THE TRANSARTICULAR GRAFT FOR INFANTILE PSEUDARTHROSIOSIS OF THE TIBIA

A NEW TECHNIQUE

SAN BAW, MANDALAY, BURMA

From the Department of Orthopaedic Surgery, General Hospital, Mandalay

Fourteen cases of pseudarthrosis of the tibia in childhood presented at a hospital in Burma over a period of eight years. The ages of the patients ranged from one month to seventeen years. Nine were treated by a pointed graft driven into the medullary cavity of the distal tibia, and usually across the ankle joint into the body of the talus, before fixation to the proximal tibia. In six of the nine union was secured, but one case required a second grafting. Transarticular segments of graft showed a marked tendency to undergo absorption. No significant deformity was observed to follow central penetration of the growth plate and epiphysis of the lower tibia.

It is generally acknowledged that pseudarthrosis of the tibia in childhood is rare; few orthopaedic surgeons have the opportunity to treat a dozen patients personally in their lifetime. Moore reported six cases in 1948; McFarland reviewed eleven in 1951; Boyd and Sage in 1958 reported fifteen from the Campbell Clinic; but Van Nes in 1966 collected no less than twenty-two cases treated personally over a span of thirty years.

Various techniques of bone grafting have been reported; the dual onlay method of Boyd and the by-pass graft of McFarland are the methods generally accepted. Moore described a method of delayed autogenous grafting and Van Nes reported the use of an intramedullary nail in combination with grafts. Eyre-Brook (1969) has improved on the McFarland operation by employing Moore’s technique for preparation of the graft. This paper is concerned with a new technique employing a transarticular graft.

Socio-economic background—It is necessary first to realise the conditions prevailing in Burma when considering the development of this technique. All except two of the patients came from remote villages. The parents of the other children were mostly poor ignorant farmers who accepted the deformities as their fate and were therefore not amenable to treatment; hence the considerable delay before they presented the child at a major city hospital. This attendance too was often a matter of chance, usually as a result of the parents coming to town for a pilgrimage at a cost of perhaps several months of meagre saving. With this background it is easy to understand why the pseudarthroses usually were fully established with gross angular deformities and several centimetres of shortening. Another relevant fact is that the parents invariably take the child home the instant the word amputation is mentioned: rather a child maimed for life than “dismembered”. It was only with patient explanation, often fortified with monetary support of the member of the family attending while the child was in hospital, that they would finally consent to operation.

TECHNIQUE OF OPERATION

The donor graft should be of suitable length and preferably autogenous. When this is not possible due to the small size of the opposite tibia, as in children below the age of three years, homogenous tibial grafts either from a donor or from cadaveric banked bone have been used (Table I). One end of the graft is made into a spike in order to facilitate driving it through the medullary cavity of the distal fragment and across the ankle joint into the body of the talus. The tapering sclerotic ends of both fragments are trimmed to reach bone as near normal as possible, while the intervening scar tissue is widely excised. The spiked end of the graft is introduced with care into the medullary cavity of the short and porotic distal fragment so as not to split the cortex, which is usually parchment thin. The alignment of the graft as it is hammered home across the ankle joint into the talus is carefully maintained with reference to the proximal tibial fragment. Loss of movement of the ankle joint usually indicates that the spiked end is well into the body of the talus. The foot and the embedded graft are now aligned to the proximal fragment. Gentle traction may be necessary to gain some length for the leg, but this should not sacrifice adequate apposition of the graft to the prepared surface of the proximal tibia. Three well-spaced screws usually suffice for rigid fixation. Cancellous bone is liberally packed into the space of the previous pseudarthrosis, along the graft, and on the host bone proximally and distally. The leg is immobilised in a long leg plaster

Dr San Baw, M.B., B.S., M.S.(Ortho), Chief of Department of Orthopaedic Surgery, Mandalay General Hospital, Mandalay, Burma.

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with the knee flexed to a right angle. The knee is gradually straightened with each change of plaster. Partial weight-bearing is permitted after three months provided the radiographs show consolidation.

**ILLUSTRATIVE CASE REPORTS**

**Case 4**—A boy aged eight years attended in March 1965 for a fully established lesion of the right tibia and fibula with anterior angulation of 90 degrees. There were café-au-lait spots all over the body. Radiographs showed the distal tibial fragment to be just a triangular blob of bone (Fig. 1); the end of the proximal fragment was attenuated to a dagger point which threatened to perforate the skin. Because of the rudimentary nature of the distal fragment it was decided that the only way to achieve fixation to the graft would be to pass it through the distal fragment and ankle joint into the body of the talus.

