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Invited Review

Surgical Treatments for Osteoarthritis

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Abstract

Osteoarthritis is a prevalent and disabling condition most commonly affecting the knees, hips, and hands. Since there are currently no disease-modifying therapies available, patients with persistent pain and functional impairment despite pharmacologic and other non-operative therapies should be considered for surgical management. For both knee and hip Osteoarthritis, the most common surgical approach is total joint arthroplasty, an elective surgical procedure that generally has favorable outcomes with most patients reporting significant improvements in pain, function, and quality of life. Total joint arthroplasty has relatively low complication rates, with most patients able to be discharged home following a short hospital stay. The optimal timing for undergoing total joint arthroplasty and patient appropriateness for surgery are important considerations, and the current guidelines leave timing and patient selection at the discretion of physicians. Surgical approaches for hand osteoarthritis are less common and more varied, and include both arthrodesis and arthroplasty.

Keywords: Osteoarthritis, arthroplasty, rheumatology

Introduction

Osteoarthritis (OA) is a prevalent and disabling condition accounting for a large global burden of pain, disability, and healthcare costs.[1,2] The joints most-commonly affected by OA are the knees, followed by the hands and hips.[3] There are currently no disease-modifying non-operative therapies available for OA, and patients may experience inadequate symptom control despite maximizing a multimodality conservative approach.[4] Patient with inadequate symptom control and poor quality of life are often referred for consideration for surgical options, most commonly total joint arthroplasty (TJA). This manuscript will provide an overview of surgical treatments for OA and will focus on procedural indications, outcomes, and complications.

Surgical Approaches for Osteoarthritis

Surgical approaches for the treatment of OA include TJA as well as other less invasive approaches. For knee OA, the alternative procedures to total knee arthroplasty (TKA) include unicompartmental knee arthroplasty (UKA) and realignment osteotomy.[5] Realignment osteotomy rebalances the force between the medial and lateral compartments of the knee in order to reduce the pressure of the cartilage and subchondral bones. It has been found to delay the progression of OA and is most often used in relatively young and active patients.[6] For patients with unicompartmental knee OA, UKA is an option that preserves the bones and spares the ligaments, and may have advantages over TKA including improved knee range of motion, better functional outcomes, and fewer medical complications, though with higher rates of revision and re-operation.[7]

For hip OA, patients with early stage disease may be candidates for joint-preserving procedures such as pelvic osteotomy or hip arthroscopy; however, these procedures are generally not used in those with severe degenerative changes.[8] Hip resurfacing as a bone-sparing alternative to total hip arthroplasty (THA), and is most commonly used in younger, more active patients with severe OA.[8]

While TJA is the gold standard for hip and knee OA, it is possible that alternative surgical approaches may become more popular in the future. Some experts have posited that UKA may become more common in the coming decades as the prevalence of OA increases, surgeon familiarity with the procedure improves, and the indications for UKA become less restrictive.[9] At present, TJA continues to be the approach used in the vast majority of patients undergoing surgery for advanced symptomatic knee or hip OA, and therefore this manuscript will mainly focus on TJA.

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Indications for Total Joint Arthroplasty

The decision to refer a patient with OA for surgical evaluation requires consideration of many factors to determine patient appropriateness for the procedure. There are currently no objective measures to help clinicians determine which patients to refer for TJA. Rather, referrals for TJA are dependent on individual clinicians' judgment and subjective interpretation of the guidelines.

Several research groups have attempted to define patient characteristics that should be considered when determining whether TJA appropriateness. In 2003, Escobar and colleagues published an algorithm to assess TKA appropriateness using the RAND/UCLA appropriateness method.[10] Their method used a panel of experts to provide ratings of a series of clinical scenarios to determine their appropriateness for TKA. They created a classification tree, which included symptomatology, radiologic factors (Ahlbäck classification), age, mobility and disability, previous surgical management, and localization. Of these factors, symptomatology and radiology had the largest contribution to the appropriateness determination. Nearly 25% of scenarios in the study were rated as uncertain appropriateness.

