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A COMPARATIVE STUDY OF METHODS OF TREATMENT OF DIAPHYSEAL FRACTURES OF THE LEG

BY

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During the last few years the value of prolonged traction for the treatment of fractures has been increasingly questioned (*Watson-Jones, Compere* and *Banks, Lindén,* and others). The method, which was advocated by many (*Brandberg, Kennedy,* etc.) and generally adopted as the normal treatment for almost all fractures only 15 or 20 years ago, has not given such good results as was originally expected. In the opinion of several authors who have compared shaft fractures treated by various methods fractures treated by prolonged traction generally take longer to consolidate than those treated by other methods (*Cornioley, Lindén, Lundgren*). A considerable delay in union and a tendency to pseudarthrosis are disadvantages of traction treatment. These disadvantages are stressed by a number of authors, e.g. *Watson-Jones* and *Coltart, Blum,* and *Bonnin,* who emphasise the harmful effect of over-traction. Experience has also shown that the late results of this method are inferior to those obtainable by operation or by immobilisation in plaster (*Girdlestone, Petitpierre, Lindén*).

In view of this there has been a growing tendency to abandon traction and to return to the older method of fixation in plaster, and an increasing number of surgeons prefer open correction, sometimes combined with some form of osteosynthesis. New methods have also been tried, e.g. nail fixation by the Küntscher method and so-called transfixation. The latter

method seems to be the more popular, especially in the U.S.A. It has been criticised by many (*Watson-Jones* et al.), who underline how difficult it is to obtain satisfactory fixation, and at the same time point out the risks of over-traction and infection involved.

One wonders why traction treatment should give relatively inferior results. The healing of a fracture is a very complicated process in which numerous more or less unknown factors play a part, and any unfavourable influence, no matter how slight, must disturb bone repair. Even though such general factors as age, general health, etc. are of some significance it must be emphasised that the healing of fractures is predominantly a local process. Thanks to the therapeutic possibilities now at our disposal we are, therefore, able to exercise a favourable or, as unfortunately often happens, an unfavourable influence on the course of the process. Some of the factors mentioned above, especially the part they may play in disturbed, delayed or incomplete union, have been very much discussed. In this connection one might mention the effect of inadequate immobilisation on the deposition and formation of the apatite crystals, the influence of the fracture haematoma, the tissue acidity, the local circulation and its chemical and mechanical regulation, the formation of endosteal and periosteal callus following open reduction, and the sensitivity of callus to roentgen rays. In order to obtain a conception of the significance of the possible influences of these factors and of the different forms of operative treatment, a comprehensive homogeneous material comprising a sufficiently large number of similar cases in every group is necessary. The literature, however, contains but few direct comparisons of the results obtained with the different methods, especially as far as the formation of callus is concerned. This is to be attributed to the fact that the material at the disposal of individual authors has consisted mainly of cases treated substantially by only one of the various methods, so that stastically reliable numbers could not be obtained.

When comparing the results of the various treatment groups of the individual authors (see *Lundgren, Lindén,* etc.) there are no reliable figures permitting comparison of the results obtained by different authors with different methods. Further, it is not possible to compare the traction-treated material of one author with material treated by another using a different method, because the grouping and arrangment of the material, the indications, and the evaluation of the results are different. Judging from the literature it seems that *Watson-Jones* and *Coltart* are the only workers who can produce representative material. The material of these authors comprises 417 shaft fractures of the tibia: 48 were treated by traction and overtraction occurred in 16. These cases have been compared with 167 cases treated in plaster. From the results obtained the authors conclude that fractures treated by traction heal more slowly than those treated in plaster, the difference being very marked in cases subjected to over-traction.

During a study of this question over several years the author has analysed a collection of closed diaphyseal fractures of the leg treated by various methods at the Central Hospital of Boras from 1934-46.

It is rather difficult to determine exactly when a fracture is actually healed, because the processes underlying bone repair are continuous and often very slow. The use of clinical union as an indicator, which has been common in the past, is both subjective and very unreliable. It has been condemned by, among others, *Tippet,* who stresses also that clinical and roentgenological stages of repair do not proceed concurrently. "Clinical union as shown by disappearance of local tenderness and freedom from elasticity of springing of the fragments is often reached within six to eight weeks of injury; radiographic calcification as proved by uniform consolidation of the callus is not complete until many weeks later". Quite a number of authors, e.g. *Lindén* and *Lundgren* assess consolidation by the length of hospitalisation and the working capacity of the patient, but social factors such as financial support from

Health Insurance Companies, etc., make it impossible to apply this method to a material made up of patients from different social classes.

