Clinical Medicine Insights: Arthritis and Musculoskeletal Disorders

PERSPECTIVE

Clinical and Economic Burden of Revision Knee Arthroplasty

Mohit Bhandari[1], Jon Smith[2], Larry E. Miller[3,4] and Jon E. Block[4]

[1]Division of Orthopaedic Surgery, Department of Surgery, McMaster University, Hamilton, ON, Canada. [2]Stonedene, Leeds, UK. [3]Miller Scientific Consulting, Inc, Arden, NC, USA. [4]The Jon Block Group, San Francisco, CA, USA.
Corresponding author email: jonblock@jonblockgroup.com

Abstract: Surgery is indicated for symptomatic knee osteoarthritis (OA) when conservative measures are unsuccessful. High tibial osteotomy (HTO), unicompartmental knee arthroplasty (UKA), and total knee arthroplasty (TKA) are surgical options intended to relieve knee OA pain and dysfunction. The choice of surgical intervention is dependent on several factors such as disease location, patient age, comorbidities, and activity levels. Regardless of surgical treatment, complications such as infection, loosening or lysis, periprosthetic fracture, and postoperative pain are known risks and are indications for revision surgery. The clinical and economic implications for revision surgery are underappreciated. Over 55,000 revision surgeries were performed in 2010 in the US, with 48% of these revisions in patients under 65 years. Total costs associated with each revision TKA surgery have been estimated to be in excess of $49,000. The current annual economic burden of revision knee OA surgery is $2.7 billion for hospital charges alone. By 2030, assuming a 5-fold increase in the number of revision procedures, this economic burden will exceed $13 billion annually. It is appealing to envision a therapy that could delay or obviate the need for arthroplasty. From an actuarial standpoint, this would have the theoretical downstream effect of substantially reducing the number of revision procedures. Although no known therapies currently meet these criteria, such a breakthrough would have a tremendous impact in lessening the clinical and economic burden of knee OA revision surgery.

Keywords: arthroplasty, knee, osteoarthritis, revision

Clinical Medicine Insights: Arthritis and Musculoskeletal Disorders 2012:5 89–94

doi: 10.4137/CMAMD.S10859

This article is available from http://www.la-press.com.

Introduction

Osteoarthritis (OA) is characterized by progressive degeneration of articular cartilage that ultimately manifests as joint pain, stiffness, and/or dysfunction. Symptomatic OA most commonly affects the knee joint, with chronic abnormal and/or excessive mechanical loading a major harbinger of disease development.[1] Knee OA affects 18 million adults in the US,[2] with 4.1 million patients reporting difficulty with ambulation.[3] Patients with symptomatic knee OA report disability in activities of daily living and significant declines in health-related quality of life.[4,5] By 2025, knee OA prevalence is expected to increase by 40%, largely due to an aging population and the obesity epidemic.[6]

Knee OA can affect the medial, lateral, and/or patellofemoral compartments. Almost two-thirds of knee OA patients present with multiple compartment disease while one-third have unicompartmental disease. Of those with unicompartmental disease, the patellofemoral compartment is most commonly affected (68%), followed by the medial compartment (30%) and, rarely, the lateral compartment (2%).[7] Given the failure of conservative therapies to delay or prevent disease progression,[8] surgical treatment of symptomatic knee OA is often necessary.

Surgery for end-stage knee OA is performed in 658,000 Americans annually.[9] Unfortunately, no surgical knee OA treatment has an ideal safety profile and all are limited by distinct survival profiles. Consequently, the possibility of future revision surgery is a major consideration in patients considering knee surgery, especially for the young knee OA patient who will likely outlive the prosthesis. Given the aging population and the increasing frequency of knee OA sufferers, the number of primary and revision surgeries will dramatically increase in the future.[10,11] This article discusses the different surgical options for knee OA, implant survival rates, clinical and economic consequences of revision surgeries, and the potential advantages of identifying novel therapies that could delay or obviate the need for surgical intervention.

