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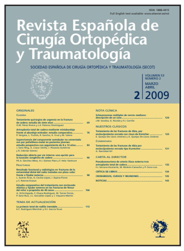

OUR CLASSICS

Treatment of tibial fractures by closed fixation with a Kuntscher nail

Tratamiento de las fracturas de tibia, por enclavijamiento cerrado con clavo de Küntcher

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In 1960 a new technique for tibial fracture mailing was developed in Prof. Merle d'Aubigné's clinic at the Hôpital Cochin in Paris.

Kuntscher's original tibial mailing technique is a laborious and complicated procedure that involves the use of curved nails that do not adapt well to the straight shape of the medullary canal, leading in many cases to an angulation of the fracture with recurvatum. Moreover, introduction of the nail through the anterior tibial tuberosity is a dif cult process, which leaves the end of the nail in contact with the subcutaneous tissue where it causes discomfort or other complications.

At the Hôpital Cochin the technique was simpli ed in the following ways:

1. he same nail is used for both the tibia and the femur, i.e. the nail is straight and has the shape of a clover leaf.
2. he nail is introduced on the posteromedial side of the patellar tendon, through the anterior border of the prespinal surface of the tibia and straight into the medullary canal.

Indications

A. According to the different tibial fracture anatomic types.

1. Oblique fractures.

In these types of fractures, with an oblique fracture line, orthopedic reduction is easy to achieve. Immobilization, however, is more dif cult because as the contact surfaces of both tibial fragments are oblique, they keep sliding against each other inside the plaster cast, which results in secondary displacements and shortenings, in spite of the fact that the patient's limb is usually kept in continuous extension. Repeated corrections, necessary at times, sometimes lead to delayed healing, which compounded with the obliqueness of the fracture line, makes it impossible to resume ambulation until full and robust healing has been achieved.

This type of fracture is a clear indication for nailing, as it prevents all kinds of secondary displacements, turning an unstable fracture into a stable one. In addition, the nail allows much prompter resumption of ambulation in periods of brous callus, with the pressure generated during ambulation accelerating the appearance of bone callus.

This is the fracture type where we systematically resort to nailing.

2. Transverse fractures.

Reduction of transverse fractures is straightforward and permits bringing together at least two-thirds of the fractures surfaces.

Plaster cast immobilization in these cases is highly effective since, as the fracture line is horizontal, it cannot slide. Nevertheless, lateral movements are possible. Moreover, these fractures, given their reduced contact surfaces, are the slowest healing ones, especially as they often rest on the junction between the middle and the lower thirds. For these reasons, we believe that transverse fractures must be nailed. Reduction achieved with the nail is complete, i.e. 100% contact between the margins is achieved.

The only circumstance in which we would not indicate nailing would be a case of a transverse dentate fracture, where perfect reduction is achieved tooth by tooth, thereby yielding a perfectly stable situation.

3. Spiral fractures:

Spiral fractures must never be nailed. Treatment In these cases should be orthopedic reduction and cast immobilization.

The large contact area between the fragments of these fractures contributes to Speedy healing. Moreover, in these cases as the nail occupies the fracture line over a fairly long distance along the shaft, its fixation to both fragments tends to be insufficient.

In these types of fractures. we sometimes resort to simple screw fixation.

4. Fractures with a third fragment.

These types of fractures can be of 3 kinds:

a) Fracture with a butterfly fragment. This third fragment may be of different sizes and it normally affects one-half or three-quarters of the width of the tibial shaft.
b) Same as above but the third wedge-shaped fragment takes up the whole width of the shaft and covers the whole contour of the medullary canal. In this same section we include fractures where there is a small angular fragment that also includes the whole contour of the medullary canal.
c) Fractures with a large cylindrical fragment, which may be of different sizes but can sometimes encompass up to one-third of the shaft.

We consider that these 3 types of severe unstable tibial fractures, characterized by multiple fracture lines, are those where nailing should be the treatment of choice, leading to more benefits than any other.

5. Comminuted fractures.

Nailing must never be indicated in comminuted fractures.

6. Isolated tibial fractures with an intact fibula.

Nailing is indicated in these fractures.

Reduction with an intact fibula is extremely difficult. The splint-like role played by the fibula on the lateral side is such that, even if perfect *per primam* reduction is achieved, it is not unusual for a varus deformity to develop secondarily inside the plaster cast. This deformity is undesirable because it compromises the horizontality of the tibiotarsal joint.

