Natural history of fixed flexion deformity following total knee replacement
A PROSPECTIVE FIVE-YEAR STUDY

J. Aderinto, I. J. Brenkel, P. Chan
From Queen Margaret Hospital, Dunfermline, Scotland

We investigated fixed flexion deformity (FFD) after total knee replacement (TKR). Data relating to 369 cruciate-retaining unilateral TKRs performed at a single institution were collected prospectively. Flexed flexion was measured pre-operatively and at one week, six months, 18 months, three years and five years after surgery.

Using binary logistic regression, pre-operative FFD was a predictor of post-operative FFD > 10° at one week (p = 0.006) and six months (p = 0.003) following surgery. Gender was a predictor at one week (p = 0.0073) with 24% of women showing a FFD > 10° compared with 37% of men.

We have shown that a gradual improvement in knee extension can be expected up to three years after surgery in knees with FFD. By this time residual FFD is mild or absent in the majority of patients, including those who had a severe pre-operative FFD.

The incidence of fixed flexion deformity (FFD) following total knee replacement (TKR) can be as high as 17%. FFD compromises results because satisfactory movement and pain relief are important for good function. The pre-operative prediction of a post-operative FFD could highlight patients at risk of a poor functional outcome. Our aim was to identify predictors and monitor the natural history of FFD up to five years post-operatively.

Patients and Methods
Data were collected on 369 consecutive unilateral TKRs performed between 1995 and 1998. All patients underwent posterior cruciate-retaining arthroplasties (PFC, DePuy International, Leeds, UK). The indications for surgery were rheumatoid or osteoarthritis with symptoms perceived to be causing significant morbidity. The operations were performed by six senior orthopaedic surgeons, or trainees supervised by one of these surgeons. The mean age of the patients was 69 years (32 to 90); there were 171 men and 198 women. The diagnosis was osteoarthritis in 328 (89%) knees and rheumatoid arthritis in 41 (11%) (Table I).

Knees were evaluated by the American Knee Society scoring system one week pre-operatively and at one week, six months, 18 months, three years and five years post-operatively. Measurements of active knee flexion and extension were measured using a goniometer by a senior physiotherapist (JM). Flexion deformity, maximum active flexion, age, gender and diagnosis were recorded one week pre-operatively. A post-operative FFD was regarded as clinically significant when > 10°. Follow-up data in relation to FFD were sufficient in 344 patients (93%) at one week, 314 (85%) at six months, 332 (90%) at 18 months, 302 (82%) at three years and 271 (73%) at five years.

At operation, a crepe compression bandage was applied. This was removed the next day and continuous passive motion commenced. Pain relief comprised intravenous morphine by patient-controlled analgesia followed by oral analgesics. These included codeine, paracetamol, nonsteroidal anti-inflammatories or combinations of these medications.

All patients received inpatient physiotherapy and on discharge self exercise was encouraged. Outpatient physiotherapy was not prescribed routinely but reserved for patients with unsatisfactory movement. No patient received post-operative irradiation. Patients were divided into four groups according to their pre-operative FFD: group 1 (hyperextension to 0°, n = 71), group 2 (1° to 10° FFD, n = 184), group 3 (11° to 19° FFD, n = 67); and group 4 (≥ 20° FFD, n = 47).

We used binary logistic regression analysis to examine the relationship between age, gender, diagnosis, pre-operative FFD and the maximum active pre-operative flexion compared with post-operative FFD > 10°. We used the chi-squared test to compare the likelihood of post-
operative FFD > 10˚ among the groups. Values for p < 0.05 were regarded as significant.

**Results**

Pre-operative FFD was a predictor of post-operative FFD > 10˚ at one week (p = 0.006) and six months (p = 0.003). Gender was a predictor at one week (p = 0.0073) with 24% of women showing a FFD > 10˚ compared with 37% of men. Variable values in relation to FFD are shown in Table II.

A total of 114 patients (31%) had a pre-operative FFD > 10˚. Three years post-operatively only one patient had a FFD > 10˚. Late onset FFD > 10˚ was identified in a further five knees at five years. The percentage of FFD > 10˚ showed an increasing trend from group 1 to 4 at one week (p = 0.004) and six months (p = 0.003). FFD > 10˚ was not seen in group 1 knees reviewed more than one week after surgery.

There was a tendency for the FFD to increase in groups 1 and 2 in the early post-operative period and then decrease. In knees with a more severe pre-operative FFD, there was a trend towards an early decrease in mean FFD followed by a gradual improvement in knee movement with time. At three years, the mean FFD was minimal in all groups and unlikely to be of clinical significance. The general trend for active knee flexion was a fall from pre-operative levels in the early post-operative period and then an improvement.

Manipulation under anaesthesia was performed for stiffness in six knees between two weeks and 24 months post-operatively, according to the discretion of the treating surgeon. All six knees improved with a mean increase in flexion of 21.5˚ (5˚ to 46˚). FFD decreased in three knees but did not change in the others. At five years, useful improvement in FFD and maximum flexion was maintained, although maximum flexion in three of six knees had decreased and FFD had reduced in all six knees compared with movement immediately after manipulation under anaesthesia.

