Analyzing Dental Arch Shape in Untreated Orthodontic Patients with Anterior Arch Crowding

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ABSTRACT

Objective: Crowding of the dentition results in distortion of the arch form and orthodontic treatment unravels the crowding based on the shape of the wire of arch form utilized. Alteration of an existing arch form with the wrong arch wire and biomechanics may result in unstable results. Selection of the appropriate arch wire shape based on the patient's original arch form results in a finished orthodontic treatment which is aesthetically pleasing, preserves the shape and function, with long term stability of the finished case. The objective of the study was to analyze the dental arch shape in untreated orthodontic patients with anterior arch crowding.

Methods: Dental casts of 100 untreated orthodontic patients with anterior arch crowding of both the maxilla and mandible were selected and classified using Angles method. Crowding was described as mild, moderate, severe and very severe using the index described by Little. The Occlusal plane was outlined for both jaws using brass wire adapted with sticky wax along the buccal cusps of the posterior teeth on one side of the arch through the incisal edges of the anterior teeth to the buccal cusps of the posterior teeth on the other side of the arch. Data analysis was done using IBM SPSS version 22.0 software. All data was expressed as frequencies, percentages and means. The results were presented using frequency tables.

Results: Upper arch shapes were identified as square in 58(58%), tapered in 18(18%) and ovoid in 24 (24%). Lower arch shapes were square in 60(60%), tapered in 36 (36%) and ovoid in 4(4%). Anterior arch crowding was seen in both arches as mild in 68(68%), moderate in 17(17%), severe in 9(9%) and very severe in 6(6%). The highest prevalence of anterior crowding was seen in the mild variant and in the square shape in both the upper and lower arch forms in 43 (63.2%), respectively. The tapered arch form was not demonstrated in the very severely crowded upper arch, while the ovoid arch form in the lower arch was not evident in the severe and very severe variant of crowding. This was however not statistically significant.

Conclusion: The square arch form is most prevalent in cases of upper and lower crowding.

Keywords: Dental arch, untreated orthodontics

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INTRODUCTION

Dental crowding can be defined as a disparity in the relationship between tooth size and jaw size which results in imbrications and rotation of teeth [1-4]. Certain conditions which may predispose to crowding include excessively large teeth, excessively small bony bases of the jaws, and a combination of large teeth and small jaws.[5-10] The resultant effect of crowding is partial or total displacement of teeth out of the arch and distortion of the arch form[1, 3-5].

The arch form is important in orthodontic diagnosis and treatment planning as shape preservation during orthodontic management helps in post treatment function and stability.[1,2-4] The dental arch form is an important factor in post treatment favourable outcomes as it may influence available space, dental

and smile aesthetics, and potential long-term occlusal stability.[5-8] The aim of maintaining the pre-treatment dental arch form may help reduce a relapse of the crowding and also prevent subsequent periodontal damage.[1,3, 5]

In orthodontics, crowding is one of the problems for which individuals seek treatment. The anterior segment where crowding is more aesthetically displeasing has been seen to be as a result of tooth size and arch length and width discrepancies.[12-14] As a result of this, the mandible exhibits various shapes and due to its narrower width, studies have found it difficult to use measurements of distances and angles to describe it numerically.[10-12]

Several studies have attempted associating a geometric curve with the anterior segment of the mandible with the aim of identifying arch forms for each type of crowding.[15] The straight wire technique utilized the concept of a circular arch form on the anterior part of the arch with an attempt to determine a particular arch form for all individuals irrespective of their malocclusion.[16,17] In present day orthodontic practice, with the introduction of newer materials, techniques and greater precision, convenience and added comfort of the patients; preformed arch-wires were introduced and have gained increased popularity.[18] However, the preformed super-elastic nitinol wires with a pre-determined shape cannot be altered easily, resulting in selection of arch forms which may vary from the patient's original arch.[18] This resulted in further research[19-21] with individualization of the mandibular arch form[19-21] or by a computer-assisted dental arch form[22] for each individual.

