Effects of immediate and delayed implant loadings on trabecular structures: a cone-beam CT evaluation

Yan Huang1, Jeroen Van Dessel1, Xin Liang2, Maarten Depypere3, Guowu Ma2, Weijian Zhong2,
Ivo Lambrichts4, Frederik Maes3, Reinhilde Jacobs1

1Oral Imaging Center, Department of Oral Health Sciences, KU Leuven, Leuven, Belgium
2School of Stomatology, Dalian Medical University, Dalian, China
3ESAT/PSI, Medical Image Computing, KULeuven, Leuven, Belgium
4Department of Morphology, Faculty of Medicine, University of Hasselt, Diepenbeek, Belgium

Background:
It has been reported that immediate loading has similar clinical success rates as delayed implant loading does in the short and medium term. However, the microarchitecture of peri-implant trabecular bone, as an important aspect of mechanical properties of bone for successful osseointegration, has received less attention. The clinically objective way in assessing trabecular structures seems increasingly promising, especially considering the 3 dimensional modalities offered by Cone Beam Computed Tomography (CBCT).

Aim:
To develop a standardized way by using CBCT, and evaluate the peri-implant trabecular bone changes after rehabilitation of immediate vs. delayed implant loadings.

Materials and methods:
Ethical approval was obtained to carry out a split mouth study in 6 mongrel dogs (male, 15-20kg). The dogs randomly received 27 custom-made threaded titanium implants (Grade V, 4.1mm Ø × 11m long) at maxillary incisors or mandibular premolars from one out of 4 treatment protocols: normal extraction socket healing (control, n=9); immediate implant placement and immediate loading (IIP+IL, n=8); delayed implant placement and delayed loading (DIP+DL, n=10); delayed implant placement and immediate loading (DIP+IL, n=9). Animals were euthanized at 8 weeks
and block biopsies were removed and scanned under 80\(\mu\)m high resolution CBCT. By using a custom-made protocol in CTAn software, bone structural parameters were calculated in a circular-shaped region with 1mm wide \(\times\) 2mm height around the implant in three levels respectively: coronal, middle and apical. ANOVA followed by Tukey’s HSD test was used to compare variables between groups and non-parametric multiple comparisons were applied when normality was not confirmed.

**Results:**
The differences \((p<0.01)\) between control vs. IIP+IL, DIP+IL and DIP+DL were statistically significant regarding to bone surface volume ratio (BS/BV), bone surface density (BS/TV), fractal dimension (FD), trabecular separation (Tb.Sp) and connectivity density (Conn.Dn); while the differences between these groups were not significant on bone volume density (BV/TV), trabecular number (Tb.N), trabecular pattern factor (Tb.Pf), structural model index (SMI), total porosity percentage (Po(tot) ). All implant protocols have significantly higher values \((p<0.01)\) than the control for BS/BV, BS/TV and Conn.Dn, while significantly lower values \((p<0.005)\) were found for Tb.Sp and FD. However, distinct implant protocols did not show significantly different bone remodeling.

**Conclusions and clinical implications:**
CBCT was used for the first time to evaluate peri-implant trabecular microarchitecture. The immediate implant placement and loading protocol may have an improved bone structural integration compared to that obtained by normal extraction healing. The present findings do not seem to suggest a different bone remodelling pattern when using a delayed vs. an immediate implant placement and loading protocol.

The study was supported by a grant from Natural Science Foundation of China (81000459).