Surgical Options for Knee Osteoarthritis

Surgical options for treatment of symptomatic knee OA include high tibial osteotomy (HTO), distal femoral osteotomy (DFO), unicompartmental knee arthroplasty (UKA), and total knee arthroplasty (TKA). Unicompartmental disease may be treated with HTO, DFO, UKA, or TKA, depending on patient characteristics and disease location, whereas multicompartment disease is treated with TKA. Although there is significant overlap in indications for these knee OA surgeries,[12] each has a distinct risk-benefit profile that must be optimized to individual patient preferences and characteristics.

High tibial osteotomy

HTO is an invasive surgical treatment for moderate unicompartmental knee OA that involves significant bone reshaping to alter the mechanical axis via valgus correction, thus reducing the load carried by the arthritic medial compartment. HTO transfers loading away from the diseased medial compartment and towards the unaffected lateral compartment, ultimately slowing medial disease progression and delaying the need for arthroplasty. HTO has largely fallen out of favor in the US given the demanding nature of the surgery, the potential for significant complications and prolonged rehabilitation, and the recent technical improvements in arthroplasty techniques. Only 1,040 HTO procedures were performed in 2010 in the US, most commonly in the 18 to 44 year age group.[9] The ideal patient for HTO is young and active with a life expectancy exceeding the expected survival of a knee prosthesis.[13] Consequently, an age of 60 years or more is a relative contraindication to HTO and advanced age is a strong predictor of poor prognosis.[14] Although satisfactory initial results are typical following HTO, patient rehabilitation is protracted with an average hospitalization of 9 days[15] and an average return to work time of approximately 3 months.[16,17] Additionally, patient outcomes reliably deteriorate over time due to disease progression.[18] At 8 to 10 years following HTO, only 60% of patients report a good or excellent result and more than 1 in 5 will undergo TKA.[19] Significant procedural risks also limit the utility of HTO, which include infection (2%–55%), deep vein thrombosis (1%–10%), delayed or non-union (0%–14%), and peroneal nerve injury (0%–20%).[18]

Total knee arthroplasty

The standard of care treatment for end-stage multicompartment knee OA, as well as many

unicompartmental cases, is TKA. This surgery removes the diseased bone and cartilage from the knee joint, which is replaced with an artificial joint made of synthetic materials. TKA reliably restores joint function and improves health-related quality of life,[20] although the surgery is associated with distinct limitations. First, most patients who suffer from end-stage knee OA endure knee pain and dysfunction for years in an effort to delay surgery.[8] In fact, only 20%–33% of patients with severe knee OA are "definitely or probably willing" to consider knee arthroplasty.[21,22] TKA is a suboptimal treatment option in patients under 65 years since younger active and high demand patients are at greater risk for prosthesis failure secondary to aseptic loosening and, consequently, revision surgery versus their older counterparts.[23] Lastly, there is a clear mismatch between patient expectations versus actual clinical outcomes following TKA, as 85% of patients expect to be completely pain-free after surgery when in fact only 43% report complete absence from pain.[24]

Unicompartmental knee arthroplasty

UKA is indicated for patients with OA restricted to only one knee compartment, usually the medial and patellofemoral, and with intact cruciate and collateral ligaments. Ideally, patients present with a low body mass index and a correctable deformity, no fixed flexion contractures, and avoid strenuous physical activity. UKA is associated with fewer complications than HTO. A distinct advantage of UKA over TKA is that it is a less invasive surgical procedure, with minimal bone resection, avoidance of patellar eversion and extensor mechanism damage, the result of which is a more rapid recovery time and earlier discharge. Additionally, by keeping the cruciate ligaments intact, normal knee kinematics are preserved. Improvement in knee pain and function following UKA are similar to that achieved with TKA, while post-surgery range of motion is superior with UKA. Complication rates are similar with UKA and TKA.[25]

