

Modern Indications, Results, and Global Trends in the Use of Unicompartmental Knee Arthroplasty and High Tibial Osteotomy in the Treatment of Isolated Medial Compartment Osteoarthritis

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Abstract

In this review, we evaluate the modern indications, subjective outcome scores, and survivorship results of unicompartmental knee arthroplasty (UKA) and high tibial osteotomy (HTO) in the treatment of isolated medial compartment degeneration of the knee. In addition, in a thorough review of the literature, we evaluate global trends in the use of both methods.

In our evaluation of articles, we note that inclusion criteria are relatively broader for UKA than for HTO, where age and body mass index should be considered before HTO surgery in order to optimize clinical

outcome and survivorship results. Exact thresholds for UKA inclusion have been studied, but there is no clear definition. Both methods have good to excellent subjective outcome scores. Expected 10-year survivorship results are in favor of UKA (90%) over HTO (75%). However, controlled data directly comparing both methods are lacking.

The broad range of UKA inclusion criteria and good to excellent subjective and survivorship results have led to an increase in UKA use among Western practices, whereas use of HTO in patients with isolated single-compartment osteoarthritis has been decreasing.

An increasingly number of patients with symptomatic isolated medial unicompartmental knee osteoarthritis (OA) are too young and too functionally active to be ideal candidates for total knee arthroplasty (TKA). Isolated medial compartment OA occurs in 10% to 29.5% of all cases, whereas the isolated lateral variant is less common, with a reported incidence of 1% to 7%.^{1,2} In 1961, Jackson and Waugh³ introduced the high tibial osteotomy (HTO) as a surgical treatment for single-compartment OA. This procedure is designed to increase the life span of articular cartilage by unloading and redistributing the mechanical forces over the nonaffected compartment. Unicompartmental knee arthroplasty (UKA) was introduced in the 1970s as an alternative to

TKA or HTO for single-compartment OA. UKA is a joint resurfacing procedure in which the affected degenerative compartment is treated with an implanted prosthesis and the nonaffected compartments are preserved (**Figure 1**).

Since the introduction of these methods, there has been debate about which patients are appropriate candidates for each procedure. Improved surgical techniques and implant designs have led surgeons to reexamine the selection criteria and contraindications for these procedures. Furthermore, given the increasing popularity and use of UKA, the question arises as to whether HTO still has a role in clinical practice in the surgical treatment of medial OA of the knee.

To clarify current ambiguities, we review the

Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

modern indications, subjective outcome scores, and survivorship results of UKA and HTO in the treatment of isolated medial compartment degeneration of the knee. In addition, in a thorough review of the literature, we evaluate global trends in the use of both methods.

High Tibial Osteotomy for Medial Compartment OA

Indications

Before the introduction of TKA and UKA for single-compartment OA, surgical management consisted of HTO. When the mechanical axis is slightly overcorrected, the medial compartment is decompressed, ensuring tissue viability and delaying progressive compartment degeneration. Decompression is established with multiple techniques, including opening-wedge HTO (OWHTO) (**Figure 2**), closing-wedge HTO (CWHTO) (**Figure 3**), and chevron and dome osteotomies. The current controlled data are limited and do not favor one technique over another.^{4,5}

Traditionally, HTO is indicated for young (age <60 years), normal-weight, active patients with radiographic single-compartment OA.⁶ The knee should be stable and have good range of motion (ROM; flexion >120°), and pain should be localized to the tibiofemoral joint line.

Over the past few decades, numerous authors have reported similar inclusion criteria, clarifying their definition. This definition should be further re-

fined in order to optimize survivorship and clinical outcomes.

Confirming age as an inclusion criterion for HTO, Trieb and colleagues⁷ found that the risk of failure was significantly ($P = .046$) higher for HTO patients older than 65 years than for those younger than 65 years (relative risk, 1.5). This finding agrees with findings of other studies, which suggests that, in particular, young patients benefit from HTO.⁸⁻¹¹

Moreover, there is a clear relation between HTO survival and obesity. In a study of 159 CWHTOs, Akizuki and colleagues¹² reported that preoperative body mass index (BMI) higher than 27.5 kg/m² was a significant risk factor for early failure. Using BMI higher than 30 kg/m² as a threshold, Howells and colleagues⁹ found significantly inferior Knee Society Score (KSS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) results for the obese group 5 years after HTO.

