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Use of Longitudinal Topographic Occlusal Projection to measure the Alveolar Bone Thickness in the Posterior Implant Sites (Pre-Clinical Study)

Nazar Ghanem Jameel[1], Osama M. Ibrahim[2]
[1]Assist. Prof / Dept. of Oral & Maxillofacial Surgery / College of Dentistry / University of Mosul / Iraq
[2]Assist. Prof. / Dept. of Oral Diagnosis / College of Dentistry / University of Tikret / Iraq

ABSTRACT

Aim of the study: to evaluate the accuracy of longitudinal topographic occlusal view (LTO) in the measurement of alveolar bone thickness, and designing the beam aiming device to improve technical application of radiographic technique.

Materials and Methods: the alveolar bone thickness of 20 posterior edentulous sites (10 sites for each jaw) in the maxilla and mandible of three dry skulls measured directly by using digital caliper and radiographically by longitudinal topographic occlusal view with newly designed beam aiming device.

Results: statistical analysis of the results with independent paired t-test showed no significant difference between the direct and radiographic bone thickness ($p \geq 0.05$).

Conclusion: the longitudinal topographic occlusal radiograph presents accurate measurements of alveolar bone thickness in the simple and uncomplicated implant cases of the proposed posterior implant sites to avoid the excessive radiation dose, cost and for time saving for patient and operator. The designed beam aiming device recommended using for standardization, and simplicity of technical application.

Key Words: topographic occlusal, beam aiming device, radiographic stent, alveolar bone.

INTRODUCTION

One of the most important targets in oral radiology is the evaluation and follow-up of implant procedures. The radiographers use visual criteria associated to radiographic parameters of the implant as well as its radiological opacity to reach a diagnosis from dental x-ray images.(1,2) Radiographic visualization of implant sites is an important extension of clinical examination and assessment. When reviewing imaging modalities for preoperative assessment of the dental implant site, many differing variables need to be considered, these include, the amount of information provided, its accuracy and its applicability need to be considered against cost, suitability, availability, radiation dose and knowledge required to produce and read the output of each modality.(3,4,5)

Intraoral radiography was the first applications of clinical radiology and has been used for about one hundred years. Till now it remains as the main non-invasive diagnostic method for the detection and assessment of internal changes in calcified oral tissues.(6) Occlusal radiographs have minimal use in implant dentistry. Cross-sectional occlusal radiographs of the mandible give information about the buccolingual dimension of the mandible, but this information is only accurate to show the inferior aspect of the body, not the width of the alveolar ridge where the implant is to be placed.(7) The use of cross-sectional occlusal radiographs can be helpful when assessing the position of the implant within the jaw following placement in the mandible and maxilla.(2)

Occlusal radiography for mandibular arch assessment can detect the size of the inner and outer cortices in addition the position of the mental foramen. It may be possible to incorporate a radiographic marker on the patient’s denture to give a viewpoint of the relationship of the mental foramen to the overlying prosthesis.(8)

The aim of this study is to evaluate the accuracy of longitudinal topographic occlusal radiograph (LTO) in the measurement of alveolar bone thickness of posterior implant site. Design the film holding device to improve the technique.

MATERIAL AND METHODS

The pre-clinical assessment of the radiographic technique was applied on in the maxilla and mandible of three dry skulls taken from Human Anatomy Class / Basic Science Department / College of Dentistry / University of Mosul. The thickness of the alveolar bone of 20 posterior edentulous sites (10 sites for each jaw) in the maxilla and mandible measured directly by using digital caliper calibrated to the nearest 0.01 mm at four points were demarcated by pencil started at the crestal part of the alveolar bone with 5mm distance separates the one point from the next one[9] (Figure 1).

Figure (1): Direct measurements of the bone thickness by the digital caliper.

The selected edentulous regions of maxillary and mandibular jaws covered by a layer of soft wax with 2mm thickness to represents the soft tissue layer. A stainless steel metallic ball with 3.88 mm of diameter placed occlusally at each selected site in order to use as a caliber for linear measurements[10,11] (Figure 2 – A and B).

