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Primary Knee

Impact of Polyethylene Thickness on Clinical Outcomes and Survivorship in Medial Mobile-Bearing Unicondylar Knee Arthroplasty

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ABSTRACT

Background: The thickness of the polyethylene bearing in medial unicondylar knee arthroplasty (UKA) is determined by the depth of the tibial resection, degree of correctable deformity, and balance of the knee. The purpose of this study is to evaluate whether polyethylene thickness in medial mobile-bearing UKA impacts clinical outcomes and survivorship.

Methods: A retrospective review from 2004 to 2017 identified patients who underwent a primary mobile-bearing medial UKA with 2-year minimum follow-up or revision. A total of 2305 patients (3030 knees) met inclusion criteria. Patients were divided in 2 groups: thin bearing (group 1): 3-mm or 4-mm bearing and thick bearing (group 2): $\geq$ 5 mm. The thin group consisted of 2640 knees (87%), whereas the thick group had 390 knees (13%). Preoperative and postoperative demographics, range of motion, Knee Society scores, complications, and reoperations were evaluated.

Results: Mean follow-up was 5.2 years (range, 0.5 to 12.6). There was no significant difference between groups in postoperative range of motion or Knee Society scores ($P > .05$). Manipulations were performed in 1.3% of patients and not significantly different between groups. The all-cause revision rate for group 1 was 4.02% and group 2 was 4.58% ($P = .6$). Revision rates for tibial aseptic loosening were significantly higher in group 2 (1.8%) than those in group 1 (0.7%) ($P = .04$). There was no significant difference in failure rates between groups for tibial collapse or fracture, femoral aseptic loosening, arthritic progression, bearing dislocation, or other cause of revision.

Conclusion: This study demonstrated that thicker bearings in medial UKA increased the risk of tibial aseptic loosening, but not all-cause failures or clinical outcomes.

Unicondylar knee arthroplasty (UKA) is a successful treatment for medial compartmental knee osteoarthritis [1]. Survivorship for patients with medial UKA ranges from 98% at 10 years [2] to 91% through the end of the second decade [3]. Both fixed- and mobile-bearing designs are available for medial UKA, with the mobile-bearing design initially developed to increase range of motion (ROM) and reduce the likelihood of polyethylene wear [4,5].

The surgical technique for UKA, as in most knee arthroplasty, is to resect only as much bone as needed to be replaced by the thickness of the tibial, femoral, and polyethylene components. The thickness of the polyethylene bearing in UKA is determined by the depth of the tibial resection, degree of correctable deformity, and balance of the knee. "Thicker" polyethene inserts may be needed in cases of increased tibial resection or "overstuffing" the medial compartment. Increased tibial resection has been reported to be associated with increased aseptic loosening and fracture

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[6–8]. Thicker bearings that "overstuff" the medial compartment may lead to lateral disease progression [6]. However, little research has been carried out on the clinical outcomes of thicker bearings in UKA.

Previous research has assessed the clinical outcomes and survivorship with the use of thicker polyethylene in total knee arthroplasty (TKA). Some studies found that thicker polyethylene bearings can increase the risk of early flexion contracture, increase polyethylene wear, and have higher failure rates [9–12]. However, other studies have reported contrary findings with thicker polyethylene in TKA having no difference in survivorship and lower rates of manipulation under anesthesia [13].

To the authors' knowledge, the impact of polyethylene thickness in medial UKA on clinical outcomes and survivorship has not been studied. The purpose of this study is to determine whether polyethylene thickness in medial mobile-bearing UKA affects clinical outcomes and survivorship. We hypothesize that the thickness of the insert will not affect clinical outcomes or implant survivorship.

Methods

A retrospective review was performed on all patients who underwent primary medial UKA with the Oxford mobile-bearing knee (Zimmer Biomet, Warsaw, IN) from 2004 to 2017 within a single private practice arthroplasty registry. All participants signed a general research consent approved by an independent institutional review board (Western IRB, Puyallup, WA) allowing for retrospective review.

Patients were included in the study analysis if they completed a minimum of 2-year radiographic and clinical follow-up and/or underwent revision surgery.

Surgery was performed by 1 of 5 fellowship-trained joint arthroplasty surgeons with the Oxford phase 3 or Oxford Microplasty instrumentation. With phase 3 instrumentation, the tibial resection was performed freehand with a recommended resection depth of 2-3 mm distal to the deepest part of the tibial erosion (Oxford phase 3 unicompartmental knee system surgical technique guide). Femoral "spoons" were added to the Microplasty instruments to aid in femoral sizing and setting the tibial resection depth by referencing the intact posterior femoral cartilage. These spoons increase from size 1 to 3 and are intended to restore native medial collateral ligament (MCL) tension for appropriate resection depth. As the spoon sizes increase, the resection depth decreases. The target with both the phase 3 and Microplasty instruments is for a tibial resection with 7 degrees of posterior slope and neutral coronal plane alignment. There are 7 polyethylene thicknesses available for this system going from 3 mm to 9 mm with 1-mm increments in increased size.

