Original Article

Individualization of the Dental Arch as a Potential Tool in Forensic Human Identification

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ABSTRACT

Background: The dental arch form is underappreciated in establishing human identity. Most of the time, the teeth are considered, although the arch form can disclose a great deal about a person's profile.

Aim: The aim is to determine the morphological variability in the arch form of an individual's maxilla and mandible.

Methodology: This is a cross-sectional descriptive study that was conducted in 219 dental casts made for various dental treatment purposes at the Tribhuvan University Dental Teaching Hospital, Institute of Medicine, Maharajgunj, Kathmandu, Nepal. The study was conducted over 6 months from January 1, 2021, to July 31, 2021. The arch form was categorized into oval, square, and tapering.

Results: The average age of the individuals was 20.71 ± 4.66 for males and 19.25 ± 5.18 for females. The oval arch form was more common in both the jaws, with 38.81% and 63.93% in the maxilla and mandible, respectively, followed by square and tapered forms.

Conclusion: The morphological variability of an individual's arch form is astounding. This can be used to limit down the search in human identification. Although it may not be able to establish identification, it can be a useful tool for narrowing down the options throughout the scientific identification process.

KEY WORDS: Dental arch forms, forensic dentistry, forensic human identification

INTRODUCTION

There may be morphological differences in the natural dental arch. The tooth arch shape is linked to the craniofacial skeletal pattern, and race and ethnicity influence the human craniofacial complex. Furthermore, the size and shape of the dental arch, as well as the location of teeth, change according to race, culture, and region.[1,2] During a forensic dental examination, the distinctive trait of the dental arch form is often neglected.

The disaster victim identification procedure is a multiphased procedure that comprises scenes, antemortem (AM), postmortem (PM), reconciliation, and debriefing.[3] Even though forensic dentists (FOs) are involved in all phases, they are especially vital during the PM examination.[4] All minute data recorded by a FO in PM case files decides the scientific identification of an individual.[5]

Identification of the deceased by examination of the teeth has been practiced for many years, has been empirically demonstrated to be accurate. The existence of both metallic and nonmetallic restorations and prosthetic replacements is frequently a determining factor in establishing an identity.[2] The arch form is often missed in the PM dental examination but can be utilized to narrow down the options during identification.

The purpose of this study was to confirm the occurrence of three different morphologies of the maxillary and mandibular dental arch forms in the given population.

METHODOLOGY

The dental casts of patients with natural occlusion aged 12–30 years who visited Tribhuvan University Dental Teaching Hospital for various dental treatments were studied in this cross-sectional descriptive study. The cast was used in the study with the informed consent of all of the patients. The study was done in accordance with the Declaration of Helsinki's ethical principles for medical research. The research took place from January 1, 2021, to July 31, 2021. There were 95 men (43%) and 124 women (56%). The dental arches were imprinted using alginate material. The occlusal surfaces of the dental cast were taken and then scanned, with a ruler added for magnification correction. ImageJ software was used to examine and mark the occlusal aspect.

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The incisal edges of the incisors, the canine cusp tips, and the premolar and molar buccal cusp tips were used as control points in each maxillary [Figure 1] and mandibular cast [Figure 2].

To aid in the estimation of the dental arch morphology, a line was drawn linking all of the spots to form Andrews perimeter line.[6] The arch's shape was classified using Nojima *et al.* method: Type I-oval, Type II-square, and Type III-tapered [Figure 3].[7]

The sample size was calculated using the reference of a previous study done by Gafni *et al.*[8] using the formula $n = Z^2 p (1-p)/d^2$ where,

$Z = 1.96$

n = minimum desired sample size

p = prevalence of square arch form in the desired population = 11.4% = 0.114

$q = 1-p = 1-0.114 = 0.886$

d = least estimated difference of prevalence = 0.05

From the above formula, the minimum desired sample size was estimated to be 155.

