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From: Assistant Technical Officer (Medical) U.S. Naval Forces, Germany
To: Chief, Bureau of Medicine and Surgery, (Attn: Chief, Publications Division).
Via: (1) Technical Officer, U.S. Naval Forces, Germany
(2) Chief of Naval Operations (Op-32-F2).

Subject: Marknagelung (Medullary Nail) - Additional Translation - Forwarding of.

Enclosure: (A) Copy of Subject Translation (Project II, Folio IV) Fresh Fractures of Upper and Lower Limbs treated by the Medullary Nail. - by Prof. Dr. C. HAEBLER.

1. Because of its bulk, Enclosure A will be forwarded under separate cover directly to each of the below listed recipients of a copy of this letter.

2. This Folio contains a review of the treatment of fresh fractures of the upper and lower limbs with the medullary nail prepared by Prof. Dr. Haebler of Hannover.

3. Subsequent Folios in this series will include a discussion of other uses of the medullary nail by Dr. Haebler and a complete discussion of the subject by its inventor Prof. Dr. Gerhard Kuentscher of Schleswig. Production of these folios has been somewhat delayed by the difficulties in obtaining photographic material to make the illustrations.

4. Attention is invited to the fact that this folio is from an unpublished manuscript prepared for the U.S. Navy and publishing rights are therefore a property of the Bureau of Medicine and Surgery, Navy Department.

5. The reserve supply of these Folios is limited. It will be forwarded to Bureau of Medicine and Surgery, Publications Division on a Government Bill of Lading. Requests for additional copies or further distribution should be addressed to that office.

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EXPERIENCES WITH THE MARROW NAIL OPERATION ACCORDING TO THE PRINCIPLES OF KUENTSCHER

by

Prof. Dr. C. HAEBLER

Translation prepared by:

U.S. Naval Technical Unit, Europe, (Medical Section)
Office of Naval Advisor
Office of Military Government (US)

In my previous publication on the marrow nail operation (1) I had not evaluated the final findings statistically because the material in question appeared to be too small. The experience obtained from 900 cases does not say a great deal of course, nevertheless a preliminary evaluation seems to be useful. The findings were obtained from my civilian practice in my own clinic and from the MUNICIPAL HOSPITAL at Ricklingen/Hannover of which I was the deputy in charge for about two years. On the other hand and to their greater part these experiences were gathered during my activities when I was a consulting surgeon of the Air Armada "REICH" during which time I had the opportunity to perform nailing operations myself and to study the course of all the other cases by means of detailed reports and after consultations. A special department of the Air Force hospital at Braunschweig (Stabsarzt von Scanzoni), which was superintended by myself, made it possible to gather experience with particularily complicated cases principally with regard to the marrow nail operation in old gun-shot wounds.

The indication and the technique were previously published in detail. BOEHLER has also contributed to these problems (2). In the second edition of his publication (1944) he is much more cautious as to the indications. Finally KUENTSCHER and MAATZ (3) have published their technique in detail and given us a detail description of all fractures suitable for the marrow nail operation. It would be rather interesting to deal with the various antithesis of those authors and compare them with our own findings. In view of the limited space, however, we have to deal only with our own findings and experiences gathered from our own material.

On the one hand we must deal with the problem whether the results obtained by marrow nail operations are an advance in comparison to the hitherto known methods of treating bone fractures. On the other, however, we must study the problem as to whether or not the number of disadvantageous effects is greater so that they offset the better results. Furthermore we must study this method as to the question of whether or not it may be generally used notwithstanding its difficult technique or whether or not it must be reserved to special surgeons because of the danger connected with its use. Finally we must come to a conclusion whether the indications stated earlier (1) may be maintained.

One general remark must be made: In general the healing of a fracture is determined according to the formation of callus as observed in the X-ray. A long time ago we had already pointed to the fact that the X-ray picture may be deceptive. From the clinical point of view a fracture may be solid and suitable for weight bearing even if the X-ray does not show what we consider to be a sufficient formation of callus (2). We often observe, however, that even an abundant formation of callus (without structures of lines of force) may not withstand the strain caused by gymnastics during the confinement to bed. At that time we came to the following conclusion: "Besides the rough mechanical examination the only criterion

is the subjective statement of the patient as to pains encountered during weight bearing, bending or pressing the fragments together.

All these symptons fail to appear after the nailing if a stabile osteosynthesis has been achieved. In case of a true stabile osteosynthesis painless weight bearing is possible at a time when a sufficient formation of callus is certainly not yet to be observed. In such a case, even X-rays are of no help. It is well known that especially in case of an ideally fixed fracture the formation of callus is particularly slight and it is restricted to the fracture cleft. In case of an inserted nail the dense shadow of that nail covers the callus to a great extent. But even if a sufficient quantity of callus was formed the shadow of the nail will render it difficult - sometimes even impossible - to determine the structures of the lines of force or their stability.

As an example it may be pointed to the X-ray demonstrated by illustration 1. It is a nailed true pseudarthrosis of the arm above the elbow in which only the connective tissue cartilage was removed from the fracture planes. The patient, a regular sergeant, had served in the field army for two years with a nailed fracture of his arm above the elbow without any trouble. According to the clinical and X-ray findings the fracture was considered to be healed. Therefore the nail was removed but the pseudarthrosis still existed.

Therefore there is no sure symptom whether and when the nailed fracture was healed. So it may happen that the nail is removed too early (BOEHLER, ref.(2), Ill. 3486/87) and vice versa we often have certainly left the nail in the bone longer than was necessary. As to the practical evaluation of the method it seems to be without significance, however, whether a bony healing is achieved early or late. As soon as the patient may use the broken limb without difficulty it does not make any difference whether the X-ray shows only a little or abundant callus and whether according to the X-ray the healing lasts 8 days or 8 months. We know that in all fractures even after the clinical healing, processes of reduction and reconstruction take place which may last years. All this is of utmost importance and of greatest interest from the scientific point of view but nobody will refer to it when evaluating this new method. Therefore in the statistics in question we take as a basis only the duration of the treatment and the incapacity for work.

The aim to be looked for was described by KUENTSCHER as a stabile osteosynthesis by which (just as in the nailing of the fracture of the neck of the femur) the fracture pieces are united by the nail in such a way that any displacement is made impossible and painless weight bearing and use of the limb in question is possible. The mechanical peculiarity of the "lashing" (fixation) obtained with the nail allows a firm pressing together of the fragments during the weight bearing. In this way particularly favorable mechanical conditions for the stabilization and formation of callus are obtained.

Illustration 1

True pseudarthrosis of the arm above the elbow 2 3/4 years after nailing. A resection was not made because the nervus radialis was lying in the newly formed joint capsule. So much of the fibrous cartilage was removed that the bleeding bone was exposed. The patient served in the field army for more than 2 years with the nail in place. From the clinical point of view the fracture is absolutely stabile. From the reontgenological point of view sufficient quantities of callus have been formed. Slight rarefactions about the nail point. The wires we see here were applied during a previous unsuccessful operation. After the removal of the nail the pseudarthrosis is flexible again.

According to my own experience gathered with the foreign body osteosynthesis we did not dare hope that the mere presence of the matallic nail would stimulate or favor the formation of callus and unfortunately all such hopes were futile. On the contrary it was observed that an abundant formation of "stimulated callus" which is caused by rust or unfavorable mechanical conditions is of little value and may even be disadvantageous. Therefore it must be kept in mind that the marrow nail will further the healing process and the formation of callus only in case of favorable mechanical conditions.

Unfortunately not all fractures are suitable for the marrow nail operation in the sense of a stabile osteosynthesis. This question cannot be dealt with in details here. The capability of appreciating the mechanical conditions of the marrow nail operation which is necessary for each healing of a fracture, and experience alone are the only means to get along with this problem.

All these experiences had to be gathered first and especially in the beginning, some fractures (especially of the leg) were nailed of which the osteosynthesis was only "relatively stabile". In many cases an absolute stabilization could not be achieved, not only because of the relative unsuitability of the fracture but principally because of the technique applied (the nail was either too short or too thin). Just like myself many an other surgeon had to make the same experience. Among my patients are several cases of "unstabile osteosynthesis".

It is my impression, however, that also a relatively stabile osteosynthesis has some advantages and therefore nailing operations of that kind were made intentionally in order to gather further experience.

I. Fresh simple Fractures.

It is characteristic for the marrow nail operation that the fracture cleft is not exposed. All dangers arising from the operative treatment of fractures such as infections, delayed formation of callus, etc. are eliminated. In fresh fractures such a "closed marrow nailing" should always be possible and I myself have always been successful. The difficulties may be very great, however, especially if the surgeon is not sufficiently experienced and therefore many surgeons decided to open the fracture after the application of the nail. Primary cause for these difficulties may be the possibility of soft parts entering the cleft (1) which was referred to also by HART (2)

Previously the interposition of soft parts was frequently considered to be an insurmountable obstacle for the reduction and therefore the fractures were exposed. BOEHLER, however, has pointed out that that obstacle had to be overcome only occasionally. In 500 cases of thigh fractures no single case of that kind was observed. He is of the opinion that in case of a dislocation soft parts penetrate the fracture cleft. But if the pressure is strong enough the bone ends slip back and the interposition disappears. This observation must be confirmed by my own experience. Muscles or fascias interposed between the bone ends are torn by the nail and after that they slip back.

For reasons mentioned above HART's (2) proposal is not acceptable according to which it would be better to expose the fracture if difficulties are encountered in setting a fracture. The danger of infection is consider-

ably increased by the exposure. We therefore rather suggest stopping the operation in such a case and to treat the patient with wire extension. (After the shortening has been eliminated it will be possible later on to try a second nailing operation). The only indication for the exposure of the fracture is the suspicion that nerves or larger vessels may have been hurt but it must be kept in mind that this suspicion has always been an indication for the exposure of the fracture.

A total of 463 cases of nailing operations of fresh simple fractures were performed, 171 of which were fractures of the legs, 141 fractures of the arm above the elbow, 133 thigh fractures and 18 fractures of one or both forearm bones. 5 fatal terminations must be regretted all of which occurred in cases of thigh fractures. They will be dealt with in detail in a special chapter.

In the first place, however, I would like to deal with the duration of the treatment and the results achieved.

a) Thigh fractures

It was possible to study the course of 118 of a total of 133 thigh fractures until a healing was achieved. In 111 or 94% of the cases, it was possible to achieve a good healing without any shortening, bending or involvement of the joints. (See table #1). In a 58 year old patient suffering from arthrosis deformans of the knee joint, a limitation of flexion amounting to 20° could not be avoided (Table No.2). In a single case the shortening amounted to 3 centimeters and in another case a lateral distortion of 30° occurred (table #3).

I have seen that patient a long time after the operation when the nail was to be removed. It was a case of a transverse fracture in the central third and the osteosynthesis was stabile. The distortion was probably not observed during the operation (it was the first case of a nailing of the thigh of that surgeon). This case was treated by transecting the bone above the fracture with the nail in place. Then a guide rod was inserted into the nail, the distortion eliminated and the nail introduced again. The final result was that the limb could be used satisfactorily.

The two other shortenings of 3 and 2 centimeters could also have been avoided. In both cases the osteosynthesis was only relatively stabile. In the first case (Ill. 2a-c) we had to deal with a subtrochanteric transverse fracture which had been nailed by exposing the broken pieces because it was not possible to fix the bone ends correctly. After the insertion of the nail the fracture pieces were firmly pressed together. X-ray controls after the nailing revealed that "the nail was lying in the marrow cavity the tip of the proximal fragment, however, pointed to the front". These findings were obtained by an X-ray taken from the side (Ill. 2a). In the proximal fragment the nail is not lying in the bone axis. After a lapse of only

a

Ill. 2a

Subtrochanteric oblique fracture after nailing, which was an open operation because the reduction was not successful. The proximal fragment came to a displaced position in the anterior direction because the nail was not inserted in the correct axial direction. Primary healing. After a lapse of 12 days the limb is subjected to some passive exercises and exercises in the manner of walking while the patient was still confined to bed. These exercises did not cause any trouble. After a lapse of four weeks the limb is subjected to weight bearing .

Ill. 2b

Same fracture 9 weeks after the operation. For eight days the patient has suffered from pains at the fracture site. Distinct protective limping. The fragments have slipped, the nail has wandered in the lateral direction. Medially from the nail the old nail bed is distinctly visible.

Ill. 2c

Same fracture 17 weeks after the removal of the nail. The shortening amounts to 3 centimeters. The bed of the dislocated nail is still distinctly visible in the trochanter massive.

c b

12 days when still confined to bed the limb was subjected to active exercises after the manner of walking. By doing so he did not complain about pains and four weeks later he was able to get up. Two weeks after that he complained about pain when walking and a distinct limping was observed. The X-ray control (Ill. 2b) revealed that the bone ends had slipped. The smooth trabeculas of the spongiosa reacted upon the constant rhythmic strain by an absorption and thus the nail moved in the outward direction. The old nail bed in the trochanter can be seen. The final result (Ill. 2c) was a shortening of 3 centimeters.

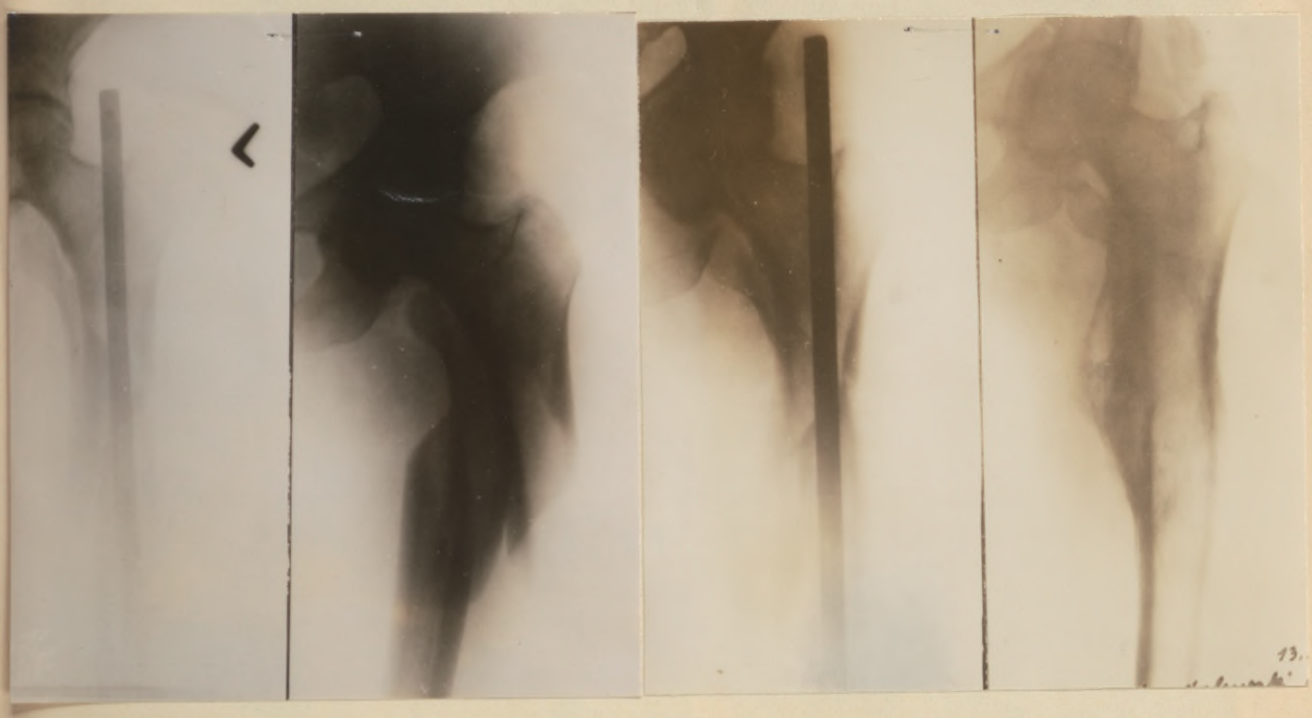
A shortening will not occur in any case in which the nail is inserted in the proper axial direction if the fragments are not pressed together and if the bone is not subjected to weight bearing too early. All these experiences had to be made first. When for the first time such a fracture was subjected to weight bearing a fortnight later the X-ray control revealed that the nail had moved in the upward direction out of the trochanter and thus a shortening of 1 centimeter had occurred. (Ill. 3).

We cannot agree with BOEHLER that spiral fractures in the upper third should not be nailed but treated with the wire extension "because they cannot be kept in place by the nail alone (1)". Illustration 4 shows such a fracture which was healed in good position without any shortening and without additional wire extension.

The only thing to be taken into consideration is that the fracture must not bear weight too early and that in fractures in the upper areas the nail must be inserted medially from the trochanter major. Only in this way does it get sufficient hold and it cannot work its way out of the bone laterally.

The shortening of 2 centimeters in a spiral fracture in the central shaft which showed a long splinter broken off (Ill. 5) was caused by the insertion of the nail into the distal fragment and in this way the bone ends were pressed together. This circumstance was not observed during the X-ray control after the operation because of the good general condition of the fracture. (Unfortunately, this picture was lost). Because of the fact that only after seven weeks post-operative was the limb subjected to weight bearing, a further shortening was avoided.

It seems to be unsuitable to use an additional wire extension or nail extension in cases of fractures with long spiral splinters or in cases of double fractures as recommended by BOEHLER. In applying his principles we would lose the great advantages the marrow nail operation grants us. It is only necessary to use nails which are long enough and which must be driven into the spongiosa of the distal epiphysis. It must always be kept in mind that this osteosynthesis is only "relatively stabile".



b a c d

Illustration 3a

Pertrochanteric spiral fracture with separation of the tro- chanter minor caused by streetcar accident of a 68 year old woman. This picture was taken five days following injury. Wire extension, followed by marrow nailing.

Illustration 3b

Same fracture after the nailing. Very good position. The separated piece with the trochanter minor is in good po- sition. The patient got up 2 weeks later.

Illustration 3c

Same fracture 4 weeks later. Under the influence of the weight bearing the fragments were firmly pressed together, shortening of 1 centimeter, the nail has slipped out of the trochanter above, because it jammed in the marrow cavity of the distal fragment. The nail was inserted medially to the trochanter (and not through it), therefore a lateral displa- ment ot curvature was avoided. The patient was able to lea the hospital 32 days p.op. and to do all kinds of house work The nail was extracted 5 months p.op.

Illustration 3d

9 months, p.op.,4 months after the removal of the nail. Healing in perfect position with a shortenig of 1 centimete The nail bed is not visible anymore. At the upper part of the trochanter a little callus head is observed. All joints are freely movable and pains are not encountered any- more.

Illustration 4

Subtrochanteric spiral fracture with separated third fragment 22 weeks after the nailing. No shortening, all joints are freely movable. After the nailing confinement to bed for 5 weeks. After that the limb was subjected to weight bearing. 9½ weeks p.op. the patient was released from the hospital as fit for service.

Illustration 5

Healed long spiral fracture in the middle of the shaft with a separated spiral splinter. The shortening amounts to 2 centimeters. The picture taken after the operation (which was lost) shows the same position of the fragments. It was not observed that the fracture had become shorter, probably during the insertion of the nail into the distal fragment (counter pressure from the direction of the knee). A further shortening did not occur because the limb was subjected to weight bearing only seven weeks p.op. In fractures of this kind the fragments must not be pressed together, it might even be necessary to diminish the counter pressure during the insertion of the nail so that the nail may push that fragment back to the former position.

In the beginning the nail finds sufficient hold in the spongiosa of the knee-joint- epiphysis so that the joint may either be moved or even bear weight. Under the strain of the rhythmic weight bearing the spongiosa spicules are absorbed very soon (4-6 weeks later) and probably even small chips break off the ends of the fragments. Thus the nail looses its hold. If in such a case the bone is subjected to weight bearing, shortening or bending will occur because the fracture callus is not yet strong enough. Its value is decreased by the constant bending and even a resorption in the vicinity of the fracture slot or a fracture of the nail may occur (see Ill. 7).

From the clinical point of view the danger of displacement is quite noticeable by the fact that the patients complain about pains even in those cases in which their fractures were subjected to painless weight bearing previously. Special attention must be attached to this fact and such a patient must be confined to bed again. X-ray controls repeated in short intervals are urgently required. Any bending that occurs must be counteracted and an additional cast is required. Shortenings must be corrected under anaesthesia by means of extension and after that a wire extension must be applied. If a shortening or a bending does not exist or if movements even without weight bearing are painful a "zinc" (Unna's paste) bandage according to the traction method will suffice. Therefore special attention must be given to those cases. By doing so even serious comminuted fractures may come to a healing in good position without having to use a wire extension from the very beginning. (Ill. 6).

Distally located spiral fractures were not nailed anymore because in two cases an additional wire extension was required besides the nail. In those fractures a nailing is not indicated. If the right technique is applied those fractures will come to a good healing with wire extension alone.

Table I demonstrates the exact data of the treatment.

Table I. Time required for the treatment and results with the marrow nailing of fresh simple thigh fractures.

	Number	Period of hospitaliz.	Unfitness for serv.	Final results I	II	III
Hospital	71	145 (64-248)	198 (74-263)	66	3	2
Civilian hospital	47	55 (19-98)	109 (30-171)	44	2	-
Total	118	108 (19-248)	162 (30-263)	111 =94%	5 =4,3%	2 =1,7%

b a

Illustration 6a

Comminuted thigh fracture after the nailing. The nail jams in the marrow cavity of the distal fragment. Th. osteosynthesis is stabile. The limb was subjected to active exercise 6 days later during the confinement to bed and 6 weeks later it was subjected to weight bearing.

Illustration 6b

Same fracture 17 weeks p.op. after the removal of the nail. All joints are freely movable, no shortening. The unfitness for service lasted 137 days.

I. Healing without shortening, curvature or impediment of the joints.

II. Slight curvature, shortening or impediment of the joints (decrease of ability to earn a living less than 20%).

III. Marked shortening, curvature or impediment of the joints (decrease of ability to earn a living amounts from 20-50%).

It is remarkable that the unfitness for service of soldiers treated in military hospitals lasts much longer than in civilians. It must be kept in mind, however, that our patients cases originate from eleven military hospitals and several surgeons participated in only two to three nailing operations. It is a matter of course that these surgeons wanted to observe the patients as long as possible. Patients treated in civilian hospitals, however, could easily be observed even after their release from the hospital, and thus it was possible to permit them resume their work.

Our data nearly correspond to those of FISCHER and MAATZ (1) (length of time required for the treatment in the hospital: 58 days, unfitness for work: 170 days.).

In table II we see the results obtained by BOEHLER (conservative treatment).

Table II. Duration of treatment and results obtained in cases of conservative treatment of fresh simple thigh fractures (according to BOEHLER).

	Average Time of treatment days	Missed working days	Permanent annuities based on % disability
Pat. treated in emergency hospitals	240	627	10,2
other than emergency hospitals	390	1819	22,6

It must be admitted that in the cases mentioned above we have not to deal with the same kind of fractures, for, the material of BOEHLER includes distally located fractures which were not nailed by us. It is a matter of fact, however, that even the longest period of medical attendance in marrow nailings is not longer than the average duration of treatment in the emergency hospital. The longest period of incapacity for work is only one third of what it is with conservative treatment in BOEHLER's clinic, which in this connection is one of the best. In this way the great advantages of this method - also from the economic point of view - are demonstrated. On the other hand the nursing of the patient is much easier and all those who have ever

had a chance to observe the strain which is taken from the patient when, in most cases even one day after the operation, the patients are lying in bed without any pains and soon may move the limb or even may subject it to weight bearing, will understand that the physicians as well as the nursing personnel and the patients are enthusiastic about this method and that under the influence of this enthusiasm the indications were sometimes too widely extended.

As demonstrated in the table above many of our patients were employed at hard labor sometimes as early as 5-7 weeks later. This may be done even if the fracture has not yet come to bony healing because the very strong thigh nail provides sufficient support in all suitable fractures. The patient must, however, be kept under permanent control, for, even in fresh fractures the marrow nail may break (1). If in such a case the patient consults a physician not acquainted with this method, such a physician may fail to extract the nail immediately and replace it with a new nail.

A 20 year old parachutist suffered a closed transverse thigh fracture in the middle from a jump. This was immediately nailed. Ten days later he was able to get up without pains and was released from the hospital 8 weeks later. 11 days after that when carrying a sack weighing a hundredweight he suffered from pains at the fracture site. Despite this fact he continued walking but his thigh is somewhat bent at the fracture site. Therefore, he was sent to a military hospital where a plaster cast was applied for a period of six weeks. After that he was transferred to a special department of the hospital in order to have his nail removed. (December 1944). Now, the fracture has come to a bony healing in a slight varus position (Ill. 7). An extraction hook so long that it could be pushed forward to the end of the nail tip was not available. The bending, however, was not so pronounced that an osteotomy with another nailing would have been indicated. Therefore only the upper part of the nail was removed and the patient was released from the hospital because of the general conditions of war. After that we lost sight of him but most recently we learned that he is in good condition. It has not yet been possible to examine him again.

Late curvature or shortening in cases of thigh fractures - besides the above mentioned cases - were not observed especially not after the release from the hospital. Most of our nailing operations (98) were in fact stabile and only in those cases were the patient granted an early release from the hospital.

