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Osteoarthritis (C Lozada, Section Editor)

Hip and Knee Arthroplasty in Osteoarthritis

Erik C. Zachwieja, MD[*]
Jose Perez, BS
Michaela Schneiderbauer, MD MBA

Address
[*]Miller School of Medicine, University of Miami/Jackson Memorial Hospital, 1611 NW 12th Avenue, Miami, FL, 33136, USA
Email: erik.zachwieja@jhsmiami.org

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Opinion statement

Osteoarthritis (OA) of the hip and knee continues to increase in prevalence with the increasing age of our population. This condition is characterized by joint pain, stiffness, and limitations in activities of daily living. Management options are initially aimed at preventing the progression of disease and delaying the need for total joint arthroplasty (TJA). This includes nonoperative measures, as well as surgical interventions, including arthroscopy, osteotomy, and arthrodesis. However, once patients fail alternative therapy, TJA is indicated. Total knee arthroplasty (TKA) and total hip arthroplasty (THA) are highly effective procedures at reducing pain and improving functional status. Patients report high satisfaction rates after TJA and experience minimal complications. Moreover, these procedures are cost effective. Significant research into patient-specific implants (PSI) and computer-navigation-assisted surgery shows improved component positioning; however, further research is needed to determine the clinical effect of this innovation. Wear rates in both TKA and THA have improved significantly over the past decade, with highly cross-linked ultra-high molecular-weight polyethylene showing promising results. New minimally invasive surgical techniques are also showing excellent short-term results, but long-term data is still lacking. Overall, hip and knee OA is a debilitating condition that can be effectively managed with TKA or THA. Indications continue to expand for these procedures and innovation continues to aim for improved outcomes.

Introduction

Osteoarthritis (OA) is a musculoskeletal disease characterized by degradation and loss of articular cartilage, bone remodeling, osteophyte formation, and inflammation of the synovial membrane

secondary to metabolic, biochemical, and structural changes within the joint [1, 2]. OA has traditionally been known to be a noninflammatory process resulting from biomechanical forces that destabilize the joint and place inappropriate levels of stress on the articular cartilage and surrounding structures. These forces may result from abnormal or excessive load bearing, deformity, or traumatic injuries [3]. In addition to biomechanical changes within the joint, studies have shown genetic and environmental factors influencing the pathogenesis of the disease. OA has been associated with increased age, the female gender, obesity, race, and occupation [4–6].

Patients with OA typically report functional limitations that remain fairly stable over a period of time [7]. Limitations can be correlated to levels of pain, comorbidities, range of motion, and the age of each individual patient [8]. Pain and stiffness are the most common symptoms reported in patients with OA. Although stiffness of the joint contributes to the functional limitations, pain is the major cause of difficulty in walking, climbing stairs, and other limitations in activities of daily living [9, 10].

In addition to the physical symptoms reported by patients, osteoarthritic changes can be seen with radiographic imaging. Studies have demonstrated the highest prevalence of OA takes place in the spine followed by the hand, knee, shoulder, and hip [11•]. Radiographic images provide information regarding the severity of OA and are often used in conjunction with physical presentation and history to dictate management. Studies predict 67 million adults will be diagnosed with OA by the year 2030, with an additional 25 million experiencing arthritis-attributable activity limitations [12]. The high prevalence and increasing incidence of OA has led to increased scientific exploration in understanding the disease to improve diagnosis, therapy, and outcomes in management.

Management for OA begins with conservative therapy (Table 1). This includes activity modification, weight loss, physical therapy, nonsteroidal anti-inflammatory medications (NSAIDs) and other analgesics including opioids, topical agents, intra-articular injections, and orthotics aimed to unload the affected joint. After conservative therapy has failed, surgical management is the preferred treatment. Surgical management options for OA include arthroscopy, osteotomy, arthrodesis, and arthroplasty. The majority of this text will focus on hip and knee arthroplasty for OA; however, we will provide the most salient points pertaining to the other surgical management options for hip and knee OA to ensure thoroughness.

