INTRODUCTION

Information regarding arch dimensions in human populations is important to clinicians in most of the dental specialties including orthodontists. It is important to clarify and understand the relationship between craniofacial structures and arch dimensions. The anatomical features of craniofacial structures, dental arch widths, and dental arch forms have been evaluated in literature. Ricketts reported that a correlation can exist between facial type and dental arch. The size and shape of the arches have a considerable clinical implication in orthodontics specially during diagnosis and treatment planning, as it affects the space available, dental aesthetics and stability of dentition.

Orthodontic movements usually require modifications in arch dimensions for the correction of the presenting malocclusion. Arch dimensions are also modified (unintentionally) by the various arch wires used during treatment affecting the stability of the results achieved.

METHODOLOGY

This cross-sectional comparative study was conducted at the dental clinics of the Aga Khan University Hospital, Karachi, Pakistan, from June 2007 to May 2008. Non-
probability purposive sampling technique was used to select 100 cases, with 40 cases being normodivergent and 30 each being hypo- and hyperdivergent cases according to mandibular plane angle (normal = 32°±4) and the Jarabak's ratio (normal = 65±4%).

Inclusion criteria included full complement of teeth (upto second permanent molars) and age range of 13 to 30 years. Exclusion criteria included severe crowding (more than 7 mm), presence of dental anomalies (of form, structure, number and development), previous dentoalveolar surgery or maxillofacial trauma, craniofacial syndromes, previous orthodontic treatment and asymmetry of greater than 2 mm in the dental arch.

Data were obtained from pre-treatment study casts and cephalographs of orthodontic patients at the study centre. Subject selection was based on facial patterns, determined by the amount of vertical growth by mandibular plane angle (normal 32°±4) and Jarabak's facial height ratio (normal 65±4%) on the cephalographs taken using standard techniques.

Reproducible reference points were marked on the study casts (both upper and lower) with a 2H pencil which included: mid mesioincisal edges of central incisors (labial side), canine tips, mesiobuccal cusp tips of the first permanent molars and distobuccal cusp tips of the second permanent molars. Occlusograms were made by photocopying study casts with two millimetric rulers placed at right angle to control parallax and magnification as shown in Figure 1. Dimensions of the dental arches were determined according to three transverse and three sagittal measurements.

These points constitute the landmarks of the dental arch form. They define the breaking points of the arch and limit sectors on which different muscle groups have an action in formulating the final arch form.

To assess measurement error, randomly selected 10 cephalographs and 10 casts were retraced and re-copied respectively, 2 weeks after the initial procedure and re-measured. Paired sample t-test was applied to evaluate intra-examiner reliability between the two groups of readings. The result was found to be insignificant (p-value > 0.05) and a high correlation (r ≥ 0.9) was found between the two set of records taken 2 weeks apart.

Statistical Package for Social Sciences (SPSS) for windows (version 15.0, SPSS Inc. Chicago) was used for statistical data analysis. Descriptive statistics including mean and standard deviation for the various arch dimensions in various vertical facial types were computed. Statistical significance level was set at < 0.05. For evaluation of arch form, ratios of three sagittal (L31, L61, L71) to transverse measurements (L33, L66, L77) were determined. As a result, one anterior (L31/L33), one middle (L61/L66) and one posterior arch dimension ratios (L71/L77) were formulated. The means of various arch dimensions and ratios were compared in the three face types by one-way ANOVA. Arch form was classified according to a method shown in Figure 2.

RESULTS

The mean age of the entire sample was 21 years and 5 months ± 7 years and 8 months. The sample consisted of 67 females and 33 males and, therefore, the collected sample was predominantly of female subjects.
Table I shows mean values along with standard deviations of arch dimensions in the three face types along with statistical difference in the means. The summary of the mandibular arch forms in the various facial patterns reveals that wide arch was the predominant arch form in all the face types as shown in Table II although frequency varied in each group: hypodivergent subjects (40%), normodivergent subjects (27.5%) and hyperdivergent subjects (36.6%).

The overall summary of the predominant maxillary arch forms in the various facial patterns, shown in Table III, reveals that wide arches were predominant arch form in hypodivergent subjects (50%) and hyperdivergent subjects (43.3%) whereas narrow arch form was more common in normodivergent subjects (32.5%). In the entire sample, however, wide arches were more frequent (38%) followed by narrow arches (26%).

