MENTORS IN ORTHOPEDICS

HIGH TIBIAL OSTEOTOMY VS. UNICONDYLAR ARTHROPLASTY: CLEARLY NOT TWO FOR THE SAME!

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SUMMARY

Background: Medial compartment osteoarthritis is the most prevalent form of knee arthropathy. While high tibial osteotomy (HTO) and medial unicondylar knee arthroplasty (UKA) are established treatments, clinical controversy persists regarding their differential indications, comparative outcomes, and the complexities associated with subsequent conversion to total knee arthroplasty.

Objective: This review aims to delineate the specific indication criteria, patient selection parameters, and clinical limitations of HTO and UKA to facilitate evidence-based surgical decision-making for unicompartmental knee disease.

Key Points: HTO is primarily indicated for metaphyseal varus deformities in younger, active patients, focusing on extra-articular realignment to offload the medial compartment. Success depends on precise frontal plane correction, with a medial proximal tibial angle (MPTA) exceeding 94° associated with higher failure rates. Conversely, UKA is indicated for anteromedial osteoarthritis with intact ligamentous structures, regardless of patient BMI. While UKA offers superior early functional recovery and higher patient satisfaction compared to total knee arthroplasty, registry data indicate higher revision rates in patients under 65 years. Complications for HTO include a 30% overall rate, involving lateral hinge fractures and non-union, whereas UKA risks include aseptic loosening and polyethylene dislocation. Conversion of either procedure to total knee arthroplasty is technically demanding, often requiring revision-style implants and resulting in inferior functional outcomes compared to primary arthroplasty.

Conclusion: HTO and UKA are complementary rather than competing procedures. Precise patient selection based on deformity location, ligamentous stability, and joint line orientation is essential to optimize long-term joint preservation and clinical performance.

KEYWORDS

Osteotomy; Tibia; Arthroplasty, Replacement, Knee; Genu Varum; Osteoarthritis, Knee

INTRODUCTION

High tibial osteotomy (HTO) and the implantation of a medial unicondylar knee arthroplasty (UKA) are very popular in symptomatic medial knee arthropathy and provide reliably good results - assuming that the indication and application are appropriately correct. Medial knee joint osteoarthritis occurs more frequently than its lateral counterpart by a factor of 10. It is known that a constitutional varus deformity of the tibia leads to a faster progression of osteoarthritis development in the case of cartilage damage than in the comparative collective with physiological axis ratios, so that an axis correction can counteract this process [1, 2]. Both procedures have their respective independent indications, and the decision to use one or the other is subject to clear preconditions. Overlaps in indications are rare and must be weighed against each other, with criteria such as patient age, constitution, life circumstances and the expertise of the surgeon playing a role. Furthermore, both are not intermediate solutions on the way to total joint replacement but are procedures with excellent long-term results in their respective fields. However, and again both, a big issue is conversion of failed HTO or UKA to TKA, resulting in worse results, frequent need of revision implants and a higher re-revision rate.

In particular, UKA shows better functional results with higher patient satisfaction than total knee arthroplasty (TKA) in the registry data [3]. Due to the development of modern, minimally invasive surgical procedures using standardized techniques, UKA has experienced a renaissance in the course of the past 30 years, with development from the 1970s to the present constantly advancing and increasingly producing cementless systems again in addition to minimal-invasive (MIS) instrumentation [4].

The pioneer of osteotomy as a principle for treating unicompartmental osteoarthritis was Mark Coventry, who described an osteotomy procedure as early as 1965 to transfer the load of the affected to the unaffected compartment [5]. Modern osteotomy strategies as medial opening wedge high tibial osteotomy in biplanar technique using the internal fixateur principle allow a soft-tissue-preserving, minimally invasive surgical technique with reduction of the complication rate and rapid load build-up [6].

For long time, both interventions were, and unfortunately still are understood as competing treatment procedures and the indication criteria are influenced by personal preferences, local and/or economic circumstances, or available expertise [7]. The following article is intended to shed light on the differential indications of both methods and provide an overview of their potential and limitations.

