combined without regard for sex, sex dimorphism may be a confounding factor when comparing the dimensions of the arches between the malocclusion groups. Evaluation of male and female patients separately can therefore be useful in determining if there are differences in dentofacial morphology between the sexes or whether differences in the observed malocclusion are due to malocclusion type.

Three-dimensional (3D) digital dental models are found to be very helpful in orthodontic research as they allow for a precise and reproducible evaluation of dental arch morphology [7]. Unlike traditional plaster casts, digital models can have measurements taken directly from the dental arches. Various parameters, like intercanine width, intermolar width, arch length, arch perimeter and arch depth, can be measured in a standard way and can be checked again if necessary. Digital records also enable retrospectivity, meaning that orthodontic records obtained in the past can be analyzed without any additional radiation or diagnostic procedures.

Dental arch morphology is a complex issue in which transverse and sagittal relationships are involved, which is especially beneficial for assessment of malocclusion using 3-D models. Digital models can be used to view each tooth and arch morphology in detail and make quantitative comparisons between malocclusion groups [8]. These measurements can contribute to a better understanding of the morphological aspects of the various relationships between the dentition and alveoli, and can offer clinically relevant information in the diagnosis and treatment planning for orthodontists.

A variety of dental arch morphology studies have been completed, but the reported results for the differences in dental arches between Class I, Class II, and Class III malocclusions are not always unanimous among populations. Variations in the results may occur due to the differences in the samples, data collection methods, age distribution, ethnicity, and sex composition of the samples. Moreover, little information is available on the combined effect of type of malocclusion and sex on three-dimensional dental arch dimension in certain populations.

Hence, the present retrospective 3D model-based study is conducted to see the difference in dental arch dimensions between male and female with dentoalveolar Class I, Class II and Class III malocclusions. The study will assess the quantitative level of the dental arch morphology by analyzing the relevant measurements of the two arches, and by comparing them based on the type of malocclusion and sex. The results may be applied to the diagnosis, individual treatment planning of the patient, selection of the arch form and understanding of the dentoalveolar characteristics of the malocclusion of different sagittal profiles.

Methodology

Study Design: The present study was designed as a retrospective, comparative, 3D model-based observational study. Previously recorded plaster dental casts of patients diagnosed with dentoalveolar Class I, Class II, or Class III malocclusion were reviewed. The study compared maxillary and mandibular dental arch dimensions, including arch widths, depths, and width-to-depth ratios, among the three malocclusion groups and between male and female patients.

Study Area: The study was conducted in the Department of Dentistry, Anugrah Narayan Magadh Medical College and Hospital, Gaya ji, Bihar, India.

Study Duration: The study was conducted over a period of one year from March 2025 to February 2026.

Study Participants: The study participants comprised patients whose previously obtained dental casts fulfilled the eligibility criteria and represented dentoalveolar Class I, Class II, or Class III malocclusion. The participants were categorized according to malocclusion type and gender.

Inclusion criteria

- Dental casts of patients with bilateral dentoalveolar Class I, Class II, or Class III malocclusion based on Angle's molar relationship.
- Patients with permanent dentition.
- Dental casts showing adequately erupted permanent teeth required for arch measurements.
- Casts with clearly identifiable anatomical and dental landmarks.
- Patients with available demographic information, including age and sex.
- Dental casts without extensive restorations that altered the mesiodistal or buccolingual dimensions of the teeth.

Exclusion criteria

- Dental casts with missing teeth affecting the measurements.
- Casts with fractured, distorted, damaged, or poorly preserved areas.
- Patients with a history of orthodontic treatment.
- Casts showing extensive restorations, prostheses, or dental anomalies that could influence arch dimensions.
- Patients with cleft lip/palate or other major craniofacial anomalies.
- Casts in which the required landmarks could not be identified accurately.

Sample Size: A total sample of 80 dental casts was included in the study. The casts were selected retrospectively and categorized into three dentoalveolar malocclusion groups: Class I, Class II, and Class III. The distribution of participants was further considered according to gender to facilitate comparison of dental arch dimensions between male and female patients.

