The treatment of tibial diaphyseal fractures is not currently an orthopedic problem that has no satisfactory solution, such as is the case, for example, of some calcaneal fractures.

The three basic postulates were detailed by Bohler in 1916. A) Reduction of the fracture, carried out as accurately as possible; b) Long-term immobilization until complete healing is achieved; and C) Applying an immediate and intensive active functional recovery program from the very beginning of treatment.

Since this time, using the Böhler method, very good results have been obtained in the treatment of tibial diaphyseal fractures, since these, in general, are not difficult to reduce, and using non-surgical methods reductions are achieved, which, if not exactly anatomical, are perfectly compatible with good function once fracture healing is achieved.

Between 1925 and 1934 in the Vienna Unfallkrankenhaus 346 leg fractures were treated in patients suffering accidents and total recovery was achieved at 3 years in 85.26% disability benefit was granted to 10.12%. The remaining patients died from other causes during or after treatment. These figures, when compared to the 81% rate of permanent disability following fractures found in Austria before the opening of the Unfallkrankenhaus, show that the Böhler method was a significant step forward in the treatment of these fractures.

If it is possible to obtain good results in leg fractures using non-surgical methods, as seen in the statistics presented above and also mentioned in a recent publication by Sanchís Olmos and Vaquero González, why is it necessary to review the issue of these fractures?

The Böhler method was criticized for not eliminating the possible risk of delayed healing, as is still currently the case in certain fractures of the lower tibia.

The incidence of non-union in tibial fractures, has been estimated at 3% (Blumenfeld and Owen), at 7% for selected non comminuted fractures (White), and at 9% for non-selected cases (Kuntzmann). They constitute 40% of the global statistics of non-union presented by Blumenfeld.

The existing large amounts of statistics on tibial fractures have provided very little information on the causes responsible for non-union in fractures of this type. Watson-Jones and Coltart, in a study of 188 tibial fractures, concluded that there are many clinical factors responsible for non-union, and that there are numerous combinations and permutations of these factors. It must be kept in mind that the intricate healing process of a fracture is influenced by a large number of diverse anatomical and biological factors, as well as mechanical ones, which in our opinion are essential, as shown by the statistics on 800 tibial diaphyseal fractures studied by Watson-Jones, amongst which there was a high percentage of severely infected comminuted fractures. Whatever the technique used for the treatment of the fractures, continued and uninterrupted immobilization was always insisted on until complete repair was achieved. There was not a single case of non-union in the whole series.

Böhler considers the mechanical factor of major importance and attributes non-unions and delayed healing to the inadequate use of treatment methods used for fixing tibial diaphyseal fractures.

One of us, comparing the statistics of the Adaro Sanatorium (Sama, Asturias, Spain) with those of the Berryhill Hall hospital, concluded with specific reference to tibial and fibular fractures, that possibly due to an excessive intervention criterion applied by British surgeons, delayed healing rates in the latter facility are almost double in the Adaro Sanatorium (Sama, Asturias, Spain), although the main reasons for this are the legal and recovery issues already mentioned.

*Presented at the IVth National SECOT Meeting. Asturias, July 1955.
**Only the most significant part of the original article, which was 84 pages long, is published. The complete bibliography is included.
Although correct and long-term immobilization by means of plaster casting can guarantee healing of tibial fractures in most cases, if this immobilization is extended beyond certain limits, even if it is combined with a well applied program of functional recovery, certain inevitable problems arise: muscular atrophies due to the muscles suffering irreversible fibrotic processes, loss of the extension capacity of these muscles, joint stiffness, perivascular sclerosis at the site of the callus due to organization of the hematoma and hydremia of the capillaries that causes hard-to-treat persistent edemas when immobilization is removed; all these require a well studied and accurately applied functional rehabilitation program if reversion is to be achieved.

For this reason, based on the recent development of osteosynthesis techniques, different treatment methods are being applied in tibial diaphyseal fractures with the purpose of achieving anatomical reconstitution, which is a major step in the direction of success. These methods make it possible to remove the immobilization devices earlier and therefore start the functional recovery programs as the therapy proceeds. These are treatments such as those already applied in certain femoral neck fractures treated with three-flanged medullary nails or in fractures of the femoral middle-diaphysis treated with medullary nails.

The aim of this study is to contribute our personal experience to clarify these extreme positions.

Our statistics are based on 323 leg fractures sustained in occupational accidents and treated in different centers in Asturias (Spain): the Adaro Sanatorium, in Sama; the San Cosme Clinic, in Oviedo; the National Disease Insurance Clinic, the Military Hospital and several private clinics in Oviedo. Most of the cases in this last group were due to fortuitous accidents or traffic accidents and their time of recovery was not influenced by psychological factors, which could have been the case in the former groups.

**VASCULAR AND NERVE LESIONS**

Occasionally fractures of the tibial diaphysis suffer complications of vascular, or, more rarely, nervous origin. Vascular lesions usually occur at the level of the tibial arteries or the popliteal artery before it branches off. Nerve lesions are usually less frequent, but undoubtedly leg nerves may suffer lesions in open fractures the same as any other soft tissue does.