Knee Surgery Survival Rates

Each knee OA surgery method is associated with a distinct survival profile that must be considered in relation to variables such as disease location, patient age, body weight, and physical activity levels. TKA survival is approximately 90% through 15 years[26] although outcomes in younger patients are inferior (76% at 10 years).[27] Survival of UKA is somewhat lower with an accepted 10-year survivorship of 90%.[26] Arthroplasty should generally be avoided in patients under 60 years since the life expectancy of the patient will usually exceed the survival of the implant. The shorter survival of UKA may be due in part to patient selection factors since UKA is generally performed in younger patients with less severe disease, with better joint function, but who wear out the prosthesis faster due to higher activity levels. HTO survival ranges from 75%–97% at 5 to 9 years, 51%–98% at 10–14 years, and 30%–90% at 15–20 years, with superior results observed in younger patients and those with less articular destruction and better range of motion.[14]

Knee Surgery Revision Rates

Given the increased demands placed on surgical knee OA repairs in terms of longevity and physical activity patterns, surgical failure requiring revision surgery is a major risk for patients. The most common reasons for revision following TKA are infection (40%), instability (20%), pain (19%), aseptic loosening (13%), and arthrofibrosis (11%).[28] The most common reasons for revision following UKA are loosening/lysis (50%), disease progression (17%), and pain (13%).[29] Disease progression and, to a lesser extent, inadequate correction, are the primary factors involved in HTO revision surgery.[30]

Regardless of the initial surgery type, revision surgeries are typically to a TKA and often require stemmed components and additional augments. Only 11% of UKA revisions utilize UKA, whereas HTO to UKA revision is rarely performed, with both of these revision surgeries associated with high re-revision rates. TKA revision rates are 2.8% through 5 years,[31] with a cumulative revision rate of 7.3% annually thereafter.[32] The revision rate of UKA is approximately 1.5 times higher than that of TKA, with much of this risk influenced by patient age since UKA patients are generally younger than those undergoing TKA.[33] Requirement for revision surgery also increases the risk for re-revision surgery. The TKA to TKA re-revision rate is 18% at 5 years while the UKA to UKA or TKA re-revision rate is 44% at 4 years.[29]

Given the limited survival of prosthetic implants, the progressive nature of OA, the continued aging of the population, and the soaring rates of obesity,

it is anticipated that many patients undergoing knee surgery for knee OA will ultimately require revision surgery, a procedure associated with considerable expense, morbidity, and inferior clinical outcomes compared to primary surgical procedures.

Clinical and Economic Burden of Revision Surgery

The demand for musculoskeletal health care services is expected to dramatically increase over the coming decades at such a rate that the supply of physicians may not be able to meet the demand.[32,34] There is also concern that, coupled with the increasing knee OA prevalence, the rising costs of healthcare may inflict a tremendous societal economic burden in the future.[8] There is currently no medical or surgical treatment that will influence this alarming trajectory.

According to data from the Healthcare Cost and Utilization Project, 658,000 knee arthroplasties were performed in the US in 2010.[9] TKA represented 92.3% (approx. 607,000) of all knee replacements, with UKA performed in only 7.7% (approx. 51,000) of patients.[35] Interestingly, 290,000 of the patients undergoing arthroplasty were under the age of 65 years. HTO was only performed 1,040 times in 2010, most commonly in the 18 to 44 year age group.

Over 55,000 revision surgeries were performed in 2010 in the US, with 48% of these revisions in patients under 65 years.[9] By 2030, nearly 2 in 3 TKA revision patients will be under 65 years, including almost 120,000 patients under 54 years who will likely experience device failure at least once in their lifetime.[36]

From a clinical perspective, revision knee surgery is a complex procedure associated with higher complication rates, extended hospitalization, unsatisfactory functional outcomes, and a relatively shorter survival compared to primary procedures.[37] In particular, revision TKA due to infection costs twice as much as aseptic revision, is associated with poor patient outcomes, and, in some cases, can lead to arthrodesis or amputation.[38] Risks of revision surgery are especially pronounced in the younger patient who may be more physically active and, consequently, subject to multiple revision surgeries over a lifetime.

The economic consequences of revision surgery for knee OA are staggering. Each TKA revision surgery is associated with total costs of $49,360,[39] including consumption of significant hospital resources and a median length of stay of 5 days.[40] The current annual economic burden of revision knee OA surgery is $2.7 billion for hospital charges alone. By 2030, assuming a 5-fold increase in the number of revision procedures,[10] this economic burden will exceed $13 billion annually.

