Original Article

Validity of ridge mapping and cone beam computed tomography in dental implant therapy

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Abstract:

Aim: The purpose of this study was to compare the validity of alveolar ridge measurements obtained with ridge mapping (RM) technique against cone beam computed tomography (CBCT) measurements. **Materials and Methods:** Twenty partially edentulous patients were recruited for implant placement in the Clinic of San Martin de Porres University. For all the measurements, a vacuum-formed stent was fabricated for each subject. A buccal and lingual point was made in the stent to provide a reference of measurement for each implant site. RM measurements with the stent were obtained before and after surgical flap reflection. Two calibrated observers made the CBCT images measurements. *T*-test was used for the statistical analysis. Values <0.05 were considered statistically significant. Also, specificity and sensibility of CBCT and RM were compared. Intra-class correlation coefficient (ICC)_ was measure between CBCT measurements. **Results:** A total of 62 implants sites were evaluated. No statistical significant differences were obtained with CBCT and RM measurements ($P = 0,207$). Detecting proper buccal-lingual ridge, the sensitivity and specificity were 59% and 91% for RM while CBCT obtained 92% of sensitivity and 94% of specificity. Concordance was found "good" (ICC 0.82). **Conclusion:** Both methods provide valid measurements. Even though, we found diagnostic limitations in the RM, it demonstrated to be a useful method for its exactitude, low cost, the immediate result and no need of radiation. CBCT was recommended when the bone ridge width and height were in the less than ideal for conventional dental implant placement.

Key words:

Cone beam, dental implants, ridge mapping

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INTRODUCTION

Nowadays, dental implants (DIs) are a reliable treatment to replace lost teeth. However, placing DI is not an isolated event, is the result of a cautious presurgical planning. In addition, precision is mandatory to fulfill esthetical and functional expectations of patients. Even more, to obtain the best result as possible is really important the technique and the three-dimensional position where the DI is placed. Furthermore, we must avoid morphologic characteristics and anatomic limitations of the surgical area to prevent unpleasant complications like sinus perforation or dental nerve paraesthesia.[1-4]

To complete the presurgical evaluation for DIs, conventional radiographic evaluation is the most common auxiliary test used. However, some authors such as Bragger, Akkesson and Hammerle agree to point out the overestimation and subestimation of the alveolar ridge real dimensions frequently showed in periapical and panoramic radiographs.[5-7]

Because of what we mentioned above and other inherent caracteristics to conventional radiograph (e.g., impossibility of tridimensional evaluation of alveolar ridge), Schwarz (1987) and other researchers, introduced cone beam computed tomography (CBCT) as an auxiliary test in presurgical planning in DIs treatment. Since then, CBCT has been obtaining more and more acceptance between dental surgeons.[4,8-10] CBCT has been studied in its diagnostic ability in multiple circumstances like for instance, the localization of dental inferior nerve or the evaluation of the maxillary sinus.

On the other hand, in a way to overcome conventional radiographic limitations, some clinical methods have been created to measure transversal alveolar bone like ridge mapping (RM) technique.[11,12] Wilson registered this technique in 1989, and Traxler (1992) suggested it is a reliable method to evaluate bone availability for DI surgery. CBCT has demonstrated to be a very useful tool in DIs presurgical planning, surpassing axial computerized tomography limitations, providing better resolution images, high diagnostic quality and in many cases excellent visualization with a large decrease in radiation dose.[13] Nevertheless the additional cost, the need for a second appointment and still the lack of availability in many points of the globe, leads many professionals to use conventional radiography and clinical methods as RM to fulfill its presurgical planning.[11,14] RM technique along

with panoramic and intraoral radiograph could be adequate to measure sites showing little bone resorption, and in sites where there is no risk of damage of anatomical structures like maxillary sinus mucosa or dental inferior nerve. Apparently treatments planned that way, despite limitations, obtain an even to document success.

The aim of this research is to provide truthful information about the validity of RM and CBCT for the determination of edentulous ridge dimensions (gold standard) in DI therapy.

MATERIALS AND METHODS

Twenty patients of the Master of Periodontology (San Martin de Porres University, Lima-Perú) about to be rehabilitated with implant therapy were recruited.

Patients were considered for inclusion if they met the following criteria: (1) Age >18 years (2) need of treatment of partially edentulous sites with DIs (3) systemically healthy. Only total edentulous patients were excluded.

