CENTRAL GRAFTING FOR PERSISTENT NONUNION OF THE TIBIA

A LATERAL APPROACH TO THE TIBIA, CREATING A CENTRAL COMPARTMENT

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We report the operative technique and results of a new method of central grafting for persistent nonunion of the tibial shaft. The operation is performed through a lateral approach, anterior to the fibula. Fresh autogenous bone from the iliac crest is used to form a central bridge between the tibia and fibula above, below and at the level of the nonunion. In 48 tibiae, most with long-standing nonunion and some with infection or bone defects, sound healing was obtained in 45 after one operation. Only one failure needed amputation.

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Nonunion of the tibial shaft is difficult to treat, especially in the presence of infection and bone loss. We report the use in 47 patients of a new operative technique called central grafting (CG). The method involves the placement of fresh autogenous corticocancellous bone from the posterior iliac crest through a lateral approach, anterior to the fibula, to create a tibiofibular synostosis above, at and below the level of the nonunion. Bony continuity does not depend upon consolidation of the nonunion itself; the central bone mass and the fibula consolidate into a tubular bone which is strong enough to bear the weight of the body.

PATIENTS AND METHODS

From 1971 to 1988 we treated by CG a total of 47 patients with 48 traumatic nonunions of the tibial shaft. There were 14 women and 33 men; all but four were referred from other hospitals. Their average age at the time of

grafting was 36 years (6 to 75), and the mean interval from the original injury was 2.4 years (0.4 to 13). The sites of the fractures are shown in Figure 1; 73% were caused by high-energy trauma.

When first seen in our department, 12 (25%) tibiae had active osteomyelitis with a purulent discharge, and 34 (71%) had a history of deep infection. Seventeen tibiae (35%) had loss of bone averaging 5.3 cm (1 to 20), and 14 of these defects were or had been infected. The average number of operations before CG was 4.7 (0 to 14). The primary treatment had been plating in 20 tibiae. Seventeen patients (36%) had been advised to have amputation.

Operative treatment was performed in two stages. After the removal of all implants, any infected screw holes were drilled to a larger diameter and all necrotic bone and soft tissues were excised widely, even if this created a large defect. The wound was left open and the leg immobilised in a long plaster cast, which was not changed unnecessarily to avoid damage to granulation tissue (Trueta and Barnes 1940). In three cases the large soft-tissue defects required free vascularised musculo-cutaneous grafts.

In another three cases, tibiae with gaps larger than 10 cm, the defect was bridged with an autogenous cortical graft as well as cancellous grafts.

The second stage was postponed until signs of

Fig. 1

The sites of 48 tibial fractures treated by central grafting.

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infection had disappeared and the wound had epithelialised. The soft-tissue cover of the anteromedial aspect was usually poor, and this led to the use of a lateral approach for grafting. We are not aware of a previous description of this approach and method of grafting.

All patients were prospectively followed from the start of treatment and all notes and radiographs were available. Clinical and radiological union was assessed by the surgeon, and the final review included a medical history, clinical examination, AP, lateral and 45° internal rotation radiographs of the tibia, and weight-bearing views of both ankles to investigate the possible influence of a tibiofibular synostosis on the ankle.

We used the Karnofsky score to assess physical performance before injury, at the time of established nonunion and at final follow-up, with a multiple-choice questionnaire to assess the social and psychological effects of the nonunion and of the treatment. These details have been published elsewhere (Rijnberg 1990).

Operative technique. On the day before operation the patients are started on a course of oral anticoagulants (acenocoumarol) which continues for three months, aiming at an international normalised ratio (INR) of 2.8 to 2.1 (thrombo-test 10% to 16%; Swierstra 1986). Antibiotics are not prescribed routinely.

The patient is placed in a lateral position with a small pillow between the legs (Fig. 2), and protection for the head of the fibula and the lateral malleolus of the lower leg. This provides access to both the lateral side of the lower leg and the posterior iliac crest. The leg is elevated for two or three minutes before the tourniquet is inflated. We did not use elastic-bandage exsanguination because of the risk of dislodging emboli (Austin 1963; Pollard, Lovelock and Jones 1983), and because some blood in the vessels makes them easier to identify.

