

**CURRENT CONCEPTS REVIEW**

# Unicompartmental Knee Osteoarthritis (UKOA): Unicompartmental Knee Arthroplasty (UKA) or High Tibial Osteotomy (HTO)?

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*Research performed at La Paz University Hospital-IdiPaz, Madrid, Spain**Received: 10 May 2015**Accepted: 21 November 2015***Abstract**

The aim of this review article is to analyze the results of high tibial osteotomy compared to unicompartmental knee arthroplasty in patients with unicompartmental knee osteoarthritis. The search engine used was PubMed. The keywords were: "high tibial osteotomy versus unicompartmental knee arthroplasty". Twenty-one articles were found on 28 February 2015, but only eighteen were selected and reviewed because they strictly focused on the topic. In a meta-analysis the ratio for an excellent outcome was higher in unicompartmental knee arthroplasty than high tibial osteotomy and the risks of revision and complications were lower in the former. A prospective comparative study showed that unicompartmental knee arthroplasty offers better long-term success (77% for unicompartmental knee arthroplasty and 60% for high tibial osteotomy at 7-10 years). However, a review of the literature showed no evidence of superior results of one treatment over the other. A multicenter study stated that unicompartmental knee osteoarthritis without constitutional deformity should be treated with unicompartmental knee arthroplasty while in cases with constitutional deformity high tibial osteotomy should be indicated. A case control study stated that unicompartmental knee arthroplasty offers a viable alternative to high tibial osteotomy if proper patient selection is done. The literature is still controversial regarding the best surgical treatment for unicompartmental knee osteoarthritis (high tibial osteotomy or unicompartmental knee arthroplasty). However, unicompartmental knee arthroplasty utilization is increasing, while high tibial osteotomy utilization is decreasing, and a meta-analysis has shown better outcomes and less risk of revision and complications in the former. A systematic review has found that with correct patient selection, both procedures show effective and reliable results. However, prospective randomized studies are needed in order to answer the question of this article.

**Keywords:** Comparison, High tibial osteotomy, Knee, Unicompartmental knee arthroplasty, Unicompartmental osteoarthritis

**Introduction**

There are two procedure options available for the treatment of unicompartmental osteoarthritis (UKOA) of the knee when nonsurgical treatment methods fail: high tibial osteotomy (HTO) or unicompartmental knee arthroplasty (UKA) and both are established and well-documented procedures (1). However, there is a high variation in the treatment of

choice by different surgeons for the same knee problem. The aim of this review article is to analyze the clinical effectiveness of HTO compared to UKA in patients with UKOA in terms of outcomes, complications and long-term survival.

**Materials and Methods**

A review has been performed on the surgical treatment

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of UKOA by means of UKA and HTO. The search engine used was MedLine (PubMed) and the keywords were: 'high tibial osteotomy versus unicompartmental knee arthroplasty'. On 28 February 2015, twenty-one articles were found, but only eighteen were selected and reviewed because of their strict relevance to the topic and the question of this article.

## Results

Eight papers compared the results of HTO and UKR in unicompartmental knee osteoarthritis (2-9). Karpman and Volz analyzed forty patients (44 knees) to assess the overall functional result following HTO as compared to UKA (2). Mean follow up was 24 months in the HTO group, and 41 months in the UKA group. Results in the HTO group were rated excellent in two patients, good in nine, and poor in 12. Results in the UKA group were rated excellent in 10, good in nine, and poor in two. Karpman and Volz concluded that UKA offers a viable alternative to HTO in the treatment of UKOA if proper patient selection and precise component placement is employed (2).

Stukenborg-Colsman et al. reported a prospective comparative study comparing the clinical outcome of patients treated either by HTO or UKA for medial UKOA (3). In total, 32 patients received a HTO and 28 patients a UKA. More intra- and postoperative complications were observed after HTO. Patients were assessed at an average of 2.5, 4.5, and 7.5 years after the operation. Using the Knee Society Score, 71% of patients after HTO and 65% after UKA had a knee score of excellent or good 7-10 years postoperatively (13, 15). The Kaplan-Meier survival analysis 7-10 years postoperatively showed a survivorship of 77% for UKA and 60% for HTO. Although the UKA used in this series did not show promising results, Stukenborg-Colsman et al. concluded that with the advanced design of UKA today, UKA offered better long-term success (3).