HIGH TIBIAL OSTEOTOMY (HTO)

HTO fully corrects bony deformities but does not address the intraarticular compart damage. The predominant form by far is extraarticular whereas the correction of intraarticular deformities is rare. Not every deformity has an unique origin and therefore an analysis of the leg axis by means of a correctly performed whole-leg weightbearing radiograph is crucial before an osteotomy. Generally, the realignment should always be performed at the site of the deformity, otherwise the osteotomy creates another new deformity and the jointline line obliquity (JLO) will be pathologic.

Indication

The main indication for HTO is symptomatic metaphyseal varus deformity of the proximal tibia. The creation of a normal or slightly overcorrected leg axis leg axis leads to relief of the cartilage and to pain reduction. As lateral closing wedge osteotomy has been widely driven back by medial open wedge osteotomy (MOWHTO) mainly for reasons of simplicity in surgical technique and less complications we will focus on MOWHTO in this article. The physiologic medial proximal tibial angle (MPTA) averages 87° (range 85-90°). If the angle is reduced, the weight-bearing axis of the leg (Mikulicz line) shifts medially, which leads to a knee joint line that slopes more medially and a supination position of the ankle joint. In most of the cases the reduced MPTA is due to a metaphyseal varus deformity.

There are several extended indications for HTO. Re-alignment procedures have a high priority in the successful therapy of cartilage or meniscus therapies today and affect the success of ligamentous reconstructions [8]. HTO with correction of a pathological slope can reduce the increased stress on the graft and contributes to its success in both anterior and posterior cruciate ligament surgeries [9]. Posttraumatic pathologies with extraarticular deformities following mainly fractures of the tibia are further extended indications which are beyond the scope of this paper.

Patient selection criteria

Age:

Regarding age and outcome after HTO, the available data are inconsistent. While several studies found that the failure rate after HTO in the group of older patients (> 47-50 years) is about twice as high as in the comparison cohort of younger age [10], another study found no significant difference in function and survival in the older patient population (> 55 years) [11]. Recent data support the hypothesis that HTO has worse outcomes in a patient population older than 60 years [12].

Weight/BMI:

The evidence is clearer for weight. Obese patients (BMI > 25-30) are not only at higher risk for procedural failure but also for other complications such as pseudarthrosis [13].

Cartilage damage in the adjacent articular compartments:

In the presence of asymptomatic cartilage damage in the lateral compartment, worse PROMs scores in terms of function and pain after HTO were stated but there was no effect of asymptomatic cartilage damage in the patellofemoral joint on functional outcome and pain [14].

Severity of arthritis:

Various studies have shown that the more pronounced the arthrosis, the worse the results - especially in the case of joint space narrowing [15]. However, very good long-term results after HTO in combination with cartilage therapy (microfracturing) even in higher-grade osteoarthritis (Kellgren-Lawrence 3-4) have been described as well [16].

Joint line orientation (JLO):

Simplified, it can be stated that a pathological laterally sloping joint line should be avoided with proximal tibia valgus osteotomy. An MPTA greater than 94° resulted in a 70% failure of the osteotomy at ten years, whereas realignments that resulted in an angle ≤ 94° did not [17]. In addition, the IKDC score was still significantly better at ten years postoperatively when the MPTA did not exceed a value of 95 degrees [16]. This again emphasizes the need of a correct analysis of the leg axis prior to osteotomy since in about 10 % the correction of the deformity cannot be done on one bone only and a double level osteotomy (DLO) at the femur and tibia will be necessary to prevent a pathological JLO. [18]

Complications

Overall, it can be stated that the complication rate of tibial open-wedge osteotomy remains high with approximately 30%. The main complications are fractures of the lateral hinge (up to 25%), pseudarthrosis (up to 5.4%), implant failure (up to 22.9%) and infections (up to 10%). Vascular injuries and compartment syndrome are rare but serious, although the data in the current literature vary widely. Using modern angle-stable implants the mechanical complications are significantly reduced (fracture: 15.6%, pseudarthrosis: 0.6%, implant failure: 0.6%) [19].

