ONE-_STAGE LENGTHENING FOR FEMORAL
SHORTENING WITH ASSOCIATED DEFORMITY

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One-stage femoral lengthening is thought to have an unacceptably high complication rate and is not widely practised. We reviewed 17 patients after one-stage lengthening for femoral shortening with associated angular or rotational deformities. Minimal dissection of the bone ends was undertaken. The mean length gain was 4 cm (2 to 7), and the average time to union was 6 months (3 to 10). There were no neurovascular complications. Four patients had delayed or nonunion, but union was achieved after bone grafting.

We conclude that with minimal dissection, and with iliac crest cancellous bone grafting, one-stage leg lengthening for correction of deformity and leg-length inequality of up to 7 cm, in selected patients, can be effected safely with a relatively short rehabilitation.

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Shortening is common after femoral fractures, although less so following the trend to the use of locked intramedullary nails. Associated deformities in the sagittal or coronal planes, as well as rotational malalignment, are frequent, and the choice of treatment for such complex deformities may be difficult. The decision must be based on the patient’s symptoms and age, the relative shortening and deformity, the stage of fracture healing, the health of the bone, and the state of adjacent joints and soft tissues. Account must also be taken of the patient’s total height and body proportions.

For discrepancies ranging from 3 to 6 cm, shortening the other limb may be the most appropriate treatment but this does not deal with the deformities in the injured leg. Both shortening and deformity can be corrected by gradual distraction in an external fixation frame, but this requires prolonged treatment, and many complications can ensue (Paley 1988). One-stage lengthening for the correction of shortening has been described (Cauchoix and Morel 1978; Herron, Amstutz and Sakai 1978), but is usually thought to involve major dissection of soft tissues with high complication rates. We report a group of patients who have undergone one-stage lengthening and correction of deformity with minimal soft-tissue dissection.

PATIENTS AND METHODS

We reviewed 17 patients after one-stage lengthening of the femur in one unit at the Nuffield Orthopaedic Centre between 1988 and 1992. Operation was for malunion (n = 13) or nonunion (n = 2), after femoral fracture (n = 15) or surgical osteotomy (n = 2); the other two patients had had growth-plate damage caused by infection or enchondroma. The average age of the patients at the time of operation was 26 years (14 to 45), and the average leg shortening was 4.5 cm (2 to 9). All patients were followed up at least until consolidation of the osteotomy.

Preoperatively, all had had scanograms and long-leg composite weight-bearing anteroposterior and lateral radiographs to assess shortening and angulatory deformity. The osteotomy was pre-planned in detail and an internal fixation device selected. Follow-up recorded the time to achieve union, functional recovery, and complications. Patients are considered in groups according to the level of the deformity (diaphyseal, proximal or distal) and the diaphyseal group was subdivided into those with or without bone loss. Those without bone loss were further subdivided according to whether the shortening was caused predominantly by angulation or by overlap.

Surgical techniques

A number of different types of osteotomy were used; these are shown diagrammatically in Figure 1.

For diaphyseal shortening (n = 10). A direct lateral approach was made over the deformity, with minimal dissection to expose the osteotomy site. In all but two patients, osteotomy was by drill and osteotome. In the
other two the main deformity was rotational and required the cutting of precise steps with a saw. In some patients difficulty in locating the medullary canal in the bone fragments necessitated radiographic screening during the operation. Reduction of the osteotomy was difficult, but leverage of bone ends against each other enabled it to be achieved without excision of bone, except in two cases in which an AO distraction device had to be used. All cases were bone grafted, in five from the iliac crest, and in five from the reamings which had been obtained. Intramedullary nail fixation was used in all cases; in five the reduction was stable without locking screws, and in five locking screws were needed. Patients were mobilised immediately postoperatively.

For diaphyseal shortening due mainly to angulation (n = 4). In this group the shortening averaged 5.5 cm and was caused predominantly by angulatory deformities averaging 55° (Fig. 2a). In one patient the deformity was in the coronal plane, in one it was in the sagittal plane, and in two it was planar. Two patients also had a 20° external rotational deformity. The correction of shortening that would be obtained by total correction of angulation was calculated preoperatively from the radiographs. A transverse or oblique closing wedge osteotomy at the apex of the deformity was used (Fig. 1A). After reduction and fixation the increase in leg length ranged from 3 to 7 cm (Figs 2b,c).