Radiographic evidence of severe preoperative compartment degeneration has been associated with early conversion to TKA. Flecher and colleagues¹¹ and van Raaij and colleagues¹³ both concluded the best long-term survival grades are achieved in HTO patients with mild compartment OA (Ahlbäck¹⁴ grade I). The question then becomes whether these patients should be treated nonoperatively instead.^{15,16}

The literature supports strict adherence to inclusion criteria in the selection of a potential HTO candidate. Age, BMI, and the preoperative state of OA should be taken into account in order to optimize clinical outcome and survivorship results in patients about to undergo HTO.

Outcomes

Multiple authors have described or compared the midterm or long-term results of the various surgical HTO techniques. Howells and colleagues⁹ noted overall survival rates of 87% (5 years after CWHTO) and 79% (10 years after CWHTO). Over the 10-year postoperative period, there was significant deterioration in clinical outcome scores and survivorship. Others authors have had similar findings.¹⁷⁻¹⁹ van Raaij and colleagues¹³ found that the 10-year probability of survival after CWHTO was 75%. In 455 patients who underwent lateral CWHTO, Hui and colleagues⁸ found that 5-year probability of survival was 95%, 10-year probability was 79%, and 15-year probability was 56%. Niinimäki and colleagues¹⁰ used the Finnish Arthroplasty Register to report HTO survivorship at a national level. Using conversion to TKA as a



Figure 1. (A) Preoperative and (B) 6-week postoperative weight-bearing radiographs of a 66-year-old woman who underwent medial unicompartmental knee arthroplasty (Oxford, Biomet) for symptomatic isolated medial compartment osteoarthritis.

cutoff, they noted 5-year survivorship of 89% and 10-year survivorship of 73%. To our knowledge, 2 groups, both in Japan, have reported substantially higher 15-year survival rates: 90%¹² and 93%.²⁰ The authors acknowledged that their results were significantly better than in other countries and that Japanese lifestyle, culture, and body habitus therefore require further investigation. At this time, it is not possible to compare their results with Western results.

In an attempt to compare the different survival rates of the various HTO techniques, Schallberger and colleagues²¹ conducted a retrospective study of OWHTOs and CWHTOs. At median follow-up of 16.5 years, comparative survival rates showed a trend of deterioration. Although data were limited, there were no significant differences in survival or functional outcome between the 2 techniques. In a recent randomized clinical trial, Duivenvoorden and colleagues⁵ compared these techniques' midterm results (mean follow-up, 6 years). Clinical outcomes were not significantly different. There were more complications in the OWHTO group and more conversions to TKA in the CWHTO group. Considering these results, the authors suggested OWHTO without autologous bone graft is the best HTO treatment strategy for medial gonarthrosis with varus malalignment of <12°.

The HTO results noted in these studies show a similar deteriorating trend; expected 10-year survivorship is 75%. Although modern implants and surgical techniques are being used, evidence supporting use of one surgical HTO method over another is lacking.

UKA for Medial Compartment OA

Indications

Since it was first introduced in the 1970s, use of UKA for single-compartment OA has been a subject of debate. The high failure rates reported at the time raised skepticism about the new treatment.²² Kozinn and Scott²³ defined classic indications and contraindications. Indications included isolated medial or lateral compartment OA or osteonecrosis of the knee, age over 60 years, and weight under 82 kg. In addition, the angular deformity of the affected lower extremity had to be <15° and passively correctable to neutral at time of surgery. Last, the flexion contracture had to be <5°, and ideal ROM was 90°. Contraindications included high activity, age under 60 years, and inflammatory arthritis. Strict adherence led to improved implant survival and lower revision rates. Because of improved

surgical techniques, modern implant designs, and accumulating experience with the procedure, the surgical indications for UKA have expanded. Exact thresholds for UKA inclusion, however, remain unclear.

The modern literature is overturning the traditional idea that UKA is not indicated for patients



Figure 2. (A) Preoperative and (B) 3-month postoperative weight-bearing radiographs of a 47-year-old man who underwent opening-wedge high tibial osteotomy for symptomatic isolated medial compartment osteoarthritis. Preoperative radiographic measurements of lower extremity were the basis for 10° correction of preexisting varus deformity of proximal tibia. Tricalcium phosphate substitution of osteotomy was used to promote rapid bone healing. TomoFix Medial High Tibial Plate (Synthes) was used for fixation.



