UNITED STATES FLEET
UNITED STATES NAVAL FORCES, GERMANY
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ATTN.: TECHNICAL SECTION (MEDICAL)
Room 111, Headquarters
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APO 403, U.S. Army

File: P 3-5
Serial: 252-Med. 20 October 1948

From: Senior U. S. Naval Liaison Officer, EUCOM HQ.,
Attn: Technical Section (Medical), APO 403, U.S.Army
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 Nailing) - Additional Translation - Forwarding of.

Reference: (a) Letter P 3-5, Serial 243-Med, dated 22 April 1948 from Assistant Technical Officer (Medical) U.S.Naval Forces, Germany.
Enclosure: (A) Copy of Subject Translation (Project II, Folio V) Discussion of other uses of the medullary nail, by Professor Dr. D. HAEBLER.

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

2. Folio IV of the same project was forwarded with Reference (a) and contained a review of the treatment of fresh fractures of the upper and lower limbs with the medullary nail. Folio V represents the continuation of the same publication by Prof. Dr. C. HAEBLER and contains a discussion of other uses of the medullary nail.

3. The editing of this folio was completed by Commander Harry J. ALVIS,(MC), USN., as Head of the Medical Section before his return to the United States. The mechanical completion of the folio was continued by a portion of the Medical Section which is presently operating under the administrative supervision of the Senior U.S. Naval Liason Officer, EUCOM HQ., APO 403.

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 Attention is invited to the fact that this folio is from an unpublished manuscript prepared for the U.S. Navy and publishing rights are therefore a property of the Bureau of Medicine and Surgery, Navy Department.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 this folio is limited. It will be forwarded to the Bureau of Medicine and Surgery, Publications Division, on a Government Bill of Lading. Requests for additional copies or further distribution should be directed to that office.

N. W. ABRAHAMS,
Captain, U.S.N.
Senior U. S. Naval Liaison Officer.

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

PART II a

by

Prof. Dr. C. HAEBLER

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Translation prepared by:

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

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a) Fractures of the Femur due to gunshot injuries.

5 fatal cases occurred all in femur fractures, so that this type of fracture has the relatively high mortality rate of 10%.

3 fatal cases which were treated outside our clinic have been dealt with in detail in another place (HAEBLER, a.a.O. page 29 and Arch.Klin.Chir. 207, (1944) page 517). The cause of death in one cases was sepsis due to an insufficient treatment of the wound infection, in one case death due to fat embolism and in the third case by operating shock.

Patient Nr.4 who was also treated outside our clinic also died from operation shock.

This patient suffered from a 4 months old fracture due to gunshot injury which was still fistulating and the X-ray picture revealed several sequestra. On the third day on the occasion of an inspection of the wound, a collapse and stagnation of the respiration occurred after the administration of 3cc. of Evipan, so that the operatio was postponed. 14 days later a blood transfusion (O donor) had to be interrupted because of nausea and labored breathi and in the following days the treatment was always jeopardized by a pronounced vasolability. Although an intensive treatment of the general circulation had been carried throug during three weeks prior to the operation and although the patient endured the removal of 6 large sequestra without special difficulty, the pulse rate rose to 140 when the connective tissue scars of the fragments were mobilized. The nailing was performed in spite of this situation and offered no difficulties. The general circulation did not recover although infusions and heat stimulants had been administered during the operation. The patient died 9 hours after the operation. The post mortem findings revealed a fatty degeneration of myocardium and liver and a generalized anemia, but no fat embolism.

There is no doubt that the nailing caused the death in this case. The nailing of a femur fracture is a major operation no matter how smooth its performance may be. This fact must be borne in mind especially in fractures due to gunshot injuries which not infrequently have only a "vita minima".

The case Nr. 5 was a late casualty having no direct connection with the marrow nailing operation.

The patient in question suffered from a one year old compound fracture of the femur which still drained pus with offensive odor and in which a 3 centimeter long tubular sequestrum had developed. Knee-and hip joints were stiffened to a considerable extant. Repeated attacks of colic and large numbers of leukocytes in the urine suggested the formation of calculi in the left kidney although stones could not be demonstrated.

Considering the atrophic bone we did not proceed to the nailing without hesitancy as a last attempt to save the limb. The patient, an active officer, insisted upon having the operation performed. The osteosynthesis was stabile in the beginning. The nail loosened very soon, however, so that rotary movements of the distal fragment became possible. Four weeks after the operation, we observed in addition to a large decubitus on the os sacrum, an empyema of the knee joint. The decubitus did not heal in spite of a permanent bath and other measures and the general condition of the patient became worse, so that the limb had to be amputated in the thigh eight weeks after the marrow nailing operation. The patient recovered at first. Later we observed gravity abscesses, septic hemorrhages and infection of the hip joint. After the resection of the hip joint, the general condition of the patient improved and the decubitus finally healed. Eight months after the nailing a nephrectomy had to be performed because of a purulent kidney with calculi. Still four weeks later an erysipelas spread from the stump of the thigh and finally caused the death of the patient.

Although the marrow nailing did not directly cause the death, it is probable that at least the metastatic infection of the knee and hip joint could have been avoided without the nailing. There is no doubt that the irritation which was necessarily caused by the nailing must have favored the infection of the stiffened joints.

<u>It must therefore be concluded that the nailing operation of a still purulent fracture should not be performed if the joints are stiffened to a considerable extent.</u> As a matter of fact it can hardly be avoided that these joints are (even unintentionally) mobilized in the course of the operation and this creates the hazard of a spread of the infection.

BOEHLER (technique of the treatment of bone fractures, Vol. III, 1981, Vienna 1944) has challenged me to prove that the treatment of infected fractures (of the upper arm) is shortened by the use of the nail. This is difficult to prove, since we do not know in the conservative treatment how long the fractures will continue to fistulate. It is also difficult to prove that the results are good, because in the majority of the cases the patient came already with considerable stiffenings and shortenings.

## Table IV

### Marrow Nailing in old Fractures due to gunshot injuries.

| | Number of cases | Bony healing | Accompanied by formation of sequestr. | Accompanied by Osteo-myelit |
|---|---|---|---|---|
| Osteotomies, wounds healed for more than 9 months | 8 | 8 | 3 | 1 |
| Osteotomies, healed for 2 - 3 months | 5 | 5 | 1 (+1) | 1 |
| Osteotomies healed for 6 weeks | 4 | 4 | (1) | - |
| Pseudarthroses 8-18 months old, with wounds healed for 6 - 7 months | 4 | 4 | 2 | 2 |
| Pseudarthroses 8-18 months old ,with wounds healed for 3 to 5 months. | 3 | 3 | (1) | - |
| Old fractures 6-14 weeks old, wounds healed for 6 weeks | 3 | 3 | - | - |
| Old fractures, 1½-12 months fistulating | 19 | 19 | 10 | [ 1 ] |
| Old fractures, 4 to 12 weeks, purulent | 7 | 7 | 7 | - |
| Total of fractures, the wounds of which were healed after less than 6 months or were still purulent. | 45 | 45 | 19 (- 3) | 3 (+ 1 ) |

( ) formation of sequestra after removal of the nail.

[ ] perforation of the point of the nail, para-articula abscess after removal of the nail.

In table VI, we give a survey of the cases of nailed thigh fractures due to gunshot injuries which we observed until the removal of the nail. In the first column, we have included fractures, the wounds of which had been healed for more than 9 months and which would have been also suitable for other methods of osteosynthesis using foreign bodies.

We see first of all that all fractures came to a bony healing and this can certainly be called a good result.

That a formation of fistulae and sequestrae will take place in purulent fractures is a matter of course and will occur in much the same way in the conservative methods. An infection of the marrow can, however, be definitely avoided by the conservative methods, and if the nail would constitute a hazard in this respect, its use should be refused.

In the cases of the seriously purulent fractures we had no osteomyelitis at all. In the fistulating fractures we observed once a case of a gravity abscess in the path of the nail which perforated the bone. Three cases of osteomyelitis were, however, observed in fractures the wounds of which had already healed. Two of these cases have already been described in detail.

In the thigh fracture of Ill. 86, 4 months old, which had healed in a faulty position, (the wounds had healed after 2 months) we observed a completely stabile osteosynthesis. The wounds had, however, been primarily sutured without drainage and when fever, swelling and pulsating pains set in, the surgeon waited 5 days before opening the wounds widely. It is logical that the infectious secretion followed the path of the nail that has the effect of a drain and finally extended into the marrow cavity.

Also in the 8 months old pseudarthrosis in the distal third (HAEBLER, a.a.O. Ill. 11), the wounds of which had been healed for more than 5 months, a primary suture was applied. The osteosynthesis was only relatively stabile in this case. In the distal fragment the nail found only a grip in the spongiosa (Ill. 87). The patient was allowed to use the limb 9 days after the operation. One week later one observed the collection of serum with an infectious infiltration of the adjacent area. The serum was drained by opening the bleb with a tweezer and the infiltration was treated by diathermy. Eight days later the secretion became purulent and fever set in. When the

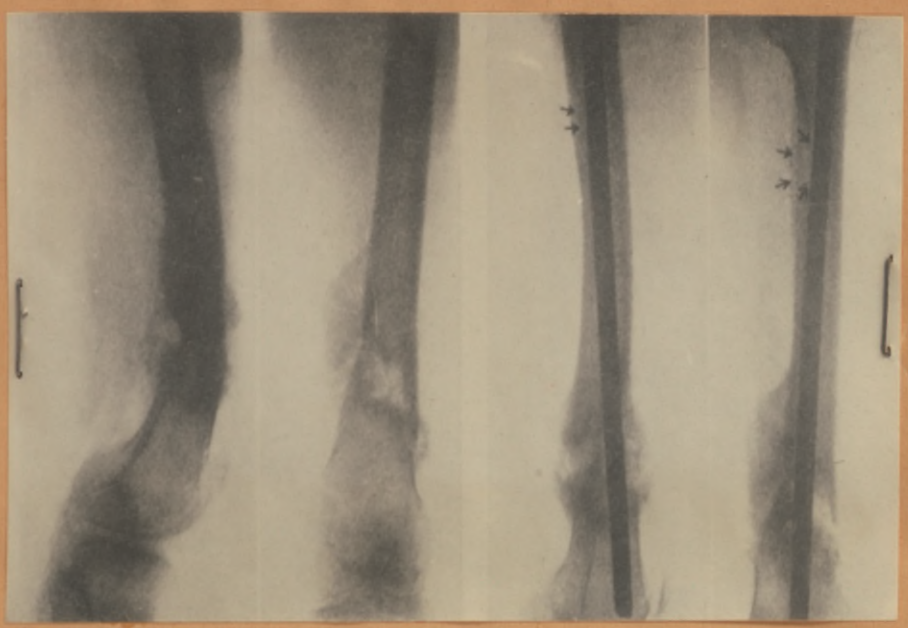
a

b

Illustration 86

a) Four month old gunshot fracture of the thigh which is in poor position. The wounds have been healed for 2 months. Open nailing with primary wound suture without drainage. Application of a VOLKMANN's splint. The day after the operation the temperature rose to 39° C. The patient complained about throbbing pains and a tight swelling of the thigh was observed. The wound was opened on the 6th day after the operation. After that the temperature decreased.

b) The same fracture 4 months after the nailing: Osteomyelitis in the fracture cleft and in the proximal fragment.



a b

Illustration 87

a) Eight month old gunshot fracture in the thigh which had been operated 5 months ago because the fragments were in bad position. At that time a primary wound healing was obtained. The fragments are not yet stabil. Open nailing with primary wound suture without drainage. No additional plaster cast or bandages. Four days after the operation the first attempt was made to subject the limb to weight bearing. One week later the patient suffered from swellings in the fracture cleft. Wound infection.

b) The same fracture 3½ months after the nailing. The osteosynthesis is not stabil. Osteomyelitis in the fracture cleft and in the proximal fragment.

wound was finally inspected (29 days after the operation) the X-ray picture reveals already a clear cut osteomyelitis with its periosteal deposits. An abscess developed at the wound of the trochanter and finally a gravity abscess and an osteomyelitis which spread as far as the subtrochanteric areas (Ill. 87b) and necessitated even after the removal of the nail (3½ months post-operative) several sequestrotomies. The final result is a difficult treatment which lasted for more than two years and resulted in a considerable stiffening of the knee joint. The nail can, however, not be blamed for this poor result. It is rather due to the unsuitable treatment.

