Original Article

The Relationship of Various Arch Forms and Cortical Bone Thickness

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Abstract:

Objective: Implants are being used in orthodontics as a reliable mode of anchorage. Among other factors, the cortical bone thickness plays a major role in determining the stability of these implants. The objective of this study was to study the relationship of various arch forms and the cortical bone thickness and to determine if the cortical bone thickness varies between various arch forms. This would help to determine the ideal length of an implant for a particular arch form.

Materials and Methods: A cross sectional tomograph was obtained from 30 patients. Based on arch forms the patients' tomographs were equally divided into three basic square, tapered and ovoid categories, each consisting of 10 patients. Consequently, their buccal and lingual cortical plate thicknesses were measured.

Results: The results showed that there was a statistically significant difference between the three arch forms, in which the square arch form had the greatest cortical bone thickness among the three arch forms.

Conclusion: Patients having a tapered arch form may require implants with greater length than patients having a square or an ovoid arch form. Since the availability of the cortical bone in square arch patients is greater, there is more stability for the implants in these cases; therefore, implants with a shorter length may be used in these cases.

Key Words: Orthodontic Anchorage Procedures; Dental Arch; Bone Development

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INTRODUCTION

Many definitions have been used to describe anchorage by various authors in Orthodontic literature but to summarize the basic meaning of anchorage it may be described as the resistance of an object to an external force acting on it which may be utilized for tooth movement [1].

More often than not the teeth themselves are used as anchorage units. Several factors have to be considered while using teeth for anchorage such as the size, shape, number and length of each root as these together comprise the resistance value offered by each tooth. This may sometimes bring about undesired movement of the anchor teeth. To prevent this, several appliances have been used such as the transpalatal arch and the headgear. Since some of these appliances require patient cooperation, skeletal anchorage devices such as implants and miniscrews have been introduced.

Placement of the miniscrews is very technique sensitive; therefore, several critical factors need to be considered during their placement. The screws should be placed in the attached mucosa as it is less likely to cause irritation. Care should also be taken during the place-

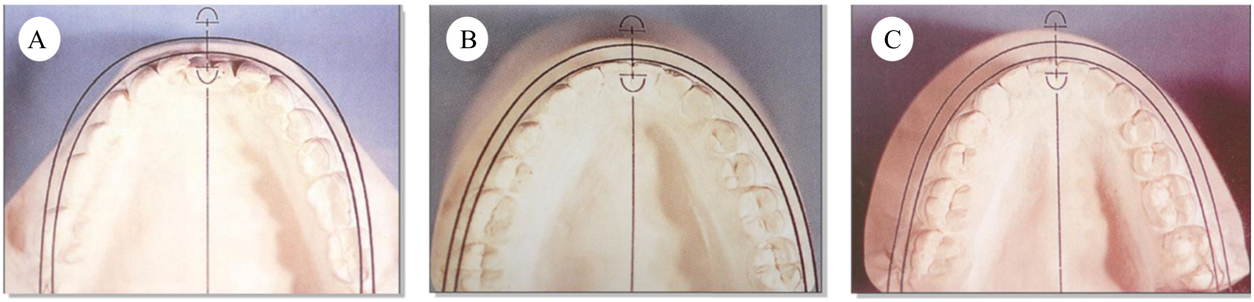

Fig 1. Square Arch Form (A), Tapered Arch Form (B), Ovoid Arch Form (C).

ment of the screws in interradicular areas due to the risk of damage to adjacent root structures through impingement [2].

The ideal implant length is critical to achieve stable anchorage and this is dependent on the amount of bone at the implant site.

Arch forms have been divided into a) Tapered arch form b) Square arch form c) Ovoid arch form [3].

The volume and the density of bone may directly affect implant stability. The thickness of the Mandibular cortical bone is greater compared to the thickness of the Maxillary cortical bone. Very few studies have been performed on the evaluation of the bone at the implant placement site [4-6].

The purpose of this study was to analyze the various arch forms and to compare the cortical bone thickness of different arch forms using the new three cross sectional and one longitudinal (3×CRS 1 LNG) radiographic technique.