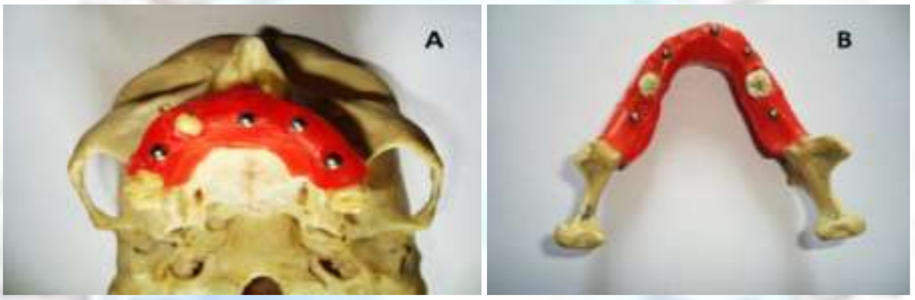

Figure (2): The edentulous regions of maxillary (A) and mandibular (B) jaws of dry skulls covered by a layer of soft wax and stainless steel metallic ball placed occlusally at each selected site.

Fabrication of Radiolucent Stent;

A simple U-shape design of radiolucent stents was fabricated from self-cure acrylic resin at each edentulous site. Four pairs of holes were made vertically in the stent with stainless steel prosthetic fissure bur, the buccal (labial) hole opposing directly the other hole on the lingual (palatal) side. Five millimeters of distance separate one pair of orifices from the next one. Stainless steel wires with gauge 0.7mm used as radiopaque markers inserted in the holes and pushed through the orifices and penetrate the wax layer till to touch the bone[12,13] (Figure 3 – A and B).

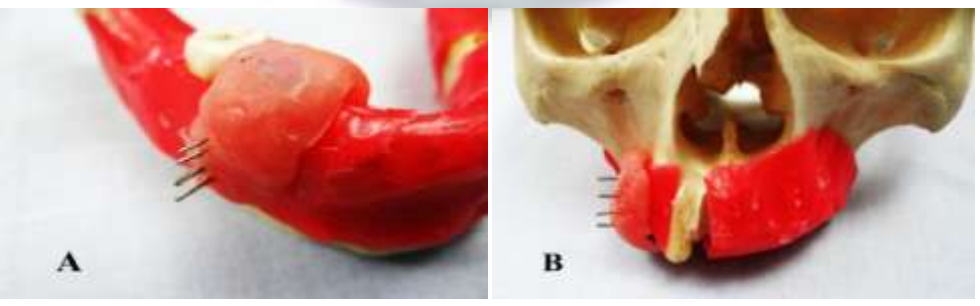

Figure (3): Radiolucent stents with stainless steel wires gauge 0.7mm used as radiopaque markers. A- Mandible. B- Maxilla.

Longitudinal Topographic Occlusal Projection (LTO)

The selected edentulous sites examined radiographically by longitudinal topographic occlusal view with designed beam aiming device. Dental x-ray machine type Planmeca Intra (Helsinki, Finland) with long cone beam operated at 70 kVp, 8 mA and 0.8 sec of exposure time (Figure 4).

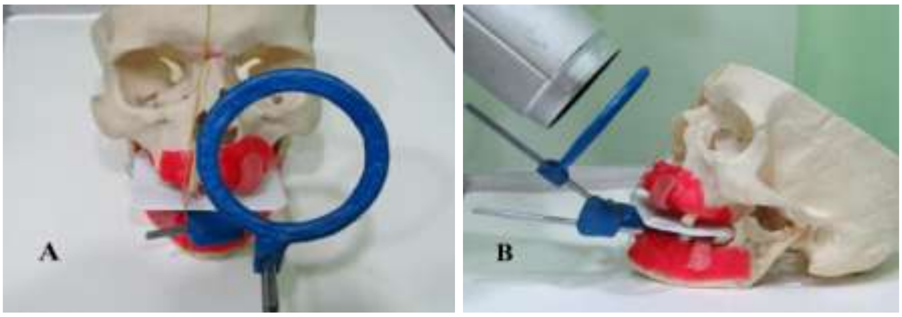

Figure (4): Assessment the accuracy of the horizontal (A) and vertical (B) angulations of the X-ray beam on the dry skull.

According to the literatures the principles of this technique is firstly applied to compensate the requirements of this study. This projection used to evaluates the alveolar bone thickness in the posterior edentulous segment of the upper and lower jaws. Generally, the topographic occlusal view follow the principles of bisecting-angle technique; where the x-ray beam directed perpendicular to the plain bisect an angle formed between the long axis of the film and the long axis of the object.[14,15] Size 4 occlusal film was placed intraorally and fixed in its position by the occluded jaws of the dry skull, with its exposure side directed toward the examined arch.