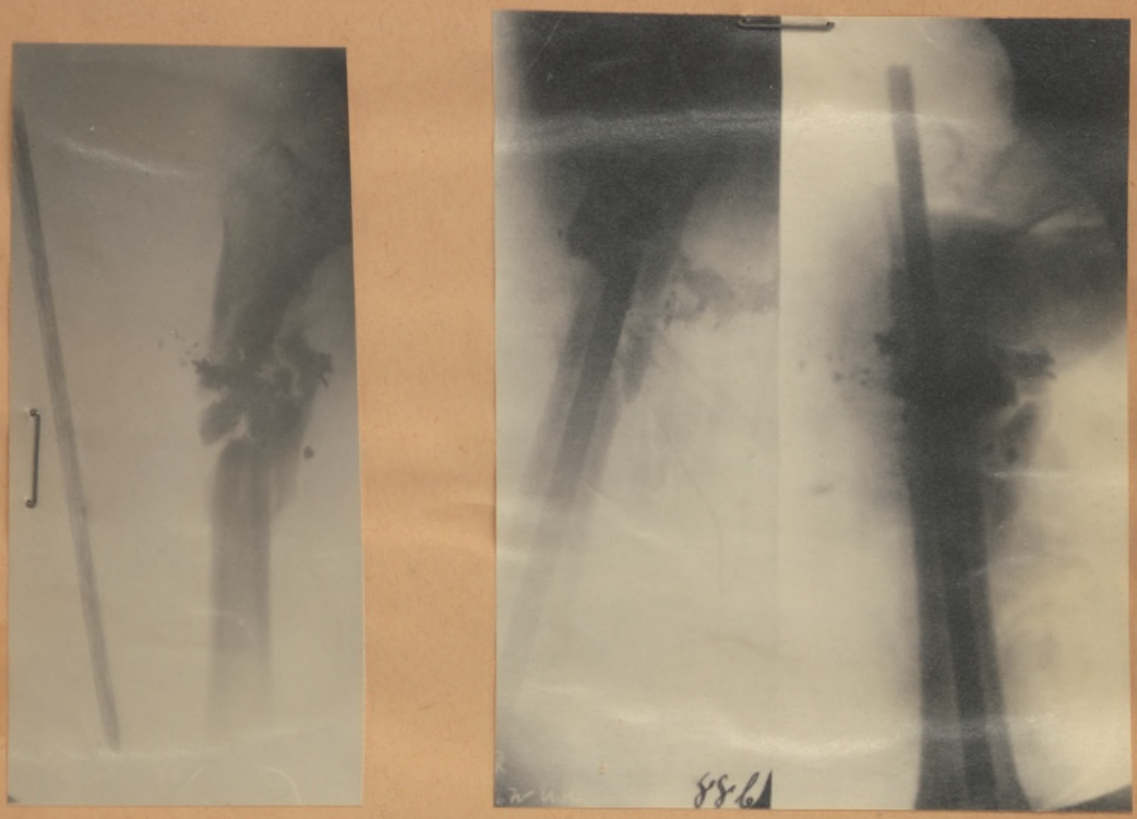
The fixation of the fracture would certainly have been possible by conservative treatment, for we read in the operation report: "with a view of reducing the fragments and of driving the marrow nail in the distal direction, it became necessary to separate the fracture cleft widely which was not easy to perform. Although the fracture is not solid we observed considerable masses of callus at the posterior part of the cleft". Impatience of the surgeon (and of the patient) as BOEHLER says influenced the indication in this case. This impatience is confirmed by other facts: osteotomy because of faulty position , justified and correctly performed, then plaster cast, additional fruit diet, Vitamin C and diathermy "because the callus formation was only slight after five weeks". After 8 weeks removal of the plaster cast, VOLKMANN's splint, diathermy, calcium, C-Bion and massage" because "more properly, although the fracture was still movable". As could not be expected otherwise, it came to a posterior angulation of the distal fragment. The limb was left on the VOLKMANN splint and the fracture was loaded with a sand bag, a measure which is never of any use. Two weeks later, that is 3 months after the osteotomy, BECK's drilling was performed and a walking cast was applied after another 4 weeks. When after 4 weeks the X-ray picture did not reveal enough callus it is "considered whether a marrow nail might bring the necessary fixation and stimulate the formation of callus. The nail could at the same time compensate the antecurvation." If one had applied a walking cast after the osteotomy or at least corrected the antecurvation under anaesthesia and then left the walking cast in position long enough, the fracture would have healed quicker and with a better result.

That the delayed opening of the wound is responsible for the spreading of the infection into the marrow is confirmed by the localization of the osteomyelitis which developed in both cases in the proximal fragment, where the lowest amount of mechanical counterpressure prevails that is in the path of the nail due to the drainage of the nail towards the soft parts above the trochanter. It does not spread into the distal fragment because the spongiosa and the bone mantle do not offer any "outlet".

The reaction is different if the nail does not have a firm hold in the bone. The nail will then permit tilting movements when the limb is used and will force or suck the secretion into the empty spaces. This result was observed in an osteotomy nailing of an 11 months old fracture due to gunshot injury, the wounds of which had healed 10 months prior to the operation. A drain and a plaster cast was applied when an osteomyelitis developed. In this cast it came to a decubitues of the heel which was incised and two weeks later to the infection of the fracture.

Also the osteomyelitis of the 8 months old comminuted fracture (Ill. 88) is due to the fact that the nail did not obtain a firm hold.

> The patient whose wounds had already healed six months before was admitted to the special ward because of a faulty position and "absence of callus formation and imminent pseudarthrosis". We were influenced by this statement when we decided to nail the fracture by the open method, although clinically the fracture had solidified to a considerable extent. I overlooked that it would be necessary to remove most of the transversely located bone splinters which would imply a considerable shortening. When checking the medium sized nail in position (Ill.88a) by means of an X-ray picture it was overlooked that the distal marrow cavity was too wide for this nail. The nail was driven in as far as the spongiosa of the epiphysis, so that at first the fracture was fixed (Ill.88b). The wound which was drained and closed by approximation suture had to be opened shortly after the operation because of a venous hemorrhage. The vessel could not be located so the wound was tamponated. The primarily closed wound of the trochanter was not opened. A dorsal plaster splint extending up to the pelvis was applied. One week later the tampon was removed, there was little secretion from the wound and the patient was free from temperature. Six weeks after the operation a rise of temperature and an abscess at the wound of the trochanter were observed, which was opened widely. Soon afterwards an abscess occurred at the fracture cleft, from which metal splinters and sequestra had to be removed.



a b

Illustration 88

a) Eight month old gunshot fracture of the thigh. The wounds had healed more than six months ago. Poor formation of callus. The nail is too short for the broad marrow cavity of the distal fragment. (The lines of the shadow of the nail were drawn on the illustration).

b) The same fracture after the nailing. The splinters which are lying obliquely must be removed in order to be able to insert the nail and to press the fragments together. In this way we obtained a shortening of 9 centimeters. The nail had been driven into the spongiosa and thus granted a good hold for the fracture. Infection of the wound and formation of abscesses in the fracture.

c d e

Illustration 88

c) Six months after the operation. Increase of temperature and circumscribed painfulness above the knee joint. Marked rarefactions around the nail tip. After that the wounds were opened and the leg was kept in an elevated position. Decrease of temperature.

d) Eight months after the operation. After the patient had subjected the limb to exercises after the manner of walking during his confinement to bed another increase of temperature and the formation of an abscess above the knee joint was observed. Marked periosteal layer in the distal fragment. The fracture healed and therefore the nail was removed.

e) 17 months after the operation. The fracture is healed and the wounds are closed. The shortening amounts to 9 cm. The knee is stiff and the impediment of the hip joint amounts to 50 %. Fractures of this kind are better treated conservatively.

Plaster cast, decrease of temperature, but strong pus secretion especially from the wound of the trochanter which subsided only very slowly. Six months after the operation there was again an increase of temperature and pains above the knee joint. An effusion into the joint did not exist. The X-ray picture (Ill. 88c) showed in addition to a loosening of the structure next to the point of the nail, a distinct rarefaction. Therefore elevation of the limb and wider opening of the wounds was prescribed. The result was a decrease of the temperature. When the secretion of pus subsided, treading exercises in the bed were instituted, which had to be stopped immediately, however, because of pains at the site of the fracture and increase of the temperature. Three weeks later an abscess above the knee joint had to be opened. The joint was not involved, rough bone was not palpable. The rarefactions at the point of the nail did not increase, but distinct periosteal deposits could be ascertained along the medial side of the whole distal fragment. (Ill. 88d). As the bone is obviously solid, the nail is removed 8 days later. Sequestra had to be removed repeatedly from the fracture cleft and the healed wounds broke open several times. The patient could be discharged from the hospital only 17 months after the operation. The final result (Ill. 88e) was a shortening of the limb by 9 cm., stiffening of the knee joint and impediment of the mobility of the hip joint by 50%.

This fracture should not have been nailed. Mobilization under anaesthesia with subsequent wire extension and plaster would have secured a quicker healing and the considerable shortening could have been avoided.

It must always be borne in mind when dealing with <u>comminuted fractures</u> that the shortening will become greater by the use of the nail than would be the case in the conservative treatment, so that the nail will not bring substantial advantages and is better not used.

If infections occur, it is imperative to open the wounds of the trochanter widely and to elevate the leg, so that no accumulation can take place in the distal fragment. The knee must be in a <u>higher</u> position than the operative wound and the wound at the trochanter.

We have suggested before that the leg be kept in a horizontal position after the operation, so that the drain becomes the deepest point and declined to use BRAUN's splint because with its use, the wound at the trochanter will be the lowest point and the secretion of the wound which is still suspected of carrying infectious matters could follow the nail in an upward direction. This

is not quite correct since the knee is generally in a lower position than the trochanter if the limb is in a horizontal position, especially so if a dorsal plaster splint or a plaster cast in the extended position is applied. The knee must in every case be kept at a somewhat higher position.

The osteosynthesis of the fracture (Ill. 89a) was only relatively stabile.

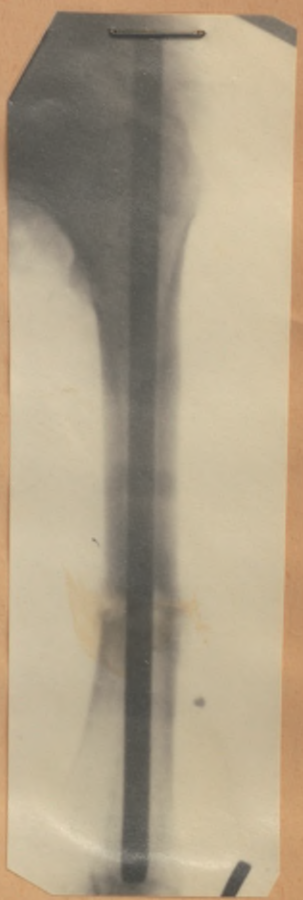
When the patient was admitted to our hospital 10 months after the injury, the fracture was still fully movable and the wounds had healed 3 months before. As the other leg was amputated we did not need to take a shortening into consideration and we resected the proximal fragment to the extent that the fracture could be easily reduced. The nail had to be driven into the spongiosa to obtain a firm hold. The wounds at the fracture and at the trochanter were drained and a pelvic plaster cast was applied. Four weeks after the operation when the wounds had healed, the plaster cast was removed and treading exercises in the sick bed were instituted as the fracture was clinically solid. (Ill. 89b). Two weeks later an increase of temperature occurred, the wound at the fracture site broke open and inspection revealed an abscess cavity at the fracture the size of a fist, which was due to the fact that the nail had loosened. The X-ray picture revealed already (Ill. 89c) the rarefactions next to the point of the nail which were lined by a distinct margin. When, after a position at rest the secretion subsided, movement exercises were again instituted and the result was a prompt increase of temperature and increased excretion of pus. Only 5 months after the operation when the X-ray picture (89d) revealed a distinct formation of callus, could the movements be performed without pain and without causing an inflammation of the wounds which had healed in the meantime. Soon afterwards the patient could use his limb and 6 weeks later the fracture was healed to an extent that allowed the removal of the nail, ($6\frac{1}{2}$ months after the operation, (Ill. 89e)). This illustration reveals an irritation space next to the relatively large rarefaction at the point of the nail. This rarefaction is, however, merely due to mechanical influence (in contrast to the rarefaction of Ill. 88d) because the limb was always put at rest and elevated in due time, so that no accumulation could occur in the distal fragment.

a b

Illustration 89

a) Ten month old gunshot fracture of the left thigh. The wounds had been healed for three months. No formation of callus to be observed. The right leg was amputated.

