ORIGINAL RESEARCH

Comparative Assessment of Three Different Alveolar Ridge Dimension Measurement Methods before Implant Placement: An *In Vivo* Study

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Abstract

Aim: The purpose of this study was to compare the three various techniques for measuring the alveolar ridge's dimensions prior to implant insertion.

Materials and methods: For this study, a total of 36 participants were chosen. To prepare a surgical stent, a study model was created from an alginate impression. A first point (reference point) was marked on the crest of the ridge in relation to the adjacent teeth. Then, one point (point 1) and another point (point 2) were marked at distances of 3 and 6 mm, respectively, from the reference point. Based on the procedure for measuring the size of the alveolar ridge, the study was divided into the following groups. Group I: Cone-beam computed tomography (CBCT) measurement method; Group II: Ridge mapping measurement method; Group III: Direct caliper measurements method. Descriptive statistics were used to estimate the mean and standard deviation (SD). The Student's unpaired *t*-test was utilized for the statistical analysis. The 5% level of significance was used.

Results: There was no significant difference found between CBCT with ridge mapping and direct caliper measurements. However, on comparison of ridge mapping and direct caliper measurements technique, at point 1, the ridge mapping was 3.88 ± 0.12 and the direct caliper measurement was 3.62 ± 0.08. At point 2, the ridge mapping was 6.58 ± 0.06 and the direct caliper measurement was 6.32 ± 0.04. There was a statistically significant difference found between these two measurement methods.

Conclusion: Within the limitation, the current study came to the conclusion that when CBCT and ridge mapping measurements were individually compared with the gold standard—the surgical open method, CBCT—demonstrated to be a highly specific and sensitive method for detecting the residual alveolar ridge width in the treatment planning of dental implants.

Clinical significance: Evaluation of alveolar bone is necessary during treatment planning for dental implant placement. Using simply panoramic and/or periapical radiographs to evaluate the bone may not be sufficient because it only provides two-dimensional information regarding the implant locations. Therefore, for better implant placement, three-dimensional information of the implant site, such as CBCT and ridge mapping technique, should be assessed.

Keywords: Cone-beam computed tomography, Direct surgical exposure, Implant placement, Ridge mapping.

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Introduction

Dental history from the previous decades demonstrates that people have tried to use organic or synthetic materials to restore damaged or missing tissues. An alternate attachment mechanism was found using an unintentional finding made by Per-Ingvar Brånemark et al. throughout the 1950s and 1960s as civilization progressed with the development of biological, chemical, and physical sciences. The repair of lost teeth is now completely transformed by dental implants.[1]

In the treatment of total and partial dentition loss, as well as single-tooth anodontia, dental implant therapy has become more popular. The success rate of using dental implants to support prosthodontic restorations is very high.[2] The size of the alveolar ridge must be assessed as a necessary prerequisite for the design of implant therapy. Utilizing computed tomography (CT), transtomography, ridge mapping, ultrasonography, and direct caliper measurement, the buccolingual portion of the alveolar ridge's width can be measured. Two-dimensional radiographs, such as panoramic and/or periapical ones, are typically used in routine practice to assess bone, but they should only be used for initial evaluation because they lack cross-sectional information

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and require corrections for the machinery's magnifying effects.[3] Therefore, advanced digital radiography such as CT or cone-beam computed tomography (CBCT) should be indicated as they provide three-dimensional information but may not be generally available for appropriate evaluation of implant sites.

Better clinical outcomes are obtained as a result of CBCT's improved visualization, more accurate picture of anatomical structures, and reflection of real osseous morphology.[4] The buccal and lingual soft tissue layers are penetrated during ridge mapping with a caliper device while the patient is under local anesthesia to measure the buccolingual breadth of the underlying bone.[5] The most accurate measurement is obtained by using a direct caliper measurement after surgically exposing the ridge's alveolar bone.[6] Since an implant should be surrounded by at least 1 mm of bone, correct measurement of the resorbing alveolar ridge is essential for the long-term effectiveness of dental implants. A successful outcome depends on a thorough diagnosis and treatment planning. Hence, this study was conducted to compare the three various techniques for measuring the alveolar ridge's dimensions prior to implant placement.

Materials and Methods

Selection of Participants

This study was conducted at the Kalinga Institute of Dental Sciences, Bhubaneswar, India, in 2022. A total of 36 participants were chosen from the oral and maxillofacial surgery department's outpatient department (OPD) and institutional approval was obtained. Prior to the implant operation, the participants were required to sign a consent form after being informed of the intended study criteria, including alternate treatments, potential hazards, and benefits. The study comprised non-pregnant, healthy individuals with partially edentulous ridges, at least one secure and healthy abutment for a radiographic stent, and at least 3 months of healing time following tooth extraction with adequate dental hygiene. Smokers, expectant mothers, immunocompromised patients, and people with debilitating illnesses were excluded from the study.

