ASSESSMENT OF THE SURVIVAL AND THE CLINICAL RESULTS OF STANMORE TOTAL KNEE REPLACEMENTS

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We review 210 Stanmore knee replacements in 163 patients to assess the survival of the prostheses and the long-term results. The annual rate of failure reached a maximum of 4.6% in the fourth year after operation; thereafter it declined to reach zero by the eighth year. Between two and eight years after operation, 66.3% of the surviving knees were completely free of pain and 30.2% had mild retropatellar pain. Fixed flexion deformities present before operation were completely corrected in 73% of the knees, and varus or valgus deformities were invariably corrected. Stability was always restored to unstable knees and 80.8% of knees flexed to 90° or more after replacement.

Aseptic loosening (8.1%), prosthetic infection (4.3%) and femoral fracture (2.9%) led to 8.5% of the prostheses being revised or removed over eight years. Modifications in prosthetic design and operative techniques have been introduced to minimise such complications in the future.

The aim of prosthetic replacement of the knee is the relief of pain and the correction of deformity, combined with the restoration of stability and a functional range of movement (Lettin et al. 1978). However, these benefits should last for an acceptable period of time with the minimum of complications and, ideally, they should last for the life-time of the patient.

To a large extent, these objectives were realised in a small group of 18 patients in which 20 knees were replaced with prototypes of the Stanmore hinged prosthesis between 1969 and 1971 (Lettin and Kavanagh 1981).

An appraisal of the prosthesis led to the development of a fully constrained prosthesis (the Mark 4 Stanmore hinged prosthesis) of smaller dimensions made in cobalt-chromium-molybdenum alloy with a redesigned bearing; ultra-high-molecular-weight polyethylene bushes with thrust faces were fitted in the femoral component, and the patella-bearing surface was extended (Scales and Lettin 1974; Wilson, Lettin and Scales 1974).

We report the long-term results of 210 knees replaced with this Mark 4 Stanmore prosthesis; 80 of these replacements were included in our earlier review (Lettin et al. 1978). The aim of this further review is to show that the objectives of prosthetic replacement have been attained in a substantially larger number of patients over an extended period of time with an acceptable number of complications.

MATERIAL AND METHOD

The Mark 4 Stanmore hinged prosthesis (Fig. 1) was used to replace 210 knees between January 1972 and December 1979; during this period the design of the prosthesis and the operative technique (Lettin et al. 1978) remained unchanged. The patients were aged between 33 and 82 years at the time of operation. Eighty-six patients (120 knees) suffered from rheumatoid arthritis and tended to be younger than the 77 patients (90 knees) with osteoarthritis. Thirty-eight operations were on men and 172 on women.

Prosthetic survival

Although prosthetic replacement may initially attain its primary objectives, the procedure cannot be considered a success if the prosthesis is soon removed. Calculation of the prosthetic failure rate can be misleading, especially if the average length of follow-up is short. Calculation of the annual failure rate provides a better method of assessing survival (Dobbs 1980; Tew and Waugh 1982). The survival time (Table 1) for the 210 Stanmore total knee replacements was calculated by the method described by Armitage (1971) and used by Tew and Waugh (1982) in their analysis of 365 knee replacements of various designs carried out between 1972 and 1980.

The "successes" in the first year after the operation are those implants that have been in situ for one year
Table I. Estimated annual failure rate and cumulative success rate of Stanmore knee replacements where success is defined as the prosthesis remaining in situ.

<table>
<thead>
<tr>
<th>Years since operation</th>
<th>Number at start</th>
<th>Result at last review</th>
<th>Number at risk</th>
<th>Annual failure rate (per cent)</th>
<th>Annual success rate (per cent)</th>
<th>Cumulative success rate (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Successes</td>
<td>Failures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 1</td>
<td>210</td>
<td>19</td>
<td>2</td>
<td>200.5</td>
<td>1.0</td>
<td>99.0</td>
</tr>
<tr>
<td>&gt;1 2</td>
<td>189</td>
<td>52</td>
<td>7</td>
<td>163.0</td>
<td>4.3</td>
<td>95.7</td>
</tr>
<tr>
<td>&gt;2 3</td>
<td>130</td>
<td>28</td>
<td>2</td>
<td>116.0</td>
<td>1.7</td>
<td>98.3</td>
</tr>
<tr>
<td>&gt;3 4</td>
<td>100</td>
<td>27</td>
<td>4</td>
<td>86.5</td>
<td>4.6</td>
<td>95.4</td>
</tr>
<tr>
<td>&gt;4 5</td>
<td>69</td>
<td>27</td>
<td>2</td>
<td>55.5</td>
<td>3.6</td>
<td>96.4</td>
</tr>
<tr>
<td>&gt;5 6</td>
<td>40</td>
<td>15</td>
<td>1</td>
<td>32.5</td>
<td>3.0</td>
<td>97.0</td>
</tr>
<tr>
<td>&gt;6 7</td>
<td>24</td>
<td>16</td>
<td>0</td>
<td>16.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>&gt;7 8</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>3.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

