

Feature

Surgeons' realizations of RoboDoc

Joanne Pransky

The author

Joanne Pransky is Associate Editor of *Industrial Robot*, Sankyo Robotics, 1001-D Broken Sound Parkway NW, Boca Raton, Florida 33487, USA. Tel: +1 561 998 9775; Fax: +1 561 998 9778; E-mail: joanne@sankyo.com

Abstract

Describes interviews with the two surgeons who have performed the most surgeries worldwide using the RoboDoc system, an integrated system that combines computer-based medical imaging and surgical robotics systems. For both doctors, the RobDoc system has exceeded their initial expectations. The article also describes the benefits of the RobDoc system as compared to the manual method of cementless implantation.

Background

RoboDoc, the most sophisticated surgical robotic technology in use anywhere in the world today, is an integrated system which combines computer-based medical imaging and surgical robotics systems. It is developed and marketed by Integrated Surgical Systems, Inc. (ISS) in Sacramento, California.

The RoboDoc system was first used for hip replacements on dogs in 1990 and in 1992 ISS received US Food and Drug Administration (FDA) authorization for clinical trials with human total hip replacements. Having successfully completed the feasibility study, ISS is now in the process of obtaining FDA approval to market the RoboDoc system in the USA. In Europe, the RoboDoc system has been sold to 12 hospitals during the past three years where a combined total of over 1,500 successful operations have taken place.

Benefits realized

According to the two doctors who have performed the most surgeries worldwide using the RoboDoc system, Prof. Dr med. G. Martin Börner of the BGU Klinik in Frankfurt, Germany, and Dr med. Herman Brüggemann at the Stadt. Kliniken Oldenburg in Oldenburg, Germany, the benefits of the surgical RoboDoc tool have far exceeded their initial expectations.

Both surgeons had previously performed thousands of manual hip replacement surgeries over a period of many years, but neither one had had any experience with a robot of any kind. Dr Brüggemann, prior to working with RoboDoc, "was convinced that it was a wonderful machine that was more precise" while Dr Börner was skeptical. "With RoboDoc", said Börner, "it was the first time in the world a robotic system was to be used for hip replacement surgery. It needed to be exact and reliable and the surgeon knew it would be the surgeon of the future."

Börner and Brüggemann were willing to try RoboDoc because of the problems with the inaccurate, current technique of cementless implantation, which utilizes a hand-held reamer and mallet-driven broach. The manual broach often leaves holes that are oversized more than 30 percent, only 20 percent of the implant is in contact with the bone, and there are gaps of 1-4mm around the implant.

The Stadtische Kliniken in Oldenburg, Germany



This leads to problems in the healing of the bone and in patient weight bearing (standing on the operated leg), in which even after six or eight weeks after surgery with a manual broach, there may still be only partial or no weight bearing at all.

What was needed was a precisely shaped and oriented cavity that only a robotic milling system could provide. Börner's expectation of full weight bearing within days of surgery was fulfilled, but neither Börner nor Brüggemann anticipated RoboDoc's extreme precision: 96 percent of the implant is in contact with the bone, and gaps between the implant and the bone are typically 0.05mm or less, resulting in no rotation or movement in the position of the implant, months or even years later.