Overweight, smoking, and hinge fractures (especially Takeuchi type II) were identified as risk factors for pseudarthrosis [20]. The amount of correction measured by the wedge base height was also found to be a risk factor for the development of pseudarthrosis [21]. Although bone healing could be accelerated by an autologous iliac crest interposition graft [22], filling the osteotomy gap did not significantly alter the pseudarthrosis rate (0.5% for autologous and allogenic and 0.4% for no interposition). Filling the gap with synthetic material might even increase the rate of pseudarthrosis (1.1%) [23].

Outcome

A 2014 Cochrane review demonstrated that HTO is an evidence-based procedure for the treatment of medial osteoarthritis of the knee in terms of improved function and pain reduction [24]. A 2013 systematic review showed survival rates of isolated HTOs of 85% at 10 years and 72% at 20 years without conversion to arthroplasty [25]. As a caveat, the results of these publications are limited since they involved non-uniform osteotomy procedures. Other studies that investigated only open-wedge procedures also demonstrated significant functional improvements as well as high survival rates at follow-up after five and ten years (96 and 82%), respectively [16]. The improvement in function is also associated with a high percentage of either early return to work or to the original work as well as return to sports [26]. However, there was a shift from high-impact to low-impact sports [27]. Revision of failed HTO to TKA can be challenging particularly in oblique joint lines with altered anatomy, pseudarthrosis, proper ligament balancing and of course infections [18].

UNICONDYLAR KNEE ARTHROPLASTY (UKA)

UKA is resurfacing the damaged compartment only but does not correct any underlying bony deformity. Extreme varus or valgus deformities, pathological JOL or extraarticular deformities cannot be addressed with UKA, therefore planning on full long leg weightbearing radiographs is also important for UKA.

Indication

The indication is varus deformity caused by intraarticular wear [7]. The decisive factor here is the integrity of the cruciate and collateral ligaments. If the ligaments are intact, anteromedial osteoarthrosis (AMOA) develops in the course of cartilage wear, being the classic indication for UKA. Medial UKA occurs more frequently than lateral UKA by a factor of 10. In AMOA severe bony deformities are rare but varus or valgus deformity should not exceed 10° since 3 to 5° of the deformity can be corrected by the UKA with resurfacing the cartilage only. In exceptional cases with more severe bony deformities the UKA might be combined with HTO. UKA candidates should not have a flexion contracture > 10° and still good range of motion.

Patient selection criteria

Kozinn and Scott in 1989 stated age under 60 years, weight over 82 kilograms, osteoarthritis in the adjacent joint segments, chondrocalcinosis, an insufficient anterior cruciate ligament, and a high activity level as contraindications for medial UKA [28]. If these indication criteria were applied, only 4-6% of the patients would be suitable for treatment with UKA. Today, the indications for UKA can be extended on the basis of more current literature results [29].

Ligament status:

Differentiation between knees which can functionally compensate the ACL insufficiency or not is important. For compensators still UKA might be an option and for none compensators the combination of anterior cruciate ligament replacement and UKA can be considered today [30]. However, an intact posterior cruciate ligament and collateral ligaments are undoubtedly required [29].

Age:

In the patient population over 65 years of age, medial UKA convinces with high survival rates, lower complication rates compared to TKA as well as its cost-effectiveness and shorter hospital stay [31]. In contrast, registry data from Australia and Sweden show higher failure rates in the young patient population under 65 years of age [32]. Data on the treatment of younger patients (< 55 years) with UKA is limited. Although these data shows encouraging results with excellent functional outcome [33], endoprosthetic treatment of younger patients should not be considered uncritical.

