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Planung von chirurgischen Eingriffen an stereolithographischen Modellen und intraoperative Umsetzung der Planung

Treatment-planning by means of stereolithographic models and intraoperative realization of the plan

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Introduction/Purpose

Application of stereolithographic (SL-) models to investigate 3-dimensional medical objects and anatomical structures for planning of surgical interventions, for the development of implants and for medical diagnostics is an established method in cranio-maxillofacial surgery. SL-models are produced by selective polymerization of photosensitive, liquid acrylic resin by a laser layer by layer corresponding to computer tomography (CT)-data or image data from magnetic resonance tomography. A typical indication for the use of SL-models in cranio-maxillofacial surgery is the correction of craniofacial deformities, but also the treatment-planning in combination with computer-assisted intraoperative navigation. In this lecture an innovative approach for treatment-planning at the SL-model and transfer of the preoperative plan to the patient is presented, including a study-protocol to evaluate the accuracy of this method.

Materials and Methods

This study is based on SL-models of patients suffering from established deformities of the zygoma due to trauma. Fabrication of the SL-models is performed by means of the data from high resolution multislice CT-scans (helix, 1.5mm thickness of slices, inter-slice distance: 0.7mm, tilt of gantry: 0). For registration during simulation on the SL-model and

for intraoperative registration an acrylic-polymer occlusion-based splint with 8 fiducial markers is attached to the patient during CT-scanning.
To place fiducial markers on the SL-model exactly corresponding to the marker-positions on the patient's splint, connection bars are added to the surface of the model (Fig.1). When these models are used for preoperative treatment planning followed by the intraoperative transfer of this plan to the patient (e.g. applying point-to-point navigation), accuracy is of eminent importance. To investigate accuracy, 6 of these SL-models are scanned in the multislice-CT again. The acquired data-sets are quantitatively compared with the corresponding CT-data of the patient by means of image-matching with the Medtronic StealthstationTM TreonTM and measurement of deviations at distinct anatomical structures.

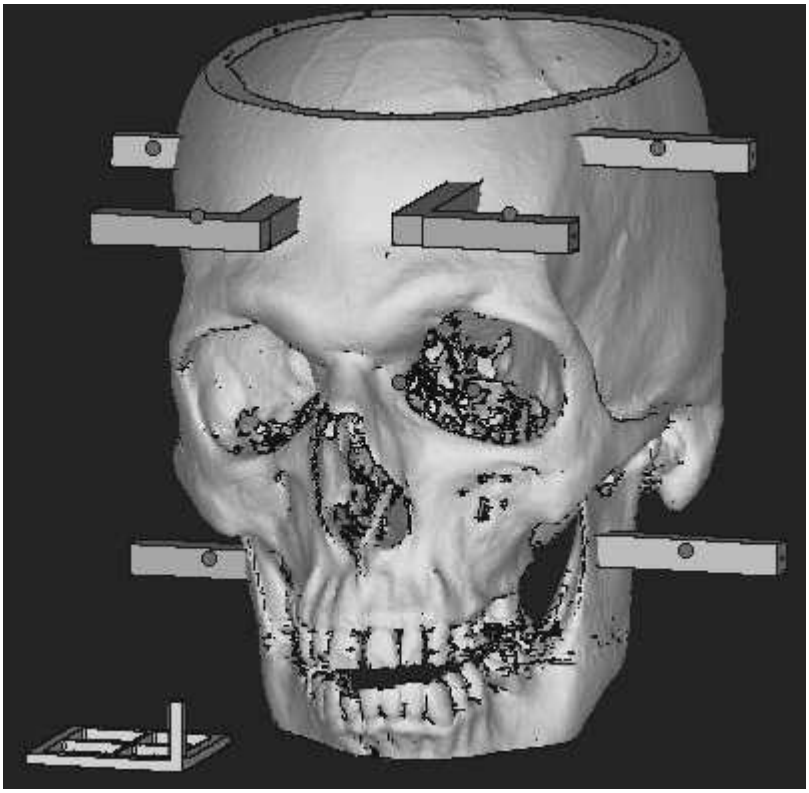
Arithmetic mean and variance of these values is being calculated, giving a measure for the deviations between computer-generated 3D-renderings based on the patient's and renderings based on the model's CT-data sets.

