



Ten years experience with computer-assisted interventions from head to toe

... from the Interdisciplinary Stereotactic Intervention-and Planning Laboratory (SIP-Lab) at the Department of Radiology Innsbruck

The future of interventional procedures is evaluated in the Interdisciplinary Stereotactic Intervention-and Planning Laboratory (SIP-Lab) at the Department of Radiology I (Chairman: Univ. Prof. Dr. Werner Jaschke), University Clinic Innsbruck. In 1994 Prof. Reto Bale started with the application of the first commercially available navigation system, the Viewing Wand, for computer-assisted videoendoscopic ENT surgery and neurosurgery.



Figure 1: Reto Bale, MD, SIP-Lab Innsbruck

Navigation systems consist of a workstation, a monitor and a 3D – localization system with different probes and instruments. They were originally developed for surgical disciplines (neurosurgery, orthopaedics, ENT,...) in order to guide the surgeon to the lesion and to avoid critical structures such as vessels and nerves. Similar to Global Positioning Systems (GPS) they provide the surgeon with orientation information in real-time. Medical navigation systems show the actual position of an instrument with

respect to preoperative imaging data during the surgical procedure.

The worldwide first patented targeting devices for the application of navigation systems not only for surgery inside the body but also for precise percutaneous punctures were developed in Innsbruck in 1995 (Patents by Bale and Vogele). Non-invasive immobilization devices and multimodal (CT/MR/PET/SPECT) registration devices are a prerequisite for precise percutaneous procedures. For cranial interventions a novel non-invasive immobilization system based on an individualized vacuum dental cast was designed, the so called Vogele-Bale-Hohner head holder. For the body the vacuum based BodyFix immobilization device was developed. Using the optical based Treon navigation system (Medtronic Inc., USA) in combination with the different immobilization devices (Medical Intelligence GesmbH, Germany) nearly every point in the whole body can be reached with high accuracy. The path is planned on fused 3D CT/MR/PET/SPECT data thus the needle can be placed in the active part of the tumour according to the PET data. In addition image fusion of the post-treatment CT with preoperative CT/MR/PET/SPECT is performed in the treatment room. In addition, the navigation system is used to register real-time acquired ultrasound images with CT and SPECT images for diagnosis of neck tumors and for percutaneous radio-frequency ablation of liver lesions. The

ultrasound images are obtained real-time. Therefore the US probe is foreseen of tracking balls (detected by the camera of the navigation system). The combination of the two registered modalities proved very useful in the accurate detection of the tumour and –in case of liver lesions- it compensates for organ movements.

The following computer-assisted percutaneous interventions are performed in an OR-converted CT scanner room by the SIP-Lab team in cooperation with the Department of Neurosurgery, Traumatology, Orthopaedics, Nuclear Medicine and Radiotherapy:

- Tumour biopsy from head to toe.
- Radiofrequency ablation of bone and liver tumours.
- Fractionated interstitial brachytherapy



Figure 2: Computer-assisted bone tumour biopsy of a pelvic tumour in the CT scanner room: camera (1), monitor of navigation system (2), targeting device with tracker of navigation system (3). The patient is immobilized in the BodyFix in prone position.

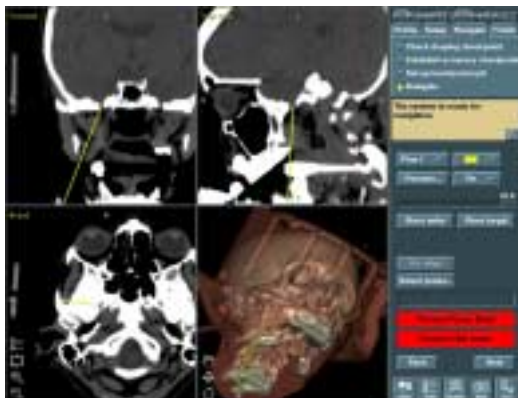


Figure 3: Electrocoagulation of the Gasserian ganglion: determination of path through the foramen ovale on the navigation system based on pre-operative CT data.

of ENT, bone and soft tissue tumours.