Fractures less than 7 centimeters distant from the knee joint were not nailed in our hospital. Operations of this kind, however, were tried three times in military hospitals but in all cases great difficulties were encountered. Two of the patients

Illustration 7

Fracture of the callus and of the nail 10 weeks after the operation due to carrying heavy loads of 50 kilograms. The osteosynthesis was not absolutely stable because the nail was not inserted medially to the trochanter but through it and the nail head was lying in the bone. Around the nail head rarefactions of the bone which proved that the nail was "working". The callus is of little use. It is cloudy and cannot take the strain which it is subjected to because of the movements at the fracture cleft. Instead of removing the nail immediately and counteracting the curvature a plaster cast was applied for a period of six weeks until the fracture was healed again.

died and in the third case we declined to perform the nailing operation and the patient was treated with a wire extension which made a good healing possible.

Fractures of that kind and spiral fractures in the lower third with a long spiral splinter are considered to be unsuitable for the marrow nail operation. Physicians not well acquainted with the technique of the wire extension and who are not able to bring the fracture into a good position by this extension will probably not be able to perform a nailing operation without an exposure of the fracture site. Even if this process can be carried through successfully an additional wire extension is required and therefore the advantage obtained is not so great.

If by applying a wire extension satisfactory results cannot be obtained and consequently the fracture site must be exposed in such a case the fracture pieces should be united by putting a wire round the fracture pieces (in spirale fractures) or by applying a LANE's plate (in transverse fractures) which will grant better results than the marrow nail. The nail can never find sufficient hold in the distal fragment and the protection against displacement is less than by an osteosynthesis with wire and plate. If an infection occurs, however, the nail will cause an infection of the entire marrow cavity and of the knee joint which may lead to a fatal termination or to the loss of the affected limb.

b) Leg fractures

A final healing was obtained in 162 out of 171 cases of nailed leg fractures and the results obtained are demonstrated by table III.

Table III. Duration of treatment and result obtained by a marrow nailing operation of fresh simple leg fractures.

	No.	Duration of stay in hosp.	Duration of serv.disab.	Final result I	II	III
Mil. Hospital	97	122 (30-220)	141 (92-245)	86	10	1
Civilian Hospital	65	67 (18-183)	131 (71-235)	63	2	-
Total	162	102 (18-220)	133 (71-245)	149 =92%	12 = 7,4%	1 = 0,6%

I. Healing without any shortening, curvature or impediment of the joints.

II. Slight curvature, shortening or impediment of the joint is less than 10%

III. Marked shortening, curvature or impediment of the joints 20-50%.

Also in these cases the time required for the treatment in civilian hospitals is considerably shorter than in military hospitals due to the above mentioned reasons. The duration of service disability, however, does not differ so much.

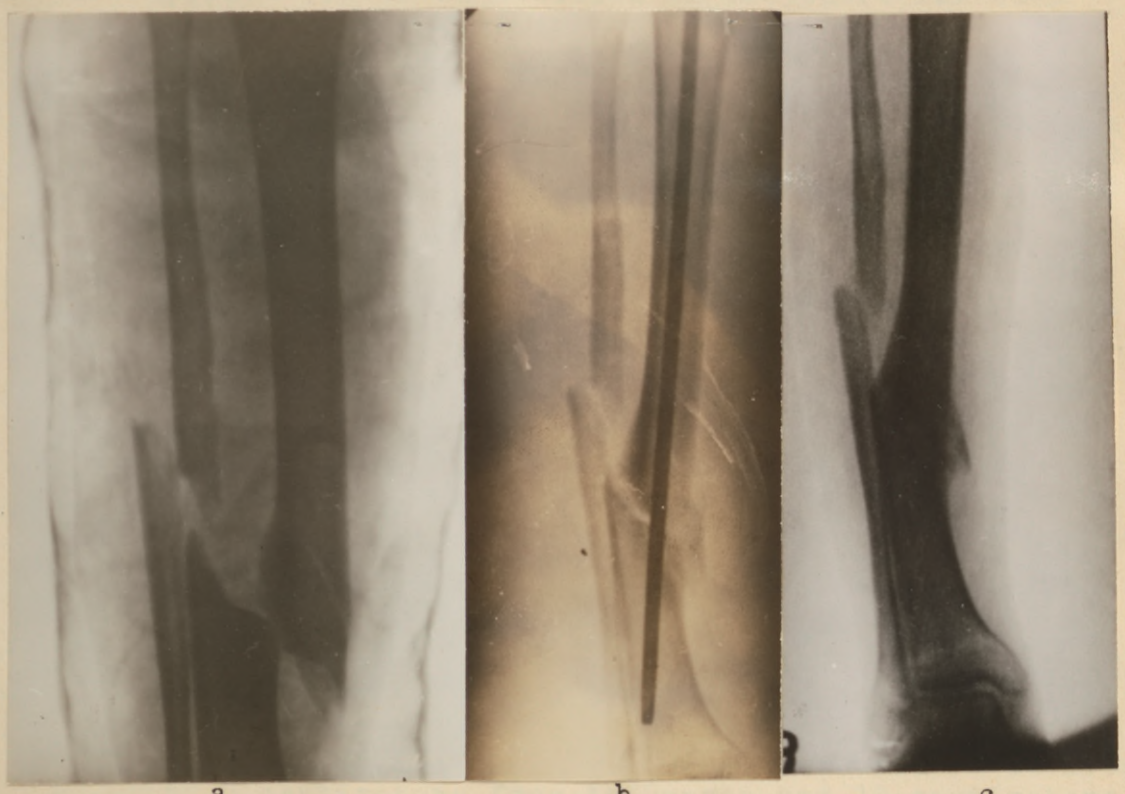
Comparable statistics for the conservative treatment are not available. The kind and duration of treatment of the different types of fractures differ considerably, (transverse and spiral fractures etc.) and according to the extent of the displacement all varieties are possible. Even favorably located transverse fractures require an additional wire traction for about three to four weeks. Patients treated with a marrow nail, however, may be released from the hospital two or three weeks later and the wire extension will in no case be required. As to the incapacity for working WOEHLER estimates a time of about 3 - 6 months which certainly will not be required by the marrow nail method. BOEHLER (1) has proved that in most simple fractures of the leg an unimpaired healing can be obtained with a conservative treatment by expert application. Three years after the treatment 85,26% of his 346 patients no longer received any pension. In comparison to that, an absolutely satisfactory healing obtained in 92% of the cases must be considered as a real progress. In this connection it must be borne in mind that in none of the cases marked as II. (Table III) would the patients have received a permanent pension (i.e. 20% reduction of earning one's own living).

In all these cases we have to deal with slight valgus positions or slight recurvations without impairment of the joints or slight shortenings of less than 1 centimeter.

On the other hand it must be taken into consideration that the material published by BOEHLER was gathered in a clinic which is well-known for its great experience and the good results obtained.

Our own two unsatisfactory cases originated from the very first time when the marrow nail was still inserted laterally from the tuberositas tibiae. In this way a recurvation is avoided, but in oblique fractures a slight valgus position may occur especially in case of an early weight bearing. Both of the patients were compulsory members of the sick fund and did not receive any pensions.

In comparison to the above cases the case demonstrated by Ill. 8 must be considered a bad result which,



a b c

Illustration 8a

Simple oblique fracture of the leg in the cast.

Illustration 8b

Same fracture after the nailing. Technical mistakes: The nail is too thin and too short, the valgus position was not corrected. An infection of the nail insertion site occurs which, because of the instabile osteosynthesis spread to the fracture cleft later (the nail acting as a drain.

Illustration 8c

Despite a long lasting treatment in the plaster cast the valgus position is somewhat increased.

however, is not due to the method but to the technique applied. In this case only one nail (the thin nail) was applied (which in addition is too short for such a distally located fracture), and the valgus position was not eliminated. Therefore the osteosynthesis was only relatively stabile and the valgus position increased later on. Besides all that an infection occurred at the point of insertion of the nail and at the fracture cleft and that is why an additional plaster cast had to be applied. The bone was subjected to weight bearing after a good formation of callus. When studying the picture with the plaster cast before the nailing it must be admitted that the physician would better not have nailed this fracture.

For comparable purposes Ill. 9 shows a similar fracture. In this case a long double nail was applied and a healing in perfect position achieved.

With one exception (slight recurvation which was not counteracted (2)) the osteosynthesis was only relatively stabile in all cases which did not show satisfactory results. Considering the shape of the marrow cavity of the tibia and the necessity to use only curved nails only a few cases may be considered as "suitable" when bearing in mind that a stabile osteosynthesis should be obtained by the double nail (transverse fractures located at least 8 centimeters from the upper and 10 centimeters from the lower ends of the tibia, furthermore oblique fractures and spiral fractures in the central third). Therefore KUENTSCHER and MAATZ have constructed double nails which spread in the distal end of the tibia and thereby obtain sufficient hold also in distally located spiral fractures and green stick fractures (turn-spread-nails, nails with an inclined plane). One disadvantageous fact, however, must be taken into consideration: A special nail is required for each fracture and sufficient quantities of nails were not and are not yet available. Due to this fact very little experience was gathered with these nails so that we are not in a position to give a final evaluation concerning these special types of nails.

In case of distally located spiral fractures and oblique fractures, best results are obtained with the simple double nail. First condition, however, is that the nails are long enough, so that they may find sufficient hold in the spongiosa of the distal fragment. In this case it must be taken into consideration, however, that the osteosynthesis is only relatively stabile and that early weight bearing is not indicated. If necessary a plaster cast or a U-splint must be applied as an additional protection for the fracture.

In 16 cases of leg fractures with a relatively stabile osteosynthesis which were treated in my civilian practice the period of stay in the hospital came up to 23 to 183 days or 77 days on an average and the inability for work came to 68 to 196 days, i.e. 134 days on an average. When considering those figures it must be said that a considerable gain is obtained in comparison to the treatment with the traction method. This is demonstrated

a b

Illustration 9a

Fracture of the same kind after a technically correct nailing with a sufficiently long double nail. The osteosynthesis is only relatively stabile therefore a short cast was applied for 4 weeks. After that a moulded splint was applied with which the limb is subjected to weight bearing. The splint is removed 14 days later. 8 weeks p.op. the patient was released to his unit.

Illustration 9b

4 months p.op. after the removal of the nail. Complete restoration. Treatment in the hospital and time of unfitness for service amounted to 74 days.

by Illustration 10-12.

As in all cases of bone fractures the nailing of distally located or complicated leg fractures requires technical understanding and skill. From the technical point of view the nailing of leg fractures is very simple. It is perhaps the simpliest nailing operation possible. There must, however, be taken into consideration that incidents may occur, which the physician must know in order to avoid failures(1).

In cases of proximally located fractures the nail may slip behind the distal fragment if it is inserted too steeply and too distally (Ill. 13). In such a case the fracture must be brought into an anticurved position. Contrary to this the nail tip may slip behind the distal fragment in distally located fractures, if an anticurvation exists. In such a case a recurvation may be successful. In conformity with the "categoric imperative of the fracture treatment" it may be said: "The distal fragment must be brought into that direction in which the nail tip points".

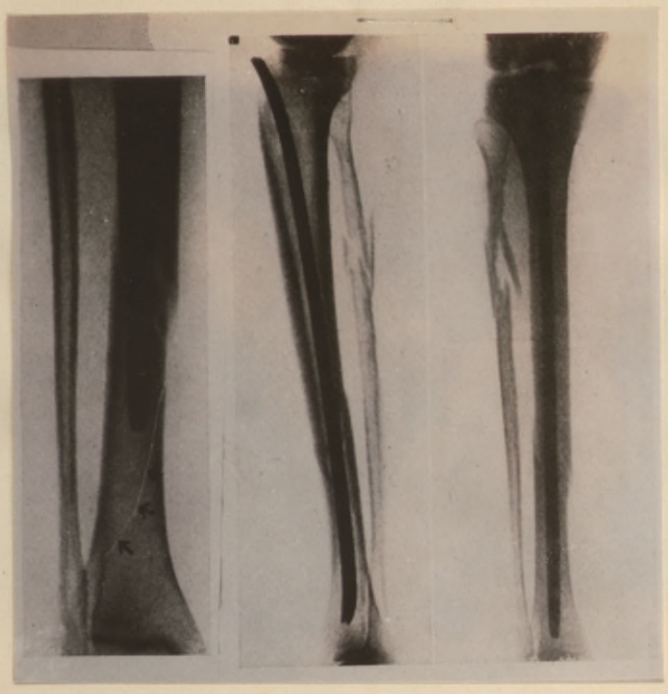
In one case the nail jammed in the corticalis of the distal fragment so much that it was impossible either to drive it in completely or to extract it. The surgeon reacted in the right way. He pinched the nail off and applied a plaster cast until a healing was obtained. After that the nail could be removed easily.

If the situation is so complicated that it is impossible to open the fracture during the operation it seems not to be advisable to apply a marrow nail. The danger of infection is imminent and increases during needless and long lasting attempt. Therefore in such a case conservative treatment will show better results.

Nevertheless only in rare cases of leg fractures will difficulties arise during the operation. They must, however, be expected during the after treatment because in leg fractures the osteosynthesis can never be as stabile as in thigh fractures.

In the case of the greenstick fracture demonstrated by Ill. 14 the fragment which had turned 180° was expected to slip back so that it would not endanger the skin anymore. Despite the fact that the skin above the fracture site was extended due to a slight valgus position which intentionally was not counteracted, a skin necrosis occurred 4 days later. Therefore the fragment which was not covered by periosteum anymore was removed. After that the plaster cast was applied, because the osteosynthesis was only relatively stabile. The valgus position was not counteracted which could have been done easily. (result II was avoidable).

In the case of the comminuted fracture demonstrated by Ill. 15a the fracture was absolutely stabile after the nailing. Therefore a U-splint was applied and the fracture was subjected to weight bearing two weeks later. In spite of the fact that the patient complained about pains at the



a

b

Illustration 10a

Spiral fracture of the leg with a fissure of the distal fragment extending in the downward direction, during and after the end of the nailing operation. The limb is subjected to painless weight bearing 19 days later with an adhesive bandage. The patient is released from the hospital three weeks after the injury.

Illustration 10b

Three months after the operation, after the removal of the nail. All joints are freely movable.

Illustration 11a

Spiral fracture of the leg with a long third fragment in a 16 year old apprentice clerk. The fracture is only slightly displaced because the periosteal tube is not damaged.

b c

Illustration 11b

Same fracture 16 days after the nailing.

Illustration 11c

Same patient same day: the damaged right leg is absolutely stabile and freely movable. Release from the hospital. From the third day on the leg was subjected to active exercise and on the 11th day the patient got up.

d

Illustration 11d

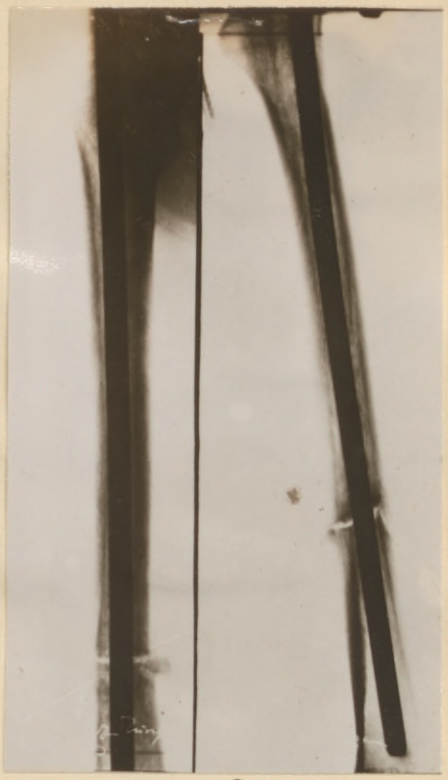
6 weeks p.op. Good formation of callus. Patient does hard labor. 8 days later serious hematoma in the right leg due to a sudden fall. The fracture was not harmed.

e

Illustration 11e

10 weeks p.op. The fracture healed, the nail going to be removed. Extraordinarily strong formation of callus extending from far above the fracture site to far below, which is not due to the nail but to the separation of the undamaged periosteal tube which probably granted additional support. No rarefactions in the vicinity of the nail tip, i.e., the nails have not "worked".

a



a

Illustration 12a

Double fracture of the leg with simultaneous fracture of the same thigh eight weeks after nailing. The patient got up on the 29th day p.op. with the plaster cast in place till the end of the 8th week p.op. Despite the fact that the formation of callus is very poor, the patient is able to subject his leg to painless weight bearing. The leg nail is removed 3½ months p.op., 14 days later the thigh nail is removed.

b

Illustration 12b

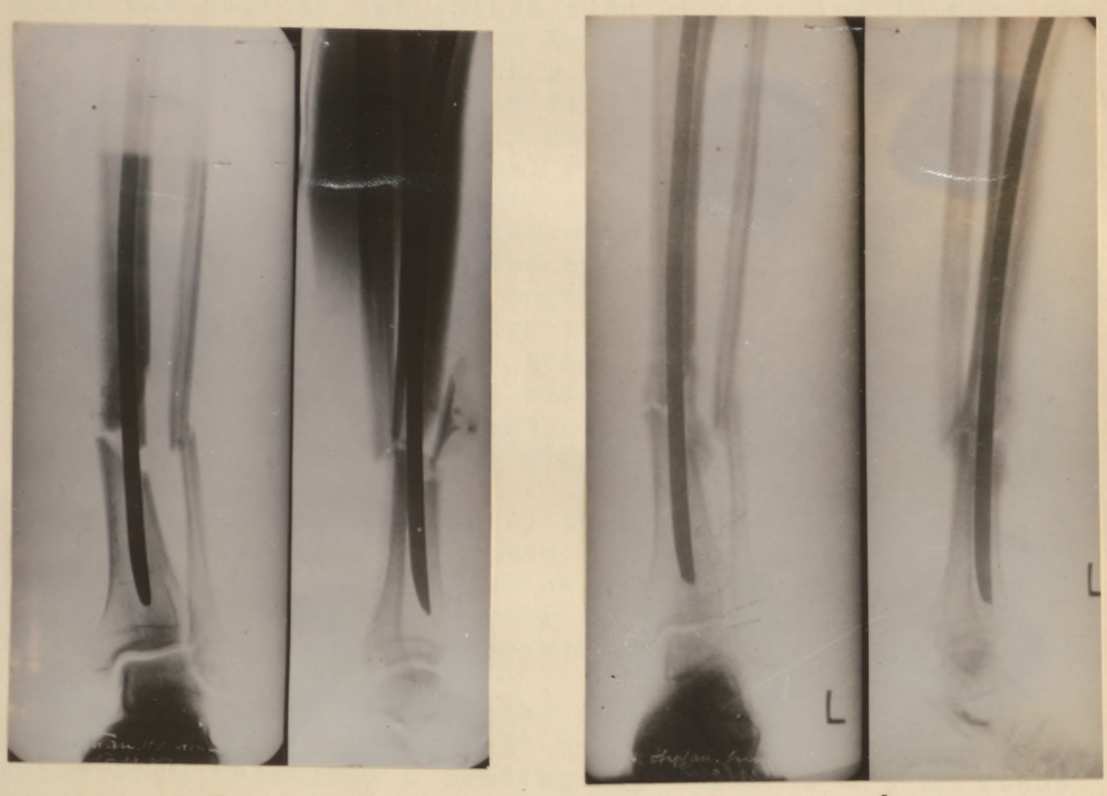
The fractures after the removal of the nails. Negligible impairment of the ankle joint which did not exist anymore 12 weeks later when a follow up examination took place. During the operation the leg was nailed first and then the thigh.

Illustration 12b

(Second part. Explanation see page 13c.)

Illustration 13

The nail slipped behind the distal fragment in this proximally seated leg fracture which is due to the fact that it was inserted distally from the tuberositas. The fracture is not sufficiently enough distracted and should have been brought into an anti-curvature position.



a b

Illustration 14

a) Greenstick fracture after the nailing. The third fragment is turned round 180°. Slight valgus position which was not corrected because otherwise the skin would have been under tension above the separated fragment. Nevertheless a necrosis of the skin was observed 4 days later. Excision of the necrosis and removal of the bone splinter which was not covered with periost. It was forgotten to counteract the valgus position (!). Primary healing.

b) Same fracture 3½ months later. The defect is well bridged over with callus. Four weeks after the nailing the patient subjected his leg to weight bearing with an ambulatory cast. The patient has been without a cast for 6 weeks. The nails will be removed.

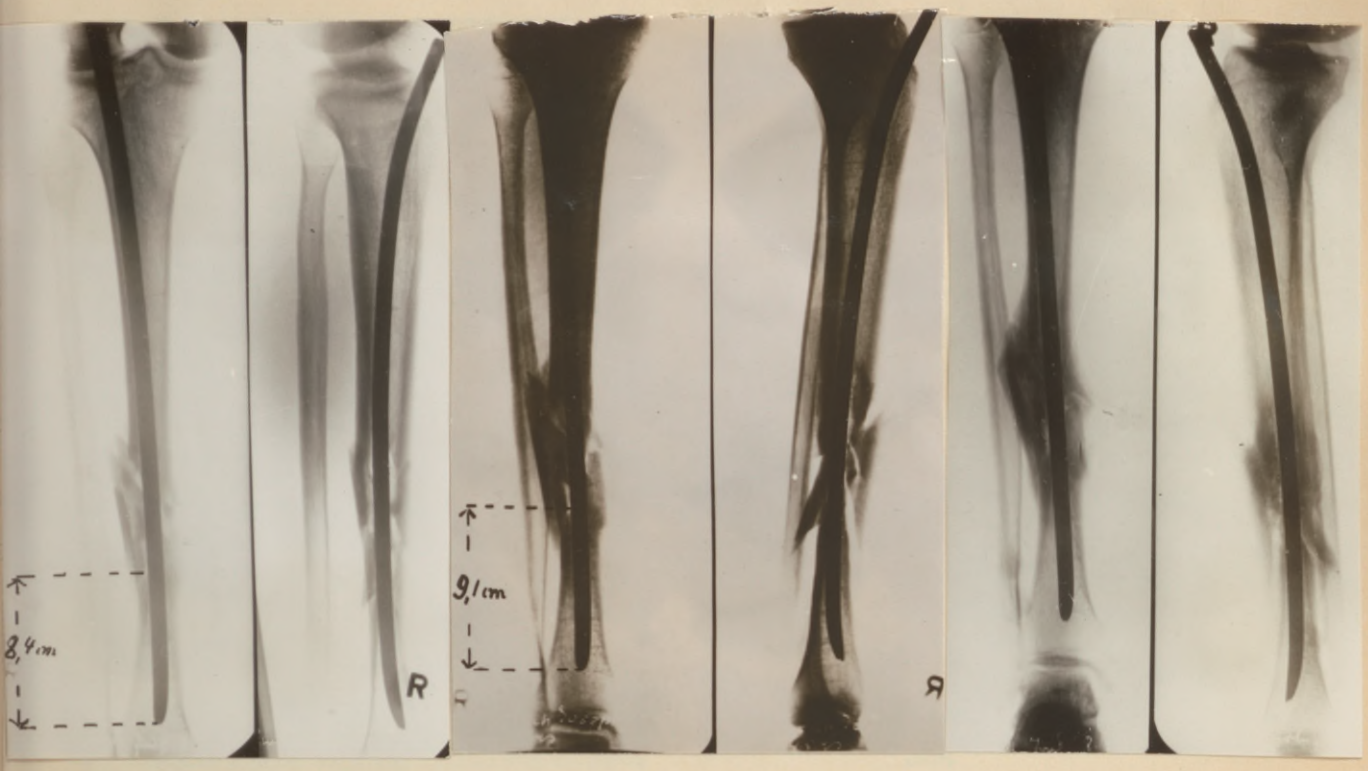
fracture site weight bearing was continued. 8 days later the patient complained also about pains in the knee joint and therefore an X-ray (Ill. 15b) was taken in order to determine whether the already very far protracting nail had worked its way out of this fragment. Unfortunately it was not observed that a shortening had occurred. The final result (Ill. 15c) is a shortening of three quarters of a centimeter. The nail had moved into the spongiosa of the distal fragment because it had jammed in the corticalis of the proximal fragment . From the very beginning it would have been better in this case to drive it in more deeply and to subject the limb to weight bearing only after some time and if so only with a plaster cast. The pains complained about during the process of weight bearing should have been a warning signal.

In case of a proximally located fracture the nail moves in the upward direction during the compression process and may cause troubles as demonstrated by Ill. 16. Due to negligence in this case the bone ends were not compressed after the operation.

If in proximally located fractures the fibula is intact the compression will be hindered and even in transverse fractures a bending may occur if the fracture is subjected to early weight bearing (Ill. 17). The smooth bone spicules of the spongiosa and the very thin corticalis cannot stand the constant slight pressure. They are resorbed and the nail begins to"wander" which may be distinctly detected by the rarefactions in the vicinity of the nail head end (Ill. 17c).

In cases in which the osteosynthesis seems to be stabile in the very beginning and the fractures may be subjected to weight bearing without difficulties, nails which are too short may cause a blocking of the freshly healed fibula and in this way may lead to disturbances of the formation of callus.

