# 20-Year Outcomes of High Tibial Osteotomy

## Determinants of Survival and Functional Outcome

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**Background:** High tibial osteotomy (HTO) is a successful joint-preserving procedure for the treatment of medial compartment osteoarthritis. Long-term survivorship of HTO ranges from 40% to 85%. There are consistent factors that predict failure.

**Purpose:** To determine the 20-year survival of HTO and identify predictors of failure.

**Study Design:** Case series; Level of evidence, 4.

**Methods:** A total of 100 consecutive patients with medial bone-on-bone arthritis were prospectively studied to provide long-term patient-reported outcome measures after lateral closing-wedge HTO and determine the time to failure. Failure was defined as conversion to arthroplasty (total knee arthroplasty or unicompartmental knee arthroplasty) or revision HTO.

**Results:** At 20 years, HTO survival was determined in 95 patients, and 5 were lost to follow-up. The overall survivorship of HTO at 20 years was 44%. The significant factors that were associated with better survivorship were age <55 years, body mass index <30, and Western Ontario and McMaster Universities Osteoarthritis Index pain score >45. These factors were used to define the favorable candidates. In the favorable candidates, survivorship was 100% at 5 years, after which there was a gradual decline to 62% survival at 20 years. Of those with HTO survival, 32 of 33 (97%) reported satisfaction with surgery, with a mean Knee injury and Osteoarthritis Outcome Score Pain score of 91 and Activities of Daily Living score of 97.

**Conclusion:** HTO is a successful surgical option to treat medial compartment osteoarthritis and prevent the need for arthroplasty in young patients. The most suitable candidates for HTO are aged <55 years, are not obese, and have not progressed to severe symptomatic disability.

**Keywords:** osteoarthritis; high tibial osteotomy; survivorship; arthroplasty

The young adult with knee osteoarthritis presents a significant challenge for the orthopaedic surgeon. High tibial osteotomy (HTO) has been the mainstay nonarthroplasty surgical management of the arthritic knee in the young patient.[8,41] The main indication still resonates from the early series of Coventry[11] from the Mayo Clinic: "the patient with early symptomatic unicompartmental osteoarthritis will remain an ideal candidate for osteotomy."

Although total knee arthroplasty (TKA) is highly successful over the long term in older patients, outcomes are considerably worse in those <55 years of age. The cumulative risk of revision of TKA at 20 years is 16% in those <55 years of age compared with 3% in those >75 years of age.[3] Surgical options such as HTO to avoid or at least delay the need for TKA are attractive until an age that yields more predictable outcomes. HTO is a joint-preserving treatment option that does not preclude TKA at a later date.

Successful clinical results of HTO rely on the (over-)correction the hip-knee-ankle axis to a valgus alignment.[11-14,24] With a sufficient shift in the mechanical axis, there are pathophysiological benefits of changing the biomechanical environment of a degenerate medial compartment. Along with improved patient symptoms and function, both Fujisawa et al[17] and Kanamiya et al[27] noted restoration of cartilage defects with fibrocartilage on secondary arthroscopy. This regenerative capacity has also been shown radiographically.[21]

This prospective study commenced in 2000, with follow-up to 10 years being previously reported.[22] Survivorship of lateral closing-wedge HTO for medial compartment osteoarthritis demonstrated 87% revision-free survival at 5 years and 79% at 10 years.[22] The predictors of failure by 10 years were a body mass index (BMI) >30, age >55 years, and a lower preoperative score on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)[22]; these findings are supported by others.[‖]

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[‖]References 1, 4, 7, 16, 23, 25, 26, 32, 42, 46-48.

No published studies have included a prospective large cohort with a minimum of 20 years of follow-up after HTO. Seven retrospective studies report 20-year survival of HTO with marked variability: 40% to 85%.[6,15,16,25,44,46,47] The aim of this prospective study was to determine the 20-year survivorship and longitudinal outcomes of the lateral closing-wedge HTO and to evaluate the predictors of conversion to arthroplasty.