only, and implants that may have been in situ longer and were satisfactory after one year, but which were never seen again for one reason or another. Implants that were satisfactory after one year but which were seen again are not included; these implants are recorded in the year of the last review. Thus, each implant is recorded only once and the number of implants reviewed each year is the number of satisfactory implants reviewed at the beginning of the previous year, minus the number removed or lost to follow-up during that year.

Fig. 1
The Mark 4 Stanmore total knee prosthesis.

"The average number at risk throughout a year is estimated as the number at risk at its start minus half the successes during that year. The proportion of failures to the average number at risk gives the estimated annual failure rate which is expressed as a percentage. The cumulative success rate is obtained by multiplying the successive proportions of annual successes (the inverse of annual failure) and again expressing the answers as a percentage. Significance is determined by the chi-square test" (Tew and Waugh 1982).

RESULTS

Prosthetic survival
Table I gives the survival time for the 210 Stanmore total knee replacements calculated by the method described above. The annual failure rate increased from 1% at one year to a maximum of 4.6% at four years, and thereafter decreased to zero at eight years. In other words, if the prosthesis survived for four years then the prospect of subsequent failure diminished rather than increased. None of the prostheses that had been in situ for more than six years failed. In eight years 18 prostheses were revised or removed in 16 patients, and 19 patients (24 knees) died.

Clinical assessment
Prosthetic survival alone in the absence of lasting clinical improvement is a misleading measure of success, for a painful, stiff, unstable or deformed artificial knee cannot be regarded as satisfactory. Therefore, pain, deformity, instability and movement, recorded before and at least two years after operation, were compared in 172 knees in 132 patients. The 18 prosthetic knees (in 16 patients) which had been removed or revised and the five knees in five patients who had died within two years of the operation were excluded from this comparison. Inadequate records of a further 10 patients did not allow pre-operative and postoperative comparison of 15 knees, leaving 172 of the 210 knees for assessment.

Table II. Pain in 172 knees before and after replacement

<table>
<thead>
<tr>
<th></th>
<th>Before (per cent)</th>
<th>After (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pain</td>
<td>0 (0.0)</td>
<td>114 (66.3)</td>
</tr>
<tr>
<td>Retropatellar pain</td>
<td>10 (5.8)</td>
<td>52 (30.2)</td>
</tr>
<tr>
<td>Severe pain</td>
<td>162 (94.2)</td>
<td>6 (3.5)</td>
</tr>
</tbody>
</table>

Pain. Before replacement every patient experienced pain which was regarded as severe in 94.2% of knees (Table II). After operation, 114 knees (66.3%) were completely
free of pain. Pain, apparently retropatellar in origin, occurred in 52 knees (30.2%), usually on rising from a chair or when climbing and descending stairs; this was rarely troublesome and was sufficiently severe to warrant further operation in only six knees. More severe and persistent pain occurred in a further six knees (3.5%), five associated with radiographic evidence of loosening in patients in whom revision had been refused or was not considered to be justified on clinical grounds. No cause could be found for the pain in the remaining knee.

**Stability.** Before operation 24 osteoarthritic knees and 42 rheumatoid knees were unstable when a varus or valgus or anteroposterior force was applied. Stability was inevitably restored unless the prosthesis became loose.

**Movement.** Theoretically a full range of movement is possible with the Mark 4 Stanmore knee prosthesis, but only two knees flexed to 130°. The range of movement (Table III) was improved in 77 knees (44.8%) after replacement, and unaltered in 39 (22.7%). However, 139 knees (80.8%) flexed to 90° or more (Fig. 4).

![Figure 2](image1.png)

**Fig. 2**
Fixed flexion deformity before and after prosthetic replacement.

![Figure 3](image2.png)

**Fig. 3**
Fixed varus and valgus deformity before operation.

**Deformity.** There was a flexion contracture of 10° or more in 80 knees before operation and in only 22 knees afterwards (Fig. 2). Fixed flexion, both before and after operation, was generally greater in patients with rheumatoid arthritis than in those with osteoarthritis.