More recently in 2014, Riddle and colleagues applied the Escobar method to 205 patients who underwent TKA, and they found that using the Escobar algorithm, 34.3% of TKA cases would have been deemed inappropriate and 21.7% cases inappropriate.[11] Escobar and colleagues recently published an update to their earlier appropriateness classification using an expert panel to evaluate more contemporary indicators of TKA prognosis.[12] They found that patient age, knee pain, function, and radiographic severity were the most important indicators of TKA prognosis. Osteoarthritis location, phycological factors, pain catastrophizing, and comorbidities played a smaller role. It should be noted that while there is no pain severity cutoff in the professional society guidelines, Escobar and colleague's updated classification tree has a first branch point of Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain score <35, below which no patients were considered appropriate TKA candidates.

Several professional societies have developed guidance on patient appropriateness for TJA and other surgical approaches to OA (Table 1). The 2008 Osteoarthritis Research Society International guidelines state that appropriate patients for TJA referral are those "with hip or knee OA who are not obtaining adequate pain relief and functional improvement from a combination of non-pharmacological and pharmacological treatment." They also recommend UKA as an effective option for patients with knee OA in a single compartment,

Main Points

- There are numerous surgical approaches for the treatment of osteoarthritis, and total joint arthroplasty is the most common one for patients with severe symptomatic hip or knee osteoarthritis.
- The guidelines regarding appropriateness criteria for total joint arthroplasty for osteoarthritis vary by professional society, but in general include pain or functional limitations not relieved by conservative treatment.
- Overall, total joint arthroplasty for osteoarthritis is a very successful procedure with high rates of patient satisfaction and low rates of complications.

Table 1. Professional Society Guidelines on Surgical Management for OA and TJA Indications

Guideline	Year	Joint	Key Components
British Orthopaedic Association (BAS) (59)	2017	Knee	• Patients should be referred for joint replacement who have symptoms refractory to non-surgical treatment for 3 months • Patients who have knee OA should be referred for surgery regardless of radiographic grade of disease
British Orthopaedic Association (BAS) (60)	2017	Hip	• THA should be considered when pain is inadequately controlled by medications, there is restriction of function, quality of life is significantly compromised, and/or there is narrowing of the joint space on radiograph
American Academy of Orthopaedic Surgeons (AAOS) (18)	2017	Hip	• Online application to determine recommendations for both non-surgical and surgical treatments for hip OA • Factors included: Age, function-limiting pain, radiographic evaluation, range of motion limitation, and individual patient risk of negative outcome
American Academy of Orthopaedic Surgeons (AAOS) (15)	2016	Knee	• Online application to determine appropriateness of TKA, UKA, and realignment osteotomy • Factors included: Age, function-limiting pain, range of motion, functional instability, pattern of arthritic involvement (one compartment vs multi-compartment), degree of joint space narrowing, limb alignment, and mechanical symptoms
Osteoarthritis Research Society International (OARSI) (13)	2008	Knee and Hip	• Joint replacement surgery should be considered in patients with hip or knee OA not obtaining adequate pain relief and functional improvement from conservative treatments • UKA should be considered in patients with knee OA in single compartment • Osteotomy should be considered in young patients with hip OA, and should be considered in young active patients with unicompartmental knee OA
European Alliance of Associations for Rheumatology (EULAR) (19)	2005	Hip	• THA should be considered in patients with hip OA and refractory pain and disability • Young adults with symptomatic hip OA should be considered for osteotomy and joint-preserving procedures

OA: osteoarthritis, TJA: total joint arthroplasty, UKA: unicompartmental knee arthroplasty, THA: total hip arthroplasty, TKA, total knee arthroplasty.

and osteotomy for young patients with knee or hip OA.[13]

The American Academy of Orthopaedic Surgeons (AAOS) published appropriateness criteria for surgical management of knee OA.[14] The AAOS report rated appropriateness of TKA, UKA, and realignment osteotomy using an expert panel of 10 orthopedic surgeons and a physiatrist. The factors included are function-limiting pain, range of motion, functional instability, pattern of arthritic involvement (one compartment vs. multi-compartment), degree of joint space narrowing, limb alignment, mechanical symptoms, and age. This appropriateness criteria was used to create an online decision aid for providers to input data to determine appropriateness of the surgical procedures.[15] An analysis of the AAOS guidelines found that the largest contributors of TKA appropriateness were age followed by knee OA severity, knee OA pattern, and knee motion.[16] They found substantial agreement to the 2003 RAND/UCLA classification system published by Escobar and colleagues as described above.[10] Interestingly they found that function-limiting pain did not play a significant role in the AAOS classification system.

