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Assessment of Optimal Sites for Interradicular Placement of Mini-Implant Using CBCT – Part 2

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Abstract

Part 1 of this research paper describes the procedure followed for determining the optimal sites for orthodontic mini-implant placement in maxillary and mandibular arches using CBCT radiographs. Part 2 discusses the results and findings obtained after studying the measurements of alveolar bone in CBCT radiographs.

Keywords: Anchorage, Cortical plate, Cone Beam Computed Tomography, Mini implant.

Introduction

The first part of this article has illustrated the importance of mini-implants in orthodontics and described about the procedure followed to determine the optimal site for orthodontic mini-implant placement by using CBCT radiographs. Part II explores and discusses the results that were found after measurements on the CBCT images and gives conclusions regarding the optimum mini-implant placement sites in maxilla and mandible.

Discussion

Anchorage conservation has always been a challenge for the orthodontists. Angle realized the limitation of moving teeth against other teeth used for anchorage, introducing ideas such as the use of occipital, stationary and occlusal anchorage. Conventional means of supporting anchorage have been used by either intraoral sites or relying on extraoral means. The extraoral force cannot be used on 24 × 7 basis to resist the continuous tooth moving force and are also taxing on patient's compliance. On the other hand, strict reliance on intra oral areas, usually dental units do not offer any significant advantage, expect the fact that patient cooperation is less critical therefore, it is important to have absolute anchorage to avoid reactive forces which might incur undesirable tooth movement.[2]

Osseo integrated implants are considered reliable sources of anchorage for orthodontists. However, the large size of these implants limits their usage. To overcome this problem, mini-implants were developed. Their advantages, in addition to size, include minimal anatomic limitations, minor surgery, increased patient comfort, immediate loading, and lower costs. Because these devices are used for specific time periods, mostly rely on mechanical retention, and do not always osseointegrate.[4] Mini-implants provide reliable three-dimensional anchorage, leading to predictable treatment outcomes and less reliance on patient cooperation. Because mini-implants may be immediately loaded, they require adequate primary stability followed by a consolidating period of secondary stabilization. Hence, primary stability is regarded as the key indicator of success.[3]

Adequate bone quantity at the placement site can affect the success or failure of the device. This has prompted studies of proper sites and stability.[9] Earlier, intraoral periapical radiographs, ultra-sonographs, and panoramic radiographs were the choice for evaluation of quantity and quality of bone since all these methods lack precise information as two-dimensional (2D) nature of imaging modalities.[11] Park proposed that the clinician can use computed tomography (CT) to determine a safe placement site, the appropriate angulation, and the best length of the mini-implant by measuring cortical bone thickness, distance between the cortical bone and the root, and interradicular space of interproximal teeth at the premolar and molar areas of the maxilla and the mandible. He showed that the largest interradicular distance in the maxillary buccal segment is between the second premolar and the first molar. In recent years, cone-beam CT (CBCT), which offers clear 3-dimensional (3D) images with small voxel size, has been widely used in head and neck diagnoses, orthodontics, and implant dentistry, and for accurate surgical guidance for mini-implant placement.[10]

Several studies provide measurements of the interradicular spaces at the posterior maxilla and mandible. It was reported that the volume of bone in the maxillary interradicular space between the second premolar and the first molar provides the optimal anatomic site for miniscrews in the maxilla. Poggio et al. ranked the safest sites available in interradicular spaces in the posterior maxilla and reported that the safest was between the first molar and the second premolar 2–8 mm from the alveolar crest; for the posterior mandible it was between the first and second molars. Hardly any data is available concerning the interradicular spaces of the anterior maxillary and mandibular areas in spite of the fact that mini-implants can also be useful in the anterior region as anchorage for mesial movement of the posterior dentition or correction of the anterior vertical occlusion. A limited number of studies have investigated

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cortical bone thickness in the maxilla and the mandible. Most of these studies have been carried out on a small sample or were limited to the posterior part of the jaws. The buccal cortical bone thickness seems to be greater in the mandible than in the maxilla.[1]

In line with various studies in literature the aim of the present study was to determine the optimal site for orthodontic mini-implant placement in maxillary and mandibular arch using cone beam computed tomography.

