We review the results of a modified quadricepsplasty in five children who developed stiffness of the knee after femoral lengthening for congenital short femur using an Ilizarov external fixator which spanned the knee.

All had a full range of movement of the knee before lengthening was undertaken. Unifocal lengthening was carried out in the distal metaphysiodiaphyseal region of the distal femur with a mean gain of 6.5 cm. The mean percentage lengthening was 24%.

At the end of one year after removal of the Ilizarov frame and despite intensive physiotherapy all patients had stiffness. Physiotherapy was continued after the quadricepsplasty and, at the latest follow-up (mean 27 months), the mean active flexion was 102˚ (80 to 130). The gain in movement ranged from 50˚ to 100˚. One patient had a superficial wound infection which settled after a course of oral antibiotics. None developed an increased extension lag after surgery and all were very satisfied with the results. Quadricepsplasty is a useful procedure for stiffness of the knee after femoral lengthening which has not responded to physiotherapy.

Submitted: 16 January 2002; Accepted: 12 June 2002

Leg lengthening is a recognised treatment for children with congenital short femur with leg-length discrepancies in the range of 5 to 15 cm.1,2 It is technically difficult, however, and has a high incidence of complications. Particular problems include stiffness of the knee, fractures and poor regenerate formation1-3 leading to an unsatisfactory outcome.4 Stiffness of the knee may improve with physiotherapy, but if it persists after removal of the frame despite intensive physiotherapy soft-tissue release may be necessary. We know of no previous report of the results of quadricepsplasty for stiffness of the knee after lengthening of the femur in children with congenital short femur using an Ilizarov frame which spanned the knee.

We present the results of quadricepsplasty for stiffness of the knee (extension contracture) in five of a series of 12 patients who had undergone Ilizarov lengthening for unilateral congenital short femur.

Patients and Methods

Between May 1998 and April 2001 five modified quadricepsplasties were carried out by the senior author (RAH) in three boys and two girls with a mean age of 11 years 7 months (9.5 to 16) at the time of operation. The indication for quadricepsplasty was stiffness of the knee (extension contracture) which was not improving despite regular physiotherapy one year after removal of the Ilizarov frame after lengthening for congenital short femur.

The mean leg-length discrepancy before lengthening was 7.7 cm (4.6 to 12.0). The range of movement of the knee in all five patients before application of the frame was from 0˚ to 130˚. A corticotomy was carried out at the metaphysiodiaphyseal level in the distal femur. The Ilizarov frame was applied using a standard technique. It was extended across the knee by spanning it with connecting rods to prevent subluxation since the anterior cruciate ligament was deficient in all knees. The mean length of time for which the frame was retained was nine months (8 to 12). The mean lengthening was 6.5 cm (4 to 9.5). The percentage lengthening (lengthening index) in each patient is shown in Table I. After the frame had been removed, all patients received a period of graduated physiotherapy under the supervision of a senior physiotherapist. The range of knee movement was measured at each outpatient clinic visit by the senior author using a goniometer with a scale marked in increments of 1˚. One arm of the goniometer was placed parallel to the long axis of the femur along a line extending from the greater trochanter to the lateral condyle while the other arm was placed parallel to the long axis of the fibula.
The mean flexion contracture before quadricepsplasty was 6° with active flexion to 32°. The mean range of movement was therefore 26° (Table I). The mean interval between removal of the frame and quadricepsplasty was 12 months (11 to 15). The length of follow-up after quadricepsplasty ranged from 4 months to 3 years 4 months. Using the criteria of Judet the final result was considered to be excellent if flexion was greater than 100°, good if between 81° and 100°, fair if between 50° and 80°, and poor if less than 50°.

Statistical analysis was undertaken using Student’s t-test.

Operative technique. Under general anaesthesia, with the patient supine, a longitudinal skin incision incorporating any existing scars was made on the lateral aspect of the thigh extending from the junction of the proximal third and distal two-thirds to the mid-patella. Distally, the incision was angled forwards to the lateral border of the patella (Fig. 1). The tensor fascia lata was identified and the distal part Z-lengthened. The quadriceps muscle was carefully defined by soft-tissue dissection, completely released from the lateral intermuscular septum and elevated from the bone with division of any adhesions. It was found to be adherent to the site of regenerate bone in all patients. Haemostasis was achieved by diathermy. The quadriceps tendon was then isolated and divided in a V-shaped manner (Fig. 2a). Care was taken not to disturb the oblique fibres of vastus medialis since these may be important for locking the knee in full extension. The patella was then elevated on the quadriceps tendon and the knee inspected. Any adhesions were divided. These were present predominantly between the patella and femur in all patients. At all stages of the operation the passive range of flexion was assessed and a gentle manipulation carried out to aid the identification of tight structures. In all patients passive flexion of 90° was achieved. The divided quadriceps tendon was sutured in a V-Y manner with the knee in 60° of flexion (Figs 2b and 2c). The wound was closed in layers over a suction drain. Epidural anaesthesia to relieve pain was used in all patients during the first 48 hours after operation.