b) The same fracture 4 weeks after the open nailing. During this operation so much of the proximal fragment had been resected, that it was possible to obtain a good reduction. The wounds are healed and from the clinical point of view the fracture is stabil. The osteosynthesis is only relatively stabil. The patient begins subjecting his limb to exercises after the manner of walking while still in bed.



c d e

Illustration 89

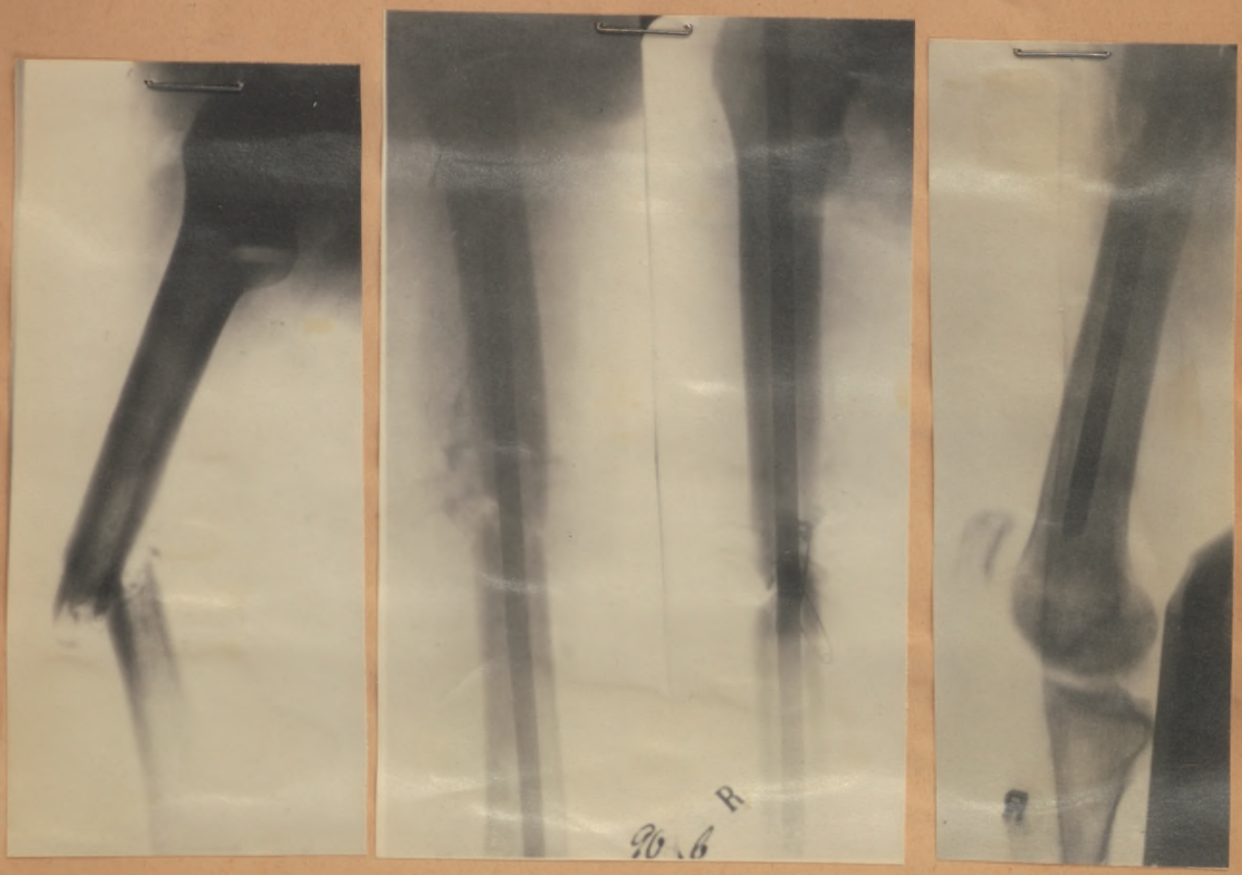
c) The same fracture 14 days later. The temperature had increased and an abscess in the fracture cleft was observed. The rarefactions round the nail tip prove that the nail became loose. Once again the fracture was immobilized by a plaster cast. After that a decrease of temperature and suppuration occurred.

d) The same fracture 5 months after the operation. Marked formation of callus. No osteomyelitis. The wounds are healed. From now on exercises and weight bearing do not show any reactions.

e) 6½ months later. The fracture is healed and the nail has been removed. An irritated margin around the nail tip is clearly noticeable.

It must thus be concluded that all wounds must be opened widely if an infection occurs, this is especially true if the osteosynthesis is not fully stabile. It is furthermore necessary to prevent, by appropriate position of the limb, that no sagging towards the distal fragment can take place. This sagging and penetration is a hazard which is still present after the removal of the nail, especially if the wounds are still excreting pus.

In the 3 months old fistulating fracture due to gunshot injury (Ill. 90a) which was in a bad position and showed little formation of callus, it was decided to perform the removal of the sequestrum and the nailing in one session. Because of the wide distal cavity, the nail had to be driven into the spongiosa (Ill. 90b) in order to obtain at least a relatively stabile osteosynthesis. A drain was applied at the trochanter and at the fracture a plaster cast was used. Temperature returned to normal and the secretion of pus subsided soon afterwards. The plaster cast was therefore, replaced by a plaster splint 4 weeks after the operation. The X-ray picture revealed a distinct dystrophy of the condyles of the femur and a very subtle rarefaction next to the point of the nail which we overlooked (Ill. 90c). Four weeks later the pus secretion increased and several abscesses due to gravity developed which subsided only after the renewed use of a pelvic plaster cast. A sequestrum had to be removed from the fracture site 6 months after the nailing. The fracture was bridged over by good callus (Ill. 90d) and the plaster cast was removed. The purulent secretion did not subside and the nail was finally removed 7 months after the operation. The limb was put at rest in a plaster splint in a horizontal position. Two weeks later a diffuse swelling in the area of the knee joint without effusion was observed which subsided by the use of wet cataplasmae. Two months after the withdrawal of the nail a paraarticular abscess had to be opened. Rough bone was palpable above the lateral condyle and a perforation on the extension side was noted (Ill. 90e). This perforation was still visible in the X-ray picture four months later when the fistulae were closed and when the path of the nail was hardly recognizable (Ill. 90f). The patient was discharged from the hospital 13 months after the operation. The fracture had healed without shortening but the knee joint was stiffened to a considerable extent. The bones were at that time still dystrophic the site of the perforation was hardly recognizable (Ill. 90g).



a b c

Illustration 90

a) Three month old fistulating gunshot fracture which is in bad position (not treated in our hospital). Slight formation of callus. The fracture is not yet stabil. Formation of sequestra in the fracture cleft.

b) The same fracture after the open nailing. The distal marrow cavity is too broad for the nail and consequently it must be driven into the spongiosa. The osteosynthesis is only relatively stabil. Application of a plaster cast.

c) The same fracture four weeks later. Slight suppuration. The temperature is normal. Slight rarefactions around the nail tip, which proves that the nail does not find sufficient hold. This, however, was not observed and the plaster cast was replaced by a splint. Marked suppuration four weeks later which subsided only after the application of a pelvic plaster cast.



d e

Illustration 90

d) Six months after the operation. A sequestrum which developed at the fracture has been removed. The fracture cleft is bridged over by good callus. Four weeks later the nail was removed. After that we applied a plaster splint with the limb in the extended position.

e) Two months after the extraction of the nail, 9 months after the operation. Para-articular abscess in the knee. A perforation of the bone on the extensor side is observed.


f g

Illustration 90

f) The fistulae were closed 4 weeks later. The fracture is healed. The place of perforation however is still distinctly visible.

g) 13 months after the operation. The fracture is healed in good position without shortening. The knee is stiff to a considerable extent. The bones about the knee joint are still atrophic.

The above case illustrates a serious mistake. The attention was always focussed on the fracture cleft and no attention was paid to the point of the nail. The point of the nail is only to be seen in one of the X-ray pictures (Ill. 90c) (and that is probably due to a coincidence). When comparing illustrations 90d and 90b it becomes evident that the nail has moved laterally and its point has presumably pierced through the bone similar to the case shown in Ill. 88. It was also a mistake that the limb was not elevated after the removal of the nail. If this had been done the infectious secretion could have flowed off through the bed of the nail which is encapsulated by smooth connective tissue and there is a likelihood that the spreading could have been avoided.

An osteomyelitis could be avoided in the above and in the preceeding case because the limb was duly put at rest. Osteomyelitis is not to be feared if the nail has a firm hold and if the wounds are immediately opened widely at the onset of the infection.

In the 6 months old fracture of Ill. 91a, the wounds had healed per granulationem, after the first wound treatment. When the attempt was made 8 weeks after the accident to correct the position under anaesthesia, it came to the formation of an abscess with a tedious secondary healing. Eight days after the healing of the wounds, a nailing osteotomy was performed at another clinic because the fracture had already solidified to a considerable extent. The wounds were sutured primarily, but had to be opened 4 days after the operation because of intense swellings. No pus was found. The fracture was in an axially correct position, but there was a gap of almost 1 centimeter at the fracture cleft (Ill. 91b). Two weeks later the wound had healed without irritation and the patient began to use the limb so that the fragments were pushed together. Eight days later the old fistula broke open again. It was enlarged and the secretion lasted for a long time without any ejection of sequestra. In spite of this, the limb was used without pains but the fracture was not pushed together. The X-ray picture (Ill. 91c) taken 3 months after the operation reveals a slight loosening of the structure at the fracture cleft, but not an osteomyelitis and a distinct still cloudy formation of callus. The nail was removed 6 months after the operation and the fistula still had a slight secretion. After the removal of the nail, the fistula subsided. An attempt to mobilize the knee joint which was already stiff before the operation had little success.

a b

Illustration 91

a) Six month old gunshot fracture of the femur which had healed in a bad position. The wounds have been closed for a week. The knee is stiff and the impediment of the hip joint amounts to 50 %.

b) The same fracture after the osteotomy nailing. The osteosynthesis is stabil but the fracture cleft is still gaping. The primarily sutured wound was widely opened on the fourth day p.op. because of an increase of temperature. Secondary healing within 14 days. The patient began subjecting the limb to weight bearing in order to press the fragments together. Eight days later another reactivation of the fistula was observed which, however, did not cause an impediment of the weight bearing.


c d

Illustration 91

c) Three months after the operation. The fragments were not pressed together. Slight structural rarefactions at the fracture cleft, an osteomyelitis however did not develop. The fracture cleft is bridged over by spongy callus.

d) Eight months after the operation. The fracture is bridged over by bone. The nail was removed 2 months ago. Shortly after that the fistula healed. The hip joint is freely movable, the motion of the knee joint amounts to 10 degrees. A shortening does not exist.

The patient was discharged from the hospital 8 months after the operation. The fracture showed a bony healing without any shortening (Ill. 91d). The defect was completely bridged over (BOEHLER denies such a possibility), hip and ankle joint are freely movable, the knee is movable by 10° .

This example shows that the nail does not constitute a hazard in case of an infection of the wounds and that the nail does not favor the spreading of the infection into the marrow and also the infection of the fracture cleft can be avoided if the wounds are widely opened in due time.

The question whether or not the postponement of the operation assures a greater safety against wound infections is of special importance with regard to the fractures healed with angulation because the chances for the restoration of normal conditions is the less and the operation is the more difficult - and this implies an increased infection hazard - the more solid the callus is. Unfortunately, the reports do not, as a rule, contain any statements as to the blood picture or sedimentation rate which could give valuable hints with regard to the infection hazard. But we still see - if the restricted number of our patient material allows for such conclusions - that the incidence of infections is just as high in the osteotomies which were performed more than 9 months after the healing of the wounds as in the earlier operated ones and that the incidence is even lower in the latter category. This is especially striking in the pseudarthroses of old fractures. The explanation probably lies in the fact that we have done without a suture of the wounds in the operations which were performed shortly after the healing.

The bad results of the nailing operations have intentionally been given so much space because it is only by the mistakes that we can learn and come to a perfection of the indications. Sincerity serves the cause and our patients more than a list of successful operations, the more so, because this might induce the beginner to underestimate the difficulties.

The results of the marrow nailing operations are superior to any other method on the condition that the osteosynthesis is stabile.

All fractures came to a bony healing, including the pseudarthroses which were one year and more old.

Only one instructive example will be given in this connection.

