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New procedures and designs can relieve pain and increase function.

By Sharon E. Hohler, BSN, RN, CNOR

Improving total knee

Mrs. H injured her knee while working on call as an OR nurse one night. She was preparing for a shoulder arthroscopic irrigation and debridement for a patient with an infected shoulder. As Mrs. H lifted the beach chair apparatus off its cart and pivoted, she felt severe left knee pain. With help from her co-workers, she finished caring for the patient before she went to the ED for treatment.

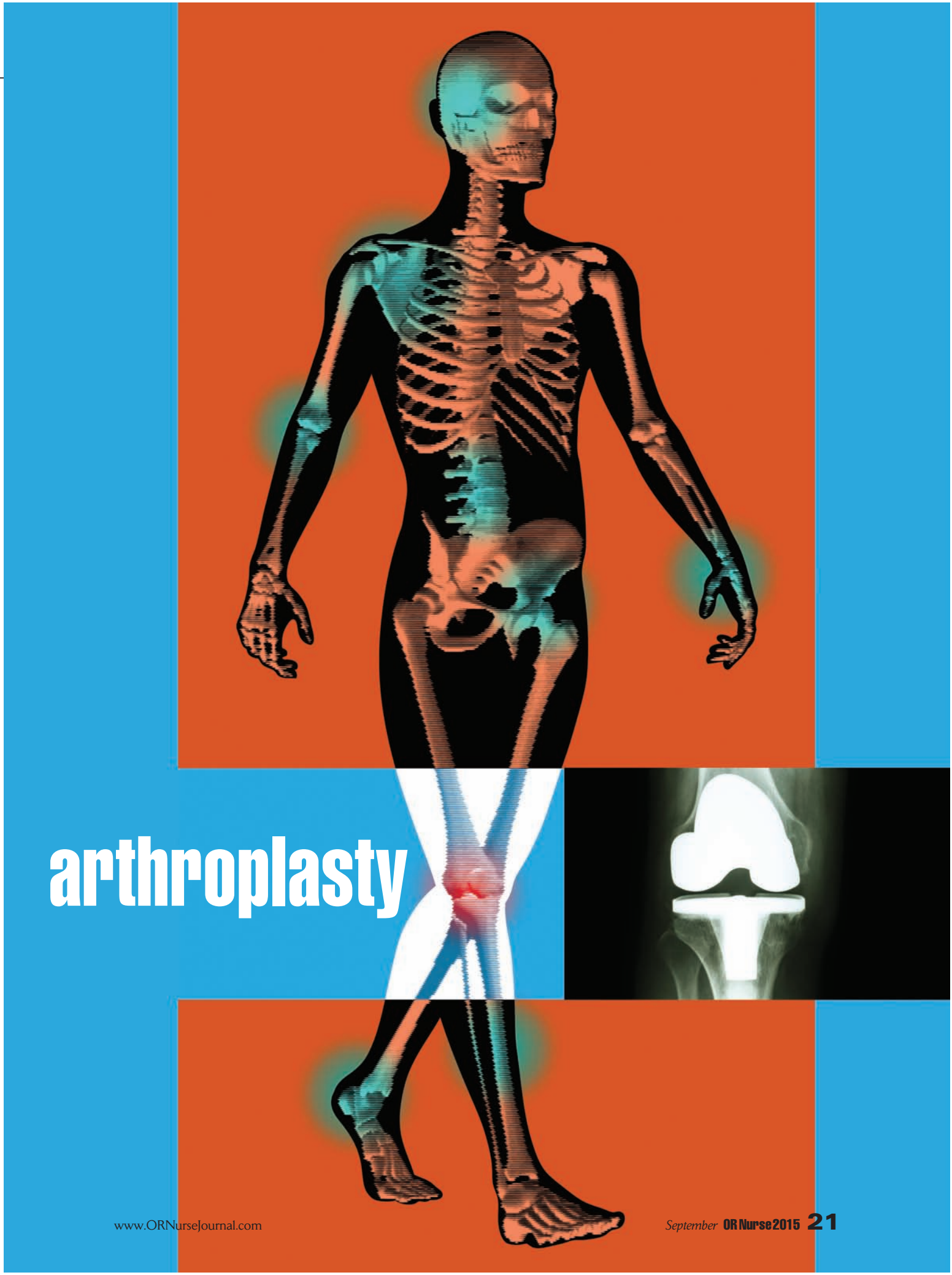
Over the next few weeks, Mrs. H underwent a magnetic resonance imaging (MRI) and knee arthroscopy. The surgeon found a chondral injury to her medial femoral condyle. Mrs. H recovered from the knee arthroscopy and returned to full-time duty, but suffered daily left knee pain. The surgeon said she would likely need a total knee replacement in the future.

