Perioperative Management of Unicompartmental Knee Arthroplasty Using the MAKO Robotic Arm System (MAKOplasty)

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Abstract

Unicompartmental knee arthroplasty (UKA) is a popular treatment for unicompartmental knee arthritis. Indications for UKA include mechanical axis of less than 10° varus and less than 5° valgus, intact anterior cruciate ligament (ACL), and absence of femorotibial subluxation. Appropriately selected patients can expect UKA to last at least 10 years.

UKA failures are not common and involve technical errors that are thought to be corrected with use of newly developed robotic technology. The surgeon using this technology may be able to arrive at a set target, enhance surgical precision, and avoid outliers. Whether improved precision will result in improved long-term clinical outcome remains a subject of research.

In this article, we describe the perioperative management of patients who undergo UKA whether with conventional techniques or robotic arm assistance. We also describe the distinct aspects of preoperative, intraoperative, and postoperative pain management and of intraoperative anesthesia and blood management.

Indications for unicompartmental knee arthroplasty (UKA) have expanded in recent years to include younger and more active patients, and UKA now is an alternative to osteotomy and total knee arthroplasty (TKA) for unicompartmental degenerative arthritis of recalcitrant full-thickness cartilage lesions. Advantages of UKA over osteotomy include higher initial success, increased longevity, and fewer early complications.[1,2] Ten-year survival rates have been reported to be 90% for UKA[3,4] versus 76% for osteotomy.[2]

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Although early reports on UKA were less favorable,[5,6] its popularity has recently increased because of improved implant design, minimally invasive techniques, bone-sparing strategies, and early rehabilitation. However, early failures of femoral and tibial components have been reported.[7-10] Failures have been attributed to overcorrection and undercorrection of coronal plane alignment leading to accelerated wear in the contralateral compartment or tibial polyethylene, failures to maintain tibial slope, implant malposition, and subchondral collapse.[11-14]

> **"Equally important [to success of UKA], but much less well understood, is a disciplined and structured program focusing on patient education and patient support."**

New technologies are being developed to reduce technical complications and ensure implantation within acceptable limits of target specification. One such device is the MAKO surgical robot (MAKO Surgical Corp., Fort Lauderdale, FL). Use of this system requires preoperative customized planning with computed tomography (CT). The software for the system is used to segment bone surfaces to produce a patient-specific 3-dimensional (3-D) model. The surgeon then positions virtual implants on the 3-D model (Figure 1). After defining optimal parameters, the surgeon uses the software to establish bone resection areas and boundaries for cutting so that incorrect cutting can be avoided during the actual operation. During the operation, the surgeon moves the robotic arm by guiding the force-controlled tip within the predefined boundaries. The active, tactile-and-auditory feedback mechanism of the robot ensures that cutting occurs only in the prespecified areas. Having augmented surgical control with this tactile-guidance robotic system and using bone-sparing UKA implants, the surgeon obtains a limited surgical exposure (Figure 2). With appropriate perioperative management, robot-guided UKA may be reliably performed on an outpatient basis or with an overnight hospital stay.

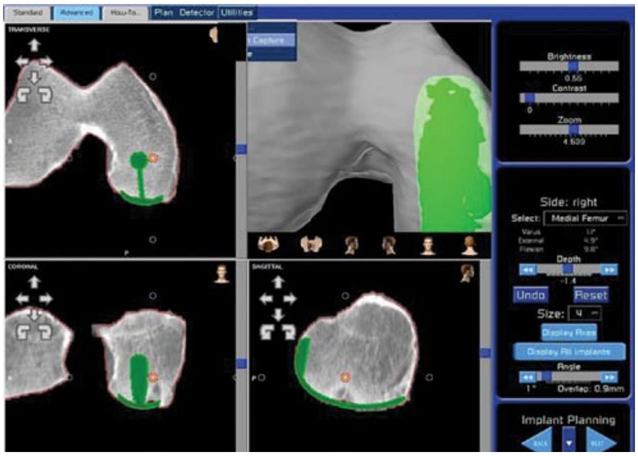

Figure 1. Surgeon positions virtual implants on a 3-dimensional model before performing the actual unicompartmental knee arthroplasty.

Factors that may affect early hospital discharge and improved recovery include operative time, incision length and location, amount of surgical trauma to various knee components, general health, blood loss, implant alignment, surgical technique, tourniquet use, and anesthesia. Equally important, but much less well understood, is a disciplined and structured program focusing on patient education and patient support.

