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Evaluation of mobile bearing unicompartmental knee arthroplasty, opening wedge, and dome-type high tibial osteotomies for knee arthritis

İbrahim TUNCAY[1], Kerem BİLSEL[1], Mehmet ELMADAĞ[1], Ömer Faruk ERKOÇAK[2], MURAT AŞÇI[3], Cengiz ŞEN[4]

[1]Bezmialem Vakıf University Faculty of Medicine, Department of Orthopedics and Traumatology, İstanbul, Turkey
[2]Selçuk University Faculty of Medicine, Department of Orthopedics and Traumatology, Konya, Turkey
[3]Tokat State Hospital, Department of Orthopedics and Traumatology, Tokat, Turkey
[4]İstanbul University, İstanbul Faculty of Medicine, Department of Orthopedics and Traumatology, İstanbul, Turkey

Objective: Three methods of surgery used in the treatment of knee osteoarthritis (OA) are mobile bearing unicompartmental knee arthroplasty (Oxford UKA), opening wedge high tibial osteotomy (HTO), and dome-type HTO. This article aimed to retrospectively compare these three methods in terms of outcomes for health status, patient satisfaction, and function.

Methods: Between 2003 and 2010, 255 knees of 235 patients underwent operations for medial knee OA. Three types of surgery were performed. Group 1 consisted of 109 knees of 94 patients who underwent Oxford UKA. Group 2 was made up of 36 knees of 36 patients who underwent HTO using circular external fixation, and Group 3 comprised 57 knees of 52 patients on whom opening wedge type HTO using locking plate fixation was performed. SF-36 and HSS knee scores were used to compare the functional outcomes among groups.

Results: Statistically significant differences were found between the preoperative and postoperative measures in all 3 of the treatment groups for physical function, physical role, pain, general health, vitality, social function, emotional role, and mental health according to SF-36 and HSS scores. In the 2nd group, the average correction of the mechanical axis deviation (MAD) was 38 mm with 11.7° along the femorotibial axis and 6.2° along the medial proximal tibial angle (MPTA). In the 3rd group, the average correction in the MAD was 28 mm with 9.7° along the femorotibial axis and 5.6° along the MPTA. All 3 of the treatment alternatives were observed to be sufficient. Satisfactory postoperative results were achieved in the UKA group in terms of social function and mental health, and the patients were able to achieve early rehabilitation and return to their previous life activities.

Conclusion: UKA is the ideal option for patients who wish for the earliest possible return to social and recreational activities.

Keywords: High tibial osteotomy; medial osteoarthritis; unicompartmental knee arthroplasty.

As the incidence of knee osteoarthritis (OA) has increased in younger populations, the grade of OA has become more severe, and there has been a broadening of the indications for surgery as surgeons have gained confidence in surgical treatments. The surgical treatment alternatives for isolated medial compartmental knee OA

Correspondence: Mehmet Elmadağ, MD. Bezmialem Vakıf Üniversitesi Tıp Fakültesi, Ortopedi ve Travmatoloji Anabilim Dalı, İstanbul, Turkey.
Tel: +90 532 – 546 47 86 e-mail: drelmadag@hotmail.com

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include high tibial osteotomies (HTO), unicompartmental knee arthroplasty (UKA) and, rarely, total knee arthroplasty (TKA). TKA is the accepted standard for the treatment of knee OA, with a survival rate of 92%–100% over 10 years.[1–4] However, undesirable complications such as deep infection and deep venous thrombosis are occasionally encountered. Although early reported results of medial UKA were unfavorable, with mid-term revision rates of 15%–28% for aseptic loosening, polyethylene wear, and progression of arthritis to the remaining compartments,[1–4] more recent reports demonstrate mid- to long-term UKA survival rates of 84%–98%.[5–8] There has been a renewed interest in UKA following recent developments in minimally invasive surgery. Despite some controversial recent reports,[9] it is assumed that this surgery will involve a smaller incision and reduced muscular dissection, thereby resulting in less postoperative pain, shorter hospital stays, reduced blood loss, and a more rapid recovery of the normal range of motion.[10–12]

HTO is a realignment procedure that aims to transfer the weight-bearing load from the affected compartment to a relatively intact compartment of the knee. It can be performed using open-up, close-up, and dome-type osteotomies with internal or external fixation methods. HTO promotes the relief of symptoms and healing of the damaged cartilage, and it inhibits disease progression in the varus knee. HTO is a generally accepted treatment for medial unicompartmental OA of the knee with varus alignment in active and relatively young patients.[13]