Physiotherapy regime. A continuous passive motion (CPM) machine was set to between 60° and 70° in the immediate postoperative period. The child remained on the CPM machine continuously during the first week after surgery apart from short periods for wound care, washing, etc. The range of movement was increased by 5° to 10° daily if the child was able to tolerate it. Twice-daily physiotherapy sessions covered by adequate analgesia were started approximately three to four days after surgery. No active quadriceps exercises were allowed. Stretches into flexion in supine, high sitting and prone positions were passive and exercises for the hamstrings were active. The range of movement was monitored daily and the time out of the CPM machine slowly increased (1 hr am followed by 1 hr am/pm etc.) The parents or carers were instructed in the stretching and exercise programme. After discharge from hospital in 10 to 14 days a CPM machine was used at home at night and the local physiotherapist contacted regarding the continuance of treatment. Active quadriceps strengthening and

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yrs)</th>
<th>Follow-up (mths)</th>
<th>Preoperative length of femur by scanogram (cm)</th>
<th>Lengthening achieved (cm)</th>
<th>Percentage lengthening index</th>
<th>Before quadricepsplasty range of movement (degrees) (FC to FA)*</th>
<th>After quadricepsplasty range of movement in theatre (degrees) (FC to FA)*</th>
<th>Final range of movement (degrees)</th>
<th>Gain in flexion (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.5</td>
<td>4</td>
<td>28.0</td>
<td>4.0</td>
<td>14.0</td>
<td>40 (30 to 70)</td>
<td>80 (30 to 110)</td>
<td>90 (20 to 110)</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>9.5</td>
<td>20</td>
<td>22.0</td>
<td>9.5</td>
<td>43.0</td>
<td>20 (0 to 20)</td>
<td>70 (0 to 70)</td>
<td>90 (0 to 90)</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>12.0</td>
<td>36</td>
<td>29.0</td>
<td>8.0</td>
<td>27.5</td>
<td>40 (0 to 40)</td>
<td>100 (0 to 100)</td>
<td>130 (0 to 130)</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>16.0</td>
<td>38</td>
<td>33.5</td>
<td>4.6</td>
<td>14.0</td>
<td>10 (0 to 10)</td>
<td>60 (0 to 60)</td>
<td>80 (0 to 80)</td>
<td>70</td>
</tr>
<tr>
<td>5</td>
<td>11.0</td>
<td>40</td>
<td>28.5</td>
<td>6.7</td>
<td>23.5</td>
<td>20 (0 to 20)</td>
<td>50 (0 to 50)</td>
<td>120 (0 to 120)</td>
<td>100</td>
</tr>
</tbody>
</table>

*FC, flexion contracture; FA, flexion achieved
further flexion were allowed six weeks after surgery under supervision of a physiotherapist.

Physiotherapy was continued until the patients had good quadriceps control, straight-leg raising, no quadriceps lag, and knee flexion which was full or had reached a plateau.

Results

All five patients were available for review. The results are shown in Table I. The final result was excellent in three patients, good in one and fair in one according to Judet’s criteria. There were no poor results. In theatre, immediately
after the quadricepsplasty, the mean passive flexion was 78° (50 to 110). The mean range of movement achieved was 72° (50 to 100) (Table I). With intensive CPM immediately and after operation and physiotherapy over a mean period of seven months (2 to 12), four of the five patients achieved a further increase in knee flexion. The mean active flexion after the period of treatment was 106° (80 to 130) with a mean range of movement of 102° (80 to 130). This range of movement has not deteriorated in any of the patients. The mean gain in flexion after quadricepsplasty was 76° (50 to 100), which was statistically significant (p < 0.01).

All five patients were pleased with the results of quadricepsplasty and thought that the procedure had been worthwhile (Fig. 3). One had a superficial wound infection which settled with oral antibiotics. None developed a further extensor lag after quadricepsplasty. Two had a prequadricepsplasty lag of 8° and 10° which persisted, but did not deteriorate.

Discussion

A stiff knee after femoral lengthening may result from muscle contracture or adhesions. Muscles which cross two joints are reported to be particularly prone to contractures. During distraction, the tension generated in the muscles which cross two joints may differ because of the varying lengths of the fibres within the same muscle. This differential tension stimulates muscle regeneration at different rates. A contracture arises when a muscle becomes relatively short compared with the bone. The flexors of the knee are reported to be more prone to contractures than the extensors. The adhesions may be intra-articular or between the quadriceps and the regenerate bone. There may also be scarring within the quadriceps muscle and subluxation of the knee. The soft tissues in congenitally short limbs are often abnormal. Although a distal corticotomy has some advantages it may contribute to the development of stiffness of the knee. A proximal corticotomy above the bulk of the quadriceps is less likely to result in stiffness because any adherence of muscle to the regenerate bone is some distance from the knee. All our patients had extension contractures with limited knee flexion. The components limiting flexion included intra-articular adhesions, adhesions between the quadriceps and the regenerate bone and scarring within the quadriceps muscle.

With the Ilizarov method, it is advisable to flex the knee when inserting wires or screws, thereby keeping the muscles under stretch. Functional use of the limb and physiotherapy are also important in limiting stiffness. Despite regular supervised physiotherapy, however, 12 months after removal of the frame which had spanned the knee, all the patients had limitation of daily activities such as walking and sitting. The mean active flexion was 32° and the mean range of movement was 26°. Kettelkamp et al have shown that this range of movement is not compatible with normal gait.

Quadricepsplasty was first described by Thompson in 1944. There have been several reports of its use for stiffness of the knee after fractures and after femoral lengthening for achondroplasia in adults, but not after lengthening of congenital short femur.

In our technique we used a lateral skin incision angled anteriorly distally. The advantages over the anterior midline skin incision used by both Thompson and Judet include: a) no tension on the wound with knee flexion (from the patella and femoral condyles) which may lead to ischaemia of the skin and subsequent wound breakdown and infection; b) excision of previous scars which are often lateral; and c) good exposure of the fascia lata.

Previous studies report extensor lag as a common problem after quadricepsplasty (8° to 52°). None of our patients developed an increased extensor lag after quadricepsplasty.

We suggest that this is a useful technique which can give reliable results in patients with extension contractures and stiffness of the knee after femoral lengthening in children in whom the frame spanned the knee and who have failed to improve with physiotherapy.

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