The Relationship Between Pre- and Postoperative Range of Motion Utilizing Three Cruciate-Retaining Knee Prostheses

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Abstract
We prospectively examined the relationship between pre- and postoperative range of motion utilizing three cruciate retaining knees with various mechanical flexion potential, i.e., two at about 130–135 degrees (one with a bearing having a posterior lip and the other without) and the third at about 140–145 degrees. Combining data from the three cohorts, patients with the following preoperative flexion values achieved the indicated mean changes in flexion (delta) at one year: <90 degrees flexion (Δ23.6 degrees), 91–105 degrees flexion (Δ19.3 degrees), and >105 degrees flexion (Δ1.8 degrees)—improvement was inversely related to preoperative flexion. The high flex knee yielded the best improvement in range of motion (9.7 degrees increase) in the highest flex preoperative group compared to that of the other knees (-7.4 degrees to 2.9 degrees).

Keywords: total knee arthroplasty, prosthesis, range of motion, flexion, outcome

Introduction
Range of motion (ROM) and flexion are important outcome measures following total knee arthroplasty (TKA).1-4 Many of the activities of daily living require knee flexion in the range of 45 degrees to ~105 degrees.5 As such, it has been recommended that the goals of TKA should include obtaining knee ROM of zero degrees to 105 degrees.2 Several factors affect postoperative ROM, including preoperative, operative and postoperative factors, with preoperative ROM one of the most important.1,2,6-10 It has been found that, postoperatively, knee ROM tends to reach a middle ground, whereby knees with poor ROM preoperatively tend to gain motion, those that have good ROM preoperatively tend to lose motion, and those that are intermediate preoperatively tend to remain about the same.1,8,10 It is possible that the specific relationship between pre- and postoperative ROM may be a function of the flexion potential of the knee prosthesis which is related to implant design. This study investigated the relationship between pre- and postoperative flexion of three cruciate-retaining knees, including two with a flexion potential of 130–135 degrees and one with a flexion potential of 140–145 degrees. The hypothesis was that the three knees would exhibit a similar relationship between pre- and postoperative flexion, with the high flex knee exhibiting superior postoperative flexion.

Materials and Methods

Prostheses
The performance of three primary, cruciate-retaining knees was studied prospectively following IRB approval, i.e., the Maxim® knee with either of two bearings, i.e., a standard bearing (PCR) (Jan. 2000–March 2001) and a bearing with a posterior lip (PCR/Lip) (Dec. 1999–June 2000), and the Vanguard™ CR knee (Jan. 2000–ongoing). The mechanical flexion potential of the Maxim® knees was 130–135 degrees, and that of the Vanguard™ knee was 140–145 degrees.

Inclusion/Exclusion criteria
Inclusion criteria were a primary diagnosis of osteoarthritis, rheumatoid arthritis or traumatic arthritis; correction of varus, valgus or post-traumatic deformity; and the correction of unsuccessful osteotomy or arthrodesis. Absolute exclusion criteria were infection, sepsis, osteomyelitis or revision of a previous total knee replacement.

Patient demographics
Patient demographics are shown in Table 1. There was no significant difference in preoperative ROM between the three cohorts.

Table 1. Patient demographics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Prostheses</th>
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<tbody>
<tr>
<td></td>
<td>Maxim® PCR</td>
</tr>
<tr>
<td>Number of patients (knees)</td>
<td>62 (71)</td>
</tr>
<tr>
<td>Age (y)</td>
<td>66.8±10.9</td>
</tr>
<tr>
<td>Female/Male</td>
<td>38/24</td>
</tr>
<tr>
<td>Principle Diagnosis</td>
<td>Osteoarthritis</td>
</tr>
<tr>
<td>Other</td>
<td>0/71</td>
</tr>
<tr>
<td>Preoperative flexion (degrees)</td>
<td>108.0±15.5</td>
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<td></td>
<td>(65–130°)</td>
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**Surgical protocol**
The Maxim® knee patients underwent a medial parapatellar approach, with cement used to fix both the femoral and tibial components. The Vanguard™ knee patients underwent a mini-subvastus approach, with the femoral component press-fit and the tibial component cemented (hybrid fixation).