The data were imported into a Microsoft Excel spreadsheet and analyzed using the Statistical Package for the Social Sciences (IBM, SPSS Software, 1 New Orchard Road Armonk, New York, United States) Version 21. The sample size was raised to 215 due to the availability of extra samples. Only casts with completely erupted, healthy permanent teeth, all anterior to the second molar, and normal tooth size and shape were considered. The study excluded patients having a history of trauma, previous orthodontic or prosthodontic therapy, craniofacial abnormalities and syndromes, fractures, and restorations that extended to contact areas, cusp tips, or incisal edges.[9]

After a 15-day gap, the intraobserver agreement was assessed[10] by the reclassification of 12% of the total sample by redrawing lines over the control points on the pictures of the digitalized casts.

RESULTS

The mean age of the individual was 20.71 ± 4.66 and 19.25 ± 5.18 in males and females, respectively. In both jaws, the oval arch type was the most common. In maxilla and mandible, the total proportion of oval arch shape was 38.81% and 63.93%, respectively. In maxilla and mandible, the total square arch form was 35.62% and 19.63%, respectively, whereas the total tapered arch form was 25.57% and 16.44% as illustrated in Figures 4 and 5.

The females had a tendency for oval arch form (35.4%) followed by a square (33%) and tapered (31.4%) in the maxilla. A similar tendency for oval arch form (65.3%) followed by a square (17.7%) and tapered (16.9%) form was reflected in the mandible as demonstrated in Table 1.

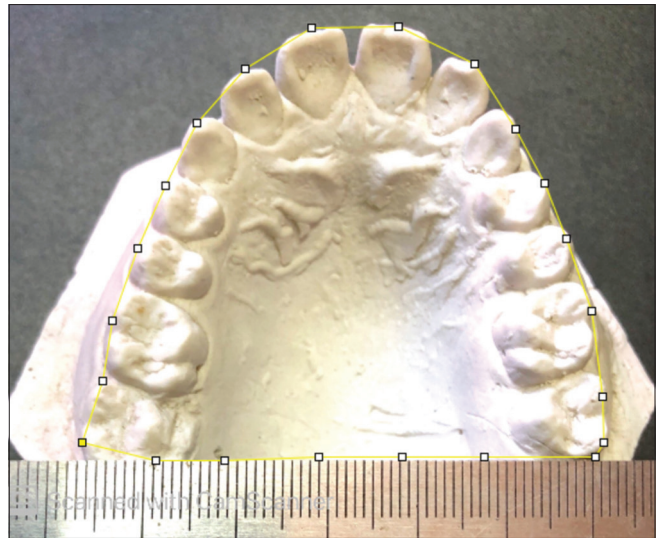The males had more oval arch form (43.1%) followed by a square (38.9%) and tapered (17.9%) in the maxilla,

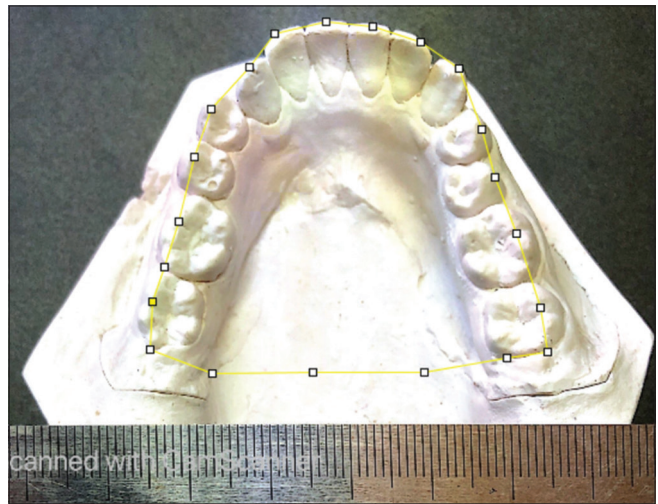**Figure 1:** Reference line marked in maxilla using ImageJ software