Despite the fact that in a transverse leg fracture near the junction of the middle and distal third the nails were too short and the fracture was not compressed (Ill. 18a) the patient was given permission to rise after a lapse of two weeks. "He had, however, to use crutches in order to examine to which extent the fracture could be subjected to weight bearing". 8 days later an X-ray was taken and it was observed that a lateral displacement of the fragments had occurred six weeks later the patient could walk without a stick and therefore was released from the hospital to do garrison duty. In the X-ray a good formation of callus was observed at the fibula and tibia, the slight valgus position, however, was not noticed (Ill. 18b). 3 months later he was sent back to the hospital because of increasing pains at the fracture site and edema of the leg. The X-ray showed a healed fibula and cloudy callus on the tibia with formation of flanges and the fracture slot remained open. Clinically a distinct springiness of the bones is observed, i.e. an unhealed fracture. In the vicinity of the nail tip a rarefaction of the bones is observed which proves that the nails are not at rest. Therefore the nails must



a b c

Illustration 15

a) Spiral fracture of the leg with a marked splitting of the tibia after the nailing in good position. The nail length is correct but it was not inserted deeply enough. Therefore, the osteosynthesis is only "relatively stabile". Nevertheless, the limb is subjected to weight bearing with the U-splint 14 days later. The patient suffered pains at the fracture cleft.

b) Apart from this the patient complains about pains when bending the knee joint. Therefore, 3 weeks p.op., an X-ray is taken which proves that the nail did not move in the upward direction. It was not observed, however that the fracture had become somewhat shorter in the distal fragment due to the moving of the nail in the downward direction. Therefore, the patient was permitted to continue subjecting the limb to weight bearing. 14 days later the U-splint was removed.

c) Three months p.op. the fracture comes to a bony healing. The shortening amounts to 3/4 of a centimeter. The nail has moved further in the downward direction.

a b

Illustration 16

a) Oblique fracture in the upper third of the leg after the nailing. The position is good, the fracture cleft is gaping. 10 days later the patient starts subjecting the limb to weight bearing. A very short time later he complains about pains when bending the knee joint.

b) Eight weeks later: Due to the effect of the weight bearing the fragments were firmly pressed together. Consequently the nail which was jamming in the distal marrow cavity moved in the upward direction.

a b

Illustration 17

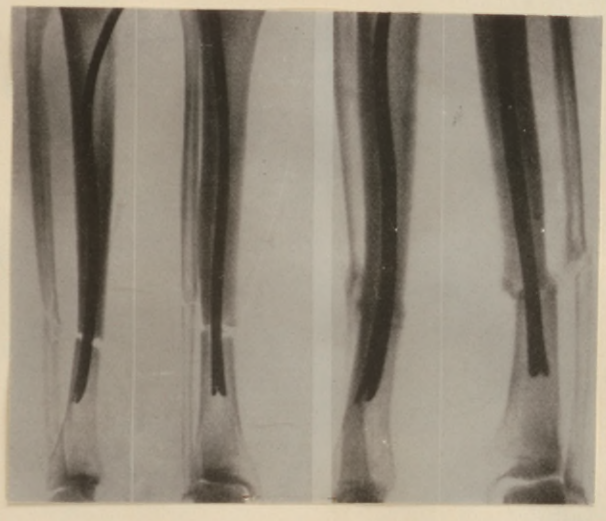
a) Proximally located transverse fracture of the tibia after the nailing. 14 days p.op. the limb is subjected to weight bearing without any additional bandage. The patient complains about "slight pains at the fracture cleft when stepping on the foot".

b) Five weeks later: "still existing distinct limping and moderate disturbances of the circulation of the leg. Distinct formation of callus. (The valgus position which had developed in the meantime was not observed). Zinc-gelatin bandage and plenty of active exercise". 14 days later the patient went on leave. After that removal of the zinc gelatin bandage, physiotherapy and half-day labor.

c

Illustration 17c

Three months p.op. Healed under a slight increase of the valgus position. The rarefactions of the bone prove that the nail had moved.



a b

Illustration 18

a) Transverse fracture of the leg at the junction of the distal and middle thirds after the nailing. The fragments were not pressed together. The nails are too short.

b) Six weeks after the nailing the limb which was not protected by a plaster cast was subjected to weight bearing too early. Due to this fact the fragments were pressed together but at the same time they came into a valgus position (which was not observed). Distinct formation of callus. Patient released to the unit for garrison duty.

c

Illustration 18c

Three months later: The fibula has come to a healing. A slit running through the cloudy callus of the tibia is observ Rarefactions round the nail tip. From the clinical point of view the fracture is spring ing. Pains and edemas. Extraction of the nails, oblique osteotomea of the fibula, BECK's drilling. Plaster cast, Secretion of the drilling woun for 14 days. Once again the varus position is not corrected

Illustration 18d

After a lapse of three further months an ambulatory cast is attached. The fracture came to a bony healing. It would have been better to leave the nails in place and to resect the fibula and to correct the varus position.

d

be removed and the fibula separated obliquely. After that multiple drilling must be accomplished according to the principles of BECK during which BECK's wire must not "cut itself free and get very warm". A plaster cast is required. A serous hemorrhagic secretion is ejected from the drill hole for a period of 14 days, a serious infection, however, does not occur. A bony healing is achieved three months later after an ambulatory cast was applied (Ill. 18d). The removal of the nail as well as the drilling according to BECK's principles was not necessary, the latter causing only an increase of the danger of infection. If in this case a piece of bone 2 centimeters long had been resected from the fibula and if the varus position had been compensated, which could have been accomplished easily, the patient would have been taken care of better.

In case of an early healed fibula and delayed formation of callus the physician should not hesitate to resect the fibula (not only to separate) and to apply a plaster cast. In this case the nails are kept in place. Even if they are too short they grant an additional support and the fracture will soon come to a bony healing. (Ill. 19).

In leg fractures it will hardly be possible to determine whether the osteosynthesis is stabile enough to make weight bearing possible. This is contrary to findings in thigh fractures (See Ill. 9 and 10, which by no means, seem to be stabile). If there is any doubt, however, as to the stability of the fracture with regard to the X-ray and the special kind of fracture it will be better to apply an additional plaster cast. It is a matter of course that edema is alway a symptom of an insufficient stability. According to my own experience the only sure criterion is the subjective statement of the patient. If the patient complains about pains something must be wrong even if an additional plaster cast was applied. This is demonstrated by the following example:

Ill. 20a shows a spiral fracture in the lower third. The nails applied were relatively short. After the application of a small ambulatory cast the fracture was subjected to painless weight bearing 8 days after the operation. A displacement did not occur. 4 weeks after the operation the patient was released from the hospital and given ambulatory treatment with a plaster cast in place. 10 weeks after the operation the fracture was clinically healed. The formation of callus observed in the X-ray, however, is not yet strong enough (Ill. 20b). Therefore the nails were not removed. The fracture was subjected to weight bearing without a cast and 8 days later the patient started working. 6 months after the operation the fracture was bridged over by good callus (Ill. 20c) and subsequently the nails were extracted. Minor rarefaction about the nail tips proved that the nails were somewhat loose.

a

Illustration 19 a b

a) Fracture of the leg with fracture of both ankle bones. It is not possible to get the fragments into the right position because of the fracture of the ankle bone. Therefore the surgeon decides to nail the fracture using the open method. Primary healing. Plaster cast, 14 days later application of a U-splint with which, three weeks p.op., the limb is subjected to weight bearing. 12 weeks p.op., removal of the u-splint. The fracture of the ankle bone came to a healing. Massage and gymnastics. Three weeks later the patient suffers pains and redness at the insertion site. After a confinement to bed for eight days these symptoms disappeared.

b) 3 months p.op., the fibula is healed. The fracture cleft of the tibia is gaping. The skin above the fracture site is flushed and distinctly warmer than the surrounding skin. Resection of the fibula and application of a U-splint.

c

Illustration 19c

5 weeks later the fracture is bridged over with bone and is stabile. The nail is removed. Fractures of this kind are better treated conservatively because of the danger of infection if the closed nailing is not successful.

a

Illustration 20a

Spiral fracture of the leg after the nailing in a 50 year old woman. The nails are rather short; they should have been of such a length that they reached the epiphyseal line. Nevertheless the patient was able to subject the limb to painless weight bearing 8 days later with a short walking cast. She was released from the hospital 4 weeks later for ambulatory treatment.

b

c

Illustration 20 b + c

b) Same fracture 10 weeks later. The fragments were firmly pressed together by the weight bearing and angulation did not occur. The callus is not yet stabile enough and therefore the nail is kept in place. Weight bearing without the plaster cast. The patient resumed her work 8 days later in a factory.

c) 10 months after the nailing the fracture is healed and a good formation of callus is observed. The nail may be removed. Slight rarefactions surrounding the nail tip prove that the nail has become somewhat loose.

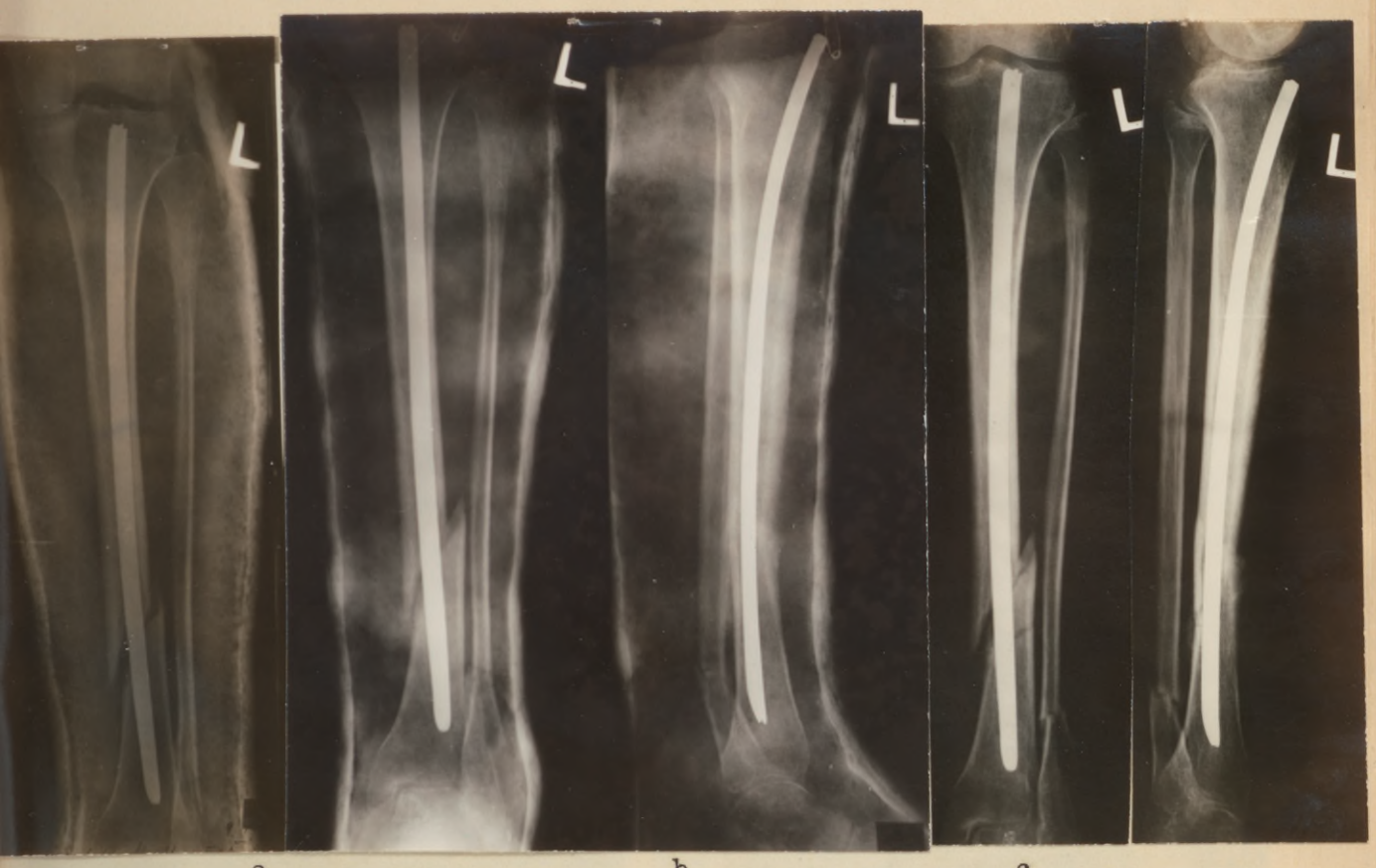
Ill. 21a shows a similar fracture of another patient who in the first weight bearing with a walking cast complained about pains at the fracture site. After a temporary observation she was considered hypersensitive. 14 days later the X-ray revealed a slight valgus position which was counteracted by the plaster cast during its repair. The patient was confined to bed for a period of 8 days and after that the bone was subjected to weight bearing. Once again her complaining about pains was not taken seriously and three weeks later the fracture had slipped into the former valgus position and a slight curvature was observed. (Ill. 21b). Once again the position was corrected and then the patient was kept in bed with a cast. Three months after the operation the X-ray (Ill. 21c) shows a beginning formation of callus. At the same time it was observed that the bone of the distal fragment was somewhat poor in calcium. From then on the patient did not complain about pains anymore and because of the terror air raids she was released from the hospital. 8 weeks later the ambulatory cast was removed by the family-doctor. 6½ months after the nailing the patient came to see us. The examination revealed that the fracture had come to a bony healing in valgus position (Ill. 21d). The patient testified that in the first weeks after the removal of the cast she had suffered from pains and edema.

Therefore one should not trust so much in the nail. On the contrary all warning symptoms well-known from the conservative treatment of bone fractures should be observed.

KUENTSCHER and MAATZ (1) write in their publication on the marrow nail operations: " It is useless to insert a nail in a fracture of the tibia so far that the point of the nail gets a hold in the distal spongy portion of the bone. This hold is negligible and unreliable."

In their explanation they point out that a tissue (and also a bone) which is subjected to a rhythmic pressure reacts with absorption at the spot of impact. This is certainly true, but, if in a leg fracture the nail is inserted deeply enough, i.e., if it is driven in as far as near the epiphysis this hold will suffice to stabilize the fracture so much that the patient may expose the broken limb and the fracture will come to a bony healing before the resorption begins.

This is proven by the spiral fracture demonstrated by Ill. 22a in which the fracture cleft extends considerably in the downward direction. The patient used the broken limb without any additional cast 10 days after the operation without encountering pains and 4 weeks after the operation he started working. Ill. 22b which was taken three months after the operation does not show any rarefactions in the vicinity of the nail point. This proves that the nail had forged a stabile union with the bone. Thus it must be concluded that the deeper insertion of the nail saves us the trouble of using the more complicated leg nails.



a b c

Illustration 21
a + b + c

a) About the same fracture as in Ill. 20 aft r the nailing with the cast in place in a 58 year old woman. Also in this case the nail should have been longer. She was allowed up after eight days with a walking cast. She complained about pains which were not given any consideration. An X-ray, taken two weeks later, proved that the fracture was angulated which was immediately corrected. Confinement to bed for one week, after that, weight bearing. Once again the patient complained about pains at the fracture site.

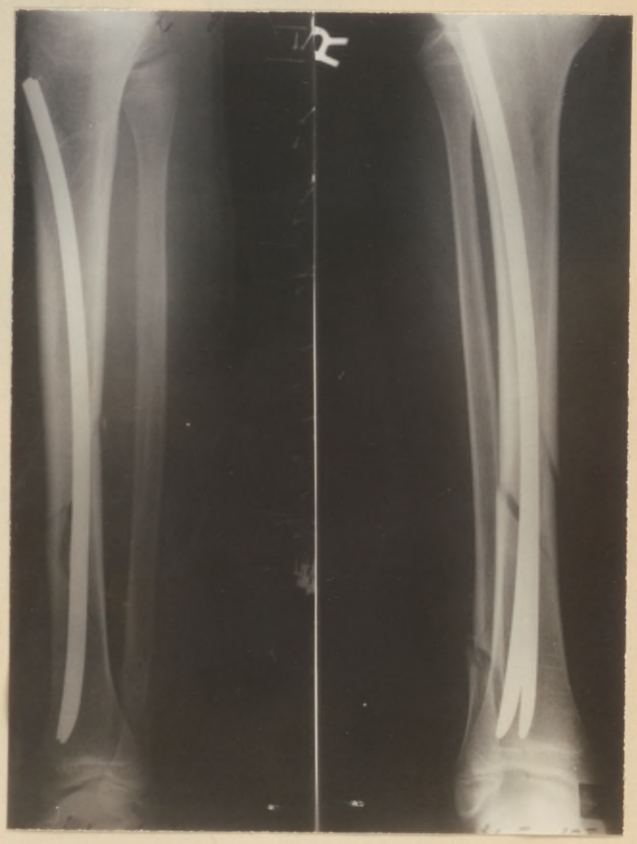
b) 9 weeks p.op. The fragments have slipped in the cast and a slight recurvature in a valgus position is observed. This position of the bones is corrected by wedge shaped excisions of the cast.

c) 3 months p.op. Beginning formation of callus. The fracture is somewhat shorter and a slight lateral displacement is observed. The axial direction, however, is correct. Painless weight bearing with the cast. Release from the hospital.

d

Illustration 21d

6½ months p.op. The fracture healed with a slight recurvature in valgus position. Five weeks after the release from the hospital the cast is removed by the family doctor. In spite of the fact that the patient suffers pains when walking another cast was not applied.



a

Illustration 22a

Spiral fracture of the leg which extends far into the distal third. The nails extend to the vicinity of the epiphysis. They are somewhat spread but not to such an extent as spread nails so that they could find sufficient hold in the corticalis. Patient starts subjecting the limb to painless weight bearing 10 days p.op., without any additional cast and resumes hard labor 4 weeks p.op.

Illustration 22b

Same fracture 3 months p.op., which came to a bony h aling. No rarefactions round the nail tip. The strong formation of callus on the bent side is not stimulated callus but due to the periosteal separation.

We never were obliged to apply an additional wire traction. Even in spiral fractures in which the nails are too short and too thin the fragments will not shift in the cast if an early weight bearing is avoided (Ill. 23).

According to my own experience, made in 21 cases of such fractures, the isolated shaft fractures of the tibia are particularly suitable to the nailing operation. Fractures of that kind, particularly transverse fractures, take a very long time to heal in case of conservative treatment (according to BOEHLER eventually 1-2 years). They show the tendency to heal in faulty position because of the blocking effect of the fibula. With the marrow nailing, however, a quick and unimpaired formation of callus is obtained and the employability is quickly restored (Ill. 24). These fractures may and must be exposed early so that a good compression of the fracture is obtained. This is especially true as to the isolated tibia fractures in the distal third, in which, however, the nail must be driven into the vicinity of the epiphyseal line (Ill. 25).

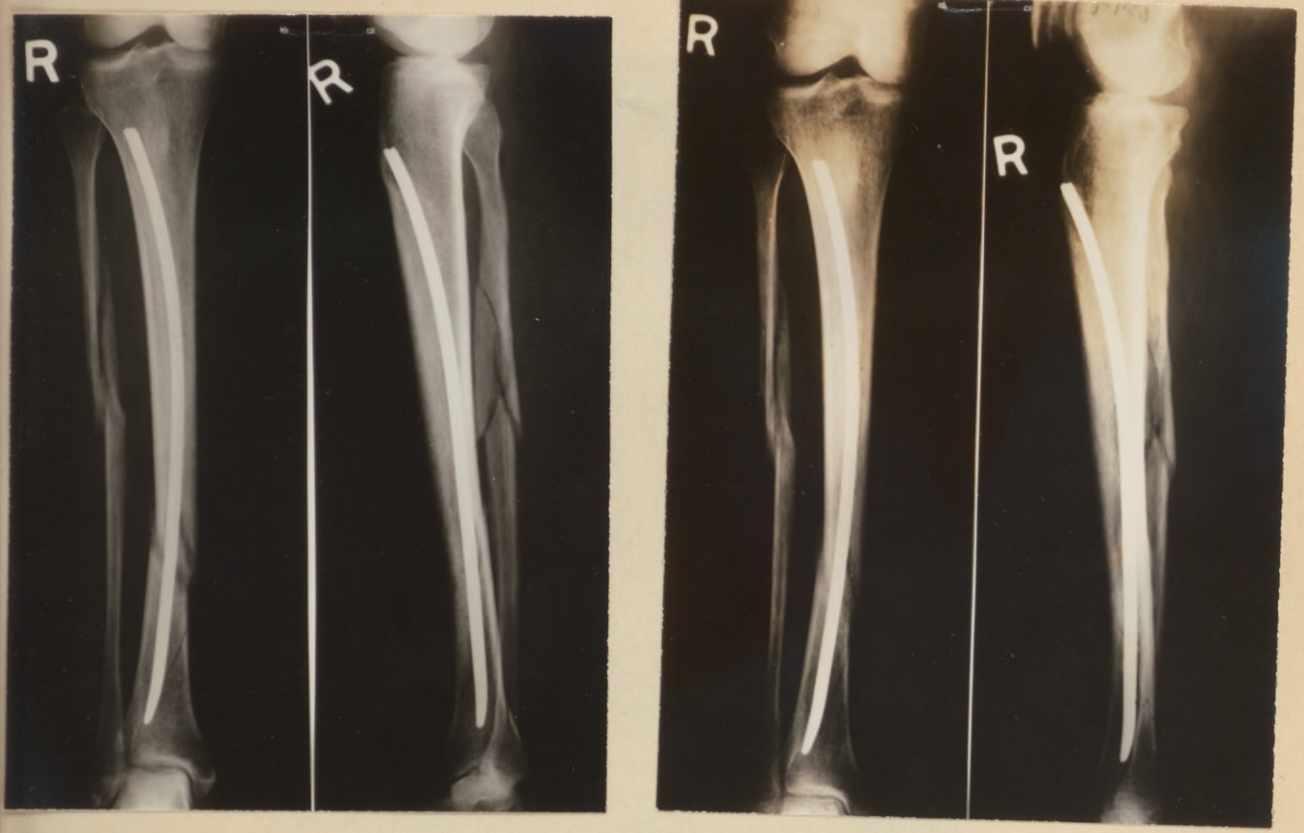
The statement of RAISCH (1) that fractures of that kind are unsuitable for the marrow nail operation "because the fibula acts as a blocking bone, which effect is accentuated when getting up with the nail" must certainly be rejected. In the case mentioned by him the nail is too short and too thin. Therefore the nail is useless and consequently we must not be surprised that in this case the formation of callus is as bad as without the nail.

With regard to my own experience I cannot agree with BOEHLER's restrictions (second edition of this publication) as to the nailing of fresh simple leg fractures. On the contrary our indication is rather extended, for, the operation is simple from the technical point of view and it does by no means cause an additional strain upon the patient. Those physicians, however, who do not know the fundamental laws of treating bone fractures should not be allowed to make use of the marrow nail operation. Such a physician will not achieve good results even in case of a conservative treatment. All this may be proved by the records of the cooperative associations (insurance companies).

Fractures in the Arm above the Elbow

131 cases of a total of 141 cases of nailed fresh fractures in the arm above the elbow could be studied as to their course until healing was achieved. The duration of the treatment and the results achieved are demonstrated by Table IV.

Table IV. Duration of treatment and results achieved by marrow nailings of fresh simple upper arm fractures.



a b

Illustration 23

a) Spiral fracture of the leg in a 40 year old woman 8 weeks after the nailing. Despite the fact that a thin nail was used which extended to only one centimeter beyond the spiral fracture the patient was able to subject the limb to painless weight bearing with the cast in place and was released from the hospital for ambulatory treatment. The nail was inserted laterally from the tuberositas tibiae and consequently the slight varus position occurred.

b) 5 months p.op., the fracture is bridged over by bone and the nail is removed. A walking cast was applied for 3 months. After that the patient was able to subject the limb to painless weight bearing.

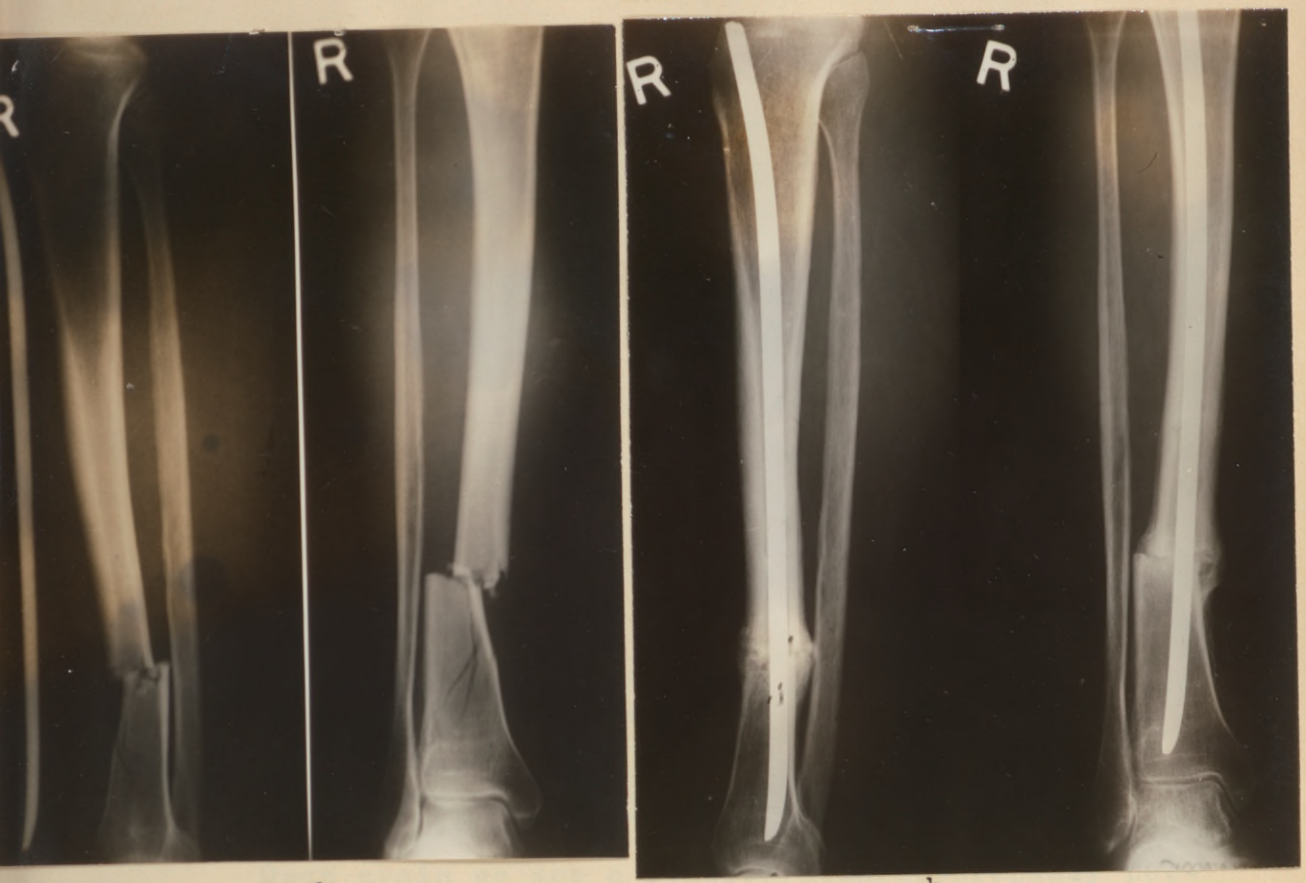
a b c

Illustration 24

a) Isolated greenstick fracture of the tibia in a 40 year old soldier after the nailing. Clinically the fracture is stabile but the fracture cleft is still somewhat gaping, despite the fact that the fragments were pressed together. Patient starts subjecting the limb to weight bearing without any cast 6 days later.

b) 14 days p.op. The fragments were firmly pressed together by weight bearing. 5 weeks p.op., patient released from the hospital as "fit for service" except for assignment requiring marching.

c) 15 weeks p.op. the fracture is bridged over by bone. The nail will be removed.



a b

Illustration 25

a) Isolated fracture of the tibia in a 52 year old workman with oblique fissures in the distal fragment.

b) Same fracture 16 weeks after the nailing bridged over by bone. The nail will be removed. On the fifth day p.op. the patient started subjecting the limb to weight bearing. He was released from the hospital on the 26th day. He resumed working on the 46th day.

