Open-wedge osteotomy of the proximal tibia with hemicallotasis

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Conventional high tibial osteotomy for osteoarthritis of the medial compartment of the knee with closed-wedge or dome osteotomy (DMO) may produce shortening of the patellar tendon and loss of inclination of the proximal tibial plateau or of the offset of the tibial condyle relative to its bony axis. This can make subsequent total knee arthroplasty technically demanding.

We undertook a prospective study comparing these changes after DMO with those after using open-wedge osteotomy hemicallotasis (HCO). A total of 50 knees with arthritis of the medial compartment in 46 consecutive patients was randomly allocated to either DMO or HCO. There were no significant differences between the groups with regard to age, gender, femorotibial angle before operation or the angle of correction.

Radiological studies showed that HCO caused little change in the length of the patellar tendon or the inclination angle of the tibial plateau, while after DMO both gradually decreased. The degree of tibial condylar offset increased in both groups, but less so in the HCO group.

Patients and Methods

The study included 46 consecutive patients (50 knees) who required tibial osteotomy for medial osteoarthritis of the knee between 1995 and 1997. They were randomly allocated to either DMO or HCO. Those requiring bilateral surgery received the same procedure to both knees. The DMO group comprised 23 patients (25 knees), 19 women (20 knees) and four men (5 knees), with a mean age at surgery of 62 years (50 to 71), and the HCO group 23 patients (25 knees), 18 women (19 knees) and five men (6 knees), with a mean age of 64 years (52 to 74). The age and gender of the groups were not significantly different. The required angle of correction was determined before operation so that the mechanical axis connecting the centre of the femoral head and the ankle would pass through a point approximately 70% of the distance from the medial edge of the proximal tibial plateau, measured on a supine anteroposterior (AP) radiograph of the lower limb.

In the DMO group, we used the technique described by Maquet. After a 2 cm resection of the upper third of the fibula, a Steinmann pin was inserted into the proximal tibia and another into the diaphysis so that the angle between them corresponded to the planned angle of correction. The osteotomy was then performed along a curved line just above the tuberosity through a 5 cm longitudinal skin incision and valgus correction was obtained by adjusting the distal fragment in order to make the pins parallel. Charnley compression clamps (Zimmer, Warsaw, Indiana) were used for fixation. Active movement and isometric exercises were allowed on the second postoperative day.
Partial weight-bearing was started after two weeks and full weight-bearing after ten. When union had been confirmed radiologically, at a mean of 12 weeks (10 to 16) after surgery, the pins and clamps were removed.

In the HCO group, we used the procedure described by Turi et al. Under fluoroscopic control, two 6/5 mm cancellous screws (Orthofix, Tokibo, Japan) were inserted transversely from the medial to the lateral aspect of the proximal tibia, and two were introduced into the medial aspect of the distal diaphysis. After making a 3 cm longitudinal skin incision at the level of the tibial tuberosity and carefully stripping the periosteum, an osteotomy was performed through 80% of the width of the bone, leaving the lateral cortex in continuity. An HCO device (Orthofix) was used for fixation. In knees with a required angle of correction of more than 15°, fibulectomy was undertaken to protect the peroneal nerve and incongruity in the proximal tibiofibular joint caused by upward displacement of the head of the fibula. Active movement of the knee and weight-bearing were allowed, as tolerated, on the day after surgery. Distraction at a rate of 0.25 mm four times a day was started two weeks after operation. The fixator was locked once the planned correction had been obtained, and a few weeks later dynamic loading was started. The pins and fixator were removed when the formation of callus and its consolidation in the distraction gap were seen on radiographs. The patients could walk fully weight-bearing without pain, at a mean of 14 weeks (12 to 18) after operation. All had antibiotics for two weeks and the pin sites were cleaned three times a week. We found inflammation at the pin sites in two of 25 knees which settled with daily cleaning. No organisms were cultured.