Procedure: Eligible plaster dental casts were retrieved from the departmental records and examined for compliance with the inclusion and exclusion criteria. The selected casts were digitized to generate three-dimensional virtual dental models. The 3D models were evaluated using appropriate model-viewing and measurement software. On each maxillary and mandibular model, standardized landmarks corresponding to the most prominent points on the facial surfaces of the clinical crowns were identified. The landmarks were placed at the approximate midpoint of the facial axis of the clinical crown, corresponding to the clinical bracket point. Landmark identification was performed by an investigator and was cross-checked to minimize measurement errors. From the identified landmarks, dental arch dimensions were calculated for both arches. The measurements included central interincisor width, lateral interincisor width, intercanine width, first interpremolar width, second interpremolar width, and intermolar width. Arch depth measurements included canine depth and molar depth, determined from the appropriate transverse reference lines to the anterior reference point. In addition, the canine width-to-depth ratio was calculated by dividing intercanine width by canine depth, while the molar width-to-depth ratio was calculated by dividing intermolar width by molar depth. The obtained measurements were recorded systematically and compared among Class I, Class II, and Class III malocclusion groups as well as between male and female participants. To assess intraobserver reliability, a subset of randomly selected casts was remeasured after an appropriate interval, and agreement between repeated measurements was evaluated.

Statistical Analysis: The collected data were entered, coded, and analyzed using IBM SPSS Statistics version 27.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. The distribution of continuous variables was assessed for normality. Differences in dental arch dimensions among Class I, Class II, and Class III malocclusion groups and between genders were evaluated using appropriate comparative statistical tests, including one-way and two-way analysis of variance (ANOVA). Where significant differences were identified, suitable post-hoc comparisons were performed. Intraobserver reliability was assessed using the intraclass correlation coefficient (ICC). A p-value <0.05 was considered statistically significant.

Result

Table 1 presents the distribution of study participants according to malocclusion class and gender among the 80 participants included in the study. The study population consisted of an equal number of males and females, with 40 (50.0%) participants in each group. Class I and Class II malocclusions were equally represented, comprising 27 (33.8%) participants each, while Class III malocclusion included 26 (32.5%) participants. Among males, Class II malocclusion was the most frequent, observed in 14 (17.5%) participants, whereas Class I and Class III each accounted for 13 (16.3%) participants. Among females, Class I malocclusion was slightly more common, comprising 14 (17.5%) participants, while Class II and Class III each included 13 (16.3%) participants. Overall, the distribution of malocclusion classes was relatively balanced between the three groups, with only one fewer participant in Class III compared with Class I and Class II. The gender distribution was also balanced within the overall study population, providing comparable representation of

males and females across the malocclusion categories.

Table 1: Distribution of study participants according to malocclusion class and gender (N=80)			
Malocclusion group	**Male, n (%)**	**Female, n (%)**	**Total, n (%)**
Class I	13 (16.3)	14 (17.5)	27 (33.8)
Class II	14 (17.5)	13 (16.3)	27 (33.8)
Class III	13 (16.3)	13 (16.3)	26 (32.5)
Total	**40 (50.0)**	**40 (50.0)**	**80 (100.0)**

Table 2 presents the comparison of maxillary dental arch dimensions among Class I, Class II, and Class III malocclusion groups. The central interincisor width was comparable across the three groups, measuring 34.2 ± 2.0 mm in Class I, 34.0 ± 2.1 mm in Class II, and 33.7 ± 1.9 mm in Class III, with no statistically significant difference (p=0.67). Similarly, lateral interincisor width showed no significant variation (27.3 ± 1.8, 27.0 ± 1.7, and 26.8 ± 1.8 mm, respectively; p=0.59). In contrast, intercanine width differed significantly, decreasing progressively from Class I (36.3 ± 2.1 mm) to Class II (34.5 ± 2.4 mm) and Class III (32.5 ± 1.9 mm; p<0.001). First interpremolar width was also significantly different (39.6 ± 2.2, 38.8 ± 2.4, and 37.5 ± 2.3 mm; p=0.006), as was second interpremolar width (45.4 ± 2.5, 44.7 ± 2.4, and 43.5 ± 2.3 mm; p=0.018). Intermolar width did not differ significantly (p=0.069).

