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Comparison of various techniques for measuring alveolar ridge dimensions prior to implant placement - A pilot study

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ABSTRACT

Background: Implants are becoming the future trend for replacement of missing teeth. The surgical procedure requires prior treatment planning and knowledge of the surgical site. The present study was conducted to assess and compare various techniques that are used for the measurement of alveolar ridge dimensions prior to treatment planning for implants. **Aim:** The aim of this study was to compare direct intra-operative ridge measurements (DIRM) using vernier calipers to measurements taken by alveolar ridge mapping (RM) ,Computed Tomography (CT) and Cone-Beam Computed Tomography (CBCT) for measuring alveolar bone dimensions prior to implant placement. **Material and Methods:.** An acrylic stent was prepared for each patient. The acrylic stent provided buccal, lingual and crestal sites for consistent measurements of alveolar ridge dimensions through ridge mapping (RM). A conventional CT and CBCT were taken and these three techniques were compared to DIRM. **Statistical analysis used:** The study data were analyzed using one sample T- test to compare the mean absolute difference with 0. Pearson's correlation was used to assess the linear relationship with DIRM. Comparisons were made between RM, CT, CBCT with DIRM using a Bland-Altman plot and pictorially represented with a bar plot. **Results:** Data were compared using bar graph. RM was found to have more correlation to DIRM than the other techniques. However CBCT had lesser variations from DIRM when compared to a conventional CT. The latter two techniques, that is, CT and CBCT are useful for 3-dimensional information of the surgical site prior to implant placement.**Conclusion**: Ridge mapping can be used effectively for measurement of alveolar bone width. Additional information about the surgical site can be obtained from a conventional CT or a CBCT.

KEY WORDS: Alveolar ridge dimensions, CBCT, Ridge mapping, Implants, Treatment planning.

INTRODUCTIONS: Implants are the most recent and widely preferred options to restore missing teeth which transmit these forces to the bone like the natural teeth and maintain bone shape and function [1]. Bone contour and soft tissue morphology vary among different individuals, races and ages [2,3]. Various two-dimensional and three-dimensional methods have been used to assess the alveolar bone dimensions ranging from the ancient direct intra-operative measurements [4,5], ridge mapping, periapical radiograph and conventional panoramic radiographs to the modern computerized tomography, cone-beam computerized tomography and 3-D tomography. A three-dimensional radiographic technique provides better information about the implant site. The clinicians usually face challenging clinical situations, and are ought to choose the best method for diagnosis and treatment planning for implant placement. Hence, this pilot study was undertaken to compare CT, CBCT and Ridge mapping to direct intra-operative measurement of alveolar bone dimensions prior to implant placement.

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METHODS : Study participants were recruited from the Department of Periodontics, Saveetha Dental College, Velappanchavadi, Chennai between August-September 2014. Restorative options presented to the patients included an implant supported crown, a fixed-bridge, and a removable partial denture. The patients who chose implant as an option to replace their missing teeth were included in the study.

Systemically healthy subjects indicated for implant placement, with a minimum of one edentulous site in which extraction was performed at least 3 months prior to implant treatment planning and placement were included. Subjects having vertical or horizontal defects, inadequate inter-arch or mesio-distal space for implant placement were not included. All subjects underwent all the techniques of diagnosis compared in the study. The study was approved by the Institutional Review board and an informed consent was obtained from all subjects.

Stent fabrication: Preliminary maxillary and mandibular diagnostic alginate impressions were made and models were poured with dental stone. As a prerequisite an acrylic stent was prepared on the models for each patient covering the edentulous ridges. Then, 1 mm diameter guide holes were drilled on the crestal, buccal and lingual/palatal side using a micro motor with a straight fissure bur. Gutta-percha points were condensed inside the holes till the end of the tissue surface. Subjects were asked to wear the stent following which a computerized tomography and a cone-beam computerized tomography were taken. The radio-opaque gutta-percha was visible in the tomographs and served as the radiological reference site for measurement.

Alveolar ridge measurements using computerized tomography: Acrylic stents were disinfected with 5% povidone iodine solution. Participants were made to wear the acrylic stent and then exposed to a CT. Siemens 6 slice CT was taken in the supine position by exposure rate of 130Kv 64mA for 22.7 seconds with a thickness of 0.63mm slice. After the CT was taken , an appropriate site was selected for ridge measurement, where the gutta-percha was most clearly visible on the CT. Alveolar ridge width between the two gutta-percha was measured. Length from the crestal gutta-percha to the nearest anatomical structure was measured. The CT was taken at Saveetha Medical college and hospitals -Thandalam, Chennai , Tamil Nadu.