Femur fracture, left, due to gunshot injury on December 27, 1941. First treatment included removal of numerous splinters. Five months extension bandage. In March 1942 osteosynthesis with LANE's plate which had to be removed after 3 weeks because of an infection. Extension bandage until June 1942, then pelvic plaster cast. In October 1942 fixation by means of ivory pins and again (allegedly slight)wound infection. Wounds closed since February 1942. Bony healing fails to develop. In June 1943 admission to the special ward. Wounds firmly healed, abnormal mobility at the site of the fracture, shortening 6 centimeters, knee stiffened in the extended position, patient could only walk with a hinged splint (Ill. 92a). On July 8, 1943, marrow nailing with exposure of the fracture site, removal of the ivory pins and the remnants of the wire, resection of the callus as sparingly as possible. Drain of the approximation suture, splint. Osteosynthesis stabile (Ill. 92b), good healing of wounds. July 15, (one week after operation ) start of movement exercises of the knee joint. September 8, discharge from the hospital. Patient walks perfectly well with a high heel, without limping. X-ray picture: distinct formation of callus, no rarefactions at the point of the nail. (Ill. 92c). The fracture pushed together and the nail pushed out at the trochanter. March 7, fracture healed, the nail which had wandered further in an upward direction was removed (Ill. 92d). The patient was discharged from the hospital 10 days later. Same findings as on September 8. Stay at the hospital after the nailing operation = 73 days. Unemployability = 125 days.

The course, the duration of the stay at the hospital and of the unemployability after the marrow nailing correspond in every respect to what is known in the nailing of fresh fractures, the same is true for all other aseptically healed cases. There are no particulars to be reported in this respect. With regard to the space and to cases described in other places no further descriptions or X-ray pictures will be given in this connection. (HAEBLER a.a.O.,Page 30 and following).

In case of smooth transverse fractures shortenings could be avoided in all cases, the same is true with regard to impediments of the joint in fractures which were not older than 3 months. If the joints are already stiff before the operation a considerable improvement was achieved in all cases with an aseptic course. The shortenings in osteotomies were in all cases considerably improved. These are results which cannot be obtained by any other method.


a b

Illustration 92

a) 20 month old gunshot fracture of the femur. An ivory bolt was inserted 10 months ago in another hospital. The wounds are healed but the fracture is freely movable. The shortening amounts to 6 cms . The knee is stiff in the extended position. The patient uses a hinged splint.

b) The same fracture after the open nailing and extraction of the ivory bolt. Conservative freshening of the bone. The osteosynthesis is stabil. Primary healing. The patient starts subjecting the limb to exercises 8 days after the operation.

c d

Illustration 92

c) Three months after the operation. The fragments were somewhat pressed together by the weight bearing but the nail has partially slipped out of the trochanter. The shortening amounts to 4½ cms. The patient's gait is not hampered when using an elevated heel. He was released from the hospital to his unit for garrison duty.

d) Eight months p.op. The fracture is healed. The nail will be removed. The motion of the knee amounts to 160 - 180 degrees, the hip and ankle joints are freely movable.

Unfortunately we had no possibility to gain experience with Penicillin. It can be expected that the infection hazard can be reduced to a considerable extent.

As a matter of fact it is not always possible to foresee if an osteosynthesis will become stabile and it is dangerous to wait and see, especially if the bone threatens to solidify in a bad position. If it becomes evident during or after the operation, that only a relatively stabile osteosynthesis will be achieved by driving the nail in as far as the spongiosa of the epiphysis, it will become necessary to provide an additional plaster cast from the very beginning. In case of an infection the fixation must be maintained until the fracture has reached an advanced degree of solidification. An important advantage of the nail is then lost and marrow nailing does not excel any other type of osteosynthesis in this case. This cannot be changed, however, and does not outweigh the risks described above. If no infection occurs it will be necessary to check very closely on the patient about 6 to 8 weeks after the operation, as we have seen before, this is the time when the nail begins to loosen in the spongiosa. This condition is indicated by rarefactions next to the point of the nail. As soon as the patient complains about the slightest pain or if swellings occur, it is imperative to insist on bed rest, which must be observed more strictly than in simple fractures because of the possible revival of the infection with all its complications.

The indication for nailing while the wounds are still fistulating or even secreting pus, depends on whether or not the nail constitutes a hazard as regards the spreading of the infection. That this is generally not the case is demonstrated by the fact that an osteomyelitis did not occur, in any of our fistulating femur fractures and also by our experience with the described fistulating femur fracture (HAEBLER a.a.O., page 48, Ill. 15) in which the nail was driven in by mistake up to the knee joint. Although we observed an (irritation) in the knee joint, asepsis was not broken and the condition subsided after 3 days.

As improbable as it may appear, the germs are obviously brushed off the smooth surface of the nail upon entering the scar tissue which closes the marrow cavity. If any germs are spread at all, they are so few that the marrow with its great amount of blood cells can easily cope with them. This mechanical cleansing seems to be almost perfect if the nail enters through solid bone (marginal lamella of the joint). The center of the infection is entirely held up by a dam of granulations as soon as the acute stage is overcome. If this granulation is pierced by the marrow nail it will close again in a very short time and full protection is afforded under the conditions, however, that the nail has a firm hold.

In consideration of these facts, we try to avoid any resection of the fracture ends and severance of the periosteum and adopt the same procedure as in the closed nailing: The nail is driven in by approach from the trochanter (and not as is customary in the open nailing in the reverse direction, that is by approach from the fracture cleft). If the nail has reached the fracture cleft, the fracture is properly reduced (as a rule traction by the assistant will suffice) and the nail or guide rod is directed into the distal marrow cavity with the finger which is introduced into the wound. This manipulation does not offer any difficulties in fractures of the tibia and upper arm. The conditions are far more difficult in femur fractures but this painstaking is worth the while. Only in the nailing carried through in this manner were we able to avoid the formation of sequestra. This may be a mere coincidence. It is rather surprising, however, that an increase of temperature always occurred and that the purulent stage was always very tedious and included the formation of sequestra, if the nailing had been performed by approach from the fracture cleft and especially so, if the fracture site had been widely exposed.

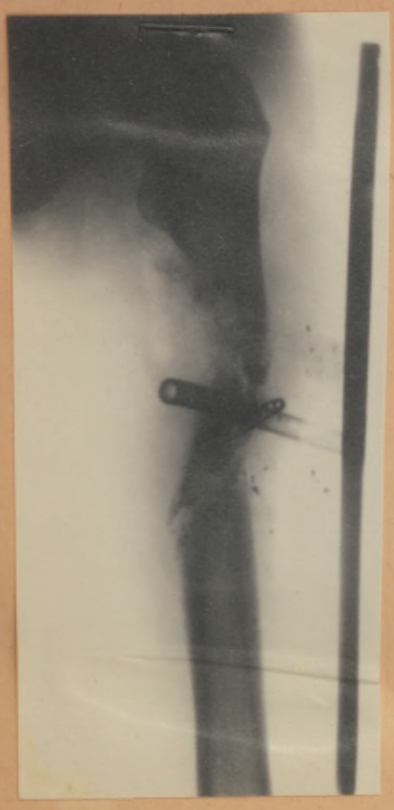
We had no opportunity to nail fistulating fractures which had healed in a faulty position. If after all one decides to nail this type of fracture, the operation should - on the basis of the above consideration - be performed in two sessions: Osteotomy (or rather refracture) of the fracture and extension fixation until the acute sequelae are overcome. If these measures do not prove satisfactory as to reduction and fixation, and only then, the nailing may be performed (after 3 weeks at the earliest, after the fever has subsided).

As set forth in the table we have nailed 7 femur fractures in a stage of most severe purulence. The marrow nail was indicated in these cases, because of purulent formation of sequestra, tubular abscesses or pneumonias and the impossibility of a proper fixation (regardless of position). Only in such emergency cases do we advocate the stabile osteosynthesis with the marrow nail. The perfect fixation which can be achieved with the nail has shown surprisingly good results in fighting infections and improving the general condition

of the patient, as is demonstrated - besides the other cases described above - in the fracture shown in Ill. 93, on which we could check up recently.

Several gravity abscesses had been opened in this 43 days old fracture of the thigh and the patient still had fever of about 40°. The wire extension did not fit the purpose because the patient was very nervous and since we had been able to separate a few loose splinters from the wound, we decided to nail the fracture. The palpable splinters and sequestra were removed without opening the wound very widely. The guide rod was then introduced into the proximal marrow cavity with X-ray control after placing several needles for guides (as is done in the closed marrow nailing) and after that the nail was driven in. When it was about 6 centimeters deep in the marrow cavity the guide rod was removed and the nail driven in until it could be felt at the fracture cleft. The nail was then directed with the finger and could be easily introduced into the distal fragment after appropriate reduction performed by the assistant. It was driven in as far as into the spongiosa of the epiphysis and gave the fracture a firm hold (Ill. 93b). The operation- and trochanter wounds were then drained, the former posteriorly. The limb was kept on a splint in a slightly elevated position.

The patient still had 40° fever on the day following the operation. After 5 days the temperature returned to normal by lysis. The patient was entirely free from pain and recovered well. The wound was still seriously purulent after 4 weeks, but after that it quickly decreased in size and 8 weeks after the operation the patient could start motion. After 3 months, the patient was allowed to be ambulatory. Several gravity abscesses had to be opened later on and when 6½ months after the operation a sequestrum of about the size of a cherry pit was removed, the secretion soon came to a standstill. The fracture revealed after 5 months a good callus formation (Ill. 93c), and the limb could be used. Nine months post-operative the nail was withdrawn with the still fistulating wound. The leg was again put at rest for two weeks, several small sequestra were ejected and finally the fistula closed and the patient could be discharged from the hospital. The hip and ankle joint were freely movable, the flexion of the knee was possible up to 60°. Six months later the same patient suffered from a fracture of the patella of the same leg and this was fixed with a wire suture.



a b

Illustration 93

a) 43 day old gunshot fracture of the femur with foul smelling secretion. A formation of sequestra was observed. High temperature. The immobilization of the limb by means of a wire extension was not sufficient. The patient was very restless.

b) The same fracture after the nailing and after the removal of the exposed grafts. The osteosynthesis is stabil. Immobilization by means of a BRAUN's splint, open wound treatment. Within five days the fever slowly decreased by lysis. 8 weeks after the operation the patient began subjecting the limb to exercises and he was able to get up 3 months p.op.

c d

Illustration 93

c) Five months after the operation. Good formation of callus. The fracture is healed from the clinical point of view and it can be subjected to weight bearing. The wound is still fistulating. Some time later another sequestrum must be removed.

The nail was removed 9 months after the operation with the wound still fistulating. After that several more small sequestra were cast off. Release from the hospital 11 months p.op. The wounds were healed, the hip and ankle joints freely movable, the flexibility of the knee amounted to 60 - 180 degrees and the shortening amounted to 9 cm. The gait of the patient is not impeded when wearing orthopedic shoes. ½ year later a fracture of the patella occurred in the same leg. Application of a wire suture. Primary healing.

d) Three years p. op. Good healing of the fracture without formation of cavities.

The shortening was 9 centimeters and was compensated about 50% by special foot wear. Hip and ankle joint were free, flexion of the knee 80° to 180°. The patient walks all right without a cane. The fracture came to a perfect bony healing and revealed no formation of cavities or sequestra (Ill. 93d). The sound leg is to be shortened in the near future using a nail.