The point at which the popliteal artery branches off is very near the tibia, therefore it is easy for this vessel to suffer lesions in high tibial diaphyseal fractures. The artery suffers lesions due to contusions or traction, as seen in the 5 cases published by Watson-Jones.

The artery usually suffers contusions at a higher level than the fracture site due to traction, as was seen in a case of a fracture of the middle third of the tibia published by Griffiths. In this case, arteriography showed that the obliteration of the artery took place at the level where it branched off.

Lesions of the popliteal artery are also possible at the moment of fracture reduction using traction devices if sufficient care is not taken when placing a pillow against the counterextension bar.

Popliteal artery lesions usually cause gangrene, and cases of ischemic retraction that are a consequence of tibial fractures are usually due to defective plaster bandage application or lack of careful surveillance of an unlined plaster bandage.

The vascular lesions that constitute complications of fractures were impressively described by Griffiths and may be classified into the following groups: complete division or rupture of the artery, lesions produced by lacerations caused by bone fragments or the object that caused the fracture in the case of open fractures; these lesions are infrequent and of little interest. The next group is made up of arterial lesions in which the integrity of the vessel is not affected. They may be more difficult to diagnose and interpret clinically; a process required for their successful treatment. In this group of lesions one of the first is reflex vascular spasm, found not only in the arteries affected after their section or rupture as a natural mechanism to prevent hemorrhage, but can also be seen in cases of intense vessel contusions or commotions. Vascular spasm is not limited to the affected part of the vessel but can, as is fairly frequently seen, affect collateral circulation.

Intramural rupture of arteries is seen mainly in lesions due to traction or crushing, there are arterial contusions accompanied by thrombi or emboli that may attach to distal branches of the affected artery and, lastly, there may be artery compression by hematomas or fragments of the fracture, due to inadequate or badly applied bandaging.

**THE CONCEPT OF DELAYED HEALING AND NON-UNION**

Delayed healing means that a fracture takes longer to heal than usual given its location and pathological characteristics, although fixed timelines cannot be established and time to healing depends, naturally, on individual conditions and the treatment applied.
Böhler\(^4\) considers that the healing time for tibial diaphyseal fractures is 8 to 10 weeks, but this time period, as is only natural, is only provided as a reference and seems to be rather short, since under ordinary conditions this time period can extend to 12 and even 14 weeks in closed fractures.

In the cases of our series, in closed fractures in adults, mean immobilization time was from 14 to 18 weeks.

To establish a criterion for considering that there is delayed healing, it is better, according to Watson-Jones\(^72\), to use follow-up X-rays. The healing process is considered to be slow if, after several weeks of treatment, the fracture line is clearly visible, with no concave surfaces, decalcification or sclerosis. In delayed healing the bony margins and the fracture line have widened creating a cavity with villous ill-defined borders, but without decalcification or sclerosis. According to Urist and Mazet\(^62\), fractures with these characteristics after 4 to 18 months can be considered tibial fractures with slow or delayed healing. In non-unions, X-ray studies show the existence of a space between the fragments that may be partially filled, and there may be abnormal mobility. The fractured extremities are widened, curved and have undergone sclerosis with obliteration of the medullary canal by compact bone. Urist and Mazet\(^62\) consider that the time period necessary to determine non-union of a tibial fracture is 18 months of uninterrupted treatment and the above described X-ray image. Kuntzmann\(^29\) considers tibial fractures are suffering from delayed healing if they are not healed after 120 days and do not present the X-ray image of a non-union. Sanchís Olmos and Vaquero González\(^37\) have established the time period to determine delayed healing as 180 days, and this is the criterion we follow.

**TREATMENT OF TIBIAL DIAPHYSEAL FRACTURES**

We can establish the existence of 3 groups based on the treatment of tibial diaphyseal fractures: a) non-surgical treatment; b) osteosynthesis; c) treatment of open fractures.

**Non-surgical Treatment.**– Whenever non-surgical reduction of a tibial diaphysis fracture is carried out it is necessary to restore the normal alignment of the leg. The restoration of this alignment is extremely important for the knee and ankle to continue to function normally, since if there is a persistence of a lateral bow-leg with an external or internal concavity, the foot remains in varus or in valgus, the lateral ligaments of the knee and those of the foot and ankle become distended with the body’s weight and these joints become disabled, and in the long term trophostatic arthritis develops with all its consequences. Needed to say, there are also problems if antero-posterior alignment of the tibial diaphysis is not restored. The most usual sequela is posterior warping of the tibia; this makes it necessary for the patient to slightly flex their knee when walking. If internal or external rotation is not corrected, the patient will walk as if they suffered from flat-foot in valgus or in internal rotation with the consequent effects on the ligaments of the knee and foot.

The restoration of the original length is not as important as the restoration of a correct alignment. Shortening of one centimeter may be compatible with a good function.

The development of talipes equinus must be prevented by right angle immobilization, and in the case of low fractures of the tibia, that must be reduced with the foot in slight equinus, this must be rectified when the healing process begins.

