Clinical Evaluation of Mandibular Bone Segmentation

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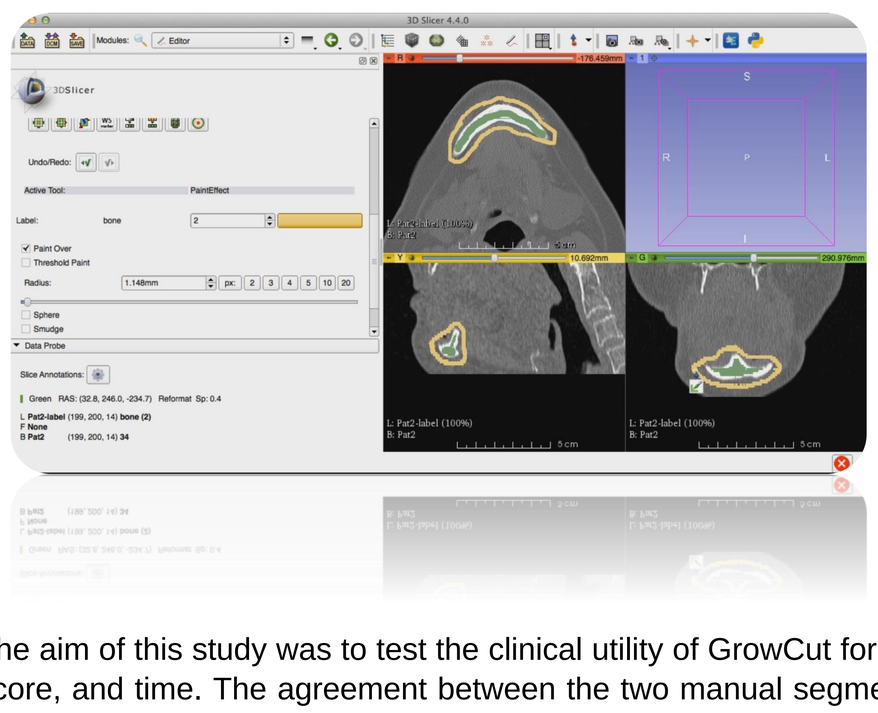
Purpose

Fractures of the mandible are the most common form of facial injury and represent about 40% of all facial fractures[1]. In the context of mandibular fractures, capturing a 3D scan and segmenting the bone structures is essential for better and faster assessment of biological structure morphology, diagnosis, treatment planning and the production of patient-specific implants[2]. Automatic segmentation can significantly shorten operative planning or treatment times, improving the treatment quality.