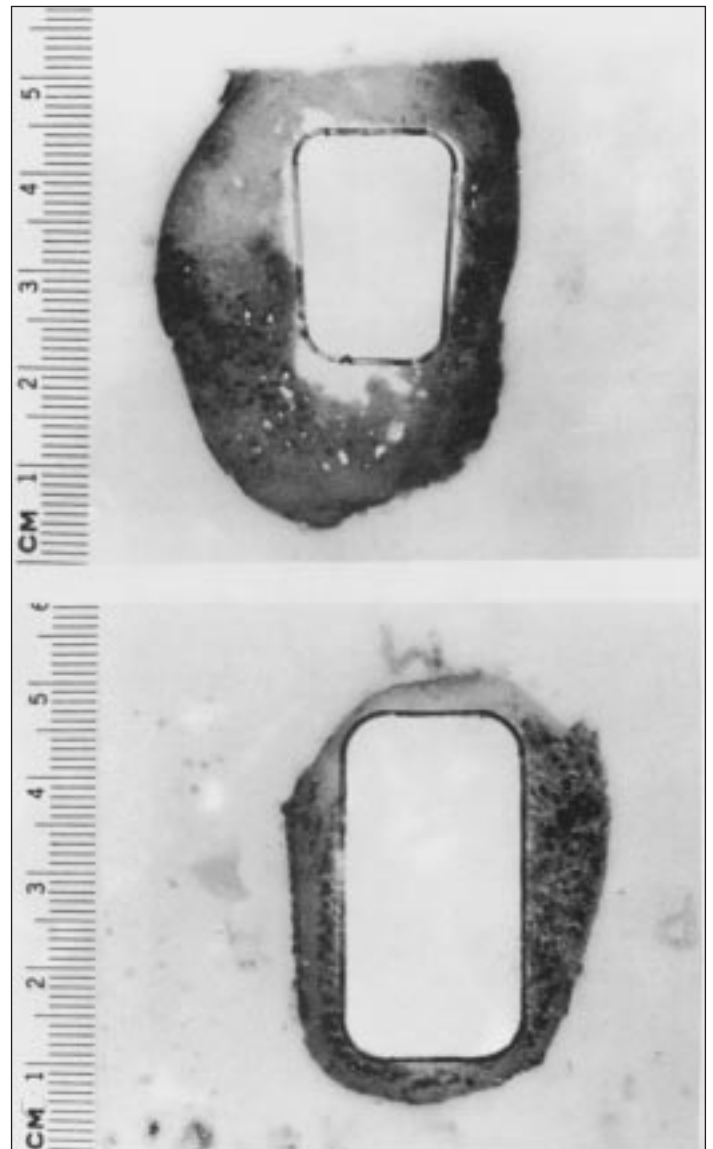
Surgeon-friendly

The RoboDoc surgical system consists of the OrthoDoc pre-surgical planner and RoboDoc, the surgical tool. In order for the robot to correctly position the cavity at the time of surgery, it has to know where the femur is and where the surgeon desires to place the implant. To do this, a computer tomography (CT) scan of the femur is taken preoperatively. The CT scan allows three-dimensional identification of certain landmarks on the femur and subsequent construction of a bone coordinate system. These landmarks must be present in the initial CT scans so that in the course of preoperative planning, the selection and desired placement of the prosthesis and its position in relation to the landmarks can be specified by the surgeon. The landmarks must also be identified by the robot at the time of surgery. For landmarks, the surgeon implants two calibration

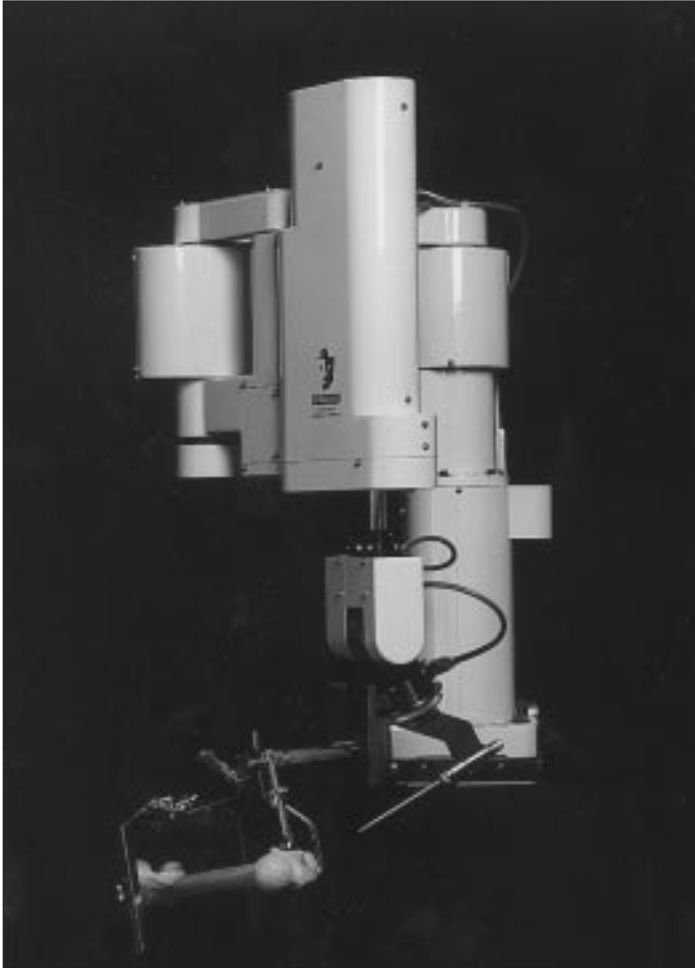
pins in the patient's femur. A CT scan of the limb is then obtained and the data are entered into the OrthoDoc software from a magnetic tape or optical disk. From this information, OrthoDoc displays a three-dimensional image of the femur. The surgeon then, through the use of a mouse, uses OrthoDoc to select the appropriate implant from a library of 3D models and to place it in the proper location relative to the bone. When the surgeon is satisfied with the orientation of the prosthesis, he instructs the computer to record his plan.

The robot system obtains the input information from OrthoDoc. During surgery, information continues to be exchanged between the surgeon and the robot system.

A comparison of cross sections of cadaver femurs. The top photo is an illustration of a section done with the broach method. The bottom photo is a section done with RoboDoc. Results with RoboDoc were up to 40 times better than hand-held broaching



The surgical robot RobDoc



The surgeon controls the procedure via a hand-held terminal, using a set of menus, and also by manually guiding the robot (by taking hold of the robot's end-effector and leading it to the desired location). The robot displays information for the surgeon on the real time monitor (RTM). Initially, the RTM displays the CT image of the bone with the implant at the desired location. While the robot is cutting the bone, the RTM displays the progress of the robot's current position of the cutter within the bone. The RTM allows the surgeon to "see" inside the bone during the procedure.

