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READING HOUNSFIELD UNITS FROM DIRECT PANORAMIC IMAGES. A SOFTWARE TECHNIQUE

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ABSTRACT

The present research was conducted as a trial to find out a simple quick low radiation and less expensive methodology to read and display the HU units expressed by the CBCT from the direct panoramic images during planning for implant placement before the decision of CBCT. A specially developed small Visual Basic program was designed to load the panoramic images to read and display the mean value of the HU of the areas clicked on the panorama and display the bone category according to Misch classification. A total of 100 edentulous sites were explored for the mean value of bone density expressed in HU from CBCT using Simplant program and by the Visual Basic program from the digitized panoramic radiographs for the same site in every patient. Results showed no statistically significant difference were found between the mean value of the HU gained from the Simplant program and those gained from the visual basic program in all categories of bone density including D1, D2, D3 and D4. The software may be a promising tool that can help in prediction of bone density during the planning for implant placement.

INTRODUCTION

The insertion of dental implants has become an increasingly common procedure in the oral rehabilitation of partially and totally edentulous patients. This trend has certainly contributed to the positive results of numerous clinical studies regarding implant survival rates[1-4]. The success of any implant procedure depends on a series of patient-related and procedure dependent parameters, including general health conditions, biocompatibility of the implant material, the features of the implant surface, the surgical procedure, and the quality and quantity of the local bone[5,6].

Many authors define bone quality as equivalent to bone mineral density. This includes physiological and structural aspects and the degree of bone tissue mineralization[7-9]. Aspects such as bone metabolism, cell turnover, maturation, intracellular matrix and vascularity were studied.

Although the clinical outcome of an implant is influenced by many factors, including the implant body, the skill of the surgeon, and the oral environment, the key factor for success is the primary stability at the implant placement. Some studies have demonstrated that the quality of the alveolar bone is the most important factor for achieving good primary stability[10,11].

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The primary stability could be increased with increased bone quality, which would improve the osseointegration and increase the survival probability of the dental implant. Poor bone quantity and especially poor bone quality are the main risk factors for implant failure using the standard protocol for implant insertion[12]. Bone density seems to be of great importance not only in primary implant stability but also in the predictability for oral implant outcomes[8].

Misch[13] suggested that computed tomography can be used for the objective quantification of direct density measurements of bone, expressed in Hounsfield units (HU) (table 1).

So the aim of the present research is to introduce a newly developed program that can read and display bone density in HU from the direct panoramic images to predict the bone quality during planning for implant placement before taking CBCT to reduce the radiation dose and costs.

MATERIALS AND METHODS

A total of 100 edentulous sites were selected from the mandibles and maxillae of 10 patients during planning for implant placement. The study included 6 males and 4 females, their ages ranged from 35 to 56 years. The study design and steps were discussed to the patients and informed consents were obtained. Digitized panoramic radiographs** were taken for each patient during the planning for implant placement as a primary diagnostic aid followed by CBCT*

Bone density measurements using Simplant

The Simplant 17.01 software*** was used to load and display the CBCT images. A reformatted panoramic curve was formed from the axial view. The measure density in ellipse tool was selected from the tools menu to measure the mean bone density in HU from the region of interest which is the edentulous area with a fixed surface area of 3.5 mm^2 at 3 successive sites of the edentulous ridge (Fig. 1-4).

TABLE (1) Bone densities in Hounsfield units (HU)

D1	D2	D3	D4	D5
> 1250 HU	850 to 1250 HU	350 to 850 HU	150 to 350 HU	< 150 HU
Dense cortical bone	Thick dense to porous cortical bone on crest and coarse trabecular bone	Thin porous cortical bone on crest and fine trabecular bone within	Fine trabecular bone	Immature, non-mineralized bone

Fig. (1) The Simplant program displaying the sagittal, axial, panoramic and 3D views.