Knee procedure perspective

Total knee procedures are very successful as pain-relieving, function-improving measures for patients suffering from osteoarthritis, rheumatoid arthritis, and traumatic injuries. In fact, the number of total knee procedures more than doubled between 2000 and 2010. In 2000, 282,350 total knee procedures were performed. In 2010, the number had climbed to 658,340 total knee procedures.[1] Experts predict that by 2020, 1.4 million total knee procedures will be performed annually.[2] (See *Total knee arthroplasty history.)*

Choices in implant materials

The traditional femoral and tibial implants are made of cobalt chrome or titanium, and the tibial articular surface and patella button are made of a plastic, ultra high-molecular weight polyethylene (UHMWPE). Efforts to improve femoral implants have resulted in ceramic and zirconium femoral components.[3] The tibial polyethylene articular surface implants are now being manufactured using techniques known to improve longevity of the implant. One such technique is crosslinking, in which the articular surface is irradiated in a



low-oxygen environment to strengthen the carbon bonds. Additionally, vitamin E is blended with the irradiated polyethylene and the articular surface is treated. Vitamin E protects the polyethylene from oxidative degradation and improves the mechanical wear of the implant.[4] (See *Design choices.*)

Avoiding metal allergies

Physicians and scientists recognize that metal implants inside the human body dissolve metal ions into body fluids. These metal ions have been found in joint fluid, blood, and urine. When patients are repeatedly exposed to a substance, including metal ions, their bodies can mount an allergic response. Total knee replacement implant metals such as cobalt and chromium can be found in cosmetics and preservatives.[3]

This sensitivity to metal can result in skin reactions or deeper hypersensitivity issues. These reactions can present as eczema-type reactions or itchy, blistering vascular eruptions. Delayed type IV cell-mediated hypersensitivity reactions may develop around implants with resulting inflammatory changes and loosening.[3] Up to 5% of all total joint arthroplasty failures may be due to delayed type hypersensitivity reactions to metals.[5]

In 2009, the North American Skin Patch testing group reported the following metals found in implants caused reactions: nickel 21% of the time and cobalt or chromium 8% of the time.[3] The American Academy of Orthopaedic Surgeons (AAOS) addressed this topic in a 2012 newsletter and recommended that only patients with a documented history of metal allergy be tested. They acknowledged that conducting a skin patch test with the mixture of metals in petroleum jelly on the patient's skin for a period of 48 hours may itself contribute to sensitivity.

For those patients with hypersensitivity to one of the implant metals, skin patch testing or a lymphocyte transformation test (LTT) should be performed prior to surgery. Skin patch testing is the gold standard for evaluation of type IV hypersensitivity reactions.[5] The LTT blood test measures the production number and rate of lymphocytes after exposure to a potential allergen over a 7-day period. The result of the LTT test is reported as a stimulation index.[5] During preoperative testing, the surgeon should ask screening questions about a history of metal hypersensitivity reactions (such as reactions to metal jewelry or other metal implants).[5] Surgeons may specify the implant metal for patients with a specific metal hypersensitivity. Alternative metals used in total knee implants include titanium, zirconium nitride, and oxidized zirconium.