Alveolar ridge measurements using Cone-beam computerized tomography: Similar to CT, a CBCT was taken with the subject wearing the acrylic stent, and similar measurements were taken. Orthophos XG Sirona CBCT was taken at Saveetha Dental college and hospitals-Velappanchavadi, Chennai , Tamil Nadu. Patients were exposed while standing with the Frankfurt-Horizontal plane parallel to the floor, with an exposure rate of 64Kv 8mA for 4.1 seconds for a normal adult and thickness of 0.01-0.04 mm slice.

Alveolar ridge measurements using ridge mapping :
After the administration of local anesthesia, the disinfected acrylic stent was placed on the edentulous alveolar ridge. A 21-gauge needle with a rubber stopper was used for ridge mapping. The needle was penetrated through the oral mucosa until the bone was reached, and the stopper was approximated in close contact with the stent. Following this, the stent was removed with the needle and stopper and placed on the sectioned model. The depth of insertion of the needle was marked on the cast and the dotted line was joined. This line gave the surface topography of the alveolar bone.

Direct intra-operative measurement with calipers:
After the flap was reflected, direct intra-operative caliper measurement of width of alveolar ridge was made with a stoma-ivanson measuring caliper. Measurements were made at the position of buccal and palatal/lingual gutta-percha points.

STASTICAL ANALYSIS:
To test among the methods CT, CBCT, and Ridge Mapping, which method is closer to the DIRM (considered as Gold standard) the absolute difference between DIRM and the other methods have been calculated. The mean of these differences were tested with constant "0" using one sample t-test. It is assumed that if the method is very closer to DIRM then the mean difference should be "0". Therefore the mean difference is tested against "0" using one sample t-test. RM showed the least mean difference from DIRM (Table 1). To assess the strength of the linear relationship between DIRM and other methods Pearson correlation was calculated. It is assumed that if any method is closer to the DIRM then the correlation will be closer to 1. Bland Altman plot is drawn for DIRM and each of the methods to know the distribution of deviations of each value. This was to show whether the differences are at random or any pattern is emerging. Finally, a bar plot was used to pictorially show the mean absolute difference between CT, CBCT, RM and DIRM. (Fig 4).

Table 1: One sample T-Test to compare the mean absolute difference with "0":

	Mean	Std. Deviation	Mean Difference	95% CI for the Difference Lower	Upper	t-Value	P-Value
Difference between DIRM and CT (N=12)	0.525	0.280	0.525	0.3471	0.7029	6.495	<0.001
Difference between DIRM and CBCT(N=12)	0.400	0.252	0.400	0.2397	0.5603	5.493	<0.001
Difference between DIRM and Ridge mapping(N=12)	0.200	0.256	0.200	0.0374	0.3626	2.708	0.021

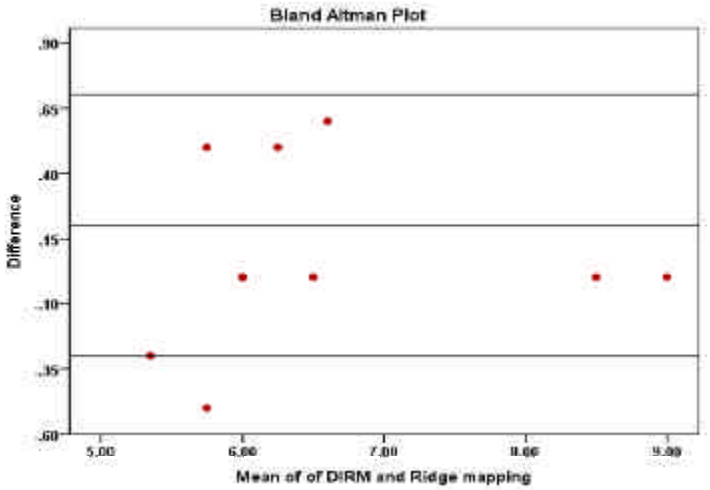

Fig 4: Mean absolute difference of CT, CBCT, RM from DIRM

RESULTS:

The 12 edentulous sites provided the information for evaluation of alveolar ridge dimensions. The one sample T-test showed that the mean difference of CT and RM was farthest and nearest from 0 respectively. CBCT mean difference lies in the center of the former values from 0. This indicated that RM has the least difference from 0, thus having least difference from DIRM compared to CT and CBCT (Table 2). The Bland-Altman plot showed that RM had least deviation from a linear pattern, whereas the others showed a random scatter pattern showing inconsistency of values with DIRM. From the data obtained we found that RM values were most consistent with DIRM, followed by CBCT being more consistent with DIRM than CT. (Fig 1-3)

Table 2: Assessing the strength of the linear relationship between DIRM and other techniques using Pearson's correlation:

		DIRM
CT	Pearson Correlation	0.870
	P-Value	<0.001
	N	12
CBCT	Pearson Correlation	0.913
	P-Value	<0.001
	N	12
Ridge mapping	Pearson Correlation	0.959
	P-Value	<0.001
	N	12

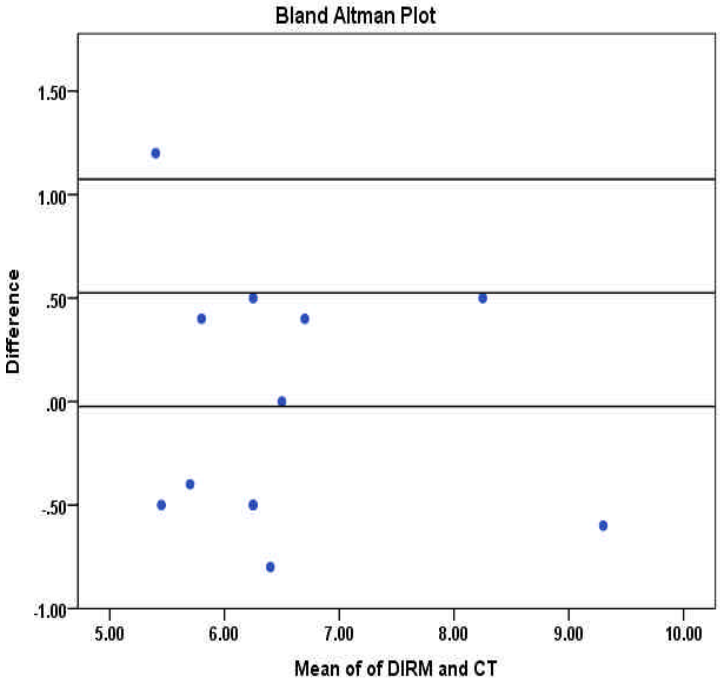

Fig 1: Bland Altman plot showing difference between ridge measurements by CT and DIRM

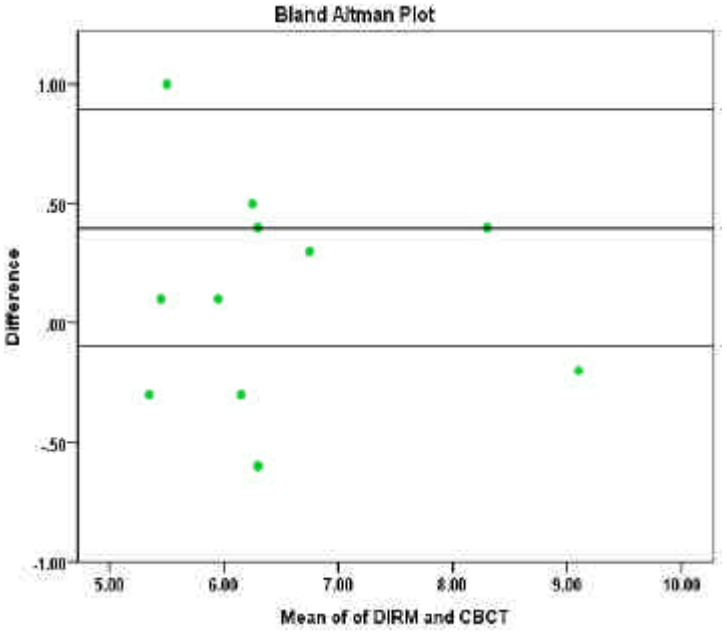

Fig 2: Bland Altman plot showing difference between ridge measurements by CBCT and DIRM