The orthopedic surgeon that reduces a tibial fracture using conservative methods must know that anatomical reduction (Figures 6.a and 7.a) is the least important objective amongst those mentioned and it is usually sufficient to achieve an apposition of one third of the sectioned area of the extremities of the tibial fragments, although for cosmetic reasons they should achieve the best possible apposition.

Although anatomical reduction is a guarantee of functional restoration, there is a significant factor in favor of non-surgical reduction, and that is the agreeable surprise when two years later, these patients whose fracture X-rays caused us great concern, are seen to walk without the slightest limp, with full recovery of their joints and muscles according to all tests, working in physically demanding environments and having completely forgotten that they suffered an injury (Figures 6.a and 7.a).

**Time at which to carry out reduction.**– Even though we consider that all fractures and dislocations must be considered as emergency surgery, and therefore it is our opinion that they must be treated during the first few hours following trauma, we consider this even more important in the case of fractures of the bones of the leg, since we are convinced that early treatment has great advantages and decreases some of the possible disagreeable consequences.

In the case of closed fractures, since there is of course no doubt that open fractures should be treated as an emergency, early reduction, subsequent to a correct X-ray diagnosis, is achieved with greater ease if advantage is taken of the muscular stupor that is present during the first hours after the injury. Occasionally, a fracture may be manipulated with a simple injection of morphine. At this time the deviated fragments, as also the dislocated bones, are trying to return to their correct position. There is usually no opposing muscular spasm, the hematoma is still small and limited to...
the fracture site and if formed by liquid blood that does not offer any resistance to apposition.

If a few days go by before attempting to treat these fractures, swellings and phlyctenas arise, the hematoma infiltrates the intermuscular spaces and there are blood effusions between the muscles, aponeurosis and bone, distal circulation can be affected to a greater or lesser degree in cases of hematomas under tension enclosed within the aponeurosis, the skin may become devitalized, the phlyctena may become infected and treatment is delayed by several weeks. In these cases reduction is more difficult and requires deep anesthesia, the forces necessary to apply are greater and in many cases reduction may be difficult or impossible to achieve.

In cases in which treatment is delayed it is very useful to decrease edema before carrying out reduction by injecting the fracture site and its surroundings with hyaluronidase. In cases in which treatment is delayed, there are other problems as well as difficulty in achieving reduction: as edema decreases, plasters loosen, and it is necessary to change all bandages several times with the consequent danger of fracture displacement. The muscles infiltrated by hematomas and seromas, as these become organized, retract and, therefore, it is more difficult to achieve muscular recovery during rehabilitation.

Early manual and mechanical reduction, placing all parts in their correct anatomical sites, removes all obstacles to circulation, especially venous circulation. Just this one step means that there is less swelling and, if there are phlyctenas, they are less in number.

However, if we add immobilization with a plaster bandage to early reduction, swelling is reduced to a minimum. If early reduction is performed followed by plaster cast immobilization, it is necessary to insist on two points of major importance, which can have disastrous consequences if omitted. We refer to the fact that any plaster applied immediately after early reduction must be opened longitudinally without a thread being uncut. The toes of the limb must be checked every 2 hours for 1 or 2 days, in case it is necessary to open the plaster further, in other words, to separate the edges of the longitudinal cut further. In this way, the pressure of the hematoma presses against the elastic resistance of the plaster bandage and distends it as much as necessary, while at the same time this resistance prevents further swelling. If this procedure is carried out in this manner, a permanent plaster can be applied 8-10 days after the first reduction in fractures with significant displacement.

In fractures with little displacement, reduction by simple manipulation is sufficient with the knee in flexion at a 35-45 degree angle; the aim of the maneuvers carried out is the restoration of correct axis and a bandage is placed first up to the knee, and then prolonged up to the upper third of the thigh. It is useful to use plaster U shaped splints to more rapidly immobilize the fracture site, bandaging is later completed with a circular bandage.

Angles greater than 15 degrees may be corrected with the help of wedges, within the plaster bandages, according to the technique described by Böhler8.

In fractures with more significant displacement, it is necessary to use a device that exerts traction by means of screws, the simple and most used model is that described by Böhler4, in which traction is achieved by means of a Steinmann nail. There are other devices for achieving traction in tibial fractures, such as the one described by Watson-Jones72, in which a support for the thigh is used and traction...
is carried out in a vertical position by means of a stirrup placed two and a half centimeters above the ankle joint. In the case of the device for traction used by Zimmer, traction is achieved by means of Kirschner wires applied to the tibial tuberosity in the supra-malleolar region. A system that achieves distraction of both stirrups or perforating units reduces the shortening of the fracture.

For the reduction of those fractures in which it is not necessary to apply a great amount of traction, the Sanchís Olmos technique, referred to by Vaquero González, is very useful. This procedure uses a system of applying plaster with 4 tongues, making it possible to apply the plaster bandages without ceasing to exert traction during their application.

In transverse fractures it may be sufficient to apply plaster bandages after reduction with the traction device; this plaster must be opened down its entire length and the leg must be maintained in a reclining position using a Braun splint.

In oblique and spiral comminuted fractures, after reduction and placement of the plaster bandage, a weight of two and a half to four kilos must be attached to the traction stirrup for 3-4 weeks.