7. Open fractures.

For open fractures we use the same criteria as for closed ones.

There are 2 basic types of open fracture:

a) Fractures lying close o a small wound (not larger than 1 cm) or a puncture hole, where there is an unquestionable communication between the fracture site and the external environment but since the skin wound occurred from the inside out it does not pose a significant contamination risk.
b) Fractures with larger contaminated wounds.

The nailing technique is performed in exactly the same way, without reducing or manipulating the fragments through the fracture site. In the first case, we carry out the nailing procedure as if we were treating a closed fracture. Applying a stitch or two on the wound may be necessary, as well as cleaning the wound edges.

In the second case, we clean the surgical wound and its suture, taking care that no pressure is applied. Following Merle D'Aubigné, in cases where the skin will not stretch we perform a long posterior longitudinal incision and we leave it ungrafted, merely covered with a fat film. When the cast is removed one month later, epithelialization is often complete; it it is not then the graft may be applied.

In our experience, fractures in the first category have always behaved as if they were closed fractures, with no infection-based complications in our series.

However, in those in the second category there is a definite risk of infection and, more often than not, of delayed healing even if no infection is present. In these cases we know that both to prevent primary infection and reinfection, and to prevent delayed healing from turning into pseudoarthrosis, perfect immobilization of the fracture site is required. Clearly, this perfect immobilization cannot be obtained with a plaster cast or with a cast plus continuous traction, or by isolated continuous traction. They best way to attain perfect immobilization is nailing plus a plaster cast, which controls the potential rotational movements that the nail cannot prevent completely.

Nonetheless, even assuming that severe complications do occur, such as skin necrosis where there is secondary skin detachment leaving the bone exposed (these lesions are nowadays more and more frequent in fractures caused by road accidents with direct trauma and extensive skin attrition), the robustness given by the nail to the fracture permits easy treatment with skin flaps from the contralateral leg (cross leg flap), which would be impossible in a leg with an unstable fracture. For all these reasons, we always nail open fractures.

Associated trauma

Some related kinds of cranial trauma formally contraindicate nailing, since general anesthesia is extremely dangerous for these patients.

Thoracic trauma precludes nailing only in cases where the anesthetist considers that general anesthesia may be contraindicated.

In summary, contraindication of nailing in these cases is in reality tantamount to contraindication of general anesthesia.

Associated trauma in the same limb (femoral or patellar fractures) are in principle a formal indication for emergency tibial nailing. The strength contributed by the nail to the tibia facilitates patient care and enables straightforward treatment of associated fractures.

B. According to the height of the tibial fracture.

Undoubtedly, the fractures most amenable to nailing are those in the middle third and, in general, all diaphyseal fractures.

This means that there are metaphyseal fractures both above (near the knee) and below (near the ankle) where the possibility of a nailing procedure must be considered very carefully.

As in everything else, we think we cannot lay down hard-and-fast rules; we should rely on logic and common sense to guide us in these cases. So when on inspecting the fracture on a radiograph we believe that the nail can succeed in xating it and prevent angled and lateral displacements, even if we think that rotation may not be fully controlled, we will opt for nailing.

When the lower or upper fragment is not shorter than 5 cm it can usually be nailed. In upper fractures, close to the knee, we must be even more exaggerated as, when the upper fragment is too small and the medullary canal is very wide and is stressed by traction from the patellar tendon, it tends to move forward provoking an anterior angulation of the fracture.

Technique

The technique we use is the same technique developed at the Hôpital Colchin. However, we shall emphasize a few details that have shown themselves to be extremely important in the cases we have treated.

The patient is placed in the supine position on the operating table. An inverted L-shaped bar is adjusted to the external track of the operating table. The bar's short arm is placed under the knee, adapted to the shape of the back of the knee (g. 1). The limb as placed over the bar must be exed around 70°; the knee must be fully exed on the bar that supports it, with the leg left hanging but the foot contacting over the plane of the table (g. 2). In this position, iodine is applied to the foot and the leg up to just above the knee and a sterile tube is glued to the area of the patellar tendon to guarantee perfect aseptic conditions in the area where the nail is introduced. An medial peripatellar incision of about 5 cm is made and the patellar tendon and the peripatellar fat are dissected, drilling into the upper tibial surface, in the prespinal area, staying always in the extraarticular area.