Studies[23] were carried out to understand the shape and curvature of the mandibular arch with six measured arch dimensions, five calculated ratios and six suggested polynomial curves to describe five different arch forms. The shape of the arch form could be square (the incisors have parallel sides), tapered (the incisors have a triangular form or are narrower at the neck) or ovoid (the incisors have ovoid or rounded form).[23] Arch shapes have also been described as 'U', 'V', square or omega. There appear to be limited information in subjects in our environment evaluating arch shapes and this study will help orthodontists in choosing the correct preformed arch wire for the correct arch shape. The results from this study will also guide practitioners on each patient getting the right archwire for their respective arch shape. The objective of this study was to analyze the dental arch shape in untreated orthodontic patients with anterior arch crowding

MATERIALS AND METHODS

This descriptive analytical cross- sectional study was carried out in the Orthodontic Unit of the Department of Preventive Dentistry, University of Benin Teaching Hospital (UBTH). Approval was sought and granted by The Ethics Committee, University of Benin, Benin City. Privacy and confidentiality of the information from the dental casts was maintained throughout the study.

Dental casts of one hundred (100) untreated orthodontic patients from the University of Benin Teaching Hospital (UBTH), Benin City was used for the study. The dental records of each cast were obtained to determine the suitability of each cast. The inclusion criteria included no history of previous orthodontic treatment, dental casts which were properly prepared, based and unbroken; presence of anterior crowding using Little's irregularity index of 1-10 in both the upper and lower jaws and dental casts with permanent teeth present (at least tooth 1-6 in all quadrants).

The upper and lower arch crowding was classified using the irregularity index as determined by Little [24] and digital calipers were used on dental casts to measure the horizontal linear displacement of each anatomic contact point on each maxillary and mandibular incisor respectively from the adjacent anatomic point and the displacement added as a score. The value represents the degree of anterior irregularity.[24] The scale of the index is listed below and each number corresponds to the distance in mm of the sum of horizontal displacements of the anatomical contact points of the maxillary and mandibular anterior teeth.

- 0 - Perfect alignment
- 1-3 - Minimal irregularity
- 4-6 - Moderate irregularity
- 7-9 - Severe irregularity
- 10 - Very severe irregularity

Exclusion criteria applied for this study included dental casts with a score of 0 or perfect alignment, casts of orthodontic patients who had completed their treatment at the Dental Clinic of the University of Benin Teaching Hospital; dental casts with missing teeth or those with primary teeth or in the mixed dentition stage. Also, dental casts without an opposing jaw were excluded from this study.

A non probability convenience sampling method was used for this study and all the dental casts that fell within the inclusion criteria were selected. These casts were then articulated with the upper and lower jaws in centric occlusion. The molar relationship of each cast was determined using the method described by Edward Angle[5] as follows:

- Class I – the mesiobuccal cusp of the upper first molar occludes on the buccal groove of the lower first molar
- Class II – The mesiobuccal cusp of the upper first molar occludes mesial to the buccal groove of the lower first molar
- Class III – The mesiobuccal cusp of the upper first molar occludes distal to the buccal groove of the lower first molar

The shape of the arch was outlined using brass wire adapted with the aid of sticky wax along the buccal cusps of the posterior teeth on one side of the arch along the incisal edges of the anterior teeth to the buccal cusps of the posterior teeth on the other side of the arch. This was done for both the upper and lower jaws. A template of various arch forms was used as a basis for comparison and the most appropriate form selected. This was transferred to a spread sheet and data analysed using the IBM SPSS version 22.0 software. All data was expressed as frequencies, percentages and means. Associations between variables were evaluated with the chi-square test. Significant values of P<0.05 were applied where applicable.

RESULTS

The mean age of the patients was 19.08 ± 6.284 with a higher number, 66 (66.0%) being in the 12-19 year old age group. Majority of the patients were female in 63 (63.0%).

A higher number of patients with mild anterior crowding were seen in the squared dental arch, with a value of 43 (63.2%). Majority of the tapered upper dental arch had moderate anterior crowding, in 9 (52.9%), Table 1 shows the distribution of crowding in the various arch forms of the upper arch.