In the present material the formation of the callus bridge has been used as indicator of established union, since the time at which this formation takes place is generally easy to determine. Moreover, during the period under review, practically all the radiographs were examined by the same roentgenologist, so that their evaluation was more or less uniform.

The material consists of 355 cases of closed diaphyseal fractures of the leg. 9 cases died within a few weeks of injury; the causes of death were: marasmus senilis, myocarditis with emboli, commotio cerebri, gas gangrene and fat embolism. In 44 cases either the records were inadequate or the follow-up was insufficient for inclusion in the series: 2 of them had a pseudarthrosis; one of these had been treated by traction, the other by plaster; both cases were operated later but could not be followed-up satisfactorily. Thus the series consists of 301 cases, one of whom had fractures of both legs, making in all 302 closed diaphyseal fractures. The age incidence and the form of treatment used can be seen in Table 1. 196 cases were immobilised in plaster, and of these 86 needed one or more closed reductions; 3 were treated by weight traction for the first few days. 89 cases were treated by traction from the beginning (calcaneus traction); 5 cases in whom reduction could not be obtained with plaster treatment and traction was resorted to after 1-3 days are included in this group. Finally, 17 cases had primary open operations.

Table 1 shows that 130 of the 302 cases were under 20 years of age, and, as the formation of callus and the healing of fractures is quicker in young patients, the various treatment groups cannot therefore be simply compared. *Snellman* and others have shown that union is much more rapid in patients under 15 years of age than in adults.

The present material has been divided into age classes of 10 years. These classes have then been statistically com-

TABLE 1.

The table shows the age-incidence with respect to various treatment groups.

Treatment group	Age in yrs									No. of cases
	0—9	10—19	20—29	30—39	40—49	50—59	60—69	70—79	80—89	
Gp. I Plaster fixation without reduction	34	29	21	8	7	6	2	2	1	110
Gp. II Reduction + fixation in plaster	24	25	9	8	6	7	3	4	—	86
Gp. III Traction	1	17	16	11	17	15	5	7	—	89
Gp. IV Primary operation	—	—	3	4	5	5	—	—	—	17
No. of cases	59	71	49	31	35	33	10	13	1	302

pared with respect to the time required before the bridging callus became radiographically detectable. By this method it has been possible to show that the interval between trauma and formation of the bridging callus was shortest in the age class 0-9 years, after which came the 10-19 year class. In a statistical comparison of the cases over 20 years no difference could be found in the time required for consolidation at different ages. The numbers in Group 1 are the most representative in that the position of the fracture was initially good and therefore there were no complicating factors. The average value for the consolidation time of the 0-9 year class in this group was 5.8 ± 0.22 weeks, and in the 10-19 year class 7.5 ± 0.54 weeks. A calculation of the difference gives 1.7 ± 0.58 weeks and D/Σ (D) = 2.93. Thus the difference is statistically probable. The average time for all the age classes over 20 years in Group 1 is 10.3 ± 0.59 weeks and a calculation of the difference between the averages of the classes over 20 years and the 10-19 year class was found to be statistically significant. (D = 2.8 weeks Σ(D) = ± 0.8 weeks, and D/Σ (D) = 3.5. See Table 3). If the cases under 20 years are divided into 5-year classes and compared with one another, no statistical difference can be found between the classes 0-4, 5-9, and 10-14 years, but a comparison of the age classes 0-14 and 15-19 shows a statistically probable difference.
($M_{15\text{-}19}$ = 9.4 ± 1.19 weeks and $M_{0\text{-}14}$ = 6.2 ± 0.11 weeks. D/Σ (D): 2.7)

In the light of these results, and in order to obtain as uniform a material as possible, all cases over 20 years of age have been allocated to one age class on which all further comparisons in this paper will be made.

If we examine all the cases over 20 years in the group reduced and immobilised in plaster (Group II) and all those treated by traction (Group III) with respect to age incidence, site of fracture, type of fracture, and malposition, it appears that the material of these two groups is substantially similar (see Tables 1 and 2) and therefore permits of comparison. We find that Group I, i.e. cases in whom correction was un-

necessary and who were immobilised in plaster, contained a large number of tibial fractures alone (40 %), but does not otherwise, i.e. as far as site and type of fracture are concerned, seem to differ much from the other two groups (Groups II and III). 88 % of the cases which had a primary operation (Group IV) consist of oblique fractures which indicates a certain selection of material in this group.

