PLATE FIXATION OF TIBIAL SHAFT FRACTURES
A Survey of 181 Injuries

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The subject of tibial plating can be guaranteed to give rise to lively discussion at any clinical meeting. The majority view in this country is that these fractures should be treated conservatively. Nicoll (1964) in a forthright paper stated that the only ground for subjecting the patient to the hazard of surgery was to ensure a good functional result unlikely to be achieved by closed means. It is true that many patients with these injuries do well with closed treatment, but I believe that in suitable cases they can be treated more satisfactorily by plating. Early experience in the school of conservative fracture treatment provided ample opportunity for appreciation of the deficiencies of the closed method when applied to all tibial shaft fractures.

Ellis (1958a) showed that the rate of union of a tibial shaft fracture was related to the severity of the injury, and this was confirmed in a larger series by Nicoll (1964). Fractures resulting from mild trauma have a good prognosis for union within three or four months, and for most of these the closed method is suitable. The main exception is in elderly patients who may be very handicapped by the injury; the need to walk with crutches can be avoided by internal fixation of the fracture supplemented by plaster splintage. In injuries of moderate severity delay in union is not uncommon and the prognosis is therefore less certain. This includes the fully displaced closed fracture, in which there may be commination, as well as the unstable open fracture without severe skin damage in which redisplacement is likely to cause disruption of the skin with ulceration and prolonged morbidity (Hampton 1955, McLaughlin 1961). Most of these fractures of moderate severity are suitable for plating, as will be shown. In severe fractures the degree of damage to the bone or overlying skin may preclude internal fixation although the method has been used in this series in order to try to assess its value.

Experience with fractures of the radius and ulna in adults showed that rigid fixation was necessary if union were to be assured (Burwell and Charnley 1964) and this principle was applied to tibial fractures. Secure tibial plating had previously been described by Murray (1941) and the method received support from Blockey (1956).

The fractures in this series have been divided into three grades corresponding to those of Ellis (1958a), as shown in Table I. If there was any doubt into which grade a fracture should be placed, the less severe one was used in order to ensure that the plating operation was not favoured.

Frequent reference will be made to the papers of Ellis (1958a and b) and Nicoll (1964) because, as pointed out by these authors, they form the basis for comparison of a series of tibial fractures treated by plating.

MATERIAL

Over a period of ten years, in an accident department responsible for an urban population of nearly 200,000 people, 181 fractures of the tibial shaft in 179 patients were treated by plating. Eight of the fractures were in patients under the age of sixteen operated upon because of irreducibility or severe compounding. The 181 fractures were graded as described above (Table I). During this period a further ninety-two tibial shaft fractures, in patients over sixteen years, were treated without operation. Sixty-three of these fractures were in the mild grade.
and there was considered to be no indication for operation. Twenty-three were in the moderate and six in the severe grade; operation was avoided in these fractures because it was considered that primary skin healing could not be assured, either because of injury to the skin or because the peripheral circulation was impaired by arterial disease. Crack fractures were excluded, as in Nicoll's (1964) series.

*Age and sex*—The age and sex distribution of the 179 patients is shown in Figure 1.

*Nature of accident*—The types of accident responsible for the injuries are shown in Figure 2.

**Level and type of fracture**—The incidence of the fractures at five levels is shown in Figure 3. The types of fractures are also shown in Table II. In each instance segmental fractures are excluded.

*Segmental fractures*—Seventeen tibiae with segmental (double) fractures were plated; one was in the mild grade, ten were in the moderate and six in the severe.

*Compound fractures*—There were sixty-three open fractures (34·8 per cent). The distribution of the three types in the moderate and severe fractures is shown in Table III.
Comminuted fractures—The distribution of fractures according to the degree of comminution in relation to the moderate and severe grade of fractures is shown in Table IV. Minor comminution is not considered.

Intact fibula—Eleven patients had no fracture of the fibula.

Figure 2—Distribution of injuries according to the nature of the accident. Figure 3—The level of fracture in 164 cases of this series of tibial fractures. Seventeen segmental fractures are excluded.