Form 1 or narrow and 3b wide narrow arches were the commonest in the normodivergent group (32.5% and 7.5% respectively). Form 2 or wide arches were most common in the hypodivergent group (50%). Form 3a i.e. narrow wide arches were commonest in the hyperdivergent group of sample (32.5%) and form 4 were more common in the normodivergent (25%).

To see possible associations between particular face types and arch form types, chi-square test was applied. The Fisher's exact value for the maxillary arch forms was 0.237 and for the mandibular arch forms was 0.218. The Fisher's exact value for the maxillary arch forms reveals that wide arches were predominant arch form in all the face types as shown in Table III although frequency varied in each group: hypodivergent subjects (40%), normodivergent subjects (27.5%) and hyperdivergent subjects (36.6%).

Comparison of means of various arch dimensions in the three vertical face types showed statistical significance in only one transverse and one sagittal dimension (that is maxillary total arch length and mandibular posterior intermolar width. For the maxillary total arch length multiple comparisons using Bonferroni test showed the difference to be mainly between normo- and hyperdivergent groups. Both the maxillary and mandibular transverse arch dimensions were seen to show a similar pattern that is: an increase from hyper to normo to hypodivergent face types. This implies relatively broad arches in the hypodivergent subjects, although the differences in transverse arch dimensions were not statistically significant. These results coincide with those of Kageyama1 and with those of Kanashiro and Vigorito, where increased arch depth and posterior segment widths were found to be greater in brachyfacial faces.4 In the maxillary and mandibular arches the mean and total arch lengths were seen to decrease from hypo to hyper but increase in normodivergent group of faces which is a surprising finding and in disagreement with the results of previously mentioned studies,1,4 however, the difference was again statistically insignificant. The overall characteristic of arch forms is influenced by both sagittal and transverse parameters and both can influence the ultimate arch form of a particular individual. Simultaneous reduction in sagittal and transverse dimension probably will affect the ultimate arch form to a lesser extent between hypo and hyperdivergent faces.
subjects, both having predominantly wide arches [hypodivergent: mandibular (40%), maxillary (50%), hyperdivergent mandibular (36.6%), maxillary (43.3%)]. The increased sagittal dimension in normodivergent changes the predominant arch form to be narrow in the maxillary normodivergent group (32.5%). The increased total arch length might be one of the possible reasons for finding more predominant narrow arches (32.5%) in the maxilla. The greatest variability in transverse arch dimension was seen in hypodivergent group as shown in their highest standard deviation in the entire mean transverse dimensions. This can be attributed to the variability in environmental factors particularly the variability in the muscle bulk and its pressure against the alveolar arches. Therefore, individualization of arch dimensions and archforms is very essential in such patients in order to produce successful orthodontic treatment results. According to Kiliaridis, the functional capacity of the masticatory muscles as well as the masticatory muscle size both can have an association with dental arch width.23

Arch form characterization has been one of the fundamental goals in orthodontics; modification within limits or maintenance of which is necessary for a successful treatment outcome and stability. Most commonly used terms of square, ovoid, tapered or wide or narrow forms of the dental arch have not yet been mathematically defined and, therefore, three ratios were chosen in the present study for each dental arch so as to better define the dimensions as well as form. The landmarks chosen define the whole dental arch and also limit the sectors on which different muscle groups can act in formulating the final arch form.

In the mandibular sample, wide arches were more common (34%) as compared to the narrow arches (22%). Similar pattern was also evident for the maxillary arch: 38% wide arches as compared to 26% narrow arches. So the overall predominant arch form in this sample was form 2 or wide arch for both the maxilla and the mandible.

The predominance of a particular arch form in the individual face groups was also seen in this study. In the mandible, wide arches were found to be predominant in all three face types, frequency, however, varied: hypo (40%), normo (27.5%) and hyper (36.6%). In the upper arch, however, the predominant arch form in normodivergent was narrow arch or form 1 (32.5%) whereas, wide arches were dominant in both hypo (50%) and hyperdivergent (43.3%). This finding confirms the concept given by Ricketts who believed that brachyfacial hypodivergent faces have relatively broad dental arches.16 The results are also in agreement with the results of Kageyama et al.1 The relatively lower frequency of broad arches in the mandibular arch in hypodivergent subjects, however, is quite debatable. Kageyama et al. in their study found that mandibular arch form did not correlate with facial types.1

The low prevalence according to Kageyama was due to anteroposterior displacement and/or rotation of mandible in vertical malocclusions. The probable cause of low frequency in these subjects, apart from other environmental factors, might be more muscular forces on the lower arch which includes the perioral muscles and the intraoral functional forces.