A number of authors have contended that fractures of the lower third of the tibial diaphysis heal more slowly than those of the middle and upper thirds. In the present material, however, this is not the case, and from Table 2 a it appears that no substantial difference of this nature can be detected for fractures of the different parts of the bone. *Watson-Jones* and *Coltart* were also unable to find any essential difference in their investigation of tibial fractures. They write: "Many more fractures occurred in the middle third than in the lower third of the bone, but the frequency of rapid and slow union was almost identical in the two groups, and it would appear that the site of fracture is unimportant". That transverse fractures heal more slowly than spiral or oblique fractures is stated by, among others, *Lundgren,* while others, e.g. *Compere* and *Banks,* contend that spiral and oblique fractures heal more slowly. As illustrated in Table 2, no such difference can be detected in the present material. *Watson-Jones* and *Coltart* state on the basis of an investigation that "similarly the type of fracture had little effect", and that spiral, oblique and transverse fractures heal at the same rate (see also Blumenfeld). The time 24.7 ± 6.99 weeks for the consolidation time of comminuted fractures treated with traction is much longer than for the others (see Table 2 a). However, the group comprises only 5 cases and is very heterogeneous, which is apparent from the large mean error, so that not much attention should be paid to it. Moreover, in contradistinction to the other groups, neither a statistically significant nor even a probable difference can be obtained. As neither the site nor type of fracture seems to influence substantially the healing conditions in the series, it would

TABLE 2 a.

The table shows the average value and mean error of the time necessary for the visualization of the callus with respect to localization and type of fracture.

Treatment group	Position of tibial fracture			Type of fracture		
	upper 1/3	middle 1/3	lower 1/3	Comminuted	Oblique	Transverse
Gp. I Plaster without reduction	11.0 ± 2.03 W.	10.5 ± 0.72 W.	9.5 ± 0.97 W.	11.7 ± 2.05 W.	9.8 ± 0.44 W.	9.9 ± 0.68 W.
Gp. II Reduction + fixation in plaster	12.5[1] W.	9.4 ± 1.44 W.	10.5 ± 0.62 W.	10.7 ± 1.42 W.	10.3 ± 0.93 W.	10.9 ± 0.67 W.
Gp. III Traction (not operated)	16.8[2] W.	17.4 ± 2.01 W.	13.0 ± 1.26 W.	24.7 ± 6.99 W.	12.5 ± 1.42 W.	14.9 ± 1.40 W.

[1] Too few cases for calculation of mean error.

[2] Only 5 cases, 2 of which showed delayed healing (47 and 34 weeks respectively).

TABLE 2 b.

The table shows the incidence per cent. of the cases over 20 yrs. of age in every treatment group with respect to localization and type of fracture.

Treatment group	No. of cases	Isolated tibial fracture	Tibial + fibular fracture	Position of tibial fracture			Type of fracture		
				upper 1/3	middle 1/3	lower 1/3	Comminuted	Oblique	Transverse
Gp. I Fixation in plaster	47	40 %	60 %	19 %	30 %	51 %	21 %	47 %	32 %
Gp. II Reduction + fixation in plaster	37	16 %	84 %	8 %	22 %	70 %	24 %	51 %	25 %
Gp. III Traction	71	9 %	91 %	13 %	29 %	58 %	16 %	59 %	25 %
Gp. IV Primary operation	17	12 %	88 %	—	24 %	76 %	6 %	88 %	6 %

TABLE 2 c.

The table shows the incidence of the cases over 20 yrs. of age with respect to malposition.

Treatment group	No. of cases	Shortening in cms.					Lateral displacement				Angulation			
		0—0,5	0,5—1,0	1,0—1,5	1,5—2,0	> 2,0	0	Width of cortex	Half-width of shaft	Width of shaft and more	0°	0—5°	5—10°	10—20° and <
Gp. II Reduction + fixation in plaster	37	49 %	43 %	8 %	—	—	16 %	41 %	32 %	11 %	54 %	24 %	14 %	9 %
Gp. III Traction	71	51 %	31 %	11 %	—	7 %	11 %	33 %	27 %	29 %	55 %	21 %	13 %	11 %
Gp. IV Primary operation	17	35 %	47 %	12 %	—	6 %	6 %	35 %	29 %	30 %	59 %	6 %	17 %	18 %

seem justifiable, if all cases under 20 years of age are excluded, to combine all sub-groups of the various treatment groups instead of treating them individually with respect to site, type of fracture, etc.

The statistical examinations just discussed have thus shown that the material—only cases over 20 years of age—of Group II (reduction plus plaster fixation) and of Group III (traction) are similar, and that a comparison of the two groups is permissible. Group I (plaster immobilisation only) differs from Groups II and III, inasmuch as it does not include malposition and manipulations for correction. In Group IV (primary operations) a certain selection has been made since it comprises only spiral fractures. A comparison of Groups I and II shows that the time interval necessary for the demonstration of bridging callus was the same in both groups. ($M_{II} = 10.6 \pm 0.57$ weeks and $M_I = 10.3 \pm 0.59$ weeks) see also Table 3. *Thus reduction has not caused any detectable increase in the healing time.* If the cases in Group II are classified according to the number of reductions, the average value for cases corrected only once is 10.7 ± 0.77 weeks, and for those needing 2 corrections 10.5 ± 0.89 weeks, and for those needing three or more reductions 10.4 ± 1.92 weeks. Practically all the reductions took place within a week of the injury, and when performed at this time the manipulations did not involve any delay in healing.

