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Radiological Assessment of Bone Morphology For Implant Treatment Planning: A Multidetector Computed Tomography Approach

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Abstract: *During last 15 years, Osseo integrated dental implants have significantly changed dental rehabilitation sciences. To assess these patients pre & post operatively, CT software programmes like Dentascan (GE medical Systems) or Syngo Dental CT (Siemens H) were developed that allow interpreting the patient jaws in all three conventional planes (e.g. Axial, Coronal and Sagital) as well as in panoramic and crossectional images as an additional. The purpose of this article is to familiarize the authors about the software programme and its application in implant dentistry practice.*

Keywords: *Dentascan, Implant Planning, Bone morphology*

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I. Introduction

Edentulism is a common cause for oral dysfunction affecting population of nearly all age group.[1] traditionally the treatment goal directed mostly to the achievement of aesthetics and were often associated with impaired masticatory function and speech difficulties.[1] The use of endosteal implant, since last two decades represent one of the most technological advances in the field of dental science in the rehabilitation of dental patients has shown increased popularity worldwide.[2,3]

Traditionally, diagnosis and treatment planning and post treatment evaluation of dental implant prosthesis was only directed toward conventional imaging modalities like intra oral periapical imaging, Panoramic imaging and conventional spiral imaging. These conventional imaging modalities were though readily available and inexpensive but met up with multiple disadvantages like lack of precision, dimensional errors, technique sensitivity etc. In recent years, computer-aided radiological methods like "Dentascan" have been revolutionized the process of diagnosis, operation planning and treatment in implant dentistry. Dentascan (GE medical Systems,) , introduced in 1980, is a CT reformatting programme that allows the maxillomandibular arches to be imaged in an additional panoramic, crossectional images along with axial, sagittal and coronal planes.[4] Transfer of the dental implant planning on the computer screen offers significant advantages such as enhanced visualization capabilities of the anatomical case, accurate measurements, data processing for optimum implant allocation and size selection and, as well as, an inclusive documentation of the patient treatment. The precision of this technology further allows a final prosthesis to be fabricated before implant placement that can then be delivered at the completion of the implantation procedure. Increased user interaction and responsibility for the evaluation of the results are still, nevertheless, present in these systems.

The purpose of this paper is to provide the readers with a comprehensive discussion about "Dentascan" as a computer-aided methodology that aims to a systematic dental implant planning approach based on appropriately processed multidetector Computed Tomography -data.

Technical considerations:

The acquisition of Dentascan is a compilation of multiple steps described as follows;

Patient positioning and Image acquisition: The patient is placed supine in the CT scan gantry minimizing the head movement. A lateral digital scout view (Fig 1) is first obtained to define the scanning range of the study and to determine the scanning plane is parallel to the alveolar ridge to be examined.

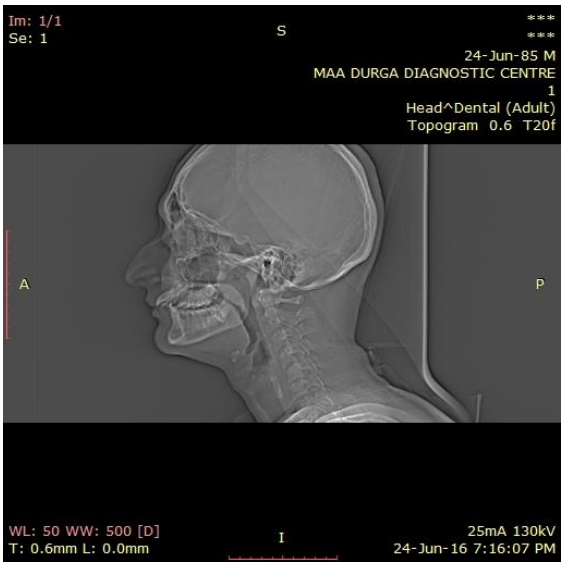

Figure 1: Lateral Scout View

The maxilla and mandible hence scanned separately. During scanning the pitch Configuration of Ct scan machine is kept in lowest so that the raw image overlap can be reduced to minimum. The axial raw images of the patient are obtained in 1mm to 0.625 mm interval (depending upon the Gantry configuration of the machine. The field of view is kept 15 cm to 18 cm in an image matrix of 512 X512.[1, 5] (Fig: 2, Fig: 3)

Figure: 2: Axial Raw Image for Maxilla

Figure 3: Axial Raw Image for Mandible

Reformatting:

The most acceptable axial images at the level of the root of the teeth and demonstrating full contour of the arch to be examined is then selected from the acquired raw images as a reference image on which the program will run.[1] Now a curved line is drawn on the axial image of the dental arch of interest along the middle of the arch by depicting the cursor at the arch at least six points. (Fig: 4)

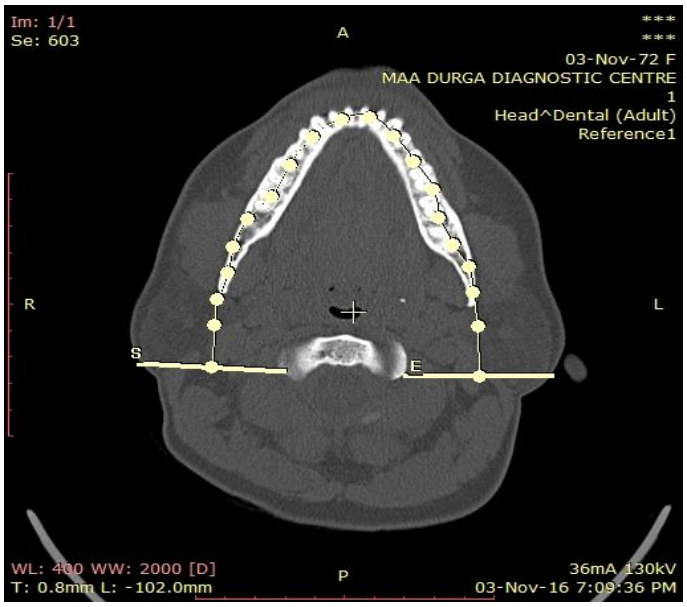

Figure 4: Curved Line Drawn Along the Midline of Mandibular Dentoalveolar Arch

This line represents where the centre panoramic view will be reformatted. Several other panoramic images are automatically reformatted by the software buccally and lingually to the centre image and the distances between the panoramic plane is determined by the software which is usually 2 mm. (Fig: 5)

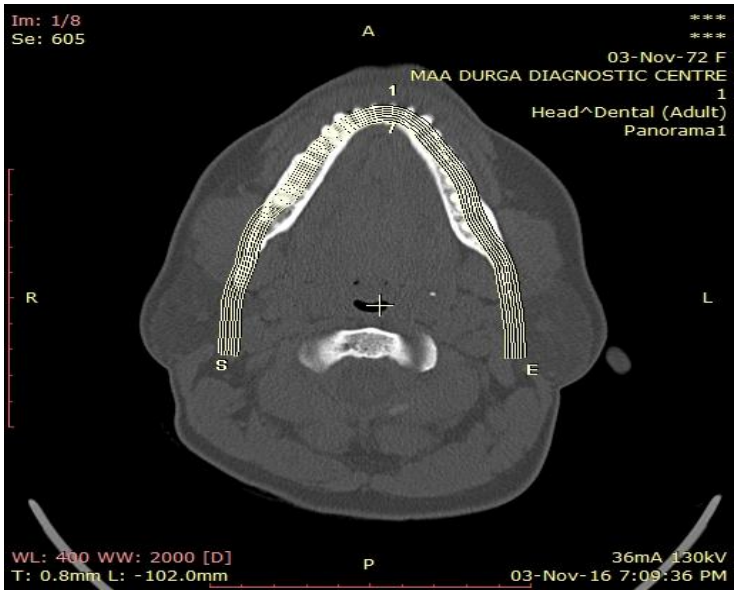

Figure 5: Multiple curved reformatted line to illustrate the panoramic images

Now the program automatically draws a series of multiple numbered line perpendicular to the curved line. These numbered lines represents where the numbered cross-sectional images to be reformatted (Fig: 6). To justify the position of each cross sectional reference line a number is assigned to each line and the same number correspond to the respective cross sectional image and the panoramic images.