A long incision is made just anterior and parallel to the fibula (Fig. 3A), carefully preserving the superficial and common peroneal nerves when the incision extends to the full length of the bone. The crural fascia is incised in the same line, and the interval between the peroneal muscles and the extensor digitorum is identified and opened. This exposes the fibula and the interosseous membrane. Muscle is detached from the anterior aspect of the interosseous membrane, using a periosteal elevator, first distal and then proximal to the nonunion to expose the lateral aspect of the tibia. The deep peroneal nerve and the anterior tibial vessels, which lie on the interosseous membrane, are retracted anteriorly with the extensor muscles (Fig. 3B). The periosteum of the tibia is then incised longitudinally 2 or 3 mm anterior to the line of attachment of the interosseous membrane, and the membrane together with the periosteum is detached in one layer from the dorsolateral edge and dorsal surface of the tibia. The interosseous membrane is incised close to its attachment to the fibula, with care to avoid damage to the underlying fibular vessels (Fig. 3C). The interosseous membrane and the periosteum of the posterior

Fig. 2

Position at operation, showing the lateral approach to the tibia.

Fig. 3

Diagrams of the operation. A, cross-section of right leg through the proximal tibia. B, the lateral approach to the tibia, between the extensors and the peroneal muscles, exposing the interosseous membrane. C, sites of incision of the periosteum and interosseous membrane. D, the space created by posterior displacement of the interosseous membrane filled with bone grafts from the iliac crest.

tibial surface, still in continuity, are displaced posteriorly, and the remaining periosteum is elevated from the lateral surface of the tibia.

This creates a central space bordered by the tibia, the interosseous membrane and periosteum and the fibula which together form the bed for the graft (Fig. 3D). Careful work from the proximal and distal ends then allows the whole interosseous membrane to be exposed, but sharp dissection is usually needed through the scarred tissues near the nonunion. The ununited part of the tibia is left undisturbed.

For a proximal nonunion, the operative technique is slightly different. At the proximal end of the anterior compartment the common peroneal nerve is identified and retracted. The anterior tibial vessels pass through and are fixed by the interosseous membrane; they are made mobile by excising the proximal part of the membrane.

The excision of the proximal part of the interosseous membrane creates space for the graft without endangering the anterior vessels. Where the nonunion is a proximal one it may be necessary to excise the articular cartilage and subchondral bone of the proximal tibiofibular joint and fuse it with a single screw.

The exposed cortex of the tibia and fibula are then roughened with a gouge by 'petalling' (Jarry and Uthoff 1960) and the leg is ready for the graft. The wound surfaces are approximated, a sterile bandage applied and the tourniquet is released.

Graft is taken from the outer layer of the posterior iliac crest in the form of thin corticocancellous strips about 4 cm long and 0.5 cm wide, and soft cancellous bone. The grafts are preserved in a blood-soaked swab and the wound is closed over a suction drain.

The bandage is removed from the leg; there is usually no need for haemostasis. The central space is filled with the corticocancellous and cancellous strips arranged like roof tiles, extending into the space behind the tibia (Fig. 3D). The volume of the graft usually makes it impossible to close the crural fascia, and meticulous

closure of the subcutaneous tissues and the skin is necessary.

A well-padded long-leg cast is applied and split at the end of the operation; for a stable or distal nonunion, a below-knee cast may be adequate. The leg is elevated and the drains are removed after 48 hours. After wound healing, the cast is changed for a long-leg 'near-skin cast' (Dehne et al 1961) and the patient is usually allowed partial weight-bearing to about 10 kg, depending on the stability of the nonunion. When there is adequate stability, the cast is removed, and a custom-made brace fitted, in which the patient is encouraged to do knee and ankle exercises. The brace is discarded only when there is full union.