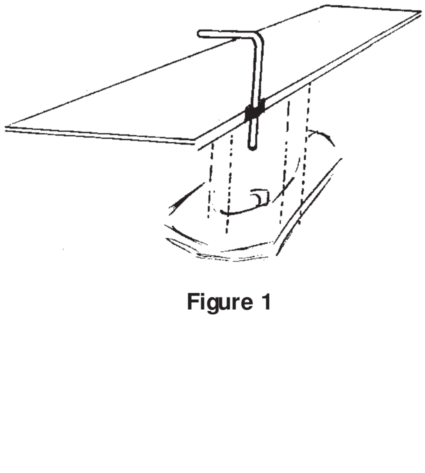

Figure 1

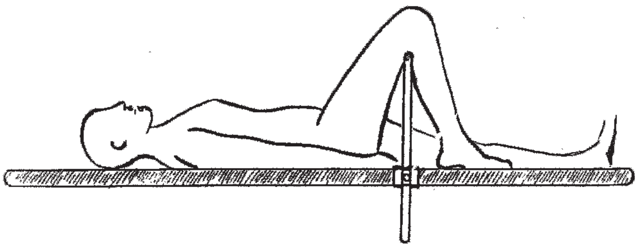

Figure 2

Next, the guide connecting both fragments is introduced, having previously reduced the fracture. This is achieved by pressing the upper fragment backward with one hand, and pushing the distal fragment forward and inward with the other. The reduction maneuver is usually the one described since in the above mentioned leg position, with the bar under the back of the knee, the upper fragment tends to rise a little as the lower fragment hangs vertically, with the fracture in an anterior and internal angle. Entrance of the guide into the lower fragment can be felt distinctly because a certain stiffness is suddenly experienced at the level of the fracture. At that point, leg x-rays are performed on both planes. The radiographs show, on the one hand, the correct introduction of the guide and, on the other, where the tip extends to. By measuring the fragment that sits proud we can know the exact length of the nail we must use.

As regards nail thickness, in 90% of cases we use a 9 mm nail without previously smoothing out the canal. We believe that in cases where the fracture site is closed smoothing out the canal would generate undesirable bone debris. We have never had dif culties inserting the nail without previously smoothing out the canal. The thickness of the nail to be used can be determined fairly precisely from the x-ray, i.e. from the x-ray we will know with a high degree of certainty whether we can introduce the 9 mm nail. If we see that the medullary canal is particularly narrow, we will use an 8 mm nail, and if it is wider than normal a 10 or 11 mm nail. Once the right nail has been selected, it must be introduced with the help of the guide, as this is done, the fracture must be kept maximally reduced. The nail must be tapped gently into position; if the surgeon is under the impression that it impinges on the walls of the medullary canal, it must be withdrawn and replaced by a thinner one. Nail tapping is carried out as described in the original technique, i.e. onto a swab to prevent burrs forming at the tip of the nail; these could hinder guide removal.

It is technically very important that during nail introduction the foot should rest rmly on the table since otherwise the fracture may develop a diastasis and the vessels and nerves of the leg may undergo an elongation.

For this same reason, there must be no rubber mat in the area of the table where the foot is supposed to rest; the surface must be as hard as possible. In our rst cases, we rested the foot on a thin mat that covered the table, but when the nail was fully inserted we found that there inevitably remained a narrow diastasis (a few millimeters wide) between the fracture fragments. As a result, in subsequent cases we removed the rubber mat and we have had no dif culties since. At any rate, at the end of the procedure we invariably apply a few strong st blows onto the sole of the foot so as to prevent any kind of diastasis.

Another important technical detail is that the nail be the appropriate size. As regards its length, it must extend as far down as possible, up to 0.5 cm or 1 cm from the ankle Joint line.

This requirement is especially relevant in fractures of the lower third or at the junction between the middle and lower thirds, very common in the tibia, because if the nail does not cover the whole length of the shaft, then the fracture will not be well xed.

It is also essential for the upper portion of the nail to be fully buried into the bone; no part of the nail must protrude. When we started performing this technique we followed the original technique in allowing the nail to protrude by approximately 1 cm, which in many cases caused patients discomfort in knee exion, probably resulting from the tip of the nail rubbing against the patellar tendon, especially at full exion. Since then we have buried the nail fully into the tibia and have had no problems with knee motion, which is normal from the outset. We have not had to remove any nails since we introduced this change. However, if a nail needs to be removed in the future, this will not pose a problem if the nail has been implanted totally ush with the bone.