In March 1965 this procedure was first performed, utilising a pointed tibial graft from an unrelated donor. Three screws gave adequate fixation to the upper tibial fragment. Four months later sound consolidation had taken place (Fig. 2). At this stage a walking plaster was applied and the parents were asked to bring the child back a month later for follow-up. It was not until two and a half years from the operation, however, that the child was seen again. By then the graft had been completely incorporated, with recanalisation of the medullary cavity; the spiked portion of the graft that traversed the ankle joint had also been completely resorbed (Fig. 3). The opposite lower femoral epiphysis was stapled in November 1967. At the last follow-up in 1972 seven years after the bone grafting union was still sound and the range of active movement of the ankle joint was 45 degrees. There was relative shortening of ten centimetres, but he had compensated well and participated in vigorous sports such as football.

**Case 5**—A boy aged fourteen years presented in March 1970 with a neglected congenital pseudarthrosis of the right tibia

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### Table 1

**Details of the Fourteen Patients**

<table>
<thead>
<tr>
<th>Case number</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Side</th>
<th>Other stigmata</th>
<th>Date of operation</th>
<th>Type of operation</th>
<th>Source of tibial graft</th>
<th>Second operation</th>
<th>Result</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>F</td>
<td>L</td>
<td>Café-au-lait spots</td>
<td>August 1964</td>
<td>Dual onlay</td>
<td>Donor (father)</td>
<td>—</td>
<td>Absorption of graft</td>
<td>Lost to follow-up after one year</td>
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<tr>
<td>2</td>
<td>4</td>
<td>F</td>
<td>L</td>
<td>Café-au-lait spots</td>
<td>November 1964</td>
<td>Dual onlay</td>
<td>Donor (unrelated)</td>
<td>May 1965</td>
<td>Fracture and absorption of graft</td>
<td>Lost to follow-up after a third operation</td>
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<tr>
<td>3</td>
<td>17</td>
<td>F</td>
<td>L</td>
<td>Café-au-lait spots</td>
<td>January 1965</td>
<td>Single onlay</td>
<td>Autogenous</td>
<td>—</td>
<td>Not known</td>
<td>Lost to follow-up</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>M</td>
<td>R</td>
<td>Café-au-lait spots</td>
<td>March 1965</td>
<td>Trans-articular</td>
<td>Donor (unrelated)</td>
<td>Nil</td>
<td>Consolidation</td>
<td>Primary union</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>M</td>
<td>R</td>
<td>Café-au-lait spots with neurofibromatosis</td>
<td>April 1970</td>
<td>Trans-articular</td>
<td>Donor (father)</td>
<td>January 1972 (autogenous)</td>
<td>Consolidation after second grafting</td>
<td>Secondary union</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>F</td>
<td>R</td>
<td>Café-au-lait spots</td>
<td>January 1971</td>
<td>Trans-articular</td>
<td>Cadaveric</td>
<td>—</td>
<td>Consolidation</td>
<td>Primary union</td>
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<tr>
<td>8</td>
<td>2</td>
<td>F</td>
<td>R</td>
<td>Café-au-lait spots</td>
<td>January 1971</td>
<td>Trans-articular</td>
<td>Cadaveric</td>
<td>—</td>
<td>Consolidation</td>
<td>Primary union</td>
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<td>10</td>
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<td>Cadaveric</td>
<td>—</td>
<td>Consolidation</td>
<td>Primary union</td>
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<td>L</td>
<td>Café-au-lait spots</td>
<td>September 1971</td>
<td>Trans-articular</td>
<td>Donor (unrelated)</td>
<td>—</td>
<td>Consolidation</td>
<td>Primary union. Sclerotic changes in opposite right tibia</td>
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<td>1/12</td>
<td>F</td>
<td>R</td>
<td>Nil</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Child taken home when mother asked to donate bone</td>
</tr>
<tr>
<td>13</td>
<td>16</td>
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<td>R</td>
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<td>December 1972</td>
<td>Trans-articular</td>
<td>Autogenous (fibula)</td>
<td>—</td>
<td>Fracture of graft</td>
<td>Waiting second grafting</td>
</tr>
<tr>
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<td>3/12</td>
<td>M</td>
<td>R</td>
<td>Nil</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Under observation</td>
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</table>
Case 4. Figure 1—The initial radiograph showing the untreated pseudarthrosis of the tibia with a very short distal fragment. Figure 2—Four months after transarticular grafting. Figure 3—Two and a half years after grafting, showing recanalisation of the medullary cavity and complete absorption of the segment of the graft across the ankle joint. The appearances at seven years were very similar.

