Good accuracy of the Phase III Oxford Mobile Bearing Unicompartmental Knee Instrumentation

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Background and purpose — Unicompartmental knee arthroplasty (UKA) needs careful balancing of flexion/extension (F/E) gaps to prevent dislocation of the mobile meniscal bearing. Assessment of gaps is based on the surgeon's subjective insertion force of a feeler gauge with different thicknesses and/or the lift-off of a trial meniscal bearing. However, the accuracy of this method remains unclear. We assessed the accuracy of the technique.

Patients and methods — A consecutive series of 33 UKAs in 32 patients (mean age 64 years, 24 women) were balanced using the Oxford Phase III (OP III) Instrumentation. The recommended technique for F/E gap assessment was performed using different feeler gauges with 1-mm increments and the meniscal bearing lift-off tests according to surgical technique. A tensiometer was inserted and both gaps were maximally distracted by hand. Measurements in mm were recorded and analyzed with a reading of 90 N for both gaps in 20 and 90 degrees of flexion.

Results — The gaps measured were 12 (11–18) mm in extension and 13 (11–18) mm in 90 degrees of flexion. The difference between the gaps was 0.4 (–0.5 to 1.0) mm ($p < 0.001$). There were no statistically significant gender differences regarding composite implant thickness, laxity, flexion gap, extension gap, or gap difference.

Interpretation — OP III instrumentation using feeler gauges and the lift-off test provides accurate balancing of F/E gaps with an accuracy of less than 1 mm.

Physiological kinematics in general and in unicompartmental knee arthroplasty (UKA) in particular require anatomic restoration of joint surfaces and physiological ligament laxity, which can be achieved in fixed and mobile-bearing UKA (Markolf et al. 1976, Price et al. 2004, Patil et al. 2005). Equal gaps without overcorrection have proven to be crucial for avoidance of higher failure rates in UKA, and are dependent on the surgeon's ability and routines (Lewold et al. 1998, Svard and Price 2001, Vardi and Strover 2004, Price et al. 2005, Okazaki et al. 2006, Emerson, Jr. and Higgins 2008, Dervin et al. 2011). To achieve equal gaps with the Phase III Oxford Mobile Bearing Unicompartmental Knee Instrumentation, a measured resection without soft tissue release is performed. The relative distal and/or posterior position of the femoral component is modified until flexion and extension gaps match.

A serious disadvantage of mobile-bearing UKA is bearing dislocation, which has been reported in almost every published series (Pandit et al. 2011, Price and Svard 2011). The free-floating meniscal bearing is locked between femoral condyle and tibial plateau and retained in this position through soft tissue tension. Since the difference between the lowest and highest point of the free-floating polyethylene insert is 3 mm in the Oxford design, it is clear that dislocations can occur when soft tissue tension is looser than this "jump height" of the meniscal bearing. Dislocations have been reported in up to 10% of cases on the looser lateral side (Pandit et al. 2010). But even for the medial tibiofemoral joint, it is crucial to accurately balance the medial flexion and extension gap to avoid bearing dislocations in mobile-bearing UKA. On the other hand, if the tension is too tight and the extension gap overstuffed, the coronal alignment may be overcorrected and the implant may fail through progression of lateral tibiofemoral osteoarthritis (Emerson, Jr. and Higgins 2008). The Oxford group developed instrumentation consisting of feeler gauges and trial inserts. Both can be inserted between the medial femoral condyle and the tibia to assess flexion and extension gaps and allow for additional bone resection until gaps are balanced within 1 mm without overcorrection.

We assessed the precision of the current recommended surgical technique using feeler gauges and trial inserts in 1-mm increments. Would it be possible to achieve flexion and extension gaps within 1 mm using this simple instrumentation?

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Patients and methods

We studied a prospective consecutive series of 33 mobile-bearing UKAs (Oxford; Biomet, Warsaw, IN) in 32 patients. There were 24 females with an average age of 64 (54–81) years and 8 males with an average age of 63 (53–80) years. IRB approval at the Brigham and Women's Hospital was obtained under the Clinical Trials number 2006-P-000190/1.