UKA and HTO are both treatment alternatives of medial compartmental OA with nearly identical indication criteria and have been called the "strange couple" by Dettoni et al.[14] In particular, health quality evaluation is important when considering the results of these treatment alternatives. Therefore, we aimed to compare these techniques using SF-36 and HSS evaluation criteria retrospectively over a mid-term follow-up period. Comparative studies in the literature primarily compared UKA to closing wedge HTO. This report investigates the comparison of UKA and HTO with open up using plate fixation and HTO with dome osteotomy using external fixator in terms of health quality and functional outcome.

Patients and methods

Between 2003 and 2010, 255 knees of 235 patients underwent operations for medial OA of the knee. Three types of surgery (UKA, open-up HTO with plate fixation, and dome-type HTO with circular external fixator) were performed by 2 orthopedic surgeons (CS for external fixation, IT for UKA and plate), and 26 patients were excluded because they failed to attend the follow-up evaluation. The initial 10 UKA cases were excluded to account for the learning curve of the surgeons. In addition, 17 patients were excluded because they did not meet the minimum follow-up of 24 months.

After the exclusion process, the patients were separated into 3 groups according to the surgical treatment

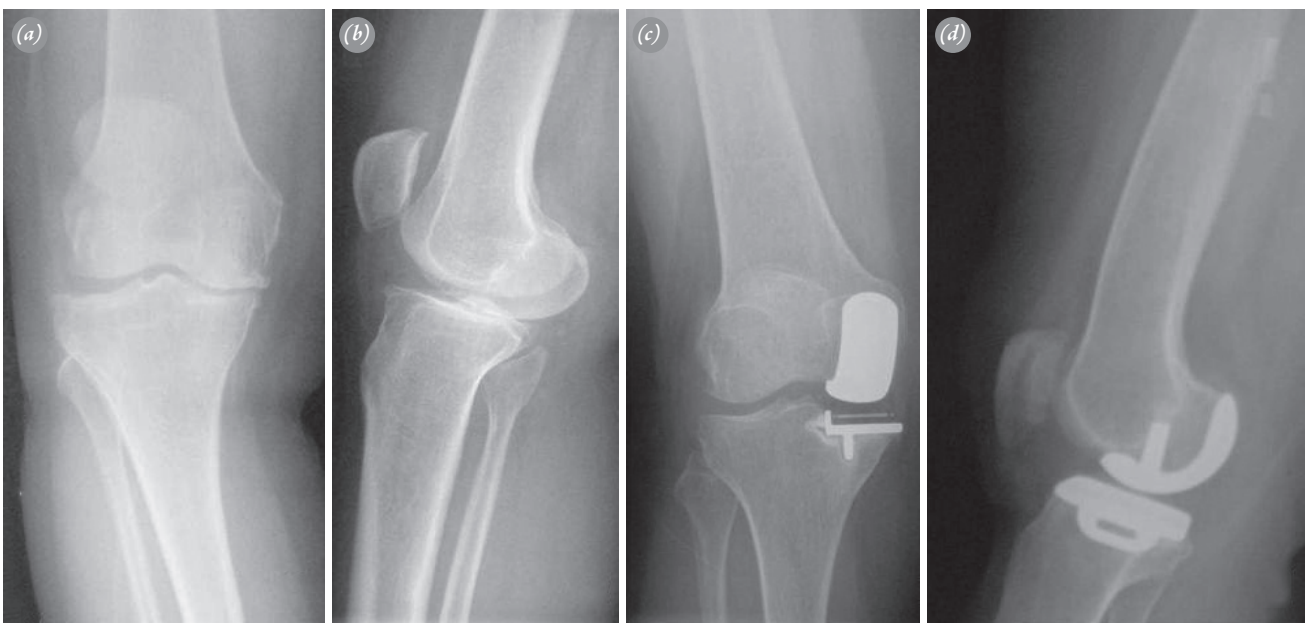

Fig. 1. **(a)** Preoperative AP view of the UKA patient, **(b)** preoperative lateral view of the UKA patient, **(c)** postoperative AP view of the UKA patient, **(d)** postoperative lateral view of the UKA patient.

