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Assessment of the Quality of Residual Alveolar Bone after Edentulism, Based on Dental CT Imaging 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 part ofdetailed operational planning. Establishing the quality of residual alveolar bone in the area of interest, for the needs of successful osseointegration of endosteal implants, is an important part of the preoperative study . In the presence of an active bone transformation in the zone of interest, severe osteoporosis zones or such, combining osteoporosis and condensing osteitis, might be present, leading to higherrisk ofearly compromise of endosteal implants. After analyzing preoperative Dental CT skenogramms of 292 jaws in our retrospective study, we found that in 55% of the cases, the quality of jawbone was appropriate for successful osseointegration process. In 38% of the cases there were osteolytic bone defects and in 21% - osteosclerotic condensing osteitis bone defects present in the area of interest.***

1. Introduction

Accordingto Lekholm and Zarb, bone quality is crucial for successful placement of endosteal implants. [7] Bone quality is categorized into 4 types for the purposes of the preoperative planning. These types describe the relativity between cortical and spongy bone in certain jaw bone regions (Figure 1).

Figure 1: Schematic representation of the four types of residual bone according to Lekholm & Zarb: Type I – Thick cortical bone combined with normal mineral content in spongy bone; Type II – normal (intact) cortical and spongy bone; Type III – Thinned cortical and normal (dense) spongy bone; Type IV - Highly thinned cortical bone and osteoporotic spongy bone [7].

The primary stability of the implant depends on the amount of cortical bone, while bone`s quality is being important for the long-term stability. However, type I does not imply optimum stability of the implant. Studies of RA Jaffin, CL Berman and MR Norton, C Gamble show that types II and III give the best results in terms of long-term stability, and that type IV is most commonly associated with early loss of endosteal implants[6],[9].

One must have in mind that bone is alive and plastic, while assessing the "quality" of the bone and predicting the risk level whenplacing endosteal implants. Bone is capable of various forms of reconstruction and most of them represent adjusting reactions. They occur in response to changes in the normal biological, biophysical and biochemical environmental conditions (changes in functional load, different pathogens` activity or trauma)[1].

The reactive transformations in bone tissue might beof an early or of late type.

The impaired metabolic exchange of bone tissue is an example for an early type of transformation. Morphologically, it is expressed by disappearance of fine histological structure of the bone /micro-architecture disorders and changes in minerals distribution /. If the effect of pathogens `activity is not long-term and it lacks significant intensity, the earliest forms of reactive changes disappear quickly and without a trace and bone structure is being restored to normal. Disorders in mineral exchange are also easily reversible.

Destructive dystrophic changes, occurrence of various types of bone resorption / cellular or acellular osteolysis / and activation of the osteoplastic function of osteogenic cell elements are all examples for late type of reactive bone transformations [1].

Bone destruction and osteolysis are being compensated by the process of bone formation. After reorganization, the ordinary course of both reactive processes, leads to the restoration of bone structure in a newform, most suitable for normal physiological functions of bone in the newly-met biological conditions.

In cases, in which the impact of the pathogen exceeds the adaptive capacity of bone, a state of decompensation occurs. It consists of disrupting the normal process of osteogenesis and leads to various types of pathological bone reconstructions. Often the processesof bone destruction and osteolysis prevail over osteogenesis.

The osteogenic processes aim at normalization of bone structure and start from specific areas,which bone needs intact for to meet the functional requirements of the body [1].

If the amount of residual bone in the edentulous region of interest is insufficient, Dental CT is being used forbone augmentation procedures planning, monitoringof their effectand of actual periodontal parameters. When there is a

sufficient amount of residual bone present in the region of interest, Dental CT gives valuable information about the quality of the bone. These conclusions are according to MG Cavalcanti, K Murakami and JJ Abrahams [2]-[5], [8].

2. Material and Method

Within our retrospective study in the Department of digital imaging MMA Sofia, for the period from 2001 to 2006, 292 jaws of 233 patients were examined through Dental 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 quality of residual bone in the area of interest.

3. Results and Discussion

- **Average CT density in the spongy bone**

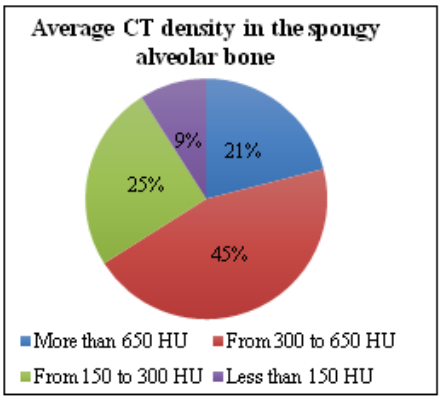
Physiological reconstruction of bone tissue is due to continuous chain of opposing processes of construction and destruction. Successful osseointegration of endosteal implants depends on the intensity of physiological bone reconstruction and the level of mineral exchange in the body.

In period of body growth the crystalline/amorphous form of calcium ratio is 1/2. On the opposite, in elders 2/3 of calcium is in crystalline and 1/3 is in amorphous form.

The variable relationship between parathyroid hormone and calcitonin determines the metabolism of calcium, regulates its constant levels in blood serum and influences the reconstruction of bone tissue.

The measurement of the average CT density in the spongy alveolar bone is a way to objectively measure the bone mineral content. We measured CT density (HU) in the area of interest (planned for placement of endosteal implant). For the patients we examined, the average CT density was 440 HU.

Diagram1

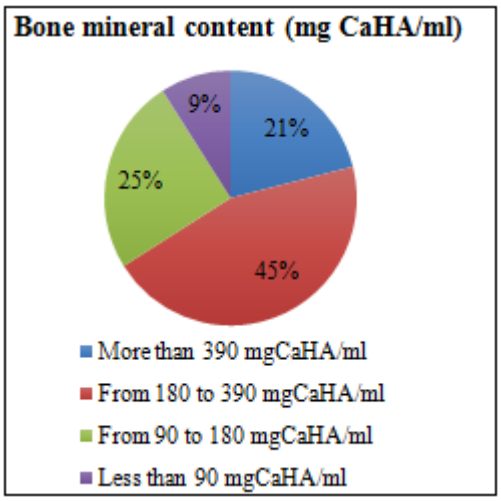


130 of the patients, or 45%, show normal values of average native CT density of the spongy bone - from 300 to 650 HU. Only 9% of all patients had a mean density of spongy bone below 150 HU, indicating grave osteoporotic transformation of the bone in the area of interest.

- **Bone mineral content (mg CaHA/ml) -**

Median native CT density of spongy bone was calculated using a mathematical model for calculation of the mineral bone content, implemented in QCT. The result is measured in mgCaHA/ml.

Diagram 2

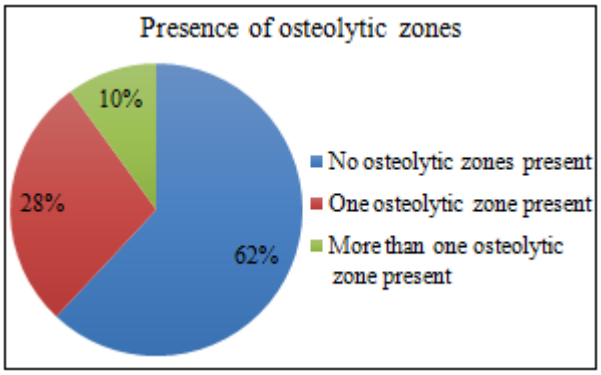


We have measured the mineral content in the examined bone by the mean values of native CT density of the spongy bone. For this reason, the chart of distribution, the mineral-weight coefficients and the participation in the resulting formula are similar.

- **Presence of osteolytic zones**

Osteolytic zones are the cause for unsuccessful osteointegration processes. Osteolytic defects are filled with granulomatous tissue, fibrous tissue or epithelium. Their CT density is equivalent to soft tissue density. There is usually a zone of perifocal osteosclerosis, which is additional reason for unsuccessful osteointegration.

Diagram 3



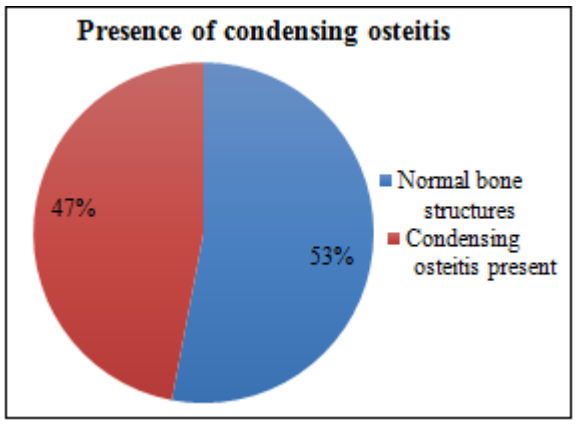
In 180 of the examined patientsthere were no osteolytic zones present in the area of implant placement. In 112 of the patients examined there were one or more osteolytic zones

in the area of interest. These cases require precise sanation of bone prior to endosteal implants placement.

- **Presence of osteosclerotic thickening of bone (condensing osteitis)**

Condensing osteitis is a common outcome of diseases responsible for edentulism. It is due to reparative processes in bone, taking place in close proximity with chronic infectious process. These reparative processes lead to accumulation of greater than normal amount of minerals in the organic matrix. This results inlocalized osteosclerotic changes, usually being well definedfrom the surrounding sound bone structures. There are enough reasons to consider that osteointegration of endosteal implants in osteosclerotically altered bone is compromised.

