Knee flexion after total knee arthroplasty

PH Li, YC Wong, YL Wai
Department of Orthopaedics and Traumatology, Yan Chai Hospital, Hong Kong

ABSTRACT

Purpose. To identify factors related to knee flexion after total knee arthroplasty in a Chinese population.
Methods. Records of 242 total knee arthroplasties were retrospectively reviewed. The parameters evaluated were age, gender, diagnosis, preoperative knee flexion and extension, preoperative flexion arc, tibiofemoral angle, Knee Society knee score and functional score, and implant design.
Results. Advanced age, female gender, and good preoperative flexion and flexion arc were related to better postoperative flexion. Postoperative flexion tended to migrate to the middle range despite different ranges of preoperative flexion. Preoperative tibiofemoral malalignment had no significant effect on postoperative flexion.
Conclusion. Contemporary designs of posterior stabilised prostheses with right and left femoral components were superior to older designs.

Key words: arthroplasty, replacement, knee; Asian continental ancestry group; range of motion, articular

INTRODUCTION

Postoperative knee flexion is an important indicator of success in total knee arthroplasty (TKA). Satisfactory flexion is required for various activities of daily living: 67º is required for the swing phase of gait, 83º for climbing up stairs, 90º for descending stairs, and 93º for rising up from a chair. In North America and Europe, 110º or 115º flexion are considered adequate for the lifestyle of seniors. Deep flexion is especially important for Asian and Middle Eastern populations as many of their cultural and religious activities demand full flexion.

The mean postoperative flexion in most western studies was around 100º to 115º. Some Japanese groups achieved excellent postoperative flexion: one attained 127º, attributing it to dedicated instrumentation for soft tissue balancing and vigorous rehabilitation. Another achieved 124º mean range of movement (ROM) using Bisurface knee prosthesis. Factors influencing the postoperative ROM were reported to be preoperative ROM, primary indication, height of postoperative joint line, patellar thickness, postoperative pain and rehabilitation.

We aimed to identify the determinants of postoperative knee flexion through reviewing the
TKA results in 173 Chinese patients.

MATERIALS AND METHODS

We retrospectively reviewed 242 (119 left and 123 right) primary TKAs in 173 patients performed by a single experienced surgeon between January 1995 and December 2003 inclusive. The follow-up period was 12 to 108 (mean, 50) months. 132 (76%) were female and 41 (24%) were male. The mean patient age was 71 (standard deviation [SD], 7; range, 38–87) years. The diagnoses were osteoarthritis (n=219), rheumatoid arthritis (n=20), and osteonecrosis (n=3).

Patients with incomplete data (n=1) or with severe complications (n=12) e.g. infection (n=3), popliteal arterial thrombosis (n=1), intra-operative patella tendon rupture (n=1), complications requiring concomitant osteotomy (n=2), revision for aseptic loosening within one year (n=1), cerebrovascular accidents (n=2), and dying of unrelated causes within one year of operation (n=2) were excluded.

Patient parameters were classified into preoperative, intra-operative or postoperative groups. A single surgeon assessed all postoperative parameters >12 months after the operation, when chance of further improvement was considered minimal.10,11 The preoperative parameters were age, gender, diagnosis (osteoarthritis, rheumatoid arthritis, or osteonecrosis), knee flexion, extension, flexion arc, tibiofemoral angle, and Knee Society knee score and functional score. The intra-operative parameter was prosthesis design: Insall-Burstein II (n=124), Legacy (n=40), Press Fit Condylar-Sigma (n=37), Anatomic Modular Knee (n=22), Legacy-flex (n=15) and Low Contact Stress (n=4). Most entailed posterior-stabilised designs. The postoperative parameters corresponded to the preoperative ones.

Active knee flexion, extension, and flexion arc were measured using a goniometer with patients lying supine. Weight-bearing radiography was used to measure the tibiofemoral angle.

The Pearson correlation test and 2-tailed Student’s t test were used to compare the change of parameters before and after surgery, as well as the association between various preoperative parameters and postoperative knee flexion. Preoperative knee flexion and tibiofemoral angle were stratified into 3 groups (≤90º, 91º–110º, and >110º) to compare differences in postoperative flexion. The postoperative flexion of patients with different prostheses was also compared.

RESULTS

Most parameters had significant changes (p<0.05) after the operation. Although flexion decreased after surgery, the flexion arc, the extension, and the Knee Society knee score and functional score improved significantly and the tibiofemoral angle optimised (Table 1).