Table 2: Comparison of maxillary dental arch dimensions among Class I, Class II and Class III malocclusion groups				
Maxillary parameter (mm)	**Class I (n=27) Mean ± SD**	**Class II (n=27) Mean ± SD**	**Class III (n=26) Mean ± SD**	**p-value**
Central interincisor width	34.2 ± 2.0	34.0 ± 2.1	33.7 ± 1.9	0.67
Lateral interincisor width	27.3 ± 1.8	27.0 ± 1.7	26.8 ± 1.8	0.59
Intercanine width	36.3 ± 2.1	34.5 ± 2.4	32.5 ± 1.9	<0.001
First interpremolar width	39.6 ± 2.2	38.8 ± 2.4	37.5 ± 2.3	0.006
Second interpremolar width	45.4 ± 2.5	44.7 ± 2.4	43.5 ± 2.3	0.018
Intermolar width	49.7 ± 2.3	50.4 ± 2.9	48.5 ± 3.6	0.069

Table 3 presents the comparison of mandibular dental arch dimensions among Class I, Class II, and Class III malocclusion groups. The central interincisor width was comparable among the three groups, measuring 23.2 ± 1.5 mm in Class I, 23.0 ± 1.4 mm in Class II, and 22.8 ± 1.5 mm in Class III, with no statistically significant difference (p=0.642). Similarly, lateral interincisor width showed no significant variation, with mean values of 19.2 ± 1.4, 19.0 ± 1.3, and 18.8 ± 1.4 mm, respectively (p=0.571). However, intercanine width differed significantly among the groups, decreasing from 27.4 ± 1.8 mm in Class I to 26.7 ± 1.9 mm in Class II and 26.1 ± 1.7 mm in Class III (p=0.038). First interpremolar width also showed a significant difference (34.4 ± 2.0, 33.8 ± 2.1, and 33.0 ± 2.0 mm; p=0.042). Second interpremolar width was not significantly different (p=0.071), whereas intermolar width showed a significant difference (44.5 ± 2.3, 43.9 ± 2.4, and 42.8 ± 2.3 mm; p=0.041)."

Table 3: Comparison of mandibular dental arch dimensions among Class I, Class II and Class III malocclusion groups				
Mandibular parameter (mm)	**Class I (n=27) Mean ± SD**	**Class II (n=27) Mean ± SD**	**Class III (n=26) Mean ± SD**	**p-value**
Central interincisor width	23.2 ± 1.5	23.0 ± 1.4	22.8 ± 1.5	0.642
Lateral interincisor width	19.2 ± 1.4	19.0 ± 1.3	18.8 ± 1.4	0.571
Intercanine width	27.4 ± 1.8	26.7 ± 1.9	26.1 ± 1.7	0.038
First interpremolar width	34.4 ± 2.0	33.8 ± 2.1	33.0 ± 2.0	0.042
Second interpremolar width	39.4 ± 2.1	38.8 ± 2.0	38.0 ± 2.1	0.071
Intermolar width	44.5 ± 2.3	43.9 ± 2.4	42.8 ± 2.3	0.041

"Table 4 presents the comparison of dental arch depth and width-to-depth (W/D) ratios among the Class I, Class II, and Class III malocclusion groups. Maxillary canine depth was comparable among the three groups, with mean values of 16.7 ± 1.8 mm, 17.0 ± 1.5 mm, and 16.5 ± 1.4 mm, respectively (p=0.468). In contrast, maxillary molar depth showed a statistically significant difference, with the highest value in Class I (28.5 ± 2.1 mm), followed by Class III (27.9 ± 2.1 mm) and Class II (26.8 ± 2.2

mm; p=0.016). Maxillary canine W/D ratio also differed significantly, measuring 2.20 ± 0.32, 2.04 ± 0.19, and 1.98 ± 0.20, respectively (p=0.005). Similarly, maxillary molar W/D ratio showed significant variation (p=0.009). Mandibular canine and molar depths did not differ significantly among groups (p=0.273 and p=0.091, respectively). Both mandibular canine and molar W/D ratios were also comparable, with p-values of 0.932 and 0.904, respectively.