Table 2 demonstrates the distribution of crowding and arch shape in the lower arch. Majority of patients with squared lower dental arch had mild anterior crowding, with a proportion of 43 (63.2%). Moderate and severe anterior crowding was not seen in patients with the ovoid dental arch. These findings are not statistically significant. P>0.05. Figure 1 shows the diagrammatic representation of the three arch forms while figure 2 shows the association between angles molar relationship and the upper arch with the class III molar relationship being more prevalent in the square arch form in 3(75%).

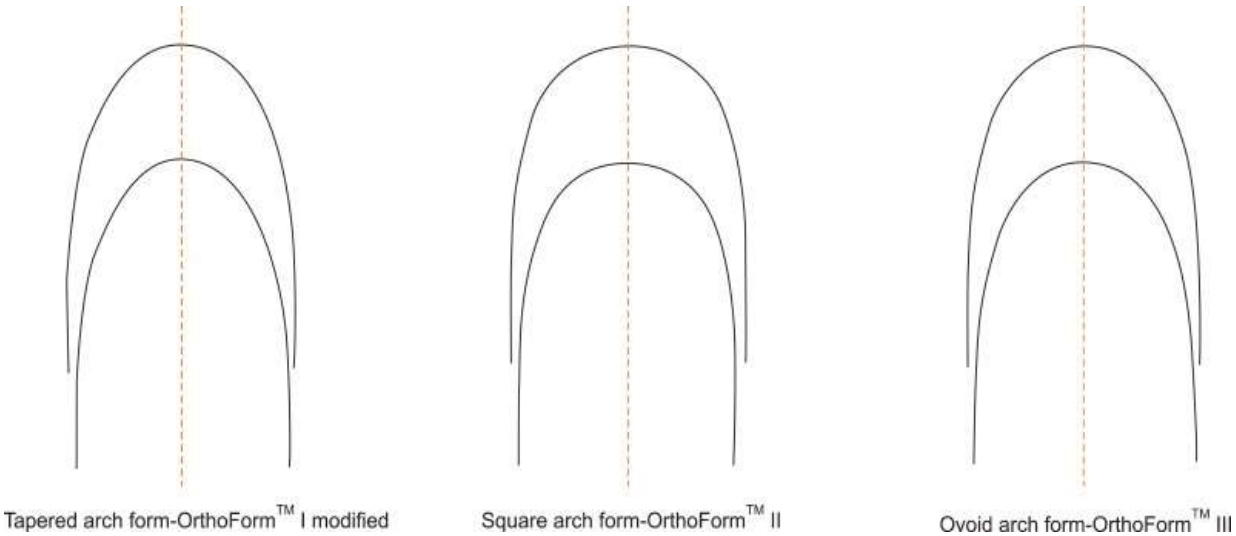


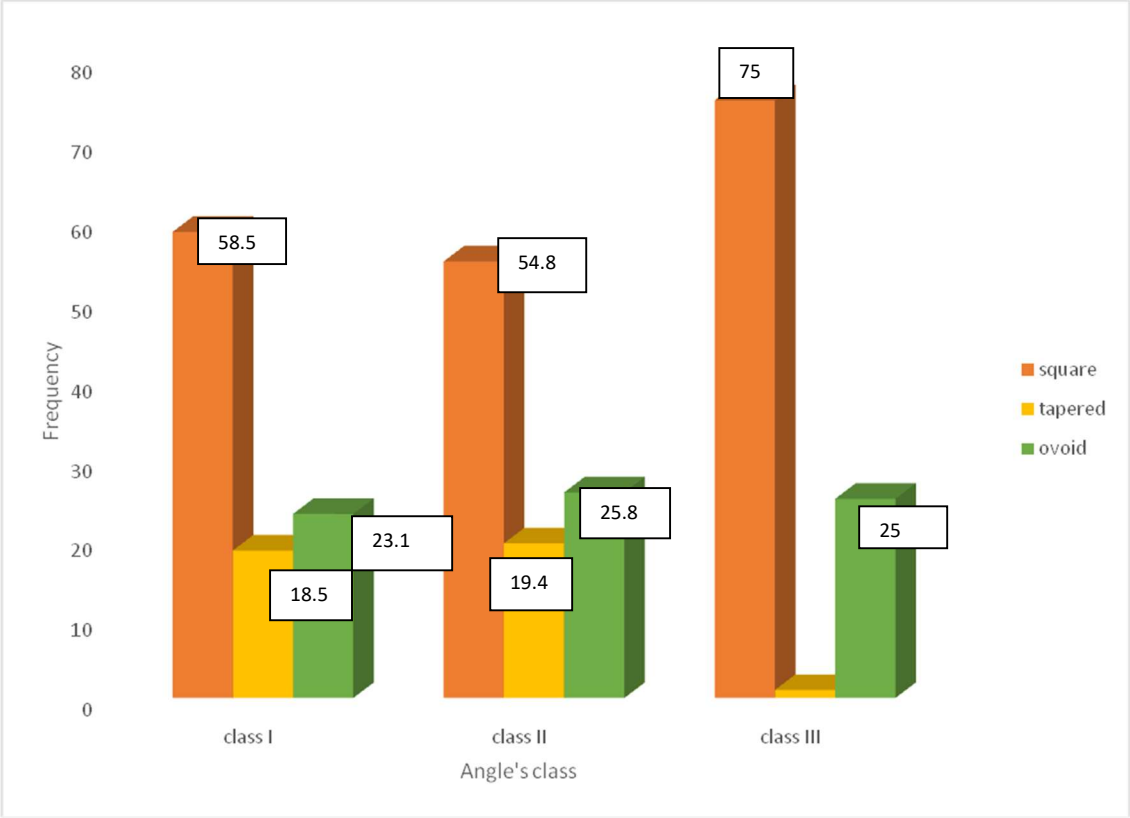
Figure 1: Arch Form Type as described by ORTHOFORM™ 3MUNITEK