We always nd that, at the end of the procedure, the nail provides perfect fracture xation, even during rotational movements. However, as rotational motion is the weak link in the nailing technique, at the end of surgery we apply a padded cast from mid-thigh to the toes in slight knee exion. At 15 days, we replace this cast by an identical unpadded cast.

Although at Hôpital Cochin it is standard practice to wait until the 75th day, we realized that ambulation could be allowed sooner. In our cases, patients have started ambulating with their plaster casts at one month and even at three weeks with transverse fractures.

Cases

In order for the ndings of this paper to be valid we decided to wait until we had at least 30 cases of recent tibial fractures subjected to nailing.

We have performed this technique for 2 years and have so far collected 37 cases.

Tibial fractures

Closed	16
Open	21
a) with a puncture or a small wound	21
b) with a large wound and the bones exposed	7

Classi cation of these fractures in terms of anatomic types is as follows:

A. Closed

1. Oblique	9
Upper third	2
Middle third	1
Lower third or junction of middle-and lower third	5
Total:	82
2. Transverse fractures	
Upper third	1
Middle third	1
Lower third	2
Total:	43
3. With a third intermediate fragment	
With a large intermediate cylindrical fragment	1
With a butter y fragment	1
Total:	2

B. Open

1. Oblique	
Middle third	2
Lower third or junction of middle and lower third	4
Total:	62
2. Transverse fractures	
Middle third	9
Lower third	2
Total:	113
3. Fractures with an intermediate fragment	
a) Butter y fragment	1
b) large cylindrical fragments	3
Total:	4

As we can see, the number of oblique fractures was 14, of which 8 were closed and 6 open.

There was a high incidence of open fractures among transverse fractures since, out of a total 15 transverse fractures, there were only 4 closed ones.

This means that the largest Group of all tibial fractures corresponded to oblique and transverse fractures, adding up to 81% of total.

The remaining 19%, i.e. 7 cases, were distributed among the remaining fracture types.

(We should mention that all the fractures in the present series were nailed, which means that spiral and comminuted fractures – by de nition not amenable to nailing – have been excluded).

Three of these nailed tibial fracture were accompanied by an ipsilateral femoral fracture. In all 3 cases the tibia was nailed in an emergency procedure, with treatment of the femoral fracture being deferred. Two of these tibial fractures were open.

Results (table 1)

For the analysis of results we shall specify two landmarks:

a) Point at which the patient was allowed to ambulate bearing weight but with a plaster cast.

b) Point at which the fracture healed.

We consider a fracture healed when x-rays show callus bridging the fragments and the patient can ambulate without a plaster cast and bearing their full weight on the fractured limb.

We had one case of pseudoarthrosis, where we considered that a surgery was necessary to obtain healing. Nevertheless, we consider that Nicoll's recommendation of applying the graft at 3 months is a little premature as we have seen some cases in which healing occurred at 4 or 5 months. However, we agree that total absence of callus at 3 months should alert us as to the need for a graft. On the other hand, if we see healing with a gradual development of callus at 3 months from fracture, even if the fracture has not fully healed by then, we believe it is well worth waiting, as in most cases rm healing will be achieved one or 2 months later.

We have not recorded the patients' age as we have observed no differences in the development of healing across the different age groups. However, it must be said that the all the cases of Speedy healing in our series occurred in patients under the age of 25.

A very important factor for rapid healing in the nailed tibial fractures in our series was awless fracture reduction. The cases where healing occurred faster were those where reduction was more complete, with full impaction of the fracture.

In other cases where good fracture xation and alignment were achieved, but where reduction was not line-to-line, the less precise the reduction, the longer was the healing period.

A. Closed fractures.

We shall now present our results, not globally but rather classi ed into the different anatomic fracture types.

At the end, we shall make a general summary. We believe that results are more meaningful if the different fracture types are distinguished from one another since this makes it possible to consider the achievement of healing in the different anatomic fracture types.

1. Oblique fractures.

a) Upper third: 2 cases.

In these 2 cases, given the obliqueness of the fracture line and the thickness of the medullary canal at that level, which could promote a slight displacement of the fragments, ambulation was not allowed until the fracture healed, which occurred, in both cases, between 8 and 10 weeks.

b) Middle third, one case.

This was only one case, where ambulation was allowed at one month and healing was obtained at 2 months.

c) Lower third, 5 cases.

