The long-term outcome of high tibial osteotomy
A TEN- TO 20-YEAR FOLLOW-UP

S. Akizuki,
A. Shibakawa,
T. Takizawa,
I. Yamazaki,
H. Horiuchi

From Nagano
Matsushiro General
Hospital, Nagano
City, Japan

We carried out a prospective study of 132 patients (159 knees) who underwent closed-wedge high tibial osteotomy for severe medial compartment osteoarthritis between 1988 and 1997. A total of 94 patients (118 knees) was available for review at a mean of 16.4 years (16 to 20). Seven patients (7.4%) (11 knees) required conversion to total knee replacement. Kaplan-Meier survival was 97.6% (95% confidence interval 95.0 to 100) at ten years and 90.4% (95% confidence interval 84.1 to 96.7) at 15 years. Excellent and good results as assessed by the Hospital for Special Surgery knee score were achieved in 87 knees (73.7%).

A pre-operative body mass index > 27.5 kg/m\(^2\) and range of movement < 100˚ were risk factors predicting early failure.

Although our long-term results were satisfactory, strict indications for osteotomy are required if long-term survival is required.

High tibial osteotomy has been used to treat medial compartment osteoarthritis of the knee, and many follow-up studies have been reported.\(^1\)\(^-\)\(^16\) Earlier reports suggested that the clinical results deteriorate over five to ten years.\(^4\)\(^-\)\(^7\) Efforts have been made to determine the factors influencing the long-term results; obtaining an adequate angle of correction and careful selection of the patients have been advocated.\(^4\)\(^,\)\(^5\)\(^-\)\(^10\) Improvements in the techniques of operation have improved the outcomes.\(^11\)\(^-\)\(^15\)

Total knee replacement (TKR) is now the most popular surgical procedure for osteoarthritis of the knee. Osteotomy tends to be used only in young and active patients,\(^17\) especially in North America, but in Asian countries, especially Japan, it is considered to be an effective surgical treatment that also preserves the original joint,\(^12\)\(^,\)\(^10\) and is now performed even in older patients with severe osteoarthritis.

We conducted a prospective follow-up of patients with severe osteoarthritis of the knee who underwent high tibial osteotomy to evaluate the long-term clinical outcome.

Patients and Methods
Between 1987 and 1996, 159 high tibial osteotomies were carried out in 132 patients. The right knee was involved in 82 (51.6%) cases and the left in 77 (48.4%). We used the Kellgren-Lawrence system\(^18\) to grade the level of pre-operative osteoarthritis, and the Hospital for Special Surgery (HSS) system\(^19\) for pre-operative clinical evaluation. Other pre-operative demographic data are shown in Table I.

Indications and surgical procedure. Osteotomy is indicated for medial compartment osteoarthritis of the knee when a patient is under 70 years of age, or older in persons who have a high level of activity. All the procedures in this series were performed or supervised by the chief surgeon of the institution (SA). An interlocking closed-wedge osteotomy was performed in all patients,\(^20\) and a Giebel plate (Waldemar Link GmbH & Co, KG, Hamburg, Germany) was used for internal fixation. We aimed to achieve a femorotibial angle of 170˚ or less after operation, which would place the mechanical axis at the middle of the lateral compartment.\(^10\)\(^,\)\(^21\) (Fig. 1).

Rehabilitation. Post-operative rehabilitation included immediate active movement and physiotherapy. Early weight-bearing was aided by crutches for six weeks. No patient had a cast after surgery.

Post-operative assessment. All patients were followed up prospectively every six months for radiological and clinical assessment.

The HSS score was assessed at each follow-up. Depending on the angle of correction at one year, we divided the cases into three groups, namely those with an insufficient angle of correction with the femorotibial angle > 174˚, those with an adequate correction with...
a femorotibial angle between 164’ and 173’, and an over-corrected group with a femorotibial angle of < 164’. We compared the mean femorotibial angle at one year with that at the final follow-up, and analysed the findings by a paired Student’s t-test, regarding p < 0.05 as significant. 

Total knee replacement. We retrospectively evaluated the angle of correction that had been achieved in those knees which had required conversion to a TKR. Failure was defined as the need for conversion to a TKR and an HSS score < 70 points. The probability of failure was estimated as a function of time using the Kaplan-Meier survival method with a 95% confidence interval.22,23

Univariate and multivariate Cox proportional hazards analyses were used to verify the relationship between survival and each possible associated factor, including the pre-operative femorotibial angle, age, gender, body mass index (BMI), the Kellgren-Lawrence grade, the range of movement and the post-operative femorotibial angle. Estimation of the hazard ratio was used to evaluate the association between the risk of failure and contributing factors.
Results

Of the 132 patients (159 knees) seven (seven knees) were lost to follow-up within ten years. A total of 15 patients (17 knees) died for reasons unrelated to the surgery and 16 patients (17 knees) were excluded because of the onset of serious medical disease. Therefore 94 patients (118 knees) (74%) were available for review at a mean follow-up of 14.4 years (10 to 20) (Table II).

Post-operative complications. A total of 15 knees (12.7%) had post-operative complications: five (4.2%) had a temporary peroneal nerve palsy, one (0.8%) a temporary deep-vein thrombosis, three (2.5%) had skin necrosis requiring a graft in one and debridement of the wound in the other two. There was one (0.8%) wound infection and one (0.8%) subcutaneous haematoma which required debridement. Nonunion occurred in two knees (1.6%), requiring bone graft and further fixation, and two (1.6%) had early loss of correction with subsequent retightening of a screw. None of these 15 patients required revision to a TKR.

