Comparison of joint awareness after medial unicompartmental knee arthroplasty and high tibial osteotomy: a retrospective multicenter study

（内側人工膝関節単顆置換術と高位脛骨骨切り術の
術後膝関節への意識の比較 −後ろ向き多施設研究−）

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Introduction

The postoperative functional outcomes of unicompartmental knee arthroplasty (UKA) and high tibial osteotomy (HTO) are generally reported to be better than those of total knee arthroplasty (TKA) when degenerative changes are localized in the medial compartment [1–6]. While HTO is often indicated for relatively younger patients compared to UKA [7–9], it is not uncommon for a surgeon to be faced with a choice between the two procedures since both UKA and HTO share a similar indication. Several previous studies have compared the outcomes of UKA and HTO [7, 8, 10–14], and the predominance of either procedure is inconclusive. One possible reason for the inconclusiveness is that the outcome measures used in previous studies are insufficient to detect differences in outcomes between the two procedures.

Although they share similar indications, UKA and HTO differ greatly in terms of concept. The major difference between UKA and HTO is that the joint surface is resected in UKA while it is preserved in HTO and that the knee alignment is significantly changed in HTO, while the change after UKA is minimal [15]. These differences in treatment modalities may produce differences in the patients' awareness after the intervention, which could be detected by the Forgotten Joint Score-12 (FJS). The FJS is a relatively new measurement tool developed to detect patients' awareness of their knee in daily life using 12 questions [16]. Recently, FJS has been reported to be useful for knee joint evaluation after various treatments [4, 17–19].

This study aimed to compare the outcomes after UKA and HTO in medial knee osteoarthritis (OA) or osteonecrosis (ON), focusing on the outcomes of FJS. Prior to the analysis, we validated the use of FJS in the postoperative evaluation of UKA and HTO. We hypothesized that, by comparing FJS, we could detect subjective differences between the two procedures.

Methods

This study was a retrospective, multicenter, comparative study. Medical records from four institutions, including one university hospital and three affiliated local hospitals, were collected anonymously and retrospectively reviewed. Because of the anonymous nature and existence without any new invasion to the patients in collecting the data, individual informed consent from patients was not required. The research protocol for this study was approved by the Institutional Review Board. The study was conducted following the strengthening of the reporting of observational studies in epidemiology (STROBE) statement [20].

Participants

Patients who received UKA or HTO at one of the four hospitals for OA or ON in the medial compartment of the knee between January 2012 and February 2019, and followed for at least one year, were included in the study. Both UKA and HTO were indicated and performed for an isolated medial compartment lesion with a preserved status of the other compartments, intact anterior and posterior cruciate ligaments, and without severe limitations in knee range of motion (ROM). All surgeries were performed by knee surgeons with more than ten years of experience. Patients with a history of previous surgery on the ipsilateral knee and patients who received additional concurrent procedures, such as autologous osteochondral transplantation or distal femoral osteotomy, were excluded from the study.

Procedures

All surgeries were performed under general anesthesia. In the UKA group, the prosthesis was chosen according to the surgeon's preference, and either a fixed or mobile type UKA was implanted. In the HTO group, we aimed for slight overcorrection of varus malalignment, as described by Fujisawa [21]. The Mikulicz line was planned to pass through the “Fujisawa point,” located at 62.5% of the entire tibial plateau width measured from the medial side. The prosthesis was chosen according to the surgeon’s preference.

Data collection

Age, sex, height, weight, body mass index (BMI), diagnosis (OA or ON), preoperative Kellgren-Lawrence (KL) grade, and preoperative and postoperative femorotibial angle (FTA) were extracted from the patient records and radiographs. The patient reported outcome measures (PROMs) were assessed by questionnaires for the Knee Injury and Osteoarthritis Outcome Scores (KOOS), Lysholm knee scoring scale (LKS), and FJS.

Statistical analysis

No studies had compared the FJS between HTO and UKA prior to this study. Therefore, no information on the expected FJS values after the two procedures was available at the time of study design, and we performed a power analysis based on LKS before the study to define the sample size. The sample size was calculated using an internet-based computer software (G*Power3.1.9.6, Duesseldorf, Germany) for a two-group t-test. According to a report presenting the mean ± standard variation (SD) score of LKS after surgery [22], a sample size of 34 patients in each group was required to detect the difference between the two groups with an alpha level of 0.05 and a beta level of 95%.

