Original Article

Early outcomes of the Tahoe Unicondylar Knee System: A prospective multicentric study

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Abstract

Background and Aims: The Tahoe Unicondylar Knee System (TUKS) includes several designs features with the aim to achieve enhanced anatomic conformity and optimal knee biomechanics through a minimally invasive, bone-sparing surgical approach. This study aimed to evaluate the early clinical and radiographic results of the TUKS implant in patients undergoing medial unicompartmental knee arthroplasty (UKA).

Methods: This prospective, multicentric study analyzed the clinicoradiographic data of 104 UKAs performed in patients with severe medial knee osteoarthritis. Pre- and postoperative Knee Society Knee Score (KSKS) and Knee Society Functional Score (KSFS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score were compared in all patients. Coronal femoral component angle (cFCA), sagittal femoral component angle (sFCA), coronal tibial component angle (cTCA), tibial slope angle (TSA), and femorotibial angle (FTA) were analyzed on postoperative knee radiographs.

Results: The mean preoperative KSKS, KSFS, and WOMAC scores significantly improved ($P < 0.0001$) at a minimum follow-up of 12 months. The mean postoperative cFCA, sFCA, cTCA, TSA, and FTA were within acceptable limits. Two (2%) knees had a postoperative tibial fracture which occurred within 3 months of UKA surgery and which required conversion to TKA with long stem tibial components.

Conclusions: This early outcome study indicates that the TUKS can be a promising option for patients undergoing medial UKA with excellent short-term functional recovery and radiographic outcomes. However, long-term follow-up is necessary to confirm implant survivorship, outcomes, and complication rates.

Keywords: Alignment, clinical outcomes, component positioning, fixed bearing, implant survivorship, knee, Tahoe Unicondylar Knee System, unicompartmental knee arthroplasty

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INTRODUCTION

Unicompartmental knee arthroplasty (UKA) is an effective and reliable surgical solution for severe medial knee osteoarthritis (OA).[1-3] Although both fixed- and mobile-bearing designs are available in UKA implants, the fixed-bearing design has been reported to provide

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several advantages when compared to the mobile-bearing design. This includes higher knee scores and superior range of motion (ROM),[4] lower incidence of short-term failures,[5,6] superior long-term survivorship with lower risk of revision,[7] better tolerance of variance in tibial implant rotation,[8] and good outcomes in "extended" indications of UKA such as anterior-cruciate ligament-deficient knees,[9] moderate-to-severe medial patellofemoral wear,[10] and post-high tibial osteotomy (HTO) knees.[11]

The Tahoe Unicondylar Knee System (TUKS) is a newly developed implant system designed to address specific shortcomings of earlier UKA designs. The fixed-bearing, cemented TUKS implant incorporates design features such as a femoral component with a triple sagittal radius and a constant coronal radius to ensure a secure natural fit and uniform load distribution throughout the knee ROM and wide variation in anterior–posterior and medial–lateral dimensions in tibial and femoral component sizes to achieve complete coverage.[12] The TUKS implant has a round-on-flat articulation designed to minimize wear and loosening, a mirror finish of the femoral articular surface designed to minimize wear, and a grit-blasted backside to enhance cement adhesion.[12] Hence this fixed-bearing, cemented implant is designed to achieve enhanced anatomic conformity, optimal knee biomechanics, using a minimally invasive, bone-sparing surgical approach.

Despite these theoretical advantages, there is currently a lack of published clinical data regarding the real-world performance of the TUKS implant. Hence, this prospective multicentric study aimed to evaluate the early clinical and radiographic outcomes of the TUKS implant in patients undergoing medial UKA surgery for severe medial knee OA.

METHODS

Study population

This prospective, multicentric study was performed at three dedicated arthroplasty units between March 2022 and March 2023 to analyze the early clinicoradiographic results of the TUKS UKA implant in the treatment of medial knee OA. The inclusion criterion was all patients with severe medial knee OA who underwent UKA surgery with the TUKS implant during the study period. The exclusion criteria were patients with inflammatory arthritis, patients who have undergone HTO, patients with severe joint instability, patients with ligament deficiency, patients with incomplete clinical and radiographic records, and patients with a follow-up of <1 year. The study protocol was approved by an institutional review board and an ethics committee. This study was performed in accordance with the Declaration of Helsinki, and all participants provided informed consent for using their anonymized clinical and radiographic records for this study.