Recommendations for Future Research

It is appealing to envision a therapy that could delay or obviate the need for arthroplasty and any subsequent risk for revision surgery. Although HTO attempts to fill this need, the complication rates and prolonged recovery times diminish the enthusiasm for this therapy. The ideal knee OA treatment would enjoy high patient acceptance, result in significant cost savings, and provide improvement in knee pain and function. For example, if a new therapy was identified that could delay primary arthroplasty by 10 years, the downstream clinical and economic benefit would be tremendous. Notably, a 10-year delay in need for arthroplasty would consequently reduce the need for future revision surgery, which is costlier and associated with more complications than primary procedures.[41] Almost 290,000 TKAs are performed annually on patients under 65 years with 369,000 performed in patients 65 years or older in the US[9] By increasing the mean age of TKA from 68 years[42] to 78 years and assuming a mean lifespan in the US of 78 years[43], a significant portion of knee OA patients would either avoid the need for arthroplasty altogether or, if required, would likely have a low risk of revision due to older age and anticipated activity reductions. If such a therapy could decrease the need for revision surgery by 50%, the resulting savings in hospital charges alone would total almost $1.4 billion annually. Additionally, such a delay in TKA need would result in the vast majority of TKA primary and revision procedures being performed on patients 65 years and older, thereby reducing the direct financial obligation of patients. Although no known therapies currently meet these criteria, such a breakthrough would have a tremendous impact in reducing the clinical and economic burden of knee OA surgery.

Author Contributions

Conceived and designed the Research: MB, JS, LM, JB. Wrote the first draft of the manuscript: LM. Contributed

to the writing of the manuscript: MB, JS, JB. Jointly developed the structure and arguments for the paper: MB, JS, LM, JB. Made critical revisions and approved final version: MB, JS, LM, JB. All authors reviewed and approved of the final manuscript.

Funding

Moximed Inc. (Hayward, CA, USA) provided financial support for development of this manuscript.

Competing Interests

MB has received consulting fees from Smith and Nephew, Stryker, Amgen, Zimmer, Moximed, Bioventus and MB's institution has received grants from Smith and Nephew, DePuy, Eli Lilly, Bioventus. Other authors disclose no potential competing interests.

Disclosures and Ethics

As a requirement of publication author(s) have provided to the publisher signed confirmation of compliance with legal and ethical obligations including but not limited to the following: authorship and contributorship, conflicts of interest, privacy and confidentiality and (where applicable) protection of human and animal research subjects. The authors have read and confirmed their agreement with the ICMJE authorship and conflict of interest criteria. The authors have also confirmed that this article is unique and not under consideration or published in any other publication, and that they have permission from rights holders to reproduce any copyrighted material. Any disclosures are made in this section. The external blind peer reviewers report no conflicts of interest.