## METHODS

### Participants

Between 2000 and 2002, 164 consecutive patients (164 knees) underwent lateral closing-wedge HTO under the care of the senior author (L.A.P.). In all cases, the indication for HTO was progressive symptomatic osteoarthritis of the medial tibiofemoral compartment with evidence of severe disease as assessed using the International Knee Documentation Committee radiological grading system[20] (ie, joint space <2 mm or >50% of joint space narrowing) on weightbearing radiographs and supported by painful bony crepitus when varus stress was applied during clinical examination. The surgeon considered the following as contraindications to HTO: severe varus deformity (>20° varus biomechanical alignment) on weightbearing radiographs, tricompartmental osteoarthritis, flexion contracture >10°, inflammatory arthritis, and painful lateral compartment bony crepitus to clinical examination. Included were patients who underwent a lateral closing-wedge HTO under the care of the senior author between 2000 and 2002 at a private hospital in Sydney, Australia, and consented to participation before HTO in a prospective longitudinal study with baseline patient-reported outcome measures (PROMs). Patients were excluded if they had a diagnosis of inflammatory arthropathy, had a previous HTO, or were receiving workers' compensation. A total of 100 consecutive patients met the criteria and were enrolled. The sample size of 100 patients was determined as reasonable at the commencement of the study in 2000. Ethics approval was obtained from a local hospital human research ethics committee.

### Surgical Technique

A modified Coventry lateral closing-wedge HTO was performed with the goal of correcting the anatomical axis to 10° femorotibial valgus. Fixation was achieved using a single Krakow staple (Smith & Nephew). This surgical technique has been previously described in detail.[22] Previous surgical hardware was only removed if it interfered with the osteotomy procedure (eg, tibial screw from previous anterior cruciate ligament reconstruction). The fibular head was ostectomized at the superior tibiofibular joint, leaving the styloid process attached. After HTO, patients were mobilized touch weightbearing for 6 weeks in a valgizing range of motion brace with movement from 0° to 90° and were prescribed chemoprophylaxis for venous thromboembolism for 6 weeks postoperatively.

### Outcome Measures

Operative data were collected prospectively and included patient characteristics and surgical details. In the event of conversion to knee arthroplasty, the date of survival was determined, and no further follow-up was performed. Patients were assessed in person preoperatively and at 5 and 10 years after HTO using normalized WOMAC[5,18] and Knee Society scores and have been reported on previously.[22] The method of scoring for the normalized WOMAC was as described by Roos and Toksvig-Larsen.[40] Individual question responses are assigned a score of between 0 (none) and 4 (extreme). Individual question scores are then summed to form a raw score. Finally, raw scores are transformed using the following formula: 100 – (raw score × 100/maximum possible score). This produces a reported WOMAC score of between 0 (worst) and 100 (best). A WOMAC pain subscore was also calculated and normalized as above. At a minimum of 20 years after surgery, patients were sent an online survey using Research Electronic Data Capture (REDCap; Vanderbilt University) tools. In the event of nonresponse or the absence of email, patients were contacted by telephone and invited to complete the survey over the telephone or via the online link according to their preference. Failure was defined as conversion to unicompartmental knee arthroplasty (UKA), TKA, or revision HTO. In the absence of failure, the normalized WOMAC score; the disease-specific instruments of the Knee injury and Osteoarthritis Outcome Score (KOOS)[39] and its subscores for Quality of Life, Pain, Symptoms, and Activities of Daily Living; and the Oxford Knee Score were collected at 5, 10, and 20 years. For the KOOS, 1 or 2 missing values were substituted with the mean value for that subscale; if >2 items were omitted, the response was considered invalid, and no subscale score was calculated.[40] For the Oxford Knee Score and EuroQol-5D (EQ-5D), any questions were set as required fields. The EQ-5D[38] was selected as a widely used generic measure of

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health status, measuring mobility, self-care, activity, pain, and anxiety at 20 years. Satisfaction with surgery was assessed using the satisfaction and expectation components of the Knee Society score,[43] as well as 2 additional questions relating to satisfaction: would the patient have the same surgery again under the same circumstances (yes/no/unsure), and how do they rate their satisfaction with the surgery results on a 5-point Likert scale from "very disappointed" to "very satisfied"?