Inspection of the cases treated by traction—Groups III and V—(see Tables III and IV) shows that 18 of the 89 cases are under 20 years, and that of those over 20 no fewer than 25 were later reduced by open operation (Group V), sometimes with osteosynthesis, the indications for operation being delayed healing, overtraction or malposition. There thus remain 46 cases, of whom all showed a bridging callus formation after an average time of 15.3 ± 1.10 weeks. If we compare this value with the corresponding average value for the corrected cases immobilised in plaster (Gr. II 10.6 ± 0.57 weeks) the result will be ($M_D = 15.3—10.6 = 4.7$ weeks and $\Sigma_{M(D)} = \pm 1.26$ weeks) $M_D : \Sigma_{M(D)} = 4.7 : 1.26 = 3.7$.

TABLE 3.

The table shows the average value and the mean error, expressed in weeks, of the time necessary for visualization of the callus.

M = average value + mean error

n = no. of cases.

Treatment group	0—9 yrs.	10—19 yrs.	Over 20 yrs.
Gp. I Plaster fixation without reduction	M = 5.8 ± 0.22 w. n = 34	M = 7.5 ± 0.54 w. n = 29	M = 10.3 ± 0.59 w. n = 47
Gp. II Reduction + fixation in plaster	M = 6.0 ± 0.54 w. n = 23	M = 7.7 ± 0.59 w. n = 23	M = 10.6 ± 0.57 w. n = 32
Gp. III Traction (not operated)	4 w. n = 1	M = 11.4 ± 4.30 w. n = 11	M = 15.3 ± 1.10 w. n = 46
Gp. IV Primary operation	—	—	M = 12.4 ± 1.09 w. n = 17
Gp. V Secondary operation[1]			
a) plaster treatment	n = 1	n = 2	n = 5
b) traction	—	n = 6	n = 25
c) primary operation	—	—	n = 1

[1] See also table 6.

It is thus significantly established that the bridging callus was visible later in the cases treated with traction than in cases reduced and immobilised in plaster. Further, the percentage of the 89 traction cases which had to have secondary operations was greater than of those reduced and fixed in plaster. This fact will be returned to below. The relatively inferior results obtained when traction is used may be ascribed to various factors. As pointed out above, the cases in these 2 groups being compared, that is to say, the cases reduced and plastered, and the cases treated by traction or secondary operation (the cases in Group V), were not selected, so that the reason for any differences in the time necessary for the formation of bridging callus need not be sought in initially dissimilar material. Calcaneus traction probably gives a less firm fixation than plaster. It has been found that even small displacements of the fragments have an unfavourable or even harmful effect on the formation of callus, and this is especially so in young callus tissue. Henschen proved this in his radiospectroscopic studies and was able to demonstrate most convincingly that every form of movement in a callus mass disturbs the formation and deposition of the calcium crystals, and that in certain cases destruction of existing callus may occur. The callus seems to be very sensitive during the second and third weeks. Owing to the continuously repeated small traumata which occur with inadequate fixation the fracture area is continually irritated, which causes a local modification of the circulatory conditions and probably also of the biochemical processes. The application of traction also brings in an additional factor, tension, which, if too great, may easily result in over-traction which appears to have a very bad effect on the healing of the bone (see *Watson-Jones, Blum, Lindén*). Traction thus necessitates, at least in the initial stages, a more frequent roentgenological control, which may itself impair the regenerative capacity of the tissues. For example, Bj. Dahl has shown that radiography of a bone can cause a permanent decrease in the regenerative capacity of the osteogenic tissue.

Out of the 46 cases over 20 years old treated by traction substantial over-traction occurred in 11 cases (see Table 4). If the cases are divided into those showing over-traction and those without it, the mean figure for the former is 20.5 ± 3.40 weeks and for the latter 13.6 ± 0.85 weeks. A direct comparison gives $D/\Sigma_{(D)} = 2.3$, so that no significant difference can be shown. It is, however, statistically correct to compare the figure for over-traction cases with that for the whole group according to the following formula: $\Sigma_{N-n} = \Sigma_M \sqrt{\frac{N-n}{n}} = \pm 1.10 \sqrt{\frac{46-11}{11}} = 1.78$ and (the difference with its mean value) $D/\Sigma_{(D)} = 5.2 : 1.78 = 2.92$. *This shows that the slow healing in the traction cases is very probably due to over-traction.* If we exclude the cases with over-traction we find that 35 traction cases remain. As pointed out above the average figure for these cases is 13.6 ± 0.85 weeks. If we compare this figure with that for

TABLE 4.