It took Börner, the first RoboDoc user in Europe, approximately three months to feel comfortable using the RoboDoc system, and Brüggemann about three weeks. Much of this time difference may be explained by product improvements made to the system since Börner's early experience. Brüggemann to date has performed over 350 operations with RoboDoc and Börner and his team have the most cases worldwide with over 1,000 surgeries achieved in the past three years.

The OrthoDoc preoperative planning workstation



Patients' responses

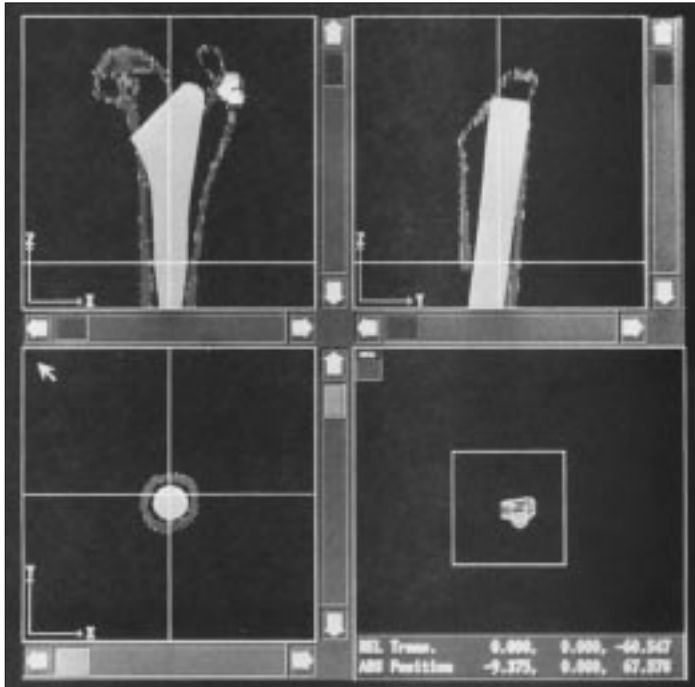
Patient results have been extremely positive. With RoboDoc, there is one-third less of a hospital stay and a full weight bearing within a day or so after surgery. The doctors reported that patients come from all over Europe to request the RoboDoc system. Only two out of Börner's 1,000 patients wanted to be operated by the hand method because of a fear of the robot.

RoboDoc of the future

With respect to what could be improved with the RoboDoc system, Brüggemann would like to see the cutting time decreased (a function of the software). It now takes about 15-20 minutes, depending on the quality and the density of the bone. Börner suggested that the RoboDoc system be used not only to implant the prosthesis, but to also implant the cup of the hip replacement.

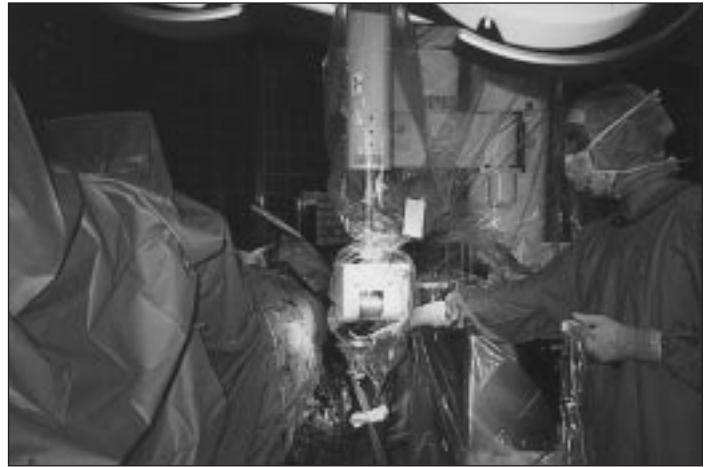
Both Brüggemann and Börner thought the RoboDoc system could be used for other surgeries such as knee replacement. Börner

A computer display of an implant being positioned by the surgeon



added that the RoboDoc and the OrthoDoc systems could be combined to be used for the implantation of screws into the spinal column to treat spinal injuries. Currently, the screws are implanted by hand. There is only a tiny place for the screws and if not implanted exactly, the spinal cord can be injured.

RoboDoc in surgery



The RoboDoc system, according to the two surgeons who have the most experience using it, will be the future for all orthopaedic and neuro surgeons. In all the cases where successful operations will depend on a surgeon's extreme exactness, RoboDoc and OrthoDoc will be needed.

For more information on the RoboDoc products, contact Integrated Surgical Systems, Inc., 829 West Stadium Lane, Sacramento, California 95834. Tel: 916 646 3487; Fax: 916 646 4075.