Diagram 4



In 148 of the cases, there were osteosclerotic zones present. They are probably due to some inflammatory processes. They were well demarcated from the surrounding sound bone, without showing any signs for osteoplastic tumor processes present. In 19 of these cases, the zones with condensing osteitis had large dimensions.

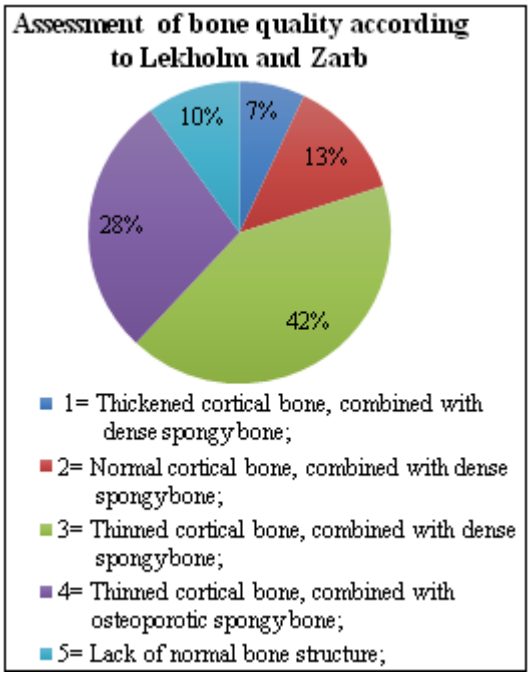
- **Assessment of one quality according to Lekholm and Zarb**

To determine the bone quality, we used the pattern of Lekholm and Zarb, and we even modified it by adding a new 5thdegree, including cases, in which the area of interest lacks normal bone structure. The modified pattern looks as follows:

1= Thickened cortical bone, combined with dense spongy bone;
2= Normal cortical bone, combined with dense spongy bone;
3= Thinned cortical bone, combined with dense spongy bone;
4= Thinned cortical bone, combined with osteoporotic spongy bone;
5= Lack of normal bone structures;

According to Lekholm and Zarb, bone types II and III are most appropriate for successful osteointegration processes of endosteal implants. The presence of residual bone from type I and type IV increases the risk of early compromise of endosteal implants.

Diagram 5



Thickened cortical bone, combined with dense spongy bone we found in 20 of the cases, or 7% of all cases. Cortical bone with normal structure, combined with dense spongy bone we found in 38 of the cases, or 13%. In the majority of cases, 122 in number or 42% of all cases, thinned cortical bone was combined with dense spongy bone. In 82 cases, or 28% of all cases, thinned vestibular cortical bone was combined with osteoporotic spongy bone. In 30 cases, or in 10% of all cases examined, there was a lack of normal bone in the area of interest.

The large number of patients with irrelevant bone quality for the purposes of successful osteointegration of endosteal implants we found within our studyproves the importance of preoperative CT study. In cases with insufficient amount of residual bone or in cases with inadequate bone quality, a thorough preoperative preparation is needed, often includingsurgical procedures forbone augmentation.

References

[1] Сиповский П.В., Компенсаторние и реактивние реакции костной ткани.
[2] Abrahams JJ, Hayt MW, Rock R. Sinus lift procedure of the maxilla in patients with inadequate bone for dental implants: radiographic appearance. AJR Am J Roentgenol 2000; 174:1289-1292
[3] Abrahams JJ. Augmentation procedures of the jaw in patients with inadequate bone for dental implants: radiographic appearance. J Comput Assist Tomogr 2000; 24:152-158.
[4] Abrahams JJ. CT assessment of dental implant planning. Oral Maxillofac Surg Clin North Am 1992; 4:1-18.
[5] Cavalcanti MG, Yang J, Ruprecht A, Vannier MW. Validation of spiral computed tomography for dental implants. DentomaxillofacRadiol 1998 Nov; 27(6):329-33.

[6] Jaffin RA, Berman CL The excessive loss of Branemark implants in type IV bone: a 5 year analysis. J Periodontol 1991; 62:2–4
[7] Lekholm U, Zarb GA Patient selection and preparation. In: Branemark PI, Zarb GA, Albrektsson T (eds) Osseointegration in clinical dentistry. Quintessence, Chicago, 1985; pp 199–209
[8] Murakami K, Itoh T, Watanabe S, Itoh T, Naito T, Yokota M. Periodontal and computer tomography scanning evaluation of endosseous implants in conjunction with sinus lift procedure. A 6-case series. J Periodontol 1999 Oct;70(10):1254-9.
[9] Norton MR, Gamble C (2001) Bone classification an objective scale of bone density using the computerized tomography scan. Clin Oral Impl Res 12:79–84

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