Case 5. Figure 4—A radiograph showing the moderate “reversed sabre” deformity of the upper tibia, with tapering sclerosed ends of both fragments. Figure 5—A radiograph one month after transarticular grafting. Figure 6—A film nine months after grafting, showing absorption of bone around the third screw track with fracture of the graft. Figure 7—Three months after the insertion of a second graft, the new graft is being incorporated but a portion of the first graft still remains avascular. Figure 8—One and a half years after the second grafting, recanalisation of the medullary cavity is almost complete but the ankle joint appears fused.

and fibula causing a right-angled deformity. Again there were café-au-lait spots all over the body. Radiographs showed a “reversed sabre” deformity of the proximal tibial fragment with a tapering sclerosed end (Fig. 4); the short distal fragment was similar but porotic.

In April 1970 paternal bone was utilised to graft the pseudarthrosis. An additional screw was inserted to fix the graft to the distal fragment which had splintered on introducing the graft (Fig. 5). At four months there was enough incorporation of the graft to permit weight-bearing in a long
leg cast. He was lost to follow-up at seven months. Repeated attempts to recall the patient failed until a year later when he presented with deformity and movement at the original site. He had removed the cast himself two months after his last visit, namely, nine months after the operation. Radiographs now showed that absorption of the graft around the third screw track had led to refraction and that the portion traversing the ankle joint had not been absorbed (Fig. 6).

A second graft was inserted in January 1972, using a tibial graft from the opposite leg. Radiographs three weeks later clearly showed the graft well opposed on the lateral side and the avascular portion of the first graft. By three months the second graft was incorporated proximally (Fig. 7) and partial weight-bearing in a long leg cast was permitted. By seven months the graft was soundly incorporated with evidence of partial recanalisation. The avascular portion of the first graft had by now been completely revascularised but the ankle joint had fused. The latest radiograph, taken one and a half years after the second graft, showed complete recanalisation of the medullary cavity (Fig. 8).

**Case 6**—A boy aged four years presented with a congenital pseudarthrosis of the right tibia and fibula after three bone-grafting procedures elsewhere. Clinically there was a right-angled deformity and the radiographs showed a bulbous expansion of the pseudarthrosis, in contrast to the other cases

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**Figure 9**—The radiographs taken after three previous operations, showing bulbous expansion of the bone at the level of the pseudarthrosis. **Figure 10**—Ten months after grafting, absorption of the graft at the second screw track and fracture has occurred. **Figure 11**—Seven months after the third of the new series of operations fracture of the graft has again occurred.

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**Case 8**. **Figure 12**—The initial radiographs. **Figure 13**—Six months after grafting, solid incorporation of the graft has taken place. The screws have been removed for local tenderness. **Figure 14**—After two years, recanalisation of the medullary cavity and absorption of the graft in the ankle joint are complete.
in which the bone ends were tapered (Fig. 9). This suggested that the initial lesion of the tibia may have been an expanding dysplastic one.

In September 1970 bone grafting was performed using maternal bone. By ten months partial absorption and fracture of the graft had taken place (Fig. 10). Complete absorption of the graft in the ankle joint had also occurred. In August 1971 a quantity of cancellous bone was packed around the fractured graft and the two lower screws were removed. Six months later there was almost complete absorption of the original maternal graft. In May 1972 a third grafting pro-

ceedure was undertaken using a tibial graft from the opposite leg, but after seven months it too had fractured (Fig. 11). At this stage the parents refused further surgical treatment.

Case 8—A girl aged two years presented in December 1970 with a pseudarthrosis of the right tibia and fibula (Fig. 12). There were multiple café-au-lait spots. In January 1971 grafting was performed with cadaveric bone, which four months later showed good incorporation. She was then permitted to bear weight in a long leg cast. At six months the three screws were removed because the overlying skin had become tender (Fig. 13). By nine months the site of the pseudarthrosis had reconstituted and the graft traversing the ankle joint had partly absorbed; the long leg cast was discarded. Two years after the grafting recanalisation of the medullary cavity and absorption of the graft in the ankle joint were complete (Fig. 14).