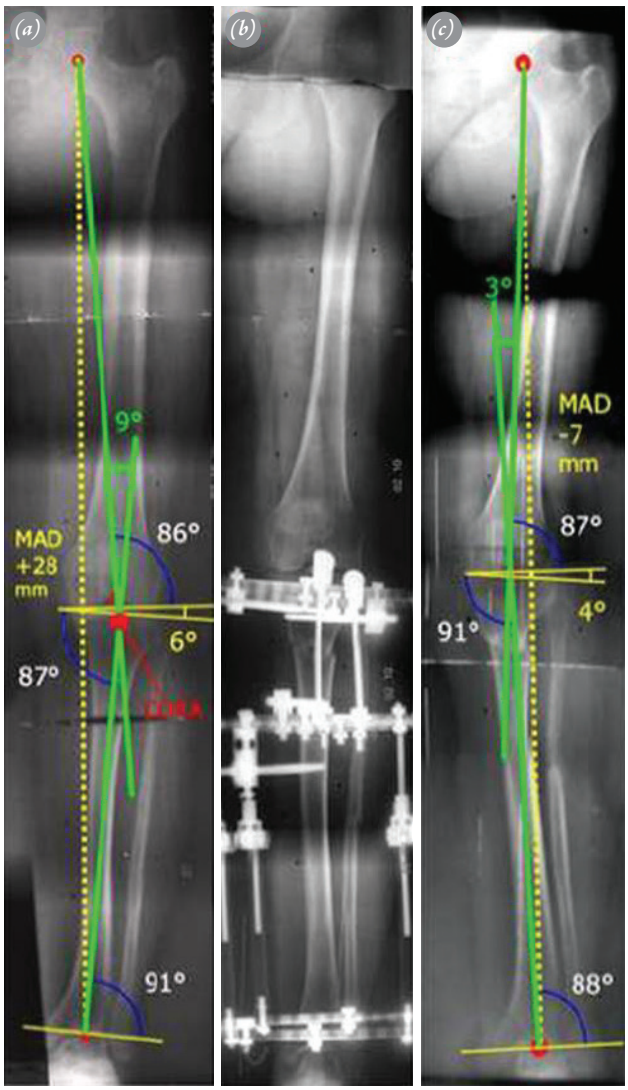

Fig. 2. **(a)** Preoperative AP orthoroentgenogram of the HTO with external fixator and its deformity analysis, **(b)** early postoperative orthoroentgenogram of the HTO with external fixator, **(c)** 2-year postoperative orthoroentgenogram of the HTO with ilizarov and its deformity analysis. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

they received. In the 1st group, 109 knees of 94 patients (mean age: 58.7 years; range: 45–69 years; sex: 79 female and 15 male) underwent Oxford Phase III mobile bearing unicompartmental knee prosthesis (Biomet Inc., Warsaw, Indiana, USA) UKA (Figure 1). The mean follow-up period was 42.5 months (range: 24–84 months). Patients selected for medial UKA had anteromedial primary OA with intact lateral compartment (patellofemoral OA was not an exclusion criteria for UKA), intact cruciate ligaments, flexion deformity of less than 150, varus deformity of less than 150, and a correctable deformity according to a valgus stress anterior-posterior (AP) radiograph. Post-surgery, a standard rehabilitation program was followed, which was supervised by a physical therapist and allowed mobilization and active knee exercises on the 1st day after surgery. All patients were discharged from the hospital within 2–3 days.

In the 2nd group, 36 knees of 36 patients (mean age: 53.5 years; range: 44–57 years; sex: 28 female and 8 male) with medial compartment arthritis underwent dome-type HTO using circular external fixator (Figure 2). The frame was constructed prior to the operation. The Ilizarov circular frame was constructed using the K-wire and half pins hybrid technique after proximal open fibular osteotomy. The hinge was at the CORA juxta-articular joint level. The desired correction was obtained by acute distraction at the concave side followed by percutaneous proximally concave-up focal dome osteotomy. Further correction was obtained using gradual distraction according to the malalignment test with full length X-ray as needed. Full weight-bearing and active and passive range of motion exercises were allowed after the operation. The frame was removed at approximately the 3rd postoperative month when the radiological and clinical findings were in agreement. The mean follow-up period was 30.7 months (range: 24–47 months).