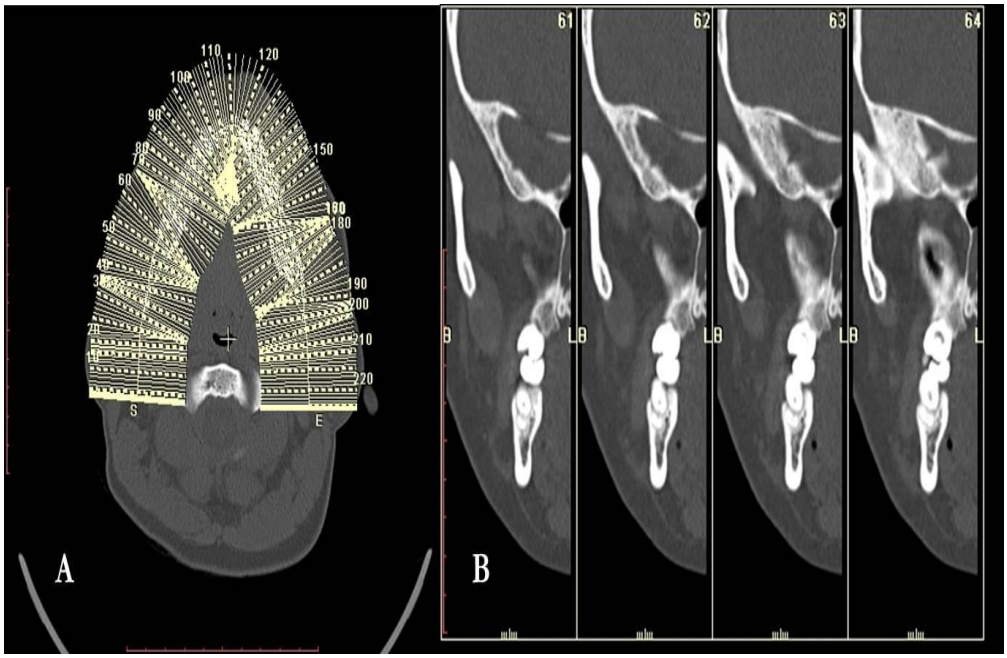

Figure 6: Reformatted Dentascan images; a. Axial image scout, b. Crossectional images with numerical.

The distance between the perpendicular line thus the cross-sectional images can be controlled by the radiographer, however it is typically kept 2 mm.[1,5] the number along the bottom of the panoramic images corresponds to the numbered perpendicular line thus to the numbered cross sectional images. The scale along the side of the panoramic images corresponds to the numbered transverse images that are used to reformat the panoramic view.

Interpretation of Dentascan:

While interpreting the dental CT scan the interpreter should first go through the axial raw images taken by the machine to have an overall idea about the conditions of the jaws. Then the interpreter concentrate on the axial image scout in order to find out the crossectional images of interest. A CT scan window of 3000 HU to 4000 HU and level of 300 HU to 500 HU are typically used. The process of interpretation of Dental Ct scan however, can broadly be classified in three steps;

a. Identification of the anatomical landmarks
b. Quantitative assessment of the dentoalveolar ridge
c. Qualitative assessment of the dentoalveolar ridge

A. Identification of anatomical landmarks;

The interpretation of dentascan images first starts with identification of the anatomical landmarks. The important anatomical in maxilla for implant placement are; (Fig: 7)

- The floor of the maxillary sinuses.
- The floor of the nasal fossa.
- The crest of the alveolar bone.
- The buccal and lingual cortical plates of alveolar bone.
- Nasopalatine canal.

The important anatomical landmarks for mandible includes; (Fig: 8)

- The inferior dental canal.
- The crest of the alveolar bone.
- Lower border of mandible
- The buccal and lingual cortical plates.
- The lingual foramen.
- The mental foramen.

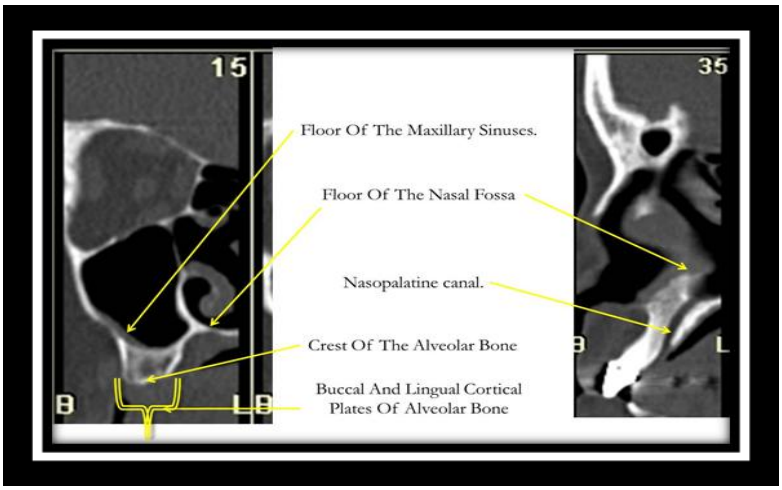

Figure 7: Important anatomical landmarks of maxilla.