Cartilage damage and chondrocalcinosis in the adjacent articular compartments:

Several studies have shown that high-grade cartilage damage on the medial side of the patellofemoral joint does not negatively influence the functional outcome of medial UKA. This also does not increase the revision rate [34]. These data are available primarily for mobile-bearing implants but data on fixed-bearing systems are also available now [35]. Chondrocalcinosis could also not be confirmed as a contraindication, so that ultimately only high-grade lateral cartilage damage, lateral subluxation or instability in the patellofemoral joint as well as cartilage damage on the lateral femorotibial side remain as contraindications [34]. In selected cases additional realignment procedures for patella instability or PFJ for severe OA can be combined with UKA.

BMI:

Although several studies show an increased general risk of complications in obese patients, which is linearly related to the degree of obesity [36], there seems to be no negative influence of obesity on the function and survival rate of the implant [37]. In fact, very obese patients seem to benefit most functionally from the treatment [38].

Sports:

Overall, the data on sports after UKA compared to HTO is limited. A 2021 systematic review examining resumption of sports after HTO and UKA found that the proportion of patients who resumed sports postoperatively was higher in the HTO collective. It must be taken into account that patients who underwent HTO were more physically active pre- and postoperatively, but patients undergoing UKA experienced an overall greater increase in their physical activity levels and knee function [51]. Furthermore a 2016 systematic review comparing UKA vs TKA confirmed that low- and higher-impact sports are possible for both, but it is clear that more patients return to sports (including higher-impact types of sports) after UKA than after TKA [39]

Complications

The most common risks of unicondylar arthroplasty are mainly overcorrection with the risk of developing arthrosis in the lateral compartment, loosening, dislocation of the polyethylene for mobile bearings, fractures, and infections. Lateral progression of osteoarthritis is rare (1.4%), but accounts for approximately one quarter of the reasons for revision after UKA [40]. Correct balancing the gaps and no femoro-tibial overcorrection is critical for preventing lateral progression of osteoarthritis [41]. The aseptic loosening rate is approximately 1.3% but the cause is often unclear. Radiolucent lines after UKA are common and often seen in association with component loosening but only their progression represents a sign of loosening [40].

Dislocations of the bearing occur in 0.58 to 5.3% of cases in mobile bearings [40]. Most commonly, these occur anteriorly or posteriorly and are associated with a mismatch of the flexion and extension gap. Other causes of failure are impingement, wear, malalignment, ligament (MCL) attenuation or combinations of these are also possible [42].

Periprosthetic fractures after UKA are rare (0.16 to 1%), mainly occur on the tibial side and are usually the result of technical errors. Risk factors for fractures are a deep vertical cut into the posterior proximal tibia, insufficient keel slot preparation, blow-out during keel slot preparation when hitting the posterior cortex with the groove cutter, use of a heavy hammer, multiple pin holes (> 2) for the tibial cutting jig, valgus inclination of the tibial component, and low bone mineral density [43]. Data on infection rates after UKA vary among authors, but are usually less than 1% [44]. Conversion from UKA to TKA can be technically demanding and often achieves worse functional results than primary total joint replacement [45].

DISCUSSION

Both UKA and HTO are highly valued in the treatment of medial knee osteoarthritis. However, in contrast to ancient reports, they are not competing procedures as their indications differ substantially. The correct indication for both procedures must therefore clearly be emphasized, as they are not intermediate solutions on the way to total joint replacement but are procedures with excellent long-term results in their respective fields. HTO is primarily a procedure to correct extra-articular, metaphyseal malalignments, mainly in with non-full-thickness cartilage damage as well as mainly intact adjacent compartments. In addition, it represents a procedure to compensate for ligament insufficiencies (ACL, PCL and partly medial collateral ligament) via bony correction and gains great importance in supporting cartilage, meniscal and cruciate ligament therapies in case of malalignment. The indication for UKA is full-thickness cartilage loss in AMOA with preserved ligament function and mainly intact adjacent compartments.