In these 5 cases ambulation was allowed, on average, at 2 months, with healing occurring at 2 and a half months.

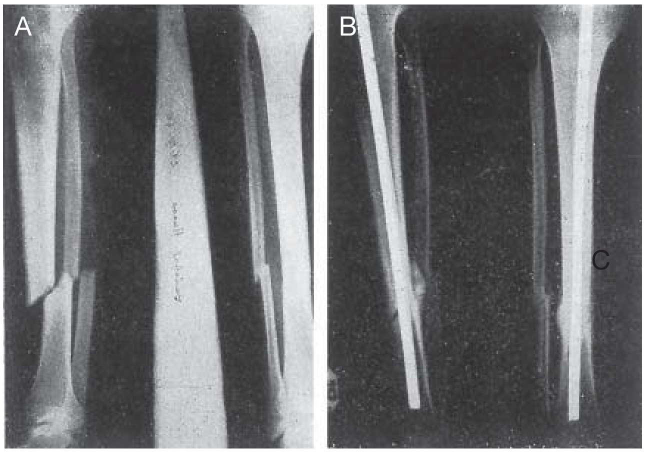

Figure 3 C.H.G. Closed oblique fracture, junction of middle-third and lower tibia and bula. A: Fracture x-rays. B: Radiographic view at 3 months.

Table 1

Tibial fractures	Accurate healing (less than 3 months)	Accurate healing (longer than 3 months)	Malunion	Nonunion	Infections	Deaths
Closed fractures						
Oblique, 8 cases	8%(9 weeks)	—	—	—	—	—
Transverse, 4 cases	2%(6 weeks)	1	—	—	—	1 (recurrent disease)
Con a third fragment, 2 cases	1 (12 weeks)	1 (14 weeks)	—	—	—	—
Con an intact bula, 2 cases	2%(5 weeks)	—	—	—	—	—
Open fractures						
Con a small wound, 14 cases	8%(11 weeks)	6 (11-16 weeks)	—	—	—	—
With a large wound, 7 cases	2%(12 weeks)	3%(19 weeks)	—	1	1, very severe, followed by amputation	—

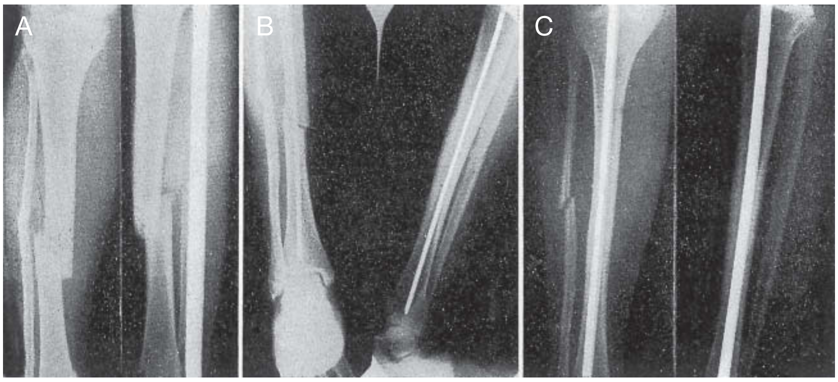

Figure 4 A.F.F. Closed transverse middle-third fracture of tibia and fibula. A: Preoperative x-rays. B. Perioperative x-rays with the guide in place. C: Radiographic image showing full healing at 1 month from surgery. In this case, the patient was allowed to walk with cast immobilization at 15 days. The cast was removed at 1 month.

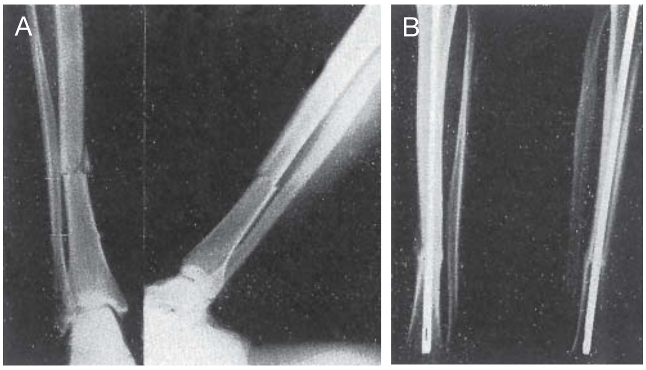

Figure 5 F.B.H. Transverse tibial fracture with an intact fibula. A: Preoperative x-rays (note slight angulation of fracture site). B: X-ray showing full bone healing at 2 months.

