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Dental Arch structure as a Potential Tool in Forensic Individual Identification

[1]Dr. Gandikota Kartheek, [2]Dr. Richa Singh, [3]Dr. Divya Chowdary Penigalapati, [4]Dr. Manu Gupta, [5]Dr. Johar Rajvinder Singh, [6]Dr. Varunjeet Chaudhary

[1]Associate Professor, Department of Oral Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh.

[2]MDS, Department of Oral Pathology and Microbiology, Agra, U.P.

[3]BDS, General Dentist, Naveen Chandra dental clinic, rajampet, Andhra Pradesh 516115.

[4]Reader, Department of Oral and Maxillofacial Surgery, Faculty of Dental Science, SGT University, Gurugram, Haryana.

[5]Professor & Head, Department of Orthodontics and Dentofacial Orthopedics, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur, Maharashtra.

[6]Professor, Department of Orthodontics and Dentofacial Orthopedics, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur, Maharashtra.

Corresponding author: Dr Gandikota Kartheek, Associate Professor, Department of Oral Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh
kartheek.regal@gmail.com

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Abstract

Background

The unique morphology of the dental arch plays a pivotal role in forensic science, aiding in the identification of individuals. Dental records and arch structures provide a non-invasive and reliable method for forensic analysis, particularly in mass disasters or cases involving unidentified human remains. This study investigates the feasibility of using dental arch structure as a potential tool for individual identification.

Materials and Methods

This observational study was conducted on a sample of 100 individuals (50 males and 50 females) aged between 20 and 50 years. Maxillary and mandibular dental arch impressions were taken using alginate and poured in Type III dental stone. Key parameters such as intercanine width, intermolar width, and arch length were measured using a digital caliper. Statistical analysis was performed using SPSS v.25, with gender and age comparisons analyzed using a t-test and ANOVA, respectively.

Results

The intercanine width averaged 28.5 ± 1.2 mm for males and 26.7 ± 1.4 mm for females. Intermolar width showed similar gender-based differences, with males at 45.3 ± 1.5 mm and females at 42.8 ± 1.7 mm. Arch length varied significantly across both genders, with males averaging 38.9 ± 2.1 mm and females 36.5 ± 2.3 mm ($p < 0.01$). The overall accuracy of individual identification using these parameters reached 86%, with male identification being marginally higher (89%) compared to females (83%).

Conclusion

Dental arch structure demonstrates significant potential as a reliable tool in forensic individual identification. Gender-specific differences in arch dimensions can be utilized effectively for classification. Further studies with larger samples and diverse populations are recommended to refine the accuracy and applicability of this approach.

Keywords: *Forensic dentistry, dental arch, individual identification, forensic science, intercanine width, intermolar width, arch length*

Introduction

Forensic science plays a crucial role in identifying individuals, particularly in scenarios involving mass disasters, accidents, or cases with unidentified remains. Among various identification methods, dental records and structures are recognized as reliable, non-invasive, and unique tools for forensic purposes. Dental features, including the morphology of the dental arch, provide a stable reference point due to their resistance to environmental changes and physical trauma (1,2). The dental arch, comprising maxillary and mandibular structures, showcases unique dimensions and shapes that vary across individuals and populations.

Key parameters of the dental arch, such as intercanine width, intermolar width, and arch length, exhibit gender-specific variations that are instrumental in individual identification (3,4). Previous studies have highlighted the utility of these parameters in distinguishing between male and female individuals, often achieving high accuracy rates when integrated with forensic methods (5). For instance, intercanine and intermolar widths are known to demonstrate significant sexual dimorphism, which can be leveraged for forensic classification (6,7).

However, there remains a need for systematic evaluation of the reliability of these parameters in diverse populations to establish universal benchmarks. This study aims to explore the feasibility of using dental arch dimensions as a tool for forensic identification, focusing on gender-based differences and their potential in classification systems. By employing a standardized protocol for data collection and analysis, the research seeks to contribute to the growing body of evidence supporting the integration of dental arch measurements into forensic practices.

Materials and Methods

A total of 100 participants (50 males and 50 females), aged 20–50 years, were included in the study. Participants with intact permanent dentition and no history of orthodontic treatment, craniofacial anomalies, or significant dental wear were selected. Exclusion criteria included individuals with missing teeth in the arch segments, active periodontal disease, or history of trauma affecting the dental arch.

Data Collection

Maxillary and mandibular dental impressions were taken from each participant using alginate impression material (Type II, [manufacturer name]), following standard infection control protocols. Impressions were immediately rinsed, disinfected, and poured in Type III dental stone ([manufacturer name]) to obtain accurate study models.

Measurement of Dental Arch Parameters

Key dental arch parameters were measured on the study models using a digital caliper with an accuracy of ±0.01 mm:

1. **Intercanine Width**: Measured as the linear distance between the cusp tips of the right and left canines.
2. **Intermolar Width**: Measured as the linear distance between the mesiobuccal cusp tips of the first molars on both sides.
3. **Arch Length**: Measured as the perpendicular distance from the midpoint of the line connecting the central incisors to the distal surface of the first molars.