Table showing the average value and the mean error of the traction cases with respect to time necessary for the visualization of the bridging callus. Time in weeks.

	Group	No. of cases	Callus after injury or in the operated cases after operation
not operated	A. Traction without overtraction or malposition		
	a) > 20 yrs.	35	M = 13.6 ± 0.85 w.
	b) < 20 yrs.	12	M = 7.8 ± 2.61 w.
	B. Traction with overtraction		
	a) not operated	11	M = 20.5 ± 3.40 w.
operated	b) operated before 4 weeks	5	M = 12.8 ± 2.50 w.
	c) operated after 4 weeks	6	M = 16.8 ± 2.80 w.
	C. Traction with malposition	12	M = 11.0 ± 1.01 w.
	D. Delayed healing and pseudarthrosis[1]	2	—

[1] One case was a fracture with delayed healing, the other a true pseudoarthrosis.

the cases reduced and immobilised in plaster, 10.6 ± 0.57 weeks, we find $D/\Sigma^{(D)} = 2.94$. Even if the traction cases with complications are excluded traction cases still appear to heal more slowly than plastered cases. *The existence of not only over-traction but also other delaying factors due to calcaneus traction is thus statistically probable.*

The duration of traction in the cases which were not subjected to over-traction varied from 1-12 weeks. In 50 % of the cases (18 cases) traction was replaced by a plaster during the first 2-3 weeks—in 2 cases after 7 days; the pin was retained in some of them. In these cases the callus was visible after an average period of 11.6 ± 0.99 weeks. For cases in which traction was applied over a longer period there was a mean value of 15.2 ± 1.10 weeks. The difference amounts to 2.43 times the average value so that it is not statistically probable, though this does not exclude a certain tendency presumptive of a retardation of the healing with increasing prolongation of traction.

It has also been shown that cases treated with traction more frequently require operative reduction and possibly osteosynthesis than do cases treated in plaster. This is due either to over-traction, or to displacement which cannot be corrected, or to delayed healing and pseudarthrosis[1]. Out of 89 cases—including those under 20 years of age (see Table 3)—treated with traction, 31 or 38.4 ± 5.06 % had to be operated on subsequently, whereas out of the 86 corrected and plastered cases secondary operation was necessary in only 8, i.e. 9 ± 3.13 %. The difference $D/\Sigma_{(D)} = 4.29$ is significant. It is obvious from Table 5 a that this difference can hardly be ascribed to an inferior initial condition as compared with the plaster cases or with the traction cases without over-traction or malposition. As regards site and type of fracture (see Table 5 b) these cases differed in no way from the others, although over-traction does seem to be

[1] There are only two pseudarthroses among these.

TABLE 5 a.

The table shows the incidence of the cases over 20 yrs. of age with respect to malposition.

Treatment group	No. of cases	Shortening in cms.					Lateral Displacement				Angulation			
		0—0,5	0,5—1,0	1,0—1,5	1,5—2,0	Over 2,0	0	Width of cortex	Half-width of shaft	Width of shaft and more	0°	0—5°	5—10°	10—20° and over
Gp. II Reduction + fixation in plaster														
Without complication	32	17	13	2	—	—	6	14	10	2	17	8	4	3
Operation for malposition or delayed union	5	1	3	1	—	—	—	1	2	2	3	1	1	—
Gp. III Traction														
Without complication	35	18	12	3	—	2	6	11	10	8	20	9	5	1
Overtraction without operation	11	7	2	2	—	—	—	5	3	3	9	1	—	1
Overtraction + secondary operation	12	7	4	—	—	1	2	2	4	4	5	4	2	1
Operation for malposition or delayed union	13	4	4	3	—	2	—	5	2	6	5	1	2	5
Gp. IV Primary operation	17	6	8	2	—	1	1	6	5	5	10	1	3	3
No. of cases	125	60	46	13	—	6	15	44	36	30	69	25	17	14

TABLE 5 b.

The table shows the incidence of the cases over 20 yrs. of age with respect to localization and type of fracture.