Instrumentation vs. patient-specific guides

In the early days of total knee procedures, inadequate instrumentation required surgeons to make freehand cuts and fill in the gaps between bone and implants with cement. As instrumentation was improved during the 1980s and 90s, surgeons found they could make precise cuts to match implant shapes and sizes.

The patient-specific technique involves cutting models built by the implant manufacturer based on the patient's MRI or CT scan results. The patient has either an MRI or CT scan done on the affected knee weeks before surgery and the cutting models are made using the results. The surgeon has digital access to this information and approves the planned cutting models before manufacturing. On the day of surgery, these patient-specific cutting models (one for femur and one for tibia) guide the surgeon as he or she saws the bone. These models not only allow

Total knee arthroplasty history

Efforts to relieve knee osteoarthritis pain began in the mid-19th century when surgeons tried to interpose soft tissue between the bones to relieve pain.

The 1950s and 60s saw great progress when two designs were developed: constrained and hinged knee (femoral and tibial components were connected and allowed bending) and condylar replacement (femoral and tibial weight-bearing components that are not connected). After Dr. John Charnley's successful cemented total hip procedures relieved patient's pain in the 1960s, surgeons began cementing condylar knee implants.

By 1974, a total knee replacement procedure included femoral, tibial, and patellar implants. Other improvements included instrumentation, porous implants, and modularity (more size choices that fit together). Current efforts continue to improve total knee designs, implant materials, surgical technique, and the patient experience.

precise cuts, but also help to balance the ligaments.[7] Some surgeons use computer navigation to perform minimally invasive techniques.

Fixation—porous vs. glued implants

With improved instrumentation, porous implants became an option. These porous implants were manufactured with a rough surface, such as tantalum or trabecular metal, which the bone grows into improving the longevity of the implant. Surgeons continue to utilize cemented implants especially for osteoporotic bone. Cementing techniques such as vacuum mixing, protecting cement from humidity, and applying cement to blood and debris-free implant surfaces help to strengthen the implant-bone attachment.

Preventing surgical site infections (SSIs)

An infection involving implants causes discomfort and fear for the patient and could result in more surgical procedures and osteomyelitis with implant removal. Over the past several years, many improvements have been implemented in an effort to decrease SSIs. According to the *National and State Healthcare-associated Infections Progress Report*, the total knee arthroplasty procedure infection rate has decreased.[8] The report reviewed 378,846 total knee arthroplasties at 1,750 different sites and found that the 2013 national standardized infection rate (SIR) was 40% lower when compared to the 2008 SIR national baseline.[8] Although this is good news, all involved agree a single SSI is unacceptable and work continues toward the goal of zero SSIs.

While many of the pathogens that cause infections can be found on the patient's skin, these same pathogens can live on environmental surfaces. For example, enterococcus and Staphylococcus can both live for months on commonly used hospital fabrics and plastics.[9]

Airborne sources can contaminate surgical wounds. That is why controlling traffic in the OR should be standard behavior. Many facilities use laminar flow ventilation and/or surgical attire that completely cover hair and body, to protect patients, surgeon, and personnel during total joint procedures.[10] Hospitals are also evaluating Ultraviolet C-band light and hydrogen peroxide technology as a means of deactivating DNA in pathogens such as bacteria and viruses.[11]

Design choices[6]

While a knee is called a hinge joint, surgeons recognize the knee has more complex movements than a simple hinge. Over the years, manufacturers have attempted to incorporate normal knee motion into implants. Both fixed-bearing and mobile bearing prostheses utilize three compartment implants (tibial tray with a polyethylene articular surface, a metal femoral component, and a polyethylene patella button). While the fixed-bearing prosthesis locks the tibial articular surface onto the tibial tray, the mobile-bearing prosthesis is designed for movement of the tibial insert upon its tibial tray.