MATERIALS AND METHODS

The authors selected ten patients of each of the three arch forms (ovoid, square and tapered) based on the patients pretreatment models (Fig 1). Clear templates by 3M Unitek were used to determine the arch form. Therefore, the three groups were square, tapered and ovoid; each consisting of 10 patients aged 18 to 26 years. The mean age of the patients was 22 years and the tooth size arch-length discrepancy was less than 4 mm. The male to female ratio was kept at 1:1 to avoid any gender bias.

A tomograph with a new technique, 3×CRS 1 LNG (3 cross sectional and 1 longitudinal) was carried out using the x-ray machine by the Planmeca Promax Company, Finland (Fig 2). This is a unique feature of this machine. It is based on the Selective Complemented Robotic Arm Technique (SCARA) technology.

Based on a study on implant placement sites, the region between the mandibular second premolar and first molar was selected for cortical bone evaluation [4]. A cross sectional image was taken of the mandibular left region in the area between the second premolar and first molar (Fig 3-4). The layer thickness measured was 3 mm; the KV was 58 and the mA was 1.3. The exposure time was fixed at 16 seconds.

The radiograph was then traced with a 0.35 mm lead pencil on a tracing sheet. A line is drawn along the long axis of the tooth. A line tangent to the apex of the root and perpendicular to the long axis of the tooth is drawn. This long axis is divided into five equal quadrants extending from the root apex to the alveolar crest (Fig 5). X denotes the buccal cortical bone thichness where x_1, x_2, x_3, x_4, x_5 are buccal cortical bone thickness at various heights. Y denotes the lingual cortical bone thickness where y_1, y_2, y_3, y_4, y_5 are lingual cortical bone thickness at various heights. The mean of the buccal cortical bone thickness at various heights from the alveolar crest (x_1) to the root apex (x_5) is calculated as $X=(x_1+x_2+x_3+x_4+x_5)/5$. The mean value of the lingual cortical bone thickness at various heights from the alveolar crest (y_1) to the root apex (y_5) is calculated as

Fig 2. PlanMeca Promax.

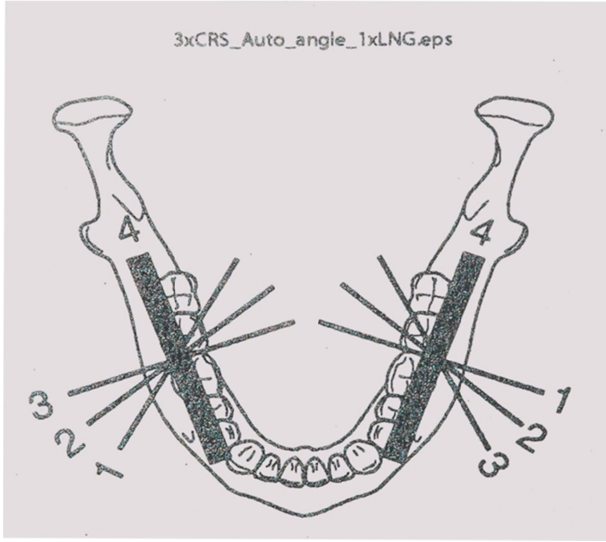

Fig 3. Schematic representation of the tomography technique.

$Y=(y_1+y_2+y_3+y_4+y_5)/5$.

The statistical analysis was performed using SPSS 13.5 for Windows (SPSS Inc., Chicago, IL). Evaluation of the data distribution was performed by means of the analysis of variance, ANOVA test, and it reflected a significant variation of cortical bone thickness between the three arch forms. For analysis, a multiple comparison test was performed and the data were calculated in terms of mean, standard deviation, P value and lower and higher 95% confidence intervals.

RESULTS

The mean values of the buccal cortical plate thickness of the three arch forms indicate that the square arch form has the greatest buccal cortical plate thickness among the three arch forms (mean:3.05 mm, SD=0.698).

Ovoid arch form shows a mean cortical thickness of 2.09 mm (SD=0.37). The buccal cortical plate thickness of the tapered arch form is the least among the three arch forms (mean:1.42 mm, SD=0.28).

The lingual cortical plate thickness of the three arch forms indicates the square arch form has the greatest lingual cortical plate thickness among the three arch forms (mean:2.44 mm, SD=1.64). Ovoid shows a mean cortical thickness of 1.39 mm (SD=0.694). The lingual cortical plate thickness of the tapered arch form is the least among the three arch forms (mean:0.78 mm, SD=0.481).