### Statistical Analysis

Statistical analysis was performed using SPSS Version 28 software (IBM Corp). Participants without follow-up at 20 years (n = 5) were not included in the analysis. Descriptive statistics are presented as means and standard deviations for continuous variables, such as mean patient-reported scores, and counts and percentages for categorical variables. Means were compared between groups using independent *t* tests. The difference in proportions of patients between groups was assessed using the chi-square test. Statistical significance was set at $P < .05$. The HTO survival was assessed using the Kaplan-Meier method. Survival tables at 5, 10, and 20 years were collated. A comparison of survival curves was made using a univariate Cox proportional hazards model. Factors examined included sex, preoperative biomechanical alignment, age (dichotimized to <55 years and ≥55 years), BMI (dichotimized to <30 and ≥30), normalized WOMAC pain score (dichotimized to <45 and ≥45), wedge size (dichotimized to >8° and ≤8°), medial ligament laxity (dichotomized to ≥3 mm and <3 mm), and primary diagnosis (dichotimized to idiopathic and traumatic osteoarthritis). The WOMAC pain score was selected over the full WOMAC score as it can be determined from only 5 questions; a score of <45 represents a mean of more than moderate pain. Factors with $P < .10$ on univariate analysis were entered into a stepwise multivariate Cox regression analysis, until only the significant factors remained. For analysis and discussion, the "favorable candidate" was defined as patients <55 years of age with a BMI <30 and a WOMAC pain score ≥45.

## RESULTS

Of the 100 participants enrolled in the study between 2000 and 2002, the outcomes at a minimum of 20 years after HTO were determined in 95 participants who were included in the analysis. Five patients were lost to follow-up. The participant flow is shown in Figure 1. There were 26 women and 69 men with a mean age of 50 years (range, 26-66 years). The primary diagnosis was idiopathic osteoarthritis in 32 (34%) and posttraumatic osteoarthritis in 63 (66%). A total of 22 patients had a history of anterior cruciate ligament injury. Three patients had a history of tibial or femoral fracture. The mean preoperative BMI was 28.6 (range, 20-39). BMI was graded as normal (BMI, 18.5-24.9) in 11 patients (12%), overweight (BMI, 25-29.9) in 54 patients (57%), and obese (BMI, >30) in 30 patients (32%). The mean preoperative biomechanical angle was 6.0° varus (SD, 3.4°; range, 0°-18°). Associated medial collateral ligament laxity was 0 mm in 27 patients (28%), 1 to 2 mm in 19 patients (20%), 3 to 5 mm in 44 patients (47%), and >5 mm in 5 patients (5%). The mean osteotomy wedge size was 11° (range, 4°-21°). Six patients (6%) died during the study period of unrelated causes.

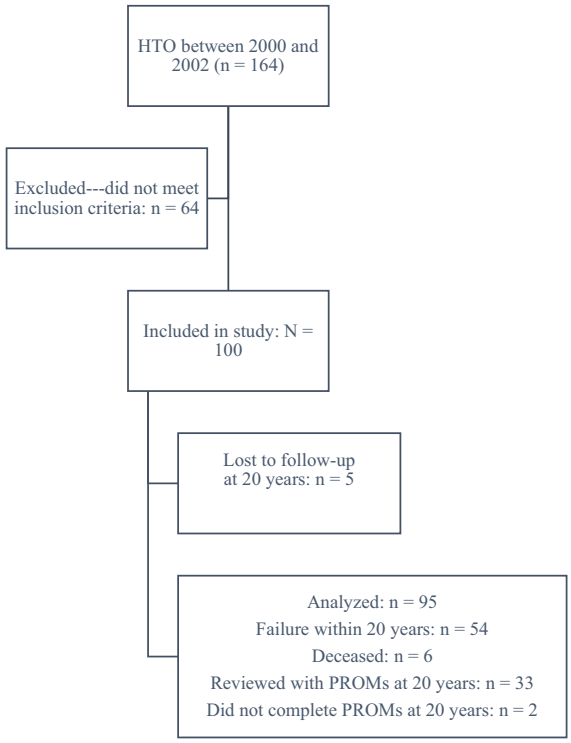


**Figure 1.** Participant flow. HTO, high tibial osteotomy; PROMs, patient-reported outcome measures.

### Further Surgery

In total, 54 patients (57%) proceeded to further surgery on the ipsilateral knee during the 20 years. There were 48 TKAs at a mean of 151 months (range, 18-255 months), inclusive of and 1 revision HTO at 14 months followed by TKA 3 months later, and 6 UKAs at a mean of 74 months (range, 29-206 months).