The vertical angulation of the x-ray beam was directed perpendicular (90º angle) to the bisecting line of an angle formed between the transverse plain (alveolar bone thickness) of the examined arch (maxilla and mandible) and the plain of the film, or in 45º angle to the plain of the film. The x-ray beam should be directed horizontally to allow that the primary x-ray beam passes nearly parallel to the medial and lateral cortical plates of the examined arch.[16] The x-ray beam directed to the posterior segment of the dental arch in 45º angle vertical angulation to the plain of the film through the infraorbital region in the maxilla, and through the mental region in the mandibular arch.

Radiographic Measurements: Dimax Classic imaging software (Helsinki, Finland) used for image analysis. Vertical line was traced to tangent the inner end of each radiopaque marker, then another horizontal line traced to connects between each two opposed vertical lines at the level of each pair of markers. The linear measurements calibrated by measuring the diameter of the metallic ball as a reference distance. The length of the horizontal line was measured represents the radiographic thickness of the alveolar bone at the level of the selected radiopaque markers which was equal to the real thickness of the alveolar bone at that site[2,17] (Figure 5 – A and B).

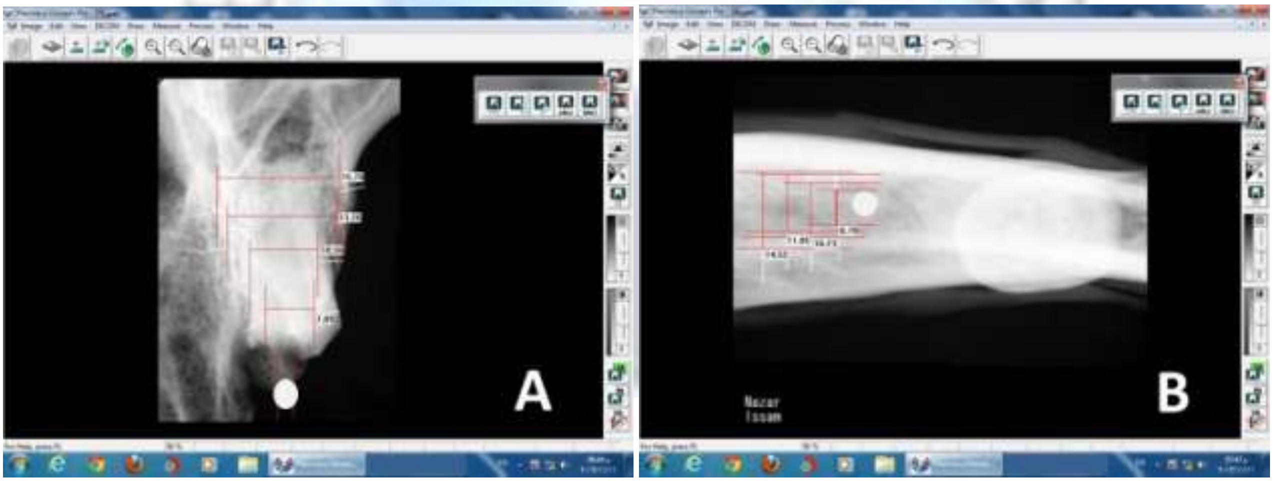

Figure (5): Radiographic measurements of the alveolar bone thickness projected by Longitudinal Topographic Occlusal Projection. A- Maxilla. B- Mandible.

Beam Aiming Device for Longitudinal Topographic Occlusal Projection

The all parts of this beam aiming device specially designed to use in this study. The basic components of beam aiming device include; (1) Bite plate. (2) Horizontal arm. (3) Joining part. (4) Vertical arm. (5) Beam aiming device.

The **Bite Plate**; has a horse shoe shape made from thin plastic material, this plate is used to hold the film holding device in its position as the patient bite on it. The plate was perforated with stainless steel fissure prosthetic bur. An extra-oral extension of the bite plate made from self-cure acrylic resin painted with blue color for esthetic and used to hold the horizontal arm of the film holder. The bite plate placed in the patient mouth along the occlusal plain and opposing to the non-exposure side of the occlusal film. The **Horizontal Arm**; it is made from stainless steel bar with square section of (3.33 mm) dimension. The bar extends from the bite plate at the level of occlusal plain horizontally, and bends in 20º angle toward the median plain. The horizontal arm has an ability to move mediolaterally in a horizontal plain through the extraoral extension of the bite plate. The horizontal arm hold the joining part which used to holds the vertical arm (Figure 6).