There are spiral, oblique and comminuted fractures of both leg bones that are difficult to maintain in position without resource to the use of continual extension, since the bone area affected is large and this causes instability of the reduction. Continual extension must be applied and controlled very carefully, since excessive traction may cause delayed healing. Continual extension may be carried out using a Braun or Thomas splint.

We are not in favor of this form of treatment of diaphyseal fractures of the tibia, and when, due to circumstances, we have had to use it, at 15-17 days, when a callus that pro-
vides certain stability to the fracture has already formed and edema has completely disappeared, we substitute plaster for continual extension.

RESULTS OF OUR PERSONAL EXPERIENCE IN THE TREATMENT OF CLOSED TIBIAL DIAPHYSEAL FRACTURES

Criteria used to assess results.– Anatomical and functional results were classified in 3 categories: perfect, good and mediocre.

Perfect anatomical result: No axis shortening or displacement, good healing, no trophic disturbances.

Good anatomical result: Shortening of less than 2 cm in length, displacement of less than 15 degrees, slight trophic disturbances.

Mediocre anatomical result: All other cases.

Perfect functional result: The patient is able to return to previous professional or sports activities, there is no decrease in physical capacity or limitation on joint mobility, lengthy walks do not cause fatigue.

Good functional result: The patient can carry out their professional activities with a certain amount of difficulty, the patient cannot practice certain sports nor take prolonged walks, there is a limitation of the range of motion of the knee and tibio-tarsal joints of less than 10 degrees.

Mediocre functional result: All other cases, walking is difficult and there is lameness, fatigue, pain, reduced activity, stiffness, edema.

Fractures have been classified in children’s and adult’s fractures: Children’s fractures are those up to and including 14 years of age.
The time period taken to consider a fracture was suffering delayed healing was 180 days.

The Kuntzmann and Meyer criteria are used to assess results.

Closed children’s fractures. We treated 40 cases of children’s fractures classified into the following groups: spiral, 18; oblique, 12; transverse, 2, and fissures, 8 (Figures 33, 34, 35 and 36).

The treatment criteria followed were the following: in the case of fissures, we used immobilization with plaster bandages, a treatment also used in other anatomical types of fracture with no or very little displacement. In oblique and spiral fractures with great displacement, we used osteosynthesis with compound cerclage, cerclage and screws (Figure 37). One transverse fracture with significant displacement and one oblique fracture were nailed using the Küntscher method (Figure 38).

In our study we have related the anatomy of the fracture to the treatment used (Figures 33, 34, 35 and 36), jointly studying mean time of immobilization, functional recovery and anatomical and functional results.

Spiral fractures (Figure 33) were those that required longer mean immobilization, 8-11 weeks, and in this group we obtained a few results classified as good, since residual displacement remained of not more than 15 degrees.

In the other anatomical groups (Figures 34, 35 and 36), the functional and anatomical results were perfect, with a time of immobilization of 4-7 weeks. Except for 10 cases of the group of spiral fractures, who had a mean recovery time of 4 weeks, functional recovery was achieved in the other groups in 2-3 weeks after suspension of immobilization.

Five cases of oblique and spiral fractures were treated with cerclage using steel wire (Figures 33 and 34). The result achieved was so extremely good that the fracture healed
by first intention (Figures 10 and 11), and, since the surgical method is extremely simple, we consider it the procedure of choice in children with spiral fractures with significant displacement. Compound cerclage (screws and wire) has been used in one case (Figure 37) of a spiral fracture with excellent results. In 3 cases with oblique fractures and 4 cases with spiral fractures screws placed perpendicular to cortical bone were used, also with excellent anatomical and functional results (Figures 18 and 19).

Medullary nailing also achieved excellent results in a transverse fracture of the middle third with severe displacement (Figure 38). Fifteen days later the child was walking without a bandage of any type. We also used nailing in an oblique fracture, but mean time of immobilization and functional recovery were longer in this case than in fractures of the same type treated with plaster (Figure 34).

In our series of fractures in children we also studied...
some interesting statistical indices. We determined mean times of immobilization and functional recovery, also typical deviation and variability indices (Figure 39). We also studied healthcare indices and anatomical and functional results with a reference number of 100 for the perfect cases, 75 for the good cases and 50 for the mediocre cases.

As far as mean time of immobilization and functional recovery, the variability index for immobilization (4.9) shows a greater uniformity in results since it is lower than the functional recovery index (7.7).

As far as healthcare indices, in all osteosynthesis methods they reach 100, and in cases treated with plaster they reach 94. The figures for functional recovery are very similar. The variability index shows by means of its low figures (2.9 and 1.2) that the results are uniform even using different procedures (Figure 40).

Complications.— Complications (Figure 41) these were reduced to 3 cases of recurvatum with displacement of less than 15 degrees and ankle stiffness, all corresponding to the group of fractures treated with plasters.