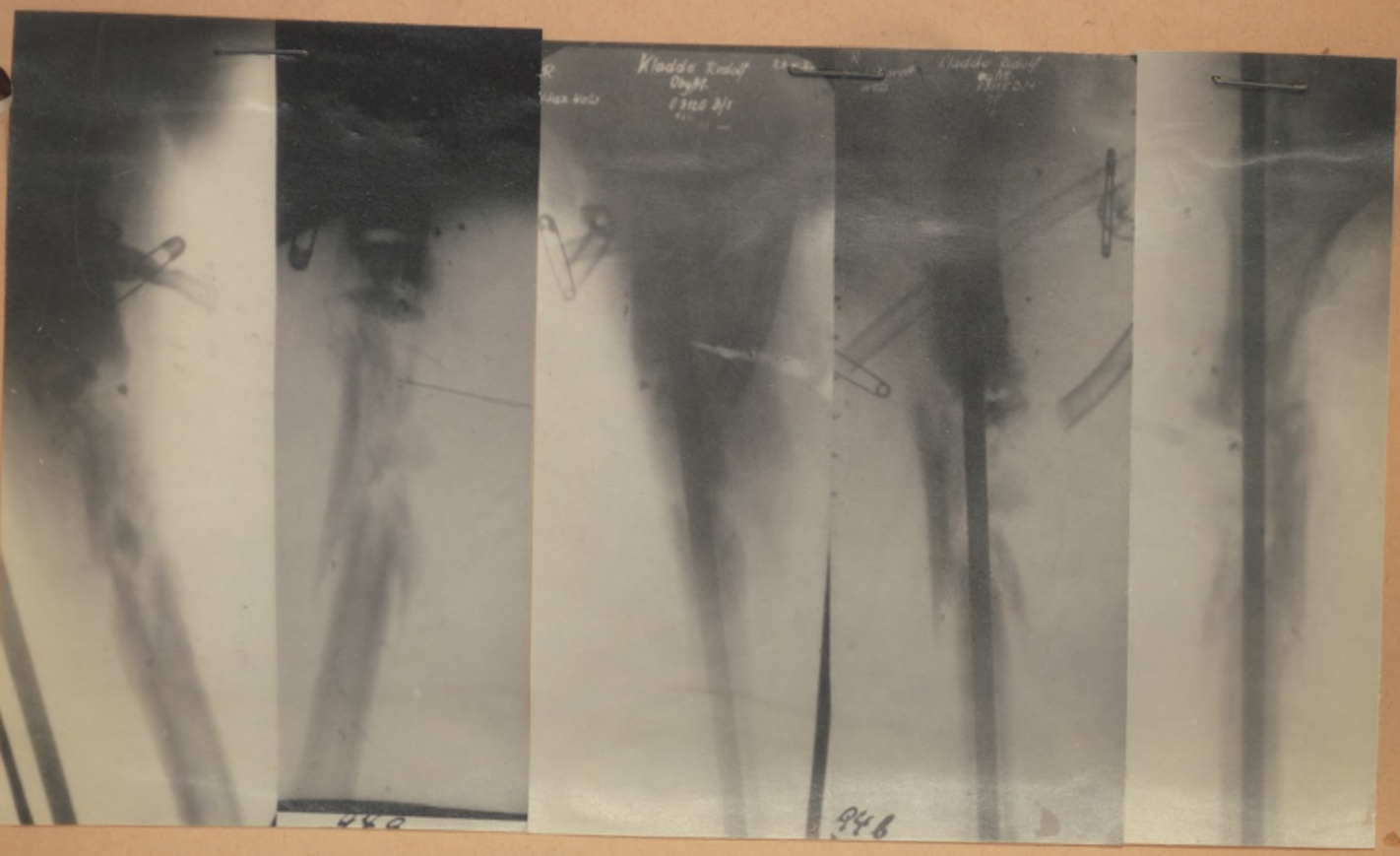
The advocates of the conservative treatment will perhaps maintain that the fracture would have solidified without using the nail. But the marrow nail means at least an alleviation of pain to the patient and it appears doubtful whether such a good mobility of the joints would have been obtained. Even BOEHLER could not help it that more than one third of his femur fractures due to gunshot injuries had a mobility of the knee joint of less than 60°.

Only 8 of the fistulating and seriously purulent fractures came in for treatment earlier than 2½ months, that is at a time when the existing impediments of the joints still seem to be repairable. Six healed without any impediment whatsoever. In three cases the knee was movable by 90° and more. Three fractures healed without shortening, in two cases we observed a shortening of 1 centimeter and three comminuted fractures healed with shortenings of 3 to 6 centimeters.

In the remaining 18 cases of fistulating and purulent femur fractures, the injuries dated 5 to 12 months back. After such a long time it is impossible to restore the full mobility of the joint. A definite improvement was, however, achieved in all of these cases.

The time of hospitalization can hardly serve as a basis for any comparative evaluation, because this depends in the conservative methods as well, solely on the type of fracture. It varied in our cases between 180 and 450 days. It was rather surprising that the stay in the hospital was particularly long in those fractures which had been opened widely and in which the guide rod or nail was introduced from the fracture cleft. These cases were characterized by gravity and tubular abscesses and formation of sequestra.

Today we would abstain from nailing a comminuted fistulating fracture in so good a position as shown in Ill. 94. The fixation of this fracture would have been just as quick by conservative treatment. Ill. 94a shows the same fracture 7½ months later with a distinct formation of callus. The nailing resulted in a shortening by 2 centimeters (Ill. 94b). Although the nail had a firm hold in the distal fragment it could under these circumstances not assure an osteosynthesis stabile enough to allow for an early use of the limb, the less so, since the ejection of



a b c

Illustration 94

a) 7½ month old fistulating comminuted fracture of the femur with formation of callus. The fragments are in good position. Beginning formation of callus is clearly noticeable.

b) The same fracture after the nailing. Due to the pressing together of the fragments a shortening of 2 cm. occurred. The nail finds sufficient hold in the distal fragment. Weight bearing is not yet possible because of the comminuted fracture. Several sequestra have been cast off.

c) 10 months p.op. A bony healing of the fracture has been obtained. The wounds are still fistulating. The nails were removed and the patient began subjecting the limb to weight bearing. Three months later the fistula was healed.

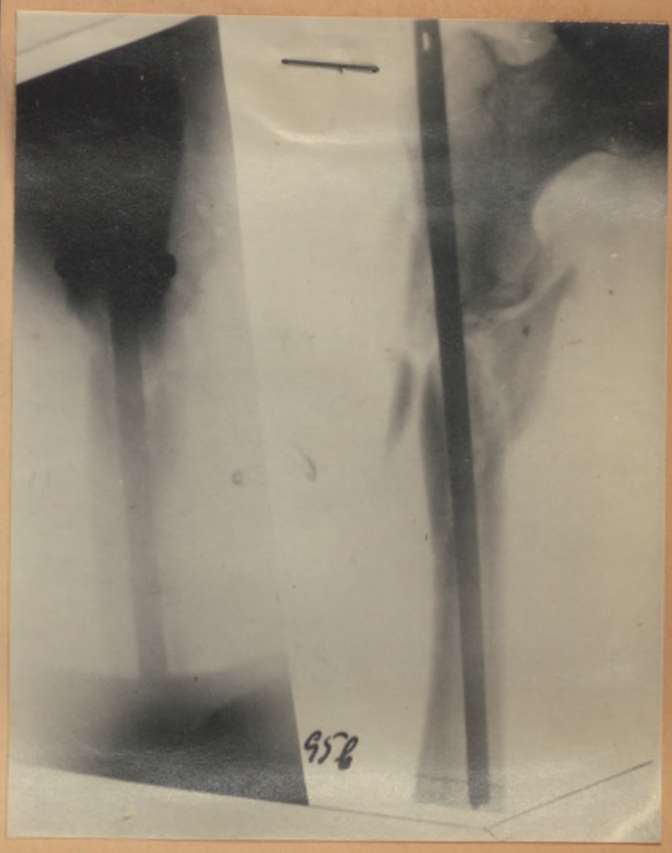
Final result: The shortening amounted to 2 cms., abduction impediment of the hip joint, motion of the knee from 110 - 180 degrees. In this case a conservative treatment would probably have shown better results.

sequestra continued for quite a long time. Only 10 months after the operation had the fracture healed to such an extent that the nail could be removed. (Ill. 59c) and only after 3 more months were the fistulae closed. The final result was a shortening by 2 centimeters, impeded abduction movement in the hip joint and a mobility of the knee of 190 to 170°. If an ordinary UNNA's extension bandage had been used instead, a better result would possibly have been obtained with a shorter delay. There is some probability that the shortening would have been avoided.

It is, therefore, deemed advisable to exclude fistulating comminuted fractures in good position with beginning formation of callus from nailing. The conditions are favorable for nailing if the position is bad and if a faulty healing is to be feared, as was the case in the 5 months old still intensely purulent fracture of Ill. 95a .

In this case sequestra and shell splinters were obviously the reason for an infection with an offensive odor which finally made the exposure of the fracture site necessary. After the removal of the sequestra the fracture was completely movable and Ill. 95b reveals distinctly (and as could be presumed in Ill. 95a) a threatening pseudarthrosis. The purulence subsided soon after the operation and the general condition of the patient improved rapidly. Temperatures were normal 4 weeks post-operative and the patient could begin with motion. A small sequestrum was later ejected and 5 months after the operation the fracture had solidified to such an extent that the patient could begin to use the limb (Ill. 95c). The nail was removed 8 months post operative (Ill. 95d), the fistula then soon closed. Two small sequestra were still ejected. The final result was a shortening by 4 centimeters (8 centimeters before nailing), the abduction of the hip joint was impeded by 1/3, mobility of the knee joint 100 to 180°.

These cases illustrate all aspects and we conclude as follows:


a b

Illustration 95

a) Five month old comminuted gunshot fracture of the femur which had healed in bad position. Formation of sequestra. The suppuration has not yet subsided and the fracture is still freely movable.

b) The same fracture after the removal of the sequestra and after the nailing. The beginning pseudarthrosis below the trochanter minor is clearly visible. The osteosynthesis is stabil. After the operation the suppuration decreased and the general condition of the patient improved. Four weeks after the operation the temperatures were normal and the patient was able to subject the limb to exercises. Some time later several more sequestra were cast off.

c d

Illustration 95

c) Five months p.op. The fracture cleft is bridged over by callus. The patient now begins subjecting the limb to weight bearing.

d) Eight months p.op. The fracture is healed and the nail will be removed. Two more small sequestra were cast off, after that the fistulae healed.

Final result: The shortening amounts to 4 cm. (before the operation: 8 cms), the impediment of the hip joint abduction amounts to 2/3, the knee: 100-180 degrees.

If an old thigh fracture due to gunshot injury has healed in a bad position, nailing osteotomy is indicated which should be performed as soon as possible under the condition, however, that a stabile osteosynthesis can be obtained.

The nailing is contraindicated in cases of comminuted fractures where splinters have to be removed and where the fracture must be pushed together. The nailing does not bring any advantages in these cases and might even imply a considerable hazard.

If a stabile osteosynthesis cannot be expected, the operation should be performed in two sessions. First the osteotomy with wire extension. If no infection occurs, the open marrow nailing can be performed after the correction of displacements and after the damage of the tissues has been overcome, generally this will be the case after 2 to 3 weeks.

In case of old thigh fractures due to gunshot with deficient callus formation and pseudarthroses, the wounds of which have just healed, the marrow nailing is indicated under the condition that a stabile osteosynthesis can be expected.

If only a relative stability can be achieved in that the nail is driven in as far as into the spongiosa, it is advisable to first mobilize the fracture under anaesthesia and to apply a wire extension and then to wait until the shortening is compensated for and until the injury to the soft parts has subsided.

If the infection flares up again it will become necessary to treat the fracture conservatively.

An additional plaster cast will become necessary if only a relatively stabile osteosynthesis has been achieved and it should be left in place until the infection hazard has definitely been overcome. Special attention is necessary when the limb is first used about 6 to 10 weeks after the operation. At this time the nail begins to become loose in the spongiosa. Rarefactions next to the point of the nail point to this hazard. Strictest bed rest must be instituted if the patient complains about the slightest pain or if a rise of temperature occurs and bed rest should be maintained until the fracture is bridged over by callus. If this is neglected there will be a considerable hazard that the infection will flare up with all its complications.

As a rule the wounds at the fracture cleft and trochanter are to be drained. If the wounds have healed only shortly before, greatest care with regard to the suture is indicated. If an infection occurs the wounds have to be opened widely without delay and the limb must be put at rest, to avoid a sag in the distal fragment.

The fistulating femur fracture due to gunshot injury may be nailed and a spreading of the infection into the marrow need not to be feared. It is, however, an important condition that the osteosynthesis be absolutely stabile.

Special care must be taken not to break the protective granulation dam of the infection center. The nail should be introduced into the proximal marrow cavity as is done in simple fractures by approach from the trochanter and not retrogradely from the fracture cleft.

The wounds must be drained and left open. An additional plaster cast is necessary.

Comminuted fractures and fractures in which a stabile osteosynthesis cannot be achieved are unsuitable for nailing.

Though the nailing of fistulating fractures offers many advantages, it is very important to be extremely careful about the indication. The first condition is a stabile osteosynthesis. If this condition can be fulfilled the nailing is indicated if a satisfactory fixation of the fracture cannot be achieved by conservative means or if a pseudarthrosis actually exists or threatens to develop or if the formation of sequestra makes the exposure of the fracture site necessary, anyhow there is no objection to perform the nailing on the same occasion if the fracture lends itself to nailing and if the general condition of the patient is good.

In case of intensely purulent fractures, the nailing should only be performed if regardless of the position, it will not be possible to obtain a satisfactory fixation of the fracture as is necessary to fight the infection and especially so if the formation of sequestra or tubular abscesses makes an operation necessary anyhow.