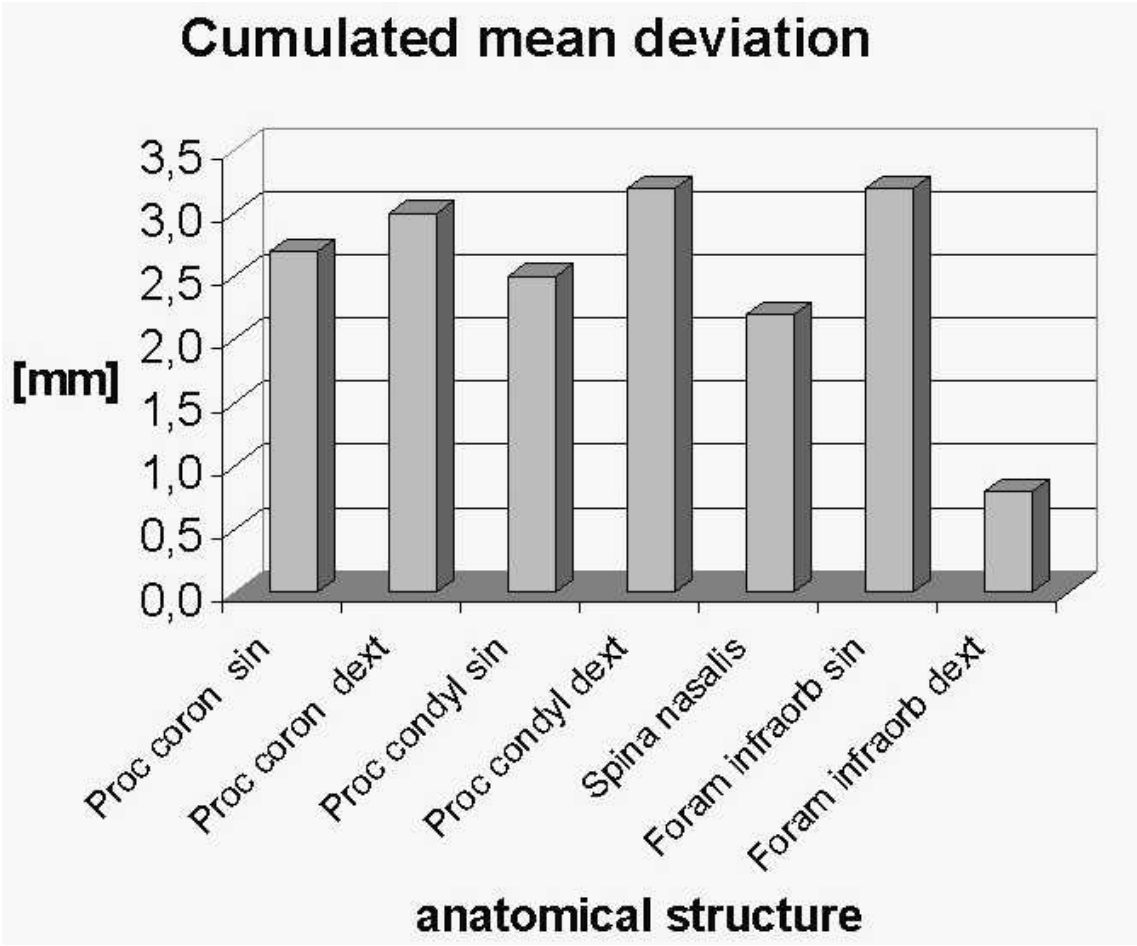
Results

Measurement data correspond well for the patient and the SL-model. Including the complete „chain of errors" (i.e. measurement- and registration errors, also during evaluation) an overall mean error of 2.5mm was found. Taking into account the errors of the point-merge process, which was between 0.98 and 1.40mm, an actual intraoperative accuracy of between 1.0 and 1.5mm can be expected. Fig.2 depicts the cumulated mean deviations at 7 anatomical structures.

Discussion

Results demonstrate high correspondence of the patient- and the SL-model. Therefore this treatment-planning technique proved to be reliable suitable for clinical routine. Valuable applications for treatment planning also in other medical fields can be expected.




Cumulated mean deviation
[mm]
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
Proc coron sin
Proc coron dext
Proc condyl sin
Proc condyl dext
Spina nasalis
Foram infraorb sin
Foram infraorb dext
anatomical structure