In the 3rd group, 57 knees of 52 patients (mean age: 51.7 years, range: 42–55 years; sex: 42 female and 10 male) with medial compartment arthritis underwent opening wedge type HTO using locking plate fixation (Figure 3). A K-wire was used as a reference and placed parallel to the joint surface. A 2nd K-wire was placed 4 cm distal from the knee joint along the fibular head direction. The lateral cortex was preserved so that the lateral hinge of the osteotomy could be used during the correction. The minimal overcorrection was performed according to Puddu angle and Fujisawa point, which had been measured preoperatively via orthoroentgenography. The correction was also tested intraoperatively with the aid of a cautery cable. Plate osteosynthesis was used with a tricortical iliac crest autograft in all cases. The mean follow-up period was 40.4 months (range: 24–64 months).

SF-36 and HSS knee scores were used to compare the functional outcomes among the 3 groups at the final follow-up.

A paired sample t-test was used to compare SF-36 and HSS scores between the pre- and postoperative conditions. Two-way repeated measures ANOVA was used to compare changes in SF-36 and HSS scores between the 2 groups. Variables were presented as the mean±standard deviation. Analyses were performed using commercial statistical software (PASW v.18.0, SPSS Inc., Chicago, IL, USA). Statistical significance

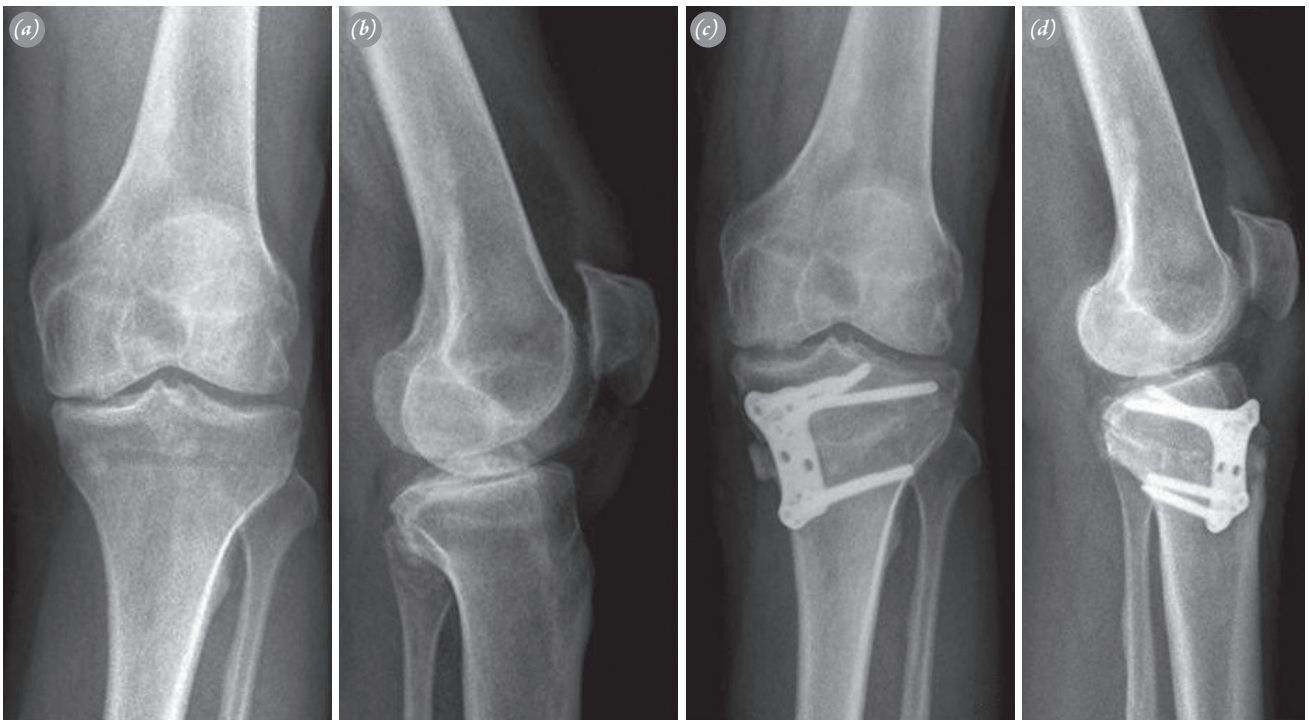

Fig. 3. **(a)** Preoperative AP view of the opening wedge osteotomy with plate, **(b)** preoperative lateral view of the opening wedge osteotomy with plate, **(c)** postoperative AP view of the opening wedge osteotomy with plate, **(d)** postoperative lateral view of the opening wedge osteotomy with plate.

was defined as $p<0.05$.