	Nr.	Time required for the Treatment in the hospital	Restoration of employab.	Final results I	II	III
Hospital	78	108 (38-238)	177 (93-346)	76	2	0
Civ.Hosp.	53	41 (14-115)	78 (43-183)	52	0	1
Total	131	78 (14-238)	112 (43-346)	128 = 97,7%	2 = 1,5%	1 = 0,8%

I. Healing without any shortening, curvature or impediment of the joints.

II. Slight curvature, shortening, or impediment of the joints (decrease of employability of less than 20%)

III. Marked shortening, curvature or impediment of the joints, (decrease of employability from 20 up to 50%)

Once again we see a considerable discrepancy between the duration of treatment in civilian hospitals and military hospitals. This discrepancy may be explained by the same facts mentioned before.

Comparable statistics as to the duration of the conservative treatment are not available. The kind of employability as well as the stay in the hospital is not substantially shorter on an average. If necessary, however, fractures in the arm above the elbow may be treated as ambulatory patients. There is no doubt, however, as to the great advantage that in general an abduction bandage is not required. As to our own patients it must be taken for granted that in fact an early employability was obtained.

The results obtained are by all means better: BOEHLER (1) has observed that 82% of the patients treated in emergency hospitals and 22.2% of the cases treated as ambulatory patients did not receive any annuities after three years. In all the cases treated in our own hospital only one patient got an annuity of 20%.

In this case our first nailing of a fracture in the arm above the elbow was performed. An infection at the nail insertion site occurred but it did not cause any general reaction. Later on, however, it caused the formation of sequestra, also in the fracture site because the osteosynthesis was not stabile enough. Consequently an impediment of 20% in extension and a slight impediment of rotation of the forearm occurred.

In the case which showed result II we had to deal with a transverse fracture in the upper third. After the nailing the fracture was in good condition from above but the nail was inserted too far distally and it was bent laterally (Ill. 26a). Therefore it did not find

a

a

Illustration 26a

Transverse fracture of the arm above the elbow in the upper third after the nailing. Satisfactory position of the fragments. The nail was inserted too far distally. The only hold the nail finds in the marrow cavity which extends in the upward direction is the thin corticalis of the insertion site. The hole drilled in there by means of an awl is in most cases larger than the diameter of the nail.

b

Illustration 26b

Same fracture 3½ months later with a typical angulation in the direction to the extensive side. Fracture is healed laterally. The limb was subjected to some active exercise on the sixth day. Consequently the fracture came to a displacement until the nail finds sufficient hold on the opposite corticalis. The nail should have been inserted somewhat more proximally and its bending should have been stronger, so that it might find some hold on the opposite corticalis (correct position of the nail). Otherwise such fractures must be nailed distally and the nail be driven into the spongiosa of the head.

sufficient hold in the proximal fragment (in the arm above the elbow the marrow cavity extends to the vicinity of the surgical neck). This condition was not observed and consequently the patient subjected the limb to wqight bearing six days later. An X-ray was taken 8 days later because the patient had suffered from pains and because a "diffuse swelling of the arm above the elbow" was observed. This X-ray showed that a lateral and backward angulation had occurred. An attempt to correct them under anaesthesia failed and thus the fracture healed in the described position (Ill. 26b). An impediment of the joints and of the limb was not observed.

Proximally located fractures require an insertion of the nail in the vicinity of the tuberculum majus. The nail should be bent at the head end so that it may jam at the corticalis of the opposite side as demonstrated by Ill. 26b (even if so done the osteosynthesis stays only relatively stabile and therefore early weight bearing must be avoided). The nail will never find sufficient hold at the insertion site. The hole in the bone was drilled with an awl and therefore it will always differ from the nail as to size and shape. Besides this the corticalis is so thin that it may break easily when the sharp edges of the nail cause a pressure on it (Ill. 29).

It is better to nail fractures of this kind from the distal end particularly in those cases in which the proximal fragment is shorter. In this way an opening of the hemorrhagic soft parts is avoided (increase of the danger of infection). The nails must be driven in beyond the line of growth into the head. In this case it is useful to insert the nail somewhat above the middle of the arm above the elbow (if the hematoma does not extend that far). The thicker nail gets a stronger curvature, the inner thin nail is bent at its point in the opposite direction. Thus it has the shape of an S. The nails spread (similar to the system of turn-spread nails)in the head and find sufficient hold there (Ill. 27a). The fracture must be strongly pressed together. If one forgets to do this the nail point may perforate the head (Ill. 27a). The nails jam so strongly in the distal fragment that they meet the least resistance in the spongiosa of the head end. If this perforation occurs outside the joint plane it is of no significance. An injury of the joint cartilage, however, would cause serious disturbances which are well-known in connection with the nailing of the neck of the femur. Therefore the nail must not be driven too closely to the joint plane.

For a long time fractures in the neck of the humerus were only exceptionally treated with the abduction splint and the traction bandage. After those fractures have been well set it will be possible to obtain such a strong jamming effect in most of the cases that 8-10 days later a DESAULT-bandage can be applied. After that the

a

Illustration 27

a) Fracture of the collum chirurgicum of the arm above the elbow in a 53 year old workman - after the nailing. The exterior nail got a stronger curvature, the inner nail was somewhat S-shaped at its top. In this way the nails spread in the head and find sufficient hold. The fracture cleft is still somewhat gaping. The arm is put in an arm sling for three days, after that it is subjected to active exercise. After a lapse of ten days the patient is released from the hospital for ambulatory treatment.

b) Same fracture 8 weeks later. Due to the exercise the fragments were pressed together. The nails are jamming in the marrow cavity of the distal fragment and consequently they worked themselves farther into the head. In doing so the outer nail has perforated the bone because it had been driven in rather deeply. Sliding along at the inner nail this nail has worked its way into the distal fragment. The inner nail, however, which had found a better hold stayed in its former position. The patient cannot take his arm up higher than 90° because of the irritating effect of the nail tip. Therefore, the nails are removed despite the fact that the callus seems not to be compact enough.

c) Same fracture 12 weeks p.op. The impediment of the shoulder joint has decreased and is only slight at this time. (Three months later no impediment at all).

limb may be subjected to movements. This kind of treatment is considered to be the most simple and well tolerated treatment possible. Therefore we do not want to nail those types of fractures on principle just like fractures of the neck of the femur. That is the reason why so far only three fractures of that kind were nailed because a jamming effect could not be attained. The experiences made so far are so good that we decided to prefer the nailing operation to the use of an abduction splint.

In the distal third of the humerus the marrow cavity is often narrower in the sagittal section than in the frontal section. The outer nail of the double nail is broader than higher at the point and therefore in such cases the front edge of the nail must lie in the frontal plane. This means that the nail must be inserted at the rear edge of the tuberculum majus at such an angle that the opening of the transverse section points to the bent side. Otherwise the nail may rotate or break. (Ill. 28).

The nail should project at the insertion site fore one centimeter at a minimum. If it is driven in too deeply it will not get sufficient hold at the insertion site and the weight of the arm will distract the fracture and the nail head will slip into the marrow cavity. In this way a stabilization does not exist anymore because the marrow cavity is very broad in the proximal fragment. When using the limb rhythmic waddling movements at the fracture site will occur and in this way the formation of callus will be disturbed (Ill. 29).

The patient suffered from a commotio and consequently was confined to bed for 4 weeks. An arm sling was not applied and movements of the limb were avoided. In this way a distraction was favored. When using the limb the patient constantly complained about pains which were considered to be due to the nail, for, in the vicinity of the nail head a distinct formation of spicules was observed in the X-ray. Unfortunately it was not observed that the formation of callus was absolutely insufficient. If the fracture pieces had been pressed firmly together and if a plaster cast had been applied with the fracture in abduction, the fracture would have come to a healing, even with the nail, and an angulation would have been avoided (Result II).

If the fracture is stabile after the nailing the arm must be held in an upward direction by means of a sling. The shoulder joint may be moved 3-4 days later, the elbow joint, however, only after a lapse of one week. The sling must be kept on for at least 14 days.

Motion should by no means cause any pains. The osteosynthesis must always be considered to be not sufficiently stabile if pains and swellings occur during or after the use of the limb. In such a case the arm must

a

b

c

Illustration 28 a + b + c

a) X-ray in order to determine the length of the nail in case of a transverse fracture of the arm above the elbow between the middle and the lower third. The nail is lying laterally and not at the extensor side. Consequently its distance from the film is smaller than that of the bone in the frontal picture. So we are deceived as to the relation of the nail to the marrow cavity, which in this case is particularly narrow. Besides this the nail was brought into a distal position whereas the operation must be made from the proximal side.

b) It was not observed that the marrow cavity was narrower in the frontal direction than in the sagittal direction. Consequently the nail was inserted with the front edge in lateral position (or: too far in front). In this way the nail cracked a piece of the bone on its flexor side. Due to the fact that the length of the nail(for purposes of the operation) was determined from the distal end it projected too much and consequently it had to be replaced by a shorter nail. It turned so much in the distal fragment that its diameter equals that of the marrow cavity. When inserting the nail into the distal marrow cavity the fracture had to be bent off in the direction of the angulation because the nail tip had left the guide wire in front. This angulation was corrected only after the complete insertion of the nail which had caused an additional angulation of the nail at the fracture side. In this way it was impossible to insert the thinner inner nail.

c) Same fracture 5 weeks after the nailing. Four weeks p.op., the arm could be subjected to painless manipulation. Due to a sudden strain the arm was subjected to, the nail cracked at the site of the fracture. (In the picture taken from in front the distortion is distinctly visible).

d

Illustration 28d

The broken nail is removed (the distal piece of the nail is extracted through a hole made into the bone above the fossa olecrani) where the new nail is immediately inserted distally. Now, the nail is lying in the correct plane and consequently both nails can be used without difficulty. The osteosynthesis is so stabile that ten days later the patient may do some exercise. Six weeks after the second operation the patient is released from the hospital as "fit for garrison duty". The nail was removed three months after the second operation.

a

Illustration 29a

Transverse fracture of the arm above the elbow 8 months after the proximal nailing which was made in another hospital. After the nailing the patient was confined to bed for 4 weeks without any bandage because of a commotio. After that the limb was subjected to some exercise for a long period of time which was harmful. Again and again the patient complained about pains when using the arm for a long period of time. From the clinical point of view the fracture appears to be stabile.

The nail head slipped into the bone and consequently did not find any hold there. The rarefactions in the X-ray prove that the nail is "working". The delayed formation of callus is due to the constant waddling movements at the fracture cleft. All this was not observed and therefore the nail was removed because of the irritated margins.

Illustration 29b

After the extraction of the nail a distinct springing (effect) was observed clinically. A slight bending occurred which was due to the firmly pressing together of the fragments. The fracture which was immobilized on an abduction splint healed in six weeks. The delayed formation of callus is not due to lues but to the instabile osteosynthesis.

be held by an abduction splint during daytime and motion exercises must be made as soon as painless movements are possible. In these motion exercises the bending of the elbow is especially valuable. Motion exercises by means of the pulley-traction method should be avoided because they favor a distraction of the fracture.

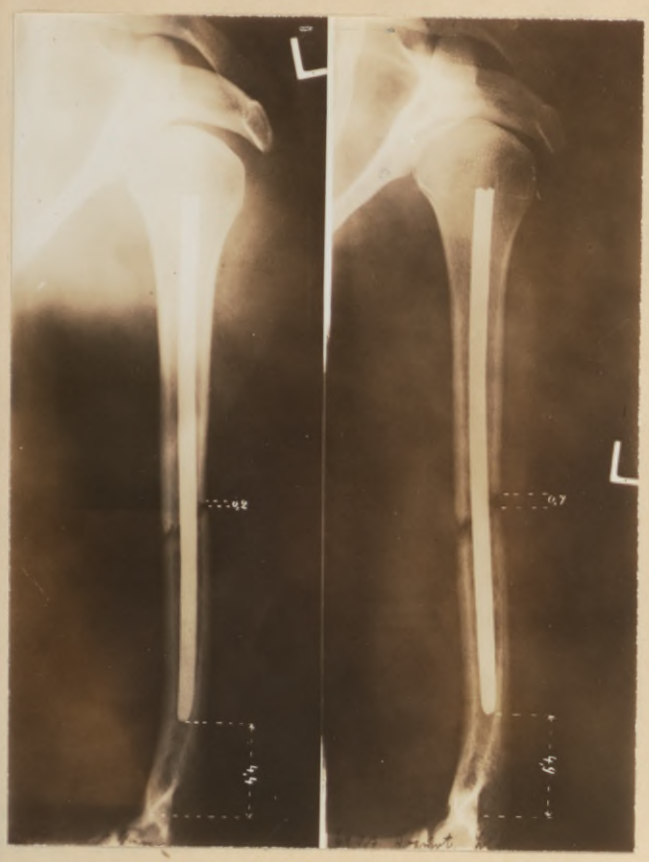
In case of an insertion from above the nail should be long enough and driven into the distal marrow cavity very firmly (strong counter-pressure from the elbow). It is not easy, however, to determine the exact length of the nail. The diameter of the distal marrow cavity must be measured thoroughly during the X-ray with the nail lying close to the bone (1). The diameters must be compared with one another and during the operation it must be taken care that the nail is lying in the proper plane. In doubtful cases it is better to insert the nail somewhat more distally from the tuberculum (if the fracture is suitable to this kind of treatment). If necessary the nail may stick out a little bit more and a harmful effect is not to be expected. This procedure is not so harmful as is too deep an insertion of the nail. (Ill. 30 and 31).

Spongy transverse spicules may permeate the marrow cavity (Ill. 32) so that the (blunt) nail cannot penetrate them. These spicules may not always be observed on the X-ray. If the fracture is in the distal third the nail does not get sufficient hold and complications of all kinds of an "instabile osteosynthesis" must be taken into consideration (late angulation, ball-callus and delayed formation of callus).

Therefore we nail fractures in the distal third from below (contrary to BOEHLER and KUENTSCHER). A possible exposure of hemorrhagically infiltrated soft parts seems to be less dangerous than the lack of stability (Ill. 33). Transverse spicules possibly hindering the insertion of the nail may be pierced by means of a drill awl or an electric drill.

If the marrow cavity is very narrow at the distal end the double nail may burst the bone (Ill.34). In such a case the only thing to do is to use a thinner nail. It must by all means be driven into the spongiosa of the head beyond the line of growth.

This is especially true as to fractures situated farther proximal. Beyond the junction of the middle and the lower thirds, the marrow cavity is considerably enlarged so that even a double nail may sometimes not find sufficient hold if it is not driven into the head. Otherwise disturbances of the formation of callus may occur (Ill. 35). In such cases an abduction splint should be used so the nailing treatment in comparison to the conservative treatment) is not considerably easier.

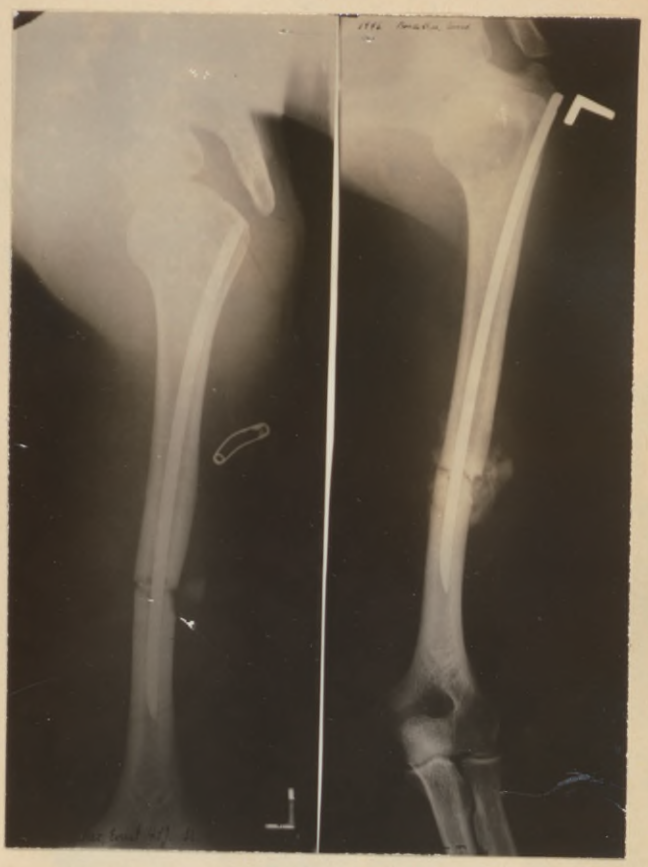


a b

Illustration 30

a) Transverse fracture of the arm above the elbow which was nailed proximally. The nail is too short. It does not find sufficient hold in the distal marrow cavity. Ten days later the patient starts subjecting the fracture to some exercise without the arm sling which cause pain.

b) Three weeks p.op. The fracture was distracted due to the weight of the arm. The distal fragment slipped from the nail. Consequently the arm was put on an abduction splint on which the elbow was movable. The splint was removed 4 weeks later and the patient could be released from the hospital. His employability has been restored after a lapse of eight weeks p.op. The nail was removed 4 months p.op.



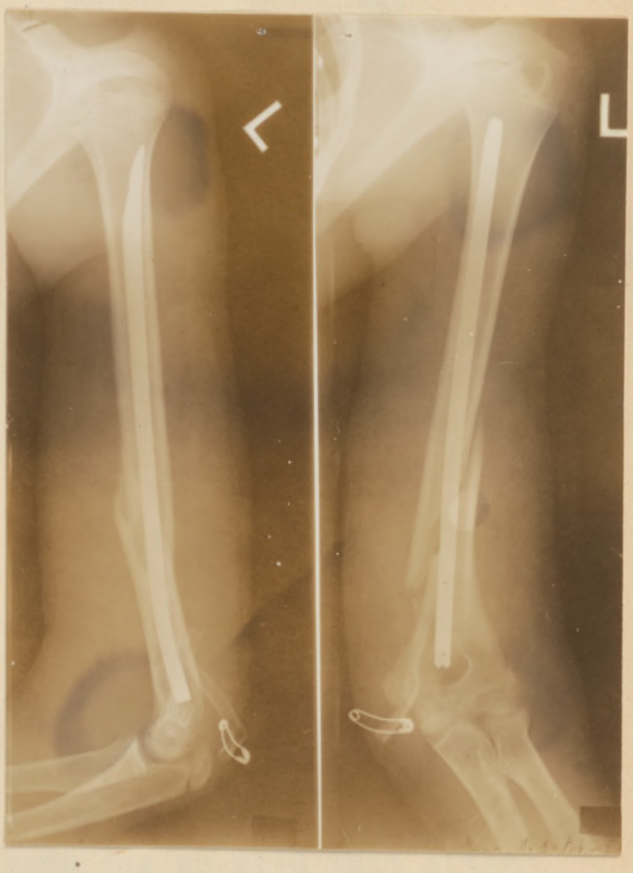
a b

Illustration 31

a) Transverse fracture of the same kind in a 41 year old workman. The nail jams in the distal fragment of the very narrow marrow cavity. It is impossible to insert it any further. The fracture cleft is somewhat gaping. The arm had to rest in an arm sling for eight days. After that the arm was subjected to some active exercise with the arm sling. Release from the hospital 3 weeks p.op.

b) Four weeks p.op. The fragments were pressed together by the strain put on the arm and consequently the nail moved upward and slipped somewhat out of the bone. The abduction is not hindered. Distinct formation of callus. The employability was restored 6 week p.op.

Illustration 32
The distal end of the marrow cavity shows a framework of spongy spicules which hinder a further insertion of the nail.



a

Illustration 33a

Spiral fracture of the arm just above the elbow after the distal insertion of the nail. The double nail found sufficient hold in the broad proximal marrow cavity. The drain to relieve the hematoma in the wound was removed 24 hours later. The arm was put into an arm sling for eight days and after that it was subjected to some exercise movements which did not cause the patient any harm. Release from the hospital 12 days p.op. Assumed working as an apprentice locksmith 3 weeks p.op.

Illustration 33b

Seven weeks p.op., the fracture is healed and the nail will be removed.

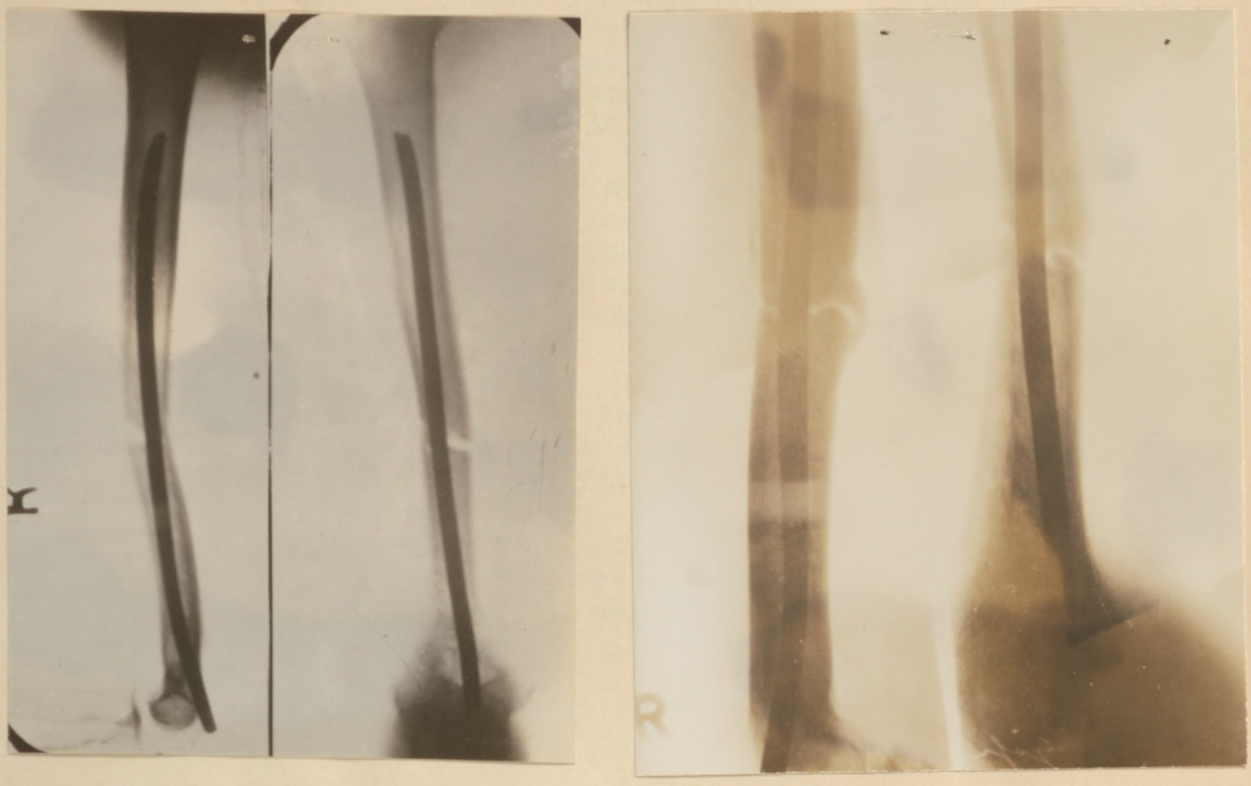
a

b

Illustration 34

a) Transverse fracture of the arm above the elbow in the middle third which was nailed distally without exposure of the fracture. The distal marrow cavity showed strong spicules which made it impossible to insert the thicker nail any further. At the insertion site a piece of the bone was split off. Therefore, we used only the thin nail which was driven into the spongiosa of the head. The hold the nail finds there was so good that after a lapse of eight days the limb could be subjected to some exercise movements, which were painless. The existing paralysis of the radialis was improving after a lapse of three weeks.

b) Same fracture 3 months after the nailing. The nail was removed. The paralysis of the radialis does not exist anymore 5 months p.op.



a b

Illustration 35

a) Fracture of about the same kind (without damage of the radialis) which was nailed distally with a double nail. At the fracture site the marrow cavity broadens so much that the nails do not find sufficient hold there. Besides this the nails are too short and consequently the osteosynthesis is not stabile. An abduction plaster cast must be applied. Only nine weeks after the operation could the limb be subjected to exercise movements.

b) 12 weeks p.op. The fracture cleft is wide open. Callus flanges may be observed which unite the bone ends to a slight extent. Only 18 weeks p.op. could the nail be extracted.

