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State of the Art of surgical robotics

Peter Paul Pott[1], Prof. Dr. med. Hanns-Peter Scharf[2], Dr. med. Markus Schwarz[3]

[1]Labor für Biomechanik und experimentelle Orthopädie
Orthopädische Universitätsklinik Mannheim
[2]Direktor der Orthopädischen Universitätsklinik Mannheim
[3]Labor für Biomechanik und experimentelle Orthopädie

Introduction

Medical robotics are in state of continuous development.
Aim of the study was to give an overview of the current state of the art in medical robotics and in particular the development of mechanical components.
The robotic systems were assigned to the medical disciplines general surgery, orthopaedics, neurosurgery, imaging, ear-nose-throat/oral-mallofacial-surgery, urology, trauma surgery, radio surgery. Additionally technical specifications and functions as well as the international distribution of the developing institutes were determined.

Material & Methods

An inquiry on the literature databases Pubmed, IEEExplore and CiteSeer has been carried out. Additionally, link lists of institutes working in the field of robot-aided medicine and the internet were searched. The proceedings of MICCAI 2002 and 2003, CAOS 2003, CARS 2003 and 2004, CURAC 2003 and MRNV 2004 were reviewed. Developments of the last three years were considered particularly.

Results

During this review 110 systems were identified.
Research is done at university research facilities as well as on the part of commercial perspectives. Among the established applications in neurosurgery, orthopaedics and cardiac surgery new developments provide individual procedures e.g. trauma surgery and urology. Some devices fit in MRI scanners others are small enough to be held in the user's

hand. A number of systems are based on industrial robots others provide especially developed kinematics for their applications.
Approximately a quarter of the robot systems have been developed for abdominal and thoracic surgery and about 20% for orthopaedics, neurosurgery and imaging each.
In minor numbers systems for oral-mallofacial surgery (OMS), ear-nose-throat-surgery (ENT), urological procedures, trauma surgery and radio surgery have been developed. Most systems (66%) use self-made robotic devices and serial kinematics (71%). About 60% of the examined projects are in experimental state and have not yet been tested on patients. A quarter have been or were tested on animals or patients experimentally and about 12% are commercially available in some countries. About 50% of the presented systems come from Europe, a quarter of the systems are being developed in Asia and in North America respectively.

Discussion

Reflecting the international efforts on research and development in the field of medical robotics a wide distribution of the technology is obvious. The systems perform several tasks such as milling cavities in bone, harvesting skin, screwing pedicles or irradiating tumours.
In every day life of surgeons only a very small number of systems is used. In addition all systems that were not clearly described as being in experimental use were considered as experimental set-ups that are not yet tested clinically.
The small acceptance can be explained by the high complexity, the strict safety precautions and FDA-clearances and the fact that most of the systems are developed in a university environment thus being not available as a commercial product.

Conclusion

The review showed a large number of robotic systems for medical use. These systems mainly are in an experimental state. So research and development has to continue to provide systems suitable for every day's work.