The mean pre-operative HSS score was 60.7 (SD 11.2). The mean post-operative score was 90 (SD 6.9) at one year, 90 (SD 6.9) at five years and 84 (SD 12) at final follow-up (Table III). An excellent or good result was achieved in 87 knees (73.7%) at final follow-up.

Angle of correction. All the patients with an insufficient correction angle showed a significant increase in mean femorotibial angle at the final follow-up (p < 0.01). The group with adequate correction or overcorrection maintained their angles (Table IV).

Conversion to TKR. A total of 17 knees (14.4%) had a poor result and of these 11 (9.3%) required conversion to a TKR. The mean time from high tibial osteotomy to TKR was 13.4 years (9 to 19). Three knees with an insufficient angle of correction (femorotibial angle > 174°) at one year showed loss of correction to > 180° before their TKR. One hypervalgus knee with a femorotibial angle of 156° at one year remained unchanged until TKR. Seven knees maintained an adequate angle of correction of between 164° and 173° before TKR (Fig. 2).

Survival. Using Kaplan-Meier survival analysis, the probability of survival after high tibial osteotomy was 99.3% (95% confidence interval (CI) 97.9 to 100) at five years, 97.6% (95% CI 95.0 to 100) at ten years and 90.4% (95% CI 89.1 to 96.7) at 15 years. In the worst case analysis, in which the seven knees that were lost to follow-up were
regarded as failures, survival was 96.7% (95% CI 93.9 to 99.5) at five years, 92.9% (95% CI 88.6 to 97.1) at ten years, and 84.2% (95% CI 79.3 to 91.7) at 15 years (Fig. 3).

Risk factors related to survival. A range of movement < 100˚ (p < 0.001) and a BMI > 27.5 kg/m² (p = 0.0015) were significantly associated with early failure. A flexion contracture of < 15˚ (p = 0.0236) and maximum flexion of < 120˚ (p = 0.0474) showed a significant association with survival. Other factors did not (Table V).

Discussion
Our survival of 90.4% at 15 years is similar to that of another Japanese series of 93.2% and better than the

Table V. Coefficient of Cox’s proportional hazards model of pre-operative and post-operative risk factors

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Hazard ratio</th>
<th>p-value</th>
<th>95% confidence interval</th>
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<tbody>
<tr>
<td>Pre-operative</td>
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<tr>
<td>Gender</td>
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<tr>
<td>Female</td>
<td>0.514</td>
<td>0.249</td>
<td>0.166 to 1.595</td>
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<td>Age (yrs)</td>
<td></td>
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<tr>
<td>&gt; 65</td>
<td>1.196</td>
<td>0.740</td>
<td>0.460 to 3.442</td>
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<td>Body mass index (kg/m²)</td>
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<tr>
<td>&gt; 27.5</td>
<td>0.174</td>
<td>0.0015*</td>
<td>0.059 to 0.513</td>
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<tr>
<td>Hospital for Special Surgery score &lt; 55</td>
<td>0.978</td>
<td>0.965</td>
<td>0.353 to 2.698</td>
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<tr>
<td>Femorotibial angle (˚)</td>
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<td>&gt; 185</td>
<td>1.496</td>
<td>0.484</td>
<td>0.484 to 4.625</td>
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<tr>
<td>Range of movement (˚)</td>
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<td>&lt; 100</td>
<td>6.785</td>
<td>&lt; 0.001*</td>
<td>2.602 to 17.692</td>
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<td>Flexion contracture (˚)</td>
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<tr>
<td>≥ 15</td>
<td>0.331</td>
<td>0.0236†</td>
<td>0.127 to 0.862</td>
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<td>Maximum flexion (˚)</td>
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<tr>
<td>&lt; 120</td>
<td>2.982</td>
<td>0.0474†</td>
<td>1.012 to 8.785</td>
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<tr>
<td>Kellgren-Lawrence IV</td>
<td>0.418</td>
<td>0.136</td>
<td>0.133 to 1.314</td>
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<tr>
<td>Post-operative</td>
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<tr>
<td>Femorotibial angle at 1 yr (˚)</td>
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<tr>
<td>≥ 174</td>
<td>0.417</td>
<td>0.138</td>
<td>0.131 to 1.324</td>
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* p < 0.001  
† p < 0.05
results from other countries, which range from 39% to 67%.

In our study, a higher BMI was related to a lower survival, as noted by others,

Previous authors have suggested that knee flexion of at least 90° and a flexion contracture less than 15° are pre-requisites for high tibial osteotomy. Naudie et al showed that pre-operative knee flexion of less than 120° was related to significantly lower survival, but Aglietti et al did not relate failure to either flexion contracture or lack of extension. We found that pre-operative range of movement of < 100° was significantly associated with early failure.

Our results indicate an upper limit for the long-term result of high tibial osteotomy in a severely arthritic knee with deteriorating movement. In Japan we tend to preserve the original joints and have, therefore, performed high tibial osteotomy in more severely arthritic knees with a deteriorating range of movement. These cases then needed conversion to a TKR at between ten and 20 years after high tibial osteotomy.

Many authors have studied the angle of correction associated with long-term outcome. Although we converted three knees to a TKR because of insufficient correction and loss of correction, the angle otherwise was not associated with survival. More than half of all converted knees maintained an adequate angle of correction until conversion to TKR. Considering that most knees that needed conversion survived for more than ten years, our long-term results of high tibial osteotomy were satisfactory.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