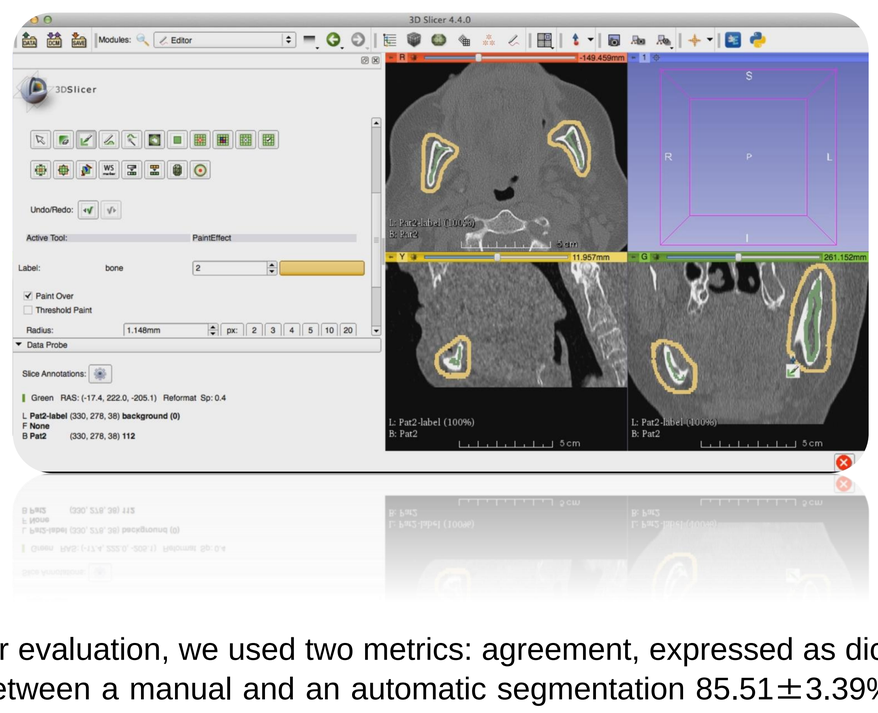
Methods

In this study, 20 high-resolution (512x512) CT datasets with physiologic, complete, mandibular bone structures without teeth were included. Incomplete data sets and mandibular structures altered by iatrogenic or pathological factors or fractured mandibles were excluded. The datasets were acquired within a nine month period in the clinical routine. Ten datasets were randomly selected (Randomizer® https://www.randomizer.at) and manually segmented in MeVisLab[3] independently by two specialists (after a five minute introduction time) to define a ground truth. In this trial, physiologic non-altered mandibles were used to provide an objective and clear bone structure assessment for the manual segmentation. For the automatic segmentation, the users marked parts of the mandibular bone and background in an axial, sagittal and coronal slice, similar to cellular automata segmentation (Figure 1a and 1b)[4]. A trained user could perform this task in less than one minute and immediately start the automatic segmentation process with this input. The results were saved as a 3D mask for statistical analysis in comparison to the ground truth segmentations.



<– Figure 1a – Fore- (green) and background (yellow) initialization of GrowCut in the lower jawbone in an axial, sagittal and coronal slice around the anterior mandible (symphysis / para-symphysis).

Figure 1b –> initialization of GrowCut in the lower jawbone in an axial, sagittal and coronal slice around upper parts of the mandible.



Results

The aim of this study was to test the clinical utility of GrowCut for mandibular bone segmentation. For evaluation, we used two metrics: agreement, expressed as dice score, and time. The agreement between the two manual segmentations was 93.67±1.03% and between a manual and an automatic segmentation 85.51±3.39%. Figure 2 presents the results of two manual segmentations and a manual segmentation superimposed into a patient's 3D visualization. Figure 3 presents the results of a manual and a semi-automatic segmentation. In addition, the automatic segmentation has been superimposed into a 3D visualization of the patient on the right side.

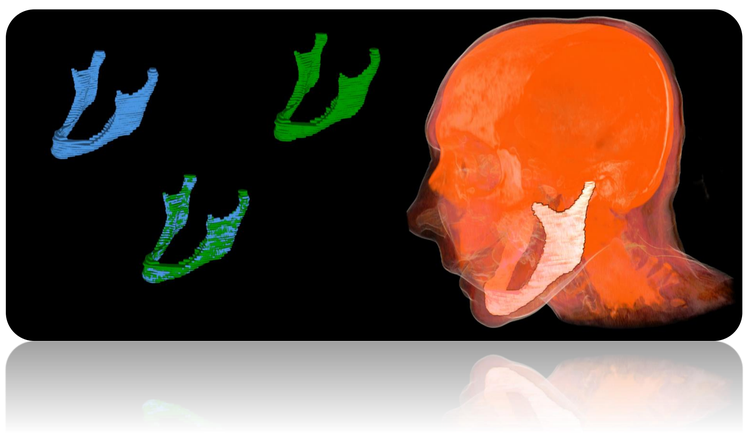
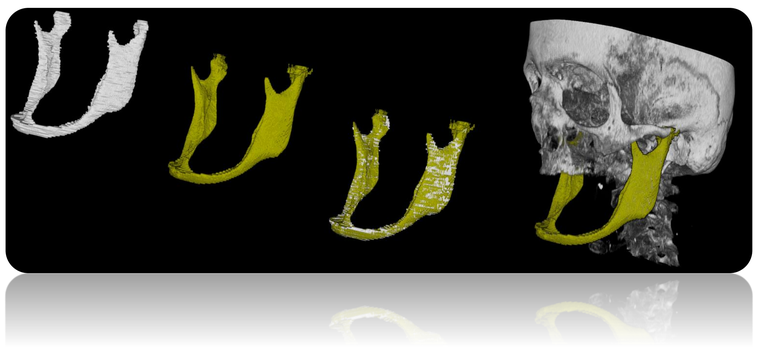


Figure 2 – Segmentation results of two manual segmentations (blue and green).

Figure 3 – Manual (white) and automatic (gold) segmentation results.



Conclusion

The software was tested with real patient CT data provided by the Clinical Department of Oral and Maxillofacial Surgery of MedUni (medizinische Universität) Graz. This study presents the clinical evaluation of mandibular bone segmentation with a semi-automatic cellular automata algorithm (GrowCut). In summary, a satisfying segmentation result could be achieved in a much shorter time. There are several areas for future work, like the comparison and evaluation with other freely available segmentation algorithms like the robust statistics segmentation algorithm.

Video Tutorial

https://www.youtube.com/watch?v=WZoEu0z1z3o

Acknowledgement

BioTechMed-Graz ("Hardware accelerated intelligent medical imaging").

References

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EMBC'16 Orlando, FL USA
38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society
August 16-20, 2016
Orlando, FL, USA