- Retrograde drilling of osteochondral lesions of the talus.
- Fixation of pelvic fractures including iliosacral screw placements.
- Thermocoagulation of the Gasserian ganglion in patients with trigeminal neuralgia.
- Placement of foramen ovale electrodes in patients with epilepsy of unknown origin.

A novel image guided template production technique for placement of dental implants was developed (Widmann, thesis) and has been transferred from phantom studies to initial clinical studies. The implants are planned based on preoperative CT. An individualized template with drill guides for the dentist is fabricated in the SIP-Lab



Figure 4: Planning of 3 dental implants using the Treon navigation system.



Figure 5: Individual template with drill guides for precise implantation of dental implants (Widmann, thesis).

using the navigation system in combination with a special targeting device.

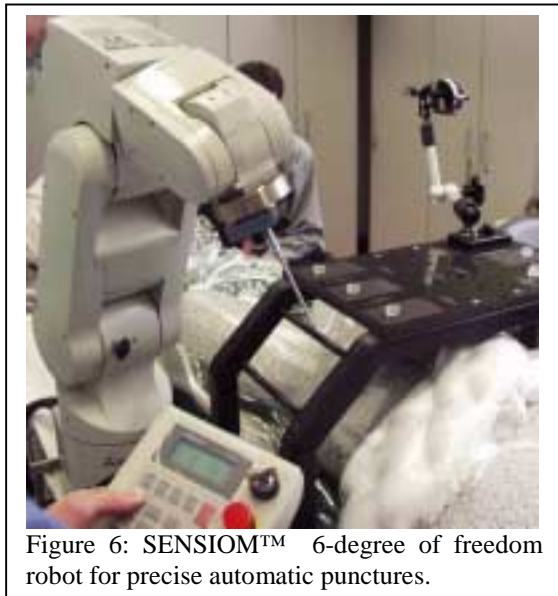


Figure 6: SENSIO M™ 6-degree of freedom robot for precise automatic punctures.

In addition we are evaluating the latest prototype of the SENSIO M™ 6-arm robot (Medical Intelligence Inc., Schwabmünchen, Germany) for accurate biopsy

and local tumor therapy in the whole body. It enables the user to quickly, safely and automatically guide an instrument along a desired trajectory to the target.

In conclusion the interdisciplinary SIP-Lab team uses navigation systems for interventional procedures from head to toe on a routinely (daily) basis based on pre-operative CT-MR-SPECT-PET data sets. It is only a matter of time before these procedures are in practice in other hospitals. Interdisciplinary cooperation between navigation experts from the SIP-Lab and specialists from other departments (Neurosurgery, Neurology, Orthopaedics, Traumatology, Nuclear Medicine, Radiotherapy, ENT, Cranio-maxillofacial Surgery) is the key for a successful application of modern visualization, navigation and robotic technology in order to improve patient outcomes.

The following persons are involved in the development and/or clinical applications of the SIP-Lab technology:

Medical Intelligence GesmbH: M. Vogele, C. Mueller, C. Janker, U. Achleithner

Medtronic Inc.: D. Legenstein

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Department of Radiotherapy (Prof. Dr. P. Lukas): Sweeney, Nevinny

Department of Neurology (Prof. Dr. W. Poewe): Trinka, Stockhammer, Unterberger

Department of ENT (Prof. Dr. W. Gunkel): Freysinger

Department of Nuclear Medicine (Prof. Dr. I. Virgolini): Moncayo, Donnemiller, Gabriel, Heute, Warwitz

Department of Surgery (Prof. Dr. R. Magreiter): Prommegger, Profanter, Oefner

Institute of Anatomy (Prof. Dr. H. Fritsch): Aigner, Longato, Künzel, Maurer