Table 4: Comparison of dental arch depth and width-to-depth ratios among the three malocclusion groups

Parameter	Class I (n=27) Mean ± SD	Class II (n=27) Mean ± SD	Class III (n=26) Mean ± SD	p-value
Maxillary canine depth (mm)	16.7 ± 1.8	17.0 ± 1.5	16.5 ± 1.4	0.468
Maxillary molar depth (mm)	28.5 ± 2.1	26.8 ± 2.2	27.9 ± 2.1	0.016
Maxillary canine W/D ratio	2.20 ± 0.32	2.04 ± 0.19	1.98 ± 0.20	0.005
Maxillary molar W/D ratio	1.75 ± 0.15	1.89 ± 0.20	1.75 ± 0.21	0.009
Mandibular canine depth (mm)	12.2 ± 1.4	12.0 ± 1.3	11.6 ± 1.3	0.273
Mandibular molar depth (mm)	21.3 ± 1.8	21.0 ± 1.7	20.3 ± 1.8	0.091
Mandibular canine W/D ratio	2.25 ± 0.31	2.23 ± 0.28	2.26 ± 0.29	0.932
Mandibular molar W/D ratio	2.09 ± 0.20	2.09 ± 0.22	2.11 ± 0.23	0.904

Table 5 presents the gender-wise comparison of selected dental arch dimensions among the 80 study participants. Maxillary intercanine width was significantly greater in males (35.2 ± 2.4 mm) than in females (34.0 ± 2.5 mm), with p=0.035. Similarly, maxillary first interpremolar width was significantly higher among males (39.6 ± 2.4 mm) compared with females (38.4 ± 2.3 mm; p=0.027). Maxillary intermolar width showed a higher mean value in males (50.3 ± 3.0 mm) than females (49.0 ± 3.0 mm), although the difference was not statistically significant (p=0.058). Mandibular intercanine width (27.2 ± 1.9 vs. 26.4 ± 1.8 mm; p=0.049), first interpremolar width (34.4 ± 2.1 vs. 33.4 ± 2.0 mm; p=0.031), and intermolar width (44.5 ± 2.4 vs. 43.2 ± 2.3 mm; p=0.018) were significantly greater in males. However, maxillary canine depth, molar depth, and both canine and molar W/D ratios showed no significant gender-wise differences (p>0.05).

Table 5. Gender-wise comparison of selected dental arch dimensions among study participants (N=80)

Parameter	Male (n=40) Mean ± SD	Female (n=40) Mean ± SD	p-value
Maxillary intercanine width (mm)	35.2 ± 2.4	34.0 ± 2.5	0.035
Maxillary first interpremolar width (mm)	39.6 ± 2.4	38.4 ± 2.3	0.027
Maxillary intermolar width (mm)	50.3 ± 3.0	49.0 ± 3.0	0.058
Mandibular intercanine width (mm)	27.2 ± 1.9	26.4 ± 1.8	0.049
Mandibular first interpremolar width (mm)	34.4 ± 2.1	33.4 ± 2.0	0.031
Mandibular intermolar width (mm)	44.5 ± 2.4	43.2 ± 2.3	0.018
Maxillary canine depth (mm)	17.0 ± 1.7	16.6 ± 1.6	0.291
Maxillary molar depth (mm)	28.1 ± 2.2	27.4 ± 2.1	0.154
Maxillary canine W/D ratio	2.08 ± 0.26	2.06 ± 0.25	0.731
Maxillary molar W/D ratio	1.81 ± 0.19	1.78 ± 0.19	0.482

Discussion

This retrospective three-dimensional model study was done to compare the dental arch dimensions of dentoalveolar Class I, Class II and Class III malocclusion, and to assess the gender difference. Total number of people in the study was 80, which were 40 males and 40 females. There were 27 participants in each of Class I and Class II malocclusions and 26 participants in Class III. Dental arch morphology was evaluated for comparative purposes based on relatively even distribution of participants in the various malocclusion groups and gender. The advantage of using 3-D models was the ability to accurately and reproducibly measure dental arch dimensions, and that digital models would not have the same limitations as 2-D images or plaster casts. Another study previously proved that virtual dental models could be useful to analyze dental morphology and arch dimensions (Lee et al., 2008) [9].

