Mobile-bearing medial unicompartmental knee arthroplasty restores limb alignment comparable to that of the unaffected contralateral limb

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Background and purpose — Medial unicompartmental knee arthroplasty (UKA) is undertaken in patients with a passively correctable varus deformity. We investigated whether restoration of natural soft tissue tension would result in a lower limb alignment similar to that of the contralateral unaffected lower limb after mobile-bearing medial UKA.

Patients and methods — In this retrospective study, hip-knee-ankle (HKA) angle, position of the weight-bearing axis (WBA), and knee joint line obliquity (KJLO) after mobile-bearing medial UKA was compared with that of the unaffected (clinically and radiologically) contralateral lower limb in 123 patients.

Results — Postoperatively, HKA angle was restored to within ± 3° of the contralateral lower limb in 87% of the patients and the WBA passed within ± 1 Kennedy and White's tibial zone of the unaffected contralateral lower limb in 95% of the patients. The mean KJLO in the operated limbs was not significantly different from that in the unaffected lower limbs ($p = 0.07$) and the KJLO in the operated limb was restored to within ± 3° of that in the contralateral lower limb in 96% of the patients.

Interpretation — Lower limb alignment and knee joint line obliquity after mobile-bearing medial UKA were comparable to that of the unaffected contralateral limb in most patients. Comparison with the contralateral unaffected lower limb is a reliable method for evaluation and validation of limb mechanical alignment after mobile-bearing medial UKA.

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Studies have reported that 98% of unaffected lower limbs do not have a neutral mechanical axis; the mean lower limb mechanical axis (MA) alignment is 2–3° varus (Eckhoff et al. 2005, Bellemans et al. 2012, Shetty et al. 2014). Although postoperative lower limb MA alignment after total knee arthroplasty (TKA) is recommended to be ± 3° within neutral, the ideal, target lower limb alignment to be achieved after medial unicompartmental knee arthroplasty (UKA) for medial arthritis is still unclear.

Minimally invasive medial UKA with the Oxford phase 3 implant involves performing the surgery in the hanging-leg position with the knee flexed. No attempt is made to assess the lower limb alignment intraoperatively and no soft tissue release is performed; postoperative alignment depends largely upon soft tissue retensioning during surgery (Mullaji et al. 2007). Since medial UKA is recommended in patients with medial OA with a passively correctable varus deformity (Kozinn and Scott 1989), restitution of the soft tissue tension should restore its alignment to "natural"—or to its pre-disease alignment rather than to neutral alignment (Mullaji et al. 2011, Kim et al. 2012).

Since it is not feasible to determine what the pre-disease alignment was, we felt that the best available surrogate for comparison would be the contralateral lower limb in patients in whom it is unaffected. We therefore decided to compare the postoperative lower limb alignment after the Oxford mobile-bearing medial UKA with that of the contralateral unaffected lower limb, which to our knowledge has not been studied previously. Our hypothesis was that restoration of natural soft tissue tension would result in a lower limb alignment comparable to that of the contralateral unaffected lower limb, after mobile-bearing medial UKA.

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Patients and methods

This retrospective analysis was based on a study population of 165 patients who underwent a unilateral Oxford phase 3 medial UKA using a minimally invasive approach for primary medial OA between July 2005 and August 2013. The inclusion criterion was patients undergoing unilateral Oxford phase 3 medial UKA using a minimally invasive approach for primary medial OA with a clinically asymptomatic and unaffected contralateral knee and a radiographic grading of less than Kellgren-Lawrence grade 2 medial OA (Kellgren and Lawrence 1957). The exclusion criteria were having incomplete clinical or radiologic records, having a history of fractures in either lower limb, and having hip arthroplasty on either side. Indications for surgery were similar to those published previously (Kozinn and Scott 1989).

Based on the inclusion criteria, 132 patients were eligible for this study and 33 patients were not eligible due to OA of more than grade 2 in the medial compartment, patellofemoral arthritis, or tricompartmental arthritis in the contralateral limb. Of the 132 patients who were eligible, 9 had to be excluded (7 patients due to incomplete clinical or radiographic records, 1 patient due to hip fracture, and 1 patient due to hip arthroplasty on the side of surgery) and 123 patients were included and analyzed for the study. The mean age of the patients was 62 (36–89) years, with 39 men and 84 women.