In this article, we organize the details of outpatient UKA into preoperative, intraoperative, and postoperative protocols. Our goal is to provide clinically proven guidelines for outpatient robotic UKA.

Preoperative Management

The operation is planned as an outpatient procedure, and patients are informed about the general surgical schedule of events. Consistently achieving same-day hospital release after robotic UKA begins with patient education. A preoperative class or session can be used to provide patients with a detailed explanation of their symptoms, treatment options, the MAKOplasty procedure, and expectations for the recovery period and to answer their questions. During the session, patients are informed about their knee anatomy, osteoarthritic disease in the knee, and indications for UKA. For MAKOplasties, pictures and models of the knee joint, the robotic arm, and the implants may be used as visual aids. Patients gain a clear understanding of the procedure and of some alternatives. Individuals who will stay with patients after surgery and provide them with assistance during recovery—referred to here as *caregivers*—benefit immensely from these sessions. Dr. Repicci,[15] who pioneered minimally invasive UKA, gives his patients complete guidelines and the direct contact information of his nurse, who is available to patients 24 hours a day and is often considered a "surrogate family member." These strategies are useful in our practices, though perioperative management has its appropriate variations.

Other elements critical to successful outpatient UKA are the awareness and commitment of the entire surgical staff.

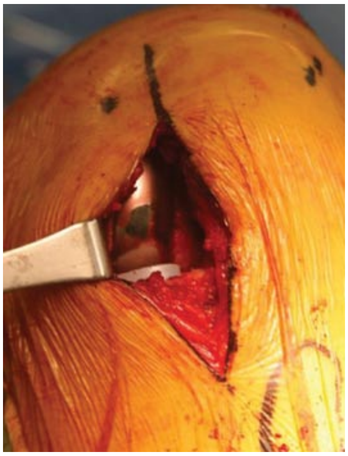

Figure 2. Robotic control of defined resection for implants allows for limited surgical exposure.

The staff includes preoperative planners, anesthesiologists, physical therapists, and nurses, all of whom must be educated regarding the accelerated discharge protocol.

Preemptive Analgesia

Inhibiting prostaglandin synthesis before surgery decreases inflammation, reduces pain, and speeds recovery. Whereas traditional nonsteroidal anti-inflammatory drugs (NSAIDs) are typically contraindicated for preemptive analgesia, selective cyclo-oxygenase inhibitors do not inhibit platelets and are recommended:

1. Celecoxib 200 mg orally, day before surgery and morning of surgery.
2. Oxycodone 20 mg orally, day before surgery and morning of surgery.

Preemptive Antiemetics

Blocking histamine and serotonin receptors before surgery prepares the gastrointestinal tract for the insult of anesthesia:

1. Metoclopramide 10 mg orally, morning of surgery.
2. Famotidine 20 mg orally, morning of surgery.
3. Ondansetron 4 mg intravenously (IV), every 4 hours day of surgery.

Intraoperative Management

Other actions that are required for MAKOplasty and that do not add surgical time are preoperative planning with the patient-based CT-generated 3-D software (described in the paper "Robotic Arm–Assisted Unicompartmental Knee Arthroplasty: Preoperative Planning and Surgical Technique," in this supplement) and setting up of the robotic arm before surgery (Figure 3). The surgical technician needs to be not only proficient in UKA and other arthroplasties but also familiar with the robotic system. Much as is the case with other technically detailed procedures, it is best if the surgical technician team has undergone dedicated training in computer-assisted surgeries.

Intraoperative Anesthesia

Aspects of anesthesia administration can significantly affect how patients feel after surgery and how much pain

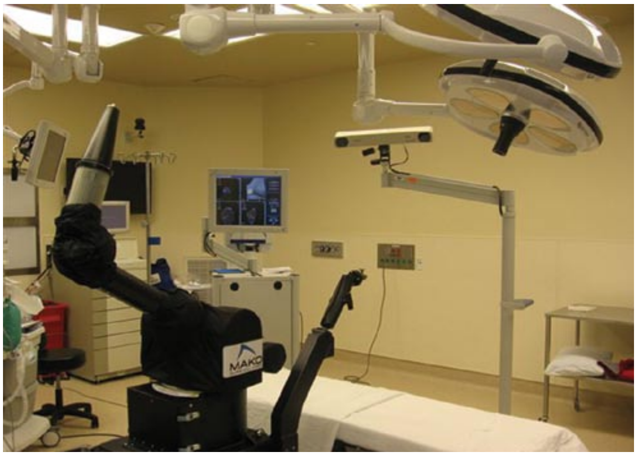

Figure 3. Setup of robotic arm and related system before patient arrives in the operating room.

