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CLOSED INTRAMEDULLARY NAILING OF TIBIAL SHAFT FRACTURES

A Comparison with Conservatively Treated Cases

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Intramedullary nailing in the treatment of fractures of the long bones was technically developed and popularized by Küntscher in the 1940's (*Küntscher* 1940). The method was widely adopted for a variety of orthopaedic conditions, but in the treatment of tibial shaft fractures the stability achieved with the original medullary nail was inadequate. Likewise, in open reductions the simultaneous severance of the medullary and periosteal nutrient systems frequently resulted in failure. The principles and results of the method were criticized by several authors (*Bauer* 1943, *Palmer* 1951, *Trueta & Cavadias* 1956, *L. Böhler* 1957, *Lange* 1962) and regarded by many as unsuitable for the treatment of tibial shaft fractures.

Two recent technical improvements have revived interest in intramedullary nailing. Firstly, the introduction of the clover-leaved nail, combined with the principle of reaming out the medullary cavity (*Küntscher* 1958, 1959), in some cases made rigid fixation possible in the strict sense of the word. Secondly, the use of TV image intensifiers has made it possible to use a closed technique as a routine procedure. Closed intramedullary nailing, with minor technical modifications, has been practised by *Alms* (1962), *J. Böhler* (1963, 1965) and *Zucman & Maurer* (1965) with encouraging results. The value of the method is still debated, however, and comparative studies including selected series treated by other methods are lacking.

In this paper an attempt is made to assess the value of primary intramedullary nailing of tibial shaft fractures by comparing the early and

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Figure 1. A compound, comminuted fracture of the tibial shaft associated with severe initial displacement was sustained in a motor-cycle accident (a). Retention could not be secured by conservative measures, and the fracture was treated with a 10 mm Ø clover-leaved intramedullary nail. Fixation was now stable. The patient walked without a stick within 24 weeks and returned to heavy work in 47 weeks. At follow-up 2 years later (b) the fracture has united solidly and the ranges of movement in the knee, ankle, and tarsus joints were good.

late results in nailed and conservatively treated fractures of comparable severity.

MATERIAL AND METHODS

During the years 1963–1964, 32 fractures of the tibial shaft in 31 patients were treated by closed intramedullary nailing at the Clinic for Orthopaedics and Traumatology. In all cases the nailing was performed within 6 weeks after the trauma, either as primary treatment or when retention of the fracture by a plaster cast proved difficult. Both closed and open fractures were operated upon; in cases with extensive soft tissue injuries operation was usually postponed until the soft tissue injury had healed.

Operative technique. The nailing was in all cases made by a closed technique. Reduction of the fracture and subsequent introduction of the intramedullary nail

were controlled by the aid of a TV image intensifier mounted on a C-arch allowing controls in two planes. The medullary cavity was entered through the patellar tendon and reamed out with a flexible drill, so that eventually a heavy clover-leaved nail (mean diameter 11 mm) could be introduced into the medullary cavity (Figure 1).

In 17 cases fixation with the nail was rigid, while in 15 cases additional plaster immobilisation was considered necessary. This was usually applied one week after the operation and discarded 6–26 weeks later (mean 15 weeks).

The conservatively treated control group comprised 53 tibial shaft fractures in 52 patients treated during the same period in the clinic. The controls were selected out of 112 fully documented fractures in adult patients in the following way:

All the cases in the nailed and conservatively treated series were analysed regarding mechanism of trauma, site of fracture, severity of initial displacement, severity of comminution and severity of wound. From these data it emerged that the fractures in the conservative group represented less severe traumas than the nailed cases. Thus, in order to render the two groups comparable regarding severity of trauma, 60 cases were discarded from the conservative group, including most of the simple low-energy fractures. Among the 53 fractures remaining in the control group 10 later needed bone grafting on account of delayed union.

The principles for conservative treatment were reduction and immobilisation in plaster. Traction was not used, and the patients were encouraged to move around on crutches as soon as possible. Delayed union was treated by early subcortical or onlay grafting procedures with cancellous bone.

The mechanism of the trauma in the two groups is shown in Table 1. Traffic accidents were the main causative factor; three-fifths of the victims were pedestrians. The group of industrial accidents included fractures caused by compression or falls from a height. Domestic accidents comprised fractures sustained by slipping, stumbling and comparable low-energy traumas.

Table 1. Mechanism of trauma in the two groups of tibial shaft fractures under observation.

