The effect of leg alignment on the outcome of unicompartmental knee replacement

Varus malalignment after total knee replacement is associated with a poor outcome. Our aim was to determine whether the same was true for medial unicompartmental knee replacement (UKR). The anatomical leg alignment was measured prospectively using a long-arm goniometer in 160 knees with an Oxford UKR. Patients were then grouped according to their mechanical leg alignment as neutral (5° to 10° of valgus), mild varus (0° to 4° of valgus) and marked varus (> 0° of varus). The groups were compared at five years in terms of absolute and change in the Oxford Knee score, American Knee Society score and the incidence of radiolucent lines.

Post-operatively, 29 (18%) patients had mild varus and 13 (8%) had marked varus. The mean American Knee Society score worsened significantly (p < 0.001) with increasing varus. This difference disappeared if a three-point deduction for each degree of malalignment was removed. No other score deteriorated with increasing varus, and the frequency of occurrence of radiolucent lines was the same in each group.

We therefore conclude that after Oxford UKR, about 25% of patients have varus alignment, but that this does not compromise their clinical or radiological outcome. Following UKR the deductions for malalignment in the American Knee Society score are not justified.

After total knee replacement (TKR), the alignment of the leg is critical since malalignment is associated with a poor outcome and an increased risk of failure.1-4 This has also been thought to be the case after medial unicompartmental knee replacement (UKR),5-12 although Larsson, Larsson and Lundkvist13 suggested that minor malalignment did not influence the outcome whereas marked malalignment did. However, even if malalignment does not compromise the initial result, it has been suggested that it will affect the outcome in the long term.10

In TKR, the alignment of the leg depends on the alignment of the components. In UKR, it is independent of component alignment but is determined by the thickness of the implant relative to the bone excised.14 There is, however, no consensus as to the ideal alignment. Various authors9-12,15 have recommended undercorrection of the deformity because overcorrection increases the risk of arthritis in the contralateral compartment. However, undercorrection increases the load medially, which may result in loosening or accelerated wear of polyethylene.9,10,16

We use the Oxford UKR (Biomet, Swindon, United Kingdom), which has a fully-congruous mobile bearing, giving minimal wear and a low risk of loosening. It should only be used if the ligaments are functionally normal. The aim of the operation is to restore knee kinematics by restoring ligament tension to normal. This enables alignment of the knee and the leg to be returned to its pre-disease state. A proportion of patients have varus alignment before they develop medial compartment osteoarthritis (OA) because of tibia vara. These patients therefore have varus alignment post-operatively. It is important to determine if this compromises their outcome.

Our aims were to determine the leg alignment after Oxford UKR and to ascertain whether there was a relationship between alignment and the clinical and radiological outcomes five years after implantation.

Patients and Methods
As part of our ongoing assessment of the outcome of UKR, data were collected prospectively for over five years on 160 knees in patients receiving a UKR for isolated medial OA. The operations were carried out by the two senior authors (DWM, CAFD) using a cemented phase-3 Oxford UKR implanted through a standard minimally invasive
approach. The series comprised 72 men and 88 women with a mean age at surgery of 65.7 years (SD 9.0).

**Assessment.** All the knees were assessed prospectively before operation and regularly thereafter. For this study we used the data collected before and five years after operation. The clinical outcome was assessed using the Oxford knee score (OKS),\textsuperscript{17-19} the American Knee Society score (AKSS)\textsuperscript{20} and the activity score of Tegner and Lysholm.\textsuperscript{21} The OKS is a sensitive, simple and validated patient-based score for assessing the outcome after knee replacement. It has 12 questions, each scoring from 0 to 4. These are summed to give an overall score of between 0 (worst) and 48 (best). The AKSS is a clinician-based score with objective and functional activities. It consists of two scores, objective and functional, ranging from 0 to 100 points each and was completed independently by physiotherapists. The objective score includes data on pain, flexion, stability, alignment, flexion contracture and extension lag of the knee. One point is given for each 5° of flexion, with flexion of 125° achieving the maximum score of 25 points.

There are no guidelines as to how alignment should be assessed for the AKSS objective. However, the assessment is of the anatomical alignment, which is the angle between the shafts of the bones, rather than the mechanical alignment, which is the angle between the centres of the joints. The only landmark around the proximal femur which can be reliably identified and lies approximately over the anatomical axis of the femur is the anterior superior iliac spine (ASIS). We therefore measure the angle between the ASIS, the centre of the knee and the centre of the ankle, using a goniometer with a magnified scale and extendable arms. Valgus of 5° to 10° is considered to be the normal alignment and three points are deducted for each degree of malalignment outside this. The AKSS objective was analysed with and without these deductions for malalignment.