In a meta-analysis reported by Zhan et al. it was shown that the ratio for an excellent outcome was higher in UKA than HTO and the risks of revision and complications were lower in UKA than HTO (4). Zhan et al. concluded that UKA reduced the risk of postoperative revision and complications and provided excellent outcomes (4).

Dettoni et al. reviewed the literature regarding HTO and UKA, focusing on indications, survivorship, and functional outcomes of the two procedures, as well as revision to total knee arthroplasty (TKA) after failed HTO or UKA (5). High tibial osteotomy and UKA shared

the same indications in selected cases of medial UKOA. These indications are summarized in Table 1. The few studies available in the literature showed slightly better results for UKA in terms of survivorship and functional outcome. Nevertheless, the differences were not significant, the study methods were not homogeneous, and most of the articles reported on closing wedge HTOs. For these reasons, no definitive conclusions were drawn. Total knee arthroplasty represented the revision option for both treatments and yielded satisfactory functional outcomes and survivorship. With the correct indications, both treatments (HTO and UKA) produce durable and predictable outcomes in the treatment of medial UKOA. There was no evidence of superior results of one treatment over the other (5).

Yim et al. compared HTO and UKA at a minimum follow-up of 3 years (6). They identified no significant differences between HTO and UKA for medial UKOA in terms of return to recreational activity and short-term clinical outcomes. Fu et al. reported a systematic review of comparative clinical trials assessing the results of HTO and UKA in patients with strictly UKOA (7). Unicompartmental knee osteoarthritis showed significantly better results compared to HTO in terms of function results. However, no difference in any of the main parameters of the knee score was observed; HTO got slightly better results in range of motion; a trend towards an increased velocity was found in UKA without significant difference. The postoperative rate of revision and complications did not differ significantly between the two groups. With the correct patient selection, both HTO and UKA show effective and reliable results.

Nwachukwu et al. compared UKA and HTO practice patterns in a large US private payer insurance database (8). Data used for UKA and HTO were taken from the database between 2007 and 2011. Between 2007 and 2011, the compound annual growth rate in using UKA was +4.7%, while that for HTO was -3.9%. Using UKA and HTO were inversely correlated. Nwachukwu et al. found that UKA use had increased, while HTO use decreased in the management of UKOA (8).

Lobenhoffer and Agneskirschner performed a multicenter study with 533 patients that revealed good functional outcome scores with a low complication rate (9). The subjective ratings were better than in the comparable groups with UKA and with TKA. The main criterion for HTO versus UKA was constitutional deformity of the femur or tibia. In constitutional deformity, HTO has a very good prognosis. The results were not dependent on age, body mass index (BMI), or grade of OA. Activity and ligament stability of the knee was secondary criterion in favor of HTO. The main conclusion was that medial UKOA without constitutional deformity should be treated with UKA. Table 2 summarizes the main data and results of the comparative studies done on HTO versus UKA.

Nine papers only focused on the role of HTO for UKOA (10-18). In 2005 Brouwer et al. assessed the effectiveness and safety of HTO for treating OA of the knee (10). The Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE (Current contents,

**Table 1. Indications for HTO and UKA in medial unicompartmental OA [5]**

Patients who are 55 to 65 years old
Moderately active
Non-obese
Have mild varus malalignment
No joint instability
Good range of motion
Moderate unicompartmental OA

HTO=High Tibial Osteotomy. UKA=Unicompartment Knee Arthroplasty. OA=Osteoarthritis.

**Table 2. Comparative studies HTO vs. UKA in the revised literature. N = Number of patients. NA=Nonavailable. Level of evidence according to JBJS. OA = Osteoarthritis. TKA = Total knee arthroplasty. UKA = Unicompartmental knee arthroplasty. HTO = High tibial osteotomy**

Author	N	Follow-up	Level of Evidence	Results
Mont [1]	NA	NA	V	NA
Karpman [2]	40	32.5 months	III	Results in the HTO group were rated excellent in 2 patients, good in 9, and poor in 12. Results in the UKA group were rated excellent in 10, good in 9 and poor in 2.
Stukenborg [3]	60	7.5 years	II	More intra- and postoperative complications were observed after HTO. Patients were assessed at an average of 2.5, 4.5, and 7.5 years after the operation. Using the Knee Society Score, 71% (15) of patients after HTO and 65% (13) after UKA had a knee score of excellent or good 7-10 years postoperatively. The Kaplan-Meier survival analysis 7-10 years postoperatively showed a survivorship of 77% for UKA and 60% for HTO.
Zhang [4]	NA	NA	I	The result of this meta-analysis indicated that the ratio for an excellent outcome was higher in UKA than HTO. The risks of revision and complications were lower in UKA than HTO.
Dettoni [5]	NA	NA	V	With the correct indications, both treatments produce durable and predictable outcomes in the treatment of medial unicompartmental OA of the knee. There was no evidence of superior results of one treatment over the other.
Yim [6]	NA	NA	IV	This study identified no significant differences between HTO and UKA for medial unicompartmental osteoarthritis in terms of return to recreational activity and short-term clinical outcomes.
Fu [7]	NA	NA	I	This systematic review of comparative clinical trials assessed the results of HTO and UKA in patients with strictly unilateral osteoarthritis of the knee. UKA showed significantly better results compared to HTO in terms of function results, however, no difference in specific knee score was observed; HTO got slightly better results of the range of motion; a trend towards an increased velocity was found in UKA without significant difference. Postoperative rate of revision and complications did not differ significantly between two groups. With the correct patient selection, both HTO and UKA show effective and reliable results.
Nwachukwu [8]	NA	NA	IV	UKA utilization was increasing, while HTO utilization was decreasing in the management of OA.  This multicenter follow-up study revealed good functional outcome scores with a low complication rate. The subjective ratings were better than in comparable groups with UKA and with TKA. The main criterium for HTO versus UKA was constitutional deformity of femur or tibia. In constitutional deformity, HTO had a very good prognosis. The results were not dependent on age, BMI, or grade of OA. Activity and ligament stability of the knee were secondary criteria in favor of HTO. Medial OA without constitutional deformity should be treated with UKA.
Lobenhoffer [9]	533	NA	IV	

and Health STAR) were searched up until October 2002 for controlled clinical trials. The reference lists of publications in the identified trials were also screened. Based on 11 studies, of which 6 were of high quality, Brouwer et al. concluded that there was silver level evidence that valgus HTO improves knee function and reduces pain. There was no evidence whether any type of HTO is more effective than conservative treatment, and the results so far did not justify a conclusion about the effectiveness of specific surgical techniques. In 2007, Brouwer et al. updated the original review published in 2005 and based on 13 studies, they reached the same conclusions (11). In 2014, Brouwer et al. performed the second update of the original review published in The Cochrane Library in 2005 (12). The conclusions of this update did not change: Valgus HTO reduced pain and improved knee function in patients with medial compartmental OA of the knee. However, this conclusion was based on within-group comparisons,

not on non-operative controls. No evidence suggested differences between different HTO techniques and no evidence showed whether any HTO was more effective than alternative surgical treatments such as UKA or noninvasive treatment. The results of this updated review did not justify a conclusion on the benefit of specific HTO techniques for UKOA.

Kim et al. compared medial opening wedge HTO using a kinematic navigation system versus a conventional method (13). The study consisted of 85 consecutive patients (90 knees), who were available at 1-year follow-up after a medial opening wedge HTO using a kinematic navigation system or a conventional method for medial UKOA. On radiographic assessment, the navigation group showed better results than the conventional group in both the mechanical axis and the coordinate of the weight-bearing line on a full-length standing anteroposterior radiograph. There was no significant difference in the alteration of the tibial slope between

the two groups. On clinical assessment, the navigation group showed better results in both the mean Hospital for Special Surgery knee score and the mean Lysholm knee score. There was no significant difference in operation times between the two groups. Kinematic navigation-guided HTO was a reproducible and reliable procedure compared to conventional HTO (13).

Ducat et al. assessed posterior tibial slope changes after opening- and closing-wedge HTO (14). In a prospective consecutive nonrandomized multicenter study Ducat et al. analyzed the modifications of the tibial slope after opening- and closing-wedge HTOs and compared the results of these two procedures (13). They hypothesized that there was no difference in postoperative tibial slope between opening- and closing-wedge osteotomies. A total of 224 patients underwent an opening-wedge HTO and 97 a closing-wedge osteotomy. The mean age was 52 years and the mean BMI was 28kg/m<sup>2</sup>. The main etiology was primary OA. Posterior tibial slope was measured preoperatively

and at the last follow-up on a lateral radiograph in relation to the posterior tibial cortex. In the opening-wedge group, a definite 0.6° increase in the tibial slope was observed. In the closing-wedge group, a definite 0.7° decrease in tibial slope was found. Fourteen percent of the opening-wedge HTOs increased the tibial slope by 5° or more versus only 2% of the closed-wedge HTOs. Twelve percent of the closing-wedge HTOs led to a decrease of 5° or more of the tibial slope versus 7% of the opening-wedge HTOs. These results confirmed what is generally reported in the literature, i.e., an increase in the tibial slope in opening-wedge HTOs and a decrease in the slope in closing-wedge HTOs. These tibial slope changes appeared to be very limited in this series: less than 1° on average. However, there was a bias since the open-wedge technique was preferred in cases with substantial varus deformity. Ducat et al. emphasized the importance of surgical techniques to avoid alteration of the tibial slope, particularly in opening-wedge HTO for which they recommended a release of posterior soft

**Table 3. Studies on HTO in the revised literature. N = Number of patients. NA=Nonavailable. Level of evidence according to JBJS. OA = Osteoarthritis. TKA = Total knee arthroplasty. UKA = Unicompartmental knee arthroplasty. HTO = High tibial osteotomy**

Author	N	Follow-up	Level of evidence	Results
Browner [10-12]	NA	NA	I	Valgus HTO reduced pain and improved knee function in patients with medial OA of the knee. No evidence suggested differences between different HTO techniques. No evidence showed whether a HTO is more effective than alternative surgical treatment such as UKA or non-operative treatment.
Kim [13]	85	1 year	IV	A comparison was done between medial opening wedge HTO using a kinematic navigation system or a conventional method, for medial OA. On radiographic assessment, the navigation group showed better results than the conventional group. There was no significant difference in the alteration of tibial slope between the two groups. On clinical assessment, the navigation group showed better results. There was no significant difference in operation times between the two groups. Kinematic navigation-guided HTO was a reproducible and reliable procedure compared to conventional HTO.
Ducat [14]	224	NA	III	An increase in tibial slope in opening-wedge HTO and a decrease in the slope in closing-wedge HTO were found. In opening-wedge HTO a release of posterior soft tissue and a complete osteotomy of the posterior cortex of the tibia was recommended.
Bastos Filho [15]	118	2 years	IV	The average IKS knee and function scores improved. There was no significant difference in IKS scores based on HTO technique. There was a trend toward an increased need for tibial tubercle osteotomy in the closing wedge group. There was an increased need for extensive medial release in the opening wedge group and extensive lateral release in the closing wedge group. No differences in tourniquet time, complication rates, or hip-knee-ankle angle were noted between the two groups.
Atrey [16]	NA	NA	I	The review of the published literature on the complications of closing wedge HTO for the treatment of unicompartmental OA of the knee showed that many of these trials included comparative studies (opening wedge versus closing wedge) and there was heterogeneity in the studies that prevented pooling of the results.
King-Martinez [17]	134	NA	IV	53% of patients had complications. None of the risk factors were statistically significant. The risk factors were age 50 or more years old, comorbidity such as type 2 diabetes, hypertension, rheumatoid arthritis, overweight and obesity (BMI > or = 25 and > or = 30), duration of ischemia longer than 60 min and local pain. None of risk factors were associated with the complications of HTO; therefore, these could be attributable to the surgical technique. It is necessary to outweigh the temporary benefits of the HTO versus the increase in the risk of complications when performing TKA.
Saraglia [18]	83	5.75 years	IV	This study demonstrated that HTO for medial femorotibial OA allow the resumption of sustained physical activity such as jogging or skiing downhill in a majority of patients.

tissue and a complete osteotomy of the posterior cortex of the tibia (13).

Bastos Filho et al. reported a total of 141 TKA's performed in 118 patients with prior HTO (24 opening-wedges and 117 closing-wedges), with a mean follow-up was two years (15). The purpose of the study was to evaluate the impact of the HTO technique on the performance and results of TKA. Reviewed data included: intra-operative factors (tourniquet time, the need for additional exposure, and intra-operative complications), clinical results (International Knee Score (IKS), and radiographic assessment of limb alignment. The average IKS knee and function scores improved from 54 and 60.3 to 87 and 79.5, with no significant difference in IKS scores based on the HTO technique. There was a trend toward an increased need for tibial tubercle osteotomy in the closing-wedge group. There was an increased need for extensive medial release in the opening-wedge group and extensive lateral release in the closing-wedge group. No differences in tourniquet time, complication rates, or hip-knee-ankle angle were noted between the two groups. The conclusion was that radiographic limb alignment, patient-reported outcomes, and complication rates are equal in patients undergoing TKA after opening and closing wedge HTO.

Atrey et al. systematically reviewed the published literature on the complications of closing-wedge HTO for the treatment of UKOA (16). Publications were identified using the Cochrane Library, MEDLINE, EMBASE, and CINAHL databases up to February 2012. They assessed randomized (RCTs), controlled group clinical (CCTs) trials, case series in publications associated with closing wedge osteotomy of the tibia in patients with UKOA and finally a Cochrane review. Many of these trials included comparative studies (opening-wedge versus closing-wedge), and there was heterogeneity in the studies that prevented pooling of the results.

King-Martinez et al. analyzed if pre-surgical risk factors or the surgical technique were associated with the complications of HTO in genu varus patients (17). A case-control study was conducted in patients that underwent HTO for treatment of genu varus. The risk factors were: age 50 or more, comorbidity such as type 2 diabetes, hypertension, rheumatoid arthritis, overweight and obesity (BMI  $\geq$  25 and  $\geq$  30), duration of ischemia longer than 60 min and local pain. One hundred and thirty-four patients were included, among which 53% had complications. None of the risk factors were statistically significant. None of the pre-surgical risk factors were associated with the complications of HTO; therefore, these could be attributable to the surgical technique. King-Martinez et al. concluded that it is necessary to outweigh the temporary benefits of HTO versus the increase in the risk of complications when performing TKA (17).

Saragaglia et al. evaluated the resumption of physical activity and sports after valgus osteotomy for medial UKOA. The series was composed of 83 patients (18). The mean age was 50.4 years at the time of operation. Before the onset of symptoms of knee OA, four (4.8%) patients practiced a competitive sport, 44 (53%) one (or

more) recreational sports on a regular basis, 17 (20%) occasionally, and 18 (21.6%) did not practice any sport but were active. Sixty-two opening wedge HTOs were performed as well as 21 double level osteotomies for severe deformity. All the osteotomies were computer-assisted in order to reach the best overcorrection. At a mean follow up of 5.75 years, 71 patients (85.5%) resumed sporting activities, and 66 (79.5%) felt they had found a sporting level equal to the level prior to surgery. The mean Lysholm score increased from 62.51 points pre-operatively to 90.49 points postoperatively. The Tegner and UCLA scores did not decrease significantly after surgery (4.53 and 7.14 pre-operatively versus 4.1 and 6.55 postoperatively). The mean postoperative KOOS score was 73.52. The frequency of sports sessions per week (2.36) did not decrease significantly after surgery (2.13 sessions). On the other hand, the duration of activities decreased significantly from 4.68 hours/week to 3.48 hours/week. Of the patients who practiced running before surgery, 85% (17 of 20) were able to resume this activity. This study showed that knee osteotomies for medial UKOA allowed the resumption of sustained physical activity such as jogging or skiing downhill in a majority of patients (15). Table 3 summarizes main data and results on HTO.