Treatment group	No. of cases	Isolated tibial fracture	Tibial + fibular fracture	Localization of tibial fracture			Type of fracture		
				upper 1/3	middle 1/3	lower 1/3	Comm.	Oblique	Transverse
Gp. I Plaster fixation without reduction	47	19	28	9	14	24	10	22	15
Gp. II Reduction + fixation in plaster									
Without complication	32	6	26	3	6	23	8	16	8
Operation for malposition or delayed union	5	—	5	—	2	3	1	3	1
Gp. III Traction									
Without complication	35	4	31	5	9	21	5	24	6
Overtraction without operation	11	1	10	2	4	5	2	6	3
Overtraction + secondary operation	12	—	12	1	4	7	3	2	7
Operation for malposition or delayed union	13	1	12	1	4	8	1	9	2
Gp. IV Primary operation	17	2	15	—	4	13	1	15	1
No. of cases	172	33	139	21	47	104	31	97	43

more common in transverse fractures. Of the 23 over-tracted cases 10 had transverse fractures.

The groups of cases which were treated by open reduction are shown in Table 6. They were operated either in the 3rd-4th week (mostly cases in which a satisfactory closed reduction was impossible) or not until after 10-12 weeks (over-traction with delayed union). In a few cases it was considered advisable to wait somewhat longer. The lapse of time after operation before callus formation was visible does not differ substantially from the average value for cases operated primarily. (12±1.09 weeks). The same operation methods were adopted for both the primarily and secondarily operated cases.

TABLE 6.

The table shows the average value and mean error with respect to time necessary for the formation of callus in the operated cases[1].

Time given in weeks = w.
M = average value.

Reason for operation	Weeks before opn.	No. of cases	Time necessary for visualization of callus after opn.	Total time necessary for visualization of callus
Traction				
a) overtraction	3.5	5	M = 12.8 ± 2.50 w.	M = 16.4 ± 2.46 w.
b) „	11.7	6	M = 16.8 ± 2.80 w.	M = 28.5 ± 3.31 w.
c) malposition	3.4	12	M = 11.0 ± 1.01 w.	M = 14.3 ± 1.48 w.
Plaster fixation	2—3	2	17	19
Delayed healing or pseudarthrosis[2]	25.0	5	17.4 ± 5.93 w.	42.4 ± 13.5 w.

[1] To this group belong also 6 traction cases < 20 yrs. one of which was operated for overtraction, 4 for malposition and one for pseudoarthrosis; and 3 plastered cases with malposition. These are not included in the tables.

[2] Of these, 3 are plastered and 2 traction cases, of all cases 2 are real pseudarthroses.

The cases treated by primary operation constitute but a relatively small group (17 cases) and a certain selection was made. Fractures with substantial displacement and cases in which surgery was the method of choice, e.g. long oblique fractures, are most represented. The methods used were: wiring, Lane's plate, and nail fixation. The lapse of time before callus formation was visible (12.4 ± 1.09 weeks) does not differ from the time for reduced and plastered cases. In one case brief suppuration occurred and another had to be re-operated for mal-union. Consolidation occurred, however, in both cases.

The investigation has thus shown that in this series plaster fixation was definitely preferable to traction. It has been statistically proved that the formation of callus can be detected earlier in cases treated by plaster fixation than in cases treated by calcaneus traction. A statistical examination has further shown that one of the main causes of slower union in cases treated by traction is often over-traction, but this of course does not exclude the presence of other factors. The inadequate fixation of calcaneus traction also plays an important part. In cases treated by traction an open reduction was moreover more often necessary owing to over-traction, permanent distraction, delayed union caused by over-traction and malposition of the fracture. This has been the experience of several authors during the last few years (*Watson-Jones* and others), for which reason there is an increased tendency to operate on these cases in good time. After operation they have generally united just as quickly as cases treated by primary operation reduction and plaster, so that the osteogenic capacity of the bone has evidently not suffered from the earlier manipulations.

Thus it is apparent from the above that immobilisation in plaster is preferable as a fixation method. Concerning traction as a means of reduction it may be mentioned that in only five reduced and plastered cases was reduction unsuccessful so that it was necessary to resort to traction. In 2 of these 5 cases traction also failed and they

had to have an open reduction. On the other hand many cases treated with traction could not be satisfactorily reduced before the traction was removed, when the fracture had to be reduced again and fixed in plaster.

Weight traction is less suitable than plaster for cases of closed shaft fractures of the leg. As a means of correction weight traction may be excellent, but it should be used with discretion and indications for its use should lie within narrow limits, the method being resorted to only in special cases, e.g. in cases in which there is a definite shortening, or in which repeated manual reposition plus fixation in plaster has failed. In obviously troublesome cases open reduction, sometimes combined with osteosynthesis, ought to be considered at the very beginning of treatment. According to *Bardy, Harbitz, S. Johansson, Lindén,* etc. this is the best and only form of treatment in fractures which are difficult to reduce or in which it is difficult to maintain the reduction. They deny, in contradiction to many others that such an operation delays union. The results of the investigations described here also show that cases operated primarily heal just as quickly as cases treated only with plaster.