TABLE II

Distribution according to Type of Fracture, excluding Segmental

<table>
<thead>
<tr>
<th>Transverse</th>
<th>Transverse/oblique</th>
<th>Oblique</th>
<th>Spiral</th>
<th>Undefined</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>33</td>
<td>26</td>
<td>51</td>
<td>2</td>
</tr>
</tbody>
</table>

TABLE III

Distribution of Sixty-three Compound Fractures according to Severity of the Wound

<table>
<thead>
<tr>
<th>Wound</th>
<th>Moderate fracture</th>
<th>Severe fracture</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>21</td>
<td>8</td>
<td>29</td>
<td>46</td>
</tr>
<tr>
<td>Moderate</td>
<td>16</td>
<td>9</td>
<td>25</td>
<td>39.7</td>
</tr>
<tr>
<td>Severe</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>14.3</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
<td>26</td>
<td>63</td>
<td>100</td>
</tr>
</tbody>
</table>

Associated injuries—Other fractures in the injured limb which could affect the progress or outcome are shown in Table V. Two fractures (in addition to the tibial fracture) occurred in three patients: shaft of femur and patella (two); shaft of femur and lateral condyle of tibia (one).
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METHOD

Summary of treatment—Operation was undertaken as soon as possible, rigid plating of the fracture was achieved, and the leg was then bandaged. Exercises of the knee, ankle and foot were practised in bed for one to three weeks, followed by full weight-bearing in an above-knee plaster for some weeks; subsequent remedial treatment was of short duration.

Timing of operation—Ninety per cent of the fractures were plated on the day of the accident.

Surgeons—The writer operated on seventy-three of the fractures (40 per cent). Ten other surgeons were responsible for the remainder.

TABLE IV
DISTRIBUTION OF FRACTURES ACCORDING TO DEGREE OF COMMINUTION

<table>
<thead>
<tr>
<th>Type</th>
<th>Moderate fracture</th>
<th>Severe fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undisplaced butterfly</td>
<td>38</td>
<td>5</td>
</tr>
<tr>
<td>Displaced butterfly</td>
<td>23*</td>
<td>18</td>
</tr>
<tr>
<td>Gross comminution</td>
<td>5†</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>31</td>
</tr>
</tbody>
</table>

* Smaller fragments than in severe fractures.
† Relatively undisplaced fracture (in moderate grade).

TABLE V
OCCURRENCE OF ASSOCIATED FRACTURES IN THE SERIES OF 181 TIBIAL FRACTURES TREATED BY PLATING

<table>
<thead>
<tr>
<th>Associated injury</th>
<th>Number of patients</th>
<th>Additional operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central dislocation of hip</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Posterior dislocation of hip</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Fractures of pelvis</td>
<td>6</td>
<td>—</td>
</tr>
<tr>
<td>Fracture of femoral shaft</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Fracture of patella</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Lateral condyle of tibia</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Medial malleolus</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Fractures of calcaneus (open)</td>
<td>2</td>
<td>—</td>
</tr>
</tbody>
</table>

Internal fixation—Burns's or Venable's stainless steel plates were used. Eighty-six per cent of the plates were 15 centimetres or longer. The 18-centimetre plate was used twice as often as any other size. In no instance were fewer than six screws used to fix the plates. Supplementary screws inserted at right angles to the fracture line were used in twenty-six oblique fractures or to fix separated butterfly fragments.

Duration of post-operative exercises—In elderly patients exercises in bed were continued for only one week in order to allow walking without delay. In younger patients exercises were continued for two to three weeks until full joint movement was regained, the longer period being usually necessary in lower shaft or comminuted fractures.
Duration of plaster splintage—In the mild grade the plaster was removed between six and ten weeks from the operation in 79 per cent of patients; in the moderate grade between eight and twelve weeks in 82 per cent; and in the severe grade between eight and sixteen weeks in 50 per cent.