Figure 3. (A) Preoperative and (B) 3-month postoperative weight-bearing radiographs of a 49-year-old man who underwent closing-wedge high tibial osteotomy for symptomatic isolated medial compartment osteoarthritis. Midshaft fibular osteotomy and then osteotomy of proximal tibia were performed, wedge was removed on the basis of preoperative radiographic measurements, gap was closed (leading to 8° correction of varus deformity), and plate and screws were used for fixation.

under age 60 years.²³ Using KSS, Thompson and colleagues²⁴ found that younger patients did better than older patients 2 years after UKA using various types of implants. Analyzing survivorship results, Heyse and colleagues²⁵ concluded that UKA can be successful in patients under age 60 years and reported a 15-year survivorship rate of 85.6% and excellent outcome scores. Other authors have had similar findings.²⁶⁻²⁸

Evaluating the influence of weight, Thompson and colleagues²⁴ found obese patients did not have a higher revision rate but did have slower progression of improvement 2 years after UKA. Cavaignac and colleagues²⁹ concluded that, at minimum follow-up of 7 years (range, 7-22 years), weight did not influence UKA survivorship. Other authors³⁰⁻³³ have found no significant influence of BMI on survival.

Reports on preoperative radiographic parameters that can potentially influence UKA results are limited. In 113 medial UKAs studied by Niinimäki and colleagues,³⁴ mild medial compartment degeneration, seen on preoperative radiographs, was associated with significantly higher failure rates. The authors concluded that other treatment options should be favored in the absence of severe isolated compartment OA.

Although the classic indications defined by Kozinn and Scott²³ have yielded good to excellent UKA results, improvements in implants and surgical techniques³⁵⁻³⁸ have extended the criteria. The modern literature demonstrates that age and BMI should not be used as criteria for excluding UKA candidates. Radiographically, there should be significant isolated compartment degeneration in order to optimize patient-reported outcome and survivorship.

Outcomes

Improved implant designs and modern minimally invasive techniques have effected a change in outcome results and a renewed interest in implants. Over the past decade, multiple authors have described the various modern UKA implants and their survivorship. Reports published since UKA was introduced in the 1970s show a continual increase in implant survival. Koskinen and colleagues,³⁹ using Finnish Arthroplasty Register data on 1819 UKAs performed between 1985 and 2003, found 10-year survival rates of 81% for Oxford implants (Zimmer Biomet), 79% for Miller-Galante II (Zimmer Biomet), 78% for Duracon (Howmedica), and 53% for PCA unicompartmental knee (Howmedica).

Heyse and colleagues²⁵ reported 10- and 15-year survivorship data (93.5% and 86.3%, respectively) for 223 patients under age 60 years at the time of their index surgery (Genesis Unicondylar implant, Smith & Nephew), performed between 1993 and 2005. KSS was good to excellent. Similar numbers in cohorts under age 60 years were reported by Schai and colleagues²⁶ using the PFC system (Johnson & Johnson) and by Price and colleagues²⁷ using the medial Oxford UKA. Both groups reported excellent survivorship rates: 93% at 2- to 6-year follow-up and 91% at 10-year follow-up. The outcome in older patients seems satisfactory as well. In another multicenter report, by Price and colleagues,⁴⁰ medial Oxford UKAs had a 15-year survival rate of 93%. Berger and colleagues⁴¹ reported similar numbers for the Miller-Galante prosthesis. Survival rates were 98% (10 years) and 95.7% (13 years), and 92% of patients had good to excellent Hospital for Special Surgery knee scores.

Although various modern implants have had good to excellent results, the historical question of what type of UKA to use (mobile or fixed-bearing) remains unanswered. To try to address it, Peersman and colleagues⁴² performed a systematic review of 44 papers (9463 knees). The 2 implant types had comparable revision rates. Another recent retrospective study tried to determine what is crucial for implant survival: implant design or surgeon experience.⁴³ The authors concluded that prosthetic component positioning is key. Other authors have reported high-volume centers are crucial for satisfactory UKA results and lower revision rates.⁴⁴⁻⁴⁶

Results of these studies indicate that, where UKAs are being performed in volume, 10-year survivorship rates higher than 90% and good to excellent outcomes can be expected.

UKA vs HTO

Cohort studies that have directly compared the 2 treatment modalities are scarce, and most have been retrospective. In a prospective study, Stukenborg-Colsman and colleagues⁴⁷ randomized patients with medial compartment OA to undergo either CWHTO (32 patients) with a technique reported by Coventry⁴⁸ or UKA (28 patients) with the unicondylar knee sliding prosthesis, Tübingen pattern (Aesculap), between 1988 and 1991. Patients were assessed 2.5, 4.5, and 7.5 years after surgery. More postoperative complications were noted in the HTO group. At 7- to 10-year follow-up, 71% of the HTO group and 65% of the UKA group

had excellent KSS. Mean ROM was 103° after UKA (range, 35°-140°) and 117° after HTO (range, 85°-135°) during the same assessment. Although differences were not significant, Kaplan-Meier survival analysis was 60% for HTO and 77% for UKA at 10 years. Results were not promising for the implants used, compared with other implants, but the authors concluded that, because of improvements in implant designs and image-guided techniques, better long-term success can be expected with UKA than with HTO.