Nailing of femur fractures due to gunshot injuries should not be performed in the state of the acute fresh suppuration, that is as long as the marrow and tissue clefts are not yet closed by protective granulations, nor in a bad general condition of the patient. It must always be borne in mind that the nailing of a fractured femur is a major operation.

The stabile osteosynthesis with the marrow nail is advantageous over all other methods hitherto known, even in fistulating and intensely suppurating fractures due to gunshot injuries if its indication is carefully considered.

## b. Tibia Fractures

In case of old tibia fractures due to gunshot injuries, the wounds of which have already healed, we were

very reserved with regard to the nailing on account of our experience gained in old simple fractures. In those fractures, the sites of which were not located in the median third, that is in which a stabile osteosynthesis cannot positively be expected, we confined ourselves to a resection of the fibula, mobilization of the fracture, reduction of the fracture (direct or by means of wire extension) and subsequent walking cast. A fixation after 8-12 weeks was obtained this way in five fractures which were 9-14 months old. In one case (12½ months old) we had to perform a bone graft after 6 weeks which lead to healing.

In only 2 cases with the fracture site in the middle of the bone, we have performed the nailing and the resection of the fibula in one session. The fractures were 10 and 11½ months old, the wounds had healed 4 and 3½ months before the operation. Both cases healed without infection. As a matter of fact we only sutured the periosteum and the soft parts. The skin was left open and a drain was applied as usual.

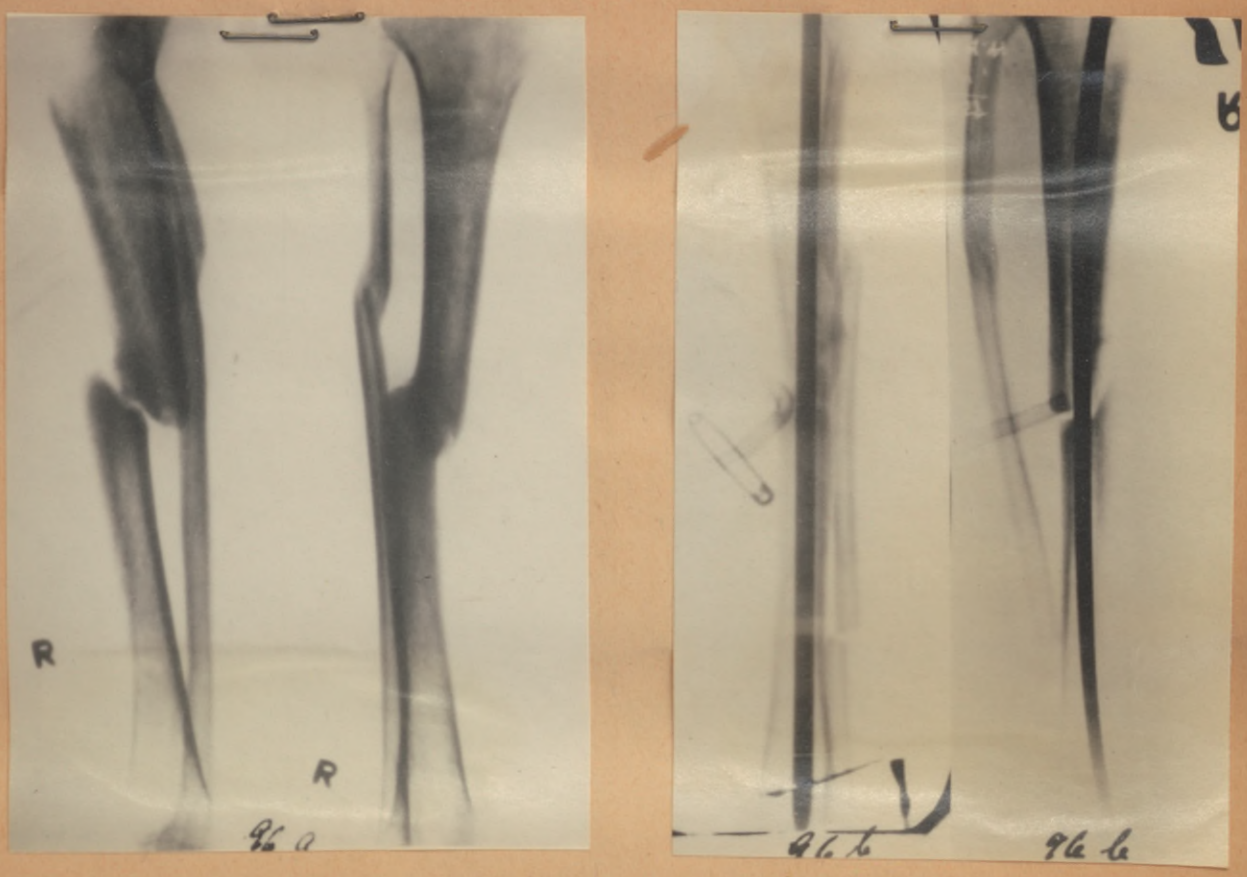
One of the patients could use the limb after 3 weeks and 6 weeks later was drafted for the Labor Service. The nail was removed 4 months after the operation. The joints were freely movable, but a shortening of 1 centimeter occurred.

In the case of the second patient, the healing was delayed, because we had only performed an osteotomy and not a resection of the fibula (Ill. 96). It healed quickly and finally became obstructive and although the osteosynthesis was apparently stabile, the patient repeatedly complained about pains when using the limb and the X-ray picture revealed (Ill. 96c) distinct rarefactions next to the point of the nail. After the resection of the fibula, the fracture quickly solidified (Ill. 96d).

The surgeons in the military hospitals were more liberal as to the indication of the nailing method. Among seven nailed fractures, there were only 3 which lent themselves for this type of treatment, only a relatively stabile osteosynthesis could be expected in all the other cases.

The operation wounds had in all cases been primarily sutured (in some of them even without drainage), although the wounds had healed only for 2 to 4 months. All cases with the exception of one with a stabile osteosynthesis resulted in long lasting suppurations, formation of sequestra and in one case in which the wounds had not been opened in osteomyelitis with abscess at the entrance spot of the nail and suppuration of the prepatellar bursa.

So a 10 to 16 months long stay in the hospital became necessary - except in that primarily healed case- and the results were decidedly bad, inferior to those which would have been obtained with the conservative methods.

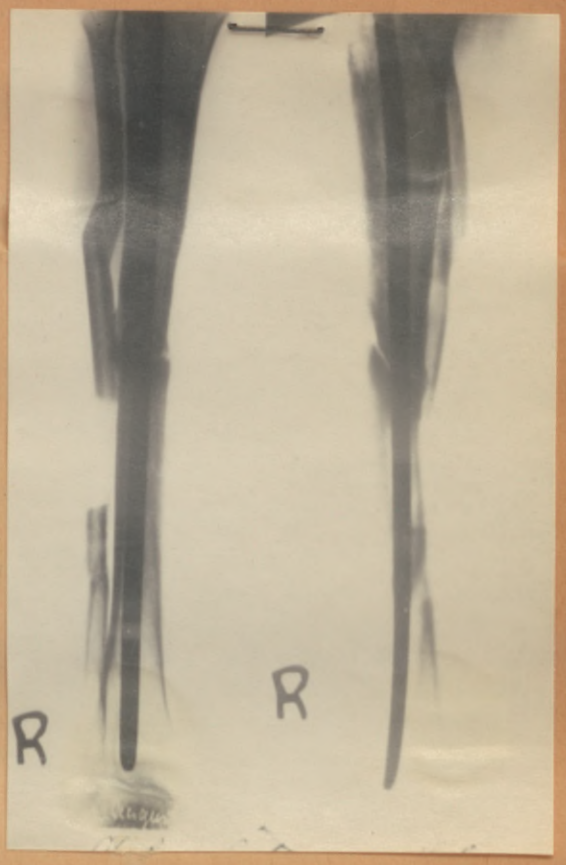



a b

Illustration 96

a) Eleven month old gunshot fracture in the leg. The wounds have been healed for 4 months. A healing of the fracture was not obtained because of the early healing and jamming of the fibula.

b) The same fracture after the osteotomy of the fibula and open nailing of the tibia. The connective tissue callosity between the fragments was removed, but the bone ends were not freshened. The fracture cleft is still slightly gaping. Primary wound healing.




c d

Illustration 96

c) Four months p.op. During weight bearing the patient constantly complained about pains at the fracture site. The fibula is healed but the fragments are not pressed together. Marked rarefactions around the nail tip. No formation of callus.

Resection of the fibula and application of a U-shaped plaster splint with which the patient starts subjecting the limb to weight bearing.

d) Eight weeks later the fracture is bridged over by bone. The nail was extracted four weeks after that.

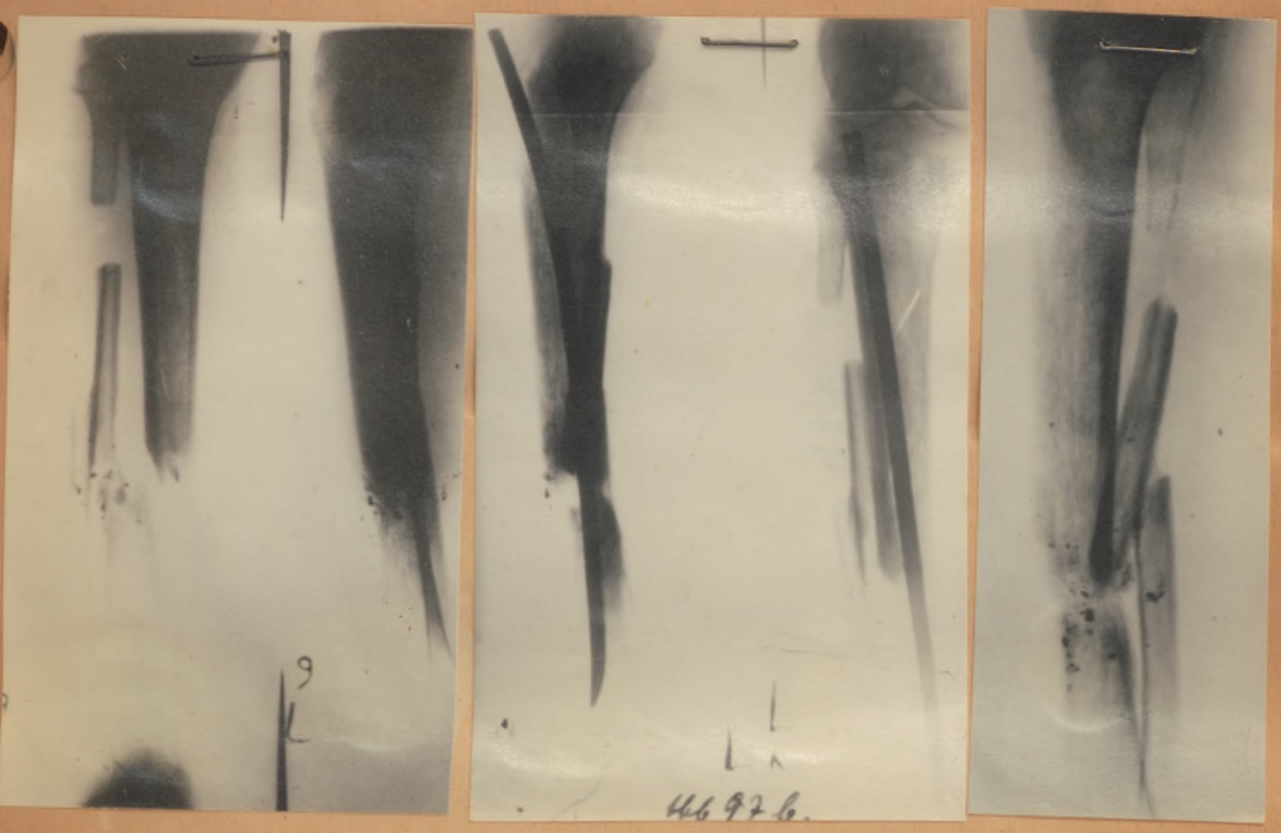
If in this case the fibula had been resected immediately the fracture would have come to a quicker healing even without a nailing operation.

The polypragmatism and impatience of the surgeon is again typical in these cases.