For diaphyseal shortening due mainly to overlap (n = 4). In this group, as well as overlap, the average angulation was 20° in addition to rotational deformity (Fig. 3a). Preoperative measurement showed that correction of angulation alone would not give adequate lengthening. Therefore, both overlap and angulation were corrected. A step osteotomy was used (Fig. 1B) to correct all the deformities. After intramedullary nailing the length gained was from 2.5 to 5 cm (Fig. 3b).

For diaphyseal shortening with bone loss (n = 2). In these two patients there was significant bone loss, no overlap and minimal angulation (Fig. 4a) with an average rotational deformity of 35°. A single-stepped or double-stepped osteotomy (Figs 1C, D) fully corrected the shortening of 5 cm and 2 cm respectively (Fig. 4b).

For shortening in the proximal femur (n = 4). In these patients, the shortening was due to an average varus angulation of the neck of 30° (Fig. 5a). A transverse or oblique osteotomy was used. Excision of a small wedge allowed direct contact between proximal and distal fragments, and the osteotomy was held by either an angled blade plate or a dynamic hip screw. These were inserted before the osteotomy. Reduction of the distal femur on to the plate was difficult, because of muscle contractures. The limb was placed in full abduction, and considerable force was applied. Supplementary iliac-crest bone graft was used in three cases. The length gained was from 2 to 5 cm (Fig. 5b).

For shortening in the distal femur (n = 3). In two of these patients, the shortening was mainly due to angulation, and in one to overlap. The methods at this level were as for diaphyseal deformities, using angle blade plates or simple plate fixation. In one patient a distraction
Diaphyseal shortening caused by overlap (a). The deformity after correction by a step osteotomy (b,c).

Diaphyseal shortening caused by bone loss, with associated rotation (a). The original intramedullary nail is still in place. After correction by a double-step osteotomy (b).
apparatus was needed and in this case iliac-crest bone grafts were used. The length gained was from 2 to 4 cm.

RESULTS

Gain in length. The mean gain in length was 4 cm (2 to 7), leaving an average residual leg-length discrepancy of about 1 cm. One patient had a residual discrepancy of 4 cm, two of 3 cm and one of 2 cm; in the others it was 1 cm or less. Only the patient with a residual 4 cm discrepancy required further surgery for shortening. The initial shortening had been 9 cm with a varus deformity in the proximal femur. The angulation was fully corrected with a 5 cm gain in length at the first operation, and the residual discrepancy was corrected by a contralateral shortening.

Angulation and rotation. In all cases there was complete correction of angulation and of rotation.

Union. The time to union ranged from 3 to 10 months (average 5 months). Most patients were able to walk without the use of external supports after one or two months.

Complications. There was no permanent loss of range of movement at either hip or knee. In most patients, knee flexion was very limited soon after the operation, but all rapidly obtained full flexion. There were no temporary or permanent neurovascular complications.

Fixation. There were two failures of internal fixation. One patient, with malunion of a subtrochanteric fracture, had migration of a previous implant within the femoral head (see Fig. 5a). Considerable force was needed to correct the varus deformity, and postoperative radiographs showed that the screw had entered the old defect. At reoperation the screw was replaced (Fig. 5b) and healing was uncomplicated. In the other patient an intramedullary nail fractured through a distal locking screw hole in association with the delayed union discussed below.

Delayed or nonunion. There were four cases of delayed or nonunion requiring secondary bone grafting, but all united satisfactorily by ten months after the initial osteotomy. In two of the delayed unions there had been diaphyseal overlap and only reamings had been used for bone graft. In one of these the intramedullary nail fractured at the site of a distal locking screw; it was replaced and bone graft applied. The other two cases of delayed union followed treatment for shortening with bone loss and rotation. In both, iliac-crest bone graft had been used initially because of the relative lack of bone contact after the osteotomy.

DISCUSSION

Our 17 one-stage corrections of leg shortening all provided correction of deformity with no neurovascular complications, infection, or loss of joint or muscle function. Up to 7 cm of length were gained when the shortening was mainly due to angulatory deformity, and 5 cm when it was mainly due to overlap or bone loss. All the corrections were made with minimal dissection of bone ends and of soft tissues.

One-stage correction of leg-length inequality and deformity has previously been described (Cauchoix and Morel 1978; Herron et al 1978), but these operations usually involved major soft-tissue dissections with powerful traction, giving leg-length gains of up to 5 cm. In addition, a significant incidence of major complications was reported, including sciatic and femoral nerve palsies, arterial occlusion, and infection.