The correlation coefficient of preoperative and postoperative flexion was 0.26 (p<0.01). The knees were divided into 3 groups according to the preoperative flexion category (≤90º, 91º–110º, and >110º) and the mean preoperative and postoperative ranges of flexion were compared. There was no significant difference in flexion for 91º–110º group before and after surgery. However, after surgery there was a flexion gain in the ≤90º group, and a flexion loss in the >110º group; both differences were statistically significant (p<0.001, Table 2).

Other factors significantly associated with postoperative flexion were gender, age, and preoperative flexion arc. The mean postoperative flexion of females and males were 109.3º and 103.9º respectively; the difference was statistically significant (p=0.01). The correlation coefficient of age with postoperative flexion was 0.26 (p<0.01), and age with preoperative flexion arc was 0.21 (p<0.01). Preoperative extension, the diagnosis, the Knee Society knee score and functional score had no significant association with postoperative flexion.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Preoperation (mean±SD)</th>
<th>Postoperation (mean±SD)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion arc</td>
<td>98.0º±18.9º</td>
<td>102.8º±15.3º</td>
<td>0.017</td>
</tr>
<tr>
<td>Flexion</td>
<td>107.5º±14.1º</td>
<td>105.1º±14.2º</td>
<td>0.002</td>
</tr>
<tr>
<td>Extension</td>
<td>9.4º±8.6º</td>
<td>2.4º±4.9º</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Tibiofemoral angle</td>
<td>186.0º±10.3º</td>
<td>175.0º±2.5º</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Knee score</td>
<td>44.1±14.2</td>
<td>92.7±6.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Functional score</td>
<td>46.3±16.2</td>
<td>69.1±21.3</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table 1

Various parameters before and after surgery
The effect of the preoperative tibiofemoral angle on postoperative flexion was examined by stratifying patients into 4 groups: tibiofemoral angle of 5°–9° as neutral, ≥10° as valgus, 4° to -10° as mild varus and <-10° as severe varus. Although the preoperative ranges of flexion of the mild and severe varus groups were significantly less than those of the neutral group, the corresponding postoperative ranges of flexion attained were not significantly different from those of the neutral group. There was no significant difference in flexion of the valgus and the neutral groups before and after surgery (Table 3).

Table 3
Preoperative and postoperative flexion in different tibiofemoral groups

<table>
<thead>
<tr>
<th>Preoperative tibiofemoral angle</th>
<th>Valgus (≥10°)</th>
<th>Neutral (5°–9°)</th>
<th>Mild varus (4° to -10°)</th>
<th>Severe varus (&lt;-10°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of knees</td>
<td>17</td>
<td>33</td>
<td>134</td>
<td>58</td>
</tr>
<tr>
<td>Mean preoperative flexion*</td>
<td>116.8° (p=0.37)</td>
<td>113.4°</td>
<td>107.0° (p=0.028)</td>
<td>104.2° (p=0.0016)</td>
</tr>
<tr>
<td>Mean postoperative flexion*</td>
<td>110.3° (p=0.085)</td>
<td>100.8°</td>
<td>105.5° (p=0.087)</td>
<td>102.7° (p=0.25)</td>
</tr>
</tbody>
</table>

* p value as compared with the neutral group

Table 4
Preoperative and postoperative flexion according to different prosthesis design

<table>
<thead>
<tr>
<th></th>
<th>Insall-Burstein II</th>
<th>Legacy</th>
<th>Press Fit Condylar-Sigma</th>
<th>Anatomic Modular Knee</th>
<th>Legacy-flex</th>
<th>Low Contact Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of knees</td>
<td>124</td>
<td>40</td>
<td>22</td>
<td>15</td>
<td>4</td>
<td>115.0°</td>
</tr>
<tr>
<td>Mean preoperative flexion*</td>
<td>106.7º (p=0.68)</td>
<td>105.8º</td>
<td>110.3º</td>
<td>107.3º</td>
<td>107.3º</td>
<td>115.0°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(p=0.14)</td>
<td>(p=0.47)</td>
<td>(p=0.87)</td>
<td>(p=0.053)</td>
</tr>
<tr>
<td>Mean postoperative flexion*</td>
<td>103.4</td>
<td></td>
<td>110.9º</td>
<td>104.3º</td>
<td>104.3º</td>
<td>91.3°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(p=0.023)</td>
<td>(p=0.0037)</td>
<td>(p=0.77)</td>
<td>(p=0.34)</td>
</tr>
</tbody>
</table>

* p value as compared with the Insall-Burstein II group

The effect of the preoperative tibiofemoral angle on postoperative flexion was examined by stratifying patients into 4 groups: tibiofemoral angle of 5°–9° as neutral, ≥10° as valgus, 4° to -10° as mild varus and <-10° as severe varus. Although the preoperative ranges of flexion of the mild and severe varus groups were significantly less than those of the neutral group, the corresponding postoperative ranges of flexion attained were not significantly different from those of the neutral group. There was no significant difference in flexion of the valgus and the neutral groups before and after surgery (Table 3).