Before operation 42 knees had a fixed varus deformity greater than 10°, and 60 had more than 10° of fixed valgus deformity (Fig. 3). All the varus and valgus deformities were corrected to within 10° of the anatomical position by virtue of the design of the prosthesis.

<table>
<thead>
<tr>
<th></th>
<th>Osteoarthritis</th>
<th>Rheumatoid arthritis</th>
<th>Total (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved</td>
<td>29</td>
<td>48</td>
<td>77 (44.8)</td>
</tr>
<tr>
<td>Unaltered</td>
<td>16</td>
<td>23</td>
<td>39 (22.7)</td>
</tr>
<tr>
<td>Reduced</td>
<td>23</td>
<td>33</td>
<td>56 (32.6)</td>
</tr>
</tbody>
</table>

In general the more limited the flexion before operation the more limited it was after operation, but the greatest percentage improvement occurred in those knees with the most limited pre-operative range of movement. Thus, one patient with a knee ankylosed in full extension,
and another patient whose knee was ankylosed at 90°, both achieved 45° of flexion after replacement, which represents an excellent percentage improvement (Figs 5 and 6).

One-third of the knees lost some movement but only 11% lost more than 20° (Fig. 7). Generally, this occurred in patients with a very good range of flexion preoperatively, so in spite of the loss of movement they still retained at least 90° of flexion.

Complications
The risk of serious complications may be too high a price to pay for lasting clinical improvement, especially if those complications threaten the survival of the prosthesis. The complications encountered in all 210 knees have therefore been divided into those which have led to the removal of the prosthesis or threaten its survival in the future (major complications), and those which do not (minor complications).

Major complications (Table IV). Infection, loosening, fractures around the prosthesis, and mechanical failure are complications which threaten the survival of the prosthesis (Table IV).

Deep infection around the prosthesis occurred in nine of the 210 knees (4.3%). One patient who had previously undergone an unsuccessful Macintosh arthroplasty required amputation for infection after breakdown of the wound and an unsuccessful attempt to close it with a myocutaneous flap. Three of the infected knees were loose; one was replaced using gentamicin-impregnated cement, but the infection recurred after a fracture of the femoral shaft; the second loose prosthesis was in an octogenarian who had a persistent discharging sinus but who refused further treatment; and the third knee, although loose and discharging intermittently, was free of pain and has remained so for three years.

Surprisingly, six infected knees have remained quiescent on maintenance antibiotics for between three and six years and have shown no clinical or radiographic evidence of loosening (Figs 8 and 9). There have been six (2.9%) spiral fractures of the femoral shaft, three resulting from significant injury, including the one revised for infection mentioned already. Three prostheses were either loose at the time of the

Function. Walking, climbing stairs or rising from a chair was found to depend on so many factors other than the knee, and particularly on the state of other joints in both limbs, that a detailed analysis of function was not considered to be worthwhile. Suffice it to say that function in no instance was impaired by replacement of the knee and frequently was significantly improved after bilateral replacement; three patients were able to walk after being confined to wheelchairs for many years.
accident or were loosened by it and were replaced with custom-built prostheses.

Seventeen other prostheses (8.1%) were unequivocally loose in the absence of infection or fracture, and 12 have been replaced by another standard prosthesis—an extended stem prosthesis or a custom-made prosthesis. Arthrodesis was attempted only once in the series and the patient has been left with a pain-free fibrous ankylosis and wears a caliper out of doors.

The overall incidence of loosening was 11%. This contrasts with the findings of Scales and Wright (1981) who reported no cases of prosthetic loosening in 123 patients in whom the Stanmore knee had been used for the treatment of bone tumours of the distal femur or of the proximal tibia (or both) between July 1949 and July 1981.

Table IV. Major complications in 210 knees

<table>
<thead>
<tr>
<th></th>
<th>Loose</th>
<th>Not loose</th>
<th>Revision</th>
<th>Ankylosis</th>
<th>Amputation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aseptic</td>
<td>17</td>
<td>—</td>
<td>12</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Infection</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Infection and femoral fracture</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Femoral fracture</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total number (per cent)</td>
<td>23 (11.0)</td>
<td>8 (3.8)</td>
<td>16 (7.6)</td>
<td>1 (0.5)</td>
<td>1 (0.5)</td>
</tr>
</tbody>
</table>

Minor complications (Table V). Complications which posed no direct threat to the survival of the prosthesis (although perhaps threatening the patient’s life) occurred in 45 patients. The attachment of the patellar ligament to the tibia is particularly vulnerable in patients with rheumatoid arthritis and may easily be partially or completely torn from the bone at operation. If this is appreciated it can be rectified with a staple but on seven occasions the extensor mechanism disrupted at a later date; repair was successful on all but one occasion.