In one of the above chapters it was pointed out that a possible damage to the radial nerve is an indication for the exposure of the fracture. As demonstrated by Ill. 34 we are very cautious also in this respect. If after a thorough clinical and neurological examination it must be supposed that the possible damage may be compensated, the nerve should not be exposed at that time. If, however, the paralysis does not subside the exposure and an eventual nerve suture may still be done even if 6-8 weeks have already passed.

A primary injury of the radialis was observed five times which in 4 cases subsided after the closed marrow nailing. In the fifth case, six weeks after the nailing the nerve was exposed and successfully sutured. Contrary to the findings of HART(1) a jamming of the nerves between the fracture fragments was not observed and therefore it must be concluded that this does not often occur.

c) Fractures of the forearm

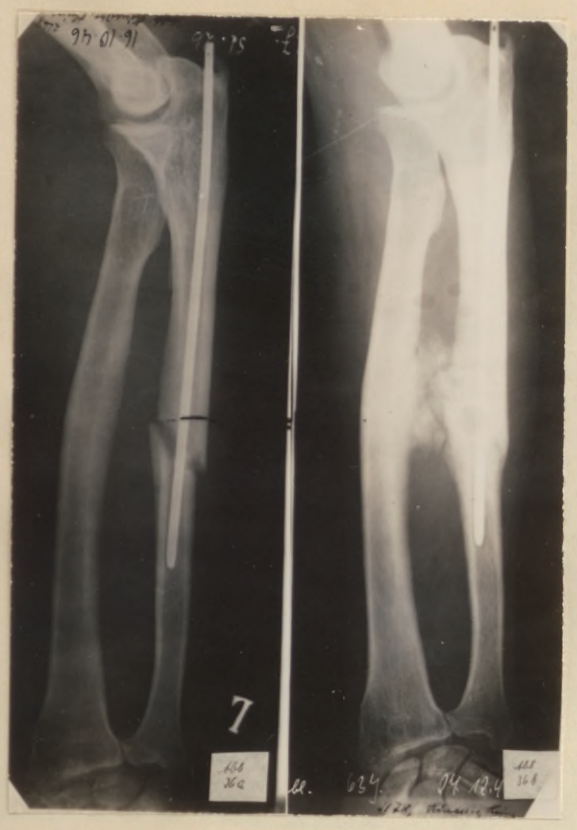
The course of 15 out of 18 cases of fresh closed fractures of the forearm was observed until a final healing was achieved. It is a matter of course that it is impossible to get final conclusions out of this small number of cases.

SCHNEIDER asserts that for anatomical reasons it is impossible to nail the ulna. This is incorrect, BOEHLER the clinic at Kiel and myself have always successfully nailed the ulna.

The isolated shaft fractures of the ulna seem to be especially suitable for the nailing operation. From the technical point of view the operation is not difficult and the straight ulna nail grants a true stabile osteosynthesis with good mechanical conditions for the formation of callus. With the conservative treatment, however, the fractures show a tendency to cause faulty positions or a delayed formation of callus because of the blocking effect of the radius.

Five out of seven uncomplicated ulna fractures came to a good healing and disturbances were not observed. 4-5 weeks later the patients were able to resume working. The fracture clefts, however, were quite visible for a relatively long period of time and consequently the nails were removed only 3-5 months later.

In two cases the nail was too short and consequently we observed either a formation of stimulated callus or a delayed formation of callus (Ill. 36 and 37).



a b

Illustration 36

a) Transverse fracture of the ulna after the nailing. Good position. The nail is too short. The patient started subjecting the limb to exercise movements 6 days p.op., 8 days later he was released from the hospital and after a lapse of three weeks he was able to do all kind of work.

b) 10 weeks p.op. It was not possible to obtain a stabile osteosynthesis with the nail. Constant movements at the fracture site which were due to this instabile osteosynthesis caused a bridging over by stimulated callus. Distinct rarefactions round the nail point has caused some erosion of the corticalis on the radial side. Due to the fact that the patient constantly uses the arm a slot occurred in the (bridge) callus so that the rotary movements are not hindered.

Illustration 37a

Jagged transverse fracture of the ulna after the nailing, by the open method because the operative reposition was not succeeful. The position is ideal but the nail is too short.

a

b

c

Illustration 37 b c

b) Four months p.op. The patient is able to use the arm and in doing so he does not suffer pains. Stimulated callus with formation of flanges which are not yet united, because of the constant movements of the fragments which are due to the instability of the fracture. Rarefactions round the nail tip which in the direction of the radius has nearly completely penetrated the corticalis. Periosteally we see here a new formation of bone.

c) 2½ months later. The fracture cleft is bridged over by bone. Now the nail point is firmly slated and consequently the rarefactions round the nail tip are less marked. The periosteally formed bone structure is much better now.

In one case we had to deal with a fracture which was complicated because of damages of the plexus and luxation of the radius head (Ill. 38a). Apart from this a transverse fracture of the other arm above the elbow had occurred which was nailed at the same time. The nail was sticking out of the bone considerably (Ill. 38b) and an inflammation at the insertion site had occurred which was due to an exposure of the limb four weeks after the operation. The physician failed to immobilize the arm or to remove the nail and thus an abscess appeared at the fracture site which had to be opened. When after a lapse of 10 weeks the nail was removed the wounds came to a quick healing and an infection of the marrow cavity or a formation of secuestra did not occur (Ill. 38c).

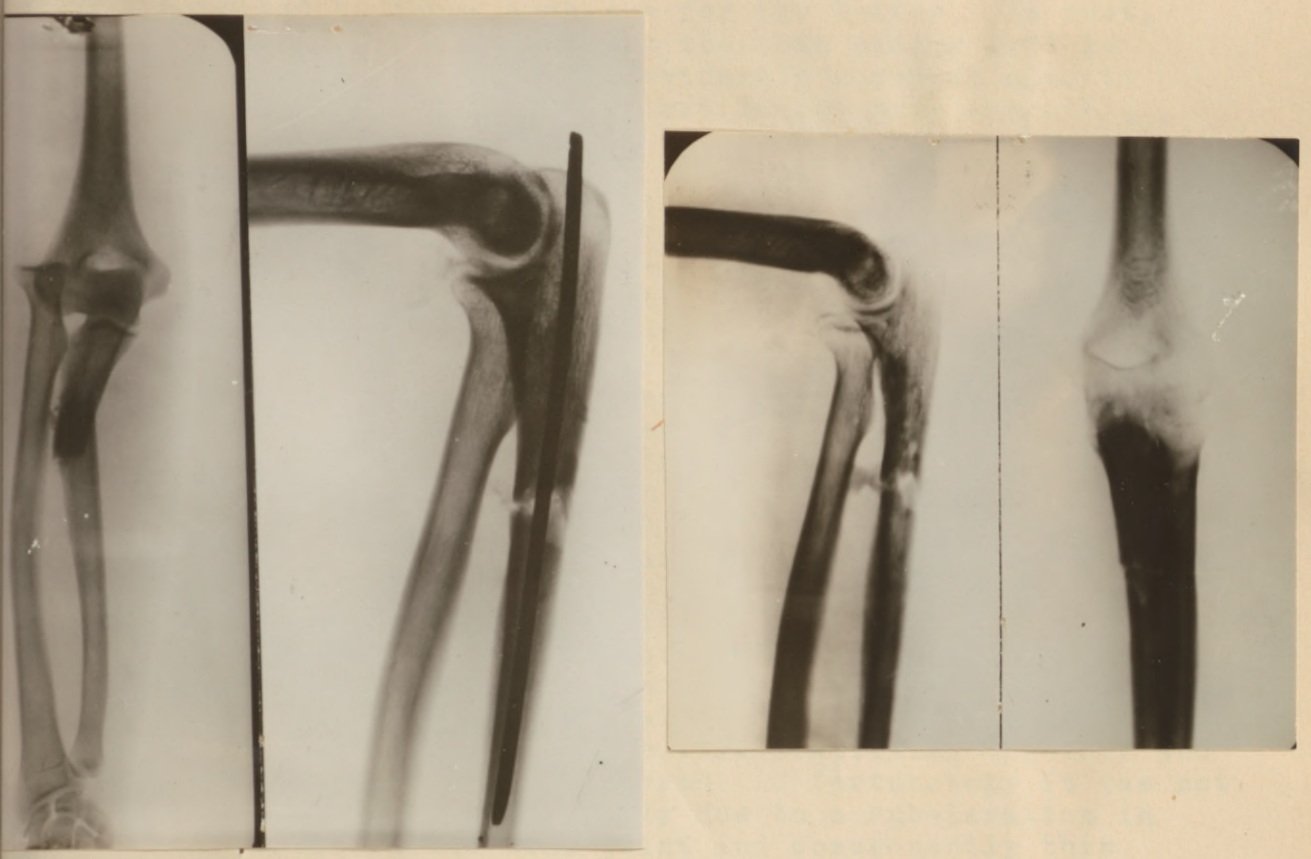
At the olecranon the nail may stick out 3 millimeters at the most and therefore it must be inserted up to the eye. If the nail is too long or if it jams in the distal fragment and consequently causes a widening of the fracture cleft the nail must be pinched off and the sectional area be smoothed by means of a file. If the patient suffers from pains at the insertion site because the nail was not inserted deeply enough or because the nail has worked its way out of the bone in such a case the arm must be immobilized in an extended position and the nail removed as soon as possible.

The nails should be as long as possible. Otherwise the fracture will not get sufficient hold. In the ulna which is relatively soft, the nail will soon get loose. If in such a case the nail is too short, rotation at the fracture cleft will occur and stimulated callus and delayed formation of callus etc. must be taken into consideration.

It seems to be unsuitable to use a simple piece of wire for the "nailing" operation. The wire is not strong enough to prevent lateral displacements of the fragments. If the marrow cavity is really too narrow or if a correspondingly thin nail is not available it will be better to treat the fracture conservatively or (especially in fractures in the upper third) to apply either a LANE's plate or a wire loop.

Due to mechanical conditions isolated shaft fractures of the radius also show a tendency to a delayed formation of callus.

An intact ulna will render it more difficult to bring the fragments accurately one upon the other. The conditions are more complicated if a physiological absorption of the ends of the fragments occurs. Even in the padded plaster cast (after a good reduction) movements of the limb are no sure help. In cases of that kind the ulna acts as a spring so that the fragments are not pressed together by the muscles but they are rather moved one against the other in a lateral direction. Therefore we have to deal with movements which are especially disadvantageous for the formation of callus. These movements cannot be completely compensated by means of the circular plaster cast because of the relatively thick pad of muscles. It is only possible to "buffer" them.



a b c

Illustration 38

a) Transverse fracture of the ulna with central luxation of the radius.

b) After the reposition and nailing of the ulna. At the olecranon the nail projects considerably. The patient begins subjecting the limb to some exercise after a lapse of ten days. Four weeks later an inflammation at the insertion site is observed. The fracture is not yet healed and consequently the nail is not removed, but, at the same time, the arm is also not immobilized. 3 weeks later an abscess at the fracture site is observed. Immobilization of the arm in a half flexed position.

c) 10 weeks p.op. The nail is removed. The wounds healed 10 days later. The limb is freely movable.

The introduction of the marrow nail method was expected to cause a change for the better. We must, however, keep in mind that the thin radius nail is not absolutely stiff but evidently somewhat elastic which was proved by our first marrow nail operation of that kind.

Within four weeks after the nailing the patient was able to move his arm freely. The fragments were not firmly pressed together, however, and the fracture slot seemed to be somewhat broader due to resorption. The patient assumed his former activities and complained about pains at the fracture site only when doing hard labor. Swelling did not occur and the fracture was clinically healed. X-ray pictures, however, did not show any formation of callus. Nine months after the operation a slight bony bridging over seemed to exist. (Ill. 39a). The patient did not complain about pains anymore and therefore the nail was removed. Distinct elastic movements of the fracture were observed. Therefore a plaster cast was applied which was removed 6 weeks later by my assistant because the fracture seemed to be clinically and roentgenologically healed (Ill. 39b). 10 days later these fragments were firmly sticking together and a slight bending had occurred. Unfortunately it was not observed that this was only due to a sub-laxation in the distal radius-ulna joint and consequently this position was not corrected. A bony healing was achieved but an impairment of the movements of the wrist could not be avoided (Ill. 39c).

The nail had forged a stabile union but the bone did not show any reactions. It prevented a luxation in the distal radius-ulna-joint but nevertheless the fracture cleft was somewhat gaping and the intact ulna prevented a pressing together of the fragments. Therefore a healing could not be obtained. The fracture should have been bent in the direction of the ulna after the nailing so that in this way at least the split up part of the bone touched the distal fragment.

Illustration 40 demonstrates that in the above case a healing could probably have been achieved. Also in this case (Ill. 40a) the fracture cleft is somewhat gaping but at the radial side of the fracture the fracture teeth touched one another. Also this patient was able to resume labor 4 weeks after the operation and the nail was removed 3 months later. The fracture is bridged over by bone on the radial side. On the ulna side, however, the fracture slot still exists and the slight flange callus indicates that despite the presence of the nail slight shearing movements must have taken place.

After the first unfavorable observation (the cause of which was found out later) we were rather cautious as to the nailing of those rare cases of radius shaft fractures. Only in one single case we decided to nail a fresh fracture of that kind because it was impossible to keep the fracture in the proper position by means of the plaster cast. The patient was released from the hospital 8 days

a

b

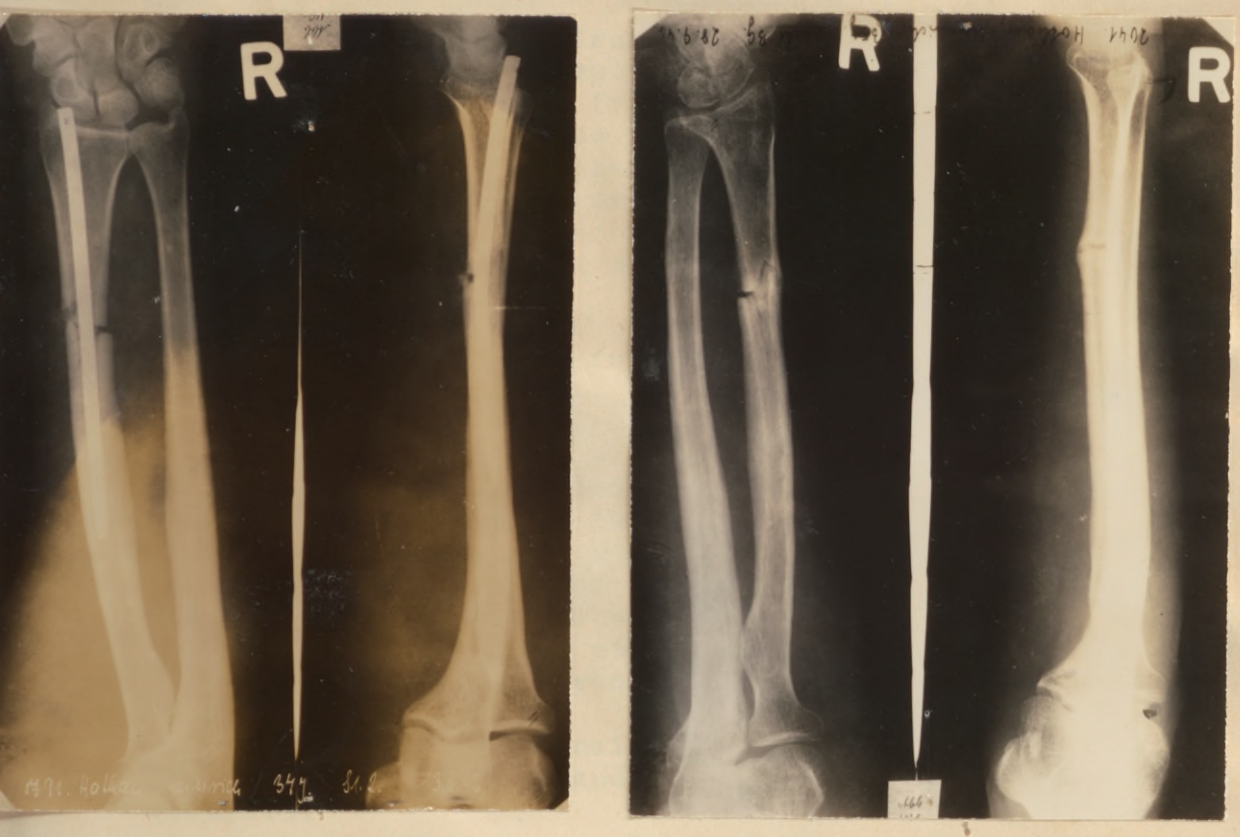
c

Illustration 39

a) Greenstick fracture of the radius 9 months after the nailing. The patient resumed working four weeks p.op. He is able to move the limb freely. When doing hard work, however, he complains about pains. From the clinical point of view the fracture is absolutely stabile. Poor formation of callus. Only at a small spot besides the nail does the fracture cleft seem to be bridged over by callus. The nail is removed, after that a distinct springing at the fracture site is observed and therefore a plaster cast was applied.

b) Six weeks later the fracture seems to be healed and therefore the cast was removed.

c) 14 days later the fragments are firmly standing together in a slightly angulated position. It was not observed, however, that a subluxation existed in the distal ulna-radius joint and consequently it was not corrected. The fracture comes to a healing in this position with an impediment of the movements of the wrist.



a b

Illustration 40

a) Shaft fracture of the radius after the nailing. The gaping of the fracture cleft is due to the jamming effect of the ulna on the ulna site. Radially the fracture teeth are firmly standing together. The patient resumed working four weeks later.

b) Same fracture four weeks after the removal of the nail. The fracture of the radial side came to a bony healing. The gaping cleft of the ulna site, however, did not heal.

later. Three weeks after that he was able to resume working and the nail was removed 3 months later (Ill. 41).

Two out of three fractures which were nailed from the outside showed good results In the third case the nail jammed in the proximal fragment so much that it was impossible to insert it to the eye. In order to be able to close the skin without tension the hand was immobilized in dorsal-flexion. In cases of that kind it would be better, however, to pinch the nail off. Otherwise the great advantages of the nailing method will not come into effect.

Fractures in both forearm bones were nailed only in those cases in which, after reduction and application of a cast, the fragments could not be held in the proper position. In the beginning we renounced the nailing of the radius under the condition that the fracture was in good position after the nailing of the ulna. A plaster splint was attached reaching to the arm above the elbow. A disturbance of the healing process in radius fractures was not observed but a distinct decalcification of the wrist bones was observed despite the fact that the patients frequently moved the limb with the cast.

Recently we have nailed two cases in which both of the bones were nailed and thus a plaster cast was not required.

Both patients were able to use the arms freely 4 weeks later and the healing did not show any disturbances. Atrophies of the wrist joint were not observed. In comparison to the conservative treatment the advantages gained by the nailing method are so great that we have decided to nail both bones from now on, if they are suitable for the nailing method.

f. The Dangers if the covered nailing.

The possibility of infection was one of the main reasons why many authors did not want to operate fresh simple fractures of the long shaft bones. It is impossible to deny that in many cases the indication was not strict enough and the insufficient technique showed terrible results. With the closed nailing operation, however, only a small incision was necessary to insert the nail and therefore the danger of infection must be less. In the first place, however, a suppuration in the fracture cleft must be avoided.

According to the statistics at hand in 458 cases of closed nailing operations primary suppurations occurred in 3 thigh fractures, 2 leg fractures, 1 fracture in the arm above the elbow and in 2 forearm fractures. During the extraction of the nail an infection was observed in 1 thigh fracture, in 1 fracture in the arm above the elbow and in 2 leg fractures.

a

b

Illustration 41

a) Radius shaft fracture with luxation in the distal radio-ulnar joint.

b) Same fracture after the nailing. Ideal position. The luxation was corrected. The fracture cleft is somewhat gaping because of the jamming effect of the ulna. The patient was released from the hospital 8 days later. The resumed working three weeks later.

c) Same fracture 11 weeks after the nailing. The fragments were firmly pressed together by the weight bearing effect. The nail head slipped somewhat out of the bone. In this way a subluxation in the radio-ulnar joint occurred which, however, does not impede the movements. The fracture is bridged over by bone. The nail is ready for removal.

In 4 out of 8 cases of primary infections the fracture cleft was impaired and 2 fatal terminations were observed in the cases of thigh infections. All these cases are of course a serious set back for the nailing method. We must take into consideration, however, that all of the infections could have been avoided, particularly those of the fracture cleft.

I am myself responsible for the following fatal termination.

A 20 year old pilot suffered from a transverse fracture of the right thigh in the middle third from a serious concussion and burns of first and third degree of the face, both arms, right leg and of the buttocks. 14 days after the accident I decided to use a marrow nail because it was practically impossible to immobilize the fracture due to motoric unrest and all movements of the patient caused unbearable pains in the fracture. I was well aware of the danger of infection considering the presence of suppurating wounds, nevertheless I hoped to be able to prevent an infection by the immobilization of the fracture because the vicinity of the trochanter was unimpaired and a good granulation of the wound of the broken legs was observed. The experiences made with marrow nail operations justified this opinion. A further reason why I decided to nail this fracture may be that shortly before I had a chance to observe a fatal termination of an infection of a closed thigh fracture with suppurating wounds of the leg which had been treated by wire extension. After the nailing the body temperature decreased considerably and the patient did not suffer from pain anymore. 5 days after the operation an infection of the intentionally unsutured operation wound occurred which was immediately opened. 14 days after the operation an abscess at the fracture cleft was observed which was also widely opened. After that we observed a serious suppuration of the burns especially at the buttocks and septic temperatures. 7 weeks after the operation the knee joint was infected and the leg had to be removed in consequence of which the patient died.

The amputation preparation showed ring sequestra at both ends of the fragments and grey-blackish granulations around the nail bed. Marrow phlegmon was not observed. The infection of the knee-joint was due to a tube abscess on the extensor side.

Let us leave the question undecided whether or not the infection of the fracture might have been prevented without the nailing. There is no doubt, however, that the new unpreventable injuries of the soft parts at the fracture site caused by the reduction are causing a considerable increase of the danger of infection. <u>As long as suppurating wounds exist in the body aseptic fractures should not be nailed</u> even if the nailing decreases the pains of the patient and facilitates his nursing.

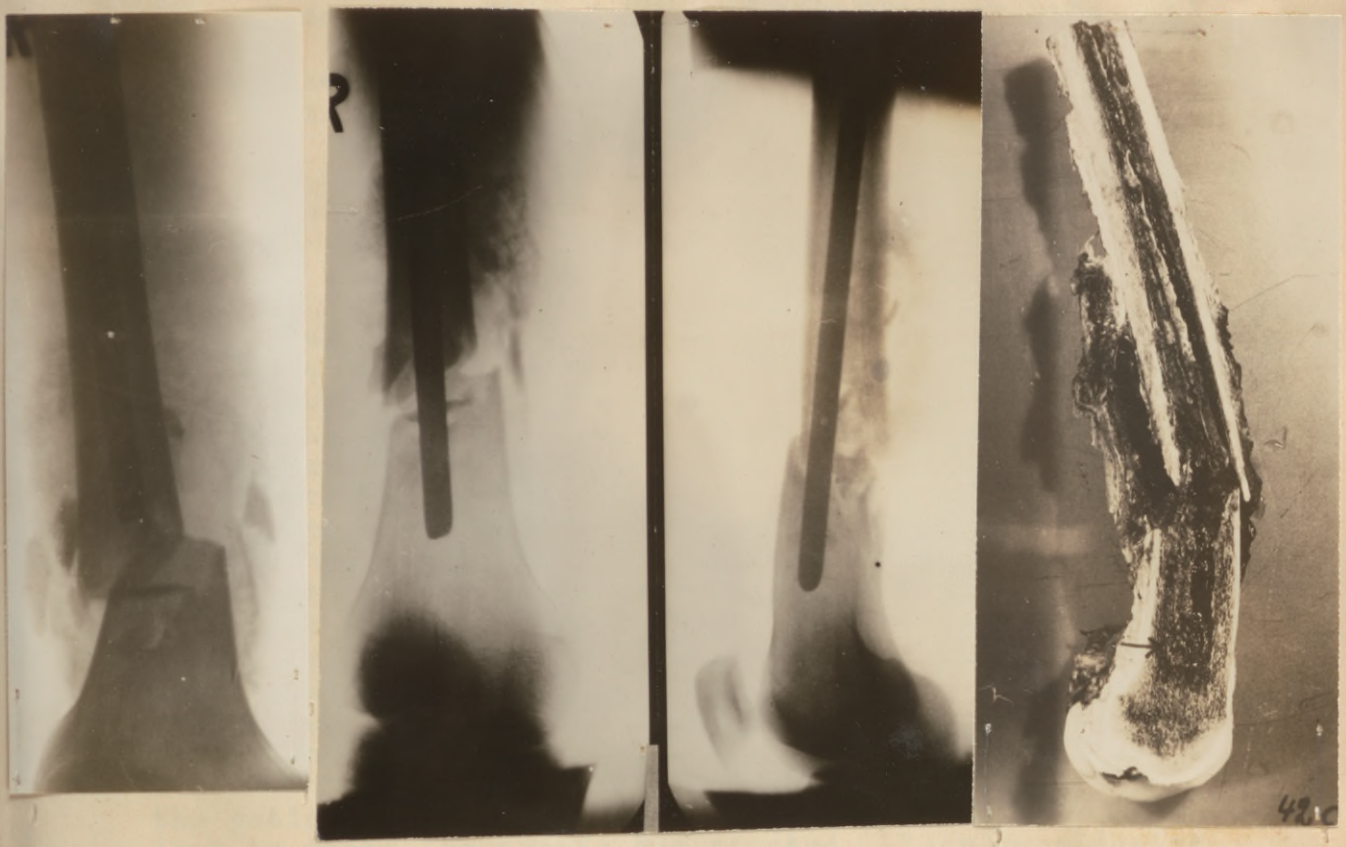
In a similar case BOEHLER has also observed an infection of the fracture hematoma. He is of the opinion that an infection can be avoided if the nail is applied

before an infection of the burns occurs. It is very difficult, however, to decide whether his theory is right or wrong because, so far at least, further experiences have not been made. It is our opinion, however, that an operation of that kind should be made only in emergency cases and if so the hematoma should be drained (1) (in the dependent direction in the septum intermusculare fibula) just as in nailed compound fractures. The hematoma is particularly endangered by hematogenous infections.