Table 1: Association between anterior crowding and upper arch shape

Anterior crowding	Shape of upper dental arch (n= 100)			Fishers Exact test	P-value
	Square no (%)	Tapered no (%)	Ovoid no(%)		
Mild	43 (63.2)	9 (13.2)	16 (23.5)	8.949	0.131
Moderate	9 (52.9)	5 (29.4)	3 (50.0)		
Severe	3 (33.3)	4 (44.4)	2 (22.2)		
Very Severe	3 (50.0)	0 (0.0)	3 (50.0)		

Table 2: Association between anterior crowding and lower arch shape

Anterior crowding	Shape of lower dental arch (n= 100)			Fishers Exact test	P-value
	Square no (%)	Tapered no (%)	Ovoid no (%)		
Mild	43 (63.2)	22 (32.4)	3 (4.4)	4.539	0.548
Moderate	10 (58.8)	6 (35.3)	1 (5.9)		
Severe	3 (33.3)	6 (66.7)	0 (0.0)		
Very Severe	4 (63.2)	2 (33.3)	0 (0.0)		

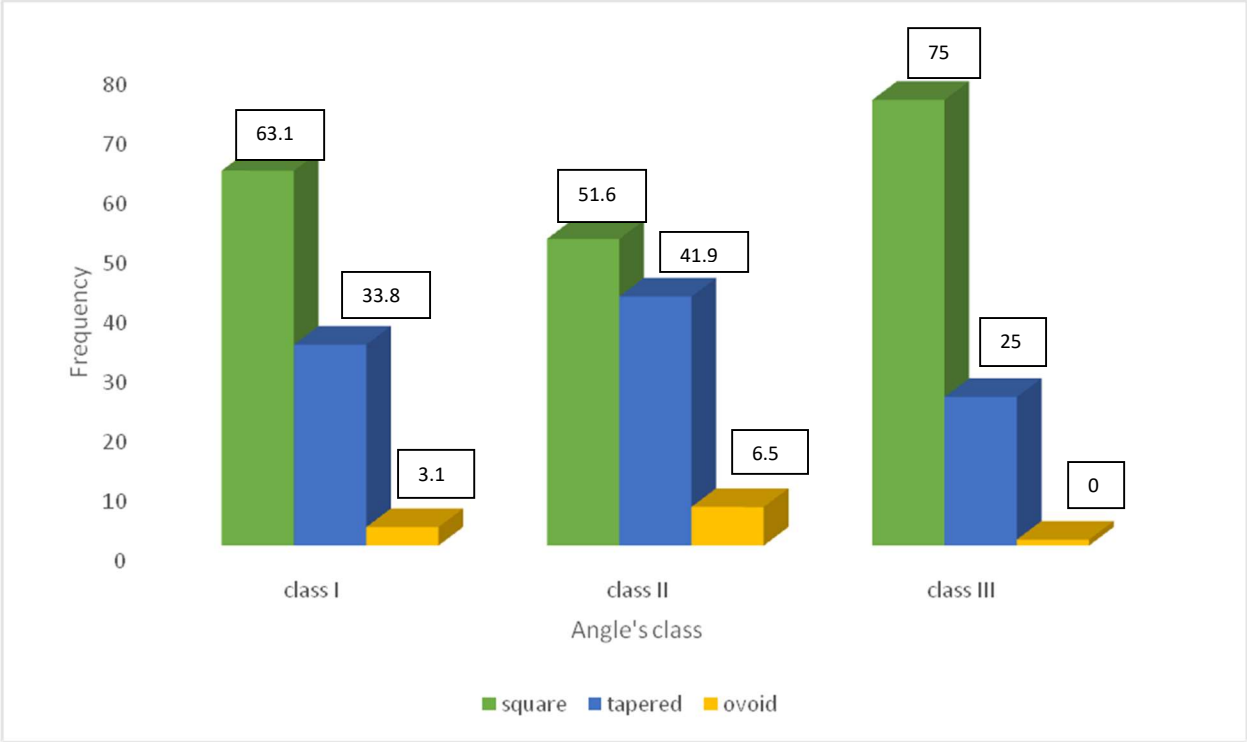


Fishers exact test=0.984, p=0.992

Figure 2: Association between angle's molar relationship and shape of upper dental arch

Figure 3 demonstrates the relationship between the various lower arch forms and angles molar relationship whereby the ovoid arch form was the least prevalent in 1(25%). The tapered shape dental arch in angle's class II, showed a distribution of 13 (41.9%). These associations are not statistically significant. P>0.05

Table 3 demonstrates the association between age and shape of the upper arch. The 12-19-year old group demonstrated the highest value in square 41(52.1%). The 27-33-yearold age groups were not represented in the ovoid arch form. Among the patients with the square shape lower dental arch, a higher percentage was among the 20-26 –year old age group, with a proportion of 15 (62.5%).The association between the age and shape of the lower arch showed that the ovoid arch form was not demonstrated in the 27-33 and 34-40-age groups see Table 4. Figures 4 and 5 show the gender distribution between the upper and lower dental arch shapes respectively. The square shape was more prominent in the upper arch in females in 39(61.9%) the tapered and ovoid dental arch was higher in males in 8(21.6%) and 10(27%) respectively. The square and ovoid shapes in the lower arch were higher in males in 25(67.6%) and 2(5.4%) respectively. The tapered shape in the lower was higher in females with a value 10(27%). The association between gender and shape of lower dental arch was not statistically significant. P>0.05