In total, 42 patients (44%) underwent contralateral knee surgery during the same 20 years, inclusive of 29 TKAs at a mean of 129 months (range, 31-252 months), 8 UKAs at a mean of 78 months (range, 30-180 months), and 5 HTOs at a mean of 60 months (range, 12-132 months).

### Survival Analysis

The 5-, 10-, and 20-year HTO survival rates were 88%, 77%, and 44%, respectively, and are shown in Figure 2. Poorer survival at 20 years was not associated with preoperative biomechanical alignment (hazard ratio [HR], 1.1; 95% CI, 1.0-1.1; $P = .179$), wedge size >8° (HR, 2.2; 95%

TABLE 1
Significant Predictors of HTO Survival on Multivariate Regression Analysis[a]

| | | 5-y Survival | | 10-y Survival | | 15-y Survival | | 20-y Survival | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | Δ | % | Δ | % | Δ | % | Δ | HR (95% CI) | *P* |
| All patients | 95 | 88 | 12 | 77 | 11 | 63 | 14 | 44 | 19 | | |
| Age, y | | | | | | | | | | | |
| ≥55 | 36 | 75 | 25 | 63 | 12 | 47 | 16 | 28 | 19 | 2.4 (1.4-4.3) | .002 |
| <55 | 59 | 97 | 3 | 85 | 12 | 73 | 12 | 54 | 19 | | |
| BMI | | | | | | | | | | | |
| ≥30 | 30 | 83 | 17 | 63 | 20 | 48 | 15 | 32 | 16 | 2.0 (1.1-3.6) | .029 |
| <30 | 65 | 91 | 9 | 83 | 8 | 70 | 13 | 50 | 20 | | |
| WOMAC pain score | | | | | | | | | | | |
| <45 | 19 | 63 | 27 | 47 | 16 | 26 | 21 | 26 | 0 | 2.9 (1.6-5.3) | .001 |
| ≥45 | 76 | 95 | 5 | 84 | 11 | 73 | 11 | 49 | 24 | | |

[a]Δ reflects a 5-year change in survival. BMI, body mass index; HR, hazard ratio; HTO, high tibial osteotomy; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

