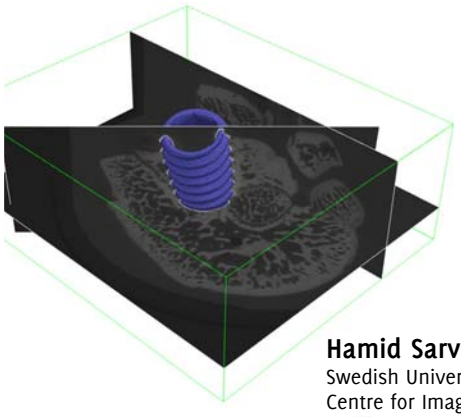

Quantification of Bone Remodeling in SRμCT Volumes of Implants

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INTRODUCTION

Bone implants are becoming more important

As the population is growing older and older, bone implants are becoming more important. A necessary step for this research field is quantitative analysis of regenerated bone tissue in the proximity of implants. Traditionally, this analysis is done in a light microscope on histologically stained cut and ground sections (10μm), see Fig. 1. These sections are analyzed both qualitatively and quantitatively.

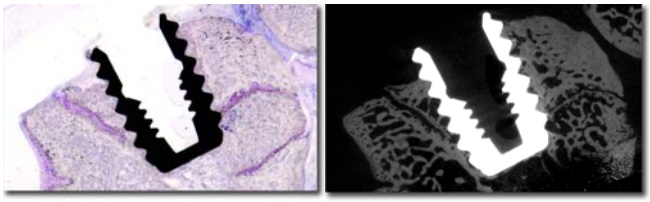


Figure 1: Histological section (left) and the corresponding registered 2D slice (right)

3D imaging gives you more information

However, a single 2D histological section provides one slice only. In order to widen the analysis and evaluation, we combine the information obtained by the microscope with 3D **SRμCT (synchrotron radiation-based computed microtomography)** volume which gives a better survey of the tissue around the entire surronding of the implant. The samples were imaged using the SRμCT device of GKSS at HASYLAB, DESY, in Hamburg, Germany. As a first step to a complete 3D-analysis, in this work we present a quantitative 3D-analysis method with comaparable results with the 2D-analysis.

METHOD

We present a segmentation method for SRμCT volumes and subsequent automatic quantitative analysis. The segmentation is done by a supervised linear discriminant analysis and is followed by quantitative analysis. This Analysisinvolves bone area, *R*, and bone-implant contact, *BIC*. We compare measurements obtained on the histological 2D sections with the ones obtained on the corresponding registered 2D slices extracted from the SRμCT volumes.

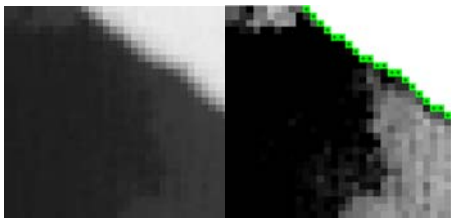


Figure 3: The implant interface region of a volume slice with implant at upper right (left) Corresponding artifact suppressed region (right)

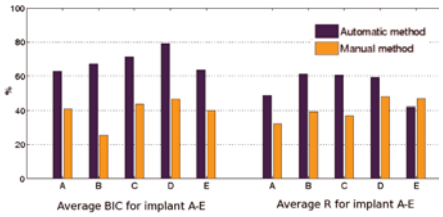
Shading artifacts suppressed

Due to the very high density difference between the titanium implant and the surrounding tissude, imaging artifacts close to the implant cannot be avoided. Unfortunately that is also the most interesting region to analyze. In the regions close to the implant, the transition from implant to tissue is characterized by a gradiual gradient from high to low (see Fig. 3a). They are removed by modelling the artefact and compensating for it.

RESULTS

Classification of the histological sections is a difficult task and the interoperator variance can be high for the manual measurements, making a direct comparison with the manual absolute measures unreliable for evaluation purposes; an important manual measurement is the judged relative order of implant integration.

Figure 4: Averaged absolute values for measures obtained by the automatic and manual method on five implants; the percentage of area measurement (R) and bone-implant contact length (BIC)



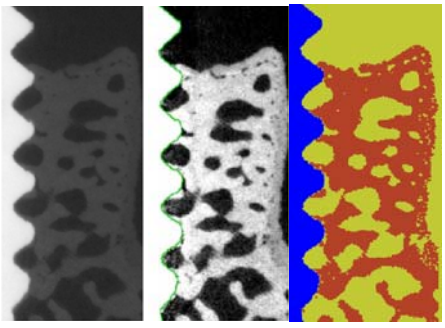


Figure 4: A slice from the SRμCT volume (left) Artifact corrected slice with the interface region marked and the implant in white to the left (middle) A slice from the segmented volume, showing three classes: bone (red), soft tissue (green) and implant (blue) (right)

CONCLUSION

SRμCT can be used for quantitative analysis

The rank correlation shows significant correlation ($P < 0.001$) between the automatic ranking of the features, and the manual one. As shown the existing artifacts can be removed with satisfactory result and the acquired volumes are similar independent of the tissue type, allowing an absolute quantification. This, in combination with 3D and no staining problems, justifies the use of SRμCT imaging as a complement to the histological evaluation.

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