Fishers' exact test = 2.388, p =0.695

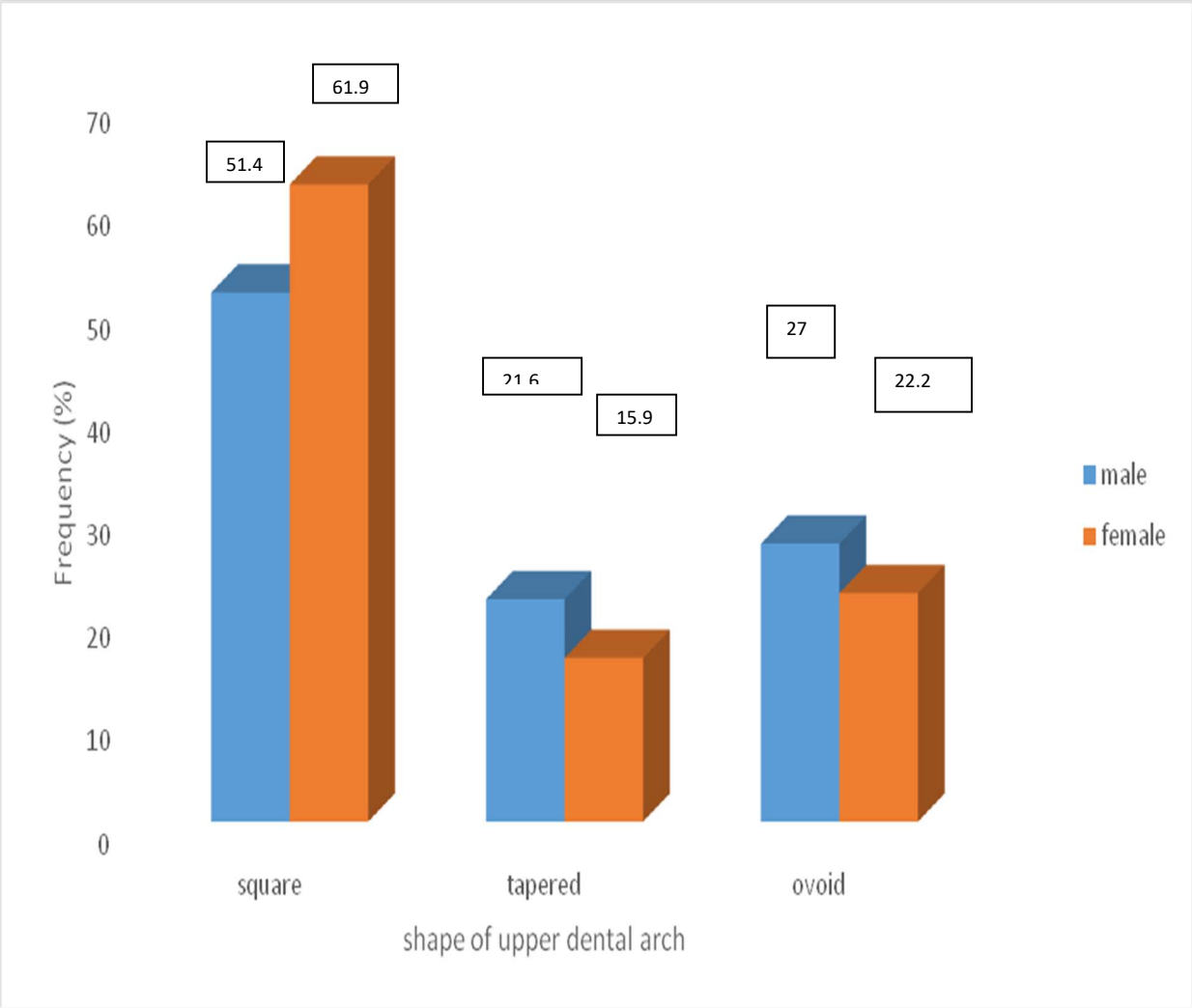
Figure 3: Association between angle's molar relationship and shape of lower dental arch

Table 3: Association between age and shape of upper arch

Age group (in years)	Shape of upper dental arch (n=100)			Fishers Exact test	P-value
	Square no (%)	Tapered no (%)	Ovoid no (%)		
12-19	41 (62.1)	13 (19.7)	12 (18.2)	7.565	0.203
20-26	11 (45.8)	3 (12.5)	10 (41.7)		
27-33	4 (80.0)	1 (20.0)	0 (0.0)		
34-40	2 (40.0)	1 (20.0)	2 (40.0)		