A total of 62 measurements were made [Table 1]. Every patient was instructed about the procedures and the nature of the research, and those who agree to participate signed an informed consent. Stone study models were fabricated from alginate impressions for each patient. In these models, a vacuum form acetate stent (0.4 mm base plate thermoforming material) was fabricated. For the measurements, two points were drilled for vestibular and linguo/palatine with a 2 mm round diamond bur in the place where DIs would be located and 10 mm approximately from the highest point in the alveolar ridge [Figure 1]. That would be the reference point for the measurements in all the methods. All patients were scanned (Vatech Picasso-Duo®) for availability with CBCT using the radiographic stent with gutta-percha markers. Two observers were calibrated in measuring alveolar ridge using an artifice in the EZ implant software, DICOM format Medical Dental CT Image Viewer program (Korea) [Figure 2]. To validate this measurement artifice, intraclass correlation coefficient (ICC) was applied to CBCT measurements obtained by the examiners to find inter-observer concordance, and also, to one observer measurements performed at an interval of 3 months, for intra-observer concordance.

Using the same tomographic stent placed in the patient, the RM was performed before opening the flap [Figure 3], obtaining measurements directly from a specialized caliper. After that, also using the stent, we proceeded to measure the width of the alveolar ridge exposed, with the same caliper [Figure 4].

Student's *t*-test was performed for statistical analysis (IBM, SPSS Statistics 19, SPSS Inc. 1989, 2010, USA). $P < 0.05$ was



Figure 1: We performed semi-rigid splint acetate, placing gutta percha indicating where future implants will be placed

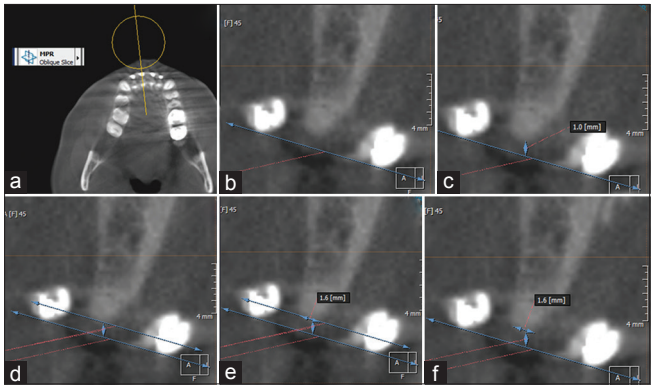


Figure 2: Alveolar ridge measurement in CBCT images. (a) An oblique slice was made across the gutta-percha markers. (b) First a parallel line was plotted joining the most superior points of the gutta-percha images (c - d) A second parallel line was plotted 1mm from the first one. (e-f) Alveolar ridge measurement

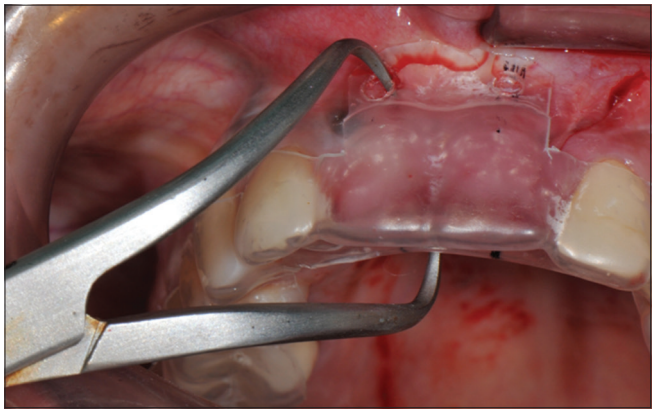


Figure 3: A specialized caliper was used for the ridge mapping measurement through the stent orifices

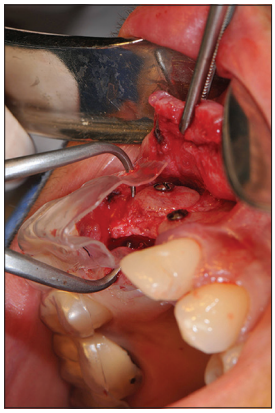


Figure 4: Perisurgical width measurement of exposed alveolar ridge (Gold Standard)

considered statistically significant. We also applied specificity/sensitivity test to RM and CT with respect to its ability to detect adequately or not adequate bone ridges to DI conventional surgery (dimensions >4.5 mm).

RESULTS

A total of 62 implants sites were evaluated. Table 1 shows mean alveolar ridge dimensions obtained from the three methods. "Strong agreement" concordance for interobserver and intraobserver CBCT measurements was found (ICC 0.82) proving the reproducibility of our measurement artifice. No statistical significant differences were obtained with CBCT and RM measurements (P = 0.207). For detecting proper buccal-lingual ridge, the sensitivity and specificity were 92% and 94% for CBCT [Table 2] while RM obtained 59% of sensitivity and 91% of specificity [Table 3].

