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Assessing the Amount of Residual Bone after Loss of Teeth through Dental CT for the Needs of Dental Implantology

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Abstract: ***The rapid development of dental implantology in recent years made the use of CT preoperative study a common practice. The establishment of sufficient amount of residual alveolar bone for the needs of successful osseointegration of endosteal implants is important part of the preoperative study. It is also important for making a final decisionwhether bone augmentation is really needed when large or complex bone defects are present in the jawbone. After analyzing preoperative Dental CT skenogramms of 292 jaws in our retrospective study, we found that in 48% of the cases there was a sufficient amount of residual bone, and in 52% of the cases there was a need for bone augmentation present.***

Keywords: bone augmentation, CT examination, Dental CT, dental implants, residual bone level

1. Introduction

Alveolar bone is one of the solid structures of the periodontium. It represents this part of upper and lower jawbone, which surrounds teeth in bed-like sockets and serves for their attachment. Periodontal ligaments are being inserted and attached to the surface of alveolar bone. [1]

According to Peneva M. et al., alveolar bone formation and development starts and continues parallel to root formation during the process of tooth eruption. Even after eruption, the alveolar bone continues to remodel, thus enabling this tissue to respond adequately to situation changes such as all kinds of physiological, pathological and orthodontic movements of the teeth. All elements of periodontium are being interrelated, interdependent and function simultaneously.

Alveolar bone exists only in order to maintain the teeth and its development and levels depend entirely on the presence of teeth. Alveolar bone initially develops to keep and protect the soft tooth germ and finally it provides the tooth eruption. Complex and dynamic changes occur in alveolar jawbone during the physiological change of primary with permanent dentition. As the child grows older, during the transition to adolescence, net-like bone structure is being gradually replaced by highly organized lamellar bone / built of secondary osteons /. With the loss of teeth, alveolar bone is being resorbed. Teeth are the major cause not only for the development but also for the state and level of the alveolar ridge. Levels of resorption after tooth loss are higher for lower jaw. [1]

Jawbone undergoes resorption not because of the pressure applied, but because bone suffers from malnutrition, combined with disturbed venous drainage. The masticatory pressure usually stimulates bone formation. Therefore, the reduction in bone volume is not due to masticatory pressure applied, but due to individual factors such as lack of intraosseous blood drainage to the gingival blood vessels that affects the periosteal regeneration.

Mandibular artery is more susceptible for atherosclerosis and partial occlusion of the branches than other arteries. According to Bradley JC, arterial occlusions are more frequent after extraction of teeth. Usually the mandibular artery suffers atherosclerosis about 15 years earlier than the large carotid artery does. Therefore, the central blood supply of the mandible will be considerably reduced, particularly in terms of advanced bone resorption. [7] According to Mercier P and Vinet A, after loss of teeth, the bone-stimulating effect of masticatory forces around the tooth roots disappears and alveolar regions of the jaws gets susceptible to atrophy due to lack of exercise and loading. The reason why blood supply to the mandible is being greatly reduced is that after loss of teeth there are no drainage pathways left. When teeth are present, the mandible`s blood flow is distributed between the roots of teeth and the periodontal ligaments, which require large amounts of blood to maintain local immune system and feed the tissue. This blood is drained through subperiostal veins. After loss of the last tooth, bone closes and venous stasis occurs in the mandible. The last available pathway for venous drainage is now in the mental vessels, which are usually too tight. [7, 10]

Yaffe A et al. show us evidence for the link between bone volume and disturbances in the venous drainage, based on experiment for mobilizing mucoperiostal flaps in rats` mandibules. He found that the resorption of internal bone structures is due to venous drainage disturbances, which reduce the adequate blood supply and thus lead to malnutrition of the bone [12].

Atrophy of the alveolar ridge is a typical consequence of edentulism. Due to the fact that the total height of the alveolar processes of both jaws may be more than 4 cm, severe atrophy can be up to 1/3 of the face height of the patient and thereby a considerable excess of soft tissues can appear. Cawood and Howell describe and classify the loss of alveolar bone volume in their anatomical studies. Their classification may be easily applied to evaluate the results of

Dental CT, because of the perfect representation of alveolar ridge by para-axial images. [9]

These 6 degrees of bone resorption represent the typical look of jawbone atrophy after loss of teeth. (Fig.1)