Surgical technique

All patients underwent UKA surgery using the fixed bearing TUKS implant (Shalby Advanced Technologies, Inc., USA) [Figure 1], under spinal anesthesia and through the medial parapatellar arthrotomy. Medial femoral, anterior tibial, and intercondylar notch osteophytes were removed after exposure to ensure accurate placement of instrumentation. The tibial cut was performed using an extramedullary tibial guide with a built-in 7° posterior slope and set to achieve approximately 2° of varus. The tibial resection was determined based on cartilage wear and the planned thickness of the tibial component and confirmed using a stylus and a depth gauge attached to the tibial cutting block. After the tibial cut, flexion and extension gaps were assessed starting with an 8 mm spacer to verify balance and ligament tension. Flexion gap measurements from the tibial resection help plan the distal femoral resection. The reamer size for the distal femoral preparation was determined based on the difference between the flexion and extension gaps, estimated using the spacer in flexion and extension after the tibial cut. Distal femoral resection was performed using an intramedullary (IM) femoral guide and a femoral IM linkage, which helped align the femoral drill guide and achieve optimal femoral axis and cut depth. After the distal femoral resection, peg holes and chamfer cuts were performed using the appropriate femoral trial component as a guide. Once the femoral preparation was complete, a trial femoral component was seated, and the surgeon reassessed the flexion and extension gaps and ligament balance throughout the knee ROM. Adjustments were made at this stage by fine-tuning the femoral cut or

Figure 1: Image of the Tahoe Unicondylar Knee System implant

changing polyethylene trial insert thickness if needed to optimize gap balance. Tibial sizing and preparation were then completed using a tibial sizer gauge and selecting the right tibial tray size to ensure maximum surface coverage and overhang of <2 mm. A final full trial was done to check joint stability, ROM, and alignment in both flexion and extension. The final tibial and femoral implants were cemented, and the appropriately sized polyethylene insert was locked into the tibial baseplate.

Outcome variables

Perioperative data were collected from all patients, including age, gender, body mass index (BMI), comorbidities, and tourniquet time. Pre- and postoperative clinical outcomes were measured using the Knee Society Knee Score (KSKS) and Knee Society Functional Score (KSFS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score in all patients. Postoperative knee anteroposterior (AP) standing and lateral radiographs were assessed for coronal femoral component angle (cFCA), sagittal femoral component angle (sFCA), coronal tibial component angle (cTCA), tibial slope angle (TSA), and femorotibial angle (FTA). The cFCA was measured on the AP view as the angle between the anatomic axis of the distal femur and the coronal axis of the femoral component; the sFCA was measured on the lateral view as the angle between the anatomic axis of the distal femur and the sagittal axis of the femoral component; the cTCA was measured on the AP view as the medial angle between the anatomic axis of the proximal tibia and the tibial joint line; the TSA was measured on the lateral view as the angle between the anatomic axis of the proximal tibia and the tibial joint line; and the FTA was measured on the AP view as the angle between the anatomic axes of the distal femur and proximal tibia.[13,14] The acceptable range for cFCA was 7.5° of varus and valgus from the anatomical axis; for sFCA, it was 7.5° extension and 5° flexion; for cTCA, it was 7.5° of varus and 2.5° valgus from the anatomical axis; for TSA, it was 2.5° to 10° flexion; and for the FTA, it was 5° of varus and 5° valgus.[14]

Statistical analysis

Data including age, gender, BMI, comorbidities, implant size, pre- and postoperative KSKS, KSFS, and WOMAC scores, and radiographic angles were analyzed. The Kolmogorov–Smirnov test of normality was applied to pre- and postoperative KSKS, KSFS, and WOMAC scores, which indicated that the data do not differ significantly from that which is normally distributed. Categorical data were compared using the Fisher's test or Chi-square test, and continuous data were compared using the *t*-test. P <0.05 was considered statistically significant. Statistical analysis was performed using the Microsoft Excel software, version 16.0 (Microsoft Corporation, Richmond, WA), and the GraphPad QuickCalcs online statistical analysis tool (GraphPad Software, San Diego, California).