In the 15 months old fracture due to gunshot injury of Ill. 97, the wounds of which were closed for two months, the fibula had been resected. It was omitted however, to reduce and fix the fracture. Diathermy had been instituted 3 times weekly instead. When no callus formation was observed after 4 weeks (which is not an abnormal fact in these circumstances), the fracture site was exposed, the fracture ends which were closed by connective tissue were freshened and united by only one nail which was much too short (Ill. 97b). Drainage of the fracture cleft towards the calf, suture and plaster cast followed. The wound had to be opened 8 days later. Several small sequestra were ejected. The nail was removed 4 months after the operation, although an advanced formation of callus could not be observed because the wounds were still fistulating. The fracture cleft was still recognizable to its full extent (Ill. 97c), the fracture was still movable. The fistula closed only three months later and after a walking cast had been applied the fracture finally solidified after two more months. The final result was a shortening of 3 centimeters, ankle and knee joint stiffened by 50%.

In this case, the same as in Ill. 98 the nailing was useless.

Ill. 98 refers to a 13 months old fracture due to gunshot, the wounds of which had been healed for two months. The same surgeon had performed a fibula resection without reducing the still movable fracture and without applying a plaster cast. An open marrow nailing was performed 4 weeks later. On this occasion "part of the wall of the disrupted fragment had to be removed as being an obstacle to proper adaption." By the fact that the nail lay laterally in the proximal fragment and that the fracture ends were pushed together, a lateral shortening of 4 centimeters (Ill. 98b) occurred. The sutured wounds became infected and had to be opened. Several sequestra were ejected. The limb was left in the plaster cast, so that a severe infection of the marrow was fortunately avoided. The distal fragment revealed a distinct loosening



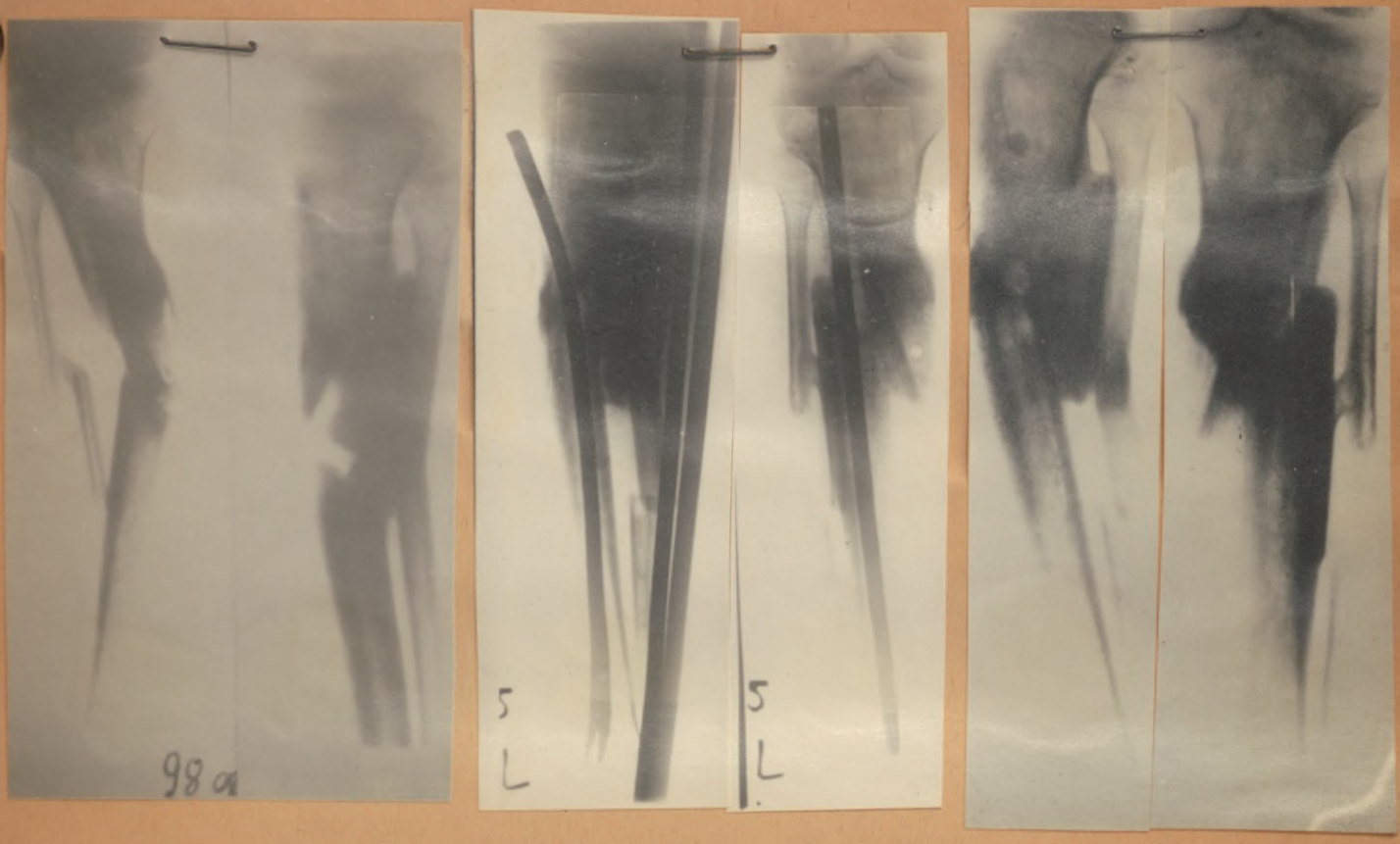
a b c

Illustration 97

a) 15 month old gunshot fracture in the leg. For two months the wounds have been closed. The fibula was resected 4 weeks ago but the fracture was not mobilized and reduced. A plaster cast was not applied. Open nailing because no formation of callus was observed.

b) The same fracture after the nailing. Only one nail was used which however is too short. Consequently the osteosynthesis is not stabil. 8 days p.op. the sutured wounds must be opened. Application of a plaster cast. Several sequestra were cast off at the fracture site.

c) Four months p.op. after the removal of the nail because the wound still fistulated. The fragments are movable and the entire fracture cleft is visible. Further plaster casts were applied. Three months later the fistulae had healed and consequently a walking cast was applied. Finally, two months later, i.e. 11 months after the nailing the fracture is healed. The shortening amounts to 3 cms. The impediment of the foot and ankle joint amounts to 50 %. A quicker healing would have been obtained if after the resection of the fibula the fracture had been reduced and walking casts applied.




a b c

Illustration 98

a) 13 month old gunshot fracture. The wounds have been healed for 2 months. Four weeks ago the fibula was resected but the fragments were not reduced and a plaster cast was not applied.

b) The same fracture after the open nailing. In the proximal fragment the nail is seated very far distally. The fragments were so much pressed together that the shortening amounted to 4 cms. The two ends of the resected fibula are standing one upon the other. Infection of the sutured wounds. Several sequestra were cast off. Plaster casts had to be applied for a long period of time. The nail was removed 4 months after the operation because the wound was still fistulating. Application of a VOLKMANN's splint despite the fact that the fragments were still movable.

c) Eight months after the operation the fracture healed in slight antecurvation and valgus position. After the extraction of the nail an angulation was observed. The shortening amounts to 4 cms. The ankle joint is stiff and motion of the knee amounts to 180 - 100 degrees. A healing would probably have been obtained more quickly without the nailing operation, if, after the resection of the fibula, the fragments had been reduced and a plaster cast applied.

of the structure. The nail was removed in this case too, 4 months after the operation, because the wounds were still fistulating at that time. The leg was only put on a VOLKMANN splint, although the fracture was still springy. So a slight antecurvation and valgus developed in which position the fracture finally healed. When the wounds were closed, the patient could be discharged from the hospital 8 months after the operation. Shortening 4 centimeters, ankle joint stiffened, knee movable between 180 and 100°. These impediments could have been avoided if the fracture had been properly reduced after the resection of the fibula and if walking casts had been applied in due time.

Table VII gives a survey over these 15 tibia fractures due to gunshot injuries the wounds of which were still purulent. Most of these fractures were not nailed in our clinic.

I have written before (See HAEBLER a. a. O. Ill. 8 page 38) under the general procedures that in such fractures the nailing should be performed only in those cases, where the formation of sequestra makes it necessary to expose the site of the fracture which has healed in a bad position. A bad position did not prevail in any of the less than 3 months old fractures, the surgeon was rather guided in all of the cases by the desire to achieve a better fixation with the nail and thereby a quicker elimination of the infection.

With this idea in mind one has also nailed isolated tibia fractures, the site of which was not exposed but the sequestrum was removed by enlarging the fistula and a "closed" nailing was performed.

In these fractures one has achieved a quick employability of the patient (case 8 and 10) but it must be admitted that similar results would have been obtained without the nail. In another case (Nr. 7) we have a rather long stay in the hospital with a "closed" nailing. It must furthermore be admitted that the nailing did not constitute a material advantage in all the less than 3 months old fractures. If the conservative methods would have been applied the time of treatment would have been shorter and the final result just as good. We have in only 3 of the 11 fractures a full mobility of the joints. Tedious suppurations occurred especially in those cases in which approximation sutures had been applied. We have pointed out already on another occassion the special hazard of "approximation" sutures which become so easily a complete closure of the wound. It may be objected that all these difficulties could have cropped up in the conservative treatment as well and that they constitute an ever present hazard in fractures due to

gunshot injuries. But it still holds true that a clear cut advantage did not become evident, although all fractures were well suitable for nailing and the osteosynthesis was perfectly stabile.

These facts may be illustrated by the following cases:

In the 10 days old fracture due to gunshot injury of Ill. 99 (Table Nr. 1), the wounds of which were intensely purulent, it was attempted to secure a better fixation and control of the suppuration by the use of the marrow nail. In the operation one not only removed the transversely located splinters but also those bridging over the medial side of the fracture, although they were connected with the periosteum. The fracture had to be pushed together after the nailing and thus resulted in a shortening of 3 centimeters. The hope that the nail would have a favorable influence on the suppuration was, however, not justified. On the contrary, gravity abscesses developed again and again which started from the entrance site of the nail and from the fracture. Several sequestra developed at the fracture site and the nail had to be removed for these reasons although the fracture had not yet solidified. Only after 11 months in a plaster cast the fistula began to subside and the patient was finally discharged from the hospital with a stiffened ankle joint and an impediment of the knee joint by 50%.

If the slight antecurvation had been corrected and the fracture put at rest from the very beginning in a fenestrated unpadded plaster cast, the shortening would presumably have been less pronounced, because the medial splinters would have presented a good matrix for the callus. The healing would have been quicker and there is a strong probability that the mobility of the joints would have been better.

In the 4 weeks old fracture of Ill. 100 we performed the nailing because the lateral displacement could not be compensated for by extension fixation and because the proximal fragment lay free in the granulating wound. We expected a stabile osteosynthesis and thought that an early use of the limb would stimulate the apparently deficient callus formation. The fragments could be reduced without special difficulty and without wide exposure with the finger introduced into the wound and the nailing was uneventful (Ill. 100b). The fracture was clinically solid after the nailing, but the nails were too short. The suppuration sub-


a b

Illustration 99

a) 10 day old gunshot fracture of the leg. We decided to perform a nailing operation because of the foul odor of the wound and it was hoped to fight the infection effectively in this way. During this operation those chips which were still covered by periosteum were removed (mistake!). Due to the pressing together of the fragments the shortening amounted to 4 cms. The wounds were kept open. Long lasting suppuration with a gravity abscess from the insertion site and from the site of the fracture. Several sequestra were cast off. The nail was removed four months later despite the fact that the fracture was not yet stabil. (The X-rays were destroyed).

b) The same fracture 5½ months after the nailing, 6 weeks after the removal of the nail. The fracture cleft is bridged over by callus which is not yet strong. Formation of sequestra at the fracture cleft. 11 months after the nailing the wounds were healed. The shortening amounted to 3 cms. The ankle joint was stiff and the impediment of the knee amounted to 50 %. The use of the nail had no advantageous effect.


a b

Illustration 100

a) Four week old gunshot fracture of the leg. The tip of the proximal fragment is exposed in the granulated exit wound.

b) Six weeks after the nailing. The loose bone chips were removed. In this way a small defect developed at the front edge. From the clinical point of view the fracture is absolutely stabil. The nail however is rather short.

c d e

Illustration 100

c) Three and ½ months after the nailing. The patient started subjecting the limb to weight bearing 8 weeks p.op. Marked structural loosening and beginning formation of sequestra at the fracture cleft. Marked rarefaction round the nail tip - the osteosynthesis is only relatively stabil. A blackish colored secretum extravasating from the fistula indicated the existence of rust damages. Therefore the nail was removed despite the fact that the fracture was not yet stabil. Application of a plaster cast. After a sequestrum had been cast off, the fistula closed.

d) Five ½ months after the nailing. The fibula is healed but the formation of callus is only slight. Therefore the fibula was resected and a plaster cast was applied.

e) Six weeks after the resection of the fibula. The callus had increased and was more compact. From the clinical point of view the fracture is healed. Application of UNNA's bandages. Ten weeks later, i.e. 9½ months after the operation the patient was released from the hospital. The shortening amounted to ½ cm. The impediment of the ankle joint was only slight, the motion of the knee amounted to 180 - 90 degrees.

sided gradually and 8 weeks after the operation the patient could start with motion exercises which were free from pain. The wound then began to excret a dark secretion which became almost black and the fracture cleft revealed a distinct loosening of the structure with a beginning formation of sequestra, which point to a rust damage (Ill. 100c). The nail was, therefore, removed 3½ months after the operation, although hardly any callus had formed. The rarefactions next to the point of the nail confirm that the nail had no firm hold. The nail revealed a thin black coating and signs of corrosion. After the removal of the nail, a small sequestrum was ejected, then the wound closed quickly. As the fibula had already healed, the callus formation was still insufficient after 8 weeks of treatment with a plaster cast (Ill. 100d). The fibula was therefore resected. Four weeks later the fracture was pushed somewhat together and clinically was solidified (Ill.100e). The patient was transferred with a walking cast to the hospital near his home from which he was discharged 9½ months after the operation. Shortening ½ centimeter, ankle joint slightly impeded, mobility of the knee between 180 and 90°.