All patients were operated by AM, under spinal anesthesia with a tourniquet according to the technique recommended by the manufacturer. All patients received Oxford phase 3 UKA implants (Biomet, Bridgend, UK). The thigh was supported in a thigh holder and surgery was performed in the "hanging-leg" position with the knee flexed. A minimally invasive quadriceps-sparing approach was used. No soft tissue releases were performed intraoperatively. No attempt was made to assess lower limb alignment during surgery; alignment was achieved only by restoration of the natural soft tissue tension and by equalizing flexion and extension gaps.

Pre- and postoperative standing, full-length hip-to-ankle radiographs were measured for mechanical alignment or hip-knee-ankle (HKA) angle, measured as the angle made by intersection of the femoral and tibial mechanical axes. All patients were radiographed at our institution using a standardized radiographic procedure for full-length hip-to-ankle radiographs, making sure that the patellae were facing forward and that both feet were at a fixed distance from each other. The femoral and the tibial mechanical axes were plotted by drawing a line between the center of the femoral head to the midcondylar point, and between the center of the tibial plateau (interspinous intercruciate midpoint) and the center of the tibial plafond. Based on the concept of Kennedy and White (1987), the tibial plateau was divided into 7 zones (medial to lateral: zones 0, 1, 2, C, 3, 4, 5). The area between medial and lateral tibial eminences formed zone "C". The medial plateau, medial to the medial eminence, was divided equally into zones 1 and 2. The lateral plateau, lateral to the lateral eminence, was divided into zones 3 and 4. Zone 0 referred to the area medial to the medial tibial plateau and zone 5 referred to the area lateral to the lateral tibial plateau. Knee joint line obliquity (KJLO) was also measured on full-length radiographs (Figure 1); these were then compared between the 2 sides. The KJLO was measured as an angle between the knee joint line and the perpendicular to the line joining the centers of the tibial plafonds of the lower limbs. This method is a modification of the one published previously by Victor et al. (2014), who defined it as the angle formed between the parallel to the floor and the tangent to the medial and lateral tibial plateau. In the present study, we used the line joining the centers of the tibial plafonds of the lower limbs as the horizontal plane, which represented the line parallel to the floor. The knee joint line on the unaffected side was plotted by joining the midpoints of the medial and lateral joint spaces at the level of the most prominent femoral condylar points. The knee joint line on the operated side was plotted by drawing a tangent from the lower surface of the femoral component to the midpoint of the lateral joint space at the level of the most prominent femoral condylar point (Figure 1). We used this method of plotting the knee joint line in order to account for the cartilage thickness in the unaffected knee and in the unaffected lateral compartment of the operated knee.

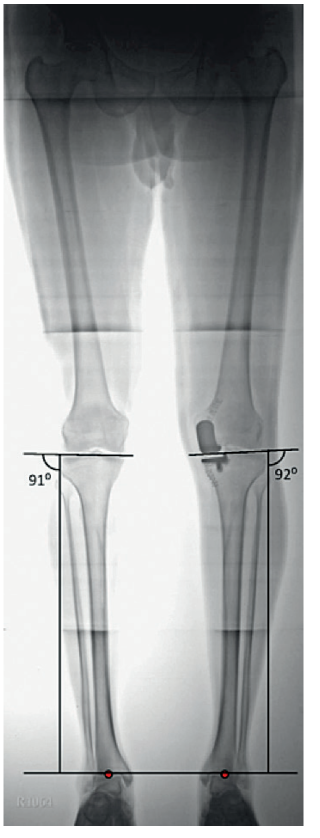

Figure 1. Measurement of knee joint line obliquity (KJLO) in the operated lower limb and in the unaffected contralateral lower limb on a postoperative full-length, standing hip-to-ankle radiograph.

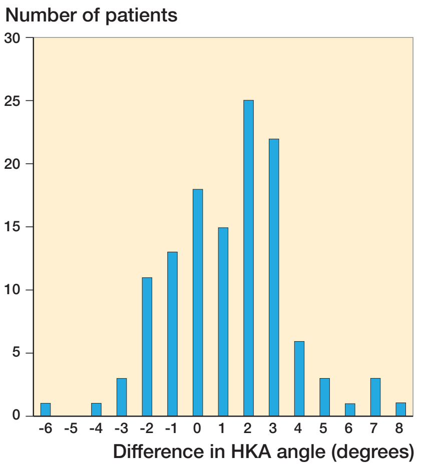

Figure 2. Distribution of patients according to the difference in hip-knee-ankle (HKA) angle between the operated lower limb and the unaffected contralateral lower limb. On the x-axis, negative values indicate undercorrection and positive values indicate overcorrection.

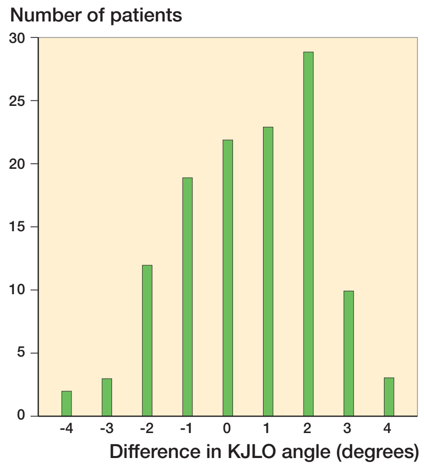

Figure 3. Distribution of patients according to the difference in knee joint line obliquity (KJLO) between the operated lower limb and the unaffected contralateral lower limb. On the x-axis, negative values indicate undercorrection and positive values indicate overcorrection.

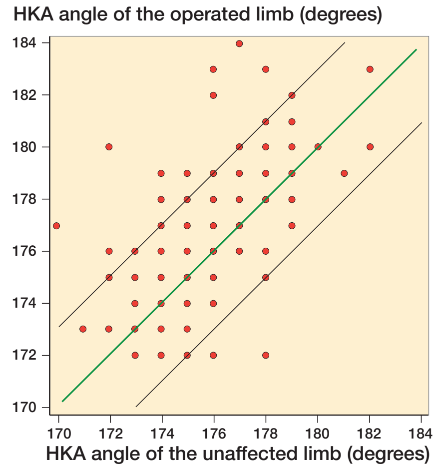

Figure 4. Scatter plot showing the distribution of hip-knee-ankle (HKA) angle in the operated and unaffected limbs.

Statistics

Numerical data were subjected to descriptive analysis, with mean (SD, range), and 95% confidence interval (CI). Categorical data were analyzed as frequency and percentage. Data between groups were compared using Student's t-test and Fisher's exact test, and any p-value less than 0.05 was taken to be statistically significant. Pearson's correlation coefficient was applied to determine any correlations between HKA angles in the operated and unaffected limbs. Data were analyzed using SPSS statistical software version 17.0.

Ethics

The approval of the institutional ethics committee was obtained for the study (application no. P35/BCH/2013; Breach Candy Hospital).

Results

The mean HKA angle of 177° (SD 2.9, range 172–187) on the operated side was significantly greater than the mean HKA angle of 176° (SD 2.4, range 170–184) on the unoperated side ($p < 0.001$). The mean difference in HKA angles between the 2 sides was 2.1º (CI: 1.8–2.3). Postoperative HKA angle was restored to within ± 3° of that of the contralateral lower limb in 107 of the 123 patients (87%) and to within ± 2° of that of the contralateral lower limb in 82 of the 123 patients (67%) (Figure 2).

Postoperatively, the HKA angle was in < 177° varus in 38% of the operated limbs, in 177–180° varus in 51% of the operated limbs, and in > 180° varus in 11% of the operated limbs. Overall, 101 of the 123 patients (82%) had an HKA angle within 177 ± 3° (174–180) on the operated side as compared to 105 of 123 (85%) on the contralateral, unaffected side ($p = 0.6$). Similarly, in the operated limb, the WBA passed through Kennedy and White tibial zones 2 or C in 99 of the 123 patients (80.5%) and it was within ± 1 zone of the contralateral, unaffected lower limb in 117 of the 123 patients (95%).

The mean KJLO of 91.5° (SD 2.2, range 84–96) in the operated limbs was not significantly different from the mean KJLO of 91° (SD 2.2, range 84–97) in the unoperated limbs ($p = 0.07$). The mean difference in KJLO between the operated and unoperated limbs was 1.5º (CI: 1.3–1.6). The KJLO in operated limbs was within ± 3° of that of the unoperated limbs in 118 of the 123 patients (96%) (Figure 3). Further analysis based on the HKA angle showed that there was no significant difference in mean KJLO in the unoperated limbs compared to the operated limbs when the HKA angle was within 3° varus from neutral (i.e. HKA 177–180°) ($p = 0.6$), when the HKA angle was > 3° varus from neutral (i.e. HKA 170–176°) ($p = 0.23$), and when the HKA angle was in valgus (i.e. HKA > 180 degrees) ($p = 0.8$).

There was a moderate positive correlation between the HKA angle in the operated limb and that in the unaffected limb ($r = 0.60$), which was significant ($p < 0.001$) (Figure 4).

Discussion

The main finding of this study was that postoperative HKA angle was successfully restored to within ± 3° of that of the unaffected lower limb in 87% patients, merely by optimum retensioning of the soft tissues, with no attempt being made to assess alignment during surgery. Although the mean difference in the HKA angle between the operated side and the contralateral side was statistically significant, this small difference may not be clinically significant. Overall, 82% of the patients had a postoperative HKA angle within 177 ± 3° (174–180°), which is similar to the findings of a previous study (Cool et al. 2006) that 80% of patients had a postoperative alignment within 175–180°. These findings confirm that acceptable alignment after medial UKA can be obtained by optimum soft tissue retensioning, even when no attempt is made to check the alignment during surgery. The WBA passed through zone 2 or zone C in 81% of our patients, as compared to 76% in a previous study (Emerson and Higgins, 2008) and in 87% patients as reported in another study (Kim et al. 2012). The WBA was restored to within ± 1 zone of the contralateral unaffected lower limb in 95% of our patients.

Excellent or good outcomes have been demonstrated in over 96% of patients in the long term with the Oxford phase 3 UKA, using a minimally invasive approach (Faour-Martín et al. 2013). However, there is no consensus regarding what the ideal postoperative alignment is after medial UKA; it is generally stated and assumed that alignment is restored to the pre-disease status, but thus far there has been no supporting evidence for this. It is becoming increasingly evident that a large proportion of normal knees do not have a "neutral" alignment and that there is a wide variation in lower limb alignment from neutral (Eckhoff et al. 2005, Howell et al. 2010, Bellemans et al. 2012, Shetty et al. 2014). It is therefore unclear what alignment one should aim for after a medial UKA, and whether there is a correlation between the postoperative alignment and the pre-disease alignment. Our hypothesis was based on the belief that since no soft tissue release was performed during medial UKA, restoration of natural soft tissue tension would result in a comparable alignment with the contralateral, unaffected lower limb, assuming that the 2 limbs were symmetrically aligned before development of arthritis. To our knowledge, postoperative alignment after medial UKA has not been compared to that of the contralateral, unaffected lower limb previously.

Previous studies have found an incidence of varus limb mechanical alignment of 25–35% in normal, asymptomatic adults (Bellemans et al. 2012, Shetty et al. 2014). The incidence of varus alignment (HKA angle < 177º) in the contralateral, unaffected lower limb in our patients was 76 of 123 (62%). Such a high incidence of varus alignment in the present study could be because our population was not representative of unaffected adults. On the other hand, we believe that our population was largely representative of that subgroup of the unaffected adult population with "inherent" varus. Presuming that the operated lower limb would have had a similar degree of varus alignment may explain the development and progression of OA in these knees (Brouwer et al. 2007). This further underscores the relevance of comparing the postoperative lower limb alignment after medial UKA with that of the contralateral unaffected lower limb.

There was no statistically significant difference in mean KJLO between the operated and the contralateral, unaffected lower limbs and the KJLO in the operated limb was restored to within ± 3° of the contralateral lower limb in 96% of patients. While varus lower limb alignment can affect the HKA angle, it does not affect joint line orientation in the coronal plane (Victor et al. 2014). Hence, it may be reasonable to evaluate postoperative lower limb alignment after medial UKA in terms of KJLO and to compare it with that of the contralateral unaffected lower limb.