Table 4 shows the extent of preoperative and postoperative flexion attained using different prostheses. Insall-Burstein II, the most common design, was compared with other prostheses. Although there was no significant difference in preoperative flexion, the Legacy group and the Press Fit Condylar-Sigma group yielded significantly better postoperative flexion. There was no significant difference in postoperative flexion between the Legacy group and the Legacy-flex group.

DISCUSSION

TKA is a standard treatment for end-stage knee pathologies aiming to provide a pain-free and stable knee with good ROM. With the advances in implant design and surgical technique, the first 2 goals are usually achieved. However, improvement in ROM is still a hotly debated issue.
The mean postoperative flexion of our patients was 105.1º, with a loss of 2.4º flexion but a gain of 4.8º flexion arc after surgery, because of an increase in extension by 7.0º. The flexion of our patients was comparable to what has been reported in other studies (ranging from 100º to 115º). This degree of flexion is sufficient for most activities of daily living for western populations. However, for the Asian and Islamic populations, flexion up to as much as 160º is required for prolonged kneeling and squatting. As flexion of contemporary TKA rarely exceeds 120º, the lifestyle of many patients has to be compromised.

Preoperative flexion is considered the most critical determinant of postoperative flexion. Poor and long-standing preoperative flexion may result in bone and soft tissue changes, which may not be reversed by TKA. There was a positive correlation between preoperative and postoperative flexion; the better the preoperative flexion, the better the postoperative flexion. However, good flexors tend to lose flexion while the poor flexors tend to gain some. Postoperative flexion therefore migrates towards the middle range. TKA can produce a predictable result, not totally dictated by poor preoperative flexion. However, restoration or even improvement in ROM for those with good preoperative flexion may be limited by implant design and soft tissue tension.

Other factors that were significantly associated with postoperative flexion included age, gender, and the preoperative flexion arc. Females and the elderly had better results, probably because of laxer soft tissue and less scarring than in males and younger patients. Younger age was related to lower postoperative ROM, though the principal predictive factor was still the preoperative ROM.

For knees with severe coronal deformities, poor postoperative ROM may result from scarring after extensive soft tissue release. A varus tibiofemoral angle of ≤6.5º preoperatively was predictive of a lower postoperative flexion. Postoperative flexion in patients who had release of the deep medial collateral ligament and the superficial medial collateral ligament for varus tibiofemoral alignment was 3.3º less than in the reference group. In our study, preoperative varus or valgus deformity did not predict poor postoperative flexion. This may be reassuring to surgeons performing extensive yet balanced soft tissue release for severely deformed knees.

Contemporary designs like Legacy and Press Fit Condylar-Sigma could produce better postoperative flexion than the classic Insall-Burstein II. Although there was no significant difference in preoperative flexion, the postoperative flexion of Legacy and Press Fit Condylar-Sigma were 6.1º and 7.4º more than that of Insall-Burstein II respectively. Legacy has a better cam-spine mechanism because of a longer trochlear groove and a more posteriorly placed femoral cam. Whether this difference is real or due to the learning curve of surgeons and better instrumentation is questionable. Legacy-flex is a high flexion arthroplasty design, with modifications in the posterior femoral condyles, tibial polyethylene insert, and cam-spine mechanism, all designed to achieve deep flexion. However, in our limited number of cases it did not produce a result superior to Legacy and Press Fit Condylar-Sigma. No difference was found in postoperative ROM between Legacy and Legacy-flex knees.

One drawback to this study was that knee flexion, extension, and flexion arc were measured using a goniometer with the knees unloaded. Unloaded flexion does not reflect functional flexion. The more accurate method with less inter- and intra-observer variation is to measure weight-bearing radiographs. Measurement bias can be eliminated by employing multiple third-party examiners instead of using a single surgeon as in this study. The interaction of different variables was not taken into account, though multiple regression analysis can eliminate this problem. Prostheses used in this study were a mixture of 6 different designs; the numbers of some were too small to yield statistically significant results.

**CONCLUSION**

Advanced age, female gender, and good preoperative flexion and flexion arc are related to better postoperative flexion. Postoperative flexion tends to migrate to the middle range despite different degrees of preoperative flexion. Preoperative axial malalignment and thus extensive soft tissue release do not affect postoperative flexion. Contemporary prostheses yield better flexion.

**REFERENCES**