**Discussion**

FFD rates of up to 61% have been reported in patients with rheumatoid and osteoarthritis. Post-operative FFD has a detrimental effect on clinical outcome and correction of this deformity is a primary objective. Although knee replacements have a high success rate, full extension is not consistently achieved. In 2003, Lam, Swift and Shakespeare reported a large FFD in 8% of knee replacements at six weeks and Tew and Forster reported similar results in 17% of TKRs. In this study, FFD > 10˚ occurred in 4% of patients at six months but in only 2% at five years.

Treatment of post-operative stiffness includes physiotherapy, manipulation under anaesthesia and, occasionally, revision surgery. Information on the natural history of such patients should help decision-making.

Menke, Schmitz and Salm examined knee movement following TKR and found that pre-operative extension predicted post-operative extension, whereas Ritter et al. in a study of knee movement in 4727 knees, found that gender and age, as well as pre-operative extension were related to post-operative extension. Our findings were similar.

We also identified pre-operative FFD as a predictor of clinically significant post-operative FFD (> 10˚), with such deformity in 11% of group 4 knees compared with none in group 1 at six months. However, after six months, FFD > 10˚ was uncommon, even in knees with a more severe pre-operative flexion deformity. We also found that knees with full active extension pre-operatively did not develop FFD > 10˚ after the early post-operative period. Four knees which developed late FFD > 10˚ more than 18 months following surgery had no identifiable cause, a finding which has been described previously. Gender was only an independent predictor of FFD, at one week following surgery, when 37% of men had FFD > 10˚ compared with 24% of women.

A greater proportion of group 4 patients had rheumatoid arthritis compared with other groups but this is unlikely to

### Table I. Diagnosis in relation to group

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of patients</th>
<th>Osteoarthritis (%)</th>
<th>Rheumatoid (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>71</td>
<td>69 (19)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>2</td>
<td>184</td>
<td>168 (46)</td>
<td>16 (4)</td>
</tr>
<tr>
<td>3</td>
<td>67</td>
<td>60 (16)</td>
<td>7 (2)</td>
</tr>
<tr>
<td>4</td>
<td>47</td>
<td>31 (8)</td>
<td>16 (4)</td>
</tr>
<tr>
<td>Total</td>
<td>369</td>
<td>328 (89)</td>
<td>41 (11)</td>
</tr>
</tbody>
</table>

### Table II. Variable values in relation to post-operative fixed flexion deformity

<table>
<thead>
<tr>
<th>Time</th>
<th>1 week</th>
<th>6 months</th>
<th>18 months</th>
<th>3 years</th>
<th>5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFD*</td>
<td>&gt; 10˚</td>
<td>≤ 10˚</td>
<td>&gt; 10˚</td>
<td>≤ 10˚</td>
<td>&gt; 10˚</td>
</tr>
<tr>
<td>Mean age in yrs (SD)</td>
<td>67 (9)</td>
<td>68 (9)</td>
<td>66 (6)</td>
<td>68 (9)</td>
<td>72 (0.7)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of men (%)</td>
<td>59 (37)</td>
<td>101 (63)</td>
<td>64 (43)</td>
<td>147 (97)</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Number of women (%)</td>
<td>44 (24)</td>
<td>140 (76)</td>
<td>7 (4)</td>
<td>156 (96)</td>
<td>1 (0.5)</td>
</tr>
<tr>
<td>Mean pre-operative FFD (˚, SD)</td>
<td>11 (8)</td>
<td>8 (7)</td>
<td>16 (10)</td>
<td>9 (7)</td>
<td>9 (8)</td>
</tr>
<tr>
<td>Mean pre-operative flexion (˚, SD)</td>
<td>104 (18)</td>
<td>104 (18)</td>
<td>99 (17)</td>
<td>105 (18)</td>
<td>101 (22)</td>
</tr>
</tbody>
</table>

* FFD, fixed flexion deformity
† no stds as only one patient
bias our results as diagnosis was not an independent predictor of FFD post-operatively. A weakness of our study was the loss to follow-up of patients, particularly at five years, when 27% were unavailable.

Our results indicate a tendency for FFD to improve up to three years following surgery. In agreement with Lam et al., knees with a small pre-operative FFD increased their FFD after surgery but then improved; those with more severe degrees of pre-operative FFD gained immediate improvement. A similar pattern has been observed in relation to flexion range after TKR. 

At three years, the mean FFD was minimal in all groups and unlikely to be of clinical significance. Our results compare favourably with those of Firestone et al. who reviewed 51 knee replacements with a pre-operative FFD > 20° and found a steady reduction from 10° at three months post-operatively to 7° at two years.

There was a tendency for knees with a high FFD to have a reduced flexion range. At 18 months, group 4 knees had a mean flexion between 4° and 10° less than other groups with milder FFD.

Manipulation under anaesthesia was performed in six patients and, immediately afterwards, maximum flexion was improved in all six. Although FFD did not improve in three knees at the time of the manipulation, the FFD had decreased on subsequent review.

We have, therefore, shown that a gradual improvement in knee extension can be expected up to three years after surgery in knees with FFD. By then, a residual FFD is mild or absent in the majority of patients.

Supplementary material

Tables showing percentage of knees with fixed flexion, mean fixed flexion deformity and active knee flexion up to five years following total knee replacement and range of movement before and after manipulation under anaesthesia and a further opinion by Mr Simon Donell are available with the electronic version of the article on our website at www.jbjs.org.uk

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References