In this case it must again be admitted that the nailing did not bring any substantial advantage. On the contrary, the necrosis at the fracture cleft would have been avoided without the nail. The delayed healing due to the obstructive fibula could not be avoided by the use of the nail.

The same is true for the other fistulating tibia fractures. The fact that the fracture Nr. 7 has healed with full function 7 months after the operation is no special success in a 6 weeks old oblique fracture, from which a sequestrum was removed. On the other hand, there is considerable hazard that the nail may penetrate unnoticed into the soft parts if a large fragment has disrupted from the proximal fragment, the more so, because the fracture ends are not exposed if at all possible. In this case the nail may be the cause of a spreading of the infection, phlegmons, gravity abscesses and tedious suppurations.

In our opinion it is completely out of place to nail an isolated tibia fracture due to gunshot as in Ill. 101 (Table Nr. 7) for the only reason that "the fracture is still movable 4½ weeks after the accident"; this is also true if a closed nailing is performed as is done in simple fractures. It must be borne in mind that the conditions are not aseptic and it is not surprising that a formation of abscesses and tedious suppurations will ensue if the entrance wound of the nail is primarily closed. It will

a b c

Illustration 101

a) Isolated fistulating gunshot fracture in the tibia, 4½ weeks old. "Closed nailing because the fracture is still movable".

b) The same fracture after the nailing. Formation of abscesses and long lasting suppuration which require additional plaster casts. The nail was extracted 5 months later.

c) Six months after the operation. 5 months after the removal of the nail. The fracture is healed but the wounds are still fistulating. A marked dystrophy of the bones of the foot is observed. The patient was released from the hospital only 10 months after the nailing operation. The impediment of the ankle joint amounted to ¼ and the motion of the knee amounted to 80-180 degrees. A better result would certainly have been obtained without a nailing.

then become necessary to apply plaster casts (as is the case without the nail).

This unsuccessful case would in itself be sufficient to outweigh the cases 8 and 10 in which favorable conditions prevailed (We can dispense here with a more detailed description which is given by HAEBLER a.a.O.,page 38, Ill. 8). In case Nr. 11, the healing was again complicated by long suppuration with formation of sequestra and delayed formation of callus due to the obstructive fibula.

It is rather surprising that in the fractures which are less than 12 weeks old a faulty position did not support in a single one of the cases the indication for the nailing. Tibia fractures due to gunshot injuries which are still movable may practically always be satisfactorily reduced with the conservative methods. If a healed or not injured fibula hinders the reduction it will be sufficient to perform a resection. This is a minor operation and presents no hazards and which we have successfully performed also in case of an insufficient callus formation.

It must therefore be concluded that the marrow nail does not bring advantages in fistulating or purulent tibia fracture due to gunshot injuries and one should abstain from nailing with regard to the considerable hazards even though the exposure becomes necessary because of a formation of sequestra.

If an early healed fibula hinders the proper reduction of the fragments or if it is the reason for an insufficient callus formation the resection with subsequent application of plaster casts will fit the purpose better and does not constitute any hazard.

Fistulating fractures of the tibia 5 to 18 months old, were nailed in four instances. The fibula had healed in all of them and if we consider the X-ray pictures critically, it appears probable that the final healing could have been obtained by resection and proper reduction. This obvious solution was - as is so often the case - not attempted. In case Nr. 15, we were ourselves not impressed by the fact that the pseudarthrosis existed already for 18 months but were simply overenthusiastic about the marrow nailing method.

In this case the nail was the cause of late complications which would very likely have been avoided without the nail.

The patient wore a hinged splint, the knee joint was freely movable, the ankle joint was stiffened by about 1/3. After the patient had been discharged from the Army, several ejections of sequestra occurred, the last time 14 days prior to his admission to the hospital (Ill. 102a). After osteotomy of the fibula and mobilization of the fracture

a b c

Illustration 102

a) 1½ year old pseudarthrosis after gunshot fracture which fistulated. 14 days ago a sequestrum was cast off.

b) After an oblique osteotomy of the fibula and closed nailing. The fracture cleft is still somewhat gaping. The patient started subjecting the limb to weight bearing 3 weeks after the operation. The fistula had healed three weeks after the nailing.

c) 3½ months p.op. Due to the weight bearing the fragments were pressed together. Marked formation of callus.

d e

Illustration 102

d) 5 months after the operation. 2 weeks after the extraction of the nail. The fracture is healed and the fistulae are closed.

e) 11 months p.op. The wounds are closed and the fracture is stabil. Release from the hospital.



f g h

Illustration 102

f) $1\frac{3}{4}$ years after the nailing. The patient constantly complains about pains and swellings which subside only after the wounds have opened up, therefore the patient was taken into the hospital again. The filling of the fistula shows the remnants of the nail canal which extends to the middle of the tibia. The clearly visible nail canal obviously ends below the central part of the contrast shadow and the marrow cavity seems to be closed.

g) Between the two sounds inserted into both fistulae the marrow cavity is closed. Therefore the marrow cavity is widely opened at the end of the upper canal of the fistula.

h) Four weeks later the wounds are healed and the patient can be released from the hospital. After that other fistulae did not develop. In this case complications would have been prevented if only the fibula had been resected and walking casts applied. With such a treatment the pseudarthrosis would have healed more quickly.

we were successful though with difficulties in nailing the fracture without exposure of the site. The fracture was clinically solid. There was, however, a slight gap at the fracture cleft (Ill. 102b). A small gravity abscess developed 10 days after the operation at the entrance site of the nail which was left open. Apart from this the healing process was uneventful and the patient could begin to use the limb 3 weeks after the operation. The fistula at the fracture had closed. Weight bearing caused the fracture to push together (Ill. 102c), a small sequestrum was ejected at the fracture cleft and then the wounds closed and the patient could be trated 2½ months after the operation on an outpatient basis. The fistula broke open some time later and secreted a dark colored liquid. After 5 months the fracture was clinically healed far enough to allow the withdrawal of the nails. The outer nail was attacked by rust at both edges so that there remained only a 3 millimeters strong bridge at the fracture cleft. The inner nail revealed similar defects. The nail would have broken in the near future. The nail had obviously obtained a firm hold in the callus which closed the marrow cavities in spite of the unfavorable location of the fracture, since there were no rarefactions to be noticed at the point of the nail. A sequestrum had formed though at the fracture cleft (Ill. 102d). This sequestrum was removed after the entrance wound of the nail had healed by flattening of the bone. The wounds had healed after 6 months when the patient was discharged from the hospital (Ill.102e).

The patient suffered later on again and again from pains and swellings at the fracture site which subsided only if one of the wounds had broken open. Sequestra were not ejected on these occasions. The patient was therefore readmitted to our hospital 1 ¾ years after the nailing operation. Sequestra could not be detected, a contrast medium introduced by approach from the tuberositas tibiae revealed that a fistula canal in the marrow cavity reached to the middle of the tibia (Ill. 102f). The fistula could even at the operation not be traced as far as the fracture cleft. There remained an area about 4 centimeters wide between the sounds which were introduced from above and from below in which the marrow cavity appeared to be closed. A blue solution which was injected by means of an urether-catheter did not appear at the fracture cleft (Ill. 102g). We there-

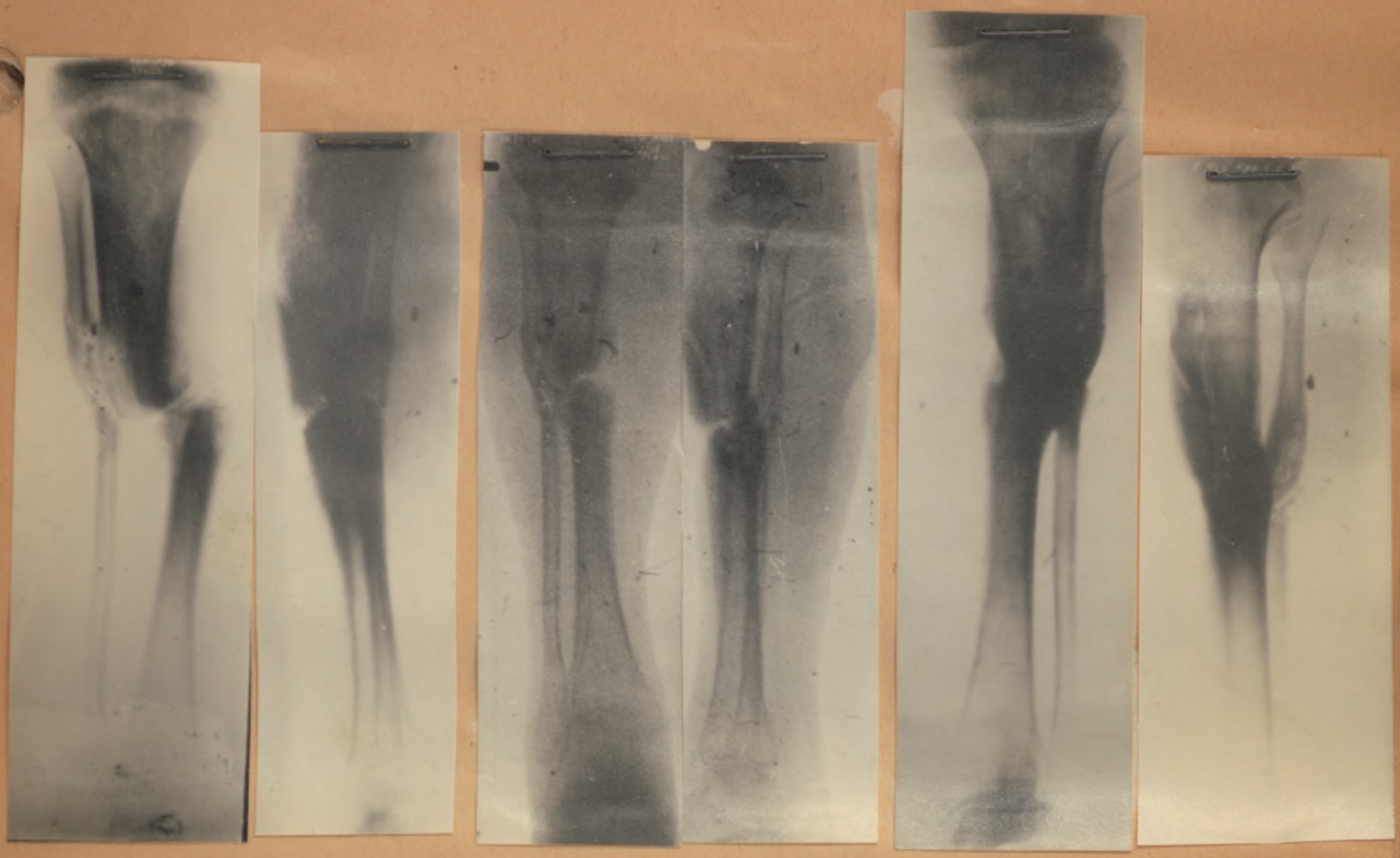
fore chiseled the bone at the upper section of the canal to expose the fistula (Ill.102 h). In a distal direction the marrow cavity was completely closed by hard bone. The patient could be discharged from the hospital 6 weeks after this operation with the wounds healed and has had no complaints since.

There is no doubt that this long stay in the hospital would have been avoided if the nail had not been used. And it is really a shame that nobