Radiological Bone Density and Bone Micro-structure at the Implant Site. Clinical Study based on Cone-Beam CT and Micro-CT

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Abstract

The present work is pioneer in checking the usefulness of determining Radiological Bone Density (RBD) by Cone-Beam CT-scan (CBCT) to pre-operatively assess the best sites for implant placement in the jaws of living patients. Translation of the desired implant site to the surgical field by stereolithographic surgical guides and examination of bone biopsies at the planned implant site by Micro-CT is proposed as an acute methodology for the evaluation of the relationship between RBD and micro-structural features of the jaw bones.

Methods and Materials

- Use of the software to pre-operatively design the position of the implants in the upper jaw. Determination of mean RBD in CBCT images along the axis of the implant surfaces for each selected site.
- Surgical transfer of the planned implant position by the use of a stereolithographic surgical guide.

Background and Aim

Background: Cone-Beam CT-scan (CBCT) offers some advantages in comparison to medical CT-scan: 1) Higher spatial resolution in the axial plane for maxillary bones; 2) Less time-consuming; 3) Lower radiation dosage; and 4) Lower cost. Otherwise, Micro-CT is a non-invasive technique that allows the acquisition of 2D and 3D images from bone biopsies with a high resolution (~1.6 µm) and also allows to calculate structural parameters such as: Bone Volume (BV), Total Volume (TV), Bone Volumetric Fraction (BV/TV), Degree of Anisotropy (DA), Structural Model Index (SMI) and others.

Aim: To demonstrate that Radiological Bone Density (RBD) measured by CBCT at the implant site may be a predictor for Histomorphometric Bone Density (HBD) expressed as BV/TV (%) and other bone micro-structural properties measured by Micro-CT.

Results

Fifty-two bone biopsies from 52 implant sites in 31 partially or totally edentulous healthy patients were obtained. Finally, 39 out of 52 biopsies were selected for the present study. The working process was: 1) Acquisition of CBCT images with i-CAT Model 17-19 ( Imaging Sciences International LLC, Hatfield, PA, USA) from the jaw bones of the patients; 2) Pre-operative planning of the implant sites by the NobelGuide model Bocare AB®, Goteborg, Sweden software using CBCT images, and measurement of mean RBD along the axis of the implant (NTC units) and also along mesial and distal implant-bone surfaces; 3) Fabrication of a stereolithographic surgical guide to translate the exact position of the guides during the surgery; 4) Obtaining a cylindrical bone biopsy with a 9.26 mm trephine HFA drill to the exact hole of the guide at the site of the analyzed implant; 5) Placement of the implant and measurement of Resonance Frequency Analysis (RFA) values by the Osstell™Mentor; 6) Acquisition of micro-structural values by micro-CT directly of the biopsy specimen; 7) Statistical analysis (SPSS 15.0 software): Chi square test, Student’s t test, Pearson’s correlation.

Conclusions

By means of the CBCT, clinicians are able to determine the maxillary and mandibular areas with the highest radiological bone density values, corresponding with areas with the highest bone volume fraction. As far as this condition has been reported to be associated with higher implant survival rates, CBCT can be considered a useful tool for clinicians to pre-operatively predict which are the best places for implant insertion.

References


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