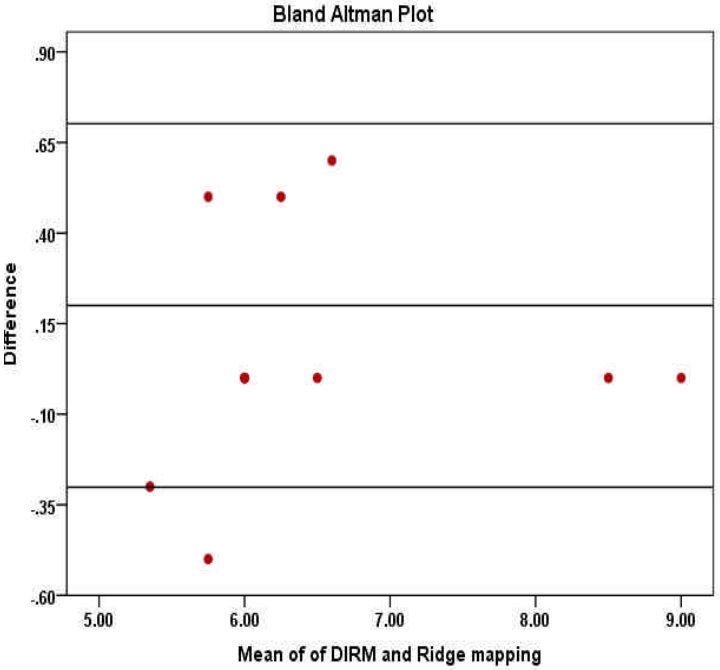

Fig 3: Bland Altman plot showing difference between ridge measurements by RM and DIRM

DISCUSSION:

The surgical procedure for implant placement requires adequate knowledge about the alveolar bone dimensions and proper treatment planning. The treatment planning involves comparing the measurements of bone dimensions on various radiographs, since treatment plan cannot be decided during the surgery [5].

In the present study, it was found that most of the values of RM coincided with DIRM values. However, in certain sites RM values were slightly lesser than the measurements of DIRM which could be a slight shift in the position of the stopper while being transferred on the model from the mouth. RM could have given inaccurate results if the needle penetrated superficial bone in areas where the consistency of bone was soft, leading to values greater than DIRM. Another reason could be due to measurement taken at the edge of a shallow bony defect with one technique and inside the defect with another.

Comparison of alveolar bone width (ABW) between CT and CBCT to DIRM showed few differences between the two measurements. This difference could be attributed to shift in intraoral stent position or difference in the hard tissue shadow between the two techniques. In a study by Wahed et al, it was stated that the accuracy of diagnostic information provided by a CBCT depends on how we use the system and manipulate the images obtained [7] . However, in our study the measurements of ABW taken with a CT and CBCT were interpreted by a single person. On interpretation, it was concluded that the values from CBCT had better correlation to the DIRM when compared to a CT. There was no significant difference in the values between maxillary and mandibular sites in this study.

The Bland-Altman plot for CT showed that 60% of the values lie outside the 95% confidence interval (CI) compared to CBCT where only ~40% values were scattered outside the CI. In contrast to these two techniques, 90-92% of RM values were scattered within 95% CI with overlapping readings, showing most consistency with DIRM. Our study findings were similar to results found by Lung-Chen Chen et al, comparing CBCT and RM to direct caliper measurement [8]. He found that the buccolingual measurement obtained with ridge mapping were more consistent with direct caliper measurement, and added that CBCT did not provide any significant additional diagnostic information about the implant site. With the results of this study, RM can be used in cases where advanced diagnostic facilities are bare, patients affordability stands an issue, or when the clinician thinks exposure to such increased radiation for a single site is not justifiable and in straight forward cases like lower posterior region along with information obtained on a much simpler radiographic techniques.

CONCLUSION:

Comparing all the three techniques to DIRM, ridge mapping was found to have maximum consistency with DIRM and can be used for measurement of ABW. However, detailed three-dimensional information of the surgical site prior to implant placement can only be obtained from a CT or CBCT. This is just a pilot study, hence larger sample sizes should be assessed to confirm the consistency of the findings and to determine the closest definitive technique to DIRM for diagnosis and treatment planning for implant placement.

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