Investigators and professional societies have also put forward guidance on appropriateness criteria for THA, and the majority of investigations have concluded that that appropriate patients have pain and functional limitation not responsive to conservative treatment.[17] AAOS published appropriate use criteria for the management of hip OA in 2017, although unlike the knee OA guidelines, the procedure recommendations include activity modifications, medications, and assistive devices in addition to surgical procedures including arthroplasty, arthrodesis, and hip preservation surgery.[18] It is also available as an online application where clinicians can input patient characteristics and access the society recommendations. The 2005 European Alliance of Associations for Rheumatology (EULAR) recommendations state that patients should be considered for THA if they have radiographic evidence of hip OA and refractory pain and disability. The EULAR recommendations also state that young adults with symptomatic hip OA should be considered for osteotomy and joint-preserving procedures.[19] Quintana and colleagues used the RAND/UCLA appropriateness method to develop criteria for THR, and their criteria included surgical risk, previous nonsurgical treatments, pain, and functional limitations.[20] They then used those criteria to assess patient response to THA, and found that patients deemed appropriate candidates who underwent THA had more improvement in pain and functional outcomes than inappropriate candidates.

Total Joint Arthroplasty Epidemiology

Total joint arthroplasty is one of the most common elective surgical procedures performed in the United States, with the vast majority being TKA or THA. According to a review of the National Inpatient Sample (NIS), in 2017 the TKA volume in the United States was 7 59 924 procedures, with an incidence of 236.7 procedures per 1 00 000 people.[21] Among Medicare enrollees in 2010, the annual volume for primary TKA was 62.1 procedures per 10 000 people.[22] At a global level, the utilization of TKA varies widely by country. A survey of 18 countries (including the United States) between the years 2007 and 2010 found an average annual incidence of primary TKA of 175 procedures per 1 00 000 population. In Romania there were only 8.8 procedures per 1 00 000 people compared to 234 procedures per 1 00 000 people in the United States.[23] The demographics of patients undergoing TKA in this global study showed that 65.8% of patients were female and 30.5% of patients were less than 65 years old.[23]

According to the NIS, the total volume of THA in 2017 was 5 32 110, with an incidence of 165.8 per 1 00 000 population.[21] The rates of TJA have consistently increased in recent years, and are expected to continue to increase in the coming years. According to data available from the NIS, the number of THAs performed annually in the United States increased from 1 33 566 in 1993 to 3 71 605 in 2014, and TKAs increased from 1 95 684 annually in 1993 to 6 80 886 annually in 2014 (Figure 1).[24] A retrospective review that built projections using NIS data from 2000 to 2014 predicted primary TKA to grow 85% and primary THA to grow 71% between the years 2014 and 2030.[25] Another recent study also used NIS data from the same time period to project out to 2040, estimating a 284% increase in THA and 401% increase in TKA by 2040 compared to 2014.[26]

Pain and Functional Outcomes from Total Joint Arthroplasty

Overall, TJA is a highly successful procedure with the majority of patients achieving improvements in pain and function.[27]

There are very few randomized trials on TKA, as the procedure is considered the standard of care for severe knee OA. Skou and colleagues randomized patients eligible for TKA to either TKA followed by supervised non-surgical treatment or to non-surgical treatment alone. Total knee arthroplasty resulted in twice the improvement in pain and function after 2 years compared with non-surgical treatment, with an average improvement in the Knee Injury and Osteoarthritis Outcomes Score (KOOS) of 42.3 points in those undergoing TKA.[28] It should be noted that in the trial, 26% of patients

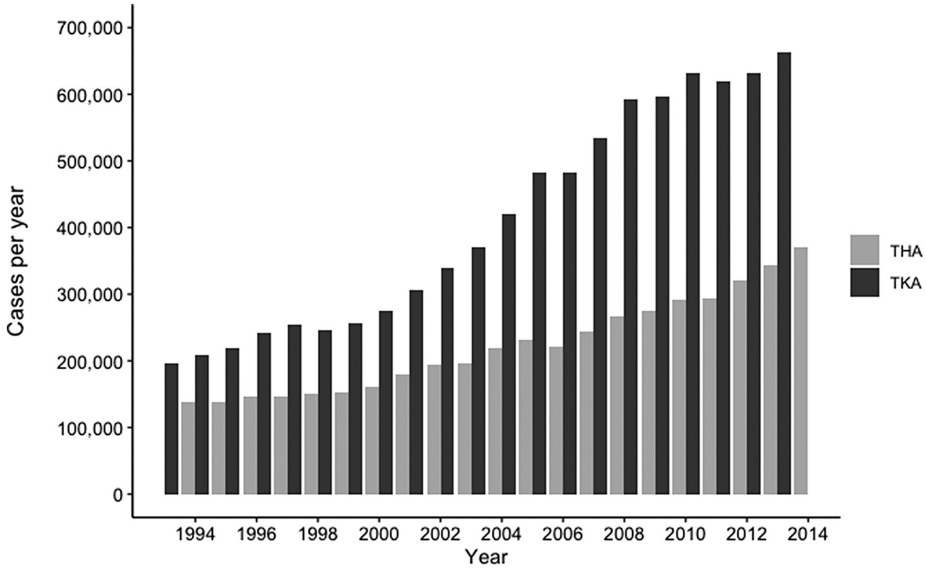

Figure 1. The number of TKA and THA procedures performed annually in the United States, based on the National Inpatient Sample (NIS) from 1993 to 2014. The annual number of THA (light gray bars) and TKA (dark gray bars) procedures were performed annually in the United States between the years 1993 and 2014. Data obtained from the National Inpatient Sample obtained from the Healthcare Cost and Utilization Project (HCUPnet). TKA: total knee arthroplasty, THA: total hip arthroplasty.

randomized to the non-surgical group crossed over and elected to undergo TKA before the 12-month follow-up.

Despite benefits for the majority of patients, some patients have a suboptimal outcome following surgery. A systematic review of TKA outcomes found that the percentage of patients with an unfavorable pain outcome ranged from 8.0% to 26.5% depending on the study.[27] The overall patient dissatisfaction rates from TKA has been estimated in a similar range, with about 8% to 30% of patients reporting being dissatisfied following surgery.[29]

Predictors of suboptimal outcomes from TKA, can help prognosticate and assist physicians with preoperative counseling. Bin Abd Razak and colleagues found that Asian patients with worse preoperative pain and function scores prior to TKA had a greater probability of having pain and function improve by more than the mean clinically important difference (MCID). However, they also found that having better preoperative pain and function predicted having overall better pain and function after surgery.[30] Based on these results, patients may be counseled that those with worse symptoms prior to surgery can expect significant benefits from surgery, but may still have impairment after surgery.

Several studies have examined age as a predictor of poor surgical outcomes, and most have found that patients who are otherwise candidates for TKA benefit regardless of age. For example, Elmallah and colleagues found that all age groups in their study (age <55, 55-74, and >74) had significant improvements in knee-society score pain, motion, and function at 5 years after TKA, however, the younger groups showed the greatest improvement in function.[31] Joly and colleagues found that patients under age 55 had lower WOMAC pain scores at 3 months following TKA, however, by 12-months there was no difference in WOMAC pain scores.[32]

Researchers have also investigated whether BMI affects TKA outcomes, with mixed results. Katakam and colleagues found that elevated BMI was significantly associated with the failure to achieve the MCID for the KOOS-PS following TKA.[33] In contrast, Collins and colleagues found that although TKA patients with higher BMI had worse preoperative pain and function scores, they had greater improvements from baseline to 3 months, and at 24 months, patients in all BMI groups had similar levels of pain, function, and satisfaction with surgery.[34]

Patients who are more sedentary prior to TKA may expect to benefit less, as Oka and colleagues found that more sedentary behavior preoperatively was associated with less improvement in knee-specific functional outcomes after surgery.[35] Widespread pain may also impact surgical outcomes; Dave et al. found that widespread pain pre-operatively as captured on a pain diagram was associated with a greater likelihood of reporting a WOMAC pain score >15 one year following TKA.[36]

Numerous studies have shown that patient expectations play a large role in determining patient satisfaction following surgery, emphasizing the importance of preoperative counseling and expectation-setting. For example, Bourne and colleagues found that the strongest predictor of patient dissatisfaction after primary TKA were expectations not being met.[37] Similarly Deakin and colleagues found that in 200 patients undergoing TKA, there was an association between the fulfillment of preoperative expectations and patient satisfaction at 6 weeks and 1 year following surgery.[38]

Total hip arthroplasty generally has very favorable patient outcomes, with over 95% of patients reporting satisfaction with the procedure.[39] A systematic review of outcomes following THA found that between 4.8% and 20.5% of patients had unfavorable pain outcomes, and studies with the highest quality evidence found an unfavorable pain outcomes in 9-13% of patients.[27] Finche and colleagues looked at different surgical approaches to THA and found that patients achieved clinically important improvements in mean patient-reported function, physical health and pain at 6 months regardless of surgical approach. At 6 months, 95.9% improved by the MCID in HOOS Jr, 78.7% achieved MCID in PROMIS-PH, and 81.1% achieved MCID in NPRS.[40]

Similar to TKA, studies on THA have found that while patients of all ages benefit, younger patients may expect a greater degree of improvement after surgery. In patients undergoing THA, Joly and colleagues found that younger patients had larger improvements in WOMAC pain scores at 3 months, and patients under age 55 had higher WOMAC scores at 12 months postoperatively compared to patients over age 55.[32] Lalani and colleagues looked at patient-reported outcomes 2 and 5 years following THA and found that patients undergoing THA at older ages had lower activity and sports scores but had similar pain, symptoms, and quality of life scores as younger patients.[41] A multicenter study of THA patients found that patients with higher preoperative expectations had greater improvements in activity, physical function, and pain scores, as well as greater postoperative satisfaction at 6 months.[42] This suggests that high expectations before surgery may be beneficial for some THA patients.

Total Joint Arthroplasty Complications

Total Joint Arthroplasty is a very safe procedure with low complication rates and very low risk of mortality; however there are risks that physicians and patients should be aware of.

Overall, TKA has a very low risk of mortality. A systematic review of TKA mortality from 15 different countries found a pooled 30-day mortality estimate of 0.20%, and a pooled 90-day mortality estimate of 0.39%.[43] This review found that the most common causes of death were cardiovascular causes followed by pulmonary embolism and stroke. The mortality rates in the United States are similar to these global estimates, as a National Surgical Quality Improvement Program (NSQIP) database study of 15 321 patients who underwent TKA between 2006 and 2010 found the 30-day mortality rate to be 0.18%.[44] A more recent study using NSQIP data from 2011 and 2015 included 15 321 TKA recipients, and found the 30-day mortality rate to be 0.11%.[45] In an Australian registry study consisting of 5662 TKA recipients, the six-month mortality rate was 0.2%.[46]

Mortality following THA is similarly rare. In a large cohort of 94 326 THA patients from the NSQIP database between 2011 and 2015, the 30-day mortality rate was 0.16%.[45] The Australian registry study included 2782 THA recipients and found an overall six-month mortality rate of 0.2%.[46] Data from the Swedish Hip Arthroplasty Register including 53 099 THA recipients found a 90-day mortality rate of 0.33%.[47]

The risk of short-term complications following TKA is low, and minor complications such as blood clots are the most common. In the aforementioned NSQIP database study of TKA recipients from 2006 to 2010, 5.55% patients experienced any complication within 30 days; 3.20% of patients experienced a minor systemic complication such as deep venous thrombosis (1.34%), pneumonia (0.37%), or a urinary tract infection (1.49%); 1.83% experienced a major systemic complication such as pulmonary embolism (0.78%), septic shock, acute renal failure, and a cerebrovascular accident (less than 0.5% each).[44] In the NSQIP database between 2011 and 2016, the most common