Study Sample

In the present study the sample size consisted of fifty CBCT images of maxillary and mandibular arches collected from the department of oral medicine and radiology, Rajarajeswari dental college and hospital. The CBCT images were selected according to the inclusion criteria. Measurements were made from the CBCT generated 3-D images using ONDEMAND software version 5.2.6. CBT, MDW, BLT was measured in between central incisors, between 1st and 2nd premolars and between 2nd premolar and 1st molar in both maxillary arch and mandibular arch at height of 5mm and 10mm in maxilla and 5mm and 7mm in mandible. Comparisons were performed using Student's paired t test.

Interpretation of Results

The present study found that as on measuring more apically thickness of the cortical bone increases, except for maxillary premolar area in lingual side, between maxillary premolar and molar in buccal, between mandibular premolar in lingual.

An additional significant finding of the present study was that, all statistically significant mesio-distal width measurements increase in both maxillary and mandibular arch as on measuring more apically.

The present study also revealed that the mean buccolingual thickness (BLT) increases in both maxillary and mandibular arch, except for mandibular central incisors and premolars as moving more apically.

Comparison of Mean Cortical Bone Thickness in Maxilla

In maxillary CI region in buccal cortical bone thickness is relatively more at 10mm height which is not statistically significant, mean cortical bone thickness in lingual is significantly more at 10mm with $p=0.001$. In both 5mm and 10mm lingual was significantly thicker than buccal with $p<0.001$.

In maxillary PM right side region buccal cortical bone is significantly more at 10mm with $p=0.02$. Mean cortical bone thickness at lingual is significantly more at 5mm with $p<0.001$. In both 5mm and 10mm lingual cortical bone was thicker and 5mm shows significant result with $p<0.001$.

In maxillary PM left side no significant difference was noted at both buccal and lingual side at 5mm and 10mm.At 5mm and 10mm lingual cortical bone was significantly thicker with $p<0.001$ and $p=0.003$.

In between maxillary 2nd PM and 1st molar in right side buccal cortical bone is significantly thicker at 10mm with $p=0.04$.

In between maxillary 2nd PM and 1st molar in left side at 10mm lingual cortical bone was significantly thicker with $p=0.001$.

In mandibular CI region in buccal and lingual cortical bone is relatively thicker at 5mm with no statistical significance. At 5mm and 7mm lingual cortical bone is significantly thicker with $p<0.001$.

In mandibular PM right side region lingual cortical bone was significantly thicker at 5mm with $p=0.001$. in both 5mm and 7mm lingual cortical bone is significantly thicker with $p=0.001$.

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In mandibular PM left side region lingual cortical bone was significantly thicker at 7mm in both buccal and lingual side with $p<0.001$ and $p=0.04$. At 5mm and 7mm lingual cortical bone is significantly thicker with $p<0.001$.

In mandibular 2nd PM and 1st molar region in right side buccal cortical bone is significantly thicker at 7mm with $p=0.002$. At 5mm and 7mm lingual cortical bone is significantly thicker with $p<0.001$.

In mandibular 2nd PM and 1st molar region in left side lingual cortical bone is significantly thicker at 7mm with $p<0.001$. At 7mm lingual cortical bone is significantly thicker with $p<0.001$.

Comparison of Mesio Distal Width

In maxillary CI region buccal and lingual MDW is significantly more at 10mm with $p <0.001$ and $p=0.001$. At both 5mm and 10mm MDW is significantly more at lingual side with $p<0.001$.