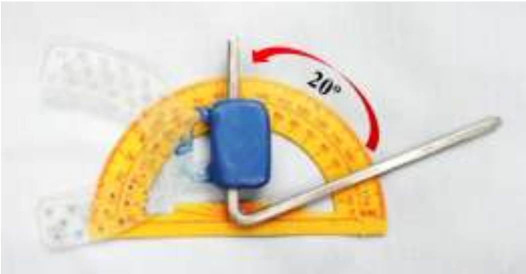

Figure (6): The horizontal arm angulation of the beam aiming device for Longitudinal Topographic Occlusal Projection.

The **Joining Part**; this part was made from the self-cure acrylic resin, which is connects the horizontal and vertical arms together. It has ability to move in anterio-posterior sliding motion along the horizontal arm. The **Vertical Arm**; it's made from stainless steel bar with square section of (3.33 mm) dimension. This arm was attached to the horizontal arm through the joining part to form a 45º vertical angulation with the occlusal plain and used to hold the ring aiming device (Figure 7).

Figure (7): The joining part and the 45º vertical angulation of the beam aiming device of the longitudinal topographic occlusal projection.

The **Ring Aiming Device**; the basic design of the ring aiming device in the standard Rinn – XCP film holder kit was used. The ring has ability to move in sliding motion along the vertical arm, it is used to oriented the direction of the x-ray beam to be in 45° vertical angulation toward the occlusal plain[18] (Figure 8).

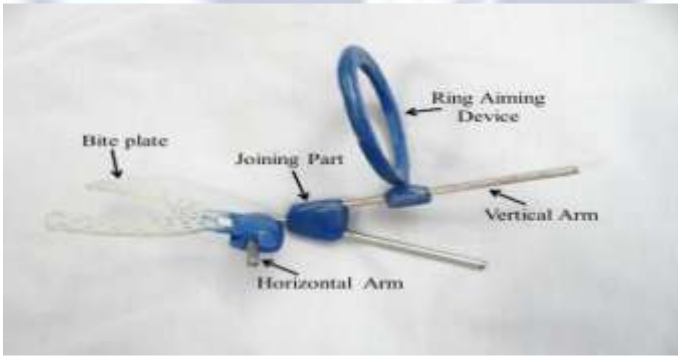

Figure (8): Beam Aiming Device for Longitudinal Topographic Occlusal Projection.

RESULTS

The independent paired *t*-test used to compare the direct bone thickness measurements (D1, D2, D3, and D4) in the posterior regions of maxillary and mandibular dental arches with the radiographic bone thickness measurements gained from intraoral longitudinal topographic occlusal view. The radiographic bone thickness measurements resulted from longitudinal topographic occlusal view show no significant difference ($p \geq 0.05$) when compared with the direct bone measurements in both maxillary and mandibular posterior regions (Tables 1). The *p*- value of the D1, D2, D3, and D4 in the maxillary posterior region are 0.607, 0.509, 0.451 and 0.408 respectively. Where, the *p*-value of the D1, D2, D3, and D4 in the mandibular posterior region are 0.279, 0.274, 0.211 and 0.196 respectively (Tables 2).

Table (1): Compares between the direct and radiographic bone thickness measurements by longitudinal topographic occlusal view (LTO) in the maxillary posterior region.

Distance	Technique	N	Mean (mm)	SD	df	*t*-value	*P*-value
D1	Direct	10	6.731	1.61504	18	-0.523	0.607
	LTO	10	7.117	1.68413			
D2	Direct	10	9.355	1.71841	18	-0.674	0.509
	LTO	10	9.888	1.81445			
D3	Direct	10	12.381	1.71585	18	-0.770	0.451
	LTO	10	12.961	1.65252			
D4	Direct	10	14.722	1.78310	18	-0.847	0.408
	LTO	10	15.397	1.78195			

Table (2): Compares between the direct and radiographic bone thickness measurements by longitudinal topographic occlusal view (LTO) in the mandibular posterior region.

