Computer-Guided Total Knee Arthroscopy
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Total knee arthroscopy is a major concern to an increasing number of people. The World Health Organization estimates that several hundred million people already suffer from bone and joint diseases, with dramatic increases expected due to a doubling in the number of people over 50 years of age by 2020. In Europe, by 2010, for the first time there will be more people over 60 years of age than under the age of 20. A study based on the American National Hospital Discharge Survey (1996–1999) predicts that there will be more than 474,000 total knee arthroplasty (TKA) procedures performed in the United States in 2030. This number is expected to increase in tandem with the life expectancy of the population.

Knee arthroplasty has evolved a great deal since the unsuccessful attempt by Verneuil to modify the articular surfaces of the knee by using soft tissues such as pig bladder, nylon, fascia lata, and so forth. This attempt was followed by an attempted resection of the entire knee by Ferguson in 1860, which resulted in better mobility but less stability of the joint. Ninety years later, in 1940, a more modern approach was reported by Campbell, in which a metallic interposition femoral mold was used. Later in 1958, MacIntosh treated painful varus or valgus deformity of the knee by inserting an acrylic tibial plateau prosthesis into the affected side to correct deformity, restore stability, and relieve pain. However, it took about 85 years to introduce one of the first navigational calculations involving bone in 1974 by Schlondorff et al., and computer-assisted orthopaedic surgery (CAOS) took almost 115 years to come into being. Indeed orthopedic surgery techniques, in general, and total knee arthroplasty, in particular, have dramatically evolved due to the introduction of computer-assisted surgery techniques and the concept of minimally invasive surgery (MIS).

Classifications for Robotics and Computer-Assisted Surgery Systems

Several classifications for robotics and computer-assisted surgery systems have been tentatively documented in the literature: Cinquin, Stulberg, Taylor, Troccaz, Bainville, and Nolte. Each of these
definitions reflects, to some extent, state-of-the-art technologies that were available at the time. In 2000, Picard et al.\textsuperscript{15} suggested combining Nolte’s and Cinquin’s definitions for computer-assisted knee systems to create a wider definition that is applicable to all CAOS systems. According to Cinquin, there are three categories for robotic systems that reflect the involvement of the robotic component in the operational procedure. The three are passive, semiactive, and active robotic systems. According to Nolte, there are three types of information systems used in the planning phase: preoperative image systems, intraoperative image systems, and image-free systems. The combination of the three robotic systems and the information systems creates a two-dimensional $3 \times 3$ table in which each cell is a combination of one type of robotic system with one type of information system; together, the two define a complete system (Table 24.1). For example, the cell that is defined by the intersection of an active robotic system with a preoperative image system defines a system that is based on an active robot that operates according to a preoperative plan, such as the ROBODOC system (Integrated Surgical Systems, Davis, CA).\textsuperscript{16} With the evolution in operating rooms (operating rooms of the future) and the availability of CT scanners inside those operating rooms, the preoperative planning can now be performed intraoperatively, hence Picard’s definition\textsuperscript{15} should be updated to make it more general. Therefore, we suggest categorizing by the source of the information systems (i.e., 3D, 2.5D, and image-free). Table 24.1 shows our modified categorization of the robotic systems versus the source of information.

In the following sections, we define and give examples of each of the categories in Table 24.1. We also review the state of the art medical technologies that are available and categorize each of these systems into the appropriate table cell.

### Active Robotic System

Active robotic systems perform surgical tasks, such as drilling or milling, without the direct intervention of the surgeon.\textsuperscript{17-27} This group in CAOS includes active robots like ROBODOC, CASPAR, PiGalileo, and MBARS. Perhaps one of the most famous active robots to date is ROBODOC, developed by Paul et al.\textsuperscript{28,29} The system was originally used for total hip replacement procedures, but was later modified for use in total knee replacement procedures.

Another robot that is used for cutting the tibia during TKA is the CASPAR by Ortho Maquet GmbH and Co.\textsuperscript{30} The robot that is being