Duration of physiotherapy after removal of plaster—The average period was four weeks.

RESULTS

Fracture union—The frequency distribution of union time (at least partial obliteration of the fracture line on radiographs) in 172 fractures which united, related to severity of the injury, is shown in Figure 4.

Non-union—There was established non-union in eight fractures (4·4 per cent). Seven were in the severe grade, in compound fractures with moderate or severe comminution. One fracture was in the moderate grade and sepsis was responsible.

Reduced function—In the mild grade there was no impairment of function attributable to the fracture.

In the moderate grade four patients (3·5 per cent) had stiffness in the ankle or foot sufficient to impair function. In two of these, associated open fractures of the calcaneus were responsible; in the other two patients the fractures were in the lower third and were open.

In the severe grade seven patients (19·5 per cent) had marked stiffness of the ankle or foot. Six of these had severe open fractures (five requiring bone grafts) and the seventh was grossly comminuted, needing a long period of immobilisation as well as a bone graft.

No patient in the series had residual stiffness of the knee.

Deformity—In the mild and moderate grades four patients had slight varus deformity: the fractures were in the lower third. In the severe grade one patient with a double fracture had some varus deformity caused by imperfect reduction; another patient with delayed union developed a valgus deformity (resulting from insufficient plaster immobilisation).
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COMPLICATIONS

One patient aged sixty-four died at seven weeks from unrelated uraemia. One patient aged eighteen with associated gross comminution of the femur suffered clinical fat embolism but recovered. One patient aged seventy-one suffered venous thrombosis and one patient aged fifty-three had non-fatal pulmonary embolism.

Local complications included the following. Drop foot occurred in two patients: both recovered in two weeks. Delayed wound healing (without sepsis) occurred in two patients. Infection developed in twelve patients of the whole series (6.6 per cent), in nine cases after moderate or severe open fractures. Some degree of osteomyelitis was present in eleven patients but it occurred only once in a closed fracture and left no permanent effects. Loosening of screws was noted in two patients with delayed union.

Plate removal—Three years after the conclusion of this series twenty-eight plates had been removed (15 per cent)—fourteen for ionisation or local aching; the others for sepsis or during the course of bone grafting.

DISCUSSION

Fracture union and plaster splintage—Reporting on the closed method of treatment both Ellis (1958a) and Nicoll (1964) assessed union as delayed if more than twenty weeks of splintage in plaster were required. After moderately severe fractures Ellis found 11 per cent and Nicoll 22.5 per cent with delayed union. In the present series of moderate grade plated fractures plaster splintage had been completed by twelve weeks in 84 per cent and by fourteen weeks in 95 per cent. This does not necessarily imply that fracture union was more rapid. It is considered that the combination of the strength of fixation afforded by secure plating and the degree of fracture repair that is usually present within fourteen weeks is sufficient for the limb to require no further external support. Little callus was usually present during the healing of securely fixed fractures and the main radiographic finding was a gradual obliteration of the fracture line. This is in keeping with the “first intention healing” referred to by many writers including Danis (1949), Blockey (1956) and Hicks (1961). It was found that fractures in porotic bone, of which there were nineteen in this series, united more rapidly than those in normal bone. It is of course essential to recognise, both from the physical signs and the radiographic evidence, the plated fracture in which healing is indolent—usually one in which comminution is marked—and to provide a further period of plaster splintage. If this is not done, breaking of the screws and bending of the fracture may occur before healing is complete. This occurred in two fractures in the severe grade.

Nicoll (1964) in his series of 672 fractures treated by the closed method had thirty-five cases of non-union (5 per cent) and he observed that “it would be difficult to imagine that this figure could be significantly reduced by routine fixation”. In the present series the rate of non-union is marginally less at 4.4 per cent, but when the two series are compared the figure is found to be significantly less since only one-third of the mild cases, which unite without difficulty, were treated by plating. The mild cases (38.9 per cent in Nicoll’s series) normally dilute the incidence of non-union in a series of fractures treated by the closed method. The corrected figure for non-union in the present series is approximately 3.3 per cent. Blockey (1956) had no instance of non-union in thirty plated tibial fractures. McLaughlin, Gaston, Neer and Craig (1949) had one case of non-union in sixty-three closed fractures and six in seventy-four open fractures.