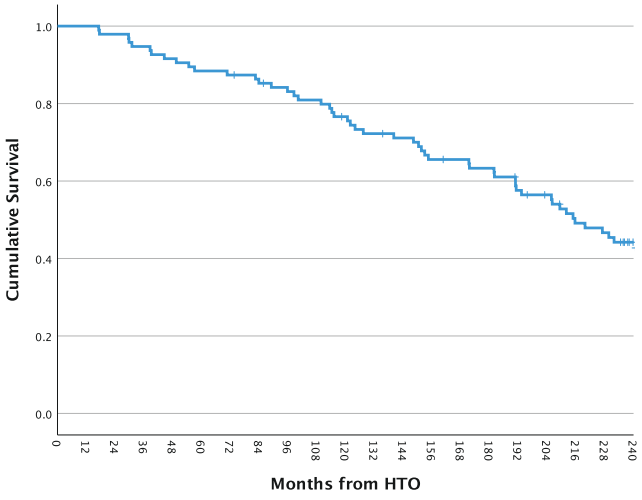


**Figure 2.** Kaplan-Meier curve of high tibial osteotomy (HTO) survivorship.

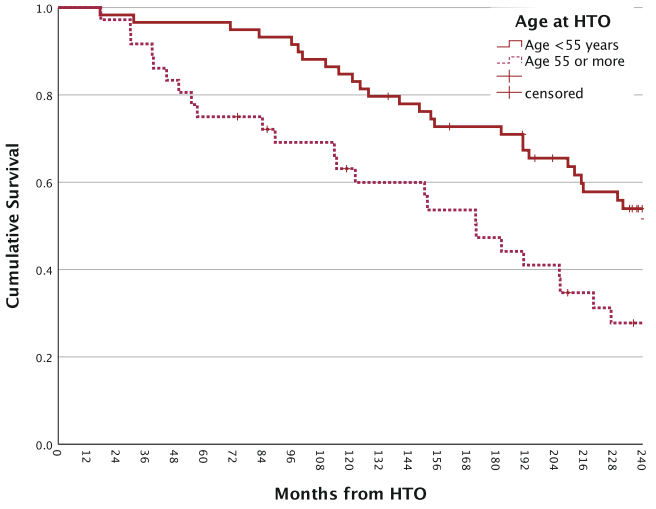


**Figure 3.** High tibial osteotomy (HTO) survivorship for those aged <55 years compared with those aged ≥55 years.

CI, 0.8-6.1; *P* = .127), medial ligament laxity of ≥3 mm (HR, 1.5; 95% CI, 0.8-2.5; *P* = .184), primary diagnosis of idiopathic osteoarthritis (HR, 1.4; 95% CI, 0.6-2.5; *P* = .189), or female sex (HR, 1.4; 95% CI, 0.8-2.4; *P* = .299). The variables of age ≥55 years, BMI ≥30 at time of surgery, and preoperative WOMAC pain <45 were significant on univariate analysis and included in a stepwise multivariate survival analysis, until only the significant factors remained (Table 1 and Figures 2–5).

## Favorable Candidates

A total of 33 patients met the criteria of age <55 years, BMI <30, and a preoperative WOMAC pain score of ≥45, our definition of the favorable candidate. This group was then compared with the remaining 62 patients who did not meet ≥1 of these categories. The survival analysis of this group is shown in Figure 6. In favorable candidates, the survival rates were 100%, 91%, 79%, and 62% at 5, 10, 15, and 20 years, respectively. In nonfavorable candidates, the survival rates were 82%, 69%, 55%, and 35% at 5, 10, 15, and 20 years, respectively (HR, 2.2; 95% CI, 1.2-4.0; *P* = .012).

## Twenty-Year PROMs

There were 41 patients who had not proceeded to TKA at a minimum of 20 years, 6 of whom were deceased. Of the remaining 35 patients, 33 (94%) completed PROMs at a mean of 251 months (range, 234-269 months). There were no missing data for Oxford Knee Score or EQ-5D questions. One patient did not answer 1 question on the KOOS survey, but the score was calculated from the mean. The mean KOOS Pain score was 91 (SD, 7), the mean Symptoms score was 83 (SD, 8), the mean Activites

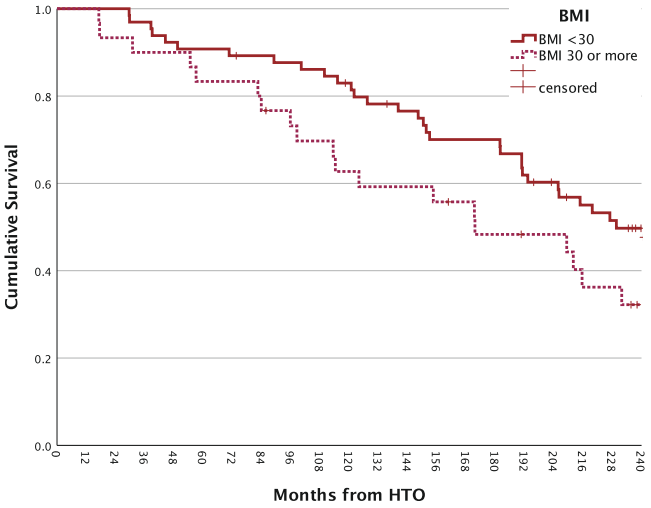


**Figure 4.** High tibial osteotomy (HTO) survivorship for body mass index (BMI) <30 compared with BMI ≥30.

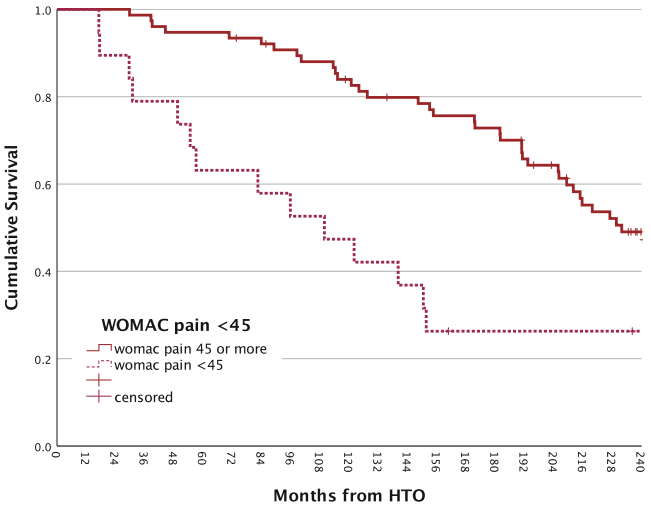


**Figure 5.** High tibial osteotomy (HTO) survivorship for Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain score ≥45 compared with <45.

