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Radiographic evaluation of bone density around immediately loaded implants

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SUMMARY

Understanding the changes in bone density after insertion of dental implants and their relation to immediate loading is essential to achieving improvements in their survival rate. Histological investigations of the bone bed in humans are limited, which in turn hampers opportunities to deepen knowledge about the remodelling process around dental implants. The aim of the present study was to follow the change in bone density by measuring the grey values of cone beam computed tomography (CBCT) at different periods subsequent to implant insertion.

The CBCTs of 20 individual immediately loaded implants were evaluated at three time points: prior to surgery, one month following, and six months after the operation. The grey values were measured at different regions around the implants.

Reduction in the grey values was observed with respect to the reference values after one month and six months from implant insertion in the apical, middle, and cervical regions. No correlation was detected either between the change in grey values and drilling method or with the measured primary and secondary stabilities by Osstell ISQ instrument.

Cone beam computed tomography can be used as a qualitative method to support clinical follow up and monitor the changes in bone density around implants in critical cases.

1. Introduction

The clinical application of the concept of osseointegration introduced in the mid-sixties soon showed predictable long term success (Lindquist et al., 1996). Nowadays, the use of implants is even popular in the replacement of a single missing tooth (Belser et al., 2004). In several studies, immediate or early loading of dental implants has shown a high implant success rate and improvement in bone formation around the implants (Cochran et al., 2002; Stavropoulos et al., 2008). Regardless of protocol, i.e. delayed or immediate loading, the development of osseointegration as defined by Brånemark et al. (1985) is a major factor determining clinical success after implant placement.

Clinical and histological studies have shown that immediate loading of dental implants is a useful and viable option beside the classical conventional loading protocol (Degidi et al., 2005, 2008; Degidi and Piattelli, 2003; Meyer et al., 2004; Proussaefs et al., 2002; Rocci et al., 2003; Testori et al., 2001, 2002). However, a thorough understanding of the early osseointegration phases could provide an additional basis to support the extended use of immediate loading therapy (Abrahamsson et al., 2008).

The ideal goal of a radiographic examination is to achieve as much information as possible about the jawbone while minimising the radiation burden to the patient according to the ALARA principle (as low as reasonably achievable) and the costs.

Cone beam computed tomography (CBCT) is a relatively new imaging technique which produces similar three-dimensional

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images to computer tomography (CT) but at lower radiation dose and lower cost (Bianchi and Lojacono, 1998). Moreover, the typical radiation artefacts of CBCT are much less in comparison to spiral and multi-slice CT.

There have been several approaches to study bone reaction and healing around dental implants. These studies are mostly based on experimental and histological investigations on animals (Barone et al., 2011; Mano et al., 2011). The lack of histological investigations in humans makes understanding of the healing processes of the bone around dental implants difficult. One possible approach is to follow-up the change in bone density based on the Hounsfield units of CT or the grey levels of CBCT. The frequent exposure of the patients to CT increases the risk of overdoses of radiation, which is the main reason for the limitation of the use of CT for monitoring the change in bone density.

Hence, it was the aim of this study to follow the changes in bone density around immediately loaded dental implants using the available CBCT data of 20 patients and thereby introduce it as a possible method for evaluating whether the bone density prior to implantation can be an indicator for use of an immediate loading protocol.

2. Materials and methods

Twenty patients at the Department of Oral Surgery, Medical University of Wroclaw, Poland who desired individual implant therapy to the upper anterior or premolar region were selected for this study (12 males and eight females). The width of the alveolar ridge in such patients was greater than 5 mm at its narrowest point, the mesio-distal distance was at least 6 mm. Site exclusion criteria were; severe periodontal disease with the need to perform an open or closed sinus lift or major grafting procedure. If a bone defect was confirmed during the implantation in the marginal region of the alveolar ridge (2–3 mm), an augmentation procedure was carried out using xenogeneic bone substitute material or synthetic material depending on the material chosen by the patient. Exclusion criteria also included poor general health, e.g. severe renal or liver diseases, history of radiotherapy in the head region, uncontrolled diabetes, recent infarction, haemophilia, bleeding disorders or cumarin therapy, metabolic disorders, signs of chronic bone disease and bruxism.

The average age of the patients was 33 ± 7 years (Table 1). All patients received tioLogic© implants (Dentaurum Implants GmbH, Germany). This implant system has fine threads at the cortical bone region, which are supposed to improve the primary stability of the implants during the healing period. Implant insertion was combined with augmentation for ten patients. The type of the augmentation materials is listed in Table 1. The primary and secondary stabilities of the implants were measured immediately after implant insertion and before the insertion of the permanent restoration (after six months), respectively. The stability was measured using Osstell ISQ Instrument (Osstell AB, Göteborg, Sweden).