RESULTS

Data from a total of 104 UKAs (in 76 patients) were analyzed for the study. There were 20 males and 56 females with a mean age of 54.5 ± 11 years (95% confidence interval, 52–57 years) with a mean BMI of 27.8 ± 3.9 kg/m^2 (95% confidence interval, 26.9–28.6 kg/m^2) [Table 1]. The various tibial, femoral, and insert sizes used in the study population are summarized in Table 2. All 104 UKAs had a minimum follow-up of 12 months, and 19 UKAs had a minimum follow-up of 24 months. The postoperative clinical and radiographic outcomes in the study population are summarized in Tables 3 and 4. The mean preoperative KSKS, KSFS, and WOMAC scores significantly improved (P < 0.0001) at 12- and 24-month follow-up [Table 3]. Similarly, the mean postoperative cFCA, sFCA, cTCA, TSA, and FTA were within acceptable limits at 12- and 24-month follow-up [Table 4]. Two (2%) knees had a postoperative tibial fracture that occurred

Table 1: Baseline demographic details of the study population

Variables	Values
Number of knees (patients)	104 (76)
Gender	
Males	20 (26.5%)
Females	56 (73.5%)
Mean Age	54.5±11 (52–57)
Mean BMI	27.8±3.9 (26.9–28.6)
Comorbidities present	23 (30.5%)

All data presented as mean±SD (95% CI) or *n* (%). BMI: Body mass index, SD: Standard deviation, CI: confidence interval

Table 2: Implant details of the study population

Variables	Values
Number of knees	104
Femur implant size	
2	18 (17.5)
3	27 (26)
4	32 (30.5)
5	15 (14.5)
6	9 (8.5)
7	3 (3)
Tibia implant size	
1	20 (19.5)
2	30 (29)
3	24 (23)
4	7 (6.5)
5	11 (10.5)
6	12 (11.5)
Insert size (mm)	
8	87 (83.5)
9	14 (13.5)
11	1 (1)
12	2 (2)

All data presented as *n* (%)

Table 3: Pre- and postoperative clinical outcomes in the study population

Variables	Preoperative	12 months postoperative	24 months postoperative
Number of knees	104	104	19
Mean KSS knee score	51.7±14.8 (48.8–54.5)	83.5±12.7 (81.0–85.9)	87.0±12.5 (80.9–93.0)
Mean KSS function score	55.9±11.9 (53.5–58.2)	87.6±12.9 (85.0–90.1)	88.3±11.4 (82.8–93.7)
Mean WOMAC score	50.4±15.6 (47.3–53.4)	16.6±12.7 (14.1–19.0)	10.5±7.1 (7.0–13.9)

KSS: Knee Society Score, WOMAC: Western Ontario and McMaster Universities Arthritis Index. All data presented as mean±standard deviation (95% confidence interval)

Table 4: Postoperative radiographic outcomes in the study population

Variables	12-month postoperative	24-month postoperative
Number of knees	104	19
Mean cFCA (°)[a]	−1.5±6.1 (−2.6–−0.3)	−1.0±6.6 (−4.1–2.1)
Mean sFCA (°)[b]	1.8±6.7 (0.4–3.1)	2.3±6.4 (−0.7–5.3)
Mean cTCA (°)[c]	−1.0±2.8 (−1.5–−0.4)	−1.8±1.4 (−2.4–−1.1)
Mean TSA (°)[d]	5.3±4.1 (4.5–6.0)	6.5±4.3 (4.4–8.5)
Mean FTA (°)[e]	3.5±3.0 (3.0–4.0)	3.8±2.8 (2.4–5.1)

[a]Varus/+valgus, [b]Extension/+flexion, [c]Varus/+ valgus, [d]Extension/+flexion, [e]Valgus/+varus. All data presented as mean±standard deviation (95% confidence interval). cFCA: Coronal femoral component angle, cTCA: Coronal tibial component angle, sFCA: Sagittal femoral component angle, TSA: Tibial slope angle, FTA: Femorotibial angle

within 3 months of UKA surgery and that required conversion to TKA with long-stem tibial components.