Often, the indication is clear: the ideal prerequisite for each option according to deformity, age, degree of cartilage damage, demands and the ability to take on the different post-treatment procedure [46]. Postoperative rehab is significantly longer for HTO compared to UKA which might play a role for patients still in the working process. Nevertheless, there are overlaps and borderline areas in the indication. For example, the indication for HTO has been expanded to include pre-existing cartilage destruction with moderate to advanced osteoarthritis. The extent of the correction can be adapted to the degree of osteoarthritis [47]. However, the basic prerequisite for success remains the extra-articular malposition, which must be fully corrected or even overcorrected. The more severe the correction is, the higher is the risk of connecting osteoarthritis of the lateral compartment. It is known, however, that the likelihood of success is more limited in the case of higher-grade arthrosis (KL ≥ 3, Ahlbäck ≥ 2) [48]. Conversely, implantation of a UKA is possible in the presence of extraarticular malalignment and full-thickness cartilage damage, although a limit of residual varus malalignment of 5 degrees after UKA has been formulated since current literature supports that deformity above 5 degrees results in a greater proportion of dissatisfied patients [48].

Patient age is not necessarily an exclusion criterion for one or the other procedure, since there are both data with excellent results in the treatment of younger (< 60 years) patients with UKA [49] and data that support the opening-wedge osteotomy in older patients, provided that the above-mentioned indication requirements are met [11]. However, the fundamentally higher risk of early revision in UKA in younger patients (< 50 years) should be pointed out [50] as well as worse outcomes in a patient population older than 60 years treated by HTO [12]. Sporting demands do not necessarily speak against one or the other procedure. There is a change from high to low-impact sports in both treatments. A systematic review from 2021 showed that patients are more active before and after surgery with HTO, but patients after UKA benefit more in terms of their activity level [51]. Unfortunately, there is a lack of high-quality studies and especially registry data for HTO that would make the two procedures directly comparable.

Although both HTO and UKA are procedures with excellent long-term results in their respective fields, it is equally true for both that the outcome depends on the expertise of the surgeon. The correlation between frequent use and outcome has already been impressively demonstrated [52]. The high complication rate of HTO has already been illustrated above. Comparing both procedures, it is not surprising that HTO showed a higher re-hospitalization rate within 30 days and higher revision rate in the HTO collective in a Korean nationwide cohort study. In contrast, deep vein thrombosis, surgical site infections and postoperative intensive care stay were more common in the UKA group in this study [53]. A systematic review and meta-analysis from 2022 showed a higher complication rate for HTO compared to UKA and partly better outcome scores (Lysholm, HSS). No difference could be found for the WOMAC score, ROM, reduction of pain, walking speed, and conversion rate to TKA between the two procedures [54].

A big issue is conversion of failed HTO or UKA to TKA, resulting in worse results, frequent need of revision implants and a higher re-revision rate. Using registry data from Finland, the survival rate of TKA after HTO is not inferior to that after primary TKA [55], while other authors showed a significant higher probability of TKA failure after HTO, with the survival rate after 15 years being 88.4% (control group: 90,6%) [56]. There are also data showing comparable survival rates and functional outcome after conversion of UKA to TKA. However, a review paper from 2021 showed that revision rates were significantly higher after conversion of a UKA or HTO to TKA [57]. In particular compared to revision TKA the revision of a UKA showed a comparably high revision rate (threefold higher revision rate than primary TKA) [58]. Similarly, a propensity-matched study from 2020 found that TKA after UKA had a significantly lower probability of survival (88%) compared with TKA after HTO (94%) at the mean follow-up after 5 years [59]. Compared to primary TKA good functional outcomes were found for conversion of a failed HTO to TKA, whereas conversion of a UKA showed significantly worse functional scores

(OKS 36.9 vs. 29.1) [60]. Both conversion surgeries are usually more complex and challenging which is evident from a larger number of revision prostheses used in both scenarios (34% after UKA, 19% after HTO) [60].

In summary, both procedures have their respective independent indications, and the decision to use one or the other is subject to clear preconditions. Overlaps in indications are rare and must be weighed against each other, with criteria such as patient age, constitution, life circumstances and the expertise of the surgeon playing a role. It is important that a knee surgeon can offer both procedures to the patient to allow a proper decision making without any personal bias.

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