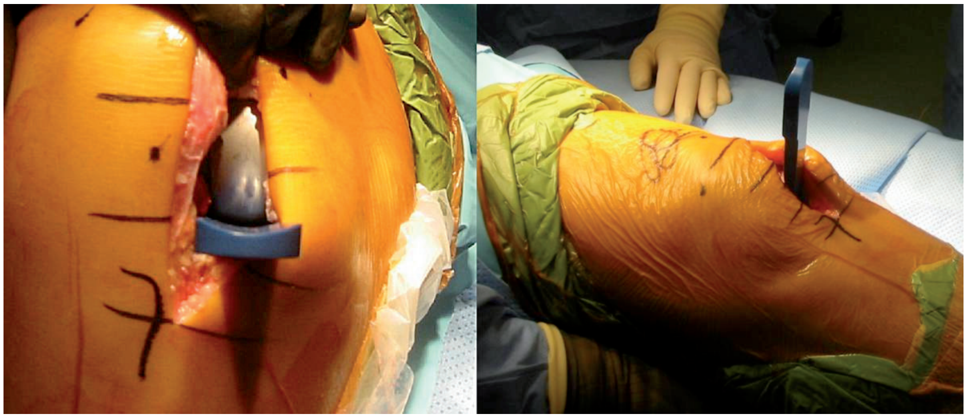

Figure 1. Feeler gauges are inserted between trial implants in 90 degrees of flexion to balance the flexion gap and in 20 degrees of flexion to balance the extension gap.

Figure 2. Lift-off of the meniscal bearing trial of 3 mm in 90 degrees of flexion and in 20 degrees of flexion.

All patients received a medial meniscal bearing UKA (Oxford) using the Phase III instrumentation and a small incision technique. After the tibia was resected, removing 3–4 mm of bone, the flexion gap was first roughly estimated using a 6-mm feeler gauge, which represents the composite tibial thickness of 3 mm for the metallic tray and 3 mm for the thinnest meniscal bearing. A full-thickness cartilage defect is assumed to measure 3 mm; therefore, 3 mm bone was resected in such a case to achieve a 6-mm gap. This resection was increased in knees with residual cartilage and reduced in knees with full cartilage and additional bone loss. The thickness of the removed bone on the tibia and femur was measured. Next, the femoral condyle was sized and the appropriate femoral sizer was inserted, referencing from the most posterior medial femoral condyle. 2 drill holes were placed on the medial femoral condyle, the posterior cutting block was seated, and 5 mm was resected off the posterior femoral condyle, matching the posterior implant thickness. A 0-spigot was inserted into the medial condyle to change the anatomic J-curve of the medial condyle to a single-radius design using a hemispherical reamer. Now trial implants were inserted and flexion and extension gaps were assessed using the feeler gauges and trial inserts to determine the difference in mm. The difference was resected off the distal femoral condyle using the appropriate spigot and the hemispherical reamer until both gaps were equal in 90 degrees and 20 degrees. The operations were performed without the Oxford leg holder. The measurements of the ligament tension in 90 and 20 degrees of flexion were performed without a supported foot, except for holding the lower leg in the required flexion position.

Figure 1 shows the same feeler gauge inserted in both positions. The feeler gauge should be inserted by holding it with 2 fingers using the same tension. If the resistance was tighter in extension, a thinner block was inserted to determine the residual difference, which was then removed from the distal femur. If gaps were equal, a trial meniscal bearing was inserted and the "lift-off technique" was applied in both positions additional to the feeler gauges (Figure 2). This technique used the force of 1 finger at the handle of the trial meniscal bearing to lift it off the tibial component. A lift-off of 3 mm should be achieved in both positions with the same effort. All knees were balanced as described above, using the manufacturer's recommended instruments, measuring flexion and extension gaps, subtracting the measurements, and equalizing them by milling with the appropriate spigots and cutters. After satisfactory balancing of flexion gap in 90 degrees and extension gap in 20 degrees, a single-unit validated tensiometer (Depuy, Warsaw, IN) was inserted in both positions and both gaps were measured in mm (Figure 3). First, the gaps were manually distracted before the tension was adjusted to 90 N, which is the manufacturer's recommended force. The gaps were measured in mm as recommended by others (Kesman et al. 2010). After the measurements were completed, the components were cemented.

