Section: **Segmentierung, Registrierung**

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Abstract-Title:
CLINICAL EVALUATION OF A CT BASED PREOPERATIVE OPERATION SIMULATION PRIOR TO ROBOTIC ASSISTED SURGERY AT THE LATERAL SKULL BASE

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Abstract-Text:
Purpose:
Surgical interventions at the lateral skull base need detailed preoperative planning due to the complex anatomical relationships. When medical robots or other mechatronic devices are actively involved in the surgical procedure, a preoperative planning is usually based on anatomical information provided by CT or MRI examinations. As a first step for preoperative planning the relevant anatomical structures of the lateral skull base have to be segmented within the image datasets. The segmentation of the cavity of the mastoid bone as the principal anatomical key structure is a tedious and critical task. Manual or automatic segmentation methods of the mastoid bone for surgery planning should correspond most closely to the effects of a real surgical procedure (mastoidectomy), and must respect vital organs (e.g. the facial nerve).
The aim of this study was to evaluate the predictive value of our CT based planning and simulation system for a complete mastoidectomy by comparing the results with the real surgical procedure.

Method:
A total of 16 patients were examined with a high resolution CT. These CT examinations were conducted as a clinically indicated preoperative procedure in all patients. A manual and a semi-automatic segmentation of the mastoid cavity was carried out in all preoperative CT datasets with the aim to simulate most closely the effect of a surgical mastoidectomy. A real surgical mastoidectomy and subsequently a postoperative CT scan was performed in all patients.
To compare the mastoid cavities resulting from planning and real surgery, the surfaces of the mastoid cavities were extracted from the CT based planning datasets and the postoperative CT's. The three-dimensional surface data of the mastoid bones including the mastoidectomy cavities were obtained by performing identical image postprocessing steps to all datasets. Subsequently the datasets containing the planned and the postoperative surface of each patient were registered. A dedicated software (imageware, EDS) was used to calculate the differences between the surfaces. Negative distance values indicate that

the surgeon removed more bone compared to the preoperative planning, whereas positive distance values resulted when bone removal by real mastoidectomy was less extended than preoperatively planned. The results were quantitatively visualized by projecting the difference values as a color-coded map onto the surface of the postoperative dataset.

Results:
Registration of the pre- and postoperative datasets was successfully carried out for all cases with a high accuracy (Fig. 1). For statistical analysis five subregions of the mastoid cavity were defined and separately evaluated (Fig. 2). Small difference values dominated in 40-60% of the mastoid surfaces, major differences presented in only 15-20% of the surfaces (Fig.3). Negative values resulted significantly more frequently than positive values, indicating a more bone conserving extend of the preoperative simulation when compared with the real surgical procedure. Negative values ranged predominantly between 0 and 1.5 mm and exceeded 2.0 mm only in few patients at subregion 5 (dorsal rim of the mastoid cavity). Positive values ranged between 0-0.5mm (75% of all subregions) and 4.5 mm.

Conclusion:
Our CT - image based simulation of a mastoidectomy reliably predicts the anatomical extent of the real surgical procedure. As a consequence, CT not only provides visual information for a preoperative planning, but can also be used to directly generate control data for medical robots or mechatronics devices. Figures:
Fig. 1: Color coded surface correlation of the pre- and postoperative CT datasets. Light and dark grey values at the cerebral surface of the mastoid bone (no surgical procedure performed) indicate an excellent registration of the pre- and the postoperative CT dataset. Fig. 2: Skull base specimen after total mastoidectomy. The five separately evaluated subregions of the surgically created cavity are indicated; 1: sigmoid sinus region; 2: deep ventral region; 3: deep dorsal region; 4: upper ventral region; 5: dorsal region.
Fig. 3: View on the lateral skull base. Dotted line: outline of the simulated cavity; line: real surgical cavity; double line: meatus acusticus externus. Light colors at the central part of the cavity indicate a high correlation between the preoperatively simulated and the real mastoidectomy cavity. The large dark blue and violet area is a part of the skull that was not removed by the surgeon, since he chose to open a smaller entry compared to the planning procedure.

Bild 1/JPG

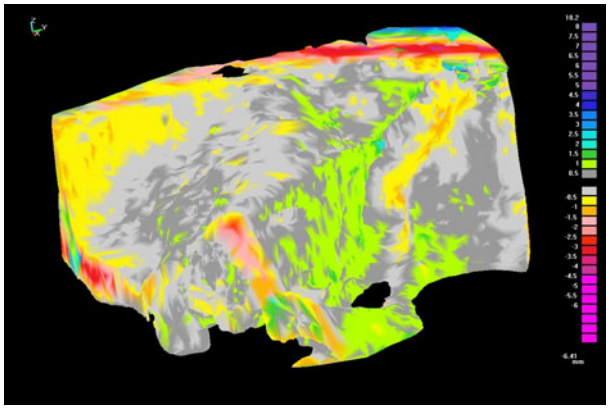
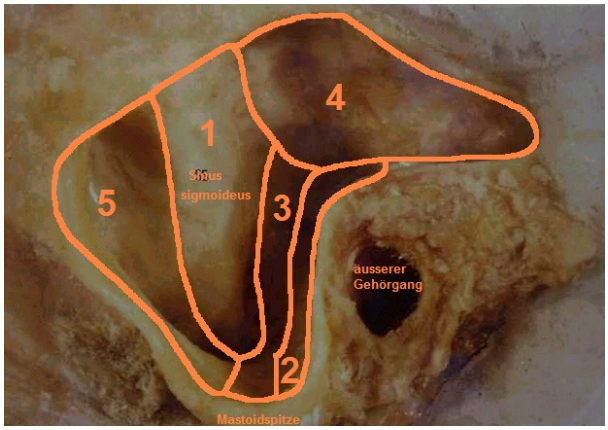


Bild 2/JPG



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