Mechanism of trauma	Küntscher-nailed	Conservatively treated
Traffic accidents	68 %	63 %
Industrial accidents (compression injuries, falls)	10 %	10 %
Domestic accidents (slipping, stumbling and low-energy traumas)	22 %	27 %

The site of the fracture. There were no fractures in the upper third of the tibial shaft. In 69 per cent of the nailed and 68 per cent of the conservatively treated cases the fracture was in the middle third; in the remainder it was located between the middle and lower thirds. Each group included two patients with double fractures.

The severity of the fracture is analysed in Table 2. Initial displacement was based on the radiographs, dropping of the distal part of the limb and obvious clinical

instability. Comminution was assessed from the radiographs, and the severity of the wound was graded according to the operative report.

Age and sex. Males outnumbered females in a ratio of 3: 1. The age of the patients in the nailed group varied from 16 to 73 years (mean 38 years) and in the conservatively treated group from 16 to 71 years (mean 32 years).

Table 2. Severity of tibial shaft fractures in the two groups according to initial displacement, degree of fracture comminution and type of wound.

Type of tissue injury	Küntscher-nailed	Conservatively treated
Displacement		
Slight	56 %	60 %
Severe	44 %	40 %
Comminution		
None	50 %	53 %
Slight	37 %	36 %
Severe	13 %	11 %
Wound		
None	50 %	55 %
Slight	28 %	28 %
Severe	22 %	17 %

All cases in the groups under observation were followed until the end of the treatment. In addition, the patients were summoned to a follow-up examination 2 years after the trauma. The end results were obtained in 24/31 patients in the nailed group (77 per cent) and in 42/52 patients in the conservatively treated group (80 per cent).

RESULTS

Rate of Union

In the nailed group, union could not be evaluated by clinical methods, since all fractures were rendered clinically stable 0–26 weeks after the operation by the metallic implant. Neither could radiographs during the first months supply conclusive evidence of solid union, which had to be assessed by disappearance of tenderness at the fracture site and improving walking ability. In the conservatively treated group the mean time of union was 20 weeks, based upon clinical stability and full weight bearing in a walking plaster. In the 10 cases, where delayed union necessitated subsequent bone grafting, the mean time of consolidation was 35 weeks: in 3 of these patients this time exceeded one year. In the group of patients treated in plaster alone (42 cases) the mean time of union was 17 weeks and in none did it exceed 36 weeks.

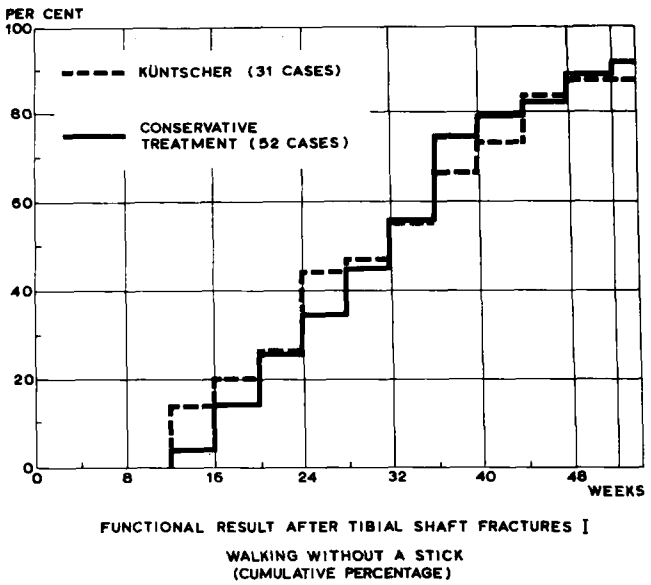

Figure 2. The early functional result in two series of tibial shaft fractures of comparable severity, treated either by closed intramedullary nailing or by conservative methods. The conservatively treated group includes 10 cases in which bone grafting was done on account of delayed union during the first year of observation. The ability to walk without a stick during the first year after the trauma is in cumulative percentages.

Functional Results

In order to evaluate the early results of treatment, the following criteria were chosen: 1) The time elapsing after the trauma until the patient was able to walk without a stick and 2) the interval between the trauma and return to work. The majority of patients were industrial workers for whom these data were accurately obtained. In sedentary workers and housewives, return to work was assessed by the time at which the patient could return to previous everyday activities.

The time elapsing before the patient could walk without a stick was about the same in the two groups (Figure 2). During the first six months after the trauma, the nailed patients did better, but the difference was negligible at the end of the observation year.