We compared the average FJS between UKA and HTO and evaluated the effect of patient-related factors and any of the clinical outcomes on FJS using simple analysis and multiple regression analysis to exclude bias. Additional analyses were performed by comparing each item of FJS between UKA and HTO and validating FJS for the outcome after UKA and HTO. Two-sample t-tests were used to compare height, weight, preoperative FTA, KOOS, LSK, and FJS between the UKA and HTO groups. Mann-Whitney U tests were used to compare age, BMI, follow-up period, postoperative FTA, and pre-and postoperative ROM between the two groups. Fisher's exact test was used for sex (male or female). The correlation between FJS results and patient-related factors and any of the clinical outcomes was analyzed using the Spearman rank correlation coefficient. To analyze the unidimensionality of FJS in patients after the surgeries, we calculated Cronbach's alpha and item-total correlations [17].

In the multivariate analysis, a multiple linear regression was calculated to predict FJS based on age, BMI, sex, diagnosis, and surgery (UKA or HTO) as common patient factors related to clinical outcomes [23, 24]. The diagnoses were classified into three categories (ON, OA KL grade 2, and OA KL grade ≥ 3).

All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). All tests were two-sided. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 117 knees of 111 patients treated with either UKA or HTO were assessed for eligibility. After excluding patients with adverse events and those who did not respond to the questionnaires, 21 knees of 21 patients were excluded, and 96 knees of 90 patients were analyzed in this study (Figure 1).

Demographics of participants

The demographics of participants in this study are shown in Table 1. Patients in the UKA group were significantly older than those in the HTO group. The mean BMI in the HTO group was significantly higher than that in the UKA group. The degree of the mean preoperative extension was - 0.9° in the UKA group and -4.9° in the HTO group. The median follow-up period after surgery for the UKA and HTO groups was 22.0 months and 22.5 months, respectively, ($p = 0.51$). There was no significant difference in the postoperative ROM and any items of KOOS and LKS between the two groups.

In the UKA group, four patients received surgery using the Tribrid unicompartmental knee system (Kyocera, Kyoto), 20 using the Persona partial knee (Zimmer Biomet, Warsaw), six using the Zimmer unicompartmental high flex knee (Zimmer, Warsaw), one using the Triathlon partial knee resurfacing (Stryker, Mahwah), and 17 using Oxford partial knee (Zimmer Biomet, Warsaw). In the HTO group, 27 patients were fixed by the Tomofix medial high tibial plate (Depuy Synthes, Switzerland) and 21 by the Tris medial HTO plate system (Olympus Terumo Biomaterials, Tokyo). Implants were removed from 27 knees in the HTO group.

Responses for the PROMs were obtained from 48 and 43 knees for FJS, 47 and 44 knees for KOOS, 48 and 46 knees for LKS, from the UKA and HTO groups, respectively. Complete responses for all three PROMs were collected from 47 knees in the UKA group and 40 knees in the HTO group.

FJS

There was no significant difference in the total FJS between the UKA and HTO groups (60.0 ± 23.9 and 66.0 ± 25.0, respectively; $p = 0.24$). The FJS did not correlate with any of the patient-related factors in a single analysis, including age, BMI, sex, and the side of surgery. There were significant positive correlations between the total FJS and each item of the KOOS and LKS (all items of KOOS, $p < 0.001$; LKS, $p < 0.001$). FJS did not correlate with any of the ROM measurement: preoperative extension ($p = 0.32$), preoperative flexion ($p = 0.36$), postoperative extension ($p = 0.487$), and postoperative flexion ($p = 0.38$).

Multiple linear regression analysis was conducted to predict total FJS value based on age, BMI, sex, diagnosis of OA KL grade ≥ 3, diagnosis of ON, and surgery. The variance inflation factor was less than four for each variable and confirmed that there was no multicollinearity. The normality of the residuals was confirmed. A significant regression equation was found ($F(6, 84) = 2.98$, $p < 0.0109$), with an R^2 of 0.1167. Participants' predicted FJS is equal to 124.3 – 0.64 (age) – 1.56 (BMI) + 9.86 (sex) + 21.4 (diagnosis of OA KL grade ≥ 3) + 22.1 (diagnosis of ON) + 0.74 (received surgery), where age is measured as years and BMI as kg/m^2; sex is coded as: 1 = male, 0 = female; diagnosis of OA grade ≥ 3 as: 1 = yes, 0 = no; diagnosis of ON as: 1 = yes, 0 = no, and received surgery as: 1 = HTO, 0 = UKA. BMI, diagnosis of OA KL grade ≥ 3, and ON were significant predictors of FJS (Table 2).