Distance	Technique	N	Mean (mm)	SD	df	*t*-value	*P*-value
D1	Direct	10	6.367	1.20623	18	-0.737	0.471
	LTO	10	6.760	1.17861			
D2	Direct	10	9.355	1.41587	18	-0.877	0.392
	LTO	10	9.938	1.55229			
D3	Direct	10	11.485	1.45544	18	-0.816	0.425
	LTO	10	12.020	1.47779			
D4	Direct	10	12.552	1.84757	18	-0.867	0.398
	LTO	10	13.226	1.62334			

DISCUSSION

According to the literatures; in the posterior topographic occlusal projection, the x-ray beam directed in 60º angle of vertical angulation to the plain of the occlusal film and the horizontal angulation follow the curvature of the arch with point of entry of x-ray beam through the species of the teeth in the examined region.[14,15,16,19,20] These principles modified to compensate the requirements of the present study; where, the x-ray beam directed in 45º vertical angulation to the plain of the film and the 20º horizontal angulation through the infraorbital region of maxilla and symphyseal region of the mandible.
The vertical angulation of the x-ray beam was limited in 45º angle which represents the most appropriate angle to produce a radiographic image of the dental arch with minimal overlapping between the examined region and the structures located anterior to it, also its provide sufficient separating between the radiopaque markers in the vertical plain.[21] While, the horizontal angulation facilitate x-ray beam to pass parallel to the lateral side of the dental arch and along the long axis of the arch in order to provide transverse sectional view of the examined site.[14,15,16] These vertical and horizontal angulations required to direct the x-ray beam anteriorly through the point of entry in the infraorbital region of maxilla and symphyseal region of mandible.

The film holder designed for this technique tool called beam aiming device because the mechanical part of the basic design of the Rinn-XCP film holder was replaced by bite plate and it is used to improve the alignment of the x-ray beam toward the examined region, where the film supported by the patient occluded teeth.[22,23,24] The bite plate was perforated in order to increase the friction between the bite plate and the teeth. The stainless steel bar extend horizontally from the bite plate at the level of occlusal plain, and bend in 20º angle toward the median plain of the patient to compensate the inclination of the longitudinal axis of the side of dental arch and has ability to move in horizontal plain mediolaterally in order to compensate the width of the dental arch. While, the vertical arm was attached to the horizontal arm through the joining part to form a 45º vertical angulation with the occlusal plain and used to hold the ring aiming device which is moved in a sliding motion along this vertical arm anterio-posteriorly in order to centering the x-ray beam toward the examined part of the posterior segment of the dental arch. There is no evidence in the literatures about the design of this beam aiming design.

The accuracy of intraoral occlusal radiograph taken by longitudinal topographic occlusal projection may be related to it is geometric principles. Where the inclination of the vertical angulation of the x-ray beam (45° angle) toward the transverse plain of the examined site lead to distortion in the vertical linear measurements, and makes the anatomic details look blurred showing an augmented jaw, while the horizontal linear measurements (distances between the radiopaque markers) which represent the alveolar bone thickness were not distorted because the horizontal angulation of x-ray beam directed to be parallel with the longitudinal plain of the examined implant site.(16,25,26)

Authors suggested the use of true occlusal radiography is able to give maximum width of alveolar ridge in mandible with buccolingual and faciolingual direction which is very useful in dental implant treatment. But, the superimposition of the other anatomical structures tends to obscure medial and lateral extent of the ridge in the posterior region.(2,27,28)
In the literatures there is no data reported any method using the intra oral occlusal radiography for assessment of alveolar ridge thickness except the study by Desai, and co-workers(29) (2013) they determine the dimensions of ridge width of bone and deviation of center of ridge in the mandibular jaw using intraoral true occlusal projection as a preprosthetic diagnostic method. Cold cure acrylic stents were fabricated with three holes were drilled occlusally, buccally, lingually and filled with gutta percha as radiopaque markers. The radiographic analysis was done to calculate the distance between the buccal and lingual gutta percha which represent the actual width of the ridge gives bone thickness and tissue thickness.

The procedure followed by Desai and co-workers(29) represents the width of the alveolar bone at a single point selected by the operator and can be applied on the mandibular arch only. In controversy, the longitudinal topographic occlusal radiographic projection represents the width of the alveolar bone at three levels (position of the radiopaque markers) which were used to mapping the shape of the ridge in transverse plain. In addition to that the present method can be applied on the both maxillary and mandibular dental arches.

The longitudinal topographic occlusal radiograph suggested to be used as alternative technique for those patients who could not use a film holder either because they gagged or had missing posterior teeth.(30)

CONCLUSIONS

The longitudinal topographic occlusal radiograph presents accurate measurements of alveolar bone thickness in the proposed posterior implant sites. The designed beam aiming device recommended using for standardization, and simplicity of technical application. The techniques recommended to be used in the simple and uncomplicated implant cases to avoid the excessive radiation dose, cost and for time saving for patient and operator.

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