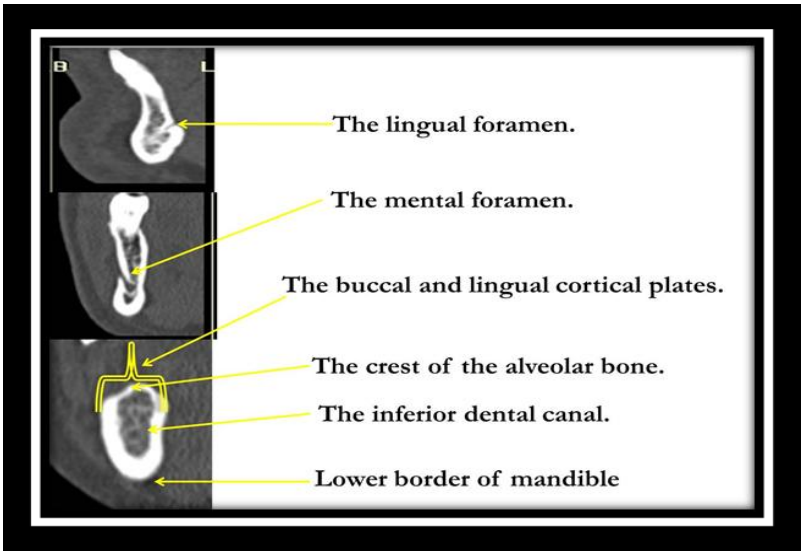

Figure 8: Important anatomical landmarks of mandible.

It is important to identify and annotate the anatomical landmarks in the reporting film to help the implantologists to identify them and thereby avoid unintentional accident during implant surgery.

B. Quantitative analysis of the jaws.

Quantitative analysis of the jaws includes the assessment of height & width of the alveolar bone.

Assessment of height of the alveolar bone:

During quantitative assessment first the height of the alveolar bone is assessed in each crossectional images as it determines the length of the implant to be placed in. In maxilla, the height of the alveolar bone in the posterior aspect of the arch is measured from the top of the crest of the alveolar bone to the floor of the respective maxillary sinuses. As the analysis goes more mesially the height becomes less confined by the maxillary sinus and is measured from the alveolar crest to the nasal fossa.(Fig: 9) In the mandible, the height of the alveolar bone in the region distal/ posterior to the mental foramen is measured from the top of the crest of alveolar bone to the respective ID canal. In the region mesial/anterior to the mental foramen, the height of the alveolar bone is measured from the crest of the alveolar bone to the inferior border of mandible. (Fig: 10) Assessment of the width of the alveolar bone; Once the height of the alveolar bone is identified the assessment of the width of the alveolar bone is assessed as it determines the diameter of implant. The width of the alveolar bone is assessed near the top of the alveolar process. Occasionally, it may become difficult as the ridge may end at the crest as pointed secondary to atrophy and resorption. It is advisable to mark that findings in the report and start the measurement at about 1 mm bellow the alveolar crest in order to make it easier to interpret both clinically and radiologically. While measuring the width of the alveolar bone the measurement should be taken from the outer cortex of the either side of the cortical bone. (Fig: 9 and 10)

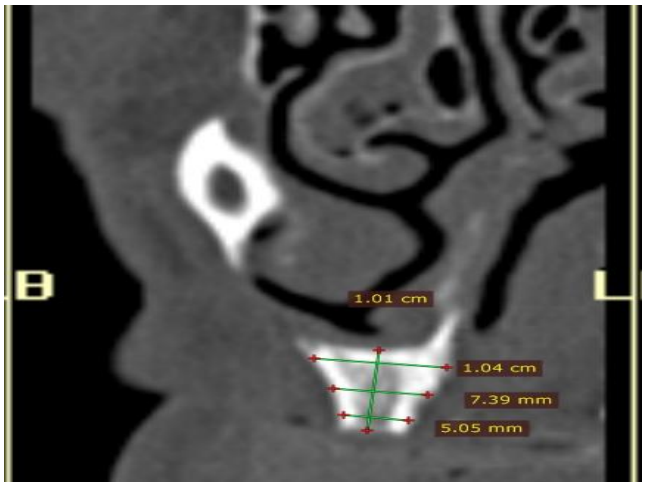

Figure 9: Height and width measurement for maxilla.