Results

Statistically significant differences ($p<0.001$) were found between the preoperative and postoperative measures in all 3 of the treatment groups for physical function, physical role, pain, general health, vitality, social function, emotional role, and mental health according to SF-36 and HSS scores (Table 1) (Figure 4).

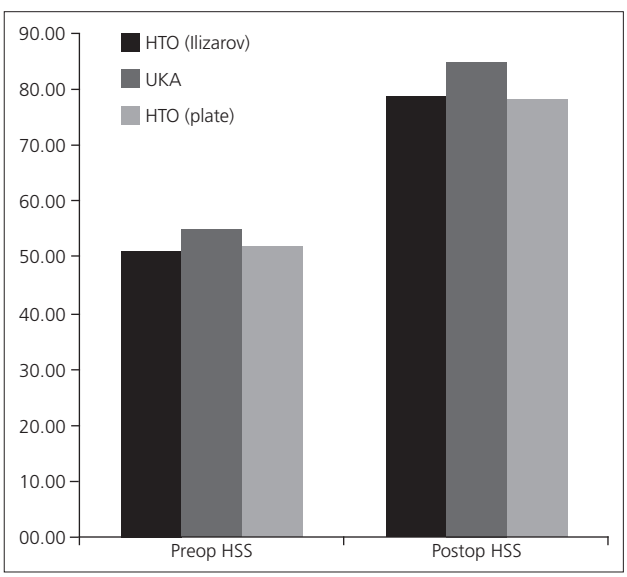

Fig. 4. Statistical analysis between the preoperative and postoperative measures in all 3 treatment groups according to HSS scores; ($p<0.001$).

Statistically significant differences were not found among the groups for preoperative scores; neither were they found among the groups for postoperative improvement. Postoperative SF-36 scores for the mental health and social function parameters were significantly higher in the UKA group than in the HTO groups. Thus, this treatment improved the social and mental health status of the patients (Figure 5). Similar results were observed in the improvement of HSS scores between the UKA and HTO groups.

The average correction of mechanical axis deviation (MAD) in the HTO with Ilizarov group was 38 mm (32.6 mm varus–6 mm valgus) with 11.7° (9° varus–3° valgus) along the femorotibial axis and 6.2° (82°–90°) along the medial proximal tibial angle (MPTA). The average correction in MAD in the HTO with plate group was 28 mm (22.6 mm varus–5 mm valgus) with 9.7° (8° varus–3° valgus) along the femorotibial axis and 5.6° (83°–90°) along the MPTA.

Some complications were observed in the 3 study groups. One patient from the UKA group experienced a medial tibial plateau fracture during the early postop-

Table 1. Preoperative and postoperative measures in all three of the treatment groups for physical function, physical role, pain, general health, vitality, social function, emotional role, and mental health, according to the SF-36 and HSS scores.

	HTO with plate	UKA	HTO with Ilizarov
Physical function pre-op	31.96	35.97	33.14
Physical function post-op	85.07	86.61	82.89
Body pain pre-op	16.64	20.55	18.09
Body pain post-op	82.88	81.32	79.31
General health pre-op	22.68	23.87	23.57
General health post-op	81.45	83.00	79.09
Vitality pre-op	36.70	39.52	39.86
Vitality post-op	83.38	85.16	81.34
Social function pre-op	26.63	33.65	29.87
Social function post-op	81.09	90.97	82.80
Role-emotional pre-op	18.27	39.45	26.46
Role-emotional post-op	78.75	87.94	80.57
Mental health pre-op	39.64	41.03	38.97
Mental health post-op	81.66	85.81	79.11
HSS pre-op	56.20	60.19	57.20
HSS post-op	83.95	90.00	83.51
Number of patients (n)	52 (57 knees)	94 (109 knees)	36 (36 knees)
Age (years)	mean 51.7 (42–55)	58.7 (45–69)	53.5 (44–57)
Female/male	42/10	79/15	28/8
Follow up (months)	40.4 (range, 24–64)	42.5 (range: 24–84)	30.7 (range: 24–47)
Average correction in MAD	28 mm (from 22.6 mm varus to 5 mm valgus)		38 mm (from 32.6 mm varus to 6 mm valgus)
Femoro-tibial axis	9.7° (from 8° varus to 3° valgus)		11.7° (from 9° varus to 3° valgus)
Medial proximal tibial angle (MPTA)	5.6° (from 83° to 90°)		6.2° (from 82° to 90°)