Demographics were recorded including patient gender, age, height, weight, body mass index, and length of follow-up. Surgical reports and postoperative clinic visits were reviewed for implant data, ROM, and Knee Society Clinical Rating System scores [14]. Follow-up was performed at 6 weeks, 1 year, and annually thereafter. Radiographs were reviewed at each visit, and any evidence of radiolucencies and/or component loosening was documented. Patients who were lost to follow-up were called a minimum of 2 times, hospital records were reviewed, referring and primary care physicians were contacted, as well as online death index lists and obituaries were queried for patient deaths.

Patients were divided in 2 groups based on polyethylene thickness: Thin bearing (group 1): 3-mm or 4-mm bearing and thick bearing (group 2): $\geq$ 5 mm. Preoperative and postoperative demographics, ROM, Knee Society scores, complications, and reoperations were evaluated (Table 1). Preoperatively, there was no significant difference between groups with patient age, body mass index, ROM, Knee Society functional score, or UCLA activity score.

Postoperative radiographic analysis was performed to measure medial tibial resection depth. To correct for magnification, the tibial baseplate width was measured, and a ratio was created to the known actual width of that size implant. A line off the intact lateral tibial plateau was drawn perpendicular to the long access of the tibia. The base of the medial tibial resection depth to this line was measured and multiplied to the normalized tibial base ratio to correct for magnification.

Failure was defined as revision of any component or revised to a TKA. Patients were determined to have aseptic loosening if there was gross change in position of components or progression of radiolucencies with clinical symptoms.

Statistical Analysis

Statistical analysis was performed using Microsoft Excel (Microsoft Corporation, Redmond, Washington) and MedCalc Statistical Software, version 18.6, (MedCalc Software bvba, Ostend, Belgium). An unpaired t-test was used for statistical analysis of demographic differences and outcome measures between groups. A chi-squared and Fisher exact test compared categorical variables. Kaplan-Meier survivorship analysis was performed between groups for all-cause survival. A *P* value of 0.05 was set for significance.

Results

The initial query revealed 3688 knees. Eighteen patients were excluded for anterior cruciate ligament deficiency at time of surgery, 74 were excluded for declined research consent, and 566 were excluded for lack of 2-year minimum follow-up. The final cohort

Table 1
Preoperative Demographics, Range of Motion, and Outcomes Between Thin and Thick Polyethylene Groups.

Characteristic	Group 1	Group 2	*P* value
Number of patients	2008	297	
Number of knees	2640	390	
Gender of knees			
Knees in male patients	910 (%)	143 (%)	
Knees in female patients	1098 (%)	154 (%)	.35
Mean body mass index (kg/m^2)	32.5	32.4	.7
Mean age (y)	62	62	.9
Mean range of motion (degrees)	116	115	.5
Mean Knee Society clinical score (0-100 possible)	39	41	**.04**
Mean Knee Society pain score (0-50 possible)	8	9.2	**.03**
Mean Knee Society functional score (0-100 possible)	58.3	58.2	.9

Group 1 = thin polyethylene; Group 2 = thick polyethylene. Bold values are statistically significant.

Table 2
Mean Postoperative Range of Motion and Outcomes Between the Thin and Thick Polyethylene Groups.

Characteristic	Group 1	Group 2	*P* Value
Mean range of motion (degrees)	118	118.4	.2
Range of motion improvement (degrees)	2.7	3.8	.14
Mean Knee Society clinical score (0-100 possible)	87	89	.06
Knee Society clinical score improvement	48	49	.4
Mean Knee Society pain component (0-50 possible)	40.7	42	.13
Knee Society pain component improvement	33	34	.51
Mean Knee Society functional score (0-100 possible)	74	76	.22
Knee Society functional score improvement	18	18.3	.73

Group 1 = thin polyethylene; Group 2 = thick polyethylene.

consisted of 2305 patients (3030 knees) who met inclusion criteria. Group 1 consisted of 2640 knees (87%), whereas group 2 had 390 knees (13%).

Mean follow-up was 5.2 years (range, 0.5 to 12.6). The mean tibial resection depth in the group 1 was 9.4 mm (range, 5.2 mm to 15.7 mm) and 11.8 mm (range 8.5 mm to 17.9 mm) in group 2 ($P < .001$). There was no significant difference between groups in postoperative ROM or Knee Society scores or change in Knee Society scores (Table 2).