In another prospective study, Börjesson and colleagues⁴⁹ evaluated pain during walking, ROM, British Orthopaedic Association (BOA) scores, and gait variables at 1- and 5-year follow-up. Patients with moderate medial OA (Ahlbäck¹⁴ grade I-III) were randomly selected to undergo CWHTO or UKA (Brigham, DePuy). There were no significant differences in BOA scores, ROM, or pain during walking between the 2 groups at 3 months, 1 year, and 5 years after surgery. Gait analysis showed a significant difference in favor of UKA only at 3 months after surgery. At 1- and 5-year follow-up, no significant differences were noted.

To clarify current ambiguities, Fu and colleagues⁵⁰ performed a systematic review of all (11) comparative studies. These studies had a total of 5840 (5081 UKA, 759 HTO) patients. Although ROM was significantly better for the HTO group than the UKA group, the UKA group had significantly better functional results. Walking after surgery was significantly faster for the UKA group. The authors suggested the difference might be attributed to the different postoperative regimens—HTO patients wore a whole-leg plaster cast for 6 weeks, and UKA patients were allowed immediate postoperative weight-bearing. Regarding rates of survival and complications, pooled data showed no significant differences. Despite these results, the authors acknowledged the limitation of available randomized clinical trials and the multiple techniques and implants used. We share their assertion that larger prospective controlled trials are needed. These are crucial to getting a definitive answer regarding which of the 2 treatment strategies should be used for isolated compartment OA.

Current Trends in Use of UKA and HTO

Evaluation of national registries and recent reports showed a global shift in use of both HTO and UKA. Despite the lack of national HTO registries, a few reports have described use of TKA, UKA, and HTO in Western populations over the past 2 decades.

Using 1998-2007 data from the Swedish Knee Arthroplasty Register, W-Dahl and colleagues⁵¹ found a 3-fold increase in UKA use, whereas HTO use was halved over the same period. Niinimäki and colleagues⁵² reported similar findings with the Finnish National Hospital Discharge Register. They noted a steady 6.8% annual decrease in osteotomies, whereas UKA use increased sharply after the Oxford UKA was introduced (Phase 3; Biomet). These findings are consistent with several reports from North America. In their epidemiologic analysis covering the period 1985-1990, Wright and colleagues⁵³ found an 11% to 14% annual decrease in osteotomies among the elderly, compared with an annual decrease of only 3% to 4% among patients younger than 65 years. Nwachukwu and colleagues⁵⁴ recently compared UKA and HTO practice patterns between 2007 and 2011, using data from a large US private payer insurance database. They noted an annual growth rate of 4.7% in UKA use, compared with an annual 3.9% decrease in HTO use. Furthermore, based on their subgroup analysis, they speculated there was a demographic shift toward UKA, as opposed to TKA, particularly in older women. Bolognesi and colleagues⁵⁵ investigated further. Evaluating all Medicare beneficiaries who underwent knee arthroplasty in the United States between 2000 and 2009, they noted a 1.7-fold increase in TKA use and a 6.2-fold increase in UKA use. As there were no substantial changes in patient characteristics over that period, the authors hypothesized that a possible broadening of inclusion criteria may have led to the increased use of UKA.

There is a possible multifactorial explanation for the current global shift in favor of UKA. First, UKA was once a technically demanding procedure, but improved surgical techniques, image guidance, and robot assistance⁵⁶ have made it relatively less difficult. Second, UKA surgery is associated with lower reported perioperative morbidities.⁵⁷ We think these factors have contributed to the global trend of less HTO use and more UKA use in the treatment of unicompartmental OA.

Conclusion

The modern literature suggests the inclusion criteria for HTO have been well investigated and defined; the UKA criteria remain a matter of debate but seem to be expanding. Long-term survival results seem to favor UKA, though patient satisfaction with both procedures is good to excellent. The broadening range of inclusion criteria and

consistent reports of durable outcomes, coupled with excellent patient satisfaction, likely explain the shift toward UKA in the treatment of isolated compartment degeneration.

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