erative period that was corrected using a locking plate, 1 patient was revised to TKA for unexplained medial knee joint pain, and 2 patients in the same group were converted to TKA due to early insert dislocation. One patient in the HTO with plate group required screw exchange due to inappropriately long articular-penetrating screw length, and 2 patients in the same group required hardware removal because of implant irritation and pain. One patient in the HTO with external fixation group experienced infection and was treated with internal fixation and autologous bone grafting due to non-union at the osteotomy site, and 5 patients in the same group with pin tract were treated with oral antibiotherapy and wound care.

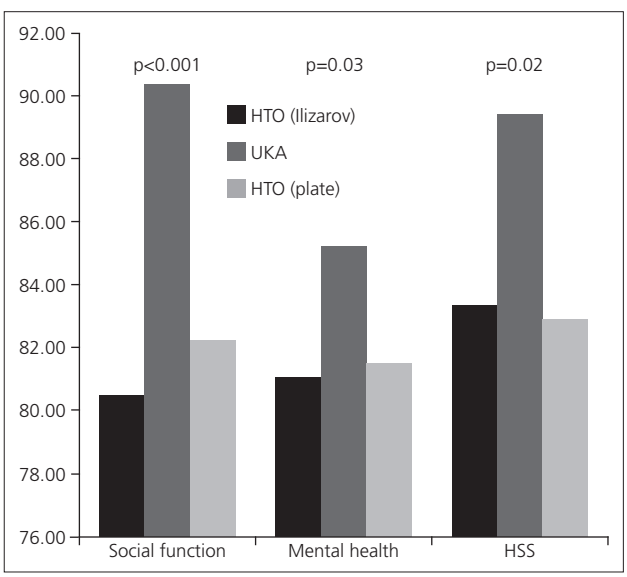

Fig. 5. Significant improvements of pre- and postoperative values for social function, mental health parameters of SF 36, and HSS scores.

Discussion

Although there has been limited comparison between UKA and HTO in the literature, several studies have compared UKA with TKA, examining aspects ranging from survival and cost to functional outcomes and patient satisfaction. Multiple authors have studied the long-term results of mobile bearing UKA and observed that the survival rate at 10 years is equivalent to that of TKA.[15,16] With the introduction of a mobile bearing

UKA device in our clinic in July 2005 and the expanding indications for its usage, we examined whether our results with this device were comparable to those achieved with open-up HTO using plate fixation and dome-type HTO using circular external fixation methods for medial compartmental knee OA. We compared UKA with HTO in terms of durability, patient perception, postoperative clinical function, patient perceived outcomes, ability to return to work, and health and mental recovery using SF-36 and HSS scores.

Younger, more active and demanding patients—sometimes referred to as 'millennium patients' in modern orthopedics—value functional improvement beyond what is accounted for by clinician-based scores. In addition to pain relief, they demand higher knee flexion and expect the postoperative improvement to persist. Knee joint-preserving HTO techniques and modern prostheses such as unicompartmental knee replacements are able to provide such results.[17]

Maly et al.[18] have shown that clinician-based scores and other self-reported measures are related to pain, whereas physical performance measures are related to self-efficacy. It is unclear why such differences have been observed between SF-36 and HSS scores. Several papers have used different assessment scores to quantify recovery, but the majority of them were focused on short-term postoperative functional improvement. Pennington et al.[19] reported on the functional aspect of recovery following unicompartmental knee replacement using the University of California Los Angeles' activity assessment score and evaluated long-term survival rates after unicompartmental knee replacement. However, differences in activity levels during recovery were not addressed, reflecting a shortcoming in their preoperative score. Many authors have used the Oxford questionnaire to evaluate prosthetic knee replacement, but Weale et al.[17] noted that it does not reflect true objectiveness because the potential bias of the clinician or patient has the potential to influence the results. Schai et al.[20] used Tegner and Lysholm scores to report the follow-up outcome after unicompartmental knee replacement, but they were not able to provide results within 2 years due to the the limited number of follow-up visits that were included. Many authors have attempted to deliver a higher level of responsiveness over clinician-based scores, as knee scores are believed to be exceedingly unreliable.[21] Although patient perceptions after knee replacement have become increasingly important, self-reported questionnaires still suffer from an inherent level of subjectivity. In agreement with Maly et al.[18] and based on our findings, we advocate the use of performance-based tests in addition to clinician-based scores and self-reported questionnaires when evaluating functional and mental recovery during follow-up.