Radiography was performed before, at three months and at one year after operation. We took anteroposterior (AP) radiographs of the whole limb with the patient standing on the involved side, with the distal pole of the patella facing forwards and supine lateral radiographs of the knee in 30° of flexion with the femoral condyles superimposed. In order to ensure consistency, all radiographs were monitored by fluoroscopy. We examined four variables; the femorotibial angle (FTA), the length of the patellar tendon, the angle of inclination of the tibial plateau and the degree of tibial condylar offset with respect to its bony axis. The FTA was measured on the AP films, the length of the patellar tendon using the Insall-Salvati method (length of the patellar tendon (LT)/length of the patella (LP) ratio), and the inclination angle of the tibial plateau as described by Moore and Harvey on the same lateral view. The tibial condylar offset was calculated on the AP view using the method of Yoshida et al. A line perpendicular to the axis through the edge of the lateral tibial plateau was drawn as for the proximal tibial resection for a conventional TKA with minimised bone loss from the lateral tibial condyle. The points on the medial cortex on this presumptive line and the lateral edge of the tibial plateau were defined as A and B, respectively, and the intersection between this line and the bony axis as C. The ratio BC/AB was defined as the degree of tibial condylar offset (Fig. 1). To avoid bias, all radiographs were measured by two of the authors (EN, SK). One of them (SK), not present at surgery, made the measurements blind. The interobserver variability showed good agreement for all four items (each probability < 0.001). Data are shown as the mean and range of measurements.

For statistical analysis of data we used the ANOVA and Mann-Whitney U tests and p < 0.05 was considered to be significant.

Results

Table I shows the radiological evaluation of all four variables before and after operation. The preoperative values were similar in both groups.

There was no difference in the mean FTA at three months or one year after operation. The postoperative values did not change until one year after surgery. The mean angles of correction at follow-up at one year were 14.8° (7 to 22) in the DMO group and 14.2° (9 to 21) in the HCO group. This difference was not statistically significant.
The DMO group showed a significant gradual postoperative shortening of the patellar tendon (LT/LP ratio) in contrast to the HCO group which showed no change. At one year after operation, patella infera with a ratio less than 0.8 was seen in eight of the 25 knees in the DMO group, but in none of the HCO group. There was a gradual decrease in the angle of inclination of the tibial plateau in the DMO group after surgery, but not in the HCO group. At one year, a decrease of more than 5° was found in 11 knees of the DMO group. Both groups showed a significant postoperative increase in the degree of the tibial condylar offset, but the rate of increase in the HCO group was less significant than that in the DMO group at each follow-up. There was a positive correlation between the offset and the angle of correction at one year in both groups (Fig. 2).

Discussion

Patella infera and loss of the posterior slope of the tibial plateau are major anatomical changes which are often seen after high tibial osteotomy. Patella infera results from scarring in and around its tendon or from the formation of new bone at the insertion of the tendon because of the surgical invasion or postoperative immobilisation.

The aetiology of the decrease in inclination has been attributed to anterior collapse resulting from the difference in the subchondral bone and the reduced strength of the osteotomised fragments. The incidence of patella infera after osteotomy has been reported as 10% to 30%. The postoperative decrease in the inclination of the tibial plateau has been reported as approximately 3° to 10°. Our study showed that at one year DMO caused patella infera in 32% of the patients and a mean decrease of 5.5° in the inclination angle ranging from 3° to 13°, which is similar to findings in other studies.

Valgus tibial osteotomy inevitably produces some transposition of the tibial condyle with respect to its bony axis. The greater the angle of correction obtained, the greater is this relative offset as our study shows (Fig. 2). The DMO had a greater offset than that with a closed wedge with the same angle of correction.