The results of the present study were that the differences between the three malocclusion groups were greater for transverse dental arch dimension than for anterior interincisor measurements. No statistically significant differences were seen in central and lateral interincisor widths in the maxillary arch between the three groups. The difference in maxillary intercanine width was highly significant with the mean value being smaller in the Class III as compared to Class I. This decrease of ~ 3.8 mm suggested that the canine region was a significant region

of sagittal malocclusion variation among the different groups. The present observation is in general agreement with that of Uysal et al. 2005 [9] who have noted significant differences in dental and alveolar arch widths between normal occlusion and Class III malocclusion. The relationship between sagittal malocclusion pattern and transverse dental arch morphology was also supported by the study of Kuntz et al., 2008 [10] who found that there were differences in arch width between Class 1 crowded, Class III and normal-occlusion subjects.

The differences found between the widths of the first and second interpremolar areas on the maxilla was significant and further illustrated that there was no restriction to transverse variation in the canine area. Rather, the gap was elongated posteriorly into the premolar area. This finding has been recorded in past research that has compared dental arch size among different malocclusion groups. Uysal et al. (2005) reported that there was a significant difference in dental and alveolar arch widths between normal occlusion, Class II division 1 and Class II division 2 patients. Similarly, Sayin and Türkkahraman (2004) [11] noted that the dental arch and alveolar width of the Class II division 1 malocclusion group were different than those of Class I group with ideal occlusion. The results of all these studies indicate that the transverse arch morphology could play a significant role in the dental traits of malocclusion patterns.

In the present study however, no significant difference was found in maxillary interincisor width among the different overall malocclusion types, indicating that the anterior transverse dimensions of incisor may be relatively constant in the face of differences in overall malocclusion classification. This discovery suggests that malocclusion has different effects throughout the dental arch. Variations between studies could also be due to differences in measurement landmarks, age, ethnic background, sample characteristics, and classification criteria. Within the Class II malocclusion, it was demonstrated by Huth et al. (2007) [12] that there could exist significant morphological differences between division 1 and division 2 malocclusion, underscoring the fact that broad classifications of malocclusion can have significant differences in morphologies.

Although there was numerical difference between the three malocclusion groups in the present study, the intermolar width in the maxilla did not show statistically significant differences. This is in contrast to the large differences which were found in the intercanine and interpremolar regions and suggests that there may be relatively more stability in the posterior molar area across the malocclusion categories studied. Previous studies have reported that the dental arch is also different in various regions, which indicates that dental arch should not be evaluated at only one level by one single measurement (Ling & Wong, 2009) [13]. Purposeful discrepancies in the canine and premolar regions can have different orthodontic implications than those in the molar region and can be clinically meaningful.

The pattern of the mandibular arch was slightly different from that of the maxillary arch. Size of the mandibular central and lateral interincisor widths were similar for the three malocclusion groups but statistically different for intercanine and first interpremolar widths. Mandibular intermolar width also was significantly different with the widest mean width recorded in Class I and the narrowest in Class III. Second interpremolar width did not show a statistically significant difference. This study has shown that "malocclusion" was also parameter specific with respect to its effect on the morphology of mandibular arches. Previous studies have described the mandibular arch in class III malocclusion being wider than in other occlusion, especially with regard to dental and alveolar widths (Uysal et al., 2005). So that the lower transverse pattern found in the present investigation does not exactly correspond to all the previous reports.

“The differences in results from previous studies and the present study can be attributed to variations in the dentoalveolar and skeletal malocclusion criteria, sex distribution, age distribution, sample size and ethnic background. Kuntz et al. 2008 also showed that the dimensions of the arches did not correspond to the type of malocclusion, and that the dimensions of each individual arch may not be applicable to other populations. Apart from that, the inclination and compensation of the teeth may also have an impact on the apparent transverse dimensions of the dental arch. Thus, the present results stress the need to consider the dental arch dimensions in the context of the studied population's characteristics.

The analysis of arch depth and arch width to depth ratio gave further information on dental arch morphology. There was no significant difference between the three groups for maxillary canine depth but there was a statistically significant difference for maxillary molar depth with the greatest depth seen in Class I and the lowest in Class II. The width to depth ratio of the molars and maxillary canine teeth were also significant. The results show that not only the absolute arch width, but also the geometric relationship between width and depth might be involved in malocclusion-related morphological difference. It was demonstrated that there is an association between arch length and the changes in dental arch width by Hnat et al. 2000 [14] indicating the idea that dental arch size should not be regarded as independent parameters.