DISCUSSION

This prospective multicentric study, which evaluated the early outcomes of the TUKS implant in a cohort of 104 knees at a minimum follow-up of 12 months, demonstrated statistically significant improvements at all postoperative time points compared to preoperative values at final follow-up. Furthermore, radiographic assessments confirmed satisfactory component and knee alignment, all within acceptable ranges [Figure 2]. These early results suggest that the TUKS implant provides excellent short-term clinical and radiographic outcomes in patients undergoing medial UKA surgery, similar to early results of other UKA implant designs [Table 5].

D'Amario *et al.*,[15] in an evaluation of 257 hypoallergenic fixed-bearing medial and lateral UKAs, reported improvements in KSKS from 44.5 to 86.1 and KSFS from 53.1 to 87.7 at 1-year follow-up. Similarly, Goh *et al.*[16] studied 87 medial fixed-bearing UKAs in patients with and without preoperative flexion contracture and reported a mean postoperative KSKS of 87 and KSFS of 81.7 at a follow-up of 2 years, which was similar to the mean KSKS and KSFS scores achieved at the end of 2 years in our study. A comparatively smaller but statistically insignificant difference in clinical scores in the current study compared to the result of D'Amario *et al.*[15] may be attributed to the younger mean age (54.5 years vs. 67.4 years) and higher baseline KSKS in our cohort, potentially reflecting a more active patient population with higher functional demands.

Gill *et al.*[14] explored the relationship between component alignment and clinical outcomes in fixed-bearing UKA and reported that minor variations in tibial and femoral component angles did not significantly affect early functional outcomes, though they suggested possible implications for long-term survivorship. Our study's radiographic analysis demonstrated component alignment within acceptable ranges. The consistency of alignment across different centers in our study suggests that the surgical instrumentation and design features of the TUKS system may aid in achieving reproducible alignment. Ozcan *et al.*[8] investigated the tolerance of tibial implant rotational variance in fixed-versus mobile-bearing UKA designs. They concluded that fixed-bearing UKAs tolerated greater rotational variance without significant compromise in short-term outcomes, whereas mobile-bearing designs were more sensitive to malrotation. Our findings of excellent clinical outcomes despite some variability in tibial alignment further confirm the observation of Ozcan *et al.*[8] regarding the forgiving nature of fixed-bearing designs. In our cohort, the TUKS design likely contributed to maintaining clinical function despite potential minor variations, owing to its enhanced kinematic properties.

A periprosthetic fracture (PF) after UKA is a relatively uncommon but potentially serious complication. The incidence of tibial PPF has been reported to be between 0.1% and 8% with a higher incidence reported by cohort studies in Asian populations.[17] In the current study, the incidence of tibial PF was 2%, similar to the incidence reported in the literature.[17] A smaller, narrower tibial metaphysis with proximal tibial vara in Asian patients when compared to the Caucasian population can predispose them to medial tibial condyle overhang, which may increase the risk of PF.[17,18] Furthermore, surgical technique errors like placing the tibial component in excessive valgus and breach of the posterior cortex of the tibial condyle due to improper cut angle are also known to increase the risk of tibial PF.[17,19] It is likely that the two tibial PFs in the current study were the result of surgical error, most likely a combination of breach of the posterior cortex and

Figure 2: Preoperative (a) anteroposterior (AP) and (b) lateral radiograph of a 64-year-old female patient with medial osteoarthritis of the left knee. Postoperative (c) AP and (d) lateral radiograph of the same patient at 1-year follow-up after a medial unicompartmental knee arthroplasty (UKA) surgery using the Tahoe Unicondylar Knee System (TUKS) implant showing satisfactory component and knee alignment. Preoperative (e) AP and (f) lateral radiograph of a 78-year-old male patient with medial osteoarthritis of the left knee. Postoperative (g) AP and (h) lateral radiograph of the same patient at 1-year follow-up after a TUKS UKA showing satisfactory component and knee alignment. Preoperative (i) AP and (j) lateral radiograph of a 72-year-old male patient with medial osteoarthritis of the right knee. Postoperative (k) AP and (l) lateral radiograph of the same patient at 1-year follow-up after a TUKS UKA showing satisfactory component and knee alignment

malpositioning of the tibial component. Hence, meticulous surgical technique is critical to minimize intraoperative errors that could predispose to tibial PF.