Nicoll (1964) referred to the risk of delayed union if the internal fixation was not absolutely rigid. Although he believed that this degree of fixation was not feasible with conventional plating it has been the aim in the present series, and it has been achieved by the use of strong plates supplemented by a cross-screw at the fracture line when indicated (Darrach 1940) (Figs. 5 and 6). Müller (1963) also obtained rigid fixation as did Key (1945), Wenger (1946) and Marshall (1958) but their methods were more complex.
Joint stiffness—Nicoll (1964) referred to “functionally insignificant” stiffness in the ankle and foot (not more than 25 per cent) which was unnoticed by the patient. A quarter of his patients had stiffness greater than this (functionally significant) and in 8 per cent there was “really disabling stiffness”. Similarly Ellis (1958b) had 6 per cent with severe limitation of movement in the ankle and foot. This figure does not take into account his nine patients who required bone grafting operations. Nicoll (1964) said that it was not established whether the results would be any better with early movement. He felt that the severity of the injury was the important cause of stiffness. He pointed out that prolonged plaster immobilisation in his cases of delayed union did not significantly increase the degree of stiffness. It is my experience however that, apart from severe open fractures with extensive soft-tissue damage, stiffness of the ankle and foot can be almost avoided by attention to the measures described in this paper. Of these, the regular practice of joint exercise during the period of two to three weeks when the wound is healing is probably the most important. This is the time when crippling fibrosis develops, and it is remarkable how mobile are the ankle and foot in these cases in which six months’ immobilisation has been required, if the regime of early exercise has been followed. Blockey (1956) who also used early mobilisation in his thirty plated tibiae had no joint stiffness and Müller (1963) reported similar findings in a much larger series. Burns and Young (1944) also considered that the principle of early mobilisation was important.

Furthermore the operation itself may well be beneficial in preventing stiffness. It releases the haematoma which is distending the leg and relieves “the tissue tension under tight fascial structures” referred to by Nicoll. It may also be of value in preventing the development of Volkman’s ischaemic contracture, of which Ellis had nine cases; there were only two in the present series, both in lower third fractures that were open. A further point is that the surgical approach to a subcutaneous bone such as the tibia should not result in the development of fibrosis.

In addition to early exercises and decompression at operation, it is my opinion that subsequent full weight-bearing in a plaster prevents disuse osteoporosis distal to the fracture and is also significant in preventing stiffness of the ankle and foot. Osteoporosis is common in fractures treated by the closed method and is associated with oedema and local pain, requiring prolonged remedial treatment and graduated walking exercise after the final plaster has been removed. Salter and McNeil (1965) reported the detrimental effect of prolonged immobilisation on articular cartilage, perhaps as a result of disuse osteoporosis.

Muscle wasting—Prolonged immobilisation of a fractured tibia in a full plaster, particularly when weight-bearing is avoided for some weeks after the accident, is often associated with marked muscle wasting, and redevelopment constitutes a real problem except in young and active patients. After plating, early full weight-bearing walking for a distance each day results in much less muscle wasting and that which does occur is more easily overcome.
Deformity—It is a long time since Lane (1905) and Hey Groves (1916) emphasised that deformed limbs could not be expected to function properly, as well as appearing unsightly. Deformity after tibial fractures treated by the closed method is still relatively common and in ninety-eight consecutive patients with tibial fractures seen personally for medico-legal reports eleven had marked deformity. Nicoll (1964) found 8.6 per cent of patients had significant deformity. Ellis (1958b) reported 5.5 per cent of his series to have had 1.2 to 2.5 centimetres of shortening, an amount that was said to be sufficient to cause "a mild dipping gait". Nichols (1960) thought that as little as 1.2 centimetres of shortening could be significant in relation to low backache.