## Discussion

The aim of this review article was to analyze the clinical effectiveness of HTO compared to UKA in patients with UKOA. The ideal indications for HTO and UKA were patients who are 55 to 65 years old, moderately active, non-obese, have mild varus malalignment, no joint instability, good range of motion, and moderate unicompartmental OA (5). Yim et al. did not identify significant differences between HTO and UKA for medial UKOA in terms of return to recreational activity and short-term clinical outcomes (6).

In a systematic review published by Fu et al., UKA has shown significantly better results compared to HTO in terms of function results, however, no difference in specific knee score was observed (7). Also, HTO got slightly better results in range of motion and a trend towards an increased velocity was found in UKA without any significant difference. Postoperative rate of revision and complications did not differ significantly between the two groups. With the correct patient selection, both HTO and UKA have shown effective and reliable results.

It has been shown that UKA utilization is increasing, while HTO utilization is decreasing in the management of OA (8). One case-control study found that UKA offers a viable alternative to HTO in the treatment of UKOA if proper patient selection and precise component placement is employed (2). A prospective comparative study has shown that with the advanced design of UKA today, UKA offers better long-term success (3). A meta-analysis found that the ratio for an excellent outcome was higher in UKA than HTO, and that the risks of revision and complications were lower in UKA than HTO. With the correct indications, both treatments produce durable and predictable outcomes in the treatment of

medial UKOA (4). Another review of the literature has shown that there was no evidence of superior results of one treatment over the other (5).

Nine papers just focused on HTO for UKOA (10-18). In 2014, Brouwer et al. did the second update of the original review published in the Cochrane Library in 2005 (12). They concluded that valgus high tibial osteotomy reduces pain and improves knee function in patients with medial compartmental OA of the knee. However, this conclusion was based on within-group comparisons, not on non-operative controls. No evidence suggested differences between different HTO techniques nor whether a HTO is more effective than alternative surgical treatment such as UKA or non-operative treatment. The results of this updated review did not justify a conclusion on the benefit of any specific HTO technique for UKOA.

Kim et al. compared medial opening wedge HTO using a kinematic navigation system versus a conventional method (13). On radiographic assessment, the navigation group showed better results than the conventional group in both the mechanical axis and the coordinate of the weight-bearing line on a full-length standing anteroposterior radiograph. There was no significant difference in the alteration of tibial slope between the two groups. On clinical assessment, the navigation group showed better results in both the mean Hospital for Special Surgery knee score and the mean Lysholm knee score. There was no significant difference in operation times between the two groups. Kinematic navigation-guided HTO was a reproducible and reliable procedure compared to conventional HTO.

Ducat et al. assessed posterior tibial slope changes after

opening- and closing-wedge HTO (14). They emphasized the importance of surgical techniques to avoid alteration of the tibial slope, particularly in opening-wedge HTO for which we have recommended a release of posterior soft tissue and a complete osteotomy of the posterior cortex of the tibia (13).

Atrey et al. systematically reviewed the published literature on the complications of closing wedge HTO for the treatment of UKOA. Many of the trials included comparative studies (opening wedge versus closing wedge) and there was heterogeneity in the studies that prevented pooling of the results (16).

Saraglia et al. evaluated the resumption of physical activity and sports after valgus osteotomy for medial UKOA (18). This study has shown that knee osteotomies for medial UKOA allows the resumption of sustained physical activity such as jogging or skiing downhill in a majority of patients.

In conclusion, the literature is still controversial regarding the best surgical treatment for UKOA (HTO or UKA). However, UKA utilization is increasing while HTO utilization is decreasing, and a meta-analysis has shown better outcomes in UKA than HTO and less risk of revision and complications in UKA than in HTO. A systematic review has found that with the correct patient selection, both HTO and UKA show effective and reliable results. Prospective randomized studies are needed for the future to answer the question of this article.

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