The SF-36 should be used for a detailed assessment of treatment in terms of the complete health status of the patient. All treatment methods that we examined were satisfactory for medial compartment knee OA. However, a detailed assessment confirmed that the mental and social improvements were better when UKA was used. In our opinion, this finding indicates that UKA produces faster and increased physiological correction.

HTO and UKA are both effective techniques with excellent long-term results for the treatment of medial OA of the knee.[22–24] Although HTO with optimal correction provides pain relief, it does not appear to prevent the progression of medial knee arthritis.[25] Radiographic progression of medial-compartment arthritis is a problem in approximately 80% of patients when assessed 10 years after closing wedge HTO.[26]

Closing wedge HTO remains the standard treatment for medial compartment OA. However, this technique suffers from disadvantages such as bone stock loss and secondary patella baja. Opening wedge HTO has recently gained popularity, and its application has increased rapidly. Dome osteotomy offers the advantage of preventing disruption of limb length discrepancy; however, external fixation is required, which can cause discomfort for patients.

Although successful osteotomy delays the progression of degeneration, progressive deterioration continues, and patients may require knee arthroplasty as a result of the progression of OA.[27] Controversies remain regarding the factors that affect the survival of HTO. Some studies have shown that a successful HTO outcome may depend on the stage of OA,[25,28] while other studies have recognized preoperative tibiofemoral alignment or individual factors such as age, sex, and obesity as predictors of patient dissatisfaction and conversion to arthroplasty.[29–31] However, our study focuses on health quality with comparison to UKA, with nearly equal indication parameters. Studies of HTO have primarily focused on closing wedge osteotomy; open wedge and dome osteotomies have rarely been investigated.

With recent developments in minimally invasive surgery, UKA has experienced renewed interest.[23] Nevertheless, there have been conflicting reports in the literature regarding the success rates of UKA. Early reports showed less predictable results with poor long-term survival[1,32] With continued improvements in surgical

technique, implant design, and patient selection, UKA has become a more reliable and effective procedure. Several authors have reported excellent results at a 10-year follow-up using modern designs.[2,5–8,10,11,33] UKAs are available in mobile and fixed bearing designs with midterm survival rates of 81%–99% reported for the mobile bearing designs and 79%–93% for the fixed bearing designs.[1,4,5,7,10,11] Most studies report that UKA provides better functional outcomes, earlier recovery, ease of revision, and lower cost.[4,17,22,23]

In a meta-analysis of comparative studies of UKA and HTO, there were no statistically significant differences between the 2 procedures in terms of the total required replacements.[34] The mean survival times of TKA were 9.7 years and 9.2 years after HTO and UKA, respectively. The clinical outcome of UKA has been observed to be significantly higher than that after HTO after a 5- to 12-year follow-up time. Beyond 12 years, the results were similar in both groups. Although HTO tended to require revision surgery more frequently than UKA after 12 years, all of the HTO surgeries were performed using closing wedge osteotomy. Based on these results, it was concluded that the clinical outcome of UKA is better than that of HTO.[33] One recent study identified no statistically significant differences between HTO and UKA for medial unicompartmental osteoarthritis in terms of return to recreational activity and short-term clinical outcomes.[35] In another study comparing opening wedge HTO and UKA, opening wedge HTO shows an improved indication for active patients with a good range of motion of the knee.[36] As UKA requires the restriction of activity, it is more suitable for older patients with a reduced range of activity.

The limitations of this study are that it was a retrospective cohort study and the follow-up was short. Prospective randomized studies with long-term follow-up are needed in the future to compare these treatment alternatives for medial knee OA. In contrast, the strength of this study is that it is the first study to compare UKA, opening wedge HTO with plate, and dome HTO with external fixation.

When the results of SF-36 and HSS are considered in the treatment of medial compartment OA, our findings demonstrate that all 3 of the treatment alternatives produce effective and satisfactory outcomes. Better postoperative results were achieved in the UKA group in terms of social function and mental health, and patients were able to complete rehabilitation early and return to their previous life activity. In conclusion, UKA is the ideal option for patients who wish for the earliest possible return to social and recreational activities.

Conflics of Interest: No conflicts declared.

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