of Daily Living score was 97 (SD, 4) and the mean Quality of Life score was 65 (SD, 23). The mean KOOS Pain score significantly decreased between 5 and 10 years ($P$ = .001) and increased between 10 and 20 years ($P$ = .001). The mean KOOS Activities of Daily Living score did not change between 5 and 10 years ($P$ = .104) and increased between 10 and 20 years ($P$ = .001). The mean Symptoms score decreased between 5 and 10 years ($P$ = .006) and increased between 10 and 20 years ($P$ = .003). The mean Quality of Life score did not change between 5 and 10 years ($P$ = .104) and increased between 10 and 20 years ($P$ = .001).

The mean WOMAC score was 85 (SD, 15). The changes in WOMAC score and KOOS over time are shown in Figures 7 and 8, respectively. On the EQ-5D, no problems

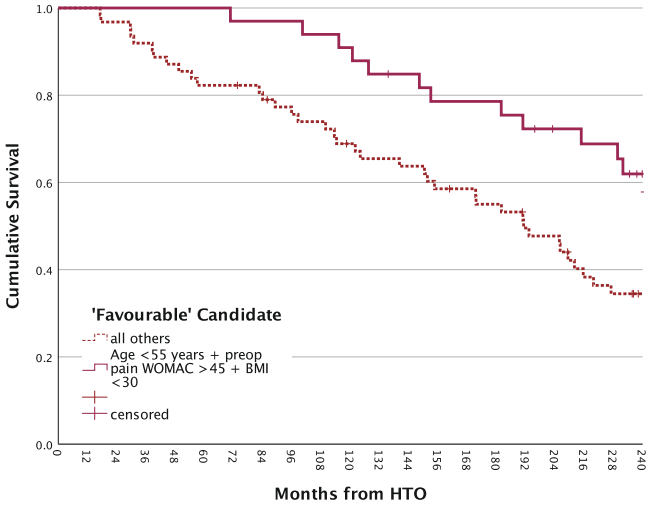


**Figure 6.** High tibial osteotomy (HTO) survivorship for the favorable candidate compared with all others. The favorable candidate is defined as patients <55 years of age with a body mass index (BMI) <30 and a preoperative Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain score ≥45.

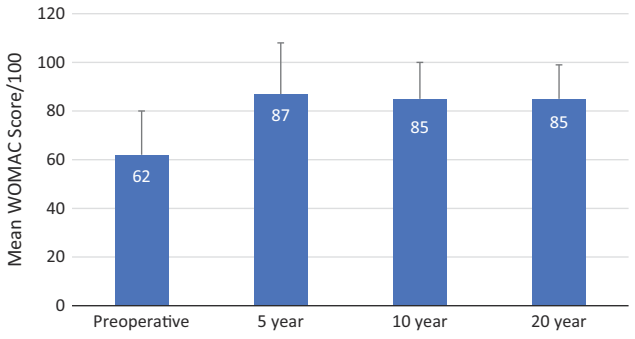


**Figure 7.** Mean normalized McMaster Universities Osteoarthritis Index (WOMAC) score over time. Error bars represent SD.

were reported by 19 patients (58%) for mobility, 30 (91%) for self-care, 22 (67%) for activities, 10 (30%) for pain, and 31 (94%) for anxiety and depression. The mean Oxford Knee Score was 40 (SD, 7).

## Satisfaction With Surgery

At 20 years, 32 of 33 (97%) were satisfied or very satisfied with the outcome of surgery, 32 (97%) reported they were better after surgery, and 29 (88%) would have the same surgery again. There were no missing data for satisfaction.