Additional analysis

There was no significant difference between UKA and HTO in each of the 12 items of postoperative FJS (Table 3). The results of the validation analyses of the FJS to assess the outcome after UKA and HTO are shown in Table 4. A significant correlation was observed between the FJS score and each item of the KOOS and LKS in both groups. ROM was not correlated with FJS in either group. Internal consistency in terms of Cronbach's alpha was 0.94 for UKA and 0.95 for HTO. Correlations between item and total score ranged from 0.38 to 0.86 in UKA and from 0.27 to 0.87 in HTO.

Discussion

There was no significant difference in the mean FJS after UKA and HTO. In a multiple linear regression analysis, lower BMI, diagnosis of OA KL grade ≥ 3, and diagnosis of ON were significant predictors of better FJS. Regarding the performed procedure, either UKA or HTO was not a significant predictor of FJS. Additionally, there were no significant differences between the two groups in any of the 12 items of the FJS. There was a correlation between the FJS and every item of the KOOS and LKS in both groups, and the internal consistency in terms of Cronbach's alpha was excellent for both UKA and HTO.

Some reports have shown that HTO is superior to UKA in ROM [10, 14, 25], and UKA is superior to HTO in pain and early recovery [11, 13, 25], but no certainty has been reached. Our results present no significant difference between the two groups in FJS results when adjusted in multiple regression analysis for age, BMI, sex, and diagnosis. The FJS results following UKA have been reported in previous studies [26, 27], but information on FJS after HTO is scarce. Jin et al. reported similar FJS results without significant differences between UKA and HTO at the final follow-up [28]. To the best of our knowledge, no other study compared the outcomes after UKA and HTO with FJS, and Jin et al. did not investigate the factors that could affect the outcomes. Furthermore, the use of FJS had not been validated for patients after these procedures. In this study, we were able to validate the use of

FJS in the postoperative assessment of UKA and HTO, providing basic and fundamental information for future studies.

In this study, we found that a higher BMI leads to lower FJS. This is aligned with the results of Giesinger et al. [24], who reported that the higher the BMI, the worse the improvement in FJS would be expected after TKA, and with Li et al. [23], who showed that females, younger age, and higher BMI have lower FJS in patients before TKA. Our results presented that the diagnosis of OA KL grade ≥ 3 or ON would predict better FJS than OA KL grade 2. Similarly, Nielsen et al. reported a higher FJS after TKA performed in OA KL grades 3 and 4 compared to TKA in OA KL grades 1 and 2 [29]. The outcomes of UKA in ON compared to OA are controversial. While better improvements in clinical outcomes were suggested in UKA after ON compared to that after OA was reported in a prospective case series [30], a recent meta analysis revealed that UKA showed similar survival and clinical outcomes in ON and OA [31]. These results suggest that patients will more likely benefit if the knee before surgery is in a worse state.

There are several limitations to this study that must be considered when interpreting these findings. First, this study was a retrospective study and did not incorporate matching demographic parameters. Thus, we adjusted the patient background in a multiple linear regression analysis to predict FJS based on surgery (UKA or HTO) and common patient factors related to clinical outcomes. A further prospective randomized controlled trial with strict criteria is required to confirm our results. Second, the sample size in this study may be relatively small. However, the sample size was calculated in advance by setting an adequate statistical power [22], and we were able to secure several cases comparable to the previous literature [11–13]. Finally, the follow-up period was too short to evaluate and compare the survival rates after the two procedures [32–34]. However, it is known that the postoperative results of the two procedures in the study increase up to one year and are maintained thereafter [12, 22]. Further studies evaluating the long-term outcomes are necessary.

Conclusion

The use of FJS as the outcome measure after UKA and HTO was validated with a good correlation between every item of the KOOS and LKS, and excellent internal consistency. There was no significant difference in the FJS between the UKA and HTO groups in this study. In multiple linear regression, lower BMI, the diagnosis of OA KL grade ≥ 3, and ON were significant predictors of better FJS.

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Table 1. Demographics of participants