In order to assess the interobserver error, two observers (CJ, KR) independently measured the alignment of 53 patients. In order to determine the accuracy of the measurement, 20 long-leg alignment radiographs were studied and the angle between the anatomical axis, passing from the centre of the knee along the femoral diaphysis, and the line from the centre of the knee to the ASIS was measured.

The AKSS functional score allocates points for walking distance and stair-climbing ability and makes deductions for use of a walking aid. The Tegner\textsuperscript{21} activity scale assesses activity on a range from 0 to 10, with a score of 10 corresponding to participation in competitive sports at the elite level and 0 being associated with problems of the knee such that the patient is on sick leave or receiving disability benefits.

Radiological assessment at five years was made using fluoroscopic guidance with the patient supine. For the anteroposterior view, the direction of the beam was adjusted so that the plateau, vertical wall and keel of the tibial component were as narrow as possible, thus ensuring that the X-ray beam was parallel to the interface between the tibial bone and the implant. For the lateral radiographs, the X-ray beam was adjusted until it was parallel to the interface between the posterior femoral bone and the implant. The films were subsequently scanned digitally at a resolution of 300 dpi and converted to jpeg format (Epson Expression 1640XL scanner with transparency unit; Epson, Long Beach, California) for evaluation. The effects of magnification were corrected by comparing the apparent radius of curvature of the femoral component on the digital image with the known radius of the implanted component. The images were studied to determine if radiolucencies were present and if they were, to categorise them. Goodfellow et al.\textsuperscript{22} subdivided radiolucent lines into two distinct subtypes. The most common, a physiological radiolucency, is the line which is narrow (1 mm to 2 mm thick), well-defined and surrounded by a radiodense line. These develop during the first year after operation and consolidate thereafter. The rarer type is a pathological radiolucent line, associated with loosening or infection, which is progressive, poorly-defined, more than 2 mm thick and without a radiodense line.
Analysis of data. The knees were subdivided according to the AKSS into groups of neutral (valgus of 5° to 10°), mild varus (valgus of 0° to 4°), marked varus (varus > 0°) and valgus (valgus > 10°). The name of the group relates to their mechanical alignment and the measurements to their anatomical alignment. Since there were only two patients in the valgus (> 10° valgus) group, no further analysis of these were undertaken. Comparisons were made between the remaining three groups at five years after operation in terms of the absolute and the change in the OKS and AKSS (total, objective, functional and objective without alignment deductions). The three groups were also compared as to the presence of radiolucent lines.

Statistical analysis. The Kruskal-Wallis test was used to perform a non-parametric statistical analysis of the scores between the groups. For comparison with the sites of the radiolucent lines, Pearson’s chi-squared test was used. A significant difference was demonstrated by a p-value < 0.05. All analyses were carried out using the statistical package SPSS for Windows (version 12.0; SPSS Chicago, Illinois).

Results

Reliability of leg alignment measurements. The accuracy of alignment of the leg, measured by the goniometer, was assessed by quantifying the interobserver error and by comparison with the long-leg radiographs. The alignment of 53 knees was measured by the two observers. The mean difference between the two measurements was 0.7° (SD 2.5). The maximum difference was 5° which occurred in a very obese patient. On 20 long-leg radiographs, the mean angle between the femoral anatomical axis and the line from the centre of the knee to the ASIS was 0.8° of valgus (SD 0.5, 0.1° to 1.4°). Thus the measurement of clinical alignment reflected anatomical alignment with an accuracy of a few degrees.

Alignment. There were 116 knees (73%) with neutral alignment (valgus of 5° to 10°), 29 knees (18%) with mild varus (valgus of 0° to 4° of valgus) and 13 (8%) with marked varus (varus > 0° of varus). The details of the three main groups are shown in Table I. The varus knees, compared with the neutral, were significantly younger (p = 0.01) and significantly (p = 0.048) more likely to be male.

The clinical scores at five years are shown in Table II and Figures 2 to 4. The mean OKS increased significantly (p = 0.027) with increasing varus. The mean OKS in the neutral group was 40.0 (SD 9.0), in the mild varus group 42.0 (SD 5.0) and in the marked varus group 45.0 (SD 4). The change in the OKS, the AKSS-function and the Tegner score had a similar trend with increasing varus being associated with improving function. However, for none of these scores was the trend statistically significant. The only score which did not show this trend was the AKSS-objective. This score was significantly worse with increasing varus (p < 0.001). The mean AKSS-objective in the neutral group was 94.0 (SD 10.0), in the mild varus group 89.0 (SD 14.0) and in the marked varus group 94.0 (SD 10.0). However, the difference disappeared if the three-point deduction for each degree of malalignment was removed (neutral 94.0 SD 10.0, mild varus 89.0 SD 14.0, marked varus 94.0 SD 8.0) (Fig. 3).
At five years the incidence of radiolucent lines under the tibial component was the same for each group (Table III). All the observed tibial radiolucent lines were categorised as physiological. There were no femoral radiolucent lines.