Unicompartmental knee implants address arthritis of either the medial or lateral aspect of the femur and tibia.

Processing and instrumentation issues

Any discussion of preventing SSIs must begin with proper hand washing by the perioperative staff, including anesthesia care providers. One group of researchers found that anesthesia care providers can cause SSIs if they contaminate stopcock and I.V. tubing.[12] Swabbing stopcocks with alcohol or chlorhexidine gluconate before injecting helps prevent bacteria from being introduced into the patient's blood stream. Perioperative staff must remain vigilant and avoid potential points of contamination to protect patients from SSIs.[13]

The Association of periOperative Registered Nurses' new recommendations for surgical attire state that the head, hair, ears, and facial hair must be covered. Skull caps no longer fit this description as they leave hair uncovered at the neck that can expose the patient to infection from dandruff, shedding hair, and skin cells.[14]

Screening for *Staphylococcus aureus* (SA)

The Institute for Healthcare Improvement recommends all patients having total joint replacement surgery be prescreened for SA. Patients who carry SA in their nares or on their skin are more likely to develop an SA SSI, such as methicillin-sensitive

SA (MSSA) or as methicillin-resistant SA (MRSA). Patients who test positive for nasal SA should be pretreated with intranasal mupirocin for 5 days preoperatively to decrease SA flora.[15]

Chlorhexidine gluconate (CHG) soap cleansing

Preoperative CHG bathing or showering and intranasal mupirocin decrease SA from the skin and nose and help protect from infection. A recent randomized, double-blind, placebo-controlled trial showed that SA carriers treated with 5 days of intranasal mupirocin and CHG washes before surgery had a 60% lower SA SSI rate than the placebo group.[16]

While perioperative staff and surgeons know the value of preadmission showers and cleansing, patients may not. A 2014 study evaluated whether using electronic reminders sent to the patient helped them comply with the recommended preadmission CHG cleansing.[16] Participants received alerts via voice mail, text message, or e-mail, and 80% chose text messages. The study found that CHG skin surface concentrations were significantly higher for participants who received the electronic reminders.[16]

Optimal preoperative health

Each patient's preoperative health and well-being is critically important. Is the patient's blood glucose level under control? A patient's normal A1C blood glucose level indicates blood glucose control for the past 2 to 3 months. Are there any signs of skin breakdown and/or infection? Intact, healthy skin provides the best defense against infection. Preoperative urine culture and sensitivity results that show a urinary tract infection should be pretreated and resolved before surgery. Does the patient smoke? Is the patient's nutritional status healthy? Many surgeons postpone total joint replacement surgery until the patient is at optimal health. Surgeons want healthy patients with intact skin, no signs of pre-existing infections, and normal blood glucose levels.

Antibiotics ordered by weight and redosing

The 2013 antibiotic recommendations of the American Society of Health-System Pharmacists, the Infectious Diseases Society of America, the Surgical Infection Society, and the Society for Healthcare Epidemiology of America include weight-based antibiotics. For patients undergoing total joint procedures, the recommendations include:

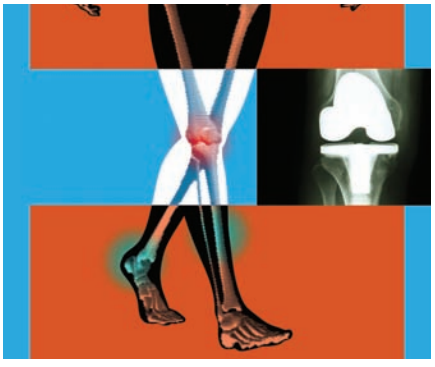
- Adult patients weighing up to 176 lb (80 kg) receive 1 g of cefazolin.
- Adult patients over 176 lb (80 kg) to 264.5 lb (120 kg) receive 2 g of cefazolin.
- Adult patients weighing above 264.5 lb (120 kg) should receive 3 g of cefazolin.
- If the patient is allergic to beta-lactam (cefazolin), clindamycin, or vancomycin will be given at a weight-based dosage.
- The appropriate time frame for antibiotic administration is within 1 hour prior to incision for cefazolin, 2 hours for vancomycin and clindamycin.
- Redose if the procedure lasts longer than two half-lives of antibiotic or if excessive blood loss occurs. For example, the half-life of cefazolin for adults with healthy kidney function is 1.2 to 2.2 hours. The recommended redosing time frame is 4 hours.
- The final recommendation involves giving a single dose antibiotic and the current guideline recommends that the antibiotic should not be continued past 24 hours of first dose.[17]