Table 1. Management options for osteoarthritis of the hip and knee

Conservative therapy
Activity modification
Weight loss
Physical therapy
Topical agents (capsaicin, topical NSAIDs, transdermal patches)
Non-steroidal anti-inflammatory medications (NSAIDS)
Analgesics (opioid and nonopioid)
Intra-articular injections
Orthotics
Surgical management
Arthroscopy
Osteotomy
Arthrodesis
Unicompartmental knee arthroplasty
Arthroplasty

Surgical treatment options

Surgical management of hip and knee OA is considered after nonoperative measures have been exhausted. In general, nonarthroplasty options are offered to younger patients to delay, but not necessarily avoid, the need for joint replacement in the future. However, with continued innovation in the field of total joint arthroplasty (TJA) and evidence supporting better outcomes in patients operated on earlier in the course of their functional decline, TJA indications are continuing to expand and younger patients are becoming recipients of these revolutionary procedures [13, 14].

Arthroscopy

Knee arthroscopy was widely used in the past as an early surgical management option for knee OA after medical therapy had failed [15]. However, recent randomized controlled trials (RCT) have shown that outcomes after arthroscopic lavage or debridement for patients with degenerative arthritis have no added benefit to optimized medical therapy and are no better than placebo [16, 17].

The rate of hip arthroscopy has exponentially increased over the past two decades [18]. Currently, its indications are for the prevention of arthritis secondary to femoroacetabular impingement (FAI). Its effectiveness for the management of osteoarthritis remains unclear. Young patients with mild forms of osteoarthritis may show modest benefit, while older patients with more severe OA tend to show limited benefit and have a high rate of early conversion to total hip arthroplasty (THA) [18, 19, 20•, 21••].

Osteotomy

Osteotomies are performed to restore the mechanical axis of a limb and offload the diseased compartment. The primary goal is to delay the onset or progression of OA.

Osteotomies around the knee are typically indicated for young patients with isolated unicompartmental OA or deformity. High tibial osteotomy (HTO) is classically performed for patients with medial compartment knee OA and varus deformity. Similarly, patients with lateral compartment knee OA and associated valgus deformity undergo a distal femoral varus osteotomy [22]. This restores the anatomic alignment of the knee and transfers the load more evenly across all compartments. Osteotomy for knee OA can be effective for carefully selected patients at delaying the need for joint replacement, however, rates continue to decline with continued evolution of the total knee arthroplasty (TKA) [23, 24].

Hip dysplasia and deformity lead to overloading of either the femoral head articular cartilage, articulating portion of the acetabulum, or both. This ultimately progresses to premature OA. Pelvic osteotomy is indicated in young patients with hip dysplasia to reorient the healthy acetabular articular cartilage over the femoral head. While clinical outcomes are not as good as those for THA, young patients with moderate dysplasia can experience benefit [25]. Conversion rate to THA at 20 years is approximately 30–40% [26, 27]. Varus

intertrochanteric femoral osteotomy can also be performed to improve hip biomechanics in carefully selected young patients with minimal arthritis [28].

Arthrodesis

Arthrodesis is a procedure which sacrifices the function of a joint to provide a stable, pain-free joint. Arthrodesis is typically performed on the small joints of the hands and feet; however, there are specific indications for hip and knee arthrodesis.

Historically, knee arthrodesis had a wide range of clinical indications, including posttraumatic arthritis and septic arthritis [29]. However, with the advent and success of the modern total knee replacement (TKR), the most common current indication for knee arthrodesis is a salvage procedure after a failed TKA [29–31]. Outcomes are poor though, and conversion to a TKA has a high complication rate [32, 33•].

Hip arthrodesis is an increasingly uncommon procedure secondary to continued improvements in THA design and longevity. It is indicated for young, active adults with end-stage arthritis who are not ideal candidates for THA [34]. Overall patient satisfaction rates are very good [35••]. It is a reasonable treatment option which can successfully be converted to a THA if adjacent joint disease develops [36].

Arthroplasty

Dr. Jon Charnley introduced total hip replacement surgery in the 1960s, and total knee replacement surgery was introduced shortly thereafter. Since that time, these procedures have continued to evolve, with expanding indications and improving outcomes.

Today, more than 7 million Americans are living with a hip or knee replacement [37••]. Current estimates suggest that by 2030, the demand for THA will grow by 174% and TKA will grow by 673% to 572,000 and 3.48 million procedures, respectively [38]. With the increasing demand for total hip and knee arthroplasty, it is imperative for medical practitioners to understand the indications and implications of these procedures.