Closed fractures in adults.— We treated 223 closed fractures in adults, classified anatomically in the following groups: closed oblique fractures, 50; transverse, 82; spiral, 70, and comminuted, 21. The highest percentage was that of transverse fractures, amongst which were included a butterfly fracture, a fracture with a wedge shaped fragment and fairly comminuted fractures. The high number of transverse fractures in our statistics is due to the fact that most of our cases are occupational accidents, which cause tibial fractures by direct trauma.

Mean immobilization for closed oblique fractures was from 14.2 weeks to 20.2 weeks, for spiral fractures, 14.2-18.5; for comminuted fractures 18.5-20 and for transverse fractures 20-52 weeks. Mean time to functional recovery varied, in spiral fractures from 18.5-42.8 weeks, for oblique, 18.5-23.8, for comminuted 23.5-25.7 and for transverse fractures 26.5-60.7 in one case (Figures 42, 43, 44 and 45).

The anatomical and functional results obtained with the different types of fractures can be seen in the tables. The study of healthcare indices shows a good amount between 94 and 82 and even higher numbers, with the exception of the healthcare index of the anatomical results in comminuted fractures that is a bit lower (77.25) (Figures 46, 47, 48 and 49).
Fifty cases of closed oblique fractures were treated in the following manner: two cases with cerclage, 3 with medullary nailing, 8 with screws, and 37 with orthopedic procedures (plaster or reduction using traction devices) (Figure 42). In general, the figures for immobilization and functional recovery were more favorable when osteosynthesis was used than when conservative treatment was used, especially when cerclage and perpendicular screws were used (figure 42). Using conservative treatment we achieved 48.9% of good anatomical results, that later became 83.7% of good functional results. In the 13 cases of osteosynthesis anatomical and functional results were perfect, and these cases also had the shortest times of immobilization and to functional recovery (figure 42).

Of the 70 spiral fractures, 2 were treated with cerclage, 5 with compound cerclage, 5 with medullary nailing, 13 with screws, 1 with continual extension and 43 by means of orthopedic procedures (figures 43, 13, 16 and 17).

In general, the times of immobilization and functional recovery were shorter when osteosynthesis and functional recovery were used than when continual extension of plaster was used.
The 2 cases of simple cerclage cured rapidly and achieved perfect anatomical and functional results. When compound cerclage was used (Figure 50) the same results were achieved in most cases, with one exception in which there was delayed healing. In this last case there was a late breakage of the cerclage and also the insertion of one of the screws was incomplete (Figure 51). This case increased the percentage of mean immobilization in this group. In another case, healing was fast, but there was secondary displacement, although this case later achieved a perfect functional result.

The six cases treated by medullary nailing clearly show that this type of fractures is not appropriate for this procedure (Figure 31). In none of these cases was the anatomical result perfect, only good and medium, although subsequently perfect functional results were achieved in most cases. Healing was fast (Figure 31).

Thirteen cases were treated with screws. Results were very favorable in all of them, both as far as reduced time of immobilization and functional recovery.

In the 43 cases treated with closed reduction and plaster, a high percentage of good and perfect anatomical results were achieved and 83.5% of perfect functional results. Time of immobilization was more prolonged in this series (20.2 weeks).

In the case treated with continual extension, anatomical and functional results were perfect, but healing was delayed and time to recovery long (Figure 43).

The group of closed transverse and fairly comminuted fractures included 82 cases. One of these cases was treated with compound cerclage and suffered delayed healing. Six cases were treated very satisfactorily with medullary nailing (Figure 32). Mean time of immobilization and functional recovery was short in these cases, and anatomical and functional results were perfect in 100% of cases. Seventy-five cases were treated with closed reduction and plaster, and these healed approximately after 5 months. A high percentage of perfect anatomical results were not achieved, although a high percentage of perfect functional results were achieved (75.4%).

Twenty-one cases were included in the group of comminuted fractures (Figure 44). Two cases with cerclage with a short time to consolidation. In these, the anatomical result was perfect in one and good in the other, and the functional result was perfect in both. Another case was treated with screws with perfect anatomical and functional results. Eigh-
teen cases were treated with closed reduction and plaster. In the previous series mean time of immobilization was 5 months. The number of perfect anatomical results was relatively small (16.5%) related to the type of fracture. The number of perfect functional results was high (88%).

Several indices were studied: mean time of immobilization and functional recovery according to the different treatments used; absolute mean, standard deviation and variability coefficient. We also studied the healthcare indices of the anatomical and functional results, and this variation can be seen in table 39.

The lowest figures for mean immobilization were those for cases treated with screws, 14.53 weeks as also those for functional recovery, 18.37 weeks. These were followed by the figures for cerclage, medullary nailing, compound cerclage, with higher figures than those seen in orthopedic procedures. The variability coefficient was quite high, 12.71 for mean immobilization and 12.29 for functional recovery, which indicates results with low uniformity.

The most favorable figures for healthcare indices of the anatomical and functional results were those of cases treated with screws and cerclage. As was also the case with continual extension, but as this was a single case, its value cannot be correctly assessed. The variability coefficient was much lower, especially with reference to functional results (2.36) (Figure 52).