## DISCUSSION

We reported prospective outcomes and survivorship of patients having a lateral closing-wedge HTO for varus

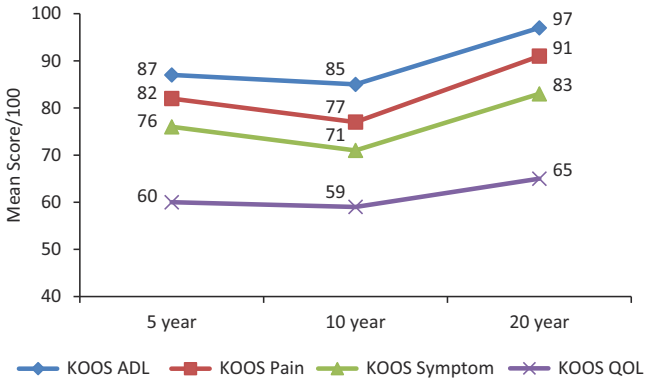


**Figure 8.** Mean postoperative Knee injury and Osteoarthritis Outcome Score (KOOS) values over time. ADL, Activities of Daily Living; QOL, Quality of Life.

medial unicompartmental osteoarthritis at a minimum of 20 years and determined the predictors of survival of this procedure. The HTO survival rates were 88%, 77%, 63%, and 44% at 5, 10, 15, and 20 years, respectively. Those with HTO survival at 20 years maintained good overall functional outcomes and pain relief, with excellent rates of satisfaction (97%).

It is apparent from this study that while HTO should not be considered the definitive treatment for medial compartment osteoarthritis, it does significantly delay TKA in those who meet selected criteria. If we compare groups for change in survival each 5 years, we can see the effective delay (Table 1). This is also evident in the survival curves when the lines diverge rather than following a parallel decline (Figures 2-5). The effectiveness of HTO to delay declining survival was not uniform across time, and the influence of predictive factors varied. A baseline WOMAC pain score of $\geq$45 and being nonobese each effectively delayed declining survival for the first 10 years after HTO ($\Delta$ survival 53% in those with a WOMAC pain score of $\leq$45 vs 16% in those with a WOMAC pain score >45, and $\Delta$ survival 17% in nonobese patients vs 37% in obese patients), after which the rate of decline became equivalent. Younger age (<55 years) also delayed rate of decline in survival for the first 5 years ($\Delta$ 3% in those aged <55 years compared with 25% in those aged $\geq$ 55 years), after which the rate of decline became equivalent (Figure 2). In more favorable candidates, the effective delay to declining survival was 10 years and most pronounced ($\Delta$ survival 9% in favorable candidates vs 31% in nonfavorable candidates). When considering HTO in those with medial compartment osteoarthritis, a decade delay to the onset of declining survival can be considered realistic with careful patient selection.

The literature reports survivorship outcomes of HTO ranging from 40% to 85% at 20 years.[¶] Largely, heterogeneity between the studies arises because of selection bias with respect to the degree of osteoarthritis. Niinimaki et al[32] assessed the largest cohort of 3195 HTOs from the Finland registry, showing a 10-year survivorship rate of 73%. Berruto et al[6] reported 79% survivorship, and Flecher et al[16] reported 85% at 20 years. These studies assessed HTO performed for minor arthritic change only (Ahlbäck grade $\leq$3). Conversely, Song et al[44] reported a survival rate of 48%, and van Wulfften Palthe et al[47] reported a survival rate of <40% at 20 years. The confidence of definitive conclusions that can be made is further reduced by small inclusion numbers at 20 years to determine survivorship.[6,15,16,25,44,46,47] Our survivorship parameters were centered on end-stage medial compartment osteoarthritis with a 20-year survivorship rate of 44%. In a recent systematic review of 7087 HTOs with 10-year follow-up, Ollivier et al[33] emphasized the need for prospective studies of higher quality to confirm whether HTO remains an appropriate treatment for medial compartment osteoarthritis of the knee. To our knowledge, this is the first prospective study reporting 20-year outcomes of HTO.

There are consistent factors that yield early conversion to arthroplasty. The predictors of failure at 20 years remain age >55 years, BMI >30, and a WOMAC pain score <45 at the time of osteotomy. BMI and age are reliably reported as predictors of survivorship.[#] Poorer baseline scores have also been associated with poor outcome after HTO by others.[45] The SKOOP (Sfa Knee OsteOtomy Predictive) score devised by Batailler et al[4] is a novel way to assess survivorship and accounts for BMI, age, and the degree of articular narrowing (incomplete or complete) to predict success or early failure in HTO. In their cohort, patients with a score of $\leq$3 had a statistically significant improvement in survivorship compared with those with a score >3.[4] The utility of this scoring system in our cohort is low because incomplete articular narrowing was an exclusion criterion, and thus all our patients would score higher. Ishizuka et al[25] also noted that in addition to BMI >25, a preoperative femorotibial angle of <5° varus was a predictor of early failure. There was no correlation of preoperative alignment with survivorship in our cohort. Female sex is another significant predictor of early failure.[4,32,37,47,48] This was insignificant in our cohort, perhaps because of low female inclusion during patient recruitment (n = 26). Other reported significant factors that hinder survival of HTO include degree of preoperative radiographic osteoarthritis,[37] range of motion <120°,[1,2,31] previous arthroscopic surgery,[2,31] loss of alignment,[30] and instability.[2] In our cohort, the factors that identified favorable patients for HTO were age <55 years, BMI <30, and WOMAC pain score >45. Survivorship in the favorable patient was 62% at 20 years.