There should be no deformity after the plating operation. However, fractures in the lower third, in which the medial surface of the bone is curved, require care during operation, since a little inaccuracy in bending the plate resulted in slight varus in four instances. The only other deformities were in a case of delayed union, in which the tibia bent during healing, and in a plated segmental fracture in an elderly patient which was a little bowed.

Rehabilitation and return to work—Most of the patients in this series (apart from those with severe open fractures) required remedial treatment for one month only after the plaster was removed. Sixty patients with fractures in the moderate grade were working at the time of the accident. As shown in Figure 7, 50 per cent of these patients were back at work four months from the time of the accident and 75 per cent were working within six months. No comparative figures are available for series treated by the closed method but in view of the longer periods of immobilisation and rehabilitation a greater delay in returning to work is inevitable.

The further advantages of tibial plating—The reduced joint stiffness, the virtual absence of deformity and the more certain union of the fracture, usually without the necessity for prolonged immobilisation, have been discussed above. There are, however, a number of other advantages to be gained from a policy of operation when indicated.

The treatment is definitive—the fracture does not need further measures such as remanipulation, skeletal traction or delayed open reduction, which are not infrequent when the closed method is used. Conventional plating, using strong plates, is a relatively easy and
well controlled operation, although experience and special care are needed to avoid devitalisation of displaced butterfly fragments. The Müller plating operation takes longer to perform with consequent increased risk of infection. Intramedullary nailing, although comparatively easy in the femur, can be a difficult and trying procedure in the tibia, needing radiographic control; in addition rigid fixation is not always obtained, particularly in fractures remote from the middle of the bone. Screw fixation alone (Lane 1905, Ronald 1942) was sometimes favoured for spiral fractures but as Charnley (1961) pointed out many of these are comminuted; the method is also uncertain since a number of the fractures became redisplaced despite plaster immobilisation, and non-union was not uncommon (White, Radley and Earley 1953; Urist, Mazet and McLean 1954).

Fractures of the tibia treated in plaster frequently cause severe pain for a few days; after plating the pain is relieved (Lam 1964).

There is no risk of loss of position after plating unless the patient is allowed out of bed without plaster immobilisation and this is not to be recommended. Supervision may be delegated except for the decision relating to unsupported weight-bearing.

The morale of the patients after the plating operation is high since they are able to see that the leg is straight and can assist in their own recovery by practising the necessary joint mobilising exercises in bed. As soon as the plaster is dry they walk without pain using only sticks and many are happy to walk as far as three to four miles each day when told that this "helps the fracture to join". These measures also work with neurotic or anxious patients and even the compensation-minded have no grounds
for complaint such as pain or real disability (for example, crutch walking) and are thus unable to prevent themselves from getting a good result.

There is no risk of refracture, which is not uncommon with the closed method, and the overall progress of recovery is materially hastened.

In the few patients who require bone grafts for non-union the fracture is in good position and if the plate is still holding firmly it is only necessary to insert strip grafts, apply a plaster and resume weight-bearing after a few days.

**Indications for plating**—The main indications for plating are unstable and fully displaced fractures.

**Unstable fractures**—These may be oblique (Figs. 8 and 9), transverse/oblique (Figs. 10 and 11) or spiral (Figs. 12 and 13).

**Displaced fractures**—Transverse fractures which are fully displaced can usually be reduced by manipulation or traction but delayed union is not uncommon. These fractures do well after plating, and the common mid-shaft type without comminution presents an easy operation (in this department new registrars begin by plating these fractures) and rapid union is certain. The fractures at the junction of middle and lowest thirds may show avascularity in the distal fragment and a careful decision concerning the time of plaster removal may be necessary.

**Comminution**—Moderate comminution (separated butterfly fragments) can be well treated by this method with care being taken to avoid devitalising the fragments (Figs. 5 and 6). In these fractures also evidence of delayed union must be sought and plaster splintage continued if required. Gross comminution is usually a contra-indication to internal fixation although it has been used at times (with care not to diminish further the vascularity of the fragments) to give a satisfactory reduction, a bone graft being inserted later (Figs. 14 and 15).

