Does improved instrumentation result in better component alignment in total knee arthroplasty?

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Abstract

Accurate component alignment and joint line reproduction in total knee replacement (TKR) is crucial for successful clinical outcome. Advances in instrumentation and better understanding of the biomechanics can help to achieve better three dimensional alignments of TKR components and joint line restoration. We compared the accuracy of component alignment and joint line restoration with the use of 2 different TKR instrumentation kits (an older Gobot and a newer Xcelerate). Retrospective study of 150 consecutive patients undergoing primary TKR had their pre and post-operative x-rays reviewed. Seventy-five patients (group A) had their TKR using the older instrumentation kit (Gobot) and 75 (group B) had the newer version (Xcelerate). The positioning of the prosthesis components were assessed using the American Knee society radiographic evaluation method and the joint line position using the Figgie's method. The results from the two groups were statistically compared. There was a significantly greater elevation of the joint line position in TKRs done with the Gobot instrumentation (mean 4.49 mm vs. 2.71 mm in group B, P=0.03), and significant differences in the mean tibial component angle cTCA (group A 88.6º, group B 90.1º, P=0.04) and the mean Q angle (group A 6.28º valgus, group B 8.45º valgus, P=0.04). Use of the newer Xcelerate instrumentation was associated with better restoration of joint line position, however the femoral component flexion and posterior slope of the tibial component ere found to be above the desired level. Hence the overall differences between the two groups were found to be small.

Introduction

A successful total knee replacement (TKR) requires that the implanted components are accurately aligned,[1-3] the collateral ligaments are equally balanced and the joint line position is restored to its anatomical level. It is widely acknowledged that the ideal coronal alignment of the knee joint following TKR should be between 4-10º of valgus. A knee with neutral alignment or one with a varus deformity results in unequal loading across the implant and is associated with a higher rate of failure.[4] Restoration of the joint line position has also been shown to be important, with elevation >8 mm associated with inferior clinical outcome. Joint line depression may be associated with retropatellar pain and increased risk of patellar subluxation.

The medial proximal tibial angle of the normal knee is 87±2°. This is equivalent to the tibial component angle (TCA). Equal loading of the components is desirable. With total condylar prosthesis this occurs when the femoral component is in 5-7° of valgus and the tibial component is perpendicular to the anatomical axis (TCA 90°). With the kinematic knee design this occurs when the femoral component is in 9° of valgus and the tibia is in 2° of tibial.[5]

Despite these differences between various prostheses, the aim of TKR is to position the tibial component in neutral, with the coronal alignment of the knee then being determined by femoral resection alone.[6] Previous studies have shown that the ideal alignment is achieved in only around two-thirds of cases.[3]

While coronal alignment and clinical outcome has been extensively investigated the ideal alignment in the sagittal plane has been mostly overlooked. One study highlights the propensity to place the femoral component in flexion but does not correlate this with clinical outcome.[3] Another factor that has been demonstrably linked to the functional outcome of the prosthesis is the restoration of the joint line position.[7] Despite maintenance of perfect axial alignment, a prosthetic joint line different to that of the natural knee can cause problems. Both elevation (>8 mm) and depression of the joint line have been associated with inferior clinical outcome, the latter being associated with retropatellar pain and patellar subluxation.[8,9] The last three decades have seen a continual development of the instrumentation designed to assist surgeons in achieving these goals. The aims of this current study are twofold: i) to examine whether either of two instrumentation systems designed to implant a particular type of TKR result in more accurate component alignment in the coronal and sagittal plane; ii) to examine if either of the two instrumentation systems reproduce the joint line position more reliably.

Materials and Methods

Pre and post-operative radiographs of 150 patients undergoing Kinemax Plus knee replacement (Stryker Howmedica, Osteonics, Newbury, UK. Ltd.) were studied. Half of the patients had their knee replacement performed with the use of the older instrumentation kit, called GOBOT (group A) (Figure 1) While for the other half, the newer version, Xelerate (group B) (Figure 2) was used. A single surgeon performed all these operations,

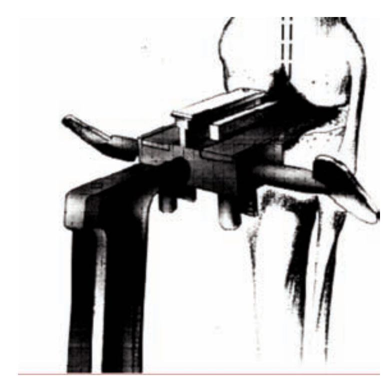

Figure 1. Illustration of the Gobot instrument.