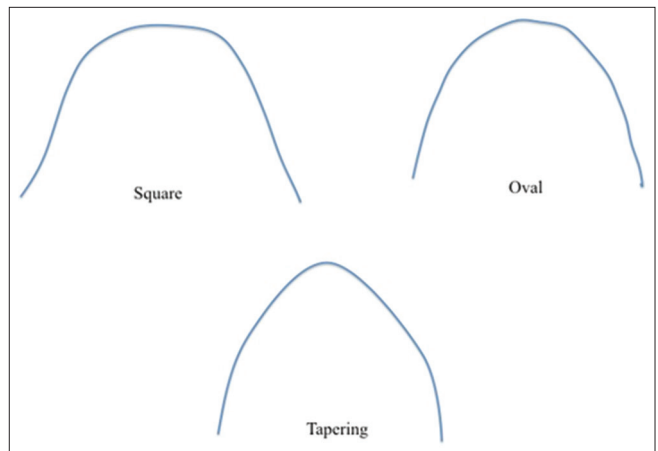**Figure 2:** Reference line marked in mandible using ImageJ software

Figure 3: Types of arch form classified in the study

and a similar pattern existed in the mandible with more oval arch form (62.1%) followed by a square (22.1%) and tapered (15.8%) as demonstrated in Table 2. The intraobserver
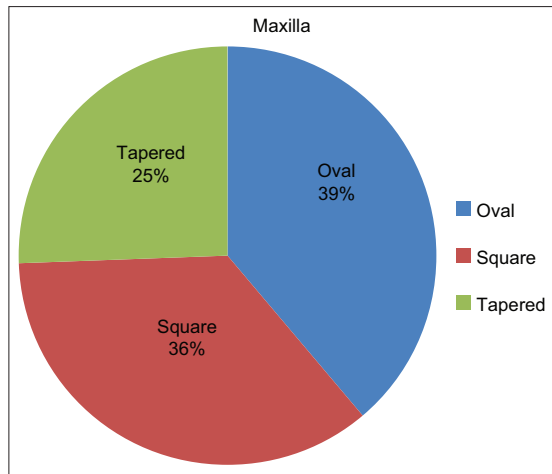
Figure 4: Total percentages of maxillary dental arch morphology in the natural normal occlusion
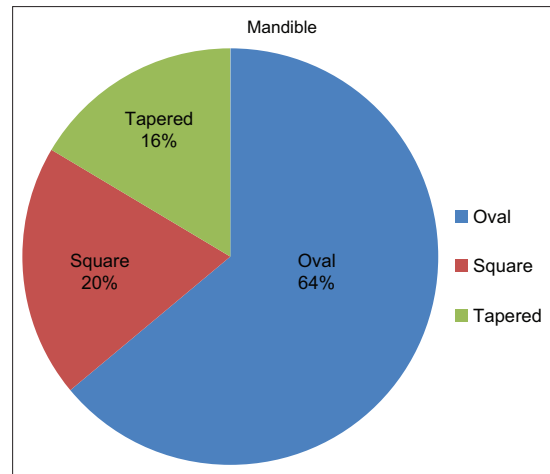

Figure 5: Total percentages of mandibular dental arch morphology in the natural normal occlusion

Table 1: Percentages of dental arch morphology in females in natural normal occlusion

Female	Arch maxilla, *n* (%)	Arch mandible, *n* (%)
Oval	44 (35.48)	81 (65.32)
Square	41 (33.06)	21 (17.74)
Tapered	39 (31.46)	21 (16.94)

Table 2: Percentages of dental arch morphology in males in natural normal occlusion

Male	Arch maxilla, *n* (%)	Arch mandible, *n* (%)
Oval	41 (43.1)	59 (62.1)
Square	37 (38.9)	21 (22.1)
Tapered	17 (17.9)	15 (15.8)

variability was tested by reevaluation of the 12% sample. The Kappa results showed 91.3% agreement for the arch configuration.