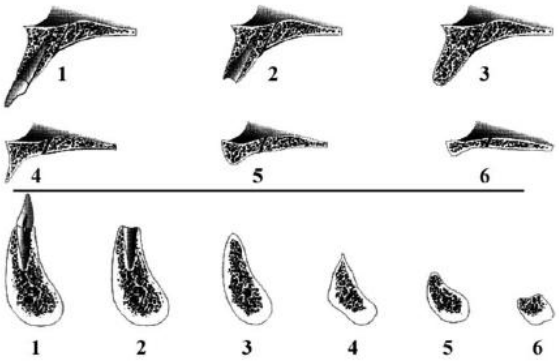

Figure 1: Levels of bone resorption after teeth loss by Cawood and Howell. Edentulism in the frontal region of the upper jaw and in the region of second mandibular premolar. [9]

In general, bone reduction after tooth extraction (class 2), continues until alveolar ridge starts to mimic the blade of a knife (class 4). If atrophy continues, bone loss begins within the height of the jawbone until there is only the body (base) of the bone left (class 6). Although atrophy is known to be a continuous process, it may sometimes skip some of the phases. For example, class 2 can directly be transformed into class 4 due to the loss of buccal cortical bone (juga alveolaria), resulting in the formation of alveolar process shaped as the blade of a knife.

2. Material and Method

Within our retrospective study in Department of digital imaging MMA Sofia, for the period from 2001 to 2006, 292 jaws of 233 patients were examined through Dnetal CT scenogramms. 143 of the jaws examined were of female patients and 149 were of male patients (the study is representative for both sexes). Jaws were tested by 25 separate criteria and by a combined criterion (age + gender). The aim was to create a mathematical model for predicting the risk level of an early compromise of endosteal implants, on basis of objective information extracted from preoperative Dental CT scenogramms.

An important part of the study was to determine the amount of residual bone in the zone of interest in cases, in which there was not enough bone for successful osseointegration of endosteal implant and thus to determine whether surgical bone augmentation is needed.

According to Abrahams JJ candidates for placement of endosteal dental implants are being tested prior to surgery in order to determine whether there is sufficient bone in the alveolar ridge for receiving and integrating the metal implant [6]. The amount of bone varies over a wide range due to the fact that in toothless areas jawbone resorbs due to atrophy.

If there is enough bone for placing the implant, a few parameters should be measured. These include the width of the alveolar ridge and the distance from the crest of the alveolar ridge to: foramen mandibularis, canalismandibularis, foramen and canalisincisivum and the floor of the maxillary sinuses. [2] Damaging these structures during surgical manipulation can lead to significant complications. The distance between the cervices and the roots of neighboring the toothless section teeth, as well as the angle between the jaw and the vertical should also be measured.

In their studies Cavalcanti MG, Murakami K and Abrahams JJ claim that *Ifthere is an insufficient amount of bone* in the toothless section of the upper jaw, Dental CT is being used for planning sinus-lifting procedures, postoperative control and monitoring of periodontal parameters [3, 4, 5, 8, 11].

3. Results and Discussion

1) Quantity of available bone

a) height of the alveolar ridge / middle value- 12 mm

The height of the available bone is directly related to the length of choice for the respective endosteal implant. For the maxilla, this height is being measured from the crest of the alveolar ridge, or edge of residual bone in the area of interest, to the floor of the corresponding maxillary sinus or bone of the lower nasal passage. For the lower jaw we have measured the height from the crest of the alveolar ridge to the ceiling of the mandibular canal or to the lower edge of the body of the mandible in the mental region. Fig.2

In the presence of additional vascular channels in the frontal zone of the mandibule, height is being measured from the crest of the alveolar ridge to the additional vascular channel.

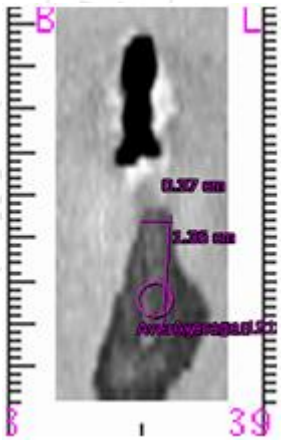

Figure 2: Para-axial image of the lower jaw at the level of the left foramen mentale, using pre-placed surgical guide in the mouth. Measurements were made for finding the vestibulo-lingual width of the bone, the height of the crest from the alveolar ridge to the ceiling of the mandibular canal and the average CT density of the cortical bone in the region of interest.