Preparation of Surgical Stent

An impression made with alginate was used to create a study model. In the research model, a first point (reference point) was marked on the crest of the ridge in relation to the adjacent teeth. Then, one point (point 1) and another point (point 2) were marked at distances of 3 and 6 mm, respectively, from the reference point. Both the lingual/palatal aspect and the buccal aspect were marked for points 1 and 2. With reference locations, an acrylic resin stent was created over the study model. Through the acrylic resin, the reference points could be seen over the stent; then, a hole with a diameter of 1 mm was created above these 5 points.

Study Design

Based on the procedure for measuring the size of the alveolar ridge, the study was divided into the following groups (all participants underwent all three methods).

Group I: Measurement using Cone-beam Computed Tomography

A 5% solution of povidone–iodine was used to disinfect acrylic stents. Participants wore acrylic stents and were later exposed. The patient was subjected to CBCT in the supine position for 22.7 seconds at a 130-kV, 64-mA exposure rate. For ridge measurement, an appropriate site where the gutta-percha was most easily seen on the CBCT was chosen. At all measurement levels (3 and 6 mm), one image with the clearest gutta-percha impressions for the buccal and lingual aspects was chosen. Using the software's built-in measurement tool, the maximum distance between the buccal and lingual bone walls was measured.

Group II: Measurement using Ridge Mapping Method

After administering local anesthesia with a disposable 2 mL syringe needle, the surgical stent was then placed in the area to be measured. The thickness of the soft tissues was measured after a calibrated periodontal probe tip was inserted into the guiding holes and passed through the soft tissues until it came into contact with the bone. The diagnostic cast was then divided at the level of the outlined spots in the edentulous area, perpendicular to the alveolar ridge. Using a pencil and scale, the clinically determined tissue thickness was overlaid onto these marked locations on the cast, which had now been divided into sections.

Group III: Direct Caliper Measurements Method

After the surgical flap was reflected, the ridge mapping caliper device and stent were used to measure the ridge width directly on the exposed bone at the various sites of the guide holes. All procedures were carried out by a single calibrated investigator.

Statistical Analysis

The data were analyzed statistically using the statistical package for the social sciences (SPSS) software for Microsoft Windows version 21.0. Descriptive statistics were used to estimate the mean and standard deviation (SD). The Student's unpaired *t*-test was utilized for the statistical analysis. The 5% level of significance was used.

Results

Evaluation of CBCT and ridge mapping technique at two different points were shown in Table 1. At point 1, the CBCT measurement was 3.70 ± 0.01 and the ridge mapping measurement was 3.88 ± 0.12. At point 2, the CBCT measurement was 6.46 ± 0.10 and the ridge

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Table 1: Evaluation of CBCT and ridge mapping technique at two different points

Comparison of groups	*n*	*Mean ± SD*	*t-value*	*p-value*
Point 1				
Group I: Measurement using CBCT	36	3.70 ± 0.01	0.462	0.914
Group II: Measurement using ridge mapping	36	3.88 ± 0.12	0.278	
Point 2				
Group I: Measurement using CBCT	36	6.46 ± 0.10	0.344	0.890
Group II: Measurement using ridge mapping	36	6.58 ± 0.06	0.480	

Table 2: Evaluation of CBCT and direct caliper measurement technique at two different points

Comparison of groups	*n*	*Mean ± SD*	*t-value*	*p-value*
Point 1				
Group I: Measurement using CBCT	36	3.70 ± 0.01	0.364	0.582
Group III: Direct caliper measurements	36	3.62 ± 0.08	0.292	
Point 2				
Group I: Measurement using CBCT	36	6.46 ± 0.10	0.682	0.761
Group III: Direct caliper measurements	36	6.32 ± 0.04	0.644	

Table 3: Evaluation of ridge mapping and direct caliper measurements technique at two different points

Comparison of groups	*n*	*Mean ± SD*	*t-value*	*p-value*
Point 1				
Group II: Measurement using ridge mapping	36	3.88 ± 0.12	0.391	0.034
Group III: Direct caliper measurements	36	3.62 ± 0.08	0.240	
Point 2				
Group II: Measurement using ridge mapping	36	6.58 ± 0.06	0.308	0.022
Group III: Direct caliper measurements	36	6.32 ± 0.04	0.288	

mapping measurement was 6.58 ± 0.06. There was no significant difference found between the two measurement methods.