DISCUSSION

The identification of the deceased is the most typical job of the FO.[11] There are two primary types of dental identification. First, comparative identification, which is used to determine whether the remains of a decedent and a person represented by AM dental data are the same people. The body or the circumstances generally offer indications as to who died. Second, in circumstances when no AM records are accessible and no clues to the possible identification exist, a FO creates a PM dental profile, which includes characteristics of the subject that is likely to narrow the search for the AM data.[12]

Chuck identified arch forms such as square, ovoid, and tapered in 1932.[13] Many academics and clinicians have used this classification for a variety of research and therapeutic objectives since then. Individualization is easier with a three-arch form method than it is with a single-arch form method.[14] In mass tragedies, this can be used for human identification to narrow down the search.

The most prevalent arch form in our analysis was oval in both the maxilla and mandible. This finding is consistent with Park *et al.* who found that O-shape arch is more prevalent in both the maxilla (52%) and mandible (56%). In both the maxilla and the mandible, the V and U-shapes appeared 28% and 20% of the time, respectively.[15] Our study had a more square shape than tapered. This disparity in the prevalence of arch form may be because of the nature of the sample used in our study.

Khatri *et al.* investigated arch form in the mandible among individuals seeking orthodontic treatment, which matches our findings. In both studies, ovoid arch forms were more common than square and tapered arch forms. The ovoid, tapered, and square form was 50%, 32.5%, and 17.5%, respectively.[14] The identical results to the Indian population could be explained by anthropometrical similarities between the Nepalese and Indian populations.[16]

The findings of this study contrast those of Nojima *et al.* who found that the tapered arch type was the most common in Caucasian samples in their study on mandibular casts. The Caucasian had a ratio of 44% followed by 38% ovoid and 18% square arch form.[7] Similarly, a study conducted by Kook *et al.* on Korean samples found that tapered arch forms were the most common, accounting for 44% of the total, followed by 38% ovoid arch and 18% square arch.[17]

On the contrary, the Japanese sample showed square arch form to be most prevalent with the ratio of 46% square, 42% ovoid, and 12% tapered arch form.[7] Similarly, the North American white sample had 47% square, 34% ovoid, and 18% tapered arch forms.[8]

According to Owais *et al.*,[18] the oval arch was the most prevalent arch form in the maxilla (58.4%) followed by the square (11.5%) and tapered (7.9%). This finding matches ours, as the oval arch type was more common in our study as well. Both findings agree with those of de Castro *et al.*[19] who found that the oval arch (58.39%) and square arch (11.49%) were more prevalent in the maxilla.

The diversity in the prevalence of the arch shape in different communities could be ascribed to genetic and ethnic differences. The variation could also be caused by discrepancies in classification employed in different research, different age groups, and sample size.

Males had a higher frequency of ovoid arch forms in both the maxilla and mandible, followed by square and tapered arch forms. Females exhibited a higher frequency of ovoid arch forms, which were followed by square and tapered arch forms. This conclusion is consistent with Khatri *et al.*[14] findings, which found a higher incidence of ovoid arch shape in both males and females. However, the females in their study had a more tapered arch, which contradicts our findings. These findings contrast the conclusions of research by Papagiannis *et al.*[20] and Ferrario *et al.*[21] who found no gender preference in arch form.

The morphological difference in the tooth arch can be utilized to narrow down the search for human identity. During the PM examination, this factor should not be overlooked. It may not be able to identify a specific person, but it can help limit down the search. It can aid a FO in the exclusion of an individual if identification is not possible.

This study verifies the dental arch individualization concept, with potential applications in forensic human identification, based on all of the findings reported here. Based on a bigger sample and more statistically meaningful analysis and comparison databases, the present study backs up the notion of the unique component in the dental arches.