The interval between trauma and return to work was likewise almost the same in the two groups (Figure 3). The trend here was also towards a better primary result in the nailed patients, but the results were soon comparable and by twelve months a relatively greater number, 90 per cent, of the conservatively treated patients had returned to work.

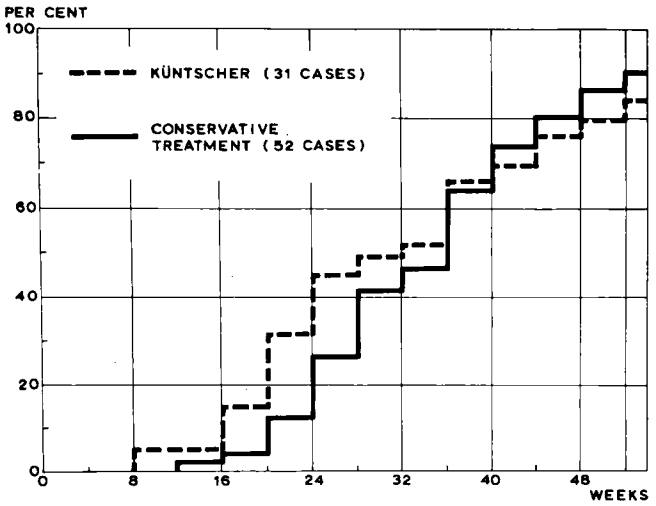

Figure 3. The time interval between the accident and return to work in the series of tibial shaft fractures under observation. The conservatively treated group includes the 10 cases treated by bone grafting during the first year of observation. Return to work is expressed in cumulative percentages.

Residual Joint Stiffness[1]

The range of movement in the knee joint, ankle joint and tarsus was recorded at the end of the treatment when the patient was encouraged

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[1] The evaluation of residual joint stiffness closely followed the criteria outlined by *Nicoll* (1964):

Knee joint:
Good = Full extension. Flexion not limited by more than 10 degrees.
Fair = Any loss of extension or loss of more than 10 degrees of flexion.
Poor = Inability to flex the knee to 90 degrees.

Ankle joint:
Good = Loss of flexion or extension less than 25 per cent.
Fair = Loss of flexion or extension 25–50 per cent.
Poor = Loss of flexion or extension more than 50 per cent.

Tarsus:
Good = Loss of inversion or eversion less than 25 per cent.
Fair = Loss of inversion or eversion 25–50 per cent.
Poor = Loss of inversion or eversion exceeding 50 per cent.

to resume work. The same was done at the follow-up examination 2 years after the trauma. The data obtained have been compiled in Table 3.

Table 3. Degree of joint movements in the knee, ankle and tarsus joints after tibial shaft fractures treated by closed intramedullary nailing and conservative methods.

Joint movement	Küntscher-nailed		Conservatively treated	
	At end of treatment	2 years after trauma	At end of treatment	2 years after trauma
Knee				
Good	58 %	87 %	77 %	90 %
Fair	42 %	13 %	21 %	10 %
Poor	–	–	2 %	–
Ankle				
Good	62 %	82 %	69 %	85 %
Fair	38 %	18 %	22 %	10 %
Poor	–	–	9 %	5 %
Tarsus				
Good	71 %	100 %	53 %	69 %
Fair	25 %	–	23 %	21 %
Poor	4 %	–	24 %	10 %

In the nailed group the range of movement in the knee joint was good in only 58 per cent of the cases at the end of the treatment. This was mostly due to tenderness in the knee region at the site of introduction of the nail. The distal joints had a better range of movement which was considered good in 62 per cent in the ankle joint and in 71 per cent in the tarsus. Two years later the mobility in the tested joints had improved: movement was good in the knee in 87 per cent and in the ankle joint in 87 per cent of the cases. The range of movement in the tarsus was uniformly good and not restricted by more than 25 per cent in any of the cases.

In the conservatively treated group the knee joint had a good range of movement in 77 per cent at the end of the treatment, whereas the distal joints were more affected. Two years later the ranges of movement had improved: there was good movement in the knee joint in 90 per cent of the cases. These figures are similar to those obtained in the nailed group of fractures. In the tarsus, however, movement was good in only 69 per cent of the cases, which in this respect differed from the nailed group.

Residual Deformity[2]

There was no significant difference between the two groups. Angulation exceeding 10 degrees was recorded in 1 case in the nailed group and in 2 cases in the conservatively treated group. Slight deformity in the 5–10 degrees range was more frequently seen after nailing than after conservative treatment.