Comparison of Mesio Distal Width

In maxillary CI region buccal and lingual MDW is significantly more at 10mm with $p <0.001$ and $p=0.001$. At both 5mm and 10mm MDW is significantly more at lingual side with $p<0.001$.

In mandibular 1st and 2nd PM in left side region at both buccal and lingual side MDW is significantly more at 7mm with $p<0.001$. At 5mm and 7mm lingual MDW is significantly more with $p<0.001$.

In mandibular 2nd PM and 1st molar region in right side buccal and lingual MDW is relatively more at 7mm. At 5mm and 7mm MDW is significantly more in buccal with $p<0.001$.

In mandibular 2nd PM and 1st molar region in left side buccal and lingual MDW is significantly more with $p<0.001$ and $p=0.04$. At 7mm MDW is significantly more in buccal with $p=0.008$.

Comparison of Mean Bucco Lingual Thickness (BLT)

In maxillary CI region a significant increase in BLT is observed at 10mm with $p<0.001$.

In maxillary PM region a significant increase in BLT is observed at 10 mm with $p=0.004$.

In maxillary 2nd PM and 1st molar region a significant increase in BLT is observed at 10mm with $p<0.001$.

In mandibular CI region a significant increase in BLT is observed at 5mm with $p=0.04$.

In mandibular PM region a relative increase in BLT is observed at 5mm.

In mandibular 2nd PM and 1st molar region a significant increase in BLT is observed at 7mm.

Clinical Implication of The Study

Mini implants provide reliable three-dimensional anchorage which will lead to predictable treatment outcomes and less reliance on patient cooperation and can be immediately loaded for that reason they require primary stability. CBT, MDW, BLT in both maxilla and mandible have an inevitable role in deciding the primary stability of the mini-implant. a critical step that determines the success of the mini-implant is the atraumatic surgical placement of the mini-implant and the quality and quantity of the bone. Our study showed certain trends in CBT, BLT, and MDW in both maxillary and mandibular arch. However individual variation was also noted. Hence, a sound knowledge about CBT, MDW, and BLT will guide the orthodontist in achieving primary stability of mini-implants which is required for the success of orthodontic treatment.

Comparison with Earlier Studies

The influence of bone quality on the success of the mini-implants is undisputed and has been known for over a decade. Knowledge about cortical bone thickness, mesio distal width and bucco lingual thickness in but maxillary

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and mandibular arch can guide clinicians in selecting proper placement site.

Fayed et al[1] conducted a study to find optimal site for mini-implant placement. He assessed CBT, BLT, and MDW and found a pattern in cortical bone thickness. He concluded that with increase in depth of measurement an increase in CBT, MDW and BLT was found.

Our study is in agreement with **Fayed et al**[1] who found a pattern in increase in cortical bone thickness as measuring away from the reference point (CEJ).

Ono et al[12] measured the thickness of cortical bone from the height if 1mm to 15mm and found similar result.

Poggio et al[5] concluded that MDW and BLT of maxillary posteriors is between premolars and between molars and premolars increases gradually with increase in depth of measurement from CEJ in mandibular arch. Fayed et al[1] also got similar result even in anterior region.

Poggio et al[5] concluded that MDW in maxillary posterior region decrease gradually as the depth of measurement increase more than 8mm.

Many other authors who conducted study on this got a similar result.[4,6,7,9]

In present study sex and ethnicity of the sample collected was not taken into consideration. Limited number of anatomical sites and depth was measured to get into final result.

Future studies may be carried out with more sample size. Analysing the variation with sex, and ethnic origin at a greater number of anatomic locations and depths.

Conclusion

The following conclusions were drawn from the present study:

- In the maxillary central incisor region mean cortical bone thickness of 1.470±0.426 at 5mm depth and 1.473±0.415 mm at 10 mm in buccal side and 1.921±0.620 at 5mm depth and 2.176±0.892 in lingual side suggesting of more cortical bone thickness at 10mm depth both buccal and lingual side to be optimal site for the placement of mini-implant
- In the maxillary premolar region mean cortical bone thickness of 1.34±0.751 at 5mm and 1.436±0.849 at 10mm in buccal side suggesting of 10 mm depth in buccal side to be the optimal site for placement of mini-implant in this region.
- In the maxillary premolar region mean cortical bone thickness of 1.797±0.642 mm at 5mm depth and 1.570±0.420 mm at 10mm depth in lingual side suggesting of 5mm depth in lingual to be the optimal site for the placement of min implant in this region.
- In the maxillary 2nd premolar and 1st molar region mean cortical bone thickness of 1.481±0.678mm at 5mm and 1.693±0.783mm at 10 mm depth in buccal side suggesting 10mm depth in buccal side to be the optimal site for the placement of mini-implant in this region.
- In the maxillary 2nd premolar and 1st molar region mean cortical bone thickness of 1.561±0.368 at 5mm and 1.711±0.527 mm at 10mm depth in lingual side suggesting 10mm depth in lingual side to be the optimal site for the placement of mini-implant in this region.
- In the mandibular central incisor region mean cortical bone thickness of 1.370±0.502 mm at 5mm depth and 1.229±0.673 mm at 7mm in buccal side. 1.794±0.453mm at 5mm and 1.687±0.585mm at 7mm depth in lingual side gives adequate cortical bone thickness but mesio distal width of 1.786±0.581 at 5mm and 1.795±0.443 at 7mm in buccal and 1.949±1.078 at 5mm and 1.720±0.494 in

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lingual made this not an optimal site for the placement of mini-implant in this region.

- In the mandibular premolar region mean cortical bone thickness of 1.494±0.395mm at 5mm depth and 1.719±0.375 mm at 10mm depth in buccal side suggesting of 7mm depth the buccal side to be the optimal site for the placement of mini-implant in this region.
- In the mandibular premolar region mean cortical bone thickness of 2.310±0.609mm at 5mm and 2.480±0.922mm at 7mm in lingual side suggesting 7mm depth in lingual side to be the optimal site for the placement of mini-implant in this region.
- In the mandibular 2nd premolar and 1st molar region mean cortical bone thickness of 2.015±0.405mm at 5mm and 2.135±0.381mm at 7mm in buccal side suggesting of 7 mm depth on buccal side to be the optimal site for the placement of mini-implant in this region.
- In the mandibular 2nd premolar and 1st molar region mean cortical bone thickness of 2.126±0.487 at 5mm and 2.330±0.645mm at 7mm in lingual side suggesting of 7mm depth in lingual side to be the optimal site for the placement of mini-implant in this region

Orthodontic anchorage describes the nature and degree of resistance to displacement provided by an anatomic unit and is crucial for the maximization of tooth movement and the minimization of undesired effects. Conventional orthodontic anchorage often results in anchorage loss, which is considered a significant potential side effect of orthodontic mechanotherapy. More than 2 mm of anchorage loss can undermine treatment efficacy, especially in critical situations. Anchorage reinforcement with miniscrew implants is associated with 2.4 mm less anchorage loss compared with conventional anchorage means. The use of mini-implant has widely been accepted because of its reliability and advantage over the conventional anchorage concern. Placement of mini-implant is crucial and is largely dependent upon the bone availability and its thickness. Recent imaging techniques such as CBCT in the field of orthodontics have helped the clinician to overcome the previously encountered difficulties. This study was done by Department of Orthodontics and Dentofacial Orthopaedics, Rajarajeswari Dental College &Hospital, to find the optimal site for the placement of mini-implant in maxillary and mandibular arch by comparing the CBT, BLT and MDW at five locations in both maxillary and mandibular arch. Measurements were comparing with student t test. The result shows that in maxillary and mandibular measurement have certain patterns: the thickness increase as the cut move apically from 5mm to 10mm except in maxillary premolar palatal region and mandibular central incisor region.

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