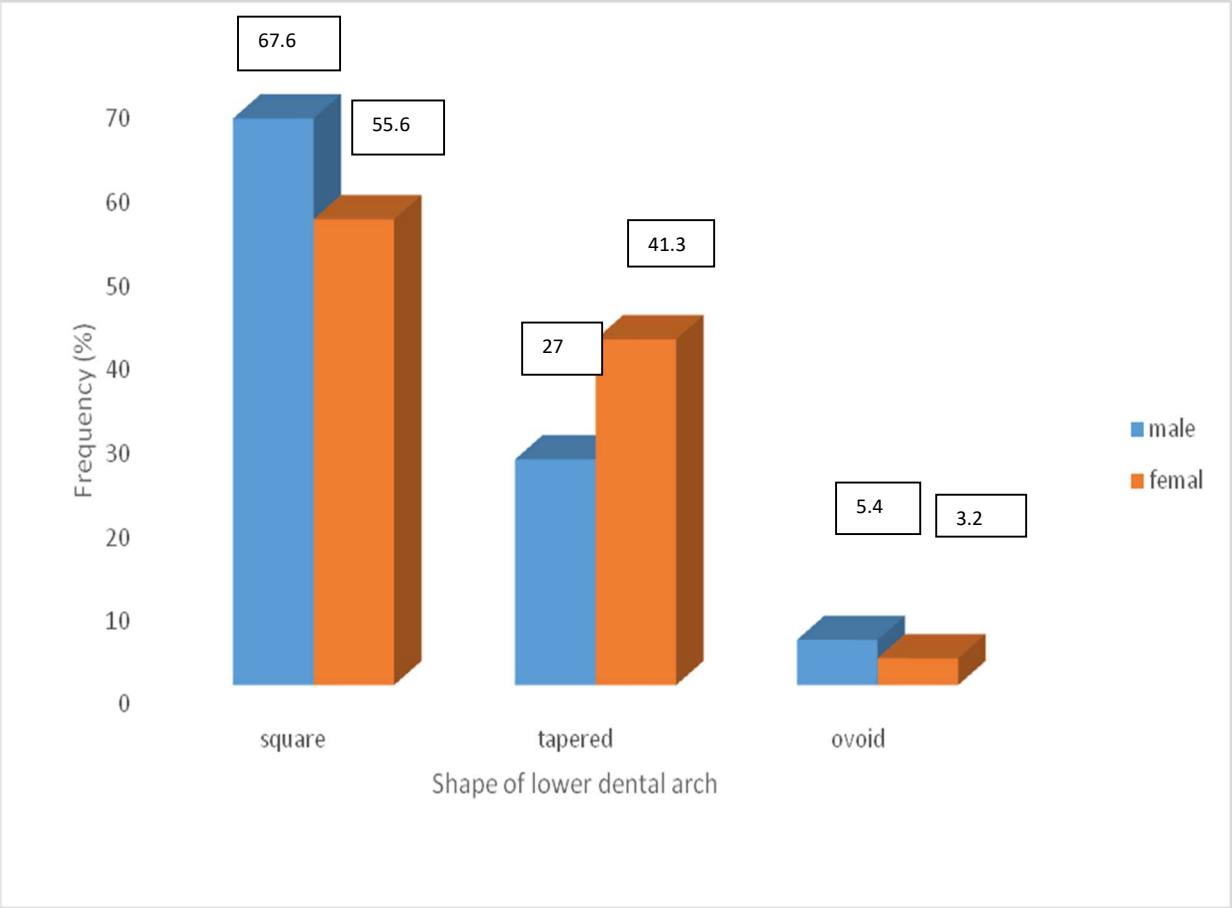
Table 4: Association between age and shape of lower arch

Age group (in years)	Shape of lower dental arch (n= 100)			Fishers Exact test	P-value
	Square no (%)	Tapered no (%)	Ovoid no (%)		
12-19	40 (60.6)	23 (34.8)	3 (4.5)		
20-26	15 (62.5)	8 (33.3)	1 (4.2)	2.292	0.932
27-33	2 (40.0)	3 (60.0)	0 (0.0)		
34-40	3 (60.0)	2 (40.0)	0 (0.0)		



$\chi^2 = 1.100$, P=0.577

Figure 4: Association between gender and shape of upper dental arch



Fishers' exact test=2.309, P=0.379

Figure 5: Association between gender and shape of lower dental arch

DISCUSSION

This current study was carried out to analyze the shape of dental arches in untreated orthodontic patients with anterior crowding in the University of Benin Teaching Hospital. The predominant arch form was identified as square, followed by the ovoid and lastly the tapered arch form in the upper jaw. This is however at variance with a Turkish study by Troedan *et al*[21], where the predominant arch form was tapered followed by the ovoid and tapered arch forms respectively. Other studies in different racial groups[12,22,23-29] namely Pakistani's[12] Indians, Jordanians[23], Kenyans[27], Iranians [30], Black and White Americans[28] showed a variation in the distribution of arch forms. While this study focused on Nigerians only, their studies[14, 23] which was carried out on Turks, suggested a variation in ethnicity in arch forms. However, another study on Iranians had an equal distribution of both ovoid and tapered arches in the mandible.[30] This present study however showed that the ovoid arch form was least predominant in the lower jaw which is in agreement with the study by Troedan *et al.* [23]

Studies by different authors[1,4,6-9,25] have shown variation in arch width and form in normal occlusion and in patients with crowded arches. The shape of the dental arch in this study differed in the same patient in the maxilla and mandible with more females with the square arch. Males, however, demonstrated more of the square arch in the mandible than in the maxilla and this could be due to the fact that crowding affects arch shape and one or both arches may have been crowded.