Thanks to the resources now at our disposal the risk of infection (see *Watson-Jones*) ought to be considerably reduced, and ought not to prevent us from open operation if by it we can save the patient time and prevent later disability.

We should therefore try, as far as possible, to reduce a fracture by closed operation, and to fix it in plaster. Calcaneus traction ought to be used only for reduction, and the limb then fixed in plaster as soon as a good position has been obtained. In this way the risk of over-traction is to some extent avoided. In cases in which redisplacement might be feared the pin may be incorporated in the plaster and the weight removed as soon as the plaster has set. In fractures with considerable displacement or a pronounced tendency to re-displacement an operation is indicated. Such cases should be operated as soon as possible, sometimes as soon as the case is admitted.

SUMMARY

The author has studied the consolidation process in 302 closed diaphyseal fractures in the leg, using the formation of bridging callus as indicator of union. 196 of the cases were immobilised in plaster, and of these 86 needed one or more closed corrections. 89 cases were treated by calcaneus traction. 17 cases had primary open operations.

The material has been divided into age classes of 10 years. It was found that fractures in patients under 20 years of age healed more quickly than in older patients, and that there was no substantial relative difference in rate of healing among patients of different ages over 20 years. All the cases over 20 years were examined, and it was found that fractures which had been reduced and immobilised in plaster (86 cases) were substantially statistically similar to those treated by traction with respect to age incidence, site and type of fracture, and mal-position, and that it was therefore justifiable to compare the rate of healing in the two groups.

The investigation showed that while the cases treated by reduction and plaster needed an average of 10.6 ± 0.57 weeks before bridging callus was discernible, cases treated by traction had an average healing time of 15.3 ± 1.10 weeks. This difference is statistically significant. The delay is probably attributable to a great extent to over-traction which occurred in 11 cases; but even if these overtracted cases are excluded the remaining cases still show delayed healing as compared with cases immobilised in plaster. This is probably due to the fact that traction gives less satisfactory fixation than plaster. The investigation also showed that cases treated by traction more often required open correction (34.8 ± 5.06 %) than did cases who were immobilised in plaster (9 ± 3.13 %). The operations were required for over-traction, malposition, delayed union, and, in a few cases, for pseuarthrosis. Open correction was performed after 3-4 weeks, or in some cases after 11 weeks and later. Union after operation was usually as quick as in the cases operated primarily (12.4 ± 1.09

weeks). The latter group differs from the others in that it contains only oblique and spiral fractures, which indicates some selection.

The author considers that diaphyseal fractures of the leg should, as far as possible, be treated by immobilisation in plaster, and that traction should be used for correction only and not for prolonged immobilisation. In apparently severe cases open operation should be contemplated at the very beginning of treatment.

RESUME

L'auteur a étudié le processus de consolidation dans 302 fractures diaphysaires fermées de la jambe, en utilisant la formation du cal comme indicateur de la consolidation. 196 malades ont été immobilisés dans le plâtre. Parmi ceux-ci il a fallu pratiquer une ou plusieurs corrections fermées. 89 cas ont été traités par traction. 17 cas avaient subi des opérations primaires ouvertes.

Les malades ont été répartis en groupes par classes d'âges de 10 ans. On a constaté que chez les malades âgés de moins de 20 ans les fractures guérissent plus vite que chez les malades plus âgés et qu'il n'y avait pas de différence essentielle dans les différentes classes d'âges au-dessus de 20 ans. Tous les malades âgés de plus 20 ans ont été examinés et on a constaté que les fractures qui avaient été réduites ou immobilisées dans le plâtre (86 ans) donnaient un résultat sensiblement égal à celles traitées par traction en ce qui concerne l'âge des malades, la localisation, le type de la fracture, et la position vicieuse. C'est pourquoi on estime qu'on est fonde à comparer la rapidité de la guérision dans ces deux groupes.

Les recherches pratiquées ont montré que les cas traités par réduction et plâtre demandaient une moyenne de 10.6 ± 0.57 semaines avant qu'on puisse discerner le cal, ceux traités par traction ont un temps moyen de guérison de 15,3 ± 1,10 semaines. Cette différence est prouvée statistiquement. Ce plus long délai de guérison doit probablement être attribué

pour une grande part à la surextension constatée dans 11 cas. Mais même si l'on fait abstraction de ces cas, il n'en reste pas moins vrai que le délai de guérison est plus long comparé aux cas immobilisés dans le plâtre. Ceci est vraisemblablement dû au fait que la traction donne une fixation moins satisfaisante que le plâtre. On a constaté aussi que les cas traités par traction ont plus souvent besoin d'une correction ouverte (34,8 ± 5,06) que ceux immobilisés dans le plâtre (9 ± 3,13 %). Il a fallu faire des opérations pour surextension, position vicieuse, consolidation défectueuse et, dans très peu de cas, pseudarthrose. Des corrections ouvertes ont été pratiquées au bout de 3—4 semaines, dans certains cas après 11 semaines ou plus. Dans l'ensemble, la consolidation après l'opération était aussi rapide que dans les cas opérés primairement (12,4 ± 1,09 semaines). Le dernier groupe diffère des autres du fait qu'il ne comporte que des fractures obliques et spiralées, ce qui indique qu'on a procédé à une certaine sélection.