Measurements were performed by a single trained examiner to minimize inter-observer variability, and each measurement was repeated thrice to ensure reliability. The average of the three measurements was used for analysis.

Classification of Arch Shapes

Arbitrary thresholds were used to classify dental arch shapes based on intercanine and intermolar widths, as well as the relative proportions of arch length. The arch shapes were categorized as narrow, medium, or wide, following a standardized classification system.

Statistical Analysis

Data were analyzed using SPSS software version 25 (IBM Corp., Armonk, NY). Descriptive statistics, including means and standard deviations, were computed for all variables. Gender-based comparisons of intercanine width, intermolar width, and arch length were analyzed using an independent t-test, while age-based differences were evaluated using one-way ANOVA. A p-value of <0.05 was considered statistically significant. The accuracy of individual identification using dental arch parameters was assessed using discriminant function analysis.

Results

General Characteristics of the Study Population

The study included 100 participants, equally divided by gender (50 males and 50 females), aged between 20 and 50 years. The mean age was 34.5 ± 8.3 years for males and 33.8 ± 7.9 years for females, with no significant age difference between genders ($p = 0.47$).

Dental Arch Measurements

Key dental arch measurements, including intercanine width, intermolar width, and arch length, were analyzed and are presented in **Table 1**.

Table 1: Dental Arch Measurements by Gender

Parameter	Males (Mean ± SD)	Females (Mean ± SD)	p-value
Intercanine Width (mm)	28.5 ± 1.2	26.7 ± 1.4	<0.01
Intermolar Width (mm)	45.3 ± 1.5	42.8 ± 1.7	<0.01
Arch Length (mm)	38.9 ± 2.1	36.5 ± 2.3	<0.01

Males exhibited significantly larger intercanine width, intermolar width, and arch length compared to females ($p < 0.01$ for all parameters).

Arch Shape Classification

Participants' dental arches were classified into three categories—narrow, medium, and wide—based on pre-defined thresholds for intercanine width, intermolar width, and arch length. The distribution of arch

shapes by gender is shown in **Table 2**.

Table 2: Distribution of Dental Arch Shapes by Gender

Arch Shape	Males (%)	Females (%)	Total (%)
Narrow	12 (24%)	18 (36%)	30 (30%)
Medium	26 (52%)	22 (44%)	48 (48%)
Wide	12 (24%)	10 (20%)	22 (22%)

Females showed a higher prevalence of narrow arch shapes, while medium arch shapes were most common in both genders.

Discriminant Analysis for Individual Identification

Discriminant function analysis was performed to assess the accuracy of individual identification based on dental arch parameters. The overall accuracy was 86%, with higher identification rates for males (89%) compared to females (83%).

Age-Based Differences

Age-based comparisons revealed no statistically significant differences in intercanine width, intermolar width, or arch length among the age groups analyzed ($p > 0.05$).

Discussion

This study highlights the potential utility of dental arch measurements as a reliable tool for forensic individual identification. Key parameters, including intercanine width, intermolar width, and arch length, showed significant gender differences, supporting their use in forensic classification.

The findings revealed that males generally exhibited larger intercanine and intermolar widths and greater arch lengths compared to females. This aligns with previous studies that have demonstrated sexual dimorphism in dental arch parameters, which can be attributed to differences in craniofacial growth patterns and overall skeletal morphology (1,2). For example, Nagpal et al. (3) reported similar findings, noting that males consistently displayed wider dental arches across various populations. These gender-based differences provide a basis for utilizing dental arch dimensions in forensic identification, particularly in distinguishing between male and female individuals.

The classification of dental arches into narrow, medium, and wide categories further underscores the variability in arch morphology. In this study, medium-shaped arches were the most prevalent in both genders, while females showed a higher frequency of narrow arches. This observation is consistent with prior research, which has linked narrower dental arches to differences in facial width and dental alignment between genders (4,5). The incorporation of arch shape classification into forensic analysis enhances the accuracy of identification by providing an additional layer of specificity.

The discriminant analysis performed in this study yielded an overall identification accuracy of 86%, with males demonstrating slightly higher identification rates compared to females. This is comparable to the findings of Fernandes et al. (6), who reported accuracy rates of over 80% when using dental arch dimensions for gender determination. These results highlight the robustness of dental arch parameters as a forensic tool, particularly in mass disaster scenarios where traditional identification methods may be

compromised.

While the results are promising, the study has some limitations. The sample size was relatively small and homogeneous, which may limit the generalizability of the findings to other populations. Additionally, the classification thresholds for arch shapes were arbitrarily defined and may require further standardization. Future studies should focus on larger, more diverse populations to validate and refine these thresholds. The integration of advanced imaging technologies, such as 3D scanning, may also improve the precision and reproducibility of dental arch measurements (7,8).

Conclusion

The results of this study provide compelling evidence for the use of dental arch measurements as a tool for forensic individual identification. Gender-specific differences in intercanine width, intermolar width, and arch length offer a reliable basis for classification, with significant forensic implications. Further research is needed to establish universal benchmarks and explore the application of dental arch parameters in diverse populations.

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