This study also evaluated patients with mild, moderate, severe and very severe anterior arch crowding. A higher proportion of patients who had mild crowding had square shaped upper and lower dental arches, when compared with those who had tapered and ovoid shape of dental arches. When compared with other studies, findings from their study showed that the most common shape of the upper dental arch was oval and square equally, while

the oval shape was more prevalent for the lower dental arch.[31, 32]

The results from this study showed that majority of the squared upper dental arch had moderate anterior crowding, while there was no anterior crowding in the tapered dental arch, with both the squared dental arch and ovoid dental arch having equal proportions. This demonstrates that crowded and non-crowded arches may show different shapes as determined by another study[11,12,22] which demonstrated that arch widths and arch lengths were greater in the non-crowded group than in the crowded group

This study identified a majority of patients with squared lower dental arch had no anterior crowding. Also, more than half of the patients in this study presented with mild anterior crowding and were seen in the squared dental arch. However, moderate and severe anterior crowding was not seen in the patients with ovoid dental arch. Studies by Oda *et al.*[17] on the arch form of the mandibular dental arches determined that a variation exists and each form suggested maintaining the patient's original arch. Bondemark et *al.*[13], determined the form and dimension of the mandibular dental arch as a factor in the stability of the therapeutic results. From other studies[14], it was determined that the mandibular arch possesses different shapes in different patients whether the occlusion is normal or crowded. These studies suggested multiple factors as determinants in the formation of the mandibular arch form which aid in the stability of a functional occlusion[13, 14, 17].

From the results of this study, findings show that among the three Angle's molar relationships, a higher proportion of the patients had a Class III molar relationship, with square shaped upper and lower dental arches respectively. These findings were not statistically significant. This was similar to a study done in other countries [31], which observed that there was no statistical significance in the correlation between the Angle's molar relationship and the shape of the upper and lower dental arches. However, their study[31] demonstrated a higher number of the tapered arch form in both angles' class II and III molar relationship. Studies by Olmez *et al.*[32] however showed that the square arch form was highest in Angles Class III molar relationship. Their study[32] however determined that this variation was due to lingual tipping of the anterior teeth in Class III patients. This current study identified majority of patients with tapered shape dental arch were in angle's class II which is in agreement with other studies[31,32], and those with an ovoid shape lower dental arch were highest in angle's class II. This is similar to the results form studies by Olmez *et al* 2011 where the ovoid arch form was the majority and equal in number with Classes II and III.

One-fifth of the patients in the age group 27-33 years had a square shaped upper dental arch, while three-fifths of this same age group have tapered shaped lower dental arch. This finding was not statistically significant. This is in contrast to a study done in Athens, Greece[33], which showed significance in the correlation between age and shape of dental arches. This indicated that the arch width/arch length ratio increased as subjects get older, for both upper and lower dental arches. From the result of this study, there was no statistical significance in the association between gender and shape of upper and lower dental arches. This finding is in agreement with their study[33], which also noted no statistical significance in either upper or lower dental arch shapes between males and females.

CONCLUSION

Within the limitations of this current study and paucity of research evaluating arch forms in untreated orthodontic patients with both maxillary and mandibular crowding, the following conclusions can be deduced:

1. The square shaped arch is most common in mild, moderate and very severe crowding in both the maxilla and mandible.
2. The tapered arch form in both the maxilla and mandible is more common in severe crowding.
3. Angles class III molar relationship is more prevalent in the tapered arch form for both the mandible and maxilla
4. There is no significant difference between the shape of the arch, age and gender.

Source of Support

Nil.

Conflict of Interest

None declared.

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