		UKA (n = 48)		HTO (n = 48)		
		mean	**SD**	**mean**	**SD**	**p-value**
Age		73.8	5.2	61.3	9.8	<0.001*
Sex (female), n (%)		39 (81)	-	36 (75)	-	0.33
Height		1.55	0.08	1.59	0.08	0.017
Weight		58.1	9.3	66.4	12.1	<0.001
BMI		24.1	2.8	26.1	3.8	0.004*
Diagnosis, n (%)	OA KL2	7 (15)	-	8 (17)	-	-
	OA KL ≥ 3	14 (29)	-	35 (73)	-	-
	ON	27 (56)	-	5 (10)	-	-
FTA (°)	Preoperative	179.3	3.6	180.9	3.9	0.041
	Postoperative	177.9	3.2	170.0	2.3	<0.001
Preoperative ROM	Extension (°)	-0.9	7.5	-4.9	3.9	0.01*
	Flexion (°)	129.5	12.3	131.9	8.2	0.31*
Postoperative KOOS	Pain	83.8	14.0	84.9	15.2	0.73
	Symptoms	84.0	11.4	84.9	14.4	0.72
	ADL	85.0	11.8	88.6	12.4	0.15
	Sports and Rec	59.4	25.8	66.4	25.2	0.20
	QOL	64.0	21.9	66.0	23.0	0.67
Postoperative LKS		82.4	16.4	80.8	17.5	0.66

n, number of knees; BMI, body mass index; OA, osteoarthritis; KL, Kellgren-Lawrence; ON, osteonecrosis; FTA, femorotibial angle; KOOS, Knee injury and Osteoarthritis Outcome Score; ADL, activities of daily living; Rec, recreation; QOL, quality of life; LKS, Lysholm Knee Scoring scale; *, Mann-Whitney U test.

Table 2. A multiple linear regression calculated to predict FJS based on their age, BMI, sex, diagnosis, and received surgery (UKA or HTO)

	Parameter estimate	Standard error	t value	95% CI	p-value
Intercept	124.3	35.8	3.47	53.2 to 195.5	<0.001
Age (years old)	-0.64	0.33	-1.97	-1.29 to 0.007	0.053
BMI (kg/m^2)	-1.55	0.77	-2.01	-3.01 to -0.01	0.048
Sex (male = 1, female = 0)	9.86	6.26	1.58	-2.58 to 22.3	0.119
Diagnosis (KL 3 and above = 1)	21.4	7.82	2.73	5.80 to 36.9	0.008
Diagnosis (ON = 1)	22.1	8.02	2.75	6.14 to 38.0	0.007
Surgery (HTO = 1, UKA = 0)	0.74	6.76	0.11	-12.7 to 14.2	0.913

BMI, body mass index; KL, Kellgren-Lawrence; ON, osteonecrosis; CI, confidence interval.

Participants' predicted FJS is equal to 124.3 – 0.64 (age) – 1.56 (BMI) + 9.86 (sex) + 21.4 (diagnosis of OA KL grade 3 and above) + 22.1 (diagnosis of ON) + 0.74 (received surgery).

Table 3. Comparison between UKA and HTO group using FJS in a single variable analysis

	UKA		**HTO**		
	mean	**SD**	**mean**	**SD**	**p-value**
total FJS	60.0	23.9	66.0	25.0	0.24
FJS 1	0.98	1.10	0.74	1.03	0.30
FJS 2	1.15	1.09	0.79	1.06	0.12
FJS 3	1.46	1.25	1.26	1.17	0.45
FJS 4	1.00	1.07	0.79	0.97	0.33
FJS 5	0.94	0.91	0.81	0.96	0.53
FJS 6	1.90	1.37	1.68	1.44	0.46
FJS 7	1.86	1.35	1.86	1.46	0.98
FJS 8	1.92	1.37	1.74	1.35	0.55
FJS 9	2.01	1.26	1.56	1.35	0.09
FJS 10	1.92	1.21	1.50	1.30	0.11
FJS 11	1.98	1.36	1.65	1.36	0.25
FJS 12	2.27	1.20	1.88	1.40	0.18

SD, standard deviation; FJS, Forgotten Joint Score-12.

Total FJS is equal to 100 − [(total score for each question)/12 (if there is no response, divided by the number of questions answered) × 25], where the score of each question ‘Are you aware of your artificial joint…,’ from 0 to 4 points (never, 0 points; almost never, 1 point; seldom, 2 points; sometimes, 3 points; mostly, 4 points).

Table 4. Correlation of the Forgotten Joint Score-12 with other clinical outcomes

		UKA		HTO	
		correlation	**p-value**	**correlation**	**p-value**
KOOS	Pain	0.71	<0.001	0.81	<0.001
	Symptoms	0.55	<0.001	0.47	0.002
	ADL	0.71	<0.001	0.69	<0.001
	Sports and Rec	0.74	<0.001	0.80	<0.001
	QOL	0.71	<0.001	0.69	<0.001
LKS		0.68	<0.001	0.79	<0.001
Postoperative	Extension (°)	0.08	0.47	0.24	0.14
	Flexion (°)	0.10	0.38	0.13	0.42

KOOS, Knee Injury and Osteoarthritis Outcome Score; ADL, activities of daily living; Rec, recreation; QOL, quality of life; LKS, Lysholm Knee Scoring scale.

