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Erweiterung eines Planungs- und Navigationssystems um ein interaktives mechatronisches Assistenzsystem für Beckenresektionen

Eenhancement of a Planning and Navigation System by an Interactive Mechatronical Assistance System for Pelvic Resection

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Purpose

The complete resection of malignant pelvic tumours including a safety margin is frequent difficulty. The preoperative planning of resection planes can be a great benefit, especially if the resected pelvic bone is replaced by an individual prosthesis. In addition this planning is the basis for the accurate intraoperative realisation based on a navigated robot system. The aim is to combine the planning and visualization software Amira (Indeed), that is established in our clinic, and the interactive assistance system Modicas (University of Siegen, Zess). The resection plane planning with Amira shall be realized with the Modicas system as accurate as possible. The robot is used for the positioning of the surgical instruments (chisel, oscillating saw) but the actual intervention is performed by the surgeon.

Material and Methods

The planning is performed completely in Amira. In the first step an individual 3D model is reconstructed from CT data. The tumour is marked manually by the surgeon and the bone is segmented automatically based on a statistical shape model. The advantage in contrast to threshold based methods is the separation of femur and acetabulum and the separation of the interior and outside bone surface. Furthermore anatomical landmarks are transferred from the model to the individual patient to define orthopaedic measures.

In the next step the surgeon defines the resection planes depending on the position of the tumour. If necessary an individual prosthesis is adjusted automatically to the resection plane and the geometry of the pelvic bone.
The resection plane is transferred to the navigated robot system. Modicas consists of an optical tracking system Polaris (NDI), a lightweight robot type "PA10" (Mitsubishi Heavy Industries), a haptical interface mounted to the robot's wrist and a self designed real time control computer system (University of Siegen, Zess).
The transformation between the preoperative model and the real patient position is computed by a surface registration algorithm. To compensate possible patient movements a reference tracker was mounted to the pelvic bone. The robot wrist is provided with an additional reference tracker, so that its position is permanently known. With the calibration matrix, which is calculated before, the position of the surgical instrument is known to the system. The robot wrist positions the instrument and the surgeon cuts the pelvic bone along the resection plane.

Results

The two systems Amira and Modicas are combined successfully to a new system for pelvic resection planning and prosthesis construction as well as interactive robot system to achieve precise surgery. A communication in both directions is possible. The planning data can be send directly to the robot system and the current position of the robot wrist, the instrument and the patient (reference tracker in the pelvic bone) can be transferred to Amira for visualization and controlling as well.

Conclusion

The base of the interaction of both systems is established. In the next step a mount for the surgical instruments on the robot wrist have to be developed and the whole system must be evaluated in an accuracy study. In the future an adaptation of the haptic interface will be implemented, that only movements along the resection plane are possible.