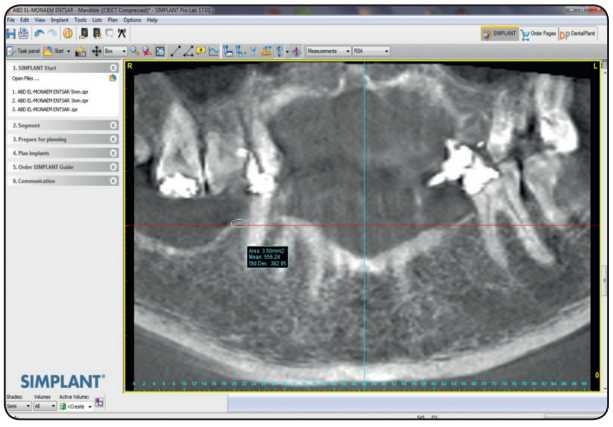

Fig. (2) The first selected area with a mean of 556.24 HU.

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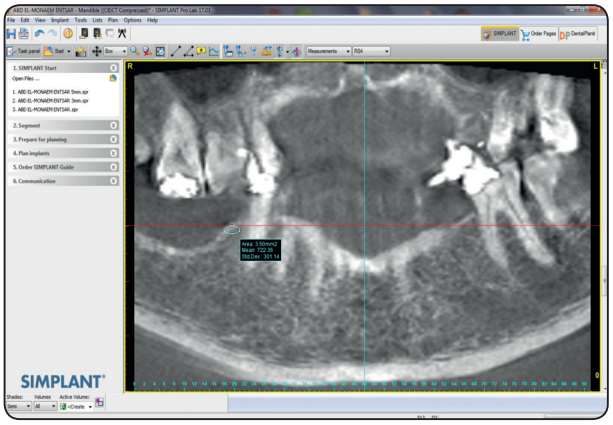


Fig. (3) The second selected area with a mean of 722.36 HU.

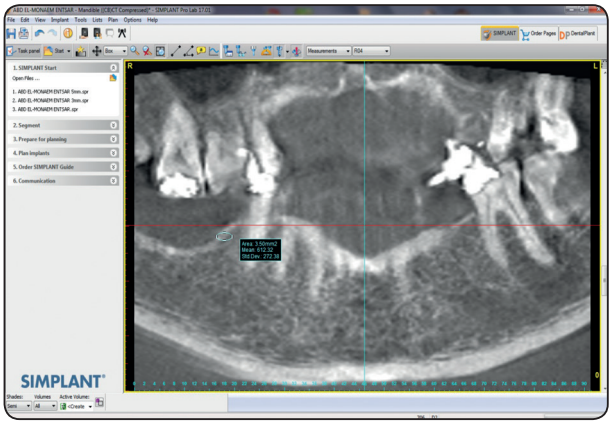


Fig. (4) The third selected area with a mean of 612.32 HU so the final mean of the 3 selected areas equals to (556.24+722.36+612.32) /3 = 630.30 which belongs to the D3 category.

The sum of the 3 readings was divided by 3 to get the mean HU of the area of interest. Such data were collected and stored as a positive control.

Bone density measurements using a Visual Basic program

The software was developed specially for the present research. It was developed in Visual Basic 6 Professional Edition*. The software contained 5 buttons named according to their functions. The "Load" button was assigned to select the panoramic image and to upload it to the software picture box then the mouse pointer is used to click on the area of interest leaving a small red dot and each time the mouse button is clicked another red spot is added.

The software contained also 4 text boxes, the first one displays the HU value of the recently clicked spot, the second text box displays the sum of the HU values of the clicked points, while the third text box displays the number of the clicked points. The "HU" button displays the mean value of the clicked points by dividing the sum HU by the number of the clicked points and displays the bone density class according to Misch[13] classification whether it is D1 or D2 etc. The "Save" button was assigned to save the current panoramic image with the clicked red points. The "Clear" button was assigned to clear all data displayed in the 4 text boxes and the red dots on the panoramic image so as to allow measurements of a new area while the "End" button was assigned to call the exit procedure and to remove the program from the computer memory (Fig. 5-8).