Indications

The main indications for arthroplasty of the hip and knee are similar and include limitations in range of motion and increased pain within the joint. Several studies have indicated pain, functional limitations, and stiffness as the key components that are taken into account when considering arthroplasty [39–43]. These physiologic changes are often associated with changes seen on radiographic images; however, the degree of radiographic changes may not reflect the physiological impact the disease has on the quality of life of the patient, hence, it should not serve as an indication for surgery [43, 44•].

Considerations

The primary goal of both TKA and THA is a restoration of function with decreased pain. While the goals are the same between procedures, the technical aspects are quite different.

The hip is a ball and socket joint, comprised of a ball, or the femoral head, and a socket, or the acetabulum. THA involves replacing the femoral head with

an artificial ball attached to a femoral stem and implanting an artificial socket into the native acetabulum (Fig. 1). The implants can be fixed to the bone with or without cement. Most modern implants utilize cementless fixation. Cemented fixation is reserved for older patients with poor bone quality [45•]. The implants contact each other at the bearing surface. These surfaces are prone to wear and, therefore, materials with excellent wear characteristics are preferred. Current bearing surfaces include ceramic-on-ceramic and ceramic-on-polyethylene (Fig. 1).

Movement of the knee joint is determined by the shape of the distal femur, proximal tibia, and the four major ligaments of the knee. Modern implants retain the collateral ligaments and typically sacrifice the cruciate ligaments. This maximizes stability and longevity. The distal femur and proximal tibia are then resurfaced with metal components after removing the damaged articular cartilage and a small amount of bone. The implants are most often fixed with cement; however, contemporary implant design allows for cementless fixation of the tibial component. A polyethylene spacer is then inserted onto the tibial component to provide a smooth gliding surface.

The average length of hospital stay after TJA continues to decrease with changes in Medicare reimbursement, as well as improvements in perioperative care and postoperative rehabilitation. Patients can expect to stay in the hospital an average of 3–4 days postoperatively and begin ambulating the next day [22, 47••, 48]. There is a trend towards ambulatory surgery in young, healthy patients [49].

Outcomes

Advances in surgical technique, prosthetic design, and surgeon experience make TKA and THA two of the most successful surgical interventions of the modern era. Current TKA implants have a survival rate of 90% at 15 years, and the gold-standard THA design shows excellent long-term results, with 23% revision rate

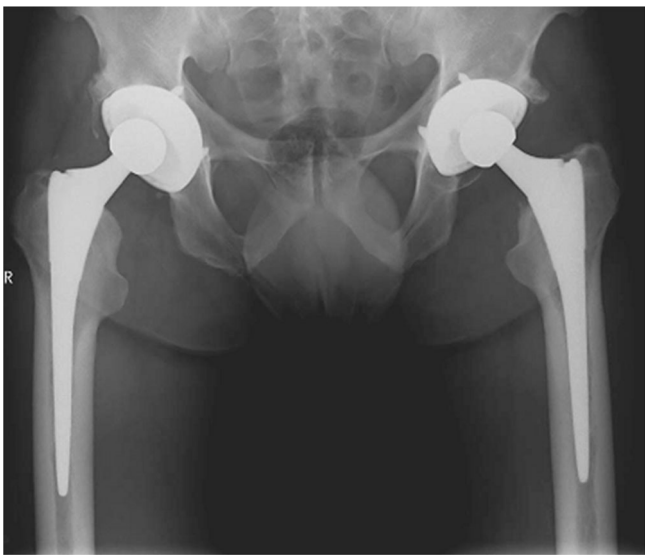

Fig. 1. Bilateral total hip replacements at 10-year follow-up [46].

at 25 years [50, 51•]. Moreover, these are relatively safe procedures. Based on Medicare data, patients can be informed that less than 5% have a serious complication following primary TKA or THA and less than 1% die [22]. In fact, mortality rates following elective THA and TKA have decreased substantially since the early 1990s, despite patients having more presurgical comorbidity [52••].

In a recent RCT, TKA was shown to be more effective than nonsurgical treatment in providing pain relief and improving function and quality of life in patients with knee OA [53]. Outcome data shows that approximately 81% of patients are satisfied after TKA [54]. THA has been coined the operation of the century, with greater than 95% of patients satisfied with the functional results [46]. Patient dissatisfaction seems to be related to patient expectations and certain preoperative factors, including advancing age, a history of depression, and limited preoperative range of motion (ROM) [54–57].