Although wide arch form predominated in all face types in both arches (except in maxillary normodivergent), the prevalence was variable being the highest in maxillary hypodivergent sample (50%). The relationship between form and function still remains unclear. Greatest variability in arch forms was seen in normodivergent sample. The predominant arch form in the mandible was wide (27.5%) followed by narrow arches (22.5%). Predominance in maxilla was narrow (32.5%) followed by wide (25%). Twenty five percent cases in both the arches were form 4 or unclassified. This shows a highly variable pattern of arch form in the normodivergent sample. The highest frequency of various arch forms in different vertical face types were as follows; in the mandibular arch, form 1 was found with highest frequency in hyperdivergent (26.6%), form 2 in hypodivergent (40%), form 3a in hypodivergent (23.3%), form 3b in hyperdivergent (20%) and form 4 in normodivergent (25%). In the maxillary arch, form 1 was found with highest frequency in normodivergent (32.5%), form 2 in hypodivergent (50%), form 3a in hyperdivergent (32.5%), form 3b in normodivergent (2.5%) and form 4 in normodivergent (25%).

Very few studies to-date have been conducted on the concept of relationship of craniofacial dimension with the arch form.1,16 The results of this study also show variations in the predominant arch form and, therefore, a strong association of arch form with vertical face types was not found. This implies that multiple epigenetic and environmental factors that come into play in the formulation of the ultimate arch form of an individual and, therefore, a particular arch form for the particular face type could not be found from this study result. A ‘particular’ arch form for a particular face type can be considered non-prevalent in nature.

Within limits, therapeutic modifications are necessary as instability in archwire changes of various arch dimensions can also lead to unfavourable periodontal sequelae and relapse, specially of crowding. Because a weak linear relationship between posterior intermolar width and other sagittal arch dimensions were noted in this study, therefore, predictability of these variables by posterior intermolar width was not achievable and hence arch form guides could not be made for a particular face type according to their specific posterior intermolar
arch dimensions and arch forms among various vertical facial patterns

width. Because of the great variability in individual arch forms a single arch form cannot be used in all orthodontic cases. Modifications are thus pivotal, but the important point to note is that almost all arch forms were of average form and, therefore, major changes to arch dimensions perhaps do not occur in every treated case. Patients having similar face types can also show individual patterns and, therefore, even in similar vertical facial patterns arches can differ in dimensions as well as forms. The final arch form, hence, is a result of interaction between the functional capacities, the size of the masticatory muscles and the underlying craniofacial and basal bone form. Therapeutic modifications should be attempted within an acceptable range for best stability and success.

Individualization of treatment leads to more effective treatment by working within the patient's natural arch form instead of making patients fit a single standard. The clinician should, therefore, anticipate the differences in size and form rather than treating all cases to a single ideal. Limitations of this study are its small sample size which was predominantly of female subjects. We recommend a large sample size to calculate population norms of arch dimensions for Pakistani subjects. We also recommend a sample selection with equal gender distribution in the sample to determine gender dimorphism in arch dimensions, if any.

CONCLUSION

Statistically significant difference in arch dimensions amongst the three face types was found in only maxillary total arch length and mandibular posterior intermolar width. Total arch length was the most variable arch dimension in the three vertical face types. Mandibular posterior intermolar width showed an increase from hyper to normo to hypodivergent group. Forty percent of the arch forms in the sample were narrowed anteriorly. Wide arch form was predominant in lower arch whereas narrow arch form was predominant in upper arch. Hypodivergent and hyperdivergent facial patterns had predominantly wide arches while normodivergent facial pattern had variable arch forms. There was insignificant association between arch forms, arch dimensions and face types.

Acknowledgement: University Research Council of the Aga Khan University for providing Grant (URC Project ID: 071012SUR) for the research protocol.

REFERENCES


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