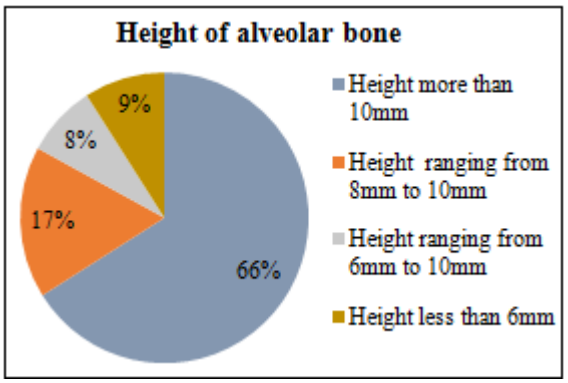

Diagram 1

From the distribution of cases (Figure 1), it is clear that there are 83% of the jaw portions within the area of interest with sufficient height of the alveolar bone. This height is below 8 mm in only 17% of the cases. In 9% of the cases, the height of the alveolar bone is less than 6mm, which is critical for the purposes of successful osseointegration of endosteal implants.

b) width / vestibulo-lingual size / - 5.7 mm in average.
The width of the alveolar ridge or residual bone determines the choice of implant diameter, aiming not to compromise the vestibular, lingual or palatal cortical bone of the jaws. The measurement is being made at the exact point of placing the implant.

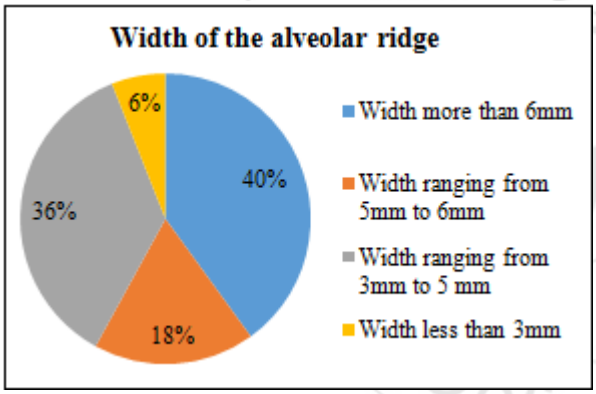

Diagram 2

58% of the patients being examined had more than 5 mm width of alveolar bone, which is sufficient for introducing an implant with a relatively large diameter. Only 6% of examined patients had vestbulo-lingual size of jawbone less than 3 mm.

c) The quantity of bone
To determine the quantity of the present bone we used the six-grade system of Cawood and Howell for evaluating bone resorption after edentulism:
1 = preserved alveolar ridge
2 = moderate, mild resorption
3 = advanced resorption of bone, reaching the bone`s basis
4 = partial resorption of bone`s basis
5 = bone defect in the region of interest
6 = severe resorption of bone`s basis

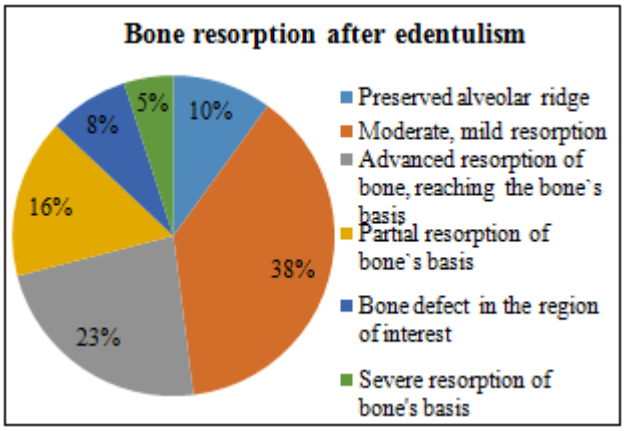

Diagram 3

In 23 of the cases there was a lack of normal bone and a defect present in the zone of interest; in 30 cases there was a preserved alveolar ridge (i.e. CT shows no bone resorption); in 110 of the cases we found moderate resorption of the alveolar ridge; in 67 cases we have diagnosed advanced resorption to the base of the bone; in 46 cases - partial resorption of bone basis; in 16 cases - severe resorption of bone base.

1. Presence or absence of bone defects
Bone defects vary in number, type, size and complications. /Fig.3 / Imaging diagnosis of bone defects was expressed through numbers from 0 to 4, concerning the number and the size of defects; in the bone defect area - 3 (when we have uncomplicated "young" bone defect) -4 (for "old" and complicated bone defect).

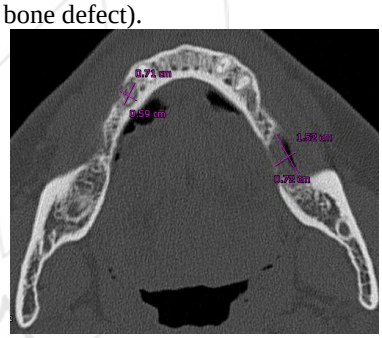

Figure 3. An axial cut at the level of the alveolar ridge of the mandible. A large uncomplicated bone defect in the area of tooth 36 and 37 and smaller in volume tetrahedral postextraction bone defect in the area of tooth 44, filled with hyperdense amorphous mass / bone void filler / after bone augmentation procedure.