References

1. Waller C, Hayes D, Block JE, London NJ. Unload it: the key to the treatment of knee osteoarthritis. *Knee Surg Sports Traumatol Arthrosc*. 2011;19(11): 1823–9.
2. Lawrence RC, Felson DT, Helmick CG, et al. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. *Arthritis Rheum*. 2008;58(1):26–35.
3. Dillon CF, Rasch EK, Gu Q, Hirsch R. Prevalence of knee osteoarthritis in the United States: arthritis data from the Third National Health and Nutrition Examination Survey 1991–94. *J Rheumatol*. 2006;33(11):2271–9.
4. Kauppila AM, Kyllonen E, Mikkonen P, et al. Disability in end-stage knee osteoarthritis. *Disabil Rehabil*. 2009;31(5):370–80.
5. Desmeules F, Dionne CE, Belzile E, Bourbonnais R, Fremont P. Waiting for total knee replacement surgery: factors associated with pain, stiffness, function and quality of life. *BMC Musculoskelet Disord*. 2009;10:52.
6. Woolf AD, Pfleger B. Burden of major musculoskeletal conditions. *Bull World Health Organ*. 2003;81(9):646–56.
7. Ledingham J, Regan M, Jones A, Doherty M. Radiographic patterns and associations of osteoarthritis of the knee in patients referred to hospital. *Ann Rheum Dis*. 1993;52(7):520–6.
8. London NJ, Miller LE, Block JE. Clinical and economic consequences of the treatment gap in knee osteoarthritis management. *Med Hypotheses*. 2011;76(6):887–92.
9. Agency for Healthcare Research and Quality. Healthcare Cost and Utilization Project. 2010; http://hcupnet.ahrq.gov/HCUPnet.jsp.
10. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am*. 2007;89(4):780–5.
11. Kurtz SM, Ong KL, Lau E, et al. International survey of primary and revision total knee replacement. *Int Orthop*. 2011;35(12):1783–9.
12. Palomo JM. Surgical options for middle-aged patients with osteoarthritis of the knee. *J Bone Joint Surg Am*. 2001;83-A(9):1429.
13. Spahn G, Hofmann GO, von Engelhardt LV, Li M, Neubauer H, Klinger HM. The impact of a high tibial valgus osteotomy and unicondylar medial arthroplasty on the treatment for knee osteoarthritis: a meta-analysis. *Knee Surg Sports Traumatol Arthrosc*. Nov 11, 2011. [Epub ahead of print.]
14. Amendola A, Bonasia DE. Results of high tibial osteotomy: review of the literature. *Int Orthop*. 2010;34(2):155–60.
15. Floerkemeier S, Staubli AE, Schroeter S, Goldhahn S, Lobenhoffer P. Outcome after high tibial open-wedge osteotomy: a retrospective evaluation of 533 patients. *Knee Surg Sports Traumatol Arthrosc*. Jun 29, 2012. [Epub ahead of print.]
16. Schroter S, Mueller J, van Heerwaarden R, Lobenhoffer P, Stockle U, Albrecht D. Return to work and clinical outcome after open wedge HTO. *Knee Surg Sports Traumatol Arthrosc*. Jul 10, 2012. [Epub ahead of print.]
17. Hoell S, Suttmoeller J, Stoll V, Fuchs S, Gosheger G. The high tibial osteotomy, open versus closed wedge, a comparison of methods in 108 patients. *Arch Orthop Trauma Surg*. 2005;125(9):638–43.
18. Dowd GS, Somayaji HS, Uthukuri M. High tibial osteotomy for medial compartment osteoarthritis. *Knee*. 2006;13(2):87–92.
19. Virolainen P, Aro HT. High tibial osteotomy for the treatment of osteoarthritis of the knee: a review of the literature and a meta-analysis of follow-up studies. *Arch Orthop Trauma Surg*. 2004;124(4):258–61.
20. Zhang W, Moskowitz RW, Nuki G, et al. OARSI recommendations for the management of hip and knee osteoarthritis, Part II: OARSI evidence-based, expert consensus guidelines. *Osteoarthritis Cartilage*. 2008;16(2):137–62.
21. Hawker GA, Guan J, Croxford R, et al. A prospective population-based study of the predictors of undergoing total joint arthroplasty. *Arthritis Rheum*. 2006;54(10):3212–20.
22. Hawker GA, Wright JG, Badley EM, Coyte PC. Perceptions of, and willingness to consider, total joint arthroplasty in a population-based cohort of individuals with disabling hip and knee arthritis. *Arthritis Rheum*. 2004; 51(4):635–41.
23. National Institutes of Health. NIH Consensus Statement on total knee replacement Dec 8–10, 2003. *J Bone Joint Surg Am*. 2004;86-A(6): 1328–35.
24. Mannion AF, Kampfen S, Munzinger U, Kramers-de Quervain I. The role of patient expectations in predicting outcome after total knee arthroplasty. *Arthritis Res Ther*. 2009;11(5):R139.
25. Griffin T, Rowden N, Morgan D, Atkinson R, Woodruff P, Maddern G. Unicompartmental knee arthroplasty for the treatment of unicompartmental osteoarthritis: a systematic study. *ANZ J Surg*. 2007;77(4):214–21.
26. Choong PF, Dowsey MM. Update in surgery for osteoarthritis of the knee. *Int J Rheum Dis*. 2011;14(2):167–74.
27. Lundblad H, Kreicbergs A, Jansson KA. Prediction of persistent pain after total knee replacement for osteoarthritis. *J Bone Joint Surg Br*. 2008;90(2): 166–71.
28. Paxton EW, Furnes O, Namba RS, Inacio MC, Fenstad AM, Havelin LI. Comparison of the Norwegian knee arthroplasty register and a United States arthroplasty registry. *J Bone Joint Surg Am*. Dec 21, 2011;93 Suppl 3:20–30.
29. Hang JR, Stanford TE, Graves SE, Davidson DC, de Steiger RN, Miller LN. Outcome of revision of unicompartmental knee replacement. *Acta Orthop*. 2010;81(1):95–8.
30. Stukenborg-Colsman C, Wirth CJ, Lazovic D, Wefer A. High tibial osteotomy versus unicompartmental joint replacement in unicompartmental knee joint osteoarthritis: 7–10-year follow-up prospective randomised study. *Knee*. 2001;8(3):187–94.