Complications (Figure 53) were relatively few in the series of closed fractures: five shortenings of not more than

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**Figure 44.**

<table>
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<td>Functional Result</td>
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TRANSVERSE FRACTURES – ADULTS 82

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<tr>
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<td>75 CASES</td>
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MEAN IMMOBILIZATION

FUNCTIONAL RECOVERY

WEEKS

ANATOMIC RESULT

EXCELLENT

GOOD

AVERAGE

FUNCTIONAL RESULT

EXCELLENT

GOOD

AVERAGE

ANATOMIC AND FUNCTIONAL RESULTS OF CLOSED OBLIQUE FRACTURES – 50

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ANATOMIC AND FUNCTIONAL RESULTS OF CLOSED SPIRAL FRACTURES – 70

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</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>20</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>30</td>
<td>55</td>
<td>54%</td>
</tr>
<tr>
<td>Average</td>
<td></td>
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<td></td>
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</tbody>
</table>

Figure 45.

Figure 46.

Figure 47.
2 cm, one in a medullary mailing and 4 in cases treated by closed reduction and plaster. Ten cases of antero-posterior axis deformities (ante-curvatum and recurvatum): One in a case treated with cerclage, 2 in medullary nailings and 7 in closed procedures (orthopedic treatment).

Edema persisted in 4 cases. 1 case of cerclage, 1 case of an operated fracture in which screws were used that suffered secondary infection, and 2 cases of closed reductions. Joint stiffness was limited to the ankle and was slight: one case was a fracture that suffered secondary infection, with screws fixated to a medullary nail and 2 were cases of closed reduction and plaster. There was suppuration in 3 cases: two were cases of spiral fractures treated with screws, although these infections did not affect fracture healing they caused osteitis in the areas of screw implanta-

**Figure 48.**

**ANATOMIC AND FUNCTIONAL RESULTS OF CLOSED COMMINUTED FRACTURES – 21**

<table>
<thead>
<tr>
<th>Anatomical result</th>
<th>Number of cases</th>
<th>% Healthcare index</th>
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</thead>
<tbody>
<tr>
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<td>18</td>
<td>68%</td>
</tr>
<tr>
<td>Good</td>
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<td>73%</td>
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<tr>
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<td>15%</td>
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</tbody>
</table>

<table>
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<tr>
<th>Functional result</th>
<th>Number of cases</th>
<th>% Healthcare index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
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<td>68%</td>
</tr>
<tr>
<td>Good</td>
<td>30</td>
<td>73%</td>
</tr>
<tr>
<td>Average</td>
<td>4</td>
<td>15%</td>
</tr>
</tbody>
</table>

**Figure 49.**

**ANATOMIC AND FUNCTIONAL RESULTS OF CLOSED OBLIQUE FRACTURES – 50**

<table>
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<tr>
<th>Anatomical result</th>
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</tr>
</thead>
<tbody>
<tr>
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<td>40%</td>
</tr>
<tr>
<td>Good</td>
<td>25</td>
<td>50%</td>
</tr>
<tr>
<td>Average</td>
<td>5</td>
<td>10%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Functional result</th>
<th>Number of cases</th>
<th>% Healthcare index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>20</td>
<td>40%</td>
</tr>
<tr>
<td>Good</td>
<td>25</td>
<td>50%</td>
</tr>
<tr>
<td>Average</td>
<td>5</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Figure 13.** A) Spiral fracture of the left tibia and fibula treated with a ring suture with steel wire. B) Results at 10 months, with the patient fully recovered and back at work.

**Figure 16.** A) Spiral fracture of the right tibia and fibula in an adult worker, treated with perpendicular screws. B) Results at 6 months, with the patient fully recovered and back at work.

**Figure 17.** A) Spiral fracture of the right tibia and fibula in an adult woman, treated with perpendicular screws. B) Results at three and a half months, when supplementary immobilization is removed.
tion, which rapidly disappeared when the screws were re-
moved and the fracture site cleaned. Other infections were
seen, 1 in a medullary mailing, that appeared very late dur-
ing treatment, 3 months after surgery (Figure 12), when the
fracture was completely consolidated. Infection cleared
quickly after extraction of the nail and cleaning of the frac-
ture site.

In this group there were 6 instances of healing taking
longer than the 180 day time period: two were in compound
cerclages, 1 of the cases has already been mentioned (Fig-

Figure 50. A) Spiral fracture of the left tibia and fibula in an adult
treated with compound cerclage. B) Results at 6 months, 3 months after
supplementary immobilization was removed.

Figure 31. A) Oblique fracture of the right tibia and fibula in an adult
after medullary nailing. B) Results at 4 months, good healing. Longitu-
dinal displacement of the fragments.

Figure 51. A) Comminuted fracture of the right tibia in an adult, treat-
ed with compound cerclage. C) Consolidated fracture with supplementary immobiliza-
tion removed after 7 months.

Figure 32. A) Transverse fracture of the right tibia in an adult, treated
by medullary nailing. B) Results at 4 months, good healing.

Figure 52.
ure 51), and the delay could have been due to defects in the vascular system rather than to the secondary breakage of the wire and the incomplete insertion of one of the screws; another case was one treated by continual extension and 3 cases were closed reduction procedures.

The percentage of non-unions was very low. There were 2 cases in fractures treated with closed procedures and plaster, these were low level oblique and transverse fractures. These non-unions subsequently cured after surgical procedures with bone grafts.

REFERENCES


5. Beranger-Feraud. Cit. por Allende G.


behi der Marknungel bei den mit Gipverband behandelten Frakturen. Arch Klin Chir. 1944;455.
23. Haines. Cit. por Watson-Jones R.
38. Marchand G. Cit. por Ottolenghi.
41. Meillerre J. A propos de l’enchevétement des fractures diaphysaires par tige métallique (Methode de Kántschey)
Mém Acad Chirg. 1944;70:110-1.
61. Trueta J. Cit. por Ottolenghi CE.
73. Watson-Jones R. Medullary nailing of fractures after fity ye-
arse y los graves traumatismos de los miembros. Rev de Ortop y Traumat. 1948;31-A:586.
Commentary

Doctors Valdés, Vallina and Álvarez, from Oviedo and Sama de Langreo presented this study on the results obtained in the treatment of 223 fractures of the tibial diaphysis at the IV Seminar of the SECOT in Asturias in 1955. It must be kept in mind that at that moment in time in the best medical centers the classical principles of Böhler and Watson-Jones were used for the treatment of bone fractures. However, the Böhler method was blamed for the delayed healing seen in many fractures. This led to questions, which more than related to treatment, were related to the causes of delayed healing and non-unions.

This study is interesting because of its review of different treatment methods, many of them currently unknown, such as the use of a U-shaped external fixators with wireless transfixation or the interesting and no longer existent Eggers compression plates. Before the AO criteria became widespread, osteosynthesis was based on the principles laid down by Danis, who justified the use of screws and plaster at the same time. To make it easier to maintain fragments in place the forceps designed by Cezón Quirós. They possess no experience in the use of plates, which they consider a risk of infection. It is also curious to see the use of the Küntscher curved nail and the technique used for its insertion so that it is adapted to the tibial medullary canal.

We must not forget that open fractures, currently systematized, were difficult to assess and classify and, in some cases, the Orr and Trueta closed method was used (with all its associated difficulties and complications).

Reading this paper one can see the evolution and improvement of osteosynthesis procedures for fractures. However, this study has a second message which we consider very interesting, such as the questions related to the biology and healing mechanism in this type of fractures, which even today require to be treated with extreme care and which still, in many cases, are difficult to resolve.

Fractures of the tibial diaphysis are very frequent and usually seen in young males. When they are severe they can become complicated suffering problems related to consolidation or infection, which constitutes a social, economic and labor problem. One of the characteristics of these lesions is the high incidence of open fractures, due to the fact that this bone is located subcutaneously.

Reviewing the series in the bibliography it is seen that the man/woman ratio is 4/1, with a bimodal distribution by age and sex and a maximum incidence in young males (15-20 years of age), this frequency decreases gradually and increases again with old age, due to osteoporosis, with an equal ratio between sexes. The proportion of affected sides is very similar, with 2% of bilateral fractures.

The time to repair depends on the type of fracture and the state of the soft tissues. Thus, a spiral fracture of the tibial diaphysis without displacement can be resolved in 12 to 16 weeks, whereas open fractures with injury of soft tissues and loss of bone require 6 to 12 months. A closed fracture of the tibial diaphysis with compartmental syndrome is comparable, according to Turen et al1, to an open fracture.

This study we are commenting on, lacks an assessment scale to achieve a classification that would allow prognosis and indicate the right treatment of fractures, this has been one of the greatest contributions of orthopedics during subsequent years. Assessment scales are frequently found in the literature, although they have little prognostic value (since most of them are aimed at determining what treatment should be used).

The AO scale, modified by Müller et al2, is the most frequently used and is a morphologic classification of fractures in 3 types: A or simple, B and C, multi-fragment, B is wedge shaped with contact between fragments and C, or complex, is without contact between fragments. Each type of fracture can be subdivided into 3 types. Previously, Nicoll3 considered 4 parameters should be considered in tibial fractures: initial displacement, if there is comminution, soft tissues and infection, of all these the worst is infection. He divided each of these parameters into 4 groups or varieties. On the other hand, Chapman4 classified tibial diaphyseal fractures according to the pattern of the lesion, classifying fractures in 7 types according to location and morphology, for each of these types he proposed a certain treatment. Johner and Wruhs5 also developed a classification scheme for tibial diaphyseal fractures considering 3 main groups (simple, butterfly or wedge, and segmented or comminuted) with 3 subtypes within each type, which resulted in a total of 9 groups. On the other hand, Trafton and Chapter6 included as data to be considered when carrying out a classification of tibial diaphyseal fractures: displacement, comminution, wounds, mechanism of the cause, and energy of the cause.

One of the most frequently used fracture classifications is that proposed by Tscherne and Oestern7, who divided fractures into 4 grades of severity from 0 to 3. Grade 0 corresponded to simple fractures and grade 1 to those that were a little less severe and in which there was a superficial lesion of soft tissues. Grade 2 fractures are those of medium severity, with a profound contaminated abrasion and local lesion of the skin and muscle, and grade 3 fractures are severe or comminuted fractures, with an extensive lesion of soft tissues and muscle destruction.