**Rehabilitation protocol**
Following surgery, patients underwent physical therapy at home or in a rehab center, as appropriate. Physical therapy included continuous passive motion (CPM) for all Vanguard™ and Maxim® PCR/Lip knees and for 28 of the 71 Maxim® PCR knees.

**Clinical follow-up**
In addition to the preoperative assessment, passive ROM was measured at one year. From this value, passive flexion was derived.

**Data analysis**
Changes in flexion were calculated on a paired patient basis by subtracting the preoperative flexion from the postoperative flexion for each patient, with a positive delta signifying improvement and a negative delta signifying regression. Patients were grouped by type of implant received, i.e., Maxim® PCR, Maxim® PCR/Lip and Vanguard™ CR knees and by their level of preoperative flexion, i.e., <90 degrees, 91–105 degrees and >105 degrees—consistent with Anouchi, et al. Statistical comparisons of means for delta flexion were performed using one-way analysis of variance, followed by a post hoc Student-Newman-Keuls test, with significance taken for p < 0.05.

**Results**
Figure 1 shows the delta flexion at one year for all of the patients combined into the three categories of preoperative flexion. For the <90 degrees, 91–105 degrees and >105 degrees groups, values were 23.6±15.3 degrees, 19.3±11.3 degrees and 1.8±14.7 degrees respectively. The delta flexion corresponding to the group with the best preoperative flexion was significantly less than that corresponding to the other two groups. Figure 2 shows the delta flexion data for patients stratified by both implant type and preoperative flexion. For the <90 degrees groups, the mean delta flexion was 21.1 to 27.3 degrees, with no significant differences among them. Similarly, for the 91–105 degrees groups, the mean delta flexion was 14.2 to 25.7 degrees, with no significant differences among them. For the group with the best preoperative flexion (>105 degrees), however, mean delta flexion for the Vanguard™ (9.7 degrees) and the Maxim® PCR (2.9 degrees) knees were significantly greater than that of the Maxim® PCR/Lip knee (-7.4 degrees). Furthermore, as can be seen from Figure 2, there was a general trend for the mean delta flexion to diminish for each knee type with improvement in preoperative flexion. The only knee to regress in flexion, -7.4 degrees on average, was the Maxim® PCR/Lip knee for the highest, preoperatively functioning group. Although the differences were not significant in all cases, Figure 2 suggests that the high flex Vanguard™ knee exhibited the greatest one-year flexion for all preoperative flexion categories.

**Discussion**
It is important that the patient and surgeon alike have realistic expectations of functional outcome following TKA. The level of postoperative ROM and, in particular, flexion, strongly influences the ability of the patient to perform the activities of daily living. To the extent that preoperative range is predictive of postoperative range, studies of this relationship can be a useful tool to the surgeon to help ensure the best possible clinical outcome.

Light has been shed on two issues. First, we have provided further evidence that there is an inverse relationship between preoperative flexion and postoperative flexion, in agreement with previous studies.
The actual relationship will, of course, depend on which values in flexion (or ROM) are used to define the patient groups. Second, we have shown that even patients with high-end preoperative flexion can achieve significant gain in flexion with the use of a high flex knee.

There were several limitations to our study, principally related to the varied surgical techniques and rehabilitation that were employed. For instance, all Maxim® knee patients underwent a medial parapatellar approach, while the Vanguard™ patients underwent a minisubvastus approach. The Maxim® knees were implanted with a fully cemented technique, while hybrid fixation was employed for the Vanguard™ knees. Finally, CPM was used postoperatively for all Vanguard™ and Maxim® PCR/Lip knees and in only about 40% of the Maxim® PCR knees. There is a large body of evidence, however, that suggests that the differences in surgical approach,¹³–¹⁷ fixation method¹⁸ and use of CPM¹⁹,²⁰ were not relevant at the one-year follow-up interval.

Conclusion

The inverse relationship between pre- and postoperative knee flexion was confirmed in our study for knees prosthesis of standard flexion (130–135 degrees) and high flexion (140–145 degrees). For the patient with high-end preoperative knee flexion, use of a high flex knee prosthesis may be of benefit to help minimize the occurrence of range regression and maximize the potential for an increase in range.

References