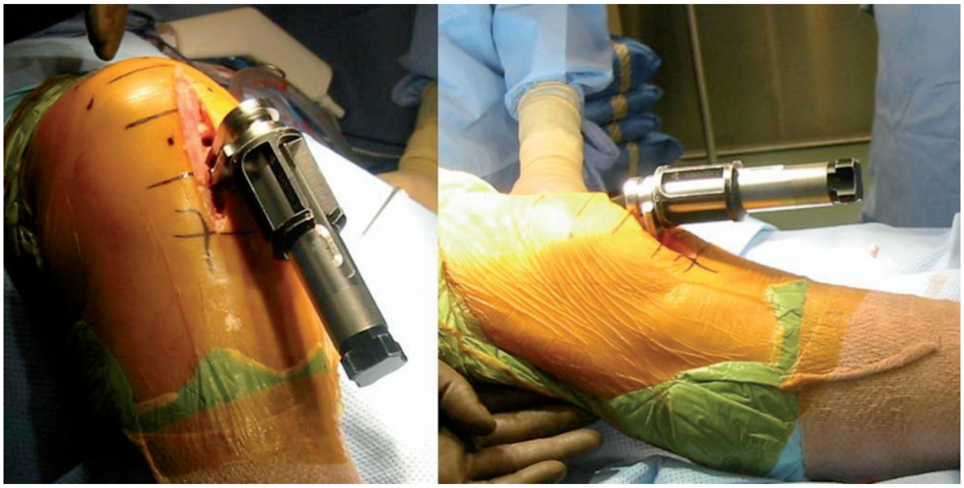

Figure 3. Measurement of the flexion gap using a single tensiometer and measurement of the extension gap (in mm) in 20 degrees of flexion.

Differences in flexion and extension gap (in mm) between males and females

	Females	Males	p-value
Composite implant thickness	11.6 (11–13)	12.0 (11–15)	
Extension gap without implants	12.1 (11–13.5)	13.1 (11.5–17.5)	
Flexion gap without implants	12.5 (11.5–14)	13.3 (11–17.5)	
Extension gap laxity	0.5 (0–1)	1.1 (0–2.5)	0.01
Flexion gap laxity	0.9 (0–2)	1.4 (0–3.5)	0.3
Gap difference	0.4 (–0.5 to 1)	0.6 (–0.5 to 1)	0.8

Statistics

1 randomly chosen side of the bilaterally operated patient was omitted from the statistical calculations. Data are presented descriptively as arithmetic mean (range). Statistical analysis was performed in 2 steps. Distribution of data was tested by Shapiro-Wilk test. The group differences were examined by Wilcoxon signed-rank test or Mann-Whitney U-test. All tests were 2-sided and p-values of < 0.05 were considered significant. Statistical analysis was performed with SPSS for Windows version 12.0.

Results

The measured average extension gap in 20 degrees of flexion was 12.4 (11–17.5) mm and it was 12.8 (11–17.5) mm in 90 degrees of flexion. The difference between extension and flexion gap was 0.37 mm (–0.5 to 1) ($p < 0.001$). There were no statistically significant gender differences regarding composite implant thickness, laxity, flexion gap, extension gap, or measured gap differences (Table). 10 of 32 knees had a difference between flexion and extension gap of ≤ 0.5 mm; 14 had a difference of more than 0.5 but equal to or less than 1 mm, and 8 knees had a difference of more than 1 mm.