The Gustilo and Anderson8 classification for open fractures, so well known and frequently used, has been used in
many countries and publications. Type 1 fractures have a laceration of less than 1 centimeter, they are clean punctures, the soft tissues are not too damaged and the fracture is normally a transverse one or a short oblique one. Type 2 fractures have a laceration greater than 1 centimeter, contamination is moderate, the soft tissue lesions are in the form of flaps or avulsions that are not too extensive and the fracture is moderately comminuted. Lastly, type 3 fractures have a large laceration, a high degree of contamination and there is extensive soft tissue, muscle, and neurovascular injury. The fracture is very comminuted and unstable.

The problem of non-union has been considered to be related to general factors, the nutritional and metabolic status of the patient, treatment with anti-inflammatory drugs, toxic habits, such as smoking, and other local factors (state of soft tissues, vascular structures, local infection, comminution, precarious fixation or insufficient immobilization, open reduction and inappropriate osteosynthesis, diastasis between fragments, irradiated bone, poly-fractures and early weight-bearing).

Non-unions have been classified, according to their X-ray images, in hypertrophic, normotrophic and atrophic. In the case of atrophic non-union, the mechanics to stabilize the fracture are correct and the biological process fails. On the other hand, hypertrophic non-unions are usually a consequence of osteosynthesis failures and there is a good biological response. This is of practical interest, since in atrophic non-unions biological treatment is more important than mechanical treatment whereas the opposite is true for hypertrophic non-unions. There are different classifications for infected non-unions. Jain and Sihna divide them into 4 categories: A1 would be a quiescent infection with a defect of less than 4 cm and A2 with a defect greater than 4 cm. B1 would be active infections in a defect of less than 4 cm and B2 with a defect greater than 4 cm.

We also proposed an assessment scale with two divisions. The first scoring long bone fractures and the second assessing the evolution.

The paper we are commenting on here, published in 1955, proposed different types of treatment, currently not valid, without using homogenous criteria. Nowadays we know a lot more, which does not mean that we do not have problems and complications. Appropriate treatment must be indicated and, biological products must be used initially (to accelerate healing and prevent secondary infections). When there is an associated soft tissue lesion, a barrier must be created to prevent the entry of microorganisms.

Fracture stability is another indispensable factor to achieve the desired results. The greatest possible area of contact between cortical bone must be achieved and interfragment diastasis must be prevented. A distance between fragments greater than 3 mm multiplies the delay in repair by 12 and risk of non-union by 4.

| Table 1. FREMAP scale for assessing long bone fractures and non-unions |
|--------------------------|-----------------|-----------------|-----------------|
| Fracture                 | Location       | Contact between cortices (%) | Comminution |
|                         | Proximal       | 75-100           | No             |
|                         | Intermediate   | 25-74            | 3-part fracture |
|                         | Distal         | < 25             | > 3 parts      |
|                         |                |                  | Wound          |
|                         |                |                  | No             |
|                         |                |                  | Grades I and II |
|                         |                |                  | Grade III      |
|                         |                |                  | Soft tissues   |
|                         |                |                  | No-C0          |
|                         |                |                  | Contusion      |
|                         |                |                  | C1-C2          |
|                         |                |                  | Excessive C3   |
|                         |                |                  | Pseudoarthrosis |
|                         |                |                  | No             |
|                         |                |                  | Slight         |
|                         |                |                  | Manifest       |
|                         |                |                  | Pain           |
|                         |                | 0                | 1-5            |
|                         |                |                  | 6-10           |
|                         |                |                  | Edema          |
|                         |                | No               | Moderate       |
|                         |                |                  | Severe         |
|                         |                |                  | Continuous     |
|                         |                |                  | Infection (drainage) |
|                         |                | No               | Occasional     |
|                         |                |                  | Atrophic       |
|                         |                |                  | Type           |
|                         |                | Hyper-           | Hyperoctic     |
|                         |                | throphic         |                |
|                         |                | Stable           |                |
|                         |                | Osteolytic       |                |
|                         |                | Unstable         |                |
|                         |                | loosening        |                |

The type of treatment applied also affects repair. Therefore, it is important to determine the precise treatment indicated for each type of fracture. Intramedullary nailing is the most frequently used treatment in tibial fractures, andreamed nails, as is pointed out by Bhandari et al., prevents 1 non-union in each 14 tibial diaphyseal fractures treated (although the percentage of delayed healing and non-unions in closed tibial diaphyseal fractures treated with intramedullary nails has been established at 0 to 10% for reamed nails and 11-27% for non-reamed nails).

Drosos et al. point out in a multivariate study of risk of non-union that this increases 2.4 times in comminuted fractures, 3.14 times when dynamization takes place and 1.65 times when there is failure of the blocking screws. In fractures with no comminution, the risk of non-union increases only when, after reduction, there is a remaining inter-fragment space greater than 3 mm.

Those initial studies that analyzed tibial fractures may seem long ago and of little use. However, without them, the subsequent development of orthopedics would not have been possible.

REFERENCES


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