The second fatal termination was due to the insufficient technique applied and the wrong indications:

A 20 year old pilot was suffering from a transverse fracture located in the distal third of the left femur, from wounds of the soft parts of the left leg, from a basal skull fracture and concussion. Immediate debridement of the wound was made and a wire extension applied at the calcaneus because excoriations were observed in the vicinity of the tuberosita tibiae. After that an abscess of the left fracture and at the same time an infection of the calcaneus wire occurred. Nevertheless we decided to nail this fracture 8 days later " in order to obtain a good fixation of the fracture ends and because the patient appears to be very unrestful". The length of the nail was determined on the sound thigh because an X-ray apparatus was not available with which a picture of the entire thigh (with the nail laid over the fracture) could be made. "The longest available nail just about fit". During the operation, however, it was observed that "the nail is a couple of centimeters too short". Therefore the operation was stopped and the nail was left in the marrow cavity. A wire extension was attached to the tibia (Ill, 42a). The operation wound healed primarily. 8 days after the operation " a cast must be applied with the traction bandage on the extension splint", because the patient is delirious. A decubitus occurred at the hollow of the knee and the temperature rose. The x-ray control showed"approximately proper axial position of the fragments". The decubitus in the hollow of the knee increased. Three weeks after the wounding we came to the conclusion that the permanent unrest of the patient requires a repetition of the nailing operation in such a way that the first nail which was inserted previously should be driven in that much by means of a second nail so that both of the fragments are bridged over". After this operation was carried through (Ill. 42b) a pelvis cast was applied. One day after the second operation the temperature rose up to 40° C and an infection of the operation wound occurred which was opened on the second

(1) According to the proposal of FELSENREICH we use with best results a long drain which is to be led to a small sterile bottle outside the bandage. In this way the formation of a humid chamber saturated with blood is avoided which would be a good medium for bacilli.



a b c

Illustration 42

a) Transverse fracture of the femur near the knee with accompanying infected wounds of the same leg, after an unsuccessful nailing with too short a nail, in wire extension.

b) The nailing operation was repeated despite the fact that a decubitus existed at the knee joint and a longer nail was not available. The patient was suffering from a serious commotio and was very restless. The nail was driven into the proximal fragment by means of a second nail. Nevertheless the nail was still too short and consequently did not find sufficient hold in the soft spongiosa. Wound infection at the trochanter, abscess at the fracture cleft, sepsis. Three weeks later the limb had to be amputated. Fatal termination.

c) Amputation specimen. Marrow abscess at the nail point.

day. 4 days later an abscess at the fracture site was observed by which 600 cubic centimeters of pus are drained off. Precious time was lost by blood and urine tests and by fighting the sepsis with sulfonamides and blood transfusions. When, finally, three weeks later the surgeon decided to amputate the limb the patient could not resist this strain.

The marrow nail does not get sufficient hold in a fracture which is located so distally and a stabile osteosynthesis can never be obtained. Therefore an additional plaster cast was required anyhow. A nailing operation should never be made if the surgeon does not have a complete armamentarium at his disposal. Otherwise technical difficulties will arise. The first condition is to determine the length of the nail as precisely as possible. After the first operation passed without any infection on no account should the second operation have been made after a decubitus was observed under the fracture site. The unavoidable injury of the soft parts caused by the reduction of the three weeks old fracture must under these circumstances lead to an infection. The nail was not inserted deeply enough and consequently a marrow abscess around the nail point occurred. (Ill. 42c). Let us leave the question undecided whether or not the life of the patient would have been saved by amputating the limb in which the sepsis had started. When considering that a wire extension could not be applied to the tibia the best thing to do would have been to set the fracture as accurately as possible (eventually using an extension apparatus) and to apply a large plaster cast to the thigh. In case it was not possible to attain a good position of the bones such a malposition could have been corrected 4-6 weeks later after a danger of infection no longer existed. Surgeons who do not know well enough the principles of the conservative treatment of fractures should less than ever be allowed to "nail".

An early repetition of the fruitless nailing seems to be particularly dangerous for infection. In case of a thigh fracture which was described in detail earlier we could not remove the nail which was not in good position. When the nailing was repeated 9 days later an infection of the wound occurred. It did, however, not extend beyond the fracture site because of the stabile osteosynthesis.

KUENTSCHER asserts that in simple fractures the infection is restricted to the insertion site. In the two leg fractures (Ill. 43 and Ill. 8,) and the fracture in the arm above the elbow, however, the fractur clefts were infected though the wounds at the insertion site were immediately opened. In all these cases a stabile osteosynthesis had not been obtained. Also in the case of a chronical osteomyelitis after a thigh nailing and the serious infection after a leg nailing in none of those cases could a stabile osteosynthesis be achieved, and this circumstance is probably due to the extension of the infection. If the nail is not firmly seated in the marrow cavity little displacements take place which are due to the movements of the limb. The empty spaces originating in this way absorbed the infectious secretum either by pressure or soaking. The stimulating effect of the shifting foreign body favors the process of inflammation.

a

b

c

Illustration 43

a) Double leg fracture after the nailing. The nailing operation was delayed for 14 days after the injury because of an abrasion and was done only after the wound was healed. The distal fracture is immobilized by the nail, the osteosynthesis of the proximal fracture, however, is not stabile. Five days p.op. infection of the nail insertion site and of the other fracture hematoma, which soon extends to the distal fracture hematoma. Broad incisions, drainage plaster cast. An infection of the bone is prevented.

b) Same fracture 3 months later. The fracture came to a bony healing, an ostitis is not observed. The wounds are considerably healed. For 8 days the patient has subjected the limb to painless weight bearing.

c) Same fracture 2 months later. The nail was removed 3 weeks before. The wound was kept open with the leg in elevated position. 10 days later the wound was healed. The gait was unhampered, no edema was observed. The shortening amounts to ½ centimeter.

If an infection occurs in cases of relatively suitable fractures (particularly in leg fractures)- in which the nail forges a stabile union in the beginning because it was long enough and because it was driven into the spongiosa, in such a case the infection is restricted to the insertion site if the wound is opened immediately and broadly enough, so that the pus may drain off. In case of such a relatively stabile osteosynthesis 2-3 weeks later the nail becomes loose because of the absorption of the spongy spicules and as soon as some strain is put on the limb (as long as the wound has not yet come to a healing) - a "late abscess" may come into existence at the fracture site. Therefore it is absolutely necessary to open the wound immediately (especially in cases of leg fractures) and to put the limb to rest by a cast as long as an infection exists. It is unsuitable to remove the nail before the fracture is healed, for, by doing so, the nail bed will facilitate the spreading of the infection.

In case of a true and stabile osteosynthesis an immobilization of the limb is not indicated. After the acute symptoms have subsided the limb may be freely moved and the patients may even get up. This was clearly proved by the experiences made with the nailing of infected fractures. If after the healing of the fracture the nail wound continues secreting, the nail must be removed. After that the limb must be kept in such an elevated position that the insertion site is lowest: otherwise a gravity abscess will occur in the marrow cavity.

It stands to reason that an infection or an inflammation may occur because the nail (just as in fractures of the forearm) is projecting too much and thus causes damage to the skin or because it was projecting out of the wound. All this may be prevented if we cut the nail off and smooth its edges by means of a file.

In all 4 cases of infections occurring after the extraction of the nail, complications arose because either adequate instruments for its removal were not available or because the nail had slipped into the bone. The limb was not kept in a good resting position and therefore in one case of a leg fractur a gravity abscess occurred at the fracture site which, however, could be brought to sound healing after an incision had been made.

I daresay, however, that after the <u>closed nailing of fresh fractures, infections are avoidable if the indication as well as the applied technique are correct.</u>

Only in six cases was the method of the open nailing of fresh simple fractures used in which either a reduction was impossible or because the nail could not be introduced into the distal marrow cavity. Infections of the fracture cleft never occurred. Only in one case of a thigh fracture was an inflammation of the nail wound observed. In this case the nail was projecting too far out of the wound and this projecting piece of the nail could not be removed because a metal saw was not

available.

In spite of this we cannot agree with HART to open the fracture as soon as difficulties arise for there is no doubt that by doing so the danger of infection is considerably increased. This was proved by experiences made with old fractures. If the technique applied is correct (the fragments must be distracted) good results will always be achieved. In no case should the operation be started before the operating surgeon has determined that it is possible to bring the fragments firmly one upon the other. If it is impossible to do that a wire extension should be applied. If a satisfactory position of the fragments cannot be obtained by this process the operation may be repeated one to two weeks later anyhow. If the necessity comes up to perform an open nailing an operation at this later time will in any case be more successful than to open the fracture cleft after needless attempts which only disturb the asepsis and damage the tissue.

One out of the three above mentioned fatal terminations has no relation to the nailing method.

An 84 year old woman who had suffered from a subtrochanteric transverse fracture of the thigh was treated with a wire extension after the closed nailing had failed. 5 weeks later she died of debility of circulation and pneumonia(1).

In the two other fatal terminations (thigh fractures) the post-mortem examination showed a fat embolus.

In one of the cases the fat embolus was due to the insertion of a second rod into the nail which had jammed with the first rod. Thus the pressure upon the marrow had become so strong that a massive fat and air embolism occurred (2).

The other patient collapsed while under the influence of a lumbar anaesthesia. Nevertheless the nailing operation was performed after he had recovered and, according to the records "rather strong forces" had to be used to insert the nail. The patient died 2 days after the operation. The post-mortem examination showed an extensive pneumonia and a slight fat embolus to which the fatal termination could not be ascribed, according to the findings of the pathologist.

In other nailings three further cases of fat embolus were observed at post-mortem examinations.

A 12 week old thigh fracture which was in bad position was mobilized under anaesthesia and after that a wire extension was applied. 8 days later a closed nailing operation was performed because of the danger of infection: Due to the difficulties encountered with this operation a debility of circulatory difficulties were encountered and 4 hours after the operation the patient died. The post-mortem examination showed a massive fat-embolism in both lungs. The fracture ends were closed by callus in which the nail was firmly seated (1).

In a 2½ months old thigh fracture which was nailed by the open method the (thinnest) thigh nail was jamming so much in the proximal fragment that repeated attempts were necessary to remove it and to replace it by a leg nail. KUENTSCHER's tackle and pulley which was used for this purpose caused a cracking of the neck of the femur. Even the insertion of the leg nail was difficult so that the operation lasted more than two hours. The collapse occurred during the operation which caused the fatal termination. The post-mortem examination revealed the existence of a fresh fracture of the neck of femur and the trochanter major was torn off (by the tackle and pulley). Besides this a slight fat-embolism was observed to which the fatal termination could not be ascribed - according to the findings of the pathologists. Other findings were not available (2).

The ideal that a displacement of fat might be caused by the marrow nailing is obvious, for, with the insertion of the nail large quantities of marrow and at the same time also numerous vessels are damaged.

MAATZ(3) proved by animal tests that a fat displacement does occur - but" it is so little that it is of no importance even if 4 large tube bones are nailed at the same time".

After all the danger of a lethal embolus is little because the insertion hole is larger than the cross section of the nail. Thus the bone marrow may drain off by the nail wound and a considerable over pressure is avoided (KUENTSCHER).

It is striking that in all of our cases fat-emboli were observed only in thigh fractures.

Clinical symptoms (as for instance: collapse of circulation, increase of pulsation) which are indications of a fat release were observed only in two cases of complicated thigh nailings.

All this may be explained by the fact that the "emergency valve" at the insertion spot becomes rather small with the thigh nailing because of the presence of the guide rod in the nail. As long as the marrow cavity is open at the fracture cleft it may suffice in general but not in old fractures in which the marrow cavity is closed by callus or connective tissue.

Furthermore it is striking that in all cases, difficulties may arise with the insertion of the nail. When in this case especially strong and repeated strokes are necessary in order to drive the nail in, the jamming nail will transfer the strokes to the bone. A prolonged striking upon a bone may cause a release of fat from the bone into the circulation (LARSEN). These "hard" strokes will probably show similar dangerous effects. In order to prevent these dangers the nail should be driven in by means of strong "long" strokes and it should be replaced by a thinner nail as soon as jamming occurs

(in thigh fractures it will always be better to use nails which are too thin instead of their being too long).

Besides this the guide rod should be removed for some time after the insertion of the nail into the proximal marrow cavity in order to facilitate an easy outflowing of the compressed marrow.

In all thigh fractures it seems to be better not to perform a nailing operation as soon as symptoms arise which are indications of shock, a bad general condition of health, or general symptoms which point to an endangering of the operation. After all the nailing represents a relatively large operation and even a small displacement of fat may lead to a fatal termination as a consequence of injuries which already exist or which may come up during the operation.

If all this is taken into consideration a danger of a lethal fat embolus scarcely exists in practice. In no case, however, should this possibility be the reason for abstaining from nailing thigh fractures.

Damages due to metal may occur if stainless steel (V2A-steel)is not used for the manufactoring of the nails especially for the double nails. Indications of damages of this kind are rarefactions around the nail (which, however, may not yet be mixed up with rarefactions caused by mechanical conditions) and periosteal deposits. They will not cause any delay in the healing process. Nevertheless it will be preferable to remove the nail as soon as possible.

A number of physicians have observed that changes of the blood picture and of the sedimentation rate settle take place. All these findings are rather interesting from the theoretical point of view, they are of no significance, however, for the practical value of this method.

SUMMARY

In fresh simple fractures the stabile osteosynthesis achieved by means of the marrow nail shows the following advantages:

In comparison to the conservative treatment the healing process shows much better results.

The time required for the treatment in the hospital and the duration of unemployability is considerably shorter.

The nursing of the patient is very much facilitated.

The danger of infection, the possibility of dislocation of fat and damages due to metal are avoidable in case of thorough indication, correct technique and good asepsis.

These dangers are so insignificant that they are of no importance considering the advantages of this method.

It must be kept in mind, however, that in fresh closed fractures a marrow nail operation should be performed only if that operation can be made without exposing the fracture site.

If the osteosynthesis achieved by the nail is only "relatively stabile" its advantages are much greater in comparison to the conservative treatment. The danger of infection and the danger of a late displacement are, however, considerably greater and therefore special consideration must be given to the after-treatment.

Counter indications against the nailing of fresh simple fractures are: burns, blisters due to pressure on the skin, suppurating wounds or other centers of infection in the body, shock, bad general condition of health and a general endangering of the operation.

In these cases the method of choice is the closed nailing for all simple fractures of the thigh between the trochanter minor and seven centimeters above the knee joint.

Spiral fractures in the upper third and shaft fractures with a long spiral splinter may also be nailed and in these cases an additional wire traction is not required. The nail which should be long enough must be inserted at the proper spot and an early weight bearing must be avoided because the osteosynthesis is only "relatively stabile".

In distally located spiral fractures the nailing is of no advantage and therefore it is better to abstain from nailing those fractures.

In leg fractures the nailing is particularly easy from the technical point of view but a true stabile osteosynthesis will be obtained only in transverse fractures, short oblique and spiral fractures in the middle third.

Even oblique and spiral fractures in the lower third may get such a strong hold by means of the usual double nail that the application of an additional wire traction is not always indicated. In these cases the nails must be driven into the line of growth (epiphyseal line) and sometimes an additional plaster cast or a U-splint will be required. In these cases and in fractures in the upper third the osteosynthesis is only relatively stabile and therefore special attention must be paid to weight bearing and thorough observation. Nevertheless the nailing method grants considerable advantages.

If the fibula has come to an early healing it should be resected without delay in order to prevent a blocking effect upon the formation of callus first of all in those cases in which the nails are too short. In those cases the nails are to be kept in position.

Isolated fractures of the tibia are particularly suitable to the nailing method. They must, however, be brought to an early weight bearing.

The danger of a spreading of infection to the fracture cleft is rather imminent if the osteosynthesis is only relatively stabile. Therefore the counter-indication should be especially strict in leg fractures because of the imminence of infection. First of all fractures with considerable swellings of the soft parts, blisters or injuries of the skin should be excluded from the nailing.

The closed nailing is the method of choice also for simple shaft fractures of the arm above the elbow. Fractures in the upper and middle third should be nailed proximally, fractures in the lower third, however, distally.

Fractures which are less than 7 centimeters distant from the shoulder joint should be nailed from the middle part of the arm above the elbow. The nails must be driven into the nail head and the inner nail should be somewhat S-shaped.

Fractures of the collum chirurgicum of the arm above the elbow should be nailed only if it is not possible to fix the fragments and firmly press them together.

Isolated shaft fractures of the ulna and radius should be nailed on principle if they are distant enough from the joint ends. In these cases the bone ends must be thoroughly fixed together because of the jamming effect of the second bone.

If both forearm bones are broken they should be nailed only if the fragments cannot be fixed and firmly held together by means of a plaster cast. It is suitable to nail both bones. If an infection occurs the wound must be broadly opened and the limb immobilized until the acute symptoms have subsided. If the osteosynthesis is only relatively stabile the cast may be removed only when the wound has come to an aseptic healing or when the fracture is bridged over by bone. Otherwise an infection of the fracture cleft may occur. In such a case the nail should be removed only after the healing of the fracture.

If after the extraction of the nail an infection occurs the limb must be immobilized in such a way that the nail insertion spot is at the deepest point, otherwise a gravity abscess may occur at the fracture cleft.

Fresh compound Fractures

In open bone fractures the healing result depends largely on the question whether a primary wound excision is possible or not. Due to the war the conditions are very unfavorable even in the home territory so that we can refer to only 76 nailed fresh compound fractures. The

technique and the experience of the surgeon, however, are decisive.

In this connection I would like to point to the insufficient data given in the patients records in other hospitals. In most of the cases we barely find the word "wound excision" and even the supplements are very often misleadingly worded.

It may be admitted that the radical wound excision with primary suture of the skin as recommended by BOEHLER, is ideal but we must recognize the limits of this method and first of all it must be kept in mind that great experience as well as mastery of the technique are necessarily required for it. If it was not possible to remove the injured tissue completely or if germs are still in the wound and consequently an infection occurs, in that case the suture of the skin must be especially endangered. The wound margins come to an early agglutination, the infectious secretum cannot drain off sufficiently - even if drainage is applied - and consequently the secretions will be pressed into the soft parts and into the bone. If symptoms of a wound infection are not observed an incision of the skin 2 millimeters distant from the margins in the sound part of the skin is indicated. This is in accordance with the practice of my own clinic. In this connection I would like to point out that we do not necessarily observe the 6-8 hour limit. Without regard to a later covering of the wound we remove all areas which seem to have their blood supply disturbed (dislocated lobes, scratched skin or contusion centers). All pockets must be broadly opened. All dirty, contused, torn out or any other injured tissues are thoroughly cut away until finally fresh wound margins appear. Bleeding vessels must immediately be pinched off. Special care must be given to a thorough removal of all damaged parts of the sinews and fascias. All dirty sheaths of nerves and large vessels must be removed. Dirty surfaces of the bones must be removed by means of the "Luer" rongeur but we remove only those bone particles which are completely loose. All the other ones are kept in position because they may be helpful for the formation of callus. After that the wound gets a temporary tamponage, the instruments, gloves, the linen and the wound covering are changed. Hemorrhage is controlled by trimming the wound margins once again near the clips. After that the bleeding vessels are tied off and the nailing may begin. Only in thigh fractures the guide rod is inserted from the fracture cleft into the proximal marrow cavity. In all other cases the procedure is the same as in simple fractures. A drain is applied to the fracture which must be led through the sound skin (and not through the wound) at the physically suitable spot. At the fracture site the soft parts must be stitched together as economically as possible but in such a way that the bone is completely covered. Special drains must be inserted into larger pockets in the musculature. If with regard to the general condition of the wound, a primary healing may be expected the skin should be closed by means of 3 millimeter wide adhesive tape (not by sutures).

I would like to underline once again that contrary to the opinion of BOEHLER the suture of the skin is especially endangered and therefore it is better to abstain completely than to obtain a closure by the transplantation of lobes, etc. The healing of the fracture takes a longer period of time anyhow and therefore there is no difference between a healing per primam and a healing per granulationem. Only in leg fractures a transplantation of lobes of the skin seems to be indicated because there is no other possibility for covering the tibia. Also in this case we use only adhesive tape.

On principle the wound should be kept wide open and an efficient drainage should be applied if symptoms of a spreading infection are observed. In such a case we content ourselves with the "wound toilet" with the economic removal of all torn out and contused parts and with the opening of all pockets. In case of an acute infection i.e. if suppuration and fever are observed, we had better renounce the nailing. It is decisive for the success of the nailing of open fractures - and in this connection I agree with BOEHLER to obtain a stabile osteosynthesis by the nail. In all cases in which this objective cannot be achieved it will be better to abstain from nailing.

BOEHLER (1) recommends: "If the union of the fragments is not absolutely stabile just like in spiral fractures at the upper or lower end of the bone it is indicated to apply one or two wire sutures". I cannot agree with that despite the fact that in many cases I have treated compound fractures with wire and plate just like my very esteemed teacher Fritz KOENIG. Also in these fractures it is possible to achieve a stabile osteosynthesis, (at least during the first weeks) if the technique applied is correct (length of the nail). Therefore the question arises: Why should we use an additional wire which causes further injuries because of the separation of the periosteum? If a stabile osteosynthesis cannot be obtained by the nail an additional wire loop will not be of any great help. This at least is my own opinion. If an infection occurs the nail which does not forge a stabile union with the bone will be especially endangered (2). It will be better to renounce the nail therefore in such a case and to use a wire loop or Lane's plate if necessary. If in such a case an infection occurs it will at least not spread to the marrow cavity.

In the following let me refer once more to the "additional immobilization" of the limb; one of the basic principles of the treatment of accidental wounds is to immobilize the injured limb as long as a danger of infection exists. The nail immobilizes the fragments and not the soft

(2) In BOEHLER's cases there is no compound fracture that came to an aseptic healing with an additional wire loop. There are, however, some cases in which an infection occurred.

parts. Therefore the limb must be kept immobilized even after the nailing. Most suitable for this purpose is the un-upholstered cast with a window or the un-upholstered cast-splint which must be attached in such a way that it may be kept in position during the change of dressing.

The limb should be kept in such a position that the drain in the wound is at the most dependent point. If, however, Braun's splints are used the insertion site must be at the most dependent point. Blood or wound secretion extravasating from the wound will easily drain off in the direction to the the insertion site along the nail which acts as an ideal drain. Eventually an infection may be transmitted to that site.

a) Fresh compound thigh fractures.

Nineteen fresh compound fractures of the femur were nailed but the course of only one of those could be observed until a final healing was obtained. This was the only fracture with an infection of the wound:

Open fractures of the left thigh and leg after a motorcycle accident in a 20 year old sergeant.

Left thigh: Double green-stick fracture in the middle of the thigh. The central fragment is 4 centimeters long (Ill. 44a). The 6 centimeter long open somewhat torn up wound reaches to the bone.

Left leg: Green-stick fracture of the tibia somewhat below the middle, fracture of the fibula in the upper third (see Ill. 48). Torn up and dirty wound which is larger in size than a hand and from which the bones project.

Immediate operation under anaesthesia: Widening and trimming of the thigh wound. All torn up and dirty parts of the musculature are removed and the blood is staunched. Exposure of the fracture site. The proximal fragment is elevated somewhat by means of a bone hook. After that the guide rod is inserted into the marrow cavity and driven through the skin at the trochanter. Insertion of a 38 centimeters long marrow nail by using the guide rod until it appears at the fracture cleft. (An X-ray to determine the correct length of the nail was not taken). Then the guide rod is extracted and inserted into the nail from above. The middle piece is slipped over the nail respectively over the guide rod and then nail and guide rod are driven into the distal fragment until finally only about 2 centimeters are projecting out of the trochanter. (Ill. 44b) MARFANIL-PRONTALBIN-powder is distributed in all wound pockets and the depth of the wound. Three drains were applied. A row of sutures of the wound is made. The wound is closed at the trochanter after the application of Marfanil-Prontalbin-powder for all wound pockets and a rubber drain is inserted. After that, trimming of the wound and nailing of the leg fracture with only one nail

a b c

Illustration 44

a + b + c

a) Comminuted compound fracture of the left thigh (with accompanying compound fracture of the left leg) due to a motorcycle accident. The wound is slightly mutilated and six centimeters long. Wound excision and marrow nailing from the fracture site immediately after the patient was brought to the hospital. Wound suture and insertion of three drains. A rubber drain is used in the trochanter wound. VOLKMANN splint. Next day the temperature rose to 39° C. Change of dressing and irrigation of the wound only four days later. Only three weeks later was the wound widely opened.

b) Same fracture after the nailing. The nail is too short, it does not find sufficient hold in the distal marrow cavity.

c) Same fracture seven weeks p.op. Distinct rarefaction of the corticalis at the distal fragment and around the nail. Again and again the drainage was dammed up and incisions were necessary.

d

e

Illustration 44$_{d\ e}$

d) Same fracture five months p.op. The central fragment is sequestrated. At the proximal fragment a typical ring sequestrum was cast off. At the distal fragment the nail has worked its way into the corticalis because the osteosynthesis was not stabile enough. The fracture came to a valgus position, at the inner side a beginning formation of callus is observed.

e) 8 months after the injury the fracture is bridged over by callus on the inner side. Above the nail point a thin formation of newly grown periosteal bone is observed. There are fistulae in the wound. The patient subjects the limb to weight bearing.

after which the fracture cleft was still gaping. A defect of the skin of the size of a 5 mark coin cannot be closed. M.P.-powder-drain. The thigh and the leg are immobilized in a Volkmann-splint.

In spite of the fact that one day after the operation the patient shows temperatures higher than 39 degrees which are increasing, the dressing is changed only four days later and a considerable secretion of pus coming from the wound is observed. "Therefore to begin with some (!) of the sutures are removed." After that"the wounds are thoroughly cleaned every second day with a solution of RIVANOL and RIVANOL-wicks are inserted into the wound". Fourteen days after the operation a pelvic cast with a window is applied and finally (three weeks after the operation) the wounds are widely opened because the temperature of the patient had not yet declined. In the X-ray which was taken 4 weeks later (Ill. 44c) we observe a distinct rarefaction of the corticalis of the distal fragment. Again and again retentions of pus occur which require further incisions. The third fragment becomes necrotic and from the proximal fragment a (typical) ring sequestrum is cast off. The nail which is too short penetrates the corticalis (Ill 44d). Thus a slight bending of the fracture occurs but at the inner side of this curvature an abundant formation of callus is growing which causes a bridging over of the fracture (7 months after the operation) so that the limb may be subjected to weight bearing (Ill. 44e). The leg wounds which had cast off some sequestra are closed now but a fistulization of the thigh still exists. 9½ months after the operation (December 1944) the ability to walk is restored to such an extent that the patient can get a Christmas furlough from which he did not return because of the events of the war. A short time ago he reported that the nail was removed one year after the accident. 14 days later a refracture had occurred which came to a healing in a varus position of 160^0. Half a year later another formation of abscess is observed at the thigh and 7 sequestra had to be removed. Since then the wounds came to a healing and other sequestrations did not take place. His hip is not afflicted but his knee and foot joint became quite stiff. Total shortening : 6 centimeters.

It is very difficult to decide whether or not the trimming of the wound was really sufficient. It is a matter of fact, however, that it is wrong to direct the drains through the wound. It is clearly proved by the course of the disease how dangerous the wound suture may be first of all in those cases in which the wound is not immediately widely opened(1) after an infection of the

(1) Again and again I have noticed that particularly young surgeons dislike open wounds and therefore want to retain the skin sutures. Consequently they hesitate to open the wound widely. Maybe they think of previous experiences with abdominal operations (abdomen evisceration, abdominal hernia). In order to meet such minds I teach my assistants from the very beginning to renounce the suture of the skin entirely

wound occurred. First of all, however, a stabile osteosynthesis had not bee achieved because the nail was too short. Therefore the infection of the fracture cleft, the necrosis of the middle fragment, the ring sequestrum at the proximal fragment and the penetrating of the nail into the corticalis must be ascribed to that instable osteosynthesis.

Also in the case of the open fracture demonstrated by Ill. 45 the osteosynthesis is only relatively stabile. Nevertheless a primary healing was achieved but in this case the nail was applied only 14 days after the injury i.e. at a time when the wounds had already come to a healing.

The green-stick fracture in the central third was complicated because of a bleeding wound 3 x 1 centimeters on the inner side. The wound was trimmed and a suture applied. 2 days later a splint was applied after that wire extension. 14 days after the accident when the wound had already come to a healing the fracture was nailed after its exposure from the outer side. 2 days after the operation a large size hematoma was opened at the fracture site and irrigated with salt solution. With an exception of two days during which the patient suffered from an increase of fever (12 days after the operation) the course of the healing process was uncomplicated and four months after the accident the patient was released as being fit for service after the nail was removed.

The diameter of the marrow cavity below the fracture site is so wide that a true jamming effect of the nail cannot be obtained. Therefore the nail should have been much longer. The osteosynthesis was only relatively stabile which may distinctly be proved by the rarefaction seen in the X-ray in the area of the nail point in the picture taken 9 months after the operation (Ill. 45).

It is certainly less dangerous to wait for an aseptic healing after the trimming of the wound and to begin with the nailing operation after that. In such a case however, we must take into consideration that we have to deal with a simple fracture and therefore we should nail without exposing the fracture cleft. This result was achieved in 6 cases, four of which must, however, be considered to be only relatively stabile regarding the peculiarities of the fractures in question.

In all cases in which a true stabile osteosynthesis can be obtained such an attitude seems not to be indicated because one will forego the advantage of the elimination of the danger of infection which is due to the immobilization of the fracture. In all cases, however, in

* (even in abdominal surgery) as soon as a danger of infection exists. I even reject the so-called approximation sutures because they may easily lead to a true suture of the skin.

Illustration 45

Compound fracture of the femur 3 months after the open nailing, which was made 7 days following the injury and when the primarily trimmed wound located on the inner side had healed. Primary healing. The osteosynthesis was only relatively stabile because the nail did not find sufficient hold in the broad distal cavity. In this way the rarefactions round the nail tip occurred. The nail should have been driven into the epiphysis. An infection did not occur.

which only a relatively stabile osteosynthesis can be obtained this procedure will be better than the primary nailing.

In those 12 cases of primarily nailed fresh compound fractures the osteosynthesis was stabile and all cases healed without any disturbances of the wound.

In those 18 fractures which could be observed until a final healing was achieved the treatment in the hospital lasted from 28 to 90 days or 69 days on an average. However, the duration of unemployability of those cases amounted to 80 to 138 days or 115 days on an average. A distinct difference between the primary nailing and the nailing after the healing of the trimmed wound could not be observed. All 18 cases healed without an impediment of the leg.

In EHALTS's cases which had healed "without any complications" the average treatment lasted 200 days. Nine of his cases of compound thigh fractures would have been suitable for the nailing operation. In two cases in which the traction was too strong, pseudarthrosis occurred which had to be eliminated operatively but in one case an impairment of the knee joint remained.

Therefore there is no doubt that the nailing of fresh compound thigh fractures shows great advantages in comparison to the conservative treatment.

b) Leg Fractures.

At my clinic all compound leg fractures were formerly fixed by means of the twisted wire method or by Lane's plates. If, however, a primary wound excision was possible (1) we frequently have used the marrow nail method. We did not treat only those cases which were "very suitable" (cases of that kind are rare) but also those in which the osteosynthesis was only relatively stabile (oblique and spiral fractures below the middle of the bone etc.). It must be admitted that many a technical mistake has been made (by using nails which were too short or by subjecting the limb to weight bearing too early). The same conditions prevailed in the field hospitals.

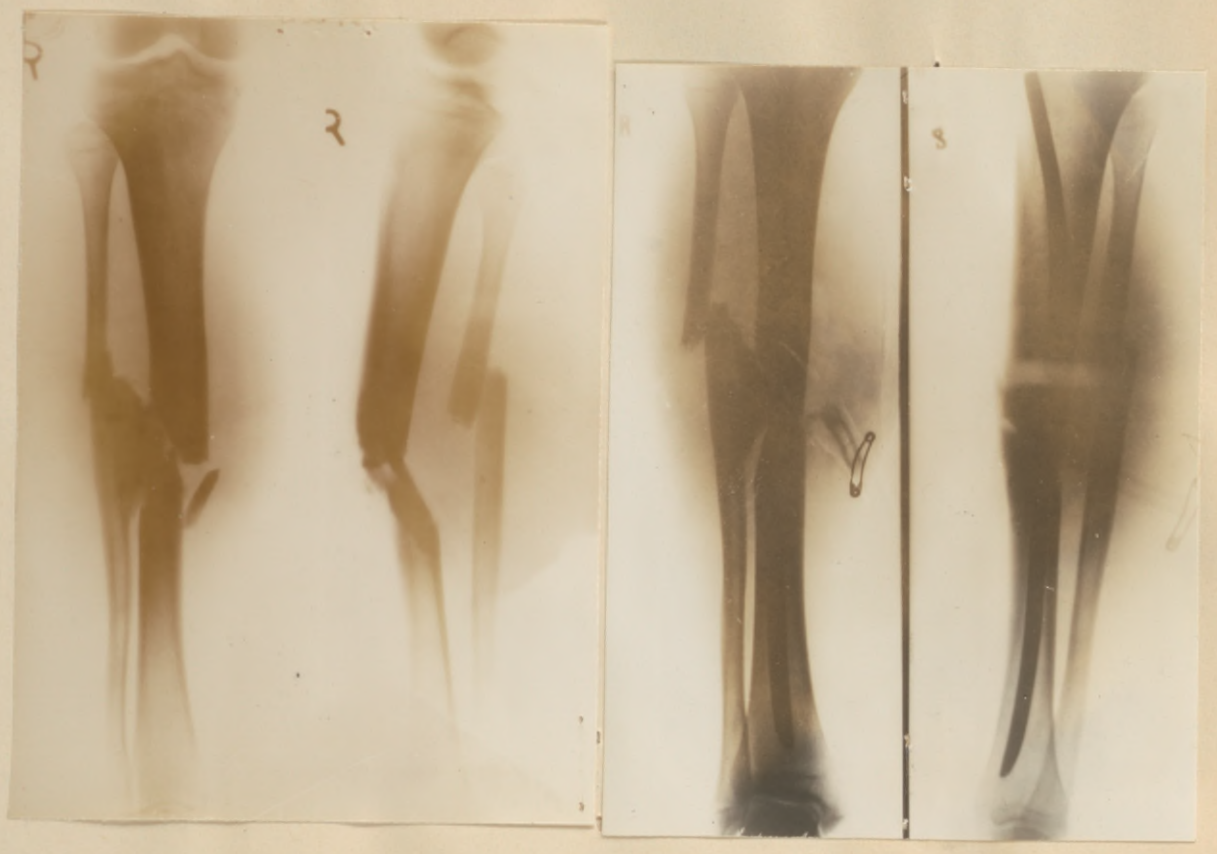
A total of 39 fresh compound leg fractures were nailed, the course of 29 of which could be observed until a final healing was achieved.

In those 39 cases of nailed fractures an infection of the wound was observed in 12 cases. In four cases the infection had extended to the bone and caused a casting off of sequestra.

(1) In general small smooth woundsout of which bone splinters were projecting were not trimmed by us. Cases of that kind were treated conservatively.

The comminuted fracture demonstrated by Ill. 46a was complicated because of a wound which was larger in size than the palm of a hand in which there were several bone splinters and torn up musculature. The skin which surrounded the wound was badly damaged and contused and on the skin of the leg there were several abscesses of the size of 2-3 mark coins. Consequently it was not possible to cover the entire bone by soft parts after the excision of the wound and the nailing. The exposed splinters were removed. The nail stabilized the fracture satisfactorily (Ill. 46b) and consequently a serious infection did not occur. At that spot where the bone was exposed corticalis sequestra were cast off so that the fracture cleft became wider but the broken out splinter was well attached to the bone (Ill 46c). Eight months after the operation the wounds were closed except for a small fistula and the nail was removed because the fracture cleft was bridged over by bone. At the fracture cleft a sequestrum of the size of a grain of barley was observed which was removed 14 days later. After that the woundshealed quickly and the patient could be released from the hospital. A late examination took place 11 months after the accident which showed that the wounds as well as the leg abscesses were healed and that the fracture was completely stabile and suitable for weight bearing. A shortening was not observed, the impediment of the ankle joint amounted to 25%. The X-rays (Ill 46d) showed that the structure of the callus was not yet sufficient at the medial side but symptoms of an osteomyelitis were not observed.

In the fracture, demonstrated by Ill. 47a, however, a considerably smaller, relatively smooth oblique wound existed at the level of the fracture site which was trimmed and primarily sutured. This operation and the one described above were made by my chief-physician. After the nailing the fracture was clinically stabile but the osteosynthesis was only relatively stabile because the fracture was rather deeply seated. The nail could have been somewhat longer. Therefore a plaster U-splint was applied (Ill. 47b). Two days after the operation the fever rose up to 39° and consequently the wound was widely opened and discharged a purulent bloody substance. Despite the fact that a cast with window was applied an osteitis occurred at the fracture cleft mainly of the proximal fragment and at the broken out splinter. An infection of the marrow cavity, however, was avoided. (Ill. 47c). A part of the splinter was cast off as a sequestrum but a good periosteal formation of callus bridged over the fracture cleft. Four months after the operation rarefactionsof the spongiosa were observed in the vicinity of the nail (Ill 47d). After the removal of the sequestrum the wound closed pretty soon. 5½ months after the accident the healing of the fracture had progressed so much that the nail could be removed. A late examination six weeks later proved that the nail channel could be recognized only at the insertion site. A coarse defect with two small sequestra was observed at the fracture cleft which, however, was not surrounded by sclerotic bone (Ill. 47e). Fistulae and swellings and an impediment of the limb were not observed. The two



a b

Illustration 46
a + b

a) Comminuted fracture of the right leg which was complicated because of a wound the size of the palm of a hand with the bone and several splinters being completely loose. Serious damage of the musculature. The skin near the wound was seriously contused. On the outside of the leg several ulcera cruris were observed. The wound excision was made immediately and the loose bone splinters were removed. Nailing operation . Due to the existence of the ulcers, the wound was kept widely open because a grafting of skin was not possible. The fracture site was partly uncovered. Application of a splint and of a drain in the posterior direction.

b) Same fracture after nailing. The double nail which was driven into the spongiosa found a good hold in the distal marrow cavity. The fragments were well pressed together. The osteosynthesis was stabile.

c

d

Illustration 46 c+ d

c) 4½ months later. In front the exposed bone was partly cast off from the inside so that the fracture cleft gaped at that point. The greenstick splinter, however, reaches from one fragment to the other. Symptoms of an ostitis were not observed. The nails forge a stabile union with the bone and reactions were not observed. The splinter had been removed 4 weeks after the operation and the patient had started subjecting the limb to some active exercise and exercises after the manner of walking. The wounds healed with exception of two spots the size of a 5 mark coin. A small fistula extended to the bone. All joints freely movable.

d) Same fracture 11 months after the injury. Bony healing. Medially the callus appears poor in calcium. The wounds were completely closed. No shortenings were observed and all joints were freely movable.

a

b

Illustration 47 a + b

a) Compound fracture of the leg with a relatively smooth wound which is 4 centimeters long and extended obliquely. Wound trimming, open nailing, drainage in the posterior direction, primary suture of the wound. U-shaped plaster splint.

b) Same fracture after the nailing. The nail should have been driven to the epiphyseal line because it could not find sufficient hold in the broad marrow cavity. The osteosynthesis is only relatively stabile. An infection of the wound occurred which was immediately opened widely. Cast with a window.

c

d

Illustration 47
c+d+e

c) Same fracture two months later. Loosening of the bone structure at the fracture cleft. Beginning necrosis of the cast off greenstick splinter but, at the same time beginning formation of callus.

d) Same fracture 4 months p.op. Sequestra at the greenstick splinter. Medially and behind a good formation of periosteal callus was observed which extended far below. This was not due to the presence of the nail, for, at the side at which it is lying a new formation of periosteal callus was not noticable. Distinct rarefactions round the nail tip which are an indication that the nail was not firmly seated. The sequestrum was removed and after that the fistula healed. The nails were extracted 4½ months p.op.

e

) Same fracture 7 months after the injury. It is bridged over by bone. Two small sequestra were observed at the fracture cleft which were spontaneously cast off later. The nail bed is noticable only at the insertion site.

sequestra were cast off spontaneously and medical assistance for that was not necessary, The late examination which took place 1½ years after the accident did not prove any limitation of the movements and the fracture cleft was barely recognizable.

The fracture had come to an ideal healing (picture was lost).

In this case the broad opening of the wound and the sufficiently long period of immobilization of the limb have obviously prevented the infection of the marrow cavity.

In the leg fracture demonstrated by Ill. 48 (and in the thigh fracture of Ill. 44), however, a serious infection of the marrow cavity with extended periosteal abscesses and abscesses of the soft parts, the formation of sequestra which required several incisions were due to the negligence of the above described procedure. Even later, several sequestra were cast off until one year after the operation the nail was extracted. Due to a sudden fall ½ year after that a refracture with an accompanying infection occurred in the course of which several other sequestra were cast off. A defect pseudarthrosis had to be expected and consequently the fibula had to be removed. The final result is a shortening of 3 centimeters with a stiffening of the knee joint and of the foot joint and scar tumors occurring again and again.

In leg fractures the primary suture of the wound seems to be particularly dangerous. In 12 out of 15 cases (80%) a wound infection occurred which in one case extended to the marrow cavity and in three cases caused the casting off of sequestra. All 17 wounds however, which had been drawn together by adhesive tape came to a good healing.

Only in one case of a relatively stabile osteosynthesis and early healed fibula a late abscess with formation of sequestra occurred after the patient had worked two weeks (1).

Even in those four cases in which the wounds had to be kept widely open because they were too extended and very dirty in only one case was an infection of the bone observed.

It stands to reason that the suture of the wound is particularly dangerous as soon as the osteosynthesis is not absolutely stabile. The immobilization of the limb is a precious means in fighting infection. In six out of 15 sutured wounds the osteosynthesis was stabile, three cases came to a primary healing and an infection of the bone never occurred. See table V.

Table V. Healing of the wound in fresh open leg fractures:

s= stabile osteosynthesis
rs= relatively stabile osteosynthesis

Illustration 48

Compound fracture of the leg(with simultaneous compound femur fracture (Ill.44)) 8 months after the nailing. The sutured wound was not immediately opened when the infection was observed and consequently an infection of the marrow cavity and periosteal abscess developed. Now, the wounds are healed but there is no doubt that a chronic osteomyelitis exists. Later on several sequestra are observed. One year p.op. extraction of the nail. 1½ year p.op. refracture with another casting off of sequestra with an imminent formation of pseudarthrosis which was counteracted by the resection of the fibula. Final result: Shortening of the leg of 3 centimeters, stiffening of the knee joint and ankle joint.

Illustration 49
(ref. Text see P. 45)
Nailed compound fracture of the arm above the elbow 2 years after the injury. The wound excision was insufficient and consequently a serious infection occurred which extended to the elbow joint and caused there a bony ankylosis. Sequestra were cast off several times.

	Total		Good heal. of the wound		Wound infect.		form. of seq.		inf. of narrow cavity		Late abscess	
	s	rs	s	rs	s	rs	s	rs	s	rs	s	rs
Prim. sut. of the wound	6	9	3	0	3	9	0	3	0	1	0	0
Wound adapt. b. means of adhes. tape.	11	6	11	6	0	0	0	0	0	0	0	1
Wound kept open	2	2	1	2	0	0	1	0	0	0	0	0
Clos. nail. after the heal. of the trim. wound	3	0	3		0	0						
TOTAL	22 39	17	17 26=66%	9	3 12=30%	9	1 4=10,3%	3	0 1=2,6%	1	0 1=2,6%	1

BOEHLER rejects the nailing of compound leg fractures because serious infections occurred in 21,7% of the 47 cases treated by him, whereas in the conservative treatment (EHALT (2) only in 6,2% of the cases were infections observed. In our own material in only one case (2,6%) a serious infection occurred and it certainly could have been avoided. If we do not consider EHALT's cases of shaft fractures which were suitable for the nailing we have to deal with 80 fractures, 18 or 25% of which showed disturbances of the wound healing including 2 gas phlegmons and 9 cases (11%) formation of sequestra. In comparison to this the results obtained by the nailing method are much better. Wound infections occur more frequently but only in those cases in which the wound were primarily sutured. Therefore there is no reason to reject a marrow nailing of fresh compound leg fractures because of an increased danger of infection. We do warn, however, against suturing the wound.

Unfortunately only 29 cases could be observed until a final healing was achieved. The results obtained and the length of the stay in the hospital and the length of time necessary to restore the employability are noted in table VI and compared with the 80 cases of EHALT.

Table VI. Duration of treatment and results obtained in fresh compound leg fractures.

	Nr.	Duration of stay in the hospital	unemployability	Final results I	II	III	IV
Marrow nailing	29	80 (33-180)	127 (53-406)	26=90%	2= 7%	1	-
Conservative treat. BOEHLER-EHALT	80	-	183 (68-399)	50 = 62%	23 = 29%	6= 7,7%	1

I. Healing without shortening, angulation or impairment of the joint.

II. Slight angulation, shortening or impairment of the joint. Pensions less than 20%

III. Marked angulation, shortening or impairment of the joint. Pensions 20% or more

IV. Pseudarthrosis.

The results obtained are distinctly better and therefor we believe that the nailing of suitable fresh compound leg fractures should be preferred to the conservative treatment.

Open oblique fractures and spiral fractures in the distal third and fractures near the joint are not considered to be suitable for the nailing operation, because in these cases it cannot be ascertained whether the nail will forge a stabile union or not. If this question must be answered in the negative (and it is not possible to say in advance with certainty) an infection of the marrow cavity may be expected. An additional wire loop cannot prevent that, which is proved by the experiences made by BOEHLER (1). In those cases the osteosynthesis is obtained by a wire loop(in oblique fractures)or a lane's plate(in transverse fractures) just as my teacher Fritz KOENIG did it and BOEHLER recommends it. In such a case, however, a plaster cast is required which must be kept in place until a final healing is achieved.

c) Fractures of the Forearm.

The course of sixteen out of 17 cases of nailed compound fractures of the arm above the elbow could be observed until a final healing was obtained. In one case a serious wound infection occurred which had extended to the elbow joint and consequently had caused a stiffening of the joint. There is no doubt that this infection was due to the insufficient trimming and the late opening of the wound.

The transverse fracture of the arm above the elbow near the limit of the middle and lower third was complicated because of a five centimeters long transverse wound and the complete separation of the flexor musculature. During the wound excision it was observed that the brachioradialis was torn off at its insertion (the wound was not extended to the elbow). Despite the fact that a paralysis of the radial and of the median nerve existed only the radial was exposed. It was not separated (cut through) but at the height of the fracture cleft an endoneural hematoma was observed. After the nailing which was made from the distal side and which resulted in an absolutely stabile osteosynthesis (the X-ray pictures

were destroyed) the wound was drained in the direction of the extension and a suture applied after administering of Marfanil-Prontalbin-powder. After that a plaster splint was applied. The temperature was not higher than 38° and consequently the drain was removed on the second day. In the evening the temperature rose to 39,2°. No symptoms of reaction appeared and so the wound was not opened. The temperature stayed between 38 and 39 and the wound seemed to come to a primary healing. An edematous swelling of the area of the elbow joint and of the forearm was observed. Eight days after the operation the temperature climbed up to 40° and after the opening of the wound plenty of pus was drained off. After that we observed abscesses at the elbow joint and on the forearm and a casting off of large necrotic muscle and fascia parts. The elbow joint became stiff. The paralysis of the radial and of the median nerves was not getting better and the final result was: a stiffening of the elbow joint which stands at an angle of 110°, a considerable stiffening of the wrist and contractures of the fingers with a paralysis of the radial and of the median nerves. Despite the bony healing of the fracture several sequestra were cast off at the fracture cleft. The nails were removed four months after the accident. But also after the extraction of the nails several sequestra were cast off at the fracture site and at the nail insertion site and fistulae were observed again and again at the olecranon. Therefore one year after the operation the bone was opened at the nail insertion site and some small sequestra were removed. After that the wounds come to a healing and a late examination two years after the accident (Ill. 49) proved that the wounds were healed without any reaction and inflammation did not occur.anymore.

There is no doubt that the infection was due to an insufficient excision of the wound. It would have been absolutely necessary to expose also the spot of the separation of the brachioradialis and to open this pocket too and to apply a drain to that spot. Sulfonamides are in no case substitutes of a thorough excision of the wound. It may be that the delayed appearance of the infection must be ascribed to those sulfonamides, but it is just because of this dealy that we were mistaken (low temperature) and consequently the wound was not immediately opened. An immediate broad opening of the wound would certainly have avoided the infection of the elbow joint and maybe also of the bone. Under consideration of all these mistakes we had made even a conservative treatment or the application of a wire suture would not have prevented an infection of the fracture cleft. The extension of the infection to the marrow cavity, however, and the formation of sequestra would certainly have been avoided without using a marrow nail. Therefore we agree with BOEHLER that the marrow nail method facilitates the treatment of fractures but at the same time it renderes it more dangerous.

In spite of these facts there is no reason to abandon the nailing method of fresh compound fractures of the arm above the elbow and to apply the old methods once again, if it is possible to obtain a stabile osteosynthesis.

It was proved in the chapter "Fresh fractures" under which conditions this objective can be achieved.

It is our opinion that an additional wire suture or wire loop - as recommended by BOEHLER - is not required. Contrary to the findings in old fractures, the musculature is intact. Therefore the afflicted arm which must be kept in the elevated position during the confinement to bed after the application of a plaster U-splint. When getting up the arm must be held in this direction by means of an arm sling or an abduction splint must be applied. 14 days later when the wounds are healed the elbow must be given some passive motion with the sling in place which may be removed three weeks later at the earliest. In all cases treated in this way we never observed a distraction of the fragments. On the contrary we even observed a pressing together of the fragments which was due to these exercises.

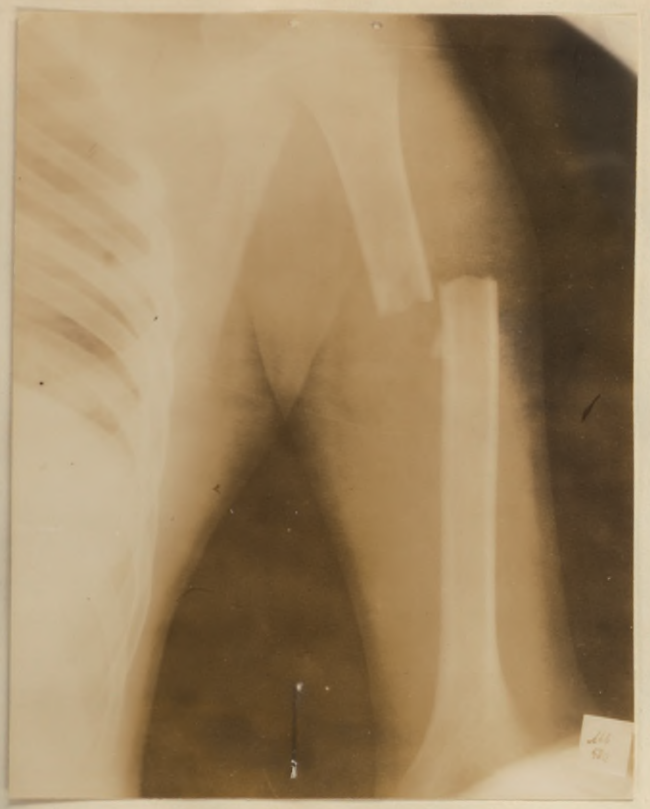
If the nail does not find sufficient hold in the bone it is not only superfluous but disadvantageous. The additional wire suture cannot prevent the nail from getting loose in the bone because of the movements of the limb. As soon as an infection exists this infection will be transferred to the marrow cavity by the nail.

The period of hospitalization, the time of unemployability and the results achieved in our 16 cases are summarized in table VII. Seven out of 24 compound fractures mentioned by EHALT would have been suitable for the nailing method and the results obtained in these cases are compared with our cases.

Table VII. Time of treatment and results obtained in fresh compound fractures in the arm above the elbow:

	Nr.	Duration of stay in hospital	Duration of unemployability	Final results I	II	III	IV
Marrow nailing	16	58 (21-186)	131 (42-325)	15	0	1	0
cons. Treatment (BOEHLER-EHALT)	7	-	168 (47-309)	5	2	-	-

Disregarding the avoidable result III some advantages in comparison to the conservative treatment are clearly noticeable, but the differences are not very great. In case of an infection, however, considerable complications may arise which are due to the nail. Therefore the strictest indication possible is required. All surgeons who are not well acquainted with the treatment of simple fractures and with the technique of the nailing and first of all with the excision of the wound should not nail compound fractures of the arm above the elbow.



a

b

Illustration 50

) Compound transverse fracture of the
rm above the elbow with a torn-out
ound of the soft parts the size of a
mark coin. Wound excision, marrow
ailing from the proximal side. A-
aption of the wound by means of ad-
esive tape, use of drainage. The
rm was put to rest by means of a
AMER splint and an arm sling.

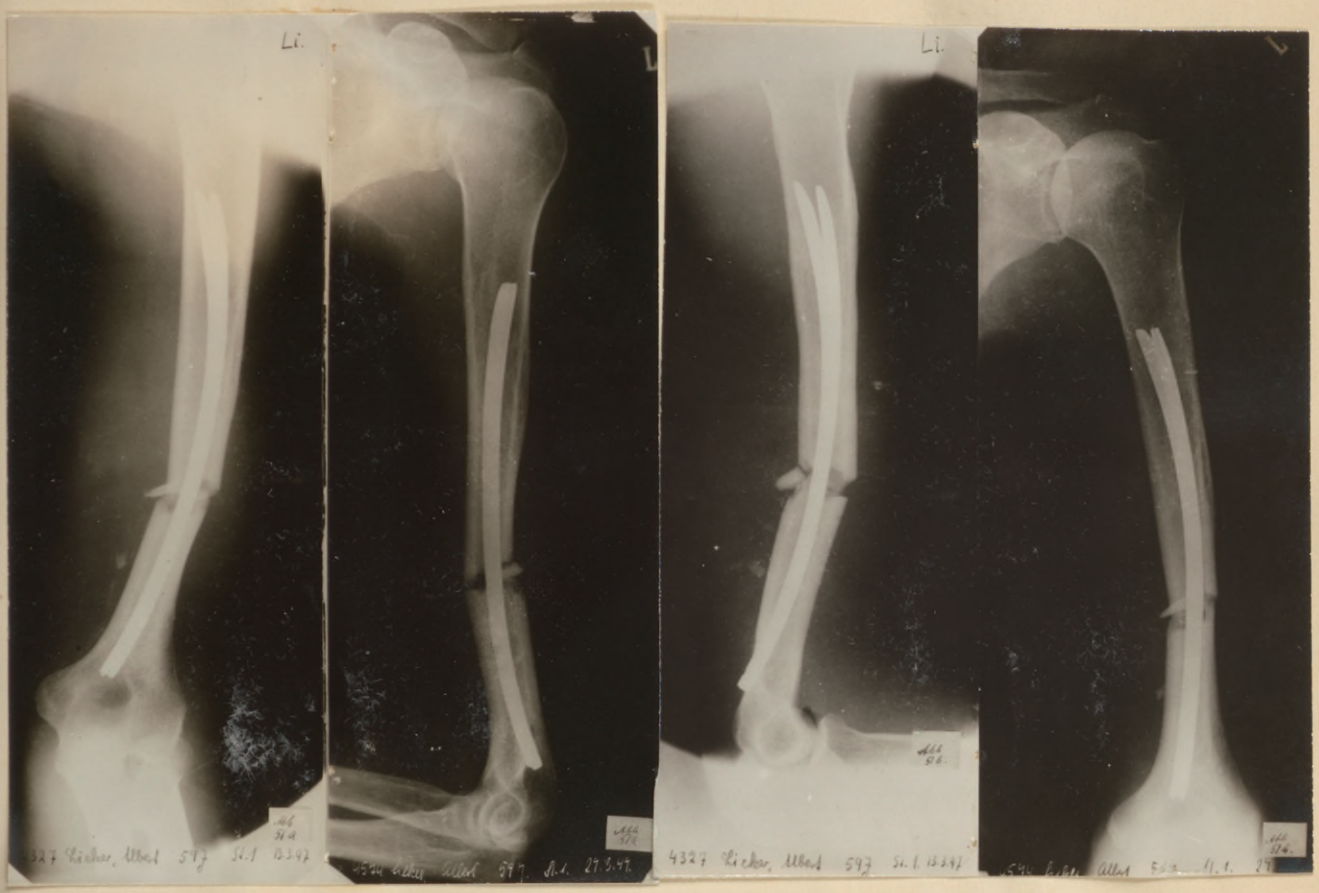
) Same fracture 2 days p.op.,the
emperatures are normal. The drain-
ge was removed and the nail grants
ufficient hold to the fracture.
ound healing per primum. The splint
as removed 14 days later. The limb
s subjected to active exercise with
he arm sling. The patient was re-
eased from the hospital on the 21st
ay, the wound being without any
andage.

) Same fracture 4 weeks p.op. The
nds of the fragments were pressed
ogether by the exercise movements.
eginning formation of callus, no
mpairment of the arm.

) Same fracture 4½ months p.op.,
hich came to a bony healing. The
ails will be removed.

c

d



a b

Illustration 51

a) Open fracture of the arm above the elbow with a torn out wound which is 5 centimeters long - after the nailing. Primary wound excision, adaption of the wound by means of adhesive tape, drainage, which was removed 24 hours later. Primary healing of the wound. 8 days later the patient began subjecting the limb to active exercise.

b) Same fracture 14 days later. It is distinctly visible that the fragments have been pressed together by the exercise movements.

In one case a closed nailing was made after the primary healing of the wound excision. In one case a nail was applied (on the third day) despite the fact that the wound was not yet closed. The wound did not show any symptoms of reaction. Though an infection did not occur this kind of treatment is not suitable according to our own experience. From the technical point of view the open nailing is much more simple and the fracture is immediately immobilized. This helps to fight infection. First of all, however, rather complicated reductions are necessary in closed nailings so that damages of the soft parts cannot be avoided, which are another source of infection.

At the same time we think it is wrong to perform the closed nailing first and then to excise the wound. This procedure had been applied in one case of a wound from which bones projected but an infection did not occur. One never knows (and this is particularly true for small wounds) to what extent the soft parts are damaged and whether or not any dirt or parts of the clothing were brought into the wound by the bone. On the other hand, these foreign bodies may be dislocated by the reduction. First of all, however, the bone ends cannot be carefully examined anymore after the nailing and even the wound cannot be checked as well as in case of a movable fracture.

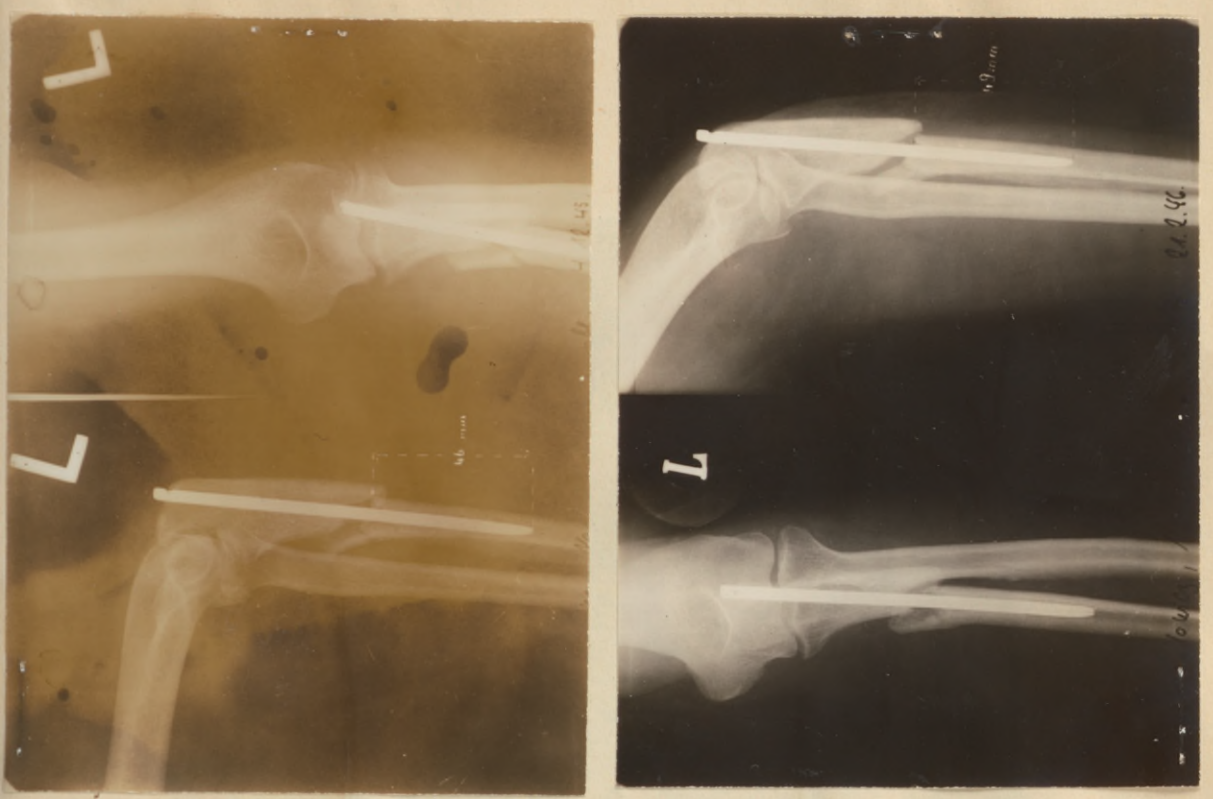
d) Fractures of the Forearm.

In my clinic compound fractures of the forearm were not nailed because according to the experiences made with simple fractures it is not possible to obtain a firm pressing together of the fragments with the nail which is particularly true for all cases in which only one bone is broken. In those cases the wire suture is applied with best result.

Two observations made by other surgeons seem to confirm our own opinion:

In an open ulna fracture with a cast off radius head the fragments were firmly standing one upon the other in a slight valgus position after the nailing (Ill. 52a). The wounds came to a primary healing and the patient was able to begin some exercises, two weeks later and he was released from the hospital three weeks later. Examinations which were made in intervals of four weeks did not reveal any formation of callus and 3½ months after the operation the fracture was distracted (Ill. 52b). The nail was removed four months later and the final result was a "tight" pseudarthrosis (Ill. 52c).

In the fracture demonstrated by Ill. 53a, which was complicated because of a serious damage of the soft parts in the distal third, a nail inserted into the radius burst the bone because the marrow cavity was very narrow.



a b

Illustration 52 a + b

a) Compound fracture of the ulna 4 weeks after the nailing. Healing of the wound after the operation. The patient started subjecting the limb to active exercise movements 2 weeks p.op. He was released from the hospital three weeks p.op. Now he is able to use the arm. The fragments stand firmly one upon the other. The nail was too short.

b) Same fracture 3½ months p.op. The fracture was distracted by the jamming effect of the radius and the nail slipped out of the distal fragment for 3 millimeters. No formation of callus is observed.

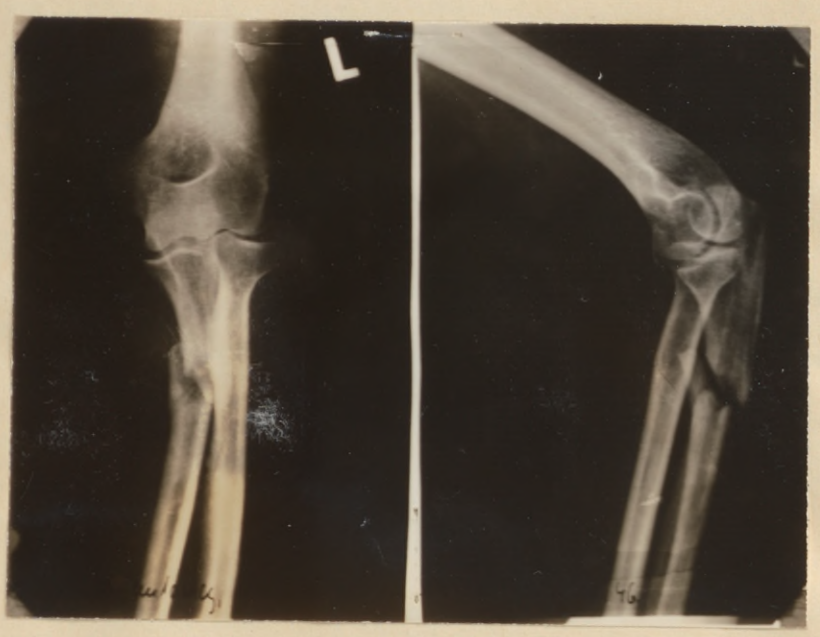


Illustration 52c

Same fracture 4½ months p.op., after the removal of the nail. Tight pseudarthrosis. The impediment of the arm is negligible.

The ulna fragments were united by means of a wire suture. (Ill. 53b). After that the radius fracture cleft was still somewhat gaping. The wounds which were kept open healed per granulationem. Three weeks later the cast was removed and the afflicted limb subjected to some exercises. In consequence of this a displacement of the ulna fragments occurred which caused a pressing together of the radius fragments. In spite of this condition not even the slightest formation of callus was observed ten weeks later (Ill. 53c). (The treatment has not yet come to an end). It is our opinion that according to the above mentioned experiences made with fractures of the forearm and which show fistulae, compound forearm fractures are not suitable for the marrow nail operation.

e) Summarization:

Any success of the nailing of fresh compound fractures depends largely on the technical correct wound excision (just as in any other compound fracture treatment).

The suture of the skin is always dangerous and its application should by no means be enforced. The wound margins should be adapted by means of 3 broad bands of adhesive tape. This procedure is much better than suture of the wound.

If it is not possible to obtain a tensionless union of the skin margins it will be much better to not attempt their union. If possible the bone should always be covered by soft parts. In case of the leg, transplants of skin may be required.

If the 8-hour limit is passed or if the wound is covered by some greasy dirt, the wound must by all means be kept wide open.

The marrow nailing is not indicated in case of an acute infection.

Open fractures should be nailed only if (at least temporarily) a stabile osteosynthesis can be obtained. In this connection we should desist from any attempt to stabilize the fracture by applying an additional wire suture. If a stabile union with the bone cannot be obtained by the nail it will be better to not apply it because in case of an infection the nail will facilitate the spreading of that infection.

If an infection occurs the wound must immediately be opened otherwise most serious complications may occur.

An additional immobilizing cast should be applied in all cases of nailing operations which must be kept in position until a danger of infection no longer exists. In this case the drain should be inserted at the most dependent point.

The nailing of fresh compound thigh fractures, however, is so advantageous in comparison to all the other methods if a stabile osteosynthesis can be obtained - that it must be considered to be the method of choice.

a b

Illustration 53_{a+b}

a) Complicated fracture of both forearm bones with serious damage of the soft parts. Excision of the wound, nailing of the radius and wire loop round the ulna. The wounds are kept open, only the soft parts above the bones are sutured. Plaster cast.

b) Same fracture after the operation. The marrow cavity of the radius is very narrow and consequently the ulna nail cracked the proximal fragment. The fracture cleft of the radius is still gaping. Healing of the wound per granulationem without infection of the bone. The wire loop round the ulna is insufficient, it is located in the fracture slot proximally. Healing of the wound per granulationem, the cast was removed 3 weeks later.

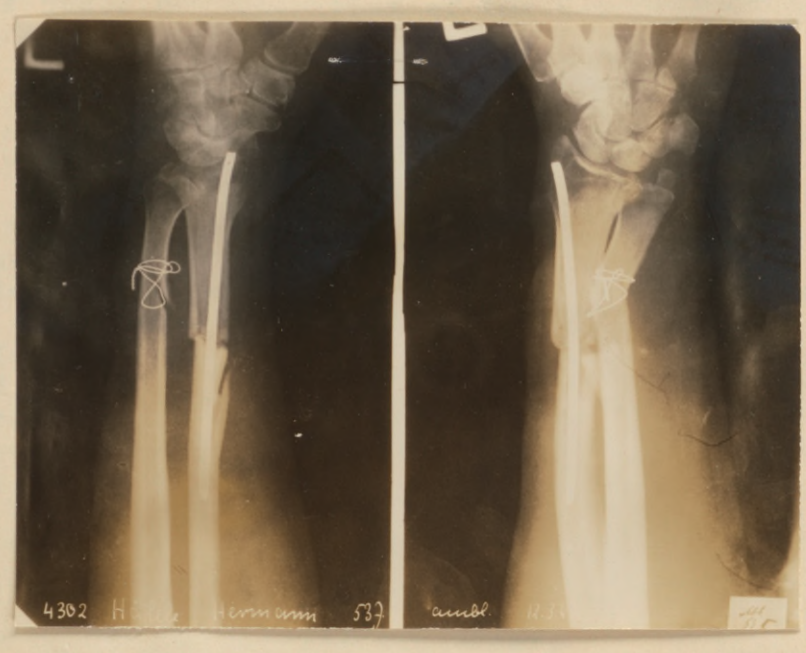


Illustration 53c

Same fracture 6 weeks p.op. The ulna is angulated in valgus position. The fragments of the radius are now pressed together (The treatment has not yet come to an end).

If under consideration of the location of the fracture site only a relatively stabile osteosynthesis can be expected it will be suitable to excise the wound first and then to wait for a primary healing with the limb in wire extension. 2-3 weeks later the closed nailing may be performed.

The suture of the wound is especially dangerous in fresh compound leg fractures particularly in those cases in which the osteosynthesis is only relatively stabile.

In these cases the results obtained with the nailing method are better in comparison to those obtained by the conservative treatment under the condition that the nails are applied in the technically correct way and the osteosynthesis is at least relatively stabile.

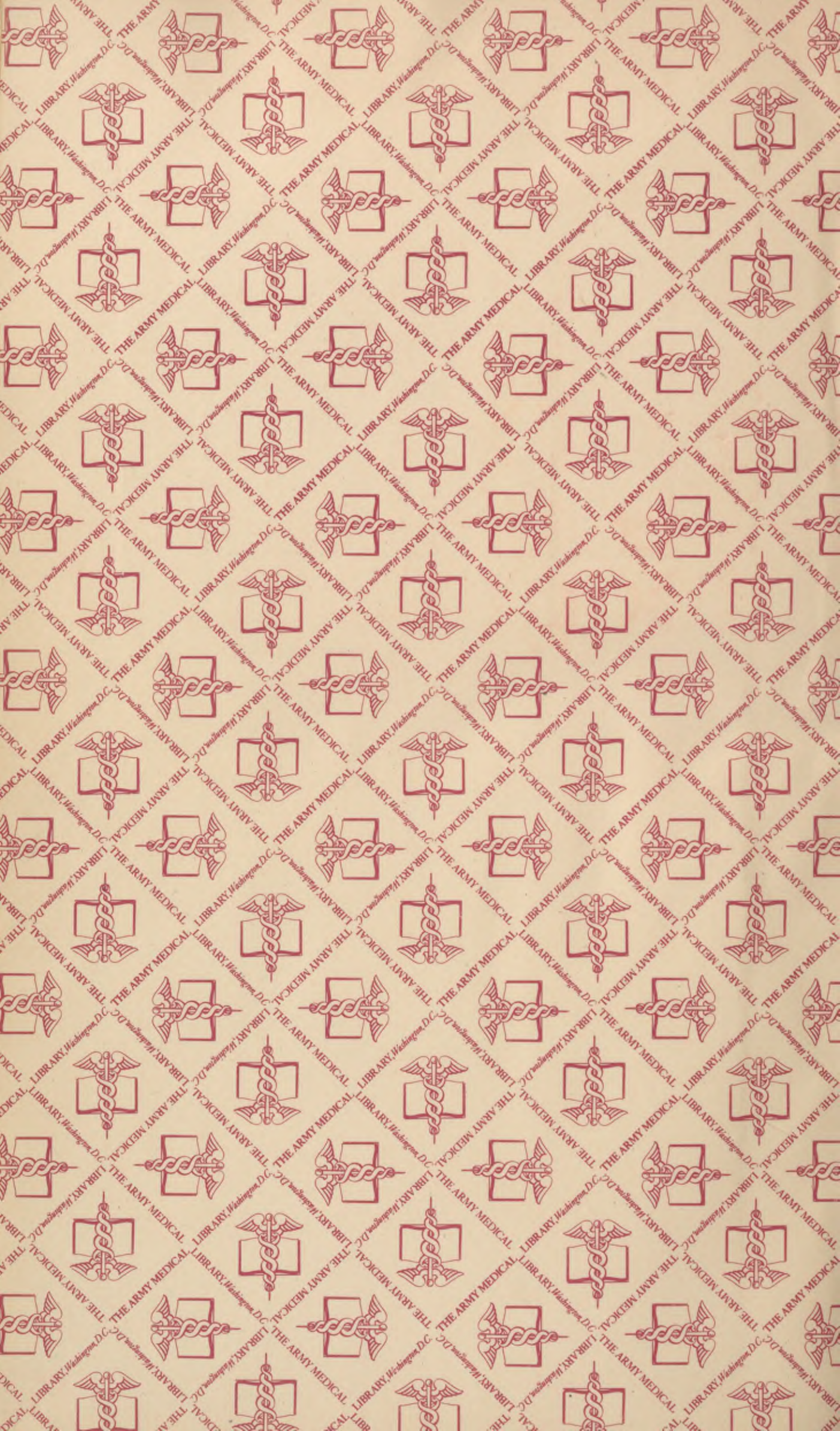
In cases in which the osteosynthesis is only relatively stabile special attention must be attached to the removal of the additional protecting cast and to weight bearing, otherwise late abscesses may occur.

Open oblique and spiral fractures and proximally located fractures are unsuitable for the nailing method. In these cases it will be better to treat the fractures either conservatively or by means of the old methods of osteosynthesis.

In fresh compound fractures of the arm above the elbow the results obtained by the nailing method are not considerably better than those by a conservative treatment. It is a matter of fact that the marrow nail method is much more simple but in cases of infection the dangers arising from the nail are much more serious. These dangers are not observed in other methods. Therefore the most strict indication possible is required and the marrow nail operation should be made only by those surgeons who dispose of sufficient experience in treating closed fractures.

If a nailing is indicated the operation should be primarily and open.

In fresh compound fractures of the forearm the marrow nail method does not show any advantages. Therefore it will be better to treat fractures of that kind by means of the old methods of osteosynthesis in consideration of the dangers arising from infection.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