Segmental (double) fractures are not usually amenable to closed reduction and with this...
method one of the fractures at times fails to unite. Boutin (1956) pointed out the bad prognosis of this fracture. Zucman and Maurer (1969) recommended blind intramedullary nailing, but with two fractures on which to thread the nail the technique is not easy. I have found plating to be little more difficult than with a single fracture, care being taken to avoid stripping the middle fragment, and one or two plates being used, depending on the length of this fragment (Figs. 16 and 17).

Open fractures—Some open fractures can be well treated by plating. The type in which there is a puncture wound presents no problem since as long as the skin is not bruised, normal healing is to be expected. Similarly the type of fracture in which there is a small wound—up to about 5 centimetres—with a bone end projecting, is suitable for plating if the skin is healthy and thorough cleaning of the wound and bone is undertaken according to the method of Trueta (1939). Short transverse wounds can be enlarged for the plating operation by a bayonet incision which can be closed by the advancement technique to avoid tension in the central part. The experience of this series has shown that the large wound with severe damage to soft tissue is often not well suited to plating because adequate skin cover may not be feasible. The benefit to be gained is skeletal stability, which makes subsequent wound treatment very much easier (Carpenter, Dobbie and Siewers 1952) and there was certainly no higher incidence of osteomyelitis than would have occurred with more conservative measures. This view was supported by Hampton (1955). It is now my opinion that internal fixation in this type of injury can probably be provided equally well by the use of a relatively broad but thin intramedullary device (McWilliam 1969) which is not difficult to insert and does not further impair the residual vascularity of the bone or leave any exposed metal.

Intact fibula—Fractures of the tibial shaft in which the fibula is intact, unless undisplaced, are considered to be an indication for plating. Clark (1959) stated that union of a tibial shaft fracture may be delayed if the fibula is intact, and my own experience with the closed method of treatment supports this view. In the present series the fibula was intact in eleven patients and no delay in union occurred after accurate reduction and plating of the tibial fracture.

Additional fractures in the injured limb—Displaced fractures involving neighbouring joints may also be a reason for plating the tibial shaft fracture although in these cases the indication for tibial plating is often present on its own merits. Patients with fractures of the upper end of the tibia involving the knee joint, or fracture-dislocation at the ankle, in each case requiring accurate reposition by open operation and internal fixation, can then receive the necessary mobilising exercises (Burwell and Charnley 1965) without delay as long as the associated tibial shaft fracture is plated (Figs. 18 and 19). Similarly, fractures of the femur and/or patella operated upon can be treated by early mobilisation of the knee (Burwell 1963) if the tibial fracture is stabilised by plating.

Elderly and disabled patients—Elderly patients with impaired balance in whom crutch walking may be difficult and disuse osteoporosis even more likely to develop are in my opinion better
treated by plating of the tibia and early full weight-bearing in a plaster. A number of patients with fractures in the mild grade came into this category. Fractures in patients with locomotor disability for other reasons, for example, neurological disease, rheumatoid arthritis or obesity, are also often better treated by plating.

**Infection**—Sepsis is a risk when any fracture is treated by open operation but in the tibia the likelihood of this complication has perhaps been magnified. It occurred in twelve patients in the whole series (6·6 per cent) but of these, five had severe open fractures in which septic complication would have been probable with any method of treatment, some would say to a greater extent if the fracture had not been fixed, since open reduction should provide the best conditions for tissue healing (Hampton 1955). The corrected incidence is therefore 3·9 per cent. Even this figure may be too high because in four other fractures in the series there was moderate compounding which could well have resulted in some sepsis in the absence of plating. This view is supported by a comparison of the incidence of wound sepsis in open fractures in this series and that of Nicoll (1964). In the present series there was sepsis in nine of sixty-three open fractures (14·3 per cent) and in Nicoll's series it was twenty-two of 144 open fractures (15·3 per cent). The occurrence of sepsis was therefore certainly no higher in the plated fractures. The incidence of sepsis attributable to the plating operation in the present series may therefore have been as low as 1·7 per cent. Wound sepsis occurred in three closed fractures but in two there was no bone involvement; the third required sequestrectomy followed by bone grafting but the final result was a normal limb.

