Section: **Future Emerging Technologies**

ID: 21

Abstract-Title:
SENSOR BASED FORCE MEASUREMENT DURING FESS FOR ROBOT ASSISTED SURGERY

Authors:
K. Tingelhoff[1], I. Wagner[1], K. Eichhorn[1], M. Rilk[2], R. Westphal[2], F.M. Wahl[2], F. Bootz[1]
[1] Universitätsklinikum Bonn, Klinik für Hals-Nasen-Ohrenheilkunde/Chirurgie
[2] Institut für Robotik und Prozessinformatik, TU Braunschweig

Abstract-Text:
Purpose
In our experiment we measure forces exerted by the endoscope to tissue within the nasal cavity during FESS (functional endoscopic sinus surgery). The results can be used for simulator-based education and for the optimization of manual skills. In our project we use force data to develop a robot assisted endoscope guidance. The robot will move the endoscope inside the nasal cavity in order to support the surgeon. The sensor based force control is one of several features which should ensure reliable and secure robot movements. Method
Throughout the entire operation forces are continuously recorded by custom software. One part of the experiment is carried out on four formalin fixed human cadaver heads, the other on nine patients. Simultaneously to the force measurement we noted the corresponding surgical steps. For the force measurement we use the force/torque sensor Nano 43 SI-36-0.5 (Schunk GmbH, Lauffen/Neckar, Germany). Force/torque sensors are tactile devices, which determine forces acting on the instrument in six degrees of freedom. The sensor is mounted between an endoscope (Karl Storz GmbH, Tuttlingen, Germany) and a video camera (Fig. 1) and measures forces and torques applied by the endoscope. The standard endoscope (No.: 28162AA) has the following hardware properties: 30° optics, 4 mm diameter and 18 cm length. The in vivo experiment needs further security components to avoid harm to the patient. Fig. 2 shows the experimental setup. We add an isolating transformer (Toennies Medizinische Elektronik, Freiburg, Germany) in order to realize a galvanic separation between socket and patient. A sterile slipcover is used to wrap the cables connected with the sensor and the endoscope (Fig. 3). Results
The experiment shows that the average force during cadaver sinus surgery is 2.8 N with a maximum of 11.8 N (Tab. 1). Most of the time forces do not exceed 5 N and there are few peak forces higher than 6 N (Fig. 4). Cadaver head 2 has very rigid tissue, which causes high average forces. The in vivo study reveals an average force of 3.38 N. Force data measured for patient 4 are influenced by the slipcover which was too narrow, so additional force was exerted to the sensor by the protective cover. If we do not include patient 4 we have an average force of 3.0 N with a maximum of 25.1 N. For 94.92 % of the time forces are lower than 7 N. In our opinion the force variances result from the anatomical varieties. During the preparation of the maxillary sinus the number of peak forces is higher than in all other surgical steps probably because of a narrow nasal passage. For a detailed force data analysis, more force measurements are needed. Conclusion
There are typical changes of force data depending on the surgical step. It takes higher

forces to perform endoscopy of the maxillary sinus than examining the ethmoidal sinus. Consequentially we need local force thresholds for the robot assisted endoscope guidance. A problem of our measurements is the sensor functionality. The sensor gauges the sum of all forces which exerts the endoscope to nasal and paranasal tissue. So far we can not differentiate between forces within the sinus and those which occur at the entrance of the nasal cavity.The measured force data are adequate to damage sensitive structure in paranasal sinuses as we found out in earlier experiments. The robot assisted endoscope guidance needs more than one security feature to preserve the patient’s integrity. In future further control of robotic endoscope movement will be obtained by developing a multisensor system.

Bild 1/JPG

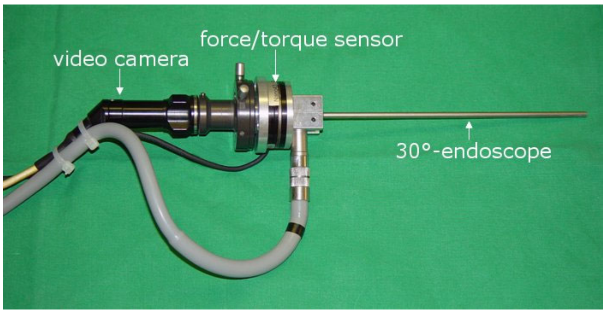

Bild 2/JPG

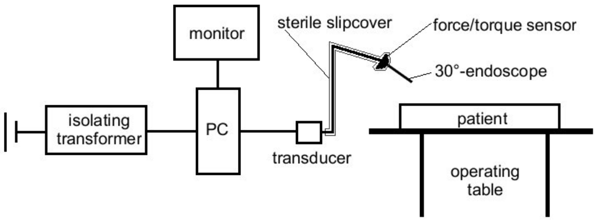

Bild 3/JPG