30-day complications were deep venous thrombosis (0.87%) and urinary tract infection (0.87%), followed by pneumonia (0.65%).[45] The Australian registry study of TKA patients found an overall 6-month major complication rate of 14.4%, with readmission and reoperation as the most common major complications; the minor complication rate following TKA was 46.6%, with joint stiffness and paresthesia as the most common minor complications.[46]

Short -term complication rates after THA differ from those following TKA. In the NSQIP database between 2011 and 2016, the 30-day rate of superficial infection was 0.69%, prosthetic joint infection was 0.53%, deep venous thrombosis was 0.4%, and pulmonary embolism was 0.27%.[45] This study also compared complications from THA and TKA, and found that the rates of some complications such as superficial infection and prosthetic joint infection were higher after THA, while others were higher after TKA, including wound dehiscence, deep vein thrombosis, and pulmonary embolism; the rates of hospital re-admission were also higher after THA.[45] When looking at THA patients, the Australian registry study found an overall 6-month major complication rate of 9.5%, with readmission and reoperation as the most common major complications; the minor complication rate following THA was 34.0%, with stiffness and pain as the most common minor complications.[46]

For TKA, the most common long-term complications that lead to revision surgery include infection and mechanical loosening.[48] A study of 61 767 TKA recipients in the Medicare database from 2001 and 2007 found a 2.0% risk of revision by 5 years.[49] Singh and colleagues looked at 6 70 000 TKAs performed in Pennsylvania in 2002 and found a one-year revision rate of 1.57% and a five-year revision rate of 5.66%.[50] For THA, revisions are predominantly due to mechanical loosening and dislocations.[51] A study of Medicare beneficiaries undergoing THA between 1995 and 1996 found a risk of revision of 2% per year for the first 18 months, then 1% risk per year for the remainder of the 12-year follow-up period.[52] An analysis of 1 31 576 THAs using German billing data found an overall rate of revision of 2.9% at one-year post-surgery.[53]

Patients should be prepared for the possibility of a discharge disposition other than home following TJA. In the study by Cram and colleagues of TKAs among Medicare beneficiaries, between 2007 and 2010, 11.1% of patients were discharged to inpatient rehabilitation.[22] George and colleagues found that 28.1% of TKA and 24.8% of THA patients were discharged to inpatient facilities rather than home.[45]

Surgical Treatment of Small Joint Osteoarthritis

While OA of the knee and hip are the sites most commonly managed surgically, some patients with small joint OA of the hands or wrists may be candidates for surgical management as well. Similar to large joint OA, the indications for surgical intervention on hand OA are pain or disability that is not responsive to non-operative treatments.

Carpometacarpal joint OA is a common and disabling condition. In the early-stage, there are several surgical treatment options for carpometacarpal (CMC) OA including ligament reconstruction, osteotomy, and arthrodesis. However, in later stages arthroplasty is the procedure of choice.[54,55] The technology for CMC arthroplasty has been advancing in recent years, and a recent analysis of a new implant found a high satisfaction rate and an implant survival rate of 91% over at least 5 years.[56]

For the proximal interphalangeal (PIP) joint, arthrodesis can lead to good improvement in pain, though it results in complete loss of PIP motion, and therefore arthroplasty generally provides the best functional outcome.[57] For the distal interphalangeal (DIP) joints, arthrodesis the preferred surgical approach, with infrequent complications (approximately 2% in most studies).[58] Arthroplasty is much less frequent for the DIP joints, but can be done using silicone implants if maintaining DIP motion is desired.[58]

Conclusion

While medical management of OA can improve symptoms, surgical intervention is the only disease modifying therapy available at this time. While other surgical modalities may be utilized in specific patient populations, TJA is the current standard surgical approach for severe knee and hip OA. Physicians should consider TJA in patients who have failed more conservative treatment options. The guidelines for determining patient appropriateness for TJA rely on physicians' subjective assessments of pain and function. Overall, most patients achieve good results from TJA with improvements in pain and function, and complication rates are low. Risk factors for poor outcomes have been identified, such as more sedentary behavior and widespread pain. Over the next few decades, the rate of OA is expected to increase, and the demand for surgical management will likely increase as well.

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