Discussion

In medial mobile-bearing UKA, equal flexion and extension gaps are essential to avoid overcorrection and bearing dislocation. The Swedish multicenter survival study reported a total of 16 (2%) dislocated meniscal bearings of 699 Oxford arthroplasties (Price et al. 2005). Another series showed a medial dislocation rate of 3% using a tensiometer (Campbell et al. 2010). The surgical technique of a mobile-bearing UKA is technically demanding and requires equal gaps, without soft tissue releases. The difference between the lowest and highest point of the free-floating meniscal bearing surface is only 3 mm. Thus, the difference of both gaps needs to be less than the 3-mm "jump height" to reduce the risk of dislocation of the meniscal bearing. Overstuffing of the medial joint, which would decrease the risk of dislocation, would overcorrect the varus deformity and push the knee in mechanical valgus, leading to higher load shift to the lateral compartment with the potential of accelerated progression of osteoarthritis in the lateral tibiofemoral joint (Emerson, Jr. and Higgins 2008). Soft tissue releases cannot therefore be performed. Undercorrection in mobile-bearing UKA would leave the knee in mechanical varus, leading to a higher load on the medial mobile meniscal bearing with the possibility of increased wear and implant loosening.

Other potential causes of bearing dislocation include bony or cement impingement, tibial component malrotation, underestimated anterior cruciate ligament stability or general joint laxity, and progressive neurologic disorders (Goodfellow and O'Connor 1992, Murray et al. 1998, Ackroyd 2003).

The surgical technique using the Phase III Oxford instrumentation involves 2 methods: feeler gauges or trial meniscal bearings. Both allow the surgeon to increase the smaller gap in 1 mm increments by increasing the resection. Even though this measured resection process is sophisticated, the subjective impression of the surgeons remains a variable and is different depending on the surgeon's experience and the frequency that this procedure is performed.

The limitations of the present study include small sample size and single-surgeon experience. We randomly excluded 1 limb of the 1 patient with bilateral knees in the analysis. The effect of this 1 case in the study changed the results only minimally (Bryant et al. 2006). Another limitation was the tensiometer used. This instrument has been developed for total knee replacements to create equal flexion and extension gaps and it accurately measures distances, while the simultaneous force measurement is quite inaccurate (Kesman et al. 2010). We used 1 of the units and measured the distance, relying less on the distraction force as recommended.

We were, however, surprised that we could confirm in our consecutive series of 32 patients that accurate balancing using simple feeler gauges and trial meniscal bearings in 1-mm increments can be achieved, within 1 mm. Sometimes the radii and widths of the feeler gauges did not match the medial femoral condyle. We observed the wider medial femoral condyles sitting more on the edges of the feeler gauges, and not at the deepest point of the concave gauges during the first rough balancing after the tibiae were cut with a 6 mm gauge. However, the final balancing was performed after the trials were placed where radii and widths of the different femoral sizes matched the geometry of the feeler gauges. We could also measure a slight difference in extension and flexion gaps related to the very small standard deviations. The flexion gaps measured were on average 0.4 mm larger than the extension gaps. However, this underlines the accuracy of this measurement technique and keeps the error of the system below 1 mm, confirming the high accuracy of this simple instrumentation relying on feeler gauges.

High-volume surgeons have shown excellent long-term results. Price reported a 92% survival rate of 562 UKAs after 16 years (Price et al. 2005). 3 high-volume surgeons performed all the UKAs, and no surgical errors or early failures were noted. Svard and Price (2001) reported a 20-year survival of 94% in the hands of the designing surgeon. However, recently this system has been criticized, with a higher earlier failure rate than fixed-bearing UKA, which may to some extent be related to overstuffing and the fear of surgeons that too much laxity may lead to meniscal bearing dislocation (Lewold et al. 1998, Vardi and Strover 2004, Emerson, Jr. and Higgins 2008, Dervin et al. 2011).

We conclude that feeler gauges and trial meniscal bearings with different thicknesses in 1-mm increments are tools sufficient to create equal flexion and extension gaps in medial UKA with an accuracy of less than 1 mm. This surgical technique could also be used in fixed-bearing UKA, and even in total knee replacement surgery.

RGB: data analysis and interpretation, and manuscript writing; AvK: data acquisition and manuscript writing; EL: statistical analysis; WF: study concept/study design, guarantor of integrity of the study, implantation of the UKAs, data acquisition, data analysis and interpretation, and manuscript writing.

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