Tranexamic acid (TA) to prevent blood loss

TA can be administered (FDA off-label use) to patients having total joint replacement surgery to decrease intraoperative and postoperative blood loss.[18] TA, classified as an antifibrinolytic, is a synthetic lysine amino acid derivative. It exerts its antifibrinolytic activity through the reversible blockage of lysine-binding sites of plasminogen molecules. The drug inhibits the action of plasmin and reduces excessive breakdown of fibrin thus exerting physiologic hemostasis.[19] TA is given preoperatively as an I.V. piggyback infusion 10 minutes prior to incision, and a second dose is administered at tourniquet release time. The infusion is given over 10 to 20 minutes.[19]

One concern surgeons have about this practice is the potential for venous thromboembolism (VTE). TA is contraindicated in patients who are at risk or have a known thromboembolic disease. A 2015 single-center, retrospective cohort study published in the *Journal of Arthroplasty* looked at 13,262 elective total joint arthroplasty procedures for both hip and knee and found the odds of postoperative VTE and 30-day mortality were unchanged with TA administration.[20] A 2010

study published in the *Journal of Bone & Joint Surgery* found that the application of TA directly into the surgical wound at completion of total knee arthroplasty with cement reduced postoperative bleeding by 20% to 25%, or 300 to 400 mL, resulting in 16% to 17% higher postoperative hemoglobin levels compared with placebo, with no clinically significant increase in complications identified in the treatment groups.[21]



Current efforts continue to improve total knee designs, implant materials, surgical technique, and the patient experience.

Intraoperative irrigation

Surgeons may recommend irrigating away bacteria to prevent SSIs. The surgeon may add antibiotics such as gentamicin, kanamycin, or bacitracin to irrigation fluids as well as antiseptics such as iodophor and CHG.[22] The 2012 meetings of both the American College of Surgeons and the Association for Professionals in Infection Control and Epidemiology reported that a 0.05% CHG cleansing and/or debridement irrigation solution was FDA-cleared for use during surgery. This CHG product has a greater than 99.99% bacteria kill rate in 1 minute against the three most common causes of SSIs: *Staphylococcus epidermidis*, enterococcus, and Coagulase-negative Staphylococcus.[22] This CHG product is equally influential against other bacteria such as *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Enterobacter aerogenes*, *E. coli*, *Streptococcus pyogenes*, and *Acinetobacter baumannii*.[22]

Pain control after surgery

Preventing postoperative pain is critically important for patient satisfaction and ease of recovery. Traditional methods have utilized options such as patient controlled analgesia, opioid analgesics, and oral pain medications such as nonsteroidal anti-inflammatory drugs (NSAIDs) and acetaminophen. Combinations of different drugs such as opioid analgesics and an NSAID (such as ibuprofen) can often provide better pain control. Anesthesia care providers can also perform regional blocks. Some surgeons inject an intra-articular pain cocktail during surgery that contains bupivacaine, ketorolac, morphine sulfate, epinephrine, and sterile injectable 0.9% sodium chloride.[23] Another option involves long-acting liposomal bupivacaine, which lasts up to 72 hours when injected into joint tissues.[24] In a 2014 study involving 216 patients, half were given a continuous femoral nerve blockade and compared with the other half who received the liposomal injection at surgery. This study concluded liposomal bupivacaine injected into knee tissues provided better pain control, increased patient satisfaction, and faster recovery.[24]