Manipulations were performed in 1.3% of patients in group 1 and 1% of patients in group 2 ($P = .62$). All-cause revision rate for group 1 was 4.02% and group 2 was 4.58% ($P = .6$). Table 3 details the reason for failure and significance between groups. Revision rates for tibial aseptic loosening were significantly higher in group 2 (1.8%) than those in group 1 (0.7%) ($P = .04$). There was no significant difference in failure rates between groups for tibial collapse/fracture, femoral aseptic loosening, arthritic progression, bearing dislocation, or other cause of revision. The tibial resection depth was significantly less for knees that failed (9.4 mm, range 5.6 mm to 13.53 mm) than that for knees that did not fail (9.73 mm, range 5.2 mm to 17.95 mm) $P = .03$. The tibial resection depth was not significantly different between patients who failed for tibial aseptic loosening (9.9 mm, range, 6.5 mm to 15.1 mm) than those who did not fail (9.71 mm, range, 5.2 mm to 17.9 mm) ($P = .4$). No revisions were performed in either group for polyethylene wear.

Kaplan-Meier all-cause survivorship at 5 years was 95.1% (95% confidence interval, 94.7% to 96.1%) for the thin group and 95.2% (95% confidence interval, 94.1% to 96.3%) for the thick group ($P = .99$) (Fig. 1).

Discussion

This study found that patients with thicker polyethylene bearings in a medial mobile-bearing UKA design had higher rates of revision for tibial aseptic loosening. However, patients with thicker polyethylene bearings displayed no significantly different postoperative ROM or Knee Society scores, manipulation rate, or failure rates due to tibial collapse/fracture, femoral aseptic loosening, arthritic progression, bearing dislocation, or other cause of revision. The thick group had significantly greater medial tibial resection depth, but increased resection depth was not associated with subsequent failure.

The goal in most all knee arthroplasty surgeries is to resect as little of native bone stock as necessary to replace with the thickness of the implant while properly restoring joint alignment and mechanics. Given that a prerequisite for medial UKA is for correctable deformity and functional MCL, surgeons should typically only need to resect enough tibia to replace with the minimal thickness of metal and polyethylene. The most common scenario of when a thicker polyethylene would be used is when there is an increased depth of tibial resection. This increased resection depth is where concerns of failure arise. Chatellard et al found that lowering the medial joint line >2 mm compared with the contralateral joint space was associated with increased aseptic loosening [6]. Furthermore, increased tibial resection, as well as component malalignment, can increase the risk of proximal tibia fracture after medial UKA [7,8]. A recent biomechanical study found that a tibial resection depth of 5.82 mm was the critical depth at which point the load to failure significantly increased [15]. Although this study did not find any increased risk in tibia fracture with thicker bearings, it did confirm that increased polyethylene thickness was associated with tibial aseptic loosening. The thicker polyethylene group did have significantly greater medial tibial resection depth. However, patients who failed for all-cause as well as aseptic loosening did not have a deeper tibial resection depth than those who did not. A possible explanation of this discordant finding is that another reason a thicker polyethylene may be needed is when patients have greater varus deformity and medial tibial erosion. In these cases, even with a thin tibial resection, a thicker bearing is needed to appropriately tension the MCL and restore the patient's native limb alignment. Areas of tibial erosion typically have more dense sclerotic bone, which is less receptive to cement interdigitation [16]. This could be a reason why there was increased risk of tibial aseptic loosening with thicker bearings, but patients who failed for aseptic loosening did not have thicker resections.

Polyethylene wear is a relatively infrequent cause of UKA failure, representing only 4% of all UKA revisions [17]. Some have

Table 3
Reason and Incidence of Revisions Between Thin and Thick Polyethylene Groups.

Mode of Failure	Group 1 (Number)	% Yes	Group 2 (Number)	% Yes	*P* value
Arthritic progression	42	1.62%	4	1.04%	.7
Instability	7	0.27%	1	0.26%	.97
Femoral septic loosening	6	0.22%	1	0.20%	.3
Tibial aseptic loosening	20	0.70%	7	1.80%	**.04**
Arthrofibrosis	2	0.08%	0	0.00%	1
Bearing dislocation	4	0.15%	2	0.52%	.13
Infection	4	0.15%	1	0.26%	.63
Other	22	0.84%	2	0.52%	.5
Total	107	4.02%	18	4.58%	.6

Group 1 = thin polyethylene; Group 2 = thick polyethylene. Bold values are statistically significant.