Other surgical procedures require consideration.
Contralateral femoral shortening is probably indicated for adults of good height with shortening and no other deformity, when corrections of over 3.5 cm are needed (Herron et al 1978). This procedure, however, has its own complications, and these involve the normal limb (Blair et al 1989). It was not appropriate for our patients since they all had significant deformity. The amount of deformity which can be accepted without loss of function or predisposing to late osteoarthritis is uncertain. Morscher (1985) recommends correction if compensatory mechanisms for deformity are failing, and advises operation if there is more than 3° of malalignment on anteroposterior radiographs.

Progressive lengthening methods should also be considered. Müller, Strosche and Scheuer (1984) advocated the Wagner method for correction of shortening and deformity, but this is a two-stage procedure: deformity is corrected at the first operation and then, after a short period of progressive lengthening, plate fixation and bone grafting are needed. Progressive lengthening by callus distraction is more satisfactory and can achieve large increases in length (DeBastiani et al 1987). When correction of deformity is needed at the same time the use of an Ilizarov circular frame is advised (Paley 1988). These progressive procedures can produce dramatic increases in length but have prolonged healing times and many complications (Wagner 1971; Paley 1990). External fixators have to be used for extended periods, and following removal refracture can occur. Pin-site problems are common, and may be serious. Most adults require crutches for six months, and are not able to perform physical work for at least one year.

Our patients were carefully selected for one-stage correction. It was not attempted unless the soft tissues and bone were healthy: previous elaborate bone-grafting procedures, old infection, previous nerve injury, or heavy soft-tissue scarring were contraindications. Detailed preoperative planning of the site and type of osteotomy and the method of fixation was undertaken (Mast, Teitge and Gowda 1990). Patients were told that the deformity would probably be corrected fully, but that length gains of more than 3 cm could not be guaranteed.

All components of the deformity were identified and shortening was measured from scanograms. The angular and translation deformity was defined from full-length anteroposterior and lateral radiographs. Rotational deformity was determined clinically.

Ideally, the osteotomy should be at the site of maximum deformity. If the deformity is at two levels, osteotomy should probably be midway between them, but will also depend on the quality of the bone and the proposed method of fixation. The type of osteotomy is determined by the predominant cause of shortening: angulation, overlap or bone loss. This is usually obvious, but some complex deformities require a study of tracings of the radiographs. These can be placed in the position that a closing wedge osteotomy would achieve and the increase in leg length measured by this technique. If this increase is inadequate the shortening is caused either by overlap or bone loss, and is best corrected by a step osteotomy. When there is overlap, the step of the osteotomy should pass between the bone fragments (see Fig. 1B). Bone loss and rotation can be treated by a single-step or double-step osteotomy: the latter provides more bone contact (Fig. 1D). We did not treat any patients with both bone loss and angulation, but believe that this could be corrected by a step osteotomy at a short distance from the deformity (Fig. 1E). Patients with bone loss alone were excluded from the study.

We used standard methods of internal fixation, with intramedullary nails rather than plates for diaphyseal deformities (Müller et al 1984; Kempf, Grosse and Abalo 1986). The use of locking of the nail depended on the stability of the osteotomy. For proximal osteotomies we used either angled blade plates or dynamic hip screws; for distal osteotomies either angled blade plates or simple plates were satisfactory. In all cases, tracings were used to determine the ideal position of the internal fixation.

There were problems with each type of osteotomy, the most common being soft-tissue resistance to lengthening. Especially after subtrochanteric osteotomy, considerable force was required to achieve reduction. Diaphyseal reduction sometimes necessitated the use of a distraction apparatus during the operation. Despite these difficulties we avoided major dissections, preferring to achieve less than full lengthening with minimal dissection. There were some difficulties in identifying the medullary canal in the proximal and distal segments after diaphyseal osteotomy.

Problems with bony union have been described (Cauchoux and Moré 1978; Herron et al 1978; Ballmer et al 1990; Mast et al 1990), and four of our patients required secondary iliac crest cancellous bone grafting, which was successful in all four. Two of these patients had only intramedullary reamings as graft at their first operation: we now believe that iliac crest cancellous bone grafts should be used for all diaphyseal lengthenings.

Conclusion. In selected patients, one-stage correction of deformity and leg-length inequality of up to 7 cm is safe and requires a relatively short rehabilitation, provided that there is minimal dissection and routine bone grafting. In such cases one-stage lengthening is preferable to either progressive lengthening or contralateral shortening.

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REFERENCES


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