When the buccal cortical plates were compared, the buccal cortical plate of the square arch form was significantly thicker compared to the other arch forms. The lingual cortical plates of the square arch form were significantly thicker compared to the other arch forms.

DISCUSSION

Skeletal anchorage devices require sufficient bone thicknesses for stability and anchorage. For orthodontic implants placed in the palate, a bone thickness of at least 4 mm is recommended since orthodontic implants are available in lengths ranging from 3 to 6 mm. The selection of longer implants is beneficial because they offer stronger anchorage [5].

It has been noted that an implant of 4-6 mm length is ideal but differences in bone morphology among different individuals makes it necessary to evaluate the amount of available cortical bone thickness prior to placement of an implant to determine the success of the im-

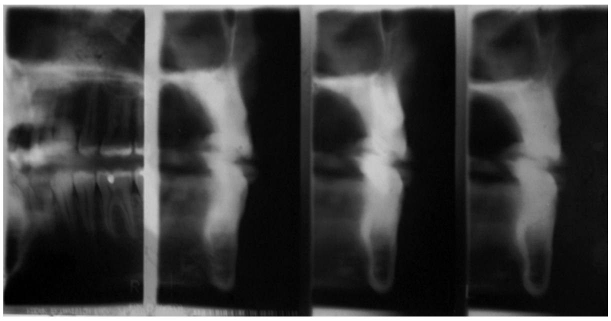

Fig 4. 3XCRS tomograph.

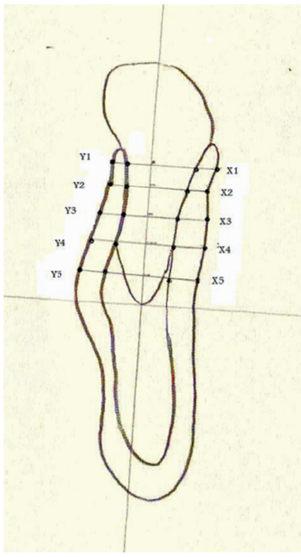

Fig 5. Tracing of the tomograph. X denotes the buccal cortical plate. Y denotes lingual cortical plate.

plant [6]. After evaluating the ideal implant placement sites, it was noted that the greatest volume of buccal cortical bone was found at the region of the CEJ (cementoenamel junction). In case of the palatal cortical bone it was noted that the palatal cortical bone was thickest at a region located 6mm apical from the CEJ of the tooth [7].

According to a study, individuals with a short face have a tendency towards a square arch form and they also have stronger masticatory muscles, patients with a long facial type usually have a tapered type of arch form and the individuals with an average facial type have an ovoid arch form [8]. According to our study, the square arch form has the greatest amount of buccal and lingual cortical bone thickness.

The Cortical bone thickness of the molar sections seems to be influenced by masticatory function. The mandibular body of the molar region has a structure resistant to torsional moments [5]. The widths of cortical bone on the buccal side are relatively thicker compared with the lingual side. The bone thickness of the mandibular molars is influenced by masticatory muscles [9].

This study shows that there is a definitive correlation between the arch forms and cortical bone thicknesses. This will help during the selection process of the microimplant. The more the cortical bone thickness, the smaller the implant length required for support and the lesser the amount of cortical bone availability, the longer the implant length required.

CONCLUSION

The square arch form has a greater buccal and lingual cortical plate thickness compared with the ovoid and tapered arch forms.

There was no significant difference regarding buccal and lingual cortical plate thicknesses between the ovoid and tapered arch forms.

There was a mild significant difference in the combined cortical plate thickness between the ovoid and tapered arch forms.

This procedure allows evaluation of the cortical bone thickness while subjecting the patients to a relatively lesser amount of radiation in comparison to a computerized tomography.

Hence, patients having a tapered arch form may require implants with a greater length than patients having a square or an ovoid arch form. Since availability of the cortical bone in square arch patients is greater, there is more stability for the implants in these cases; therefore, implants with a shorter length may be used in these cases.

The Shortcoming of the research is that radiographic technique is operator dependent and depends on the film processing. If this technique is digitized it helps eliminate any radiographic film development error, which may compromise the quality of the radiograph.

Scope for further research: It is always better to know the quantity of bone thickness available during implant placement since the quantity of bone thickness varies in different head types. Further research may be carried out using a digitized tomographic technique and by undertaking a large sample size which would help attain a better statistical analysis.

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