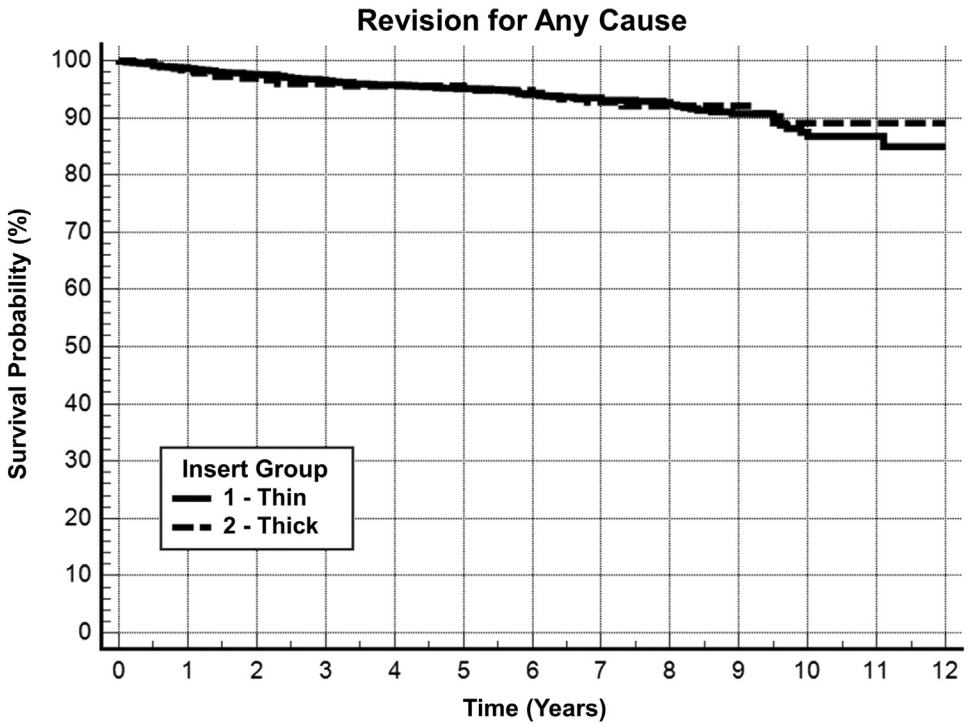

Fig. 1. All-cause Kaplan-Meier survivorship between thin and thick polyethylene groups.

advocated for a minimum polyethylene thickness of 6 mm with UKA [17,18]. However, the polyethylene wear rate of the implant evaluated in this study has been shown to be only 0.022 mm/y [19], which at 20 years would only be 0.44 mm of wear. Therefore, a thicker polyethylene insert would not be needed with this design to lessen the risk of failure due to polyethylene wear.

Arthritic progression is the most common cause of midterm and long-term failure of medial UKA [17]. The most significant predictor of arthritic progression is the arthritic grade of the lateral compartment at the time of surgery [20]. However, overstuffing of the medial compartment through thicker bearings has been associated with lateral compartment disease progression [6]. One of the tenants of surgical technique for the mobile-bearing design is to not perform any MCL release. Candidates for UKA have correctable deformity with a functional MCL. As such, balancing of the knee is to restore the patient's native alignment to the tension of their MCL and not overcorrect. If the MCL is released, then this may lead to needing a larger bearing for balancing and ultimately could alter alignment shifting the mechanical axis laterally. With a mean follow-up of 5.2 years in this study, further long-term evaluations will be needed to determine if the thicker polyethylene results in an increased risk for arthritic progression.

This study has several limitations including its retrospective design which is subject to loss to follow-up and inaccuracies in documentation. The length of follow-up averaging 5.2 years is also a limitation as it is uncertain as to whether patients may develop arthritic progression or other modes of failure after longer follow-up. Another limitation is that the thick group had higher preoperative Knee Society clinical and pain scores. However, the change in these scores did not differ between groups. The number of patients in each group varied significantly, as the thin group included 2008 patients with 2640 knees, whereas the thick group included 297 patients with 390 knees. This difference in the number of patients may have prevented the researchers from seeing contrasting results from those presented. Finally, the radiographic measurement of tibial resection depth may not equate to actual tibial resection depth as the measured depth was based off the intact lateral tibial plateau. Patients undergoing medial UKA often have medial tibial wear, and furthermore, their preoperative height of the medial tibial may not be at the level of the lateral tibial plateau. However, the method of measurement was standardized for all patients, and the relative difference in resection depth between groups could be analyzed.

Conclusion

This study demonstrated that thicker bearings in medial UKA increased the risk of tibial aseptic loosening, however, did not affect other modes of failure or clinical outcomes. Surgeons should strive to preserve as much as native bone as possible and resect only what is needed to replace with the implant and balance the knee.

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