DISCUSSION

According to the results, measurements with CBCT and RM compared with those obtained directly of the exposed alveolar ridge (gold standard), have no statistically significant differences. This finding differs to some extent with those obtained by Chen *et al*. who found statistically significant equivalences between RM and gold standard measurements, but not with those from CBCT and the gold standard.[9] Chen *et al*. suggested that this finding could be due to the difficulty of: First the reproducibility in tomographic readings, second, in determining cortical bone limits in tomographic images and finally, to define a measurement line that crossed the pairs of gutta-percha at the same point each time.[9]

We overcome this difficulties encountered by Chen *et al*., creating the aforementioned artifice for reading CT images, managing to standardize these measurements [Figure 2].[9]

On the other hand, our results agree with Loubele *et al*. and other researchers who confirmed the accuracy of measurements of alveolar ridges that provides CBCT; similarly highlight its versatility as a diagnostic tool prior to placement of DIs.[15-17]

Following our analysis, we found that our results also differ from those obtained by Luk *et al*. who concluded that bone ridge measurements obtained on CBCT and the RM were significantly different (average discrepancy of 0.3–0.5 mm).[14] As mentioned before, our study found that both methods showed no statistically significant differences among themselves, with an average discrepancy of 0.19 mm between each method.

Alternatively, results obtained by applying the specificity and sensitivity analysis, show that RM technique had a sensitivity for detecting ridges suitable for DIs with a value of 59%, not as high as found on CBCT (92%). This sensitivity value of RM, translated in an underestimation of the values of alveolar ridge width coincides with Perez *et al*., who found an average of 3.6 ± 1 mm below the averages measurements of the gold standard.[18] An explanation for this could be found in the application of excessive pressure when caliper points passed through soft tissue and bone, which could lead to perforation of the cortical bone, having, as a result, some millimeters less in the reading of the ridge width. This could be worsened if reading is repeatedly performed in the same area of the maxilla.[18]

Furthermore we found that both methods, RM and CBCT showed a high specificity of 91% and 94% respectively [Table 4], a high probability of detecting ridges unsuitable for implant placement in a conventional manner (without ridge augmentation techniques). This result shows that RM could be useful and sufficient in those cases in which the ridge size is ideal, also showing those in which additional diagnostic tests are required.

Data obtained in this study reaffirm the usefulness and accuracy of CBCT for presurgical planning of DIs, and likewise, give validity to the use of RM technique as a useful tool for buccolingual width measurements in ideal cases.

Table 1: Measures of central tendency of gold standard, CBCT and ridge mapping measurements

	Mean	*n*	SD	SEM
Gold standard	3.39	62	1.56	0.2
CBCT measurements	3.42	62	1.41	0.18
Ridge mapping measurements	3.23	62	1.73	0.22

SD – Standard deviation; SEM – Standard error of mean; CBCT – Cone beam computed tomography

Table 2: Sensitivity and specificity of CBCT to detect ridge bone width where implant surgery is possible

	Favorable CBCT Detection (+)	Not favorable CBCT Detection (–)	Total
Adequate ridge bone (+)	12	3	15
Not adequate ridge bone (–)	1	46	47
Total	13	49	62

+ – Implant surgery is possible; – – Implant surgery is not possible. Specificity=94%; Sensitivity=92%; Positive predictive value=80%; Negative predictive value=94%. CBCT – Cone beam computed tomography

Table 3: Sensitivity and specificity of ridge mapping technique to detect ridge bone width where implant surgery is possible

	Favorable ridge mapping Detection (+)	Not favorable ridge mapping Detection (–)	Total
Adequate ridge bone (+)	10	4	14
Ridge bone (–)	7	41	48
Total	17	45	62

+ – Implant surgery is possible; – – Implant surgery is not possible. Specificity=91%; Sensitivity=59%; Positive predictive value=71%; Negative predictive value=90%

Table 4: Sensitivity and specificity of ridge mapping technique and CBCT to detect ridge bone width where implant surgery is possible

	CBCT (%)	Ridge mapping (%)
Sensitivity	92	59
Specificity	94	91
Positive predictive value	80	71
Negative predictive value	94	90

CBCT – Cone beam computed tomography

CONCLUSIONS

It was found that CBCT and RM measurements when compared individually with the gold standard have not statistically significant differences. Also, CBCT proved to be a highly specific and sensitive method detecting suitable maxillary ridges for placement of DIs in a conventional surgery. Likewise, RM technique proved to be highly specific but not highly sensible on detecting suitable maxillary ridges for DIs placement. We believe bone RM is a method of great utility supplemented by conventional radiographic methods, being a technique that does not involve irradiation to the patient, it is low cost and gives immediate results for ridge bone with ideal width and height. Whereas, in cases that would be required, like sites with maxillary sinus proximity or sites where a regeneration is needed, might be a prelude to CBCT examination.

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