There is significant interest in understanding preoperative factors which may contribute to poor outcomes postoperatively in TKA and THA. Strong evidence suggests poorer outcomes in association with elevated BMI, increased age, multiple comorbidities, worse preoperative physical function, and worse mental health status [57]. Similarly, low-volume hospitals and surgeons are associated with poorer outcomes [58].

Complications

Overall readmission rates within 30 days of surgery have been reported at 4.2% for TKA and 4.6% for THA. The predominant reasons for readmission are wound infection, sepsis, and thromboembolic-, cardiac-, and respiratory-related events [59•]. It appears that the readmission rate does increase with time, as the overall unplanned readmission rate is 7% at 90 days following primary THA [60]. Risk factors for readmission include increased body mass index (BMI) and greater than two medical comorbidities [61••]. Similarly, male sex, discharge to inpatient rehabilitation, increased duration of hospital stay, decreased age, and decreased distance between the home and the hospital are predictors of readmission within 90 days [62, 63•]. Understanding modifiable risk factors such as increased BMI and multiple medical comorbidities is imperative in counseling and selecting operative candidates prior to these elective procedures. Moreover, recognition of nonmodifiable risk factors can help practitioners counsel patients and manage expectations.

With the increasing demand for TJA and the increasing number of primary TJAs being performed, there is an associated increased rate of revision TJA procedures. Overall, the rate of implant failure leading to revision surgery is estimated to be about 1% in TKR and THR recipients [22]. For both procedures, younger and more active patients are at a higher risk of failure.

Aseptic prosthetic loosening, infection, and postoperative instability are the three most common reasons for contemporary revision TKA procedures. Prosthetic joint infection is the most common cause in patients that undergo revision within 2 years of their index procedure, and loosening is the most common reason for revision more than 2 years after the primary procedure [64].

Contemporary THA implants show similar causes for failure. Early failures are most commonly associated with prosthetic joint infection, followed by aseptic loosening and instability. Late failures are related to aseptic loosening,

periprosthetic fracture, and polyethylene wear [65•, 66]. Much attention has recently been paid to metal-on-metal (MoM) hip arthroplasty and its high failure rate. This bearing surface allows for improved postoperative stability and provides superior wear rates. Unfortunately, these implants are susceptible to a unique mode of failure: adverse local tissue reaction (ALTR) due to delayed-type hypersensitivity-like reactions termed asepctic lymphocytic vasculitis-associated lesions with formation of pseudotumor. Patients with ALTR present with groin pain aggravated by weight-bearing activities, and patients often feel that they are no better than they were prior to THA [67]. Advanced imaging studies, including MRI, reveal a pseudotumor and significant soft tissue reaction surrounding the hip. There are currently more than 500,000 patients with MoM hips in the USA; thus, this will continue to be a source of revision surgery in the future [68].

Cost effectiveness

With the aging population and increased demand for TJA, the economic burden of these procedures is considerable. The current cost burden to Medicare for primary THA is greater than US$13 billion [69]. However, the quality of life gains achieved with TKA and THA are cost effective in most patients [70]. Patients with unusually high preoperative quality of life scores and lack of severe OA, though, may not receive maximal benefit and, hence, the procedure is not cost effective [71].

Trends

The field of total joint replacement is filled with innovation and development. The goal is to reduce the rate of failure, accommodate the increased demands placed on implants by the modern patient, and improve overall patient satisfaction. This has led to the development of patient-specific implants, computer-navigation-assisted implantation, implants with improved wear characteristics, and new minimally invasive techniques for implantation.

Patient-specific implants were founded on the idea that adequate component positioning is an important factor in the rates of early failure and patient satisfaction. Utilizing preoperative computed tomography (CT) scans or magnetic resonance imaging (MRI), patient-specific instruments and implants are designed and used to theoretically improve accuracy of implant placement. This, however, comes at an increased cost. Early results with patient-specific implants (PSI) show likely improved component positioning without significant improvement in patient outcomes [72, 73, 74•, 75–77].