Our study had some limitations. First, it was based on the assumption of symmetry between the 2 sides, and that the operated limb would have the same alignment as the unaffected contralateral limb (prior to the onset of medial OA). A related concern would be the presence of limb length discrepancy (LLD) between the 2 sides, and its influence on KJLO. However, none of the full-length radiographs in our study subjects showed evidence of obvious asymmetry or LLD. Moreover, exclusion of patients with previous reconstructive procedures or fractures further reduced the likelihood of asymmetry or LLD between the 2 sides. Secondly, we have not taken into account factors such as preoperative lower limb alignment that may influence postoperative alignment after medial UKA (Mullaji et al. 2011). Thirdly, we did not perform an intra- or inter- observer reliability analysis for the measurements on the scanograms. However, studies published previously have confirmed that there is high intra- and inter-observer reliability for parameters measured on full-length radiographs (Skytta et al. 2011, Marx et al. 2011). Moreover, since all measurements were performed by a single observer in our study, this ensured consistency in measurements. Fourthly, we have presented a radiological study to address the dilemma of "ideal" postoperative alignment after UKA, which is especially relevant in the light of recent evidence that suggests high variability in normal lower limb alignment (Bellemans et al. 2012, Shetty et al. 2014). No clinical outcomes have been reported, as this was not the aim of the study; nevertheless, none of the patients have been revised and they are being regularly evaluated on an annual basis. Finally, the postoperative HKA in 51% of operated limbs was 177–180°, in 38% it was in significant varus (172–176°), and in 11% it was overcorrected and in valgus alignment (181–187°). The effect of postoperative HKA alignment in significant varus or valgus on outcome of mobile-bearing medial UKA is unknown, and should be evaluated further in the long term.

Despite the above limitations, we feel that our study offers several important messages. Firstly, the study introduces the novel concept of comparison of postoperative alignment with the contralateral, unaffected lower limb after medial UKA; we have not found any previously published literature in this regard. We feel that this is relevant, as the definition of "ideal" postoperative alignment is not yet clear and "unaffected" lower limb alignment itself shows wide variation. Secondly, our study has confirmed that acceptable alignment can be obtained after medial UKA by optimum retensioning of the soft tissues, even when no attempt is made to assess the lower limb alignment during surgery. Thirdly, the concept of restoration of lower limb alignment by optimum soft tissue retensioning without any releases during surgery is akin to the concept of kinematically aligned TKA. Kinematically aligned TKA aims to restore the kinematics of the knee using patient-specific cutting blocks based on preoperative MR/CT imaging of the knee, without performing any collateral or retinacular ligament releases (Dossett et al. 2012, Howell and Hull 2012). While both mechanically and kinematically aligned TKAs may have a neutral HKA angle, only kinematically aligned TKAs have been shown to restore the KJLO to unaffected—unlike mechanically aligned TKAs, which may change the joint line obliquity and also raise it (Dossett et al. 2012, Howell and Hull 2012, Nunley et al. 2012, Howell et al. 2013). We found that the KJLO (i.e. kinematic alignment) was restored to within ± 3° of that of the contralateral, unaffected lower limb in a larger number of patients compared to the HKA angle (i.e. mechanical alignment): 118 of 123 as opposed to 107 of 123, respectively ($p = 0.02$). While this difference must be investigated further, we believe that it may be worthwhile to include KJLO as an index of postoperative alignment after medial UKA and compare it with that of the unaffected lower limb.

In conclusion, lower limb alignment and knee joint line obliquity after mobile-bearing medial UKA were comparable to that of the unaffected contralateral limb in most patients merely from restoration of natural soft tissue tension during surgery. Comparison with the contralateral, unaffected lower limb is a reliable method to evaluate and validate limb mechanical alignment after mobile-bearing medial UKA.

No competing interests declared.

All the authors participated in the conception and execution of the study. AM designed and supervised the study, SS measured radiographs and collected data, and GS analyzed data and prepared the manuscript.

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