Table 2 depicted the comparison of CBCT and direct caliper measurements. At point 1, the CBCT measurement was 3.70 ± 0.01 and the direct caliper measurement was 3.62 ± 0.08. At point 2, the CBCT measurement was 6.46 ± 0.10 and the direct caliper measurement was 6.32 ± 0.04. There was no significant difference found between these two measurement methods.

On comparison of ridge mapping and direct caliper measurements technique, at point 1, the ridge mapping was 3.88 ± 0.12 and the direct caliper measurement was 3.62 ± 0.08. At point 2, ridge mapping was 6.58 ± 0.06 and the direct caliper measure ment was 6.32 ± 0.04. There was a statistically significant difference found between these two measurement methods (Table 3).

The inference of this study indicates that the CBCT and ridge mapping measurements when compared individually with the gold standard—the surgical open method, CBCT—proved to be a highly specific and sensitive method for detecting the residual alveolar ridge width in the treatment planning of dental implants.

Discussion

The correct diagnosis and treatment planning are crucial at every level of clinical dentistry because they produce more predictable results. The shape of the ridge and implant orientation are the two crucial elements, both esthetically and functionally, that are responsible for implant-supported restorations. Prior to implant implantation, the residual ridge's contour must be assessed to ensure appropriate implant position.[7]

Preoperative radiographic evaluation now plays a bigger part in implant-supported prosthetics treatment planning than ever before. A panoramic radiograph provides a comprehensive image, but because of the aberrations and uneven magnification it produces, it is insufficient. Periapical radiographs of the edentulous region show the bone height, the inter-radicular mesiodistal space, and the position of the anatomical structures in a buccolingual plane.[8]

However, these diagnostic techniques do not provide information on the sagittal bone architecture or the optimal orientation to place the implant to satisfy restorative needs. The choice of implants will depend on the quantity and quality of bone in terms of their number, diameter, length, and kind. It frequently necessitates a more thorough radiographic evaluation than that carried out for other kinds of oral rehabilitation. The use of numerous imaging modalities, such as periapical, panoramic, cephalometric, and tomographic radiography, CT, interactive CT, and magnetic resonance imaging (MRI), for dental implant therapy has been documented.[9]

The current investigation demonstrates that at either point 1 or 2, there is no significant difference between direct caliper measurement and CBCT. When compared to the ridge mapping methodology in this study, CBCT proved to be an accurate method of determining the width of residual ridge width in therapy planning for dental implant placement. This, however, conflicts with the findings of a study by Chen et al.,[10] who found alike measurements in the buccolingual dimension with ridge mapping as well as the use of direct caliper and thus concluded that CBCT offered no additional diagnostic information pertaining to the area of implant placement. According to research by Castro-Ruiz et al.,[11] ridge mapping was more accurate than other radiography methods at determining the width of residual bone. The accuracy of diagnostic information discovered with a CBCT, according to Abdel–Wahed et al.,[12] depends on how the device is used and how the obtained images are modified.

The ridge mapping calipers method can also be used to determine the ridge's width. With calipers designed for this purpose, the buccal and lingual mucosa is entered all the way to the bone with this technique. Before mucoperiosteal flap reflection, a number of measurements of the intended implant placement site are taken. Wilson[13] and Traxler et al.[14] have advocated for this strategy, claiming that it is a reliable and appropriate way to assess the accuracy of potential implant sites. The lack of radiation exposure to the patient and the simplicity of the ridge mapping approach are its benefits.

The study's findings, which contradict those of Perez et al.[15] and Goulet et al.[16] which support the use of the ridge-mapping procedure for the evaluation of alveolar ridge width for partially edentulous ridges, show a significant difference between direct surgical exposure and ridge-mapping measurements. Following surgical exposure of the bone, ridge mapping has produced buccolingual width values that are consistent with those obtained by direct caliper measurements.

This study's limitations include the fact that it was conducted by a single observer, that the population was selected based on convenience sampling, and that the accuracy of the dental materials used in the study could have an impact on the results. As a result, additional studies with larger and more diverse samples are required.

Conclusion

Within the limitation, the current study came to the conclusion that when CBCT and ridge mapping measurements were individually compared with the gold standard-the surgical open method-CBCT demonstrated to be a highly specific and sensitive method for detecting the residual alveolar ridge width in the treatment planning of dental implants. Similarly, ridge mapping is a helpful technique when combined with traditional radiography techniques that don't expose the patient to radiation.

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