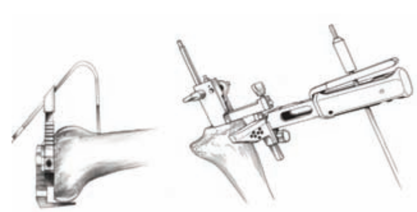

Figure 2. Illustrations of the Xcelerate instrumentation.

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using a standard medial para-patellar approach, with the use of tourniquet.

All patients had weight-bearing, short-leg, AP and lateral radiographs pre and post-operatively, once they were fully mobile. The most representative pre and post-operative radiographs were utilized. Two fully trained, independent observers then assessed these radiographs. Component position was assessed using the American Knee Society Radiological Evaluation System (Figure 3). Joint line position assessment was performed by Figgie's method. Component alignment was measured using the method described by Bach *et al.*[10] and employed by Bankes *et al.*[3]

Coronal alignment

The coronal alignment of the knee was determined on the AP knee radiograph. The alpha angle was measured between the parallel to the femoral condyles and a line drawn along the femoral shaft axis. The beta angle was calculated between the parallel to the tibial metal baseplate and a line drawn along the tibial axis shaft. The femoral and tibial axis lines were determined by connecting the midpoints at three points on the femur and tibia. The angle between the anatomical axes of the tibia and femur is the coronal angle of the knee (CAK). This is calculated indirectly as the sum of (cTCA-90) and (cFCA-90), with a positive value indicating valgus alignment (Figure 4).

Sagittal alignment

The sagittal alignment was determined on the lateral knee radiograph. The femoral component flexion/extension angle was determined by a line drawn perpendicular to the distal metal-cement interface of the femoral prosthesis and a line parallel to the femoral shaft axis. The sagittal tibial angle was calculated from a line drawn parallel to the tibial metal baseplate and the tibial shaft axis (Figure 4).

Joint line measurement

The pre and post-operative joint line measurements were made on the lateral knee radiograph. The perpendicular distance between two parallel lines, one along the weight-bearing surface of the tibia and the second, parallel to the tibial tuberosity determined joint line position. In the post-operative radiographs as the tibial polyethylene insert is radiolucent, the femoral condyle margin was taken as the origin of the weight bearing line. The difference in this perpendicular distance between pre and post-operative radiographs represented the change in the joint line position. The joint line was considered to be elevated in cases where the difference between pre and post-operative radiographs exceeded 5 millimetres (Figure 5).

The tibial and femoral Component angles in the coronal plane (cTCA and cFCA) and in the sagittal plane (sTCA and sFCA) were measured, as was the change in joint line position. Table 1 represents the values obtained for group A (GOBOT) and Table 2 for group B (Xcelerate)

Statistical methods

Results for the two groups were compared using *t*-testing (parametric data) and Wilcoxon Sum-of-Ranks testing (non-parametric data). Inter-observer reliability was calculated.

Results

Pre and post-operative radiographs of 150 consecutive patients undergoing primary knee replacement between 2004 and 2008 were studied. A single surgeon performed all these operations through a medial Para patellar approach. Tourniquet was used in all of the patients.

Seventy-five patients had their operation performed with the older instrumentation (group A) and 75 with the newer version (group B). Component alignment in coronal and sagital plane and joint line restoration were analyzed.

Coronal plane alignment

Tibial component placement in valgus was statically better with the newer instrumentation. There was a significant difference in the mean cTCA (group A: 88.6°, group B: 90.1°, P=0.04). Femoral component alignment in the coronal plane did not appear to be affected by change in instrumentation.

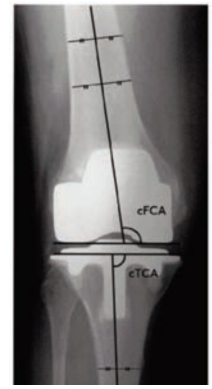

Figure 3. Radiographic assessment of the femoral and tibial components as proposed by the Knee Society.

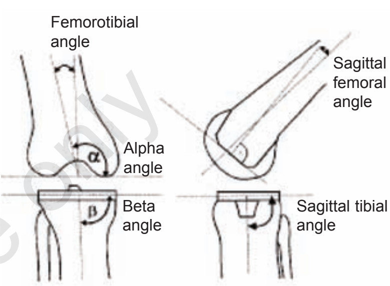

Figure 4. Radiographic evaluation proposed by the American knee society. Assessment of the femoral and tibial component.

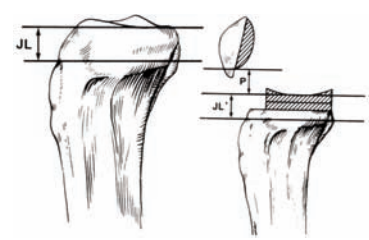

Figure 5. Measurement of joint line position as described by Figgie *et al.*

Table 1. Measurements of cTCA, cFCA, CAK, sTCA, sFCA and joint line elevation for Group A Gobot.

Group A	No. of knees	Mean	Standard deviation	Min	Max
cTCA, degrees	75	88.53	2.43	80.00	92.00
cFCA, degrees	75	97.72	3.79	92.00	111.00
CAK, degrees	75	6.26	4.48	-4.00	21.00
sTCA, degrees	75	84.00	3.94	75.00	92.00
sFCA, degrees	75	5.19	3.51	-2.00	14.00
JL elevation, mm	75	3.04	5.25	-9.00	19.00

Table 2. Measurements of cTCA, cFCA, CAK, sTCA, sFCA and joint line elevation for Group B Xcelerate.

Group A	No. of knees	Mean	Standard deviation	Min	Max
cTCA, degrees	75	90.1	2.43	80.00	92.00
cFCA, degrees	75	97.72	3.79	92.00	111.00
CAK, degrees	75	7.17	4.48	-4.00	21.00
sTCA, degrees	75	82.38	3.94	75.00	92.00
sFCA, degrees	75	6.64	3.51	-2.00	14.00
JL elevation, mm	75	1.62	5.25	-9.00	19.00

Sagittal plane alignment

Newer instrumentation appeared to affect both femoral and tibial component alignment in the sagittal plane. Increased flexion of both components was noted with the Xcelerate instrumentation, although this was statistically different with femoral components only. There were significant differences in the mean Q angle (group A 6.26° valgus, group B 8.45° valgus, P=0.04).

Joint line measurement

Knees with Xcelerate instrumentation appeared to have better joint line restoration. There was a significantly greater change in joint line position (group A 4.49 mm, group B 2.71 mm, P=0.03), with a lesser value indicating a joint line closer to normal.

The results in general are favourable with the use of the new Xcelerate kit. Tibial component position in the coronal plane and joint line restoration were much superior compared to the older kit. With the use Accelerate instrumentation, the sagital alignment however appeared less than favourable with the femoral component being placed in significantly more flexion, compared the older instrumentation. Joint line restoration was much more superior with the Xcelerate kit.

Discussion

The importance of physiological alignment of components in total knee arthroplasties has been proven to be of importance in providing a successful clinical outcome.[1-3] The subsequent result of a mal-aligned prosthesis has detrimental affects on the knee, in particular contributing to the unequal load sharing of the tibial plateau.[5] Due to the bio-mechanics, knee arthroplasty, unlike hip arthroplasty is very reliant on instruments providing accurate and reliable bone cuts, before component positioning. Modernization of instrumentation hopes to achieve this.

Our results show that both versions of knee arthroplasty instrumentation achieve good component alignment in both the coronal and sagital plane, in comparison to expected normal values, suggesting that both systems are effective. Xcelerate instrumention does achieve a more valgus tibial placement. This is beneficial in the long-term survivorship of the arthroplasty. The new version however seemed to place the femoral component in more flexion than the GOBOT. Lot of research has been aimed at looking at femoral component rotation, as it crucial to patello-femoral articulation. Increased flexion of the femoral component could limit the maximum flexion achieved by the patient and in the long-term lead to stress risers around the femoral component. The results of the inter-observer reliability for the mean and standard deviations of the five measured angles proved to range from fair to good with an average of 0.49, illustrating a reasonable level of reliability for the obtained results. The results of this study suggest that, the use of the Xcelerate instrumentation is associated with a higher success in restoring the joint line position, and is more effective in preventing the implantation of the tibial component in varus.

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