Although several meta-analyses comparing fixed- and mobile-bearing UKA designs reported equivalent or similar functional improvements,[4-6] survivorship and revision rates

Table 5: Early clinical results of the TUKS implant compared to similar published studies on other unicompartmental knee arthroplasty designs

Study	Country/year	*n*	Implant	Mean KSKS 1-year	Mean KSKS 2-year	Mean KSFS 1-year	Mean KSFS 2-year
D'Amario *et al*.[12]	Italy 2025	257	Journey II UK Unicondylar Knee System (Smith and Nephew, USA)	86.1±11.9	89.3±10.4	87.7±10.7	90.4±11.0
Goh *et al*.[13]	Singapore 2021	87	Sigma High Performance Partial Knee (DePuy, USA) and Zimmer Unicompartmental High Flex Knee (Smith and Nephew, UK)	86.1±12.7	87.0±12.2	81.7±14.8	81.7±17.1
Current study	India 2025	104	Tahoe Unicompartmental Knee System (TUKS) (Shalby Advanced Technologies, India)	83.5±12.7	87±12.5	87.6±12.9	88.3±11.4

n: Number of knees, KSKS: Knee Society Knee Score, KSFS: Knee Society Functional Score, NR: Not reported, TUKS: Tahoe Unicondylar Knee System

may differ based on UKA design. Kannan *et al*.[7] in an analysis of data of 50,380 medial UKAs from the Australian Orthopaedic Association National Joint Replacement Registry to determine the difference in survivorship and revision rates between different UKA designs, reported better survivorship and a lower risk of revision with the fixed-bearing design at both 5- and 10-year follow-ups. The TUKS implant is designed to address some of the historical limitations of fixed-bearing UKA designs. Its key features include an anatomically contoured femoral component, optimized tibial tray geometry, and high-conformity polyethylene inserts. The femoral component of TUKS offers a broad surface area contact, minimizing peak stresses and potentially reducing polyethylene wear. The tibial component features a keel design that enhances initial fixation and minimizes the risk of subsidence, particularly critical in patients with higher BMI. The TUKS implant is engineered to facilitate easy intraoperative adjustments and accurate component placement, contributing to consistent radiographic alignment across different centers. These design enhancements likely underlie the favorable early outcomes seen in our study and may improve long-term survivorship similar to other fixed-bearing UKA designs.

There are several limitations to be considered when interpreting the results of our study. First, the patients in this study had a relatively short follow-up duration, with only 19 UKAs having a 2-year follow-up. Although the early results are promising, we need to follow-up for a longer time to check how well the implant lasts, how OA develops in the untreated area, and if there are any complications like wear or loosening of the polyethylene. Second, the study lacked a control group using a different UKA system, which limits the ability to directly attribute outcome differences to the TUKS design alone. A randomized comparative study design would provide stronger evidence regarding the superiority or equivalence of TUKS to other available systems. Third, there is potential for intercenter variability in surgical technique, postoperative rehabilitation protocols, and patient counseling, despite standardized guidelines provided to participating surgeons. This variability could introduce confounding factors affecting functional and radiographic outcomes.

CONCLUSION

The TUKS implant demonstrated excellent early clinical and radiographic outcomes in patients undergoing medial UKA. Although the TUKS implant represents a promising option for patients undergoing medial UKA, these findings are based on early results and require validation through long-term follow-up to confirm implant survivorship, outcomes, and complication rates.

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Conflicts of interest
There are no conflicts of interest.

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