The patients were fully informed about the study and frequency of the exposure to radiation. This study was approved by the ethics committee of the University of Wroclaw (CB no. 93/2009). Three CBCT-data sets were documented per patient: before implant placement as a reference of the bone density, one month after insertion and six months after insertion which was considered a stable time point for full osseointegration of the implants.

The number of CBCTs per patient in the course of treatment was based on clinical criteria: The first CBCT before implantation was taken to indicate bone quality and the available bone volume, in particular the distance to the floor of maxillary sinus. The second and the third CBCT were taken to assess bone volume and osseointegration around the implants.

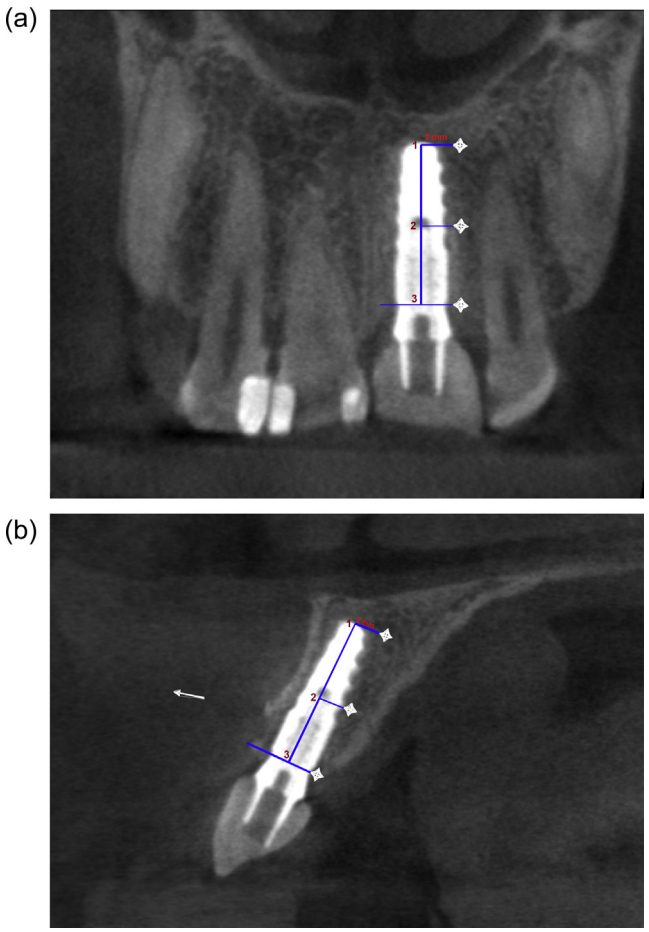

Fig. 1. The three measurement regions of the grey values: apical (1), middle (2), and cervical (3). The values were registered in a spot diameter of 1 mm at a distance of 2 mm from the implant. (a) Coronal view of the mesial and distal measurements. The arrow indicates the region of the reference value at the lip/cheek area. (b) Sagittal view of the vestibular and palatal measurements.

For CBCT imaging, the orientation beam was used to align the jaw bone parallel to the reference surface. The tube voltage was 70 kV, the tube current was 107 mAs, radiation effective doses were 4.7–18.8 μSv (FOV is 50 mm × 37 mm from producer catalogue) and the exposure time was 12 s. The grey values were measured using KODAK 9000 3D System (Carestream Dental, Atlanta, USA). This software automatically illustrates the changes in the grey values in numbers by moving the pointer from region to another on the monitor. The grey values of the bone around each implant were measured in three regions of interest and at four points: Apical region, middle region of the radiological implant length, and cervical region, each mesially, distally, vestibularly, and palatally. A coronal view along the middle of the implant was used to measure the grey values in the three regions mesially and distally (Fig. 1a), while a sagittal view along the middle of the implant was used to measure the grey values vestibularly and palatally (Fig. 1b). Since the angulation of the implant is individual and dependent upon the desired position of the implants as well as the available bone volume, the definition of the region of interest and the evaluation of grey values were done manually.

As the titanium artefact at the bone–implant interface was within 0.5 mm for the all CBCT-data, the values were registered in a distance of 2 mm from the implant in a spot diameter of 1 mm.

The reference values of the grey level (as water) were the mean of the grey values at the lip or cheek soft tissue region. The measurements were done by a dentist who is familiar with image

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