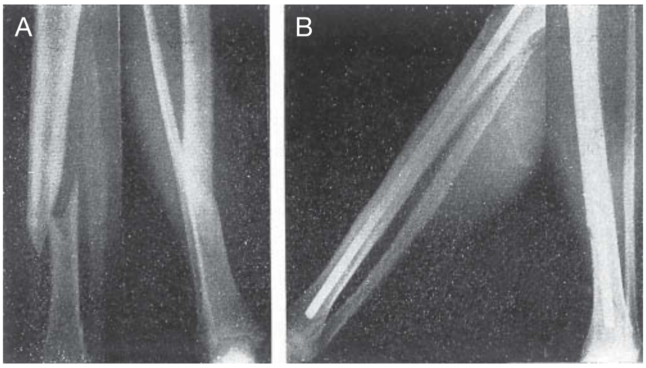

Figure 6 Mrs. H. Open fracture, middle-third of tibia and upper-third of fibula. A: Preoperative x-rays. B: X-ray view at 1 month.

The fastest healing was achieved at 7 weeks in an 18-year-old subject and the latest at 3 months in a 52-year-old patient (fig. 3).

2. Transverse fractures.

One case was lost to follow-up since the patient died of a heart attack 2 months alter surgery.

In the other 3 cases, ambulation with a plaster cast was allowed at 15 days from surgery.

In 2 cases healing occurred within 2 months.

In one case there was delayed healing. Healing did not occur until 4 months and a half. This is one of the cases we mentioned above, in which a small 0.5 cm diastasis remained, which could not be corrected, not even by allowing weightbearing from the very beginning (diastases did not occur again after we stopped using a rubber mat on the operating table) (fig. 4)

3. With a third fragment.

a) Cylindrical fragment: ambulation was allowed at 2 months and healing occurred at 3 months.

b) Butterfly fragment: healing was achieved at 3 and a half months; walking was restricted until then.

4. Tibial fracture with an intact fibula.

Both were cases of transverse middle-third fractures-Gait with cast immobilization was allowed at 15 days and healing was obtained in both cases within one month and a half (fig. 5).

B. Open fractures.

We shall study the results of open fractures all together as the diversity of the skin lesions associated to the different types of fractures makes it impossible to individualize them.

We have treated 21 open tibial fractures, of which 14 were associated to a puncture or a small wound and 7 presented with severe skin lesions with a large wound and open Communications between the fracture site and the external environment. In 3 of these last 7 cases there was a secondary loss of cutaneous tissue, leaving the bones exposed. To address this problem, we applied a cross-leg flap in one case and a local rotation flap in 2 (figs. 6–9).

In all but 3 cases, the nailing procedure was performed as emergency surgery. In the three cases in which it was performed as elective surgery, the patients had been treated in other departments, where their wound had been sutured and a plaster cast placed. In these cases, all of which came to us more than 24 h after the accident, we preferred to nail the fractures once the skin lesions had healed.

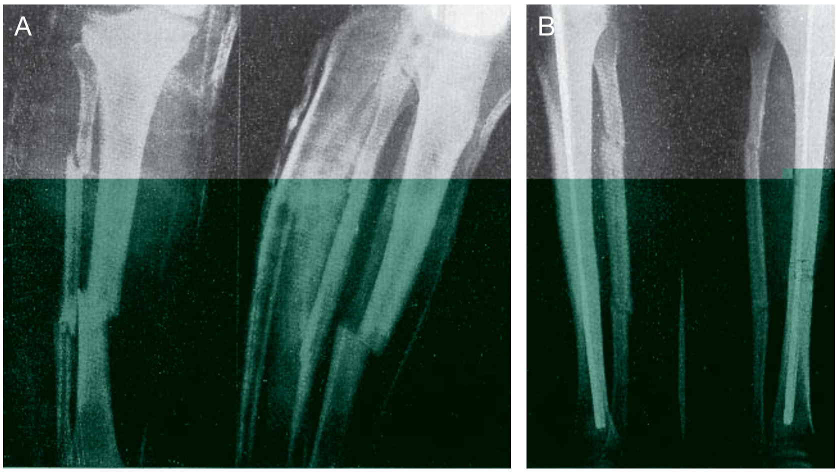

Figure 7 F.M.M. Open transverse tibial and bular fracture. A: Preoperative x-rays. B: X-ray view showing complete bone healing at 1 month. This patient was allowed to return to his occupational activities one and a half months alter surgery.

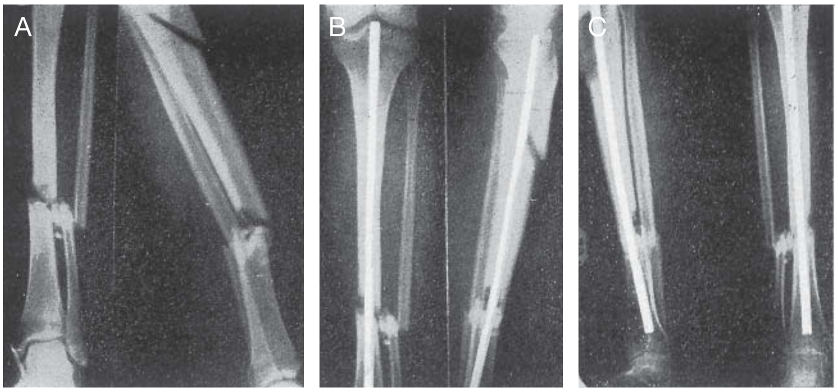

Figure 8 A.R.S. Open tibia and bula fracture with intermediate fragment and comminution in the lower fracture site. A: Preoperative x-rays. B: Radiographs at 1 month from the procedure. C: Final result at 6 months. Note that when healing occurred, a tibio- bular synosthosis appeared through the free fragments.

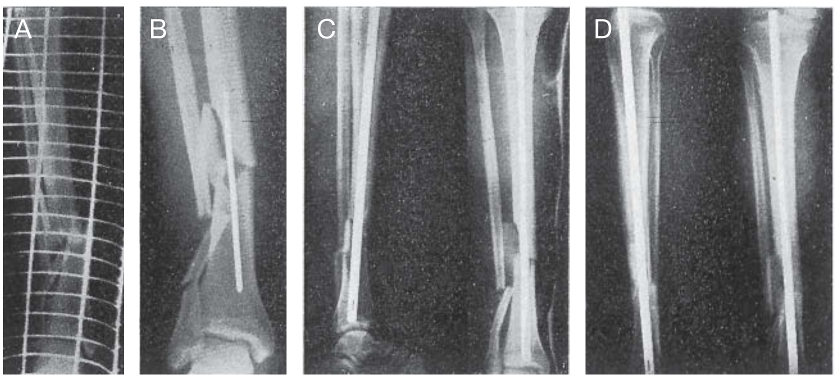

Figure 9 J.L.S. Open tibial and bular fracture with a third fragment (this patient had an associated ipsilateral femoral fracture). A: Preoperative x-rays. B: Perioperative x-ray showing the guide in place. C: Radiographic image at 2 months. D: View at 7 months, nal result.

Of the 14 cases with a small wound, the fastest healing occurred in one month. This patient was allowed to ambulate with a plaster cast at 15 days and was fully discharged and allowed to resume work at one month and a half (the patient himself asked to be allowed to go back to his job). The slowest healing occurred at 5 months, following an oblique lower third fracture.

Mean healing time for these fractures was 3-4 months. Ambulation in these cases was allowed at the same time as for the corresponding closed fractures.

Of the 7 cases with severe skin lesions, one resulted in amputation. This was a transverse fracture with severe skin and muscle attrition resulting from burying. Wound cleansing could not be complete, since the medullary canals in both fragments were full of earth. There was massive infection of the fracture site, which forced us to perform an amputation.

A pseudoarthrosis occurred in one of the cases in which we had to perform a rotation ap to cover for the loss of cutaneous tissue. Use of a graft prompted the fracture to heal uneventfully.

In the remaining 5 cases, healing occurred in 4 and a half months on average.

With the exception of the case that had to be amputated. We did not have any instances of infection with suppuration.

Summary

We present 37 cases of leg fractures treated by means of closed intramedullary tibial nailing with a straight Kuntscher nail, with the nailing procedure performed primarily, both in closed and in open fractures. The nail was introduced into the medial side of the patellar tendon in the extraarticular area of the upper tibia. The knee, supported on a transverse stem, is placed in maximum exion, with the bail being introduced over a guide.

The results obtained are extremely encouraging since the technique described reduces fracture healing times and permits prompt weight-bearing and ambulation.