they have to endure before hospital discharge. Although we understand that individuals react differently to anesthesia, this protocol is recommended:

1. Intrathecal morphine with a spinal anesthetic agent.
2. IV sedation.
3. Intracapsular anesthesia through injection:
   a. Ropivacaine (0.2%) 40 mL.
   b. Morphine 10 mg.
   c. Ketorolac 30 mg.
   d. Epinephrine (1:1000) 0.2 cm^3.
4. Key injection sites:
   a. Posterior capsule.
   b. Medial and lateral capsular flaps.
   c. Subcutaneous infiltration after incision.
   d. Pin sites.
   e. Drain site (if applicable).

Blood Management

Meticulous hemostasis is required to prevent postoperative hemarthrosis, which can be a source of pain and quadriceps inhibition. Typically, only a small amount of blood is lost from UKA, and there is no need for routine monitoring of postoperative hemoglobin levels. Post-UKA blood transfusions are seldom required. Whether a deep-wound drain is needed after robotic UKA remains debatable.

Postoperative Management

Postoperative management, which is critical for outpatient UKA, must be informed by a specific plan predefined by both patient and caregivers. Teamwork is essential to avoid the traditional "reactive" pain management and rehabilitation program that is common after inpatient arthroplasties.

Postoperative Pain Management

We advocate a proactive postoperative pain management regimen.[15] Patients should be kept well hydrated to prevent postoperative hypotension and nausea. Ketorolac 30 mg is injected intramuscularly (IM) after surgery. Patients with discomfort in the postanesthesia recovery room may be administered hydromorphone IV or IM.

Five hours after the injection of ketorolac, ibuprofen 800 mg and hydrocodone 5 mg are given orally.[15] During postoperative days 1 to 4, when primary healing occurs, the following pain management protocol should be established (the around-the-clock, ATC, dosing takes advantage of the half-lives of ibuprofen and hydrocodone, 2 and 4 hours, respectively):

1. Ibuprofen 400 mg every 4 hours ATC for 72 hours, then every 4 to 6 hours as needed.
2. Hydrocodone 5 mg every 4 hours ATC for 72 hours, then every 4 to 6 hours as needed.

Secondary, soft-tissue healing occurs from postoperative day 5 to postoperative week 5. During this period, pain management should consist of:

1. Ibuprofen 400 mg 4 times a day or as needed (an alternative NSAID may also be used, if necessary).
2. Hydrocodone 5 mg every 4 hours as needed.

Postoperative Rehabilitation

Critical to accelerated recovery is establishing knee joint motion soon after surgery:

1. Early high continuous passive motion (0°-100° of knee flexion) immediately after surgery (optional).
2. Ambulation as soon as spinal wears off (~2 hours after surgery).

"We advocate a proactive postoperative pain management regimen."

Although same-day discharge is expected, patients should be informed that discomfort or unmet ambulatory discharge requirements may necessitate a stay of 1 or 2 days. They must understand that they will not be released from the hospital if they do not feel comfortable leaving. Several discharge goals must be met:

1. Independent ambulation, 100 feet.
2. Active straight-leg raise.
3. Active knee flexion to 90°.
4. No wound complications.
5. Adequate pain control with Schedule III oral agents (hydrocodone, codeine).

Discharge Instructions

In most cases, formal physical therapy is not required. Patients are instructed to perform these exercises:

1. Walk as much as possible.
2. Perform straight-leg raises, quadriceps sets, and range-of-motion exercises 3 times a day. Reaching the extent of knee flexion and extension should be emphasized.

Conclusions

Outpatient UKA requires the cooperation and effort of all individuals who interact with the patient—beginning with preoperative patient education and establishment of appropriate expectations and continuing with all aspects of the surgery. Maintaining minimal incisions, preserving muscles and tissues, shortening surgical and anesthesia times, and providing baseline postoperative pain medications require the surgical staff's special attention. Dedication to these preoperative, intraoperative, and postoperative issues makes outpatient UKA a safe and reliable procedure.

Authors' Disclosure Statement

Dr. Repicci wishes to note that he receives royalties from and is on the speaker's bureau for Biomet. The other authors report no actual or potential conflict of interest in relation to this article.

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