Assessment of bone grafting materials in oral surgery

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INTRODUCTION: The efficacy of bone grafting materials is generally assessed on the basis of histological evaluations. In the present study three augmentation materials were analyzed by a combination of micro computed tomography (µCT) and histology. The registration of the two-dimensional histological slices with their counterpart from the three-dimensional µCT data set was performed manually and automatically. It allowed the compilation of a joint histogram.

METHODS: First, the extraction site was filled with easy-graft™ (Sunstar Degradable Solutions AG, Schlieren, Switzerland). Second, another bone defect was substituted with Bio-Oss® Block (Geistlich Biomaterials, Baden-Baden, Germany). Third, a vertical bone defect in the region of a right first molar was augmented with BoneCeramic® (Institute Straumann AG, Basel, Switzerland). To reveal the 3D morphology of the three specimens, synchrotron radiation-based micro computed tomography (SRµCT) measurements were carried out at the HZG beamline W2 / DORIS III at DESY, Hamburg, Germany in the conventional absorption contrast mode at 25 keV photon energy and 2.2 µm pixel size. After the SRµCT analysis the three biopsies were further processed for histology. The combination of histological images and µCT data for the bone assessment requires the multi-modal mapping of 2D slices on 3D data sets. Due to the complexity of 2D-3D registration the present study followed manual and algorithmic approaches. The preparation of joint histograms included the non-rigid registration of the selected 2D images. The entries of the 2D joint histogram represent the number of pixels within the physical absorption intervals of the µCT slice and the color values of the corresponding histological slice.

RESULTS: After the healing period, sufficient bone was offered to place the implant in all cases. Based on the histogram of the µCT data sets the amount of bone, augmentation material and soft tissue was determined. In the first specimen we found 1.3 % easy-graft™, 34.1 % bone, and 64.6 % embedding material, which also includes the soft tissue components. The second specimen included 57 % soft tissue and embedding, 14.2 % bone, 25.7 % Bio-Oss®, the third one contained 45.5 % soft tissue and embedding, 4.7 % BoneCeramic® and 48.9 % bone. The joint histogram revealed anatomical structures such as the early-formed bone. It allowed for the identification of anatomical features, which can neither be extracted from histology nor from µCT data alone.

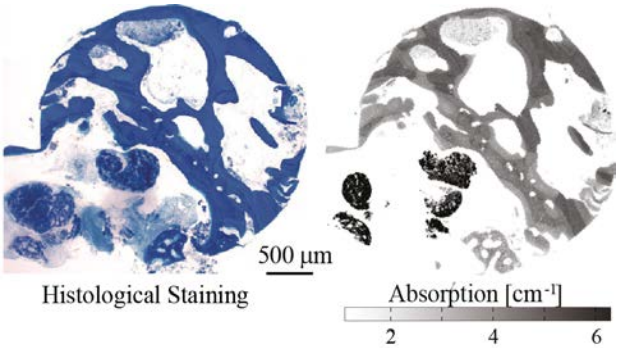

Fig. 1: Histological slice (left) and the corresponding µCT image (right) registered from the 3D data set for the biopsy containing easy-graft™ (Sunstar Degradable Solutions AG, Schlieren, Switzerland).

DISCUSSION & CONCLUSIONS: The combination of SRµCT and selected histological sections provides a detailed quantitative view of bone morphology and maturation. The combination of the techniques leads to insights, not delivered by one method alone. To this end, SRµCT and histology are complementary methods to assess the bone quality, including bony tissues formed as the result of augmentation materials.

REFERENCES: [1]A. Stalder et al. (2014) *Combined use of micro computed tomography and histology to evaluate the regenerative capacity of bone grafting materials* Int J Mater Res **105** online [2]B. Ilgenstein et al. (2012) *Combined micro computed tomography and histology study of bone augmentation and distraction osteogenesis* Proc SPIE **8506**: 85060M