RESULTS

The operating time averaged 125 minutes (75 to 200). The mean operative blood loss was 570 ml (200 to 2000), and the mean postoperative drainage was 460 ml (40 to 1185).

Union and consolidation after one CG was achieved in 45 legs (96%) with an average time to clinical consolidation of 6 months (1.5 to 23), and to radiological consolidation 8 months (2 to 27; Fig. 4) but some patients preferred to use the brace for longer because they had not regained full confidence (Fig. 5).

One patient had a below-knee amputation for persistent infection after 13 operations, including three attempts at CG. This was the only case with signs of active infection at the time of grafting. One other patient had a second cancellous graft because of refracture after significant trauma distal to the first graft. One patient committed suicide and in one other patient with psychiatric problems consolidation remained uncertain. **Complications.** There were two intraoperative complications: in one case the deep peroneal nerve was damaged resulting in a persistent drop foot, and in another a laceration of the anterior tibial artery needed repair.

After operation, one patient developed a compart-

Fig. 4

Time to clinical union and radiological consolidation, by cumulative percentages of the whole series.

Fig. 5

Time to full weight-bearing with or without splintage. Some patients were out of their plaster or brace before they were allowed to take full weight.

Fig. 6a

Fig. 6b

Fig. 6c

Fig. 6d

Fig. 6e

Fig. 6f

Fig. 6g

Fig. 6h

A 29-year old man sustained a grade-III compound fracture of the tibia in a car accident. Radiographs show: a) the fracture after initial treatment; b) after the resection of necrotic bone; c) before central grafting; d) three months after grafting; e) eight months after grafting; f) and g) anteroposterior and lateral views after three years. The cancellous graft has matured into a tubular structure that is strong enough to bear full weight. Figure 6h - Clinical appearance of the leg at review. The free vascularised soft-tissue graft was applied before the central grafting procedure.

Fig. 7

CT scan after successful central grafting showing that the grafted bone has developed a cortex and marrow cavity.

ment syndrome due to misguided suture of the crural fascia; after immediate release slight weakness and sensory deficit in the foot persisted. One developed wound haematoma which required evacuation, and one had non-fatal pulmonary emboli six weeks after surgery and was found to have an inadequate level of anticoagulation. Superficial wound infection occurred in four legs and two iliac-crest wounds, but all healed with conservative treatment. There were no cases of refracture. Examples of the maturation of the graft and the appearance of the leg at review are shown in Figures 6 and 7.

Review. Forty-three of the 47 patients (91%) were available for review at a mean time after CG of 7.3 years (0.9 to 19). There was one failure in a patient who had amputation and three patients had died. Two of them had sound union and death was not related to the grafting. The third, however, had a very long history of infected nonunion with multiple operations, and committed suicide 14 months after CG, before the nonunion had fully healed.

Twenty-six patients (60%) had no complaints, and 17 (40%) had some form of discomfort in the lower leg. Despite this all but one of the surviving patients were satisfied with the result; none would have preferred early amputation. Over 70% of them could walk 2.5 km or more. Prolonged nonunion had had serious social and psychological consequences for many patients; healing was often, but not always, associated with improvement.

Two patients had chronic discharging fistulae; one had chronic osteomyelitis at the level of the healed nonunion despite three sequestrectomies and a free vascularised flap performed by plastic surgeons. Three

other patients had sporadic recurrence of infection, but usually had a good response to antibiotics.

Thirty-five patients had shortening of the lower leg averaging 2.0 cm (0.5 to 10). There was varus malalignment of 7° to 13° in ten legs and valgus malalignment of 7° to 28° in nine legs. Six patients had anterior angulation of 7° to 10° and 13 had recurvatum deformity of 7° to 22°.