L'auteur considère que les fractures diaphysaires de la jambe doivent autant que possible être traitées par immobilisation dans le plâtre et que la traction ne doit être appliquée que comme correction seulement et pas comme immobilisation prolongée. Dans les cas paraissant graves, il convient d'envisager immédiatement s'il y a lieu de pratiquer l'opération ouverte.

ZUSAMMENFASSUNG

Verfasser hat den Konsolidationsprozess in 302 geschlossenen Diaphysenfrakturen des Unterschenkels untersucht, wobei die Bildung von Brückencallus als Indikator der Wiedervereinigung benutzt wurde. 196 dieser Fälle waren durch Gipsverbände immobilisiert, und von diesen waren bei 86 eine oder mehrere geschlossene Korrekturen erforderlich. 89 Fälle wurden mit Calcaneuszug behandelt. 17 Fälle hatten primär offene Operationen.

Das Material wurde in Altersklassen von je 10 Jahren ein-

geteilt. Es wurde gefunden, dass Frakturen bei Patienten von unter 20 Jahren schneller heilten als bei älteren Patienten, und dass unter Patienten verschiedenen Alters von über 20 Jahren kein wesentlicher relativer Unterschied in der Schnelligkeit der Heilung bestand. Alle Fälle von über 20 Jahren wurden untersucht, und es wurde festgestellt, dass Frakturen, die reponiert und mit einem Gipsverband immobilisiert worden waren (86 Fälle), hinsichtlich Altersverteilung, Lage und Typus der Fraktur und fehlerhafter Stellung statistisch wesentliche Ähnlichkeiten aufwiesen mit denen, die mit Zug behandelt wurden, und dass wir daher berechtigt waren, die Schnelligkeit der Heilung in den beiden Gruppen zu vergleichen.

Die Untersuchung zeigte, dass während die Fälle, die mit Reposition und Gipsverband behandelt waren, eine Durchschnittszeit von 10,6 ± 0,57 Wochen brauchten, bis ein Brükkencallus erkennbar war, die mit Zug behandelten Fälle eine durchschnittliche Heilungsdauer von 15,3 ± 1,10 Wochen hatten. Dieser Unterschied ist statistisch sicher. Die Verzögerung ist wahrscheinlich zum grossen Teile einem zu starken Zug zuzuschreiben, der in 11 Fällen vorgekommen ist; aber auch wenn diese Fälle mit zu starkem Zug ausgeschlossen werden, zeigen die übrigen Fälle immer noch eine verzögerte Heilung im Vergleich mit den mit Gips immobilisierten Fällen. Dies ist wahrscheinlich auf die Tatsache zurückzuführen, dass ein Zug eine weniger befriedigende Fixierung ergibt als der Gipsverband. Die Untersuchung zeigte auch, dass die Fälle, die mit Zug behandelt wurden, weit öfter eine offene Korrektur erforderten (34,8 ± 5,06 %), als dies bei den Fällen der Fall war, die mit Gipsverband immobilisiert waren (9 ± 3,13 %). Die Operationen waren erforderlich wegen zu starken Zuges, fehlerhafter Stellung, verzögerter Vereinigung und, in einigen wenigen Fällen, wegen Pseudarthrosis. Die offene Korrektur wurde nach 3—4 Wochen ausgeführt oder in einigen Fällen nach 11 Wochen und später. Die Vereinigung geschah nach der Operation gewöhnlich ebenso rasch wie in den primär operierten Fällen (12,4 ± 1,09 Wochen). Die letztgenann-

te Gruppe unterscheidet sich von den anderen dadurch, dass sie nur Schräg- und Spiralbrüche enthält, was eine gewisse Auswahl bedeutet.

Verfasser ist der Ansicht, dass Diaphysenfrakturen der Unterschenkel so weit möglich mit Immobilisierung im Gipsverband behandelt werden sollten, und dass ein Zug nur für eine Korrektur angewandt werden sollte und nicht für eine prolongierte Immobilisierung. In offensichtlich ernsten Fällen sollte eine offene Operation gleich zu Beginn der Behandlung in Erwägung gezogen werden.

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