Figure 1. The flow of participants through the study

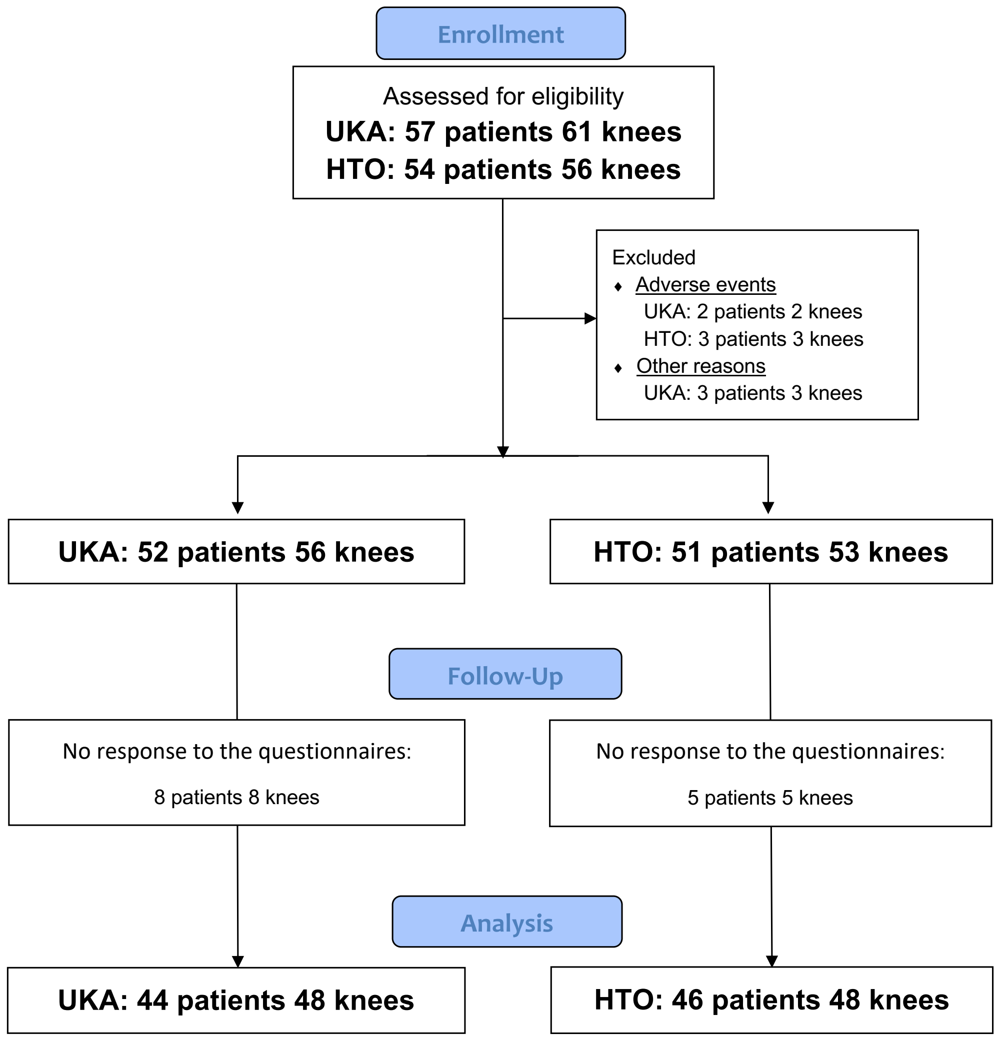

Figure Legends

A total of 117 knees from 111 patients with medial unicompartmental OA or ON who were followed-up after surgery for at least one year were included in this cross-sectional study. In the UKA group, two knees of two patients who suffered from tibial fracture after surgery and three knees of three patients who died from unrelated disease during the following period were excluded from further analysis. Six knees of six patients were lost to follow-up. Two knees of two patients who did not respond to the paper questionnaires were excluded. In the HTO group, two knees of two patients who suffered from breakage of the screw after surgery, the knee of one patient who suffered from an infection after surgery were excluded. Six knees of six patients were lost to follow-up. Four knees of four patients who did not respond to the paper questionnaires were excluded. Finally, 21 knees of 21 patients were excluded, and 96 knees of 90 patients were analyzed in this study.

Archives of Orthopaedic and Trauma Surgery
2021 年 7 月 16 日 Online ahead of print. 公表済
DOI: 10.1007/s00402-021-03994-x.