Ankle function was often severely restricted before CG, but many cases had recovered a useful range of movement at review. In 36 patients with a tibiofibular synostosis a standardised clinical and radiological examination of the ankle was performed. Eleven were excluded because of other causes for restriction of ankle function. All but one had no pain or very little pain in the lower leg or ankle, and only three complained of inconvenience from stiffness. Function was measured clinically by adding the weight-bearing dorsiflexion and plantar flexion, expressing the result as a percentage of that of the normal ankle. The average range in legs with synostosis was 70% $\pm$ 22% (17 to 98). Thus, the average loss of ankle function was 30%. The average narrowing of the talocrural joint was 15%. We concluded that residual stiffness was usually related to the soft-tissue injury of the primary injury, prolonged immobilisation and multiple operations, rather than to the synostosis.

DISCUSSION

Nonunion is more common in the tibia than in any other bone (Boyd, Lipinski and Wiley 1961) and infection or bone loss make the prognosis even worse (Nicoll 1964). Patients with tibial nonunion have severe problems, and many have total loss of confidence in medical care after many months or even years of failed surgery. Many of our 47 patients had this condition; most had a scarred, dystrophic leg, and amputation had been considered for 17 of them.

Our results confirm that central grafting is a reliable procedure, much better than amputation. Normal function is not often attained, but a painless, stable limb is much better than an artificial one, even if there is some shortening, malalignment or ankle stiffness. We had only one complete failure, and in this case the first CG was probably performed too early, while there was still an infected fistula.

Many techniques of bone grafting have been described, and it is difficult to compare results. Elmslie in 1920, as reported and agreed by Burrows (1940) had taught that resection of the nonunion was unnecessary, and Phemister (1947) showed that the tissue between the bone ends may ossify after bone grafting, and that rigid immobilisation was not necessary.

Milch (1939) described the creation of a tibiofibular synostosis for tibial nonunion and several authors have reported satisfactory rates of union (Jones and Barnett 1955; Lamb 1969; Freeland and Mutz 1976; Weinberg et al 1979; Reckling and Waters 1980; Simon and

Hoogmartens 1984; Simpson et al 1990). All these authors used a posterolateral approach (Harmon 1945) with the bone graft laid posterior to the interosseous membrane. Some considered that the interosseous membrane was a barrier against infection, which usually involves the anterior compartment (Hanson and Epworth 1966; Vidal et al 1982).

We used an anterolateral approach, in front of the fibula and peroneal muscles, which gives excellent exposure of the interosseous membrane. Even in severe cases and multiple operations the soft tissues of the lateral side of the leg are usually well preserved; wound healing was not a problem. Dissection of the interosseous membrane from the tibia and fibula and its displacement backwards create a central gutter which gives ample room for the graft and holds it in position against the petalled cortices of the tibia and fibula. Bone graft of good quality and adequate quantity is essential, and we advocate the use of large amounts of fresh cancellous bone from the iliac crest (Friedlander 1987; Heiple et al 1987). Union may result either from healing of the nonunion or in the case of a bone defect transformation of the graft into a new weight-bearing central shaft with a cortex and marrow cavity.

Early in the series, we accepted minor malalignment to avoid loss of stability at the time of central grafting. We have gained confidence, and do not now hesitate to perform a corrective osteotomy at the level of the pseudarthrosis. In some cases, however, malalignment helped to compensate for a fixed equinus or varus position of the foot and was accepted. The addition of a cortical graft as a spacer makes it possible to bridge large defects, and this technique has been successful after tumour resection (Swierstra, Rijnberg and van Linge 1990).

Recent developments in the treatment of tibial nonunion include the use of the Ilizarov technique (Paley et al 1989), and of free vascularised fibular transplants. The advantages of central grafting are its simplicity and the avoidance of implants that may provoke recurrence of infection and of operation on the contralateral leg.

Conclusions. Central grafting is a reliable, safe and relatively easy procedure for the treatment of tibial nonunion. The method works irrespective of the length of the tibial defect. Infection requires thorough debridement before grafting, but the technique does not lead to recurrence of infection, partly because of the absence of metal implants. The tibiofibular synostosis that is created does not appear to cause problems at the ankle, although the mobility of this joint is often impaired in such cases.

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