However, the depths of the mandibular canine and molar teeth showed no significant differences among the three malocclusion groups. Likewise, the

width to depth ratios of the mandible's canine and molar teeth were fairly similar. The overall mandibular arch depth and geometry may have been more similar than differences between the malocclusion types in the present study, thus highlighting differences between the groups in selected transverse dimensions and parameters of the maxilla. These results justify a separate study of maxillary and mandibular arches as they can have different morphological adaptations when the occlusal position is unhealthy.

Gender-wise analysis revealed that there were significant sexual dimorphism for some transverse dental arch dimensions. The intercanine and first interpremolar width of the maxilla was significantly greater in males than females. Likewise, the widths of the intercanine, first interpremolar and intermolar regions of the mandible were significantly larger in male specimens. The results showed that the dental arches of the selected transverse sections were wider in men. This observation is corroborated by the overall evidence that dental arch dimensions may show sexual dimorphism. Ling and Wong (2009) made a note of the need for demographic characteristics in interpreting arch dimensions in their assessment of dental arch widths in Southern Chinese subjects. So it is important to take sex into account when setting reference values, and or comparing dental arch dimensions between individuals.

Interestingly, there was a numerical difference in intermolar width in the Maxilla which was larger in male subjects but failed to reach statistical significance. In the same way, the depth of the maxillary canine, molar depth, and the width to depth relationship of the maxillary canine and molar were similar between the sexes. The results of this study indicate that sexual dimorphism is mainly reflected in the absolute width in the present study and not in arch depth or the overall width-depth shape. This is significant because increased dental size in males does not necessarily mean that there is a difference in the basic dental arch pattern. Rather, males and females can have similar geometric forms with respect to relatively similar transverse dimensions.

The present study findings have some implications in the diagnosis and treatment planning of orthodontics. The significant decrease in the intercanine width in the maxilla from Class I to Class III (36.3mm to 32.5mm) and the relatively large difference in the interpremolar width also suggests that the transverse dimension of a dental arch should be taken into account when assessing malocclusions. In past literature, it has been pointed out that the dental arch form is different depending on the malocclusion type and race, and should be assessed individually rather than using a standardized dental arch form (Nojima et al., 2001) [15]. The variation of dental arch morphology can also have implications for selection of archwire, transverse correction, space management, and post-treatment stability.

The present study showed that dental arch morphology changed with different types of malocclusions and gender, but these changes were of varying magnitude and location among the parameters. The most uniform intergroup differences occurred in the transverse dimensions (maxillary intercanine and interpremolar widths and selected mandibular transverse dimensions), while the interincisor widths were relatively constant. The findings were similar to those from previous studies that showed a correlation between malocclusion and transverse arch morphology but with inconsistent direction and amount of change of the mandible. Gender-related difference was mostly seen in the transverse width, and depth and width-to-depth relationships were relatively consistent. The results indicate the significance of measuring the 3D dental arches of each individual rather than a general malocclusion classification. Using digital three-dimensional models is a helpful way for accurate morphological evaluation and can help with more personalised orthodontic diagnosis, treatment planning and appliance selection."

Conclusion

The present retrospective three-dimensional model-based study demonstrated that dental arch morphology varied significantly among dentoalveolar Class I, Class II, and Class III malocclusions, particularly in selected transverse dimensions. Maxillary intercanine and interpremolar widths showed significant intergroup differences, while mandibular intercanine, first interpremolar, and intermolar widths also varied significantly. Maxillary molar depth and width-to-depth ratios further demonstrated morphological differences among malocclusion groups, whereas interincisor widths and most mandibular depth parameters remained relatively stable. Significant gender-related differences were observed, with males generally exhibiting greater transverse arch widths than females, while arch depths and width-to-depth ratios were largely comparable. Overall, the findings emphasize that dental arch morphology is influenced by both malocclusion pattern and sex. Three-dimensional digital model assessment can therefore provide valuable quantitative information for individualized orthodontic diagnosis and treatment planning.

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