CONCLUSION

In both the maxilla and the mandible, the oval arch was the most prevalent, followed by the square and tapered arch. More oval forms were found in both sexes, followed by square and tapered forms both in maxilla and mandible. During a forensic dental examination, this information should not be neglected, and it must be recorded in PM forms without fail.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Noroozi H, Nik TH, Saeeda R. The dental arch form revisited. Angle Orthod 2001;71:386-9.
2. Wood RE, Kogon SL. Dental radiology considerations in DVI incidents: A review. Forensic Sci Int 2010;201:27-32.
3. Sweet D. Forensic dental identification. Forensic Sci Int 2010;201:3-4.
4. Sims CA, Berketa J, Higgins D. Is human identification by dental comparison a scientifically valid process? Sci Justice 2020;60:403-5.
5. Queiroz CL, Bostock EM, Santos CF, Guimarães MA, Silva RH. A forensic identification case and DPid – Can it be a useful tool? J Appl Oral Sci 2017;25:346-53.
6. Andrews LF, Andrews WA. Syllabus of the Andrews Orthodontic Philosophy. 9th ed. San Diego: Lawrence F. Andrews Foundation; 2001.
7. Nojima K, McLaughlin RP, Isshiki Y, Sinclair PM. A comparative study of Caucasian and Japanese mandibular clinical arch forms. Angle Orthod 2001;71:195-200.
8. Gafni Y, Tzur-Gadassi L, Nojima K, McLaughlin RP, Abed Y, Redlich M. Comparison of arch forms between Israeli and North American white populations. Am J Orthod Dentofacial Orthop 2011;139:339-44.
9. Paranhos LR, Andrews WA, Jóias RP, Bérzin F, Daruge Júnior E, Triviño T. Dental arch morphology in normal occlusions. Braz J Oral Sci 2015;10:65-8.
10. Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod 1983;83:382-90.
11. Jones DG. Odontology often is final piece to grim puzzle. J Calif Dent Assoc 1998;26:650-1.
12. Pretty IA, Sweet D. A look at forensic dentistry – Part 1: The role of teeth in the determination of human identity. Br Dent J 2001;190:359-66.
13. Subramanian SK, Periyakaruppiah A, Jeyaraj Y, Vaidyalingam T, Anbarasu P, Annamalai I. Relationship between dental archform and dermtoglyphics. J Pharm Bioallied Sci 2019;11 Suppl 2:S289-92.
14. Khatri JM, Madaan JB. Evaluation of arch form among patients seeking orthodontic treatment. J Indian Orthod Soc 2012;46:325-8.
15. Park SJ, Leesungbok R, Song JW, Chang SH, Lee SW, Ahn SJ. Analysis of dimensions and shapes of maxillary and mandibular dental arch in Korean young adults. J Adv Prosthodont 2017;9:321-7.
16. Kallianpur S, Desai A, Kasetty S, Sudheendra U, Joshi P. An anthropometric analysis of facial height, arch length, and palatal rugae in the Indian and Nepalese population. J Forensic Dent Sci 2011;3:33-7.
17. Kook YA, Nojima K, Moon HB, McLaughlin RP, Sinclair PM. Comparison of arch forms between Korean and North American white populations. Am J Orthod Dentofacial Orthop 2004;126:680-6.
18. Owais AI, Abu Alhaija ES, Oweis RR, Al-Khateeb SN. Maxillary and mandibular arch forms in the primary dentition stage. Oral Health Dent Manag 2014;13:330-5.
19. de Castro LA, Modesto A, Vianna R, Soviero VL. Cross-sectional study of the evolution of the primary dentition: Shape of dental arches, overjet and overbite. Pesqui Odontol Bras 2002;16:367-73.
20. Papagiannis A, Halazonetis DJ. Shape variation and covariation of upper and lower dental arches of an orthodontic population. Eur J Orthod 2016;38:202-11.
21. Ferrario VF, Sforza C, Poggio CE, Serrao G, Colombo A. Three-dimensional dental arch curvature in human adolescents and adults. Am J Orthod Dentofacial Orthop 1999;115:401-5.