Discussion

After implantation of an Oxford UKR, 116 knees (73%) were neutrally aligned, 29 (18%) were in about 5° (mild varus) and 13 (8%) were in about 10° (marked varus). It would be unacceptable to have such a high incidence of varus with a TKR since this is associated with an unsatisfactory functional outcome and increased failure from loosening and wear.1-3 Our study has shown that for UKR, varus malalignment does not compromise the functional outcome. Furthermore, since the incidence of radiolucency was the same in each group and as the mobile-bearing Oxford UKR is highly resistant to wear,23 varus malalignment is unlikely to increase the rate of failure from wear or loosening. Further evidence that varus malalignment does not compromise the long-term outcome is that although 25% of Oxford UKRs may be implanted in varus, the long-term failure rate is less than 10%.15,24,25

With all the scores of functional outcome, there was a trend towards improved results with increasing varus. With the OKS, this trend was statistically significant. Although this may be because patients with varus tend to be younger and male, it may also be that varus provides a functional advantage. There is some anecdotal evidence to support this, such as the observation that football players have a high incidence of varus.26 Whatever the explanation, it is clear that varus does not compromise the outcome. It is therefore surprising that there was a highly significant decrease in the AKSS-objective with increasing varus. Since this decrease disappeared when the three-point deduction for each degree of malalignment was removed, it is likely that it was a result of this deduction. An analysis25 of the marked varus group made it clear that the deduction is inappropriate. None of the patients in this group had an excellent AKSS-objective score, yet they had the highest OKS, and 75% had an excellent AKSS-functional, and 92% an excellent AKSS-objective score without the deduction. This somewhat arbitrary deduction may be appropriate for TKR, but it does not appear to be justified for UKR. Since 25% of knees with UKR may be in varus, these patients will have worse AKSS scores than those with a TKR even if they have a similar or better functional outcome. This bias against UKR is made worse by the fact that the AKSS gives a maximum score for 125° of flexion,
whereas a knee with a UKR tends to flex to much more than 125° compared with that of a TKR which tends to flex less than 125°. Thus the AKSS in its current form is not a reliable tool for assessing the outcome of UKR.

Biomechanical analysis explains why varus causes problems after TKR, but not after UKR. If a TKR is in varus there will be eccentric loading and rocking of the components which will induce tension in the implant-bone interface on the unloaded side of the component, and will result in loosening. With UKR, whatever the alignment of the leg, the centre of the force is likely to be near the centre of the component. Therefore the implant-bone interface will be compressed and there should be no loosening. A further concern is that if the leg is in varus, the loading on the components will increase in a UKR. Although this may be the case in extension, it is unlikely to be a problem since the overall loads are relatively low. The very high loads occur in a knee when it is flexed, such as when getting out of a chair. In flexion, most loads are generated by the quadriceps muscle. Since the patellar tendon is roughly central between the compartments, the forces generated in them will not be influenced greatly by malalignment.

The philosophy behind the use of the Oxford UKR is very different to that of TKR. The former is only used when the ligaments are functionally normal with the aim of restoring knee kinematics. The ligaments are never released. The balance of the ligaments is restored by positioning the femoral component accurately and their tension by inserting an appropriate thickness of bearing. As the tension is restored to normal, the intra-articular deformity secondary to arthritis is corrected. However, many patients also have an extra-articular deformity, tibia vara. This is not corrected. Therefore after the operation these patients have the alignment restored to their pre-disease varus. The patients with varus alignment of 5° or 10° post-operatively would have had varus of 5° or 10° before they developed arthritis.

Our study does not demonstrate that alignment after UKR does not matter, but that it should be returned to the pre-disease state. If this is not restored, the outcome is likely to be compromised. For example, if the deep fibres of a normal medial collateral ligament are released, either deliberately in an attempt to achieve a straight leg in a patient with tibia vara, or accidentally during preparation of the tibia, this will result in overcorrection of the intra-articular deformity, which will alter the knee kinematics and give an increased risk of dislocation of the bearing, poor function and failure.

The main limitation of our study was that the alignment of the leg was measured clinically rather than by long-leg radiographs. We routinely assess the AKSS, which requires a clinical measurement of alignment. Since we were unable to find any reliable method for measuring this clinically, we developed a technique involving the use of a long-arm goniometer with a magnified scale to measure the angle between the ASIS, the knee and the ankle. The technique is accurate to within a few degrees and therefore can reliably categorise alignment into 5° intervals, which is the required level of accuracy for this study.

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References