The important factors in avoiding sepsis are considered below.

**Operative details**—The operation should be done on the day of the accident if possible; otherwise blistering of the skin is likely or there may be skin damage caused by unreduced bone fragments.

Bruised skin which might become necrotic is a contra-indication to operation. Abrasions or short lacerations do not preclude plating but it is essential to clean the area thoroughly and to undertake operation without delay.

The arterial circulation, as confirmed by palpation of the peripheral pulses, must be satisfactory if plating is to be undertaken.

Except in elderly patients, and in cases where the injury occurred some days before, in which there may be a risk of pulmonary embolism (Austin 1963), the use of a tourniquet prevents the development of oedema during the operation and facilitates wound closure.

The skin incision should not lie over the plate and either a curved incision or one situated vertically behind the line of the plate is advisable.

The exposure of the bone should not be subperiosteal, as advised by some writers (Murray 1944, Venable and Stuck 1947) because of the risk of further impairing the viability of the bone ends. The fracture is reduced with minimal muscle stripping and the position maintained by means of the clamp described by Charnley (1953). Stainless steel (EN58J) plates have been used in this series because of their strength, although they are prone to give rise to ionisation. It is probable that titanium plates, which cause less reaction, would be better, but Vitallium is not as strong. The plate is placed on the subcutaneous surface of the bone. The screws used have been of the Venable coarse-threaded type, nine sixty-fourths of an inch in diameter. Larger screws are not recommended because of the risk of later fracture of the bone. A hand-drill has been used to avoid bone necrosis around the screws. The occasional fracture of a stainless steel drill was initially a problem but this has been overcome by using Vitallium drills which bend but do not break. No less than six screws should be used and Blockey (1956) has shown that the key screws are on each side of the fracture, as far away from it as possible. In porotic bone four screws in each fragment are essential and in fractures towards the end of the shaft secure fixation in cancellous bone also requires four screws even in young subjects. It is important to impact the fracture before plating as emphasised by Peterson and Reeder (1950) and Müller (1963) who used engineering techniques to achieve
this. With the more simple technique used in this series impaction is assisted by drilling first the holes on each side of the fracture lateral to their centres; when the screws are inserted and tightened the bone ends are driven together. It is important not to displace comminuted fragments situated posteriorly, and therefore not visible, during insertion of the screws. Sizeable butterfly fragments are overdrilled (nine sixty-fourths of an inch) in order to achieve impaction to the main fragment when the screws are tightened. Screws have to be inserted frequently low in the tibial shaft and care must be taken to avoid entering the ankle joint. This may require an oblique direction of the screw (Figs. 8 and 9).

Suction drainage of the wound for forty-eight hours has been found to be valuable in preventing haematoma and thereby protecting the overlying skin from pressure. Subcutaneous catgut stitches also relieve tension in the skin which is repaired with numerous fine black silk stitches on a small needle inserted close to the skin edge; in this way the scar should ultimately be almost invisible.

Routine administration of antibiotics is to be deplored. In open fractures or in those cases in which operation is not completed within a short time a combination of penicillin and streptomycin has been given for a few days after the operation.

**SUMMARY**

1. One hundred and eighty-one fractures of the tibial shaft were treated by rigid fixation using conventional plates.
2. Comparison is made with series of fractures treated by the closed method.
3. The incidence of non-union, or delayed union requiring a long period of plaster immobilisation, was found to be less with the open method of treatment.
4. Plating was also found to give better functional results with a shorter period of disability except in severe open fractures.
5. Plating is a valuable method of treatment for tibial fractures in the elderly.

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