Similar to PSI, computer-navigated-assisted TJA aims to improve overall alignment of the implant. The first computer-navigated TKA was performed in 1997, and since that time, has been touted as a means to reduce component malposition, reduce revision rates, and improve survival [78]. Although a multitude of studies, including a systematic review in 2013, have concluded that navigation can improve alignment and radiographic outliers, there is no evidence to support the use of computer-navigated-assisted TJA as a means to improve functional outcomes or improve survival rates of the implant [79, 80]. Future long-term clinical trials will need to be performed to determine whether computer navigation should play a role in primary TJA.

Osteolysis and prosthesis loosening remains one of the major problems associated with TJA. As younger patients are receiving TJA, it is paramount to find alternative bearing surfaces with reduced wear characteristics. Highly cross-linked ultra-high molecular-weight polyethylene (UHMWP) shows promising results. Short- and mid-term clinical results show a reduced wear rate versus conventional polyethylene [81, 82]. Ceramic-on-ceramic implants also show excellent wear characteristics in THA. Previous concerns about fracture risk to the ceramic may be obsolete with new composite ceramics that have recently been introduced [83].

Minimally invasive TJA is another area of recent innovation. The minimally invasive technique involves a smaller surgical incision and utilizes special instrumentation. Proponents claim that these procedures reduce blood loss, postoperative pain, the length of the hospital stay, and improve outcomes. A meta-analysis comparing limited incision THA to standard THA reveals limited incision THA is better in four measures: length of hospitalization, pain at discharge, blood loss, and pain and function 3 months postoperatively [84•]. While these measures show a significant statistical difference, it is important to note that they may not be clinically important. Minimally invasive TKA techniques have also been developed, with similar results. Patients undergoing the minimally invasive technique experience less blood loss, have less pain postoperatively, and have better functional outcomes up to 9 months postoperatively. However, there is no significant difference between the groups at 1-year postoperative and beyond [85, 86]. The primary drawback to the minimally invasive technique is reduced surgical exposure and steep surgeon learning curve. Long-term follow-up is needed to ensure that the excellent long-term outcomes of TJA are not being compromised by new, minimally invasive techniques.

Unicompartmental knee arthroplasty

A surgical option in patients with osteoarthritis confined to a single compartment within the knee is unicompartmental knee arthroplasty (UKA). Rather than replacing the entire joint surface, as in TKA, a UKA involves replacement of one diseased compartment. UKA is indicated when there is isolated arthritis in one knee compartment with intact cruciate and collateral ligaments, minimal correctable varus/valgus deformity, and flexion greater than 100° intraoperatively. Contraindications include a fixed varus deformity, flexion contracture, and instability [87, 88].

This procedure offers several advantages over TKA, such as maintenance of autologous bone, lower morbidity and mortality, quicker recovery, and improved range of motion [89, 90]. Outcomes show high patient satisfaction rate, a high survival rate, and good functional performance [91, 92]. Data also suggests that UKA may prevent the progression of opposing compartment arthritis [93]. UKA has proven to be an effective means by which patients can return to sports as well, with two thirds of the patients reportedly reaching a high activity level following the procedure [94•].

Complications associated with UKA include dislocation of the mobile bearing, infection, aseptic loosening/lysis, and unexplained pain [95••, 96–98]. Conversion to TKA has been shown to be challenging due to the need for augmentation from bone loss, as well as restoration of the joint

line and rotation [90]. Overall, the success of UKA relies on its minimally invasive technique that results in early recovery and good functional outcomes. Proper patient selection is critical [99].

Conclusions

The increasing prevalence of OA, in association with the functional limitations and pain associated with its diagnosis, has led to an exploration in both medical and surgical management. Conservative therapy is the first-line treatment for OA; however, surgical management is the preferred therapy. Although there are different surgical interventions available for the management of OA, arthroplasty has proven to be a staple treatment due to its efficaciousness and cost effectiveness. The functional improvements and high satisfaction rates after TJA has led to an increased prevalence of Americans living with artificial joints, with studies projecting the demand to increase drastically over the coming years. This high demand has led to innovations in the form of patient-specific implants, computer-navigation-assisted surgery, and minimally invasive procedures; although further research is needed to verify improved long-term clinical outcomes in these options. Arthroplasty continues to be an effective method by which physicians can treat the increasing incidence and prevalence of hip and knee OA.

Compliance with Ethical Standards

Conflict of Interest
The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent
This article does not contain any studies with human or animal subjects performed by any of the authors.

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