These anatomical changes after high tibial osteotomy, including patella infera and the malposition of the tibial plateau, make subsequent TKA technically demanding. Patella infera makes eversion of the patella and access to the lateral compartment more difficult, resulting in the frequent need for procedures such as V-Y quadricepsplasty or resection of the tibial tuberosity. The decrease in inclination requires considerable resection from the posterior aspect of the tibial plateau. This leads to a decrease in trabecular bone strength, which may cause difficulty in obtaining satisfactory fixation of the tibial component and affect the biomechanics of the knee and

Table I. Comparison of mean values (range) for the FTA, the length of the patellar tendon, inclination angle of the tibial plateau and tibial condylar offset for the 25 knees treated by DMO and the 25 by HCO

<table>
<thead>
<tr>
<th></th>
<th>DMO</th>
<th>HCO</th>
<th>p value</th>
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</thead>
<tbody>
<tr>
<td>FTA in degrees</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Preoperation</td>
<td>182 (177 to 186)</td>
<td>181 (177 to 186)</td>
<td>0.176</td>
</tr>
<tr>
<td>At three months</td>
<td>167 (164 to 169)</td>
<td>167 (166 to 169)</td>
<td>0.160</td>
</tr>
<tr>
<td>At one year</td>
<td>168 (163 to 171)</td>
<td>167 (166 to 169)</td>
<td>0.396</td>
</tr>
<tr>
<td>Patellar tendon length as a ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperation</td>
<td>0.92 (0.80 to 1.12)</td>
<td>0.94 (0.84 to 1.05)</td>
<td>0.375</td>
</tr>
<tr>
<td>At three months</td>
<td>0.89 (0.77 to 1.09)</td>
<td>0.94 (0.83 to 1.05)</td>
<td>0.160</td>
</tr>
<tr>
<td>At one year</td>
<td>0.80 (0.71 to 0.95)</td>
<td>0.93 (0.83 to 1.05)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inclination angle in degrees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperation</td>
<td>10.6 (3 to 18)</td>
<td>10.9 (6 to 16)</td>
<td>0.831</td>
</tr>
<tr>
<td>At three months</td>
<td>6.5 (0 to 15)</td>
<td>10.2 (7 to 15)</td>
<td>0.003</td>
</tr>
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<td>At one year</td>
<td>4.7 (0 to 13)</td>
<td>10.1 (7 to 15)</td>
<td>&lt;0.001</td>
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<tr>
<td>Tibial condyle offset as a ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperation</td>
<td>0.50 (0.45 to 0.55)</td>
<td>0.50 (0.45 to 0.53)</td>
<td>0.171</td>
</tr>
<tr>
<td>At three months</td>
<td>0.60 (0.57 to 0.66)</td>
<td>0.56 (0.50 to 0.61)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>At one year</td>
<td>0.61 (0.58 to 0.68)</td>
<td>0.56 (0.50 to 0.61)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
supporting structures. Moreover, the tibial condylar offset makes it hard to centre the component on the diaphyseal axis while also covering a sufficient area, leading to difficulty in obtaining appropriate alignment of a conventional tibial component.

Our study showed that HCO did not alter the patellar height and caused little change in the inclination of the tibial plateau. In addition, it led to a significantly smaller tibial condylar offset than did DMO. In HCO, the osteotomy is carried out below the insertion of the patellar tendon to the tuberosity, and active knee movement is permissible immediately after operation. The medial opening by distraction is done so that the proximal fragment above the site of the osteotomy can be on the extension side of the diaphyseal axis in the sagittal plane. This position is maintained by the external fixator until union occurs. Furthermore, in the coronal plane, the site of the osteotomy in HCO is opened with a fulcrum on the lateral cortex, while in closed-wedge ostotmy, the divided ends are brought together with the medial cortex in continuity after resection of the wedge. In DMO the distal fragment is placed into valgus along the curved line of the osteotomy, causing medialisation of the axis of the tibia. This explains why HCO gives little postoperative shortening of the patellar tendon and less relative malposition of the tibial plateau. In addition, it led to a significantly smaller height and caused little change in the inclination of the supporting structures.

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References