Preventing complications

Perioperative nurses can take the following actions to help support patients' health and promote recovery:

- Keep patients normothermic during all phases of surgery and recovery to prevent complications of hypothermia.[25]
- If the operative area needs hair removal, hair should be clipped (not shaved) in the preoperative holding area.[26]
- Patients with diabetes should have their blood glucose level monitored and kept within approved limits.[27]
- Perioperative staff and surgeons provide early ambulation, anti-embolism boots, and anticoagulants as options in their efforts to prevent deep vein thrombosis and pulmonary embolism.[28]

Outpatient total knee replacement surgery

Over the past few decades, hospital stays for total joint replacement patients have shortened dramatically. In 2012, researchers reported on a study of 108,000 Medicare patients who had total knee arthroplasty surgery performed between 1997 and 2009.[29] During that time period, 23,500 patients stayed in the hospital 5 or more days, 73,000 patients stayed in the hospital 3 to 4 days, 6,756 stayed 2 days, 1,374 had 1-day hospital stays, and 2,883 had outpatient knee surgery. When comparing the length-of-stay patient groups, the 90-day mortality was higher in outpatients versus the 3-4 day patients. The study authors noted that Medicare data do not

include important risk factors such as body mass index and smoking status.[29]

Surgeons continue developing programs that support the outpatient plan of care. Critical aspects in outpatient total joint replacement surgery begin with careful preoperative patient screening. One group's criteria for outpatient procedures include the patient having a body mass index of less than 40 and a healthy preoperative status with no cardiopulmonary issues, sleep apnea, or history of blood clots, such as deep vein thrombosis or pulmonary embolism. To qualify for this outpatient program, these patients were required to live within 1 hour of the hospital and have good family support.[30] A study reported at the 2014 annual meeting of the AAOS looked at 235 total joint arthroplasties performed between September 2010 and May 2011 by one surgeon. In this study, outpatient total joint arthroplasties involved 137 patients, while 98 patients had a 2-day hospital stay. No statistically significant difference was found and the lead researcher reported, "Outpatient TJR has the potential benefit to cut costs and improve patient satisfaction...While larger studies are needed to better evaluate the etiology of readmissions and potentially lower them in the outpatient setting, overall outpatient surgery appears a safe and viable option in appropriately selected patients."[30]

Enhancing patient outcomes

At the author's facility, Saint Francis Medical Center in Cape Girardeau, Missouri, patients participate in Joint Camp, a perioperative program that begins with extensive education. The joint camp emphasizes an attitude of health, wellness and positive attitude toward the total joint surgical experience and rehabilitation. Patients can choose a family member or friend as a coach, who supports them through the event. Preoperative classes provide patients and coaches with helpful information and booklets help reinforce what is taught in class. Physical and occupational therapists provide preoperative education so the patient learns to practice exercises before surgery (prehabilitation). During these classes, patients become acquainted, and this social aspect can add to a friendly competition as patients go through rehabilitation and measure their postoperative progress.

Researchers identified three indicators for a probable longer postoperative hospital stay: increased patient comorbidities, lack of family support for the patient's return home, and patients undergoing bilateral procedures.[31] Many continue to watch the outpatient trend to evaluate its outcomes.

What happened to Mrs. H?

When Mrs. H met with her surgeon, they recognized that her left knee pain was limiting her quality of life. Because only the medial femoral condyle had been damaged, her surgeon recommended a left medial unicompartmental knee arthroplasty. Her surgeon had her tested for metal allergy and found she needed nickel-free implants. He scheduled titanium implants for her. Mrs. H attended the Joint Camp and learned the exercises she would need to practice before and after surgery. (See *Enhancing patient outcomes.*) The day of surgery, Mrs. H received general anesthesia, TA, and liposomal bupivacaine. She went home on the first postoperative day to recuperate. **OR**

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