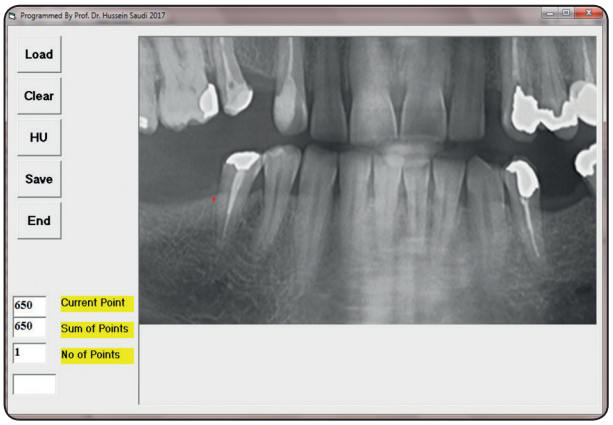


Fig. (5) The first clicked point displaying 650 HU.

* Microsoft Company, USA.

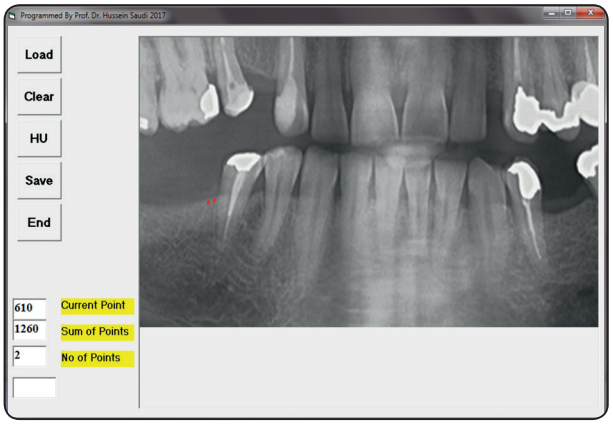


Fig. (6) The second clicked point displaying 610 HU.

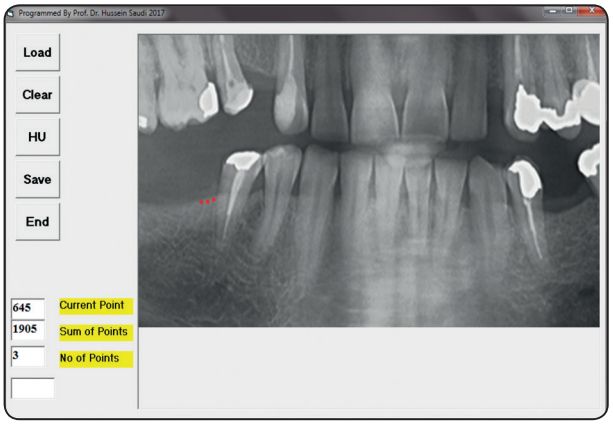


Fig. (7) The third clicked point displaying 645 HU.

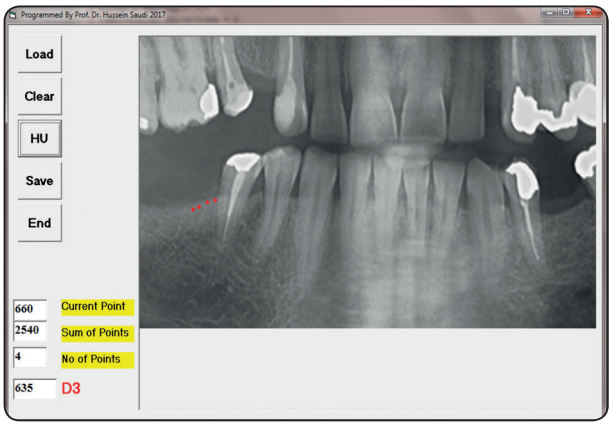


Fig. (8) The fourth clicked point displaying 660 HU with a total mean of 635 HU which belongs to the D3 category as that of Simplant readings (630.30 HU).