Case 10—A girl aged eight years presented in June 1971 with a neglected pseudarthrosis of the left tibia and fibula causing a right-angled deformity; the lower end of the proximal fibula protruded like a nipple at the apex (Fig. 15). Numerous café-au-lait spots were present. Radiographs showed marked attenuation of the fragments with sclerosis of the ends. The upper tibial fragment had a “reversed sabre” deformity; the distal fragment was of adequate length but porotic (Fig. 15).

In July 1971 grafting was performed using cadaveric bone; the spiked end was not driven across the ankle joint because firm fixation in the lower tibial fragment alone was obtained. The marked curvature of the proximal tibial fragment made it impossible to fix the upper end of the graft by means of the usual three screws. Accordingly the graft was embedded in a deep slot in the metaphysis and fixation was achieved by wiring. One month later the graft was stable, with the point just short of the lower tibial epiphysis (Fig. 16). Partial weight-bearing was permitted with a long leg cast and crutches at three months. By one year (Fig. 17) there was sound incorporation of the graft, and by two years revascularisation and canalisation were well advanced.

RESULTS

Over a period of eight years from July 1964 to November 1972 fourteen cases of established congenital pseudarthroses were seen (Table I). The sex distribution was eight girls to six boys. The right side was involved eight and the left six times. The ages ranged from one month to seventeen years.

The first three cases have been excluded from the analysis because the technique of grafting under consideration was not employed in them. One infant, Case 12, was taken home by the mother when she was asked to donate her tibial bone, and has therefore received no treatment. A second infant, Case 14, is still being observed. Of the remaining nine patients who have been subjected to this operation, six have achieved solid union. The youngest was aged two years and the oldest sixteen. Of these six, five had primary union, but one, Case 5, needed a second operation. It is interesting to note that in the five patients who achieved primary union three cadaveric and two donor grafts were used; the sixth patient received an autogenous graft at the second operation which healed. The longest follow-up in these six
patients was eight and a half years (Case 4) and the shortest two years (Case 11).

Of the remaining three patients, one, Case 6, had had three unsuccessful operations elsewhere, and two additional operations by this technique failed to secure union. In Case 9, an infant of eleven months, the graft was rapidly absorbed; a second grafting was done a year later but is yet too early for assessment. In Case 13, a girl of sixteen, the graft fractured through a screw track after four months and she awaits a second grafting.

DISCUSSION

The decision to drive the distal end of the graft across the ankle joint into the talus resulted from failure to achieve adequate fixation of the graft in the first three cases, where dual onlay grafts were employed in the first two and a single onlay graft in the third case. On review of the causes of such failure it was noted that the distal tibial fragments were either too short or too porotic to provide sufficient grip for the screws. That the growth plate of a child is violated by driving a graft through it cannot be denied, but considering that the majority of the cases were fully established, with considerable shortening and refusal of amputation, it was thought not unreasonable to transgress the sanctity of the joint in order to achieve union of a difficult pseudarthrosis. Stiffness of the ankle joint following the grafting was also considered, and it was thought that if union could be achieved at the expense of residual stiffness this would indeed be a small sacrifice.

In the event, anxiety on these two points was not well founded. Thus Cases 4, 6 and 8 show the portion of the graft across the ankle joint to have been absorbed as early as nine months after grafting, with minimal restriction of active dorsiflexion in Case 4. It seemed, however, that partial closure of the epiphysis could take place especially towards the centre, as evidenced by "tenting" of the epiphysis (Cases 6 and 8). Such "tenting" is identical with the "dipping" of the epiphyseal plate reported by Barash and Siffert in 1966. They observed that "dipping" occurred in animals subjected to midline longitudinal osteotomy of the epiphysis, growth plate and metaphysis of growing bones, whereas in very young animals with ossific centres not yet visible in radiographs "dipping" was not demonstrated. This corroborated the earlier experimental findings of Ford and Key (1956) who concluded that "a small part of the central portion of the epiphysis can be damaged and result in only mild or moderate growth interference". It might therefore be desirable in future cases to attenuate the spiked end of the graft still further in order to avoid marked "tenting" of the epiphysis.

The late development of a varus deformity of the ankle as a sequel to partial closure of the growth plate is also a distinct possibility, but no evidence of such deformity has yet been encountered, even in Case 4 after eight and a half years.

REFERENCES