The success of HTO also hinges on the ability to correct preoperative alignment. Insall et al[24] in 1974 commented that "success … depended in large part on obtaining satisfactory postoperative alignment." Undercorrection will lead to early failure. Our mean correction was 11°. Cazor et al[10] noted in their cohort that the only statistically significant predictor of failure was correction <10° from the preoperative alignment.

[¶]References 1, 4, 6, 10, 12, 13, 15, 16, 19, 23, 25, 26, 31-35, 37, 42, 44, 46-48.

[#]References 1, 4, 7, 13, 16, 22, 23, 25, 26, 32, 37, 42, 47, 48.

In principle, higher-demand patients in need of a surgical solution for medial compartment knee arthritis without contraindication should strongly consider HTO for joint preservation. Currently, in Australia, 36% of patients having a TKA and 37% of patients having a UKA are <55 years of age.[3] After HTO, both TKA and UKA are safe and valid options with similar functional outcomes.[36] However, when considering a patient for HTO or UKA, one must note a statistically significantly worse risk of revision with TKA after UKA compared with TKA after HTO.[28] In our series for patients <55 years of age, HTO was effective in delaying TKA ≥5 years before they experienced an equivalent rate of declining survival compared with those ≥55 years. If surgeon or patient selection bias was significantly contributing to the delay to TKA in younger patients, we would expect to observe a rapid decline in survival after 10 years once they reached their 60s, which was not observed. The benefit of HTO for those aged <55 years was sustained with avoidance of TKA by at 20 years in more than half of the cohort.

Survivorship is a satisfactory endpoint for determining the success of HTO; however, PROMs and return to activity indicate how the patient has benefited functionally. Patients having HTO consistently show improved function, pain, and return to activity.[9,12,49] Liu et al[29] reported an 88.2% rate of return to sport at 7.5 months, albeit mostly at a reduced capacity. Perhaps, though, longitudinal PROMs are not an ideal way to measure functional outcome, as the patients who report more symptoms eventually proceed to arthroplasty, which falsely elevates the mean at a distant time point as they are excluded from the survival group. Subjective satisfaction may reliably support functional improvement, with our cohort demonstrating 97% satisfaction with the outcome of surgery and 88% reporting that they would have the surgery again.

### Limitations

The authors acknowledge both strengths and limitations in this study. This is a single-surgeon study, which means there was no variability in surgical technique. During recent decades, the use of an opening-wedge technique, compared with a closing-wedge technique, for HTO has gained popularity. The patients in this study were all under the care of the surgeon at a single center, and a closing-wedge technique for HTO was used exclusively. The results of the current study cannot be generalized to techniques involving medial opening-wedge HTO. The surgical aim was to recreate 10° valgus alignment with HTO, which was determined with preoperative planning. The achieved alignment after HTO was not determined with radiological follow-up, so we cannot make any conclusions regarding the effect of achieved alignment on outcomes. The cohort followed in this study had both posttraumatic and idiopathic osteoarthritis as a primary diagnosis, which may differ from other studies of HTO. Additionally, we were not able to assess alignment of the lower limb at the time of failure and factor this into the analysis.

## CONCLUSION

In the surgical armamentarium to treat medial compartment osteoarthritis in adults, HTO is a successful option. The most suitable candidates for HTO are <55 years of age, are not obese, and have not progressed to severe symptomatic disability. In our cohort, survivorship in these more favorable patients was 100% at 5 years, 91% at 10 years, and 62% at 20 years. HTO is therefore a successful method of treating medial compartment osteoarthritis as well as preventing premature TKA in those who may have a poorer risk of TKA longevity.

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