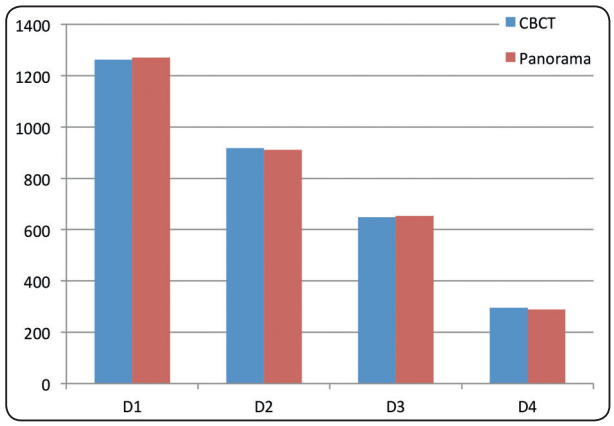
RESULTS

The mean values of the D1 and D3 sites gained by the Simplant program from CBCT were slightly less than that gained from the panoramic images without statistically significant differences. On the other hand the mean values of the D2 and D4 sites gained from CBCT were slightly higher than that gained from panoramic images using the Visual Basic program without statistically significant differences. table 2 and graph 1).

TABLE (2) Comparing the mean HU units gained from CBCT and that of panoramic images using the unpaired student t test.

Bone quality	No.	CBCT Mean ± SD	Panorama Mean ± SD	P value	t value
D1	16	1263±41	1271±39	0.8885	0.1414
D2	20	918±54	911±62	0.9326	0.0851
D3	35	649±33	653±47	0.9447	0.0697
D4	29	295±61	289±57	0.9430	0.0719

Statistically significant at the 5% level of significance.



Graph (1) Showing the mean HU values obtained from CBCT and digital panoramic images based on Misch(13) classification.

DISCUSSION

Imaging is the key investigative tool for many diseases in diagnostic medicine.[14] It has been proven that the success of any placed implant highly depends on both, the quality and the quantity of the surrounding bone[15]. There is a correlation between high bone density and high rate of implant success, and between high bone density and implant primary stability[16]. Bone density assessment is therefore essential prior to every plan operation and for the success of the treatment[17,18].

The digitized panoramic radiography was selected as it is often the first choice method for the placement of implants because it provides information on the overall shape of the jaws, the position of the maxillary sinus floor and the nasal cavity floor, and the proximal distal as well as vertical position of the mandibular canal and the mental foramen. In addition, it provides information on the presence or absence of residual dental roots or asymptomatic lesions in the dental root apex, lesions within the bone, the interval between remaining teeth[19].

The reformatted panoramic view created from the axial view of the CBCT was selected to mimic the digitized two dimensional panoramic view and to facilitate the process of locating the region of interest and density comparison. Also the digitized panorama and the reformatted panoramic view of the CBCT share the same magnification level 1:1 avoiding view distortion by shortening or elongation.

The mean values of the HU for the D1 and D3 categories obtained from the CBCT agree with those obtained from the two dimensional digitized radiographic images with slight increase for the panoramic images without statistically significant differences. Also the mean values of HU for the D2 and D4 categories obtained from the CBCT agree with those obtained from the panoramic images with slight increase for the CBCT without statistically significant differences.

To the best of our knowledge the present research is the first to introduce a software that can read and display the HU from the two dimensional digitized panoramic radiographs. However the software may be useful in predicting the bone quality in HU from digitized panoramic radiographs during the treatment plan for implant placement before tacking the decision of CBCT.

However more further applications are needed with various types of digitized radiographs and different CBCT machines to verify the Visual Basic program.

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