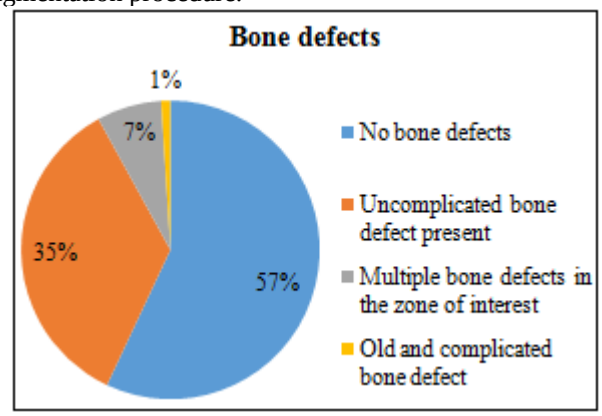

Diagram 4

At the time of this study bone defects were present in 128 cases and in 26 of them they were large enough to require bone augmentation.

3. The need for bone augmentation

The choice of an actual endosteal implant / system and size / directly depends on the amount of available bone. The prosthodontic treatment plan depends on the type, number and current condition of the implants. Bone augmentation gives us a surgical solution when there is insufficient amount of bone present by using different bone void fillers, substances with osteoinductive properties and different types of bone grafts.

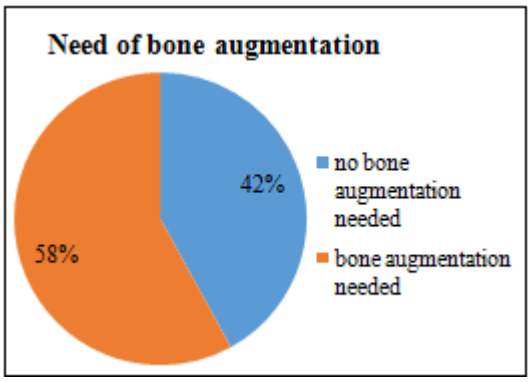

Diagram 5

According to our results, surgical bone augmentation was a needed in 159 cases and in 17 of them it was absolutely necessary.

Dental CT is also being used to assess the condition of the bone, following a bone augmentation through a sinuslift procedure. It is also important to evaluate the homogenicity of the bone void fillers placed and the lack of pores (areas with soft tissue density, seen among hiperdensive bone void fillers. (Figure 4 /a, b, c)

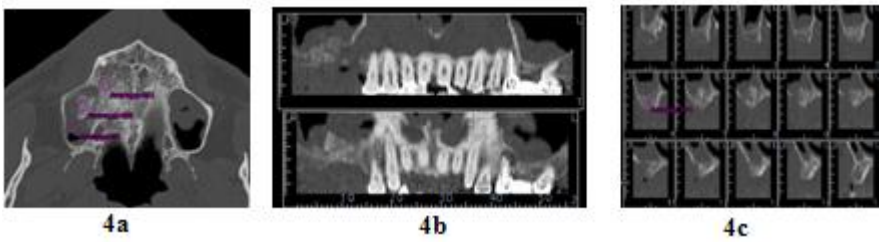

Figure 4 a / An Axial cut at the level of the maxillary sinuses and **b, c** / A panoramic and a para-axial reconstruction with Dental CT, showing condition after sinuslift procedure for treatment of unlimited distal defect on the right. At the level of tooth 16, the substitute bone looks like a group of multiple granules with hyper-density and many areas with soft- tissue- density between them. At the level of tooth 17, the substitute bone has the look of a compact mass, associated with the cortical bone at the floor of the sinus. The appropriate positions for the introduction of endosteal implants are positions 15 and 17.

4. Implications

Assessing the degree of bone resorption is important part of the preoperative planning in dental implantology and has influence on the choice of type and number of implants to be placed. It is also used for planning the most proper surgery manipulation for increasing bone level such as sinus lift, surface or lateral bone graft. These surgical methods are used to increase the amount of bone available by supplementing its own bone or by using artificial bone substitutes. [2]

The exact representation of location, shape and size of the bone defect, the exact dimensions of residual bone in the zone of interest and proper dimensional orientation is of great importance for the surgeon in the preoperative phase. This important information can be obtained quickly and easily using preoperative Dental CT study and this makes it an indispensable part of the preoperative planning in dental implantology.

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