31. Ong KL, Lau E, Suggs J, Kurtz SM, Manley MT. Risk of subsequent revision after primary and revision total joint arthroplasty. *Clin Orthop Relat Res*. 2010;468(11):3070–6.
32. Iorio R, Robb WJ, Healy WL, et al. Orthopaedic surgeon workforce and volume assessment for total hip and knee replacement in the United States: preparing for an epidemic. *J Bone Joint Surg Am*. 2008;90(7):1598–605.
33. Robertsson O, Knutson K, Lewold S, Lidgren L. The Swedish Knee Arthroplasty Register 1975–97: an update with special emphasis on 41,223 knees operated on in 1988–97. *Acta Orthop Scand*. 2001;72(5):503–13.
34. Knee surgery in arthroses and rheumatoid arthritis. *Lakartidningen*. May 28, 1980;77(22):2085–118.
35. Riddle DL, Jiranek WA, McGlynn FJ. Yearly incidence of unicompartmental knee arthroplasty in the United States. *J Arthroplasty*. 2008;23(3):408–12.
36. Kurtz SM, Lau E, Ong K, Zhao K, Kelly M, Bozic KJ. Future young patient demand for primary and revision joint replacement: national projections from 2010 to 2030. *Clin Orthop Relat Res*. 2009;467(10):2606–12.
37. Ritter MA, Carr KD, Keating EM, Faris PN, Bankoff DL, Ireland PM. Revision total joint arthroplasty: does medicare reimbursement justify time spent? *Orthopedics*. 1996;19(2):137–9.
38. Blom AW, Brown J, Taylor AH, Pattison G, Whitehouse S, Bannister GC. Infection after total knee arthroplasty. *J Bone Joint Surg Br*. 2004;86(5):688–91.
39. Bozic KJ, Kurtz SM, Lau E, et al. The epidemiology of revision total knee arthroplasty in the United States. *Clin Orthop Relat Res*. 2010;468(1):45–51.
40. Maradit Kremers H, Visscher SL, Moriarty JP, et al. Determinants of Direct Medical Costs in Primary and Revision Total Knee Arthroplasty. *Clin Orthop Relat Res*. Aug 3, 2012. [Epub ahead of print.]
41. Burns AW, Bourne RB, Chesworth BM, MacDonald SJ, Rorabeck CH. Cost effectiveness of revision total knee arthroplasty. *Clin Orthop Relat Res*. 2006;446:29–33.
42. Memtsoudis SG, Della Valle AG, Besculides MC, Esposito M, Koulouvaris P, Salvati EA. Risk factors for perioperative mortality after lower extremity arthroplasty: a population-based study of 6,901,324 patient discharges. *J Arthroplasty*. 2010;25(1):19–26.
43. Heron M, Hoyert DL, Murphy SL, Xu J, Kochanek KD, Tejada-Vera B. Deaths: Final Data for 2006. *Natl Vital Stat Rep*. 2009;57(14):1–134.