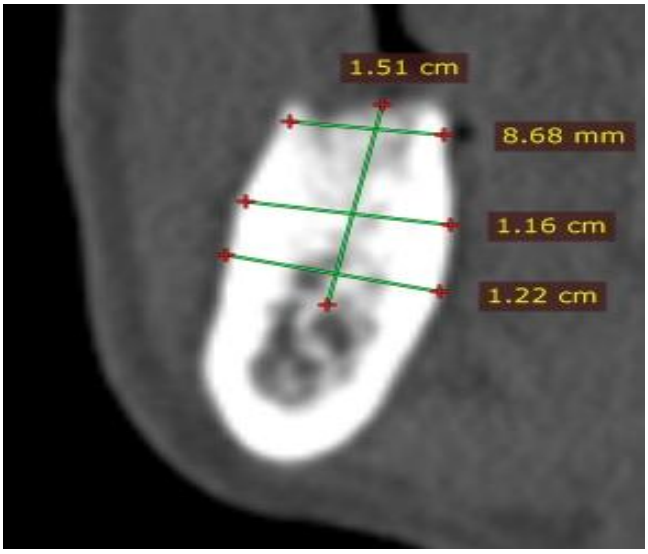

Figure 10: height and width measurement in mandible

C. Qualitative Assessment Of The Jaws;

The qualitative assessment of the jaws is mainly dedicated to the assessment of density of alveolar bone. The density of dentoalveolar bone is a determining factor in treatment planning, implant design, surgical approach, healing time as well as successful Osseo- integration of the implant prosthesis.[6] Some authors believe bone density to be the most significant factor while other suggest that the combination of volume and density is a better predictor for implant success.[7] It is been proven in the medical literature that the bone density varies in different portion of dental arch.[6,8] techniques such as histomorphometry of bone biopsies, or densitometry, quantitative ultrasound, dual photon absorptiometry, qualitative computed tomography although reliable yet not feasible in routine dental implant practice.[8]

As CT images are displayed as a matrix of individual boxes called as Voxels(Volume elements), each of them are characterized by a numerical value that reflects the X- ray beam attenuation, which is mainly affected by the density of the tissue and its thickness.[9] This is called the CT number and is expressed in Hounsfield's unit (HU). This X- ray attenuation unit characterizes the relative density of a substance.[10] So variability of bone density in the dentoalveolar arches can possibly be best assessed in implant practice by determining the beam attenuation coefficient values expressed in Hounsfield's Unit.[3,8] Misch have categorised dentoalveolar bone based of HU values in five categories as D1: > 1250 HU, D2: 850-1250 HU, D3: 350 – 850 HU, D4: 150 - 350 HU, D5: < 150 HU; where D1 represents the maximum density and D5 the minimum.[6,8, 11]

Formulation of Report:

Based on the feature available in dentascan images the maxillofacial radiologist should formulate a complete and well formulated report making interpretation easy for the referring dental surgeon.[1] It should contain the detailed information about the bone morphology in the site/s were implant prosthesis are to be

planned as well as it should contain a consisted information about the general health and density of the jaw bone, as are such conditions as sinus diseases, periodontal and periapical conditions of the jaws, state of dentition. The measurement of the jaws should be provided in a tabular fashion stating the reference cross-sectional image number. If radio-opaque markers are used then it should be noted in the report and marked accordingly. **Table 1** and **2** represent implant reporting formats of dentascan report for either the jaws.

Table 1: implant reporting format for maxilla.

Cross Section no (Distance between each cross section is 1 /2 mm	Distance from maxillary sinus/nasal floor to the crest:	Radiographic Ridge angulation	Bicortical distance (from crest)		Bone density (D1 – D5)	Respective tooth region	Marker no. (If any)
			Distance from the crest	Bicortical distance			
			1 mm				
			3 mm				
			5 mm				
			7 mm				
			9 mm				
			11 mm				
			13 mm				
			15 mm				
			17 mm				
			19 mm				
			21 mm				
			23 mm				

Table 2: implant reporting format for mandible.

Cross Section no (Distance between each cross section is 1 /2 mm	Distance from Inferior dental canal /lower border of mandible to the crest:	Radiographic Ridge angulation	Bicortical distance (from crest)		Bone density (D1 – D5)	Respective tooth region	Marker no. (If any)
			Distance from the crest	Bicortical distance			
			1 mm				
			3 mm				
			5 mm				
			7 mm				
			9 mm				
			11 mm				
			13 mm				
			15 mm				
			17 mm				
			19 mm				
			21 mm				
			23 mm				

II. Conclusion

Successful implant imaging must be individualized to the particular needs of each patient. Technological advances have resulted in the development of clinically relevant new CT techniques like Dentascan which can provide more precise information than conventional radiographic techniques so that the patient is placed at minimal risk in the reconstruction of completely or partially edentulous jaws.

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