Post-Traumatic Swelling

In both groups 5 patients complained of persistent swelling of the fractured limb. This became worse after strenuous exercise. In 1 case of the nailed and in 2 cases of the conservatively treated group this swelling was severe and partially disabling. In addition, 2 patients in the nailed group developed a pigmented, varicose eczema around the lower leg without detectable varicosities in the unaffected leg. Two years after the trauma 1 patient of each group was using a walking stick.

Complications

In the nailed group, 1 patient with a compound fracture developed a severe infection, eventually resulting in chronic osteitis. The nail was removed and the fracture treated later by bone grafting. The infection recurred and bony union has not yet been obtained.

Likewise, in the conservative group, 1 patient with a compound fracture developed chronic osteitis. The infection gradually subsided and the fracture was successfully treated by bone grafting.

In the nailed group two refractures were recorded, one at 26 weeks and the other at 28 weeks. Both eventually healed; one was treated with plaster alone, the other by changing to a heavier nail.

DISCUSSION

A conservatively treated fracture of the tibial shaft heals basically by formation of a callus sheath around the fracture. The rate of miner-

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[2] The following criteria were adopted as significant in assessing residual deformity.

Valgus or varus deformity Anterior or posterior curve	5 degrees or more.
Rotational deformity:	10 degrees or more.

alisation depends on the ingrowth of extraperiosteal vessels into the callus and on the osteogenic properties of the callus tissue (*Slätis & Rokkanen* 1967). If, however, the fragments are tightly held together by means of metallic implants of sufficient strength, using either intramedullary nails (*Küntscher* 1958) heavy plates (*Hicks* 1959), or compression devices (*Müller, Allgower & Willenegger* 1965), the main route of fracture repair is converted to direct new bone formation between the apposed fragments (*Schenk & Willenegger* 1964). There are so far very few experimental data concerning the rate of union or tensile and compression strength of fractures treated by such implants. Although the methods of osteosynthesis have greatly improved during recent years, it is still justified to state that osteosynthesis of a fractured diaphyseal bone does not promote union, but, at best, yields reliable retention of the fragments and union within a normal time.

Rigid internal fixation makes the use of external splinting unnecessary and thus allows early mobilisation of the knee, ankle, and tarsus joints. This is an important argument in favour of operative treatment. The results in this comparative study do not, however, reveal any significant difference between the nailed and conservatively treated fractures, although in the nailed group the good range of movement in the tarsus was impressive.

The functional result, as measured by the ability to walk without a stick and to return to work, were similar in both groups under observation. But this should be interpreted neither as evidence against the use of internal fixation nor as an argument in favour of intramedullary nailing. The fact that operative fixation in tibial shaft fractures yields results comparable to conservative treatment, is worth noting. It should be emphasized, however, that the series comprises a higher proportion of severe fractures than are to be found in unselected series and also that the best results with intramedullary nailing in this series were obtained in fractures of moderate severity.

The similarity of the results in the nailed and conservatively treated patients indicate that the severity of the trauma and the type of fractures basically determine the end result. The findings also support earlier observations that severe soft tissue injury is an essential causative factor in delayed union (*Ellis* 1958, *Wray* 1965) and residual joint stiffness (*Nicholl* 1964).

In our opinion, most fractures of the tibial shaft can be adequately treated by conservative measures, if necessary combined with early subcortical bone grafting according to Phemister-Charnley (*Charnley*

1963). However, in selected cases with difficult fracture retention or combined with skin problems, and quite often in multitraumatic patients presenting nursing problems, the method of intramedullary nailing affords a valuable alternative to conservative treatment.

SUMMARY

The results obtained in 32 fractures of the tibial shaft in 31 patients treated by closed intramedullary nailing in the years 1963–1964 are presented. The medullary cavity was reamed out and the fracture stabilized with a heavy nail 11 mm in mean diameter . All patients were operated upon within 6 weeks after the trauma.

For comparison, a series of 53 fractures of the tibial shaft in 52 patients was selected out of 112 fully documented cases treated by conservative methods during the same period.

The two groups under observation were comparable regarding mechanism of trauma, site of fracture and severity of displacement, comminution, and wound. The series comprised more severe fractures than the average unselected series; 50 per cent of the fractures were compound, and the conservative control group included 10 fractures which needed bone grafting on account of delayed union.