Patellar malalignment was noted in 24. Curiously, this complication did not invariably give rise to symptoms, and normal pain-free active extension of the knee from the flexed position was often unimpaired. Patellotomy was carried out on six knees for patellar subluxation associated with severe retropatellar pain.

Superficial infection and delayed healing without serious complications occurred on 14 occasions and there were two cases of lateral popliteal palsy, both of which recovered spontaneously.

No specific search was made for thrombo-embolic complications but three instances of deep vein thromboses and one of pulmonary embolus were diagnosed on clinical grounds.

The high-density polyethylene bushes were replaced on two occasions after appreciable “rock” in the bearing was detected on routine clinical examination. At operation it was found that the bushes were not worn through but had deformed.

DISCUSSION

The clinical assessment has demonstrated that the Stanmore hinged knee replacement is capable of restoring stability to most unstable knees, of correcting the severest deformities, and of restoring or preserving a functional
range of flexion; moreover, it almost invariably relieves the severest pain.

In common with many other types of prosthesis, retropatellar pain has been a common sequel, although rarely disabling.

An implant which is removed, however, cannot be considered a success no matter how well it has performed before failure. Deep infection (4.3%), aseptic loosening (8.1%) and femoral fracture (2.9%) led to the revision or removal of 18 prostheses (8.5%), which compares favourably with other prostheses, both constrained and unconstrained (Bargren et al. 1976; Freeman, Sculco and Todd 1977; Gibbs, Green and Taylor 1979; Bargar, Cracchiolo and Amstutz 1980; Hui and Fitzgerald 1980; Wilson et al. 1980; Hamilton 1982). If prosthetic survival is the sole criterion of success, the proportion of successful operations in this series exceeds that in the series of 365 prostheses analysed by the same statistical method and reported by Tew and Waugh (1982). Their annual failure rate increased progressively from 0.9% in one year to 18.2% at eight years, whereas the annual failure rate with the Stanmore prosthesis, although increasing progressively from 1% at one year to a maximum of 4.6% at four years, thereafter diminished. In other words, if the prosthesis survived for four years then the prospect of subsequent loosening diminished rather than increased.

Taking a more stringent and pessimistic view and assuming that the surviving knees with severe pain are incipient failures and will ultimately come to revision, the annual rate of failure as previously defined continues to increase until the end of the seventh year; but even then it is no more than 6.1% (Table VI). Calculated on the same basis, Tew and Waugh reported an annual failure rate at the end of the seventh year of 28.6%.

The reasons for the early rather than the late failure of some of the Stanmore prostheses are a matter of speculation, although it may be relevant that the longest surviving prostheses in this series (and all but one of the prototypes) were inserted by the originator of the technique, whereas many of the later operations were carried out by surgeons at various stages of training.

Modifications

The Stanmore hinged knee replacement has given consistently good clinical results over a period of nine years. The operation is simple and is no more prone to the complications of knee replacement than are other techniques, so justifying its continued use. The prosthesis and the operative technique have recently been modified, however, in an endeavour to improve the results still further.

1. The intramedullary stem of the femoral component is now straight rather than curved, since the tip of the curved stem was observed lying in contact with the posterior femoral cortex in prostheses which loosened and in those cases in which the femur fractured (Figs 10 to 12).

2. The gap between the anterior surface of the stem and the posterior surface of the articulation for the patella has been widened so that the periosteum and soft tissues on the anterior femoral cortex can be preserved (Fig. 13). In the knees which have been revised this part of the cortex was often devitalised, a fact which may have contributed to the loosening.

3. The size of the plateau can now be increased by using one of four sizes of washer-like plateau plates which are available for the femur and tibia. These distribute the load in shear and bending over a larger area of the resected surfaces of the bones.

4. Unless a previous incision can be conveniently used, a midline incision is now employed in order to reduce the incidence of superficial wound problems. A lateral release is routinely performed to allow the extensor mechanism to take its own line in the hope that this will reduce the...
incidence of retropatellar pain and subluxation. Prophylactic antibiotics are given as a matter of routine. 

(5) After resecting the femoral condyles, the posterior remnant is removed flush with the posterior cortex of the femur to improve the range of flexion and prevent pistoning (Fig. 13). The medullary canals are carefully cleaned with a water-jet and brush and plugged before the cement is introduced with a gun; this not only improves the penetration of the cement but also centres the tips of the intramedullary stems in the canals (Fig. 13).

It is hoped that these modifications in operative technique and prosthetic design will reduce still further the already low incidence of revision.

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REFERENCES