There were no significant differences between the two groups as regards the length of time elapsing before the patient could walk without a stick or the interval between trauma and return to work. Two years later, the residual joint stiffness in the knee and ankle joints were of the same degree, whereas tarsus movement was better in the nailed group of patients.

It is concluded that in most cases conservative treatment of tibial shaft fractures gives good results. In selected cases, where fracture retention is difficult, in fractures combined with skin problems and in multitrauma cases presenting nursing problems, closed intramedullary nailing may offer an alternative to conservative treatment.

RESUME

Les résultats du traitement de 32 fractures du corps du tibia chez 31 malades par clouage intramédullaire fermé dans les années 1963–64 sont présentés. Le canal médullaire a été évidé et la fracture stabilisé par une forte tige d'un diamètre moyen de 11 mm. Tous les malades ont été opérés dans l'espace de six semaines après le trauma.

A titre de comparaison, une série de 53 fractures du corps du tibia chez 52 malades a été sélectionnée parmi 112 cas de fractures parfaitement documentées, traitées par des méthodes conservatrices durant la même période.

Les deux groupes mis en observation étaient comparables en ce qui concerne le mécanisme du trauma, la localisation de la fracture, la gravité du déplacement, le caractère comminutif et la plaie. Les séries comportaient des fractures plus graves que la moyenne des séries non sélectionnées; 50 pour cent fractures étaient compliquées et dans le groupe de contrôle soumis au traitement conservatur, il y avait 10 fractures qui ont nécessité une greff osseuse en raison d'un défaut de soudure.

Il n'a pas été constaté de différences sensibles entre les deux groupes par rapport à la durée des délais qui se sont écoulés jusqu'au moment où le malade a pu marcher sans canne ou en ce qui concerne l'intervalle entre le trauma et la reprise du travail. Deux ans plus tard, la raideur dans les articulations du genou et de la cheville était la même, alors que le movement du tarse était meilleur dans e groupe des malades traités par enclouage.

Il est conclu que, dans la plupart des cas, le traitement conservateur des fractures du corps du tibia donne de bons résultats. Dans les cas sélectionnés où la rétension de la fracture est difficile, dans ceux où la fracture est combinée à des problèmes de la peau ou dans les cas de trauma multipe présentant des problèmes quant aux soins à donner aux malades, l'enclouage intramédullaire fermé peut offrir une alternative au traitement conservateur.

ZUSAMMENFASSUNG

32 Brüche des Tibiaschaften bei 31 Patienten, die durch geschlossene Marknagelung in den Jahren 1963–64 behandelt worden waren, werden besprochen. Die Markhöhle wurde bei der Operation ausgeborht und die Bruchestücke wurden duch einen groben Marknagel mit einem Durchmesser von 11 mm fixiert. Die Patienten wurden innerhalb von 6 Wochen nach dem Unfall operiert.

Unter 112 vollkommen dokumentierten Fällen von Brüchen des Tibiaschaftes, die durch konservative Methoden behandelt worden waren, wurde eine Gruppe von 53 Brüchen bei 52 Patienten zum Vergleich ausgewählt.

Im Hinblick auf dem Mechanismus des Traumas, auf Bruchstelle und auf Schwere der Verschiebung, Aufsplitterung und Hautwunde waren die beiden Gruppen vergleichbar. In beiden Gruppen ergab sich eine grössere Anzahl von schwereren Brüchen als sich sonst in nicht ausgewählten Serien durchschnittlich findet. 50 Prozent der Brüche waren aufgesplittert und in der Gruppe der konservativ behandelten Fällen waren 10, die wegen verzögerter Heilung mit Knochenspange, operiert werden mussten.

Es war kein signifikanter Unterschied zwischen die beiden Gruppen im Hinblick auf die Zeitdauer, bevor der Patient ohne Stock gehen konnte oder im Hinblick auf den Zeitraum zwischen Unfall und Rückkehr zur Arbeitsfähigkeit. Zwei Jahre später war die Steifheit des Knies und des Fussgelenkes gleich gross, während die Beweglichkeit der tarsalen Gelenke in der genagelten Gruppe besser war.

Die Schlussfolgerung ist, dass konservative Behandlung in den meisten Fällen von Tibiaschaftbrüchen erfolgreich ist. In ausgewählten Fällen, bei denen die Bruchstücke schwierig aneinander zu halten sind, bei Brüchen mit Hautwundproblemen sowie bei Fällen, die wegen vielfacher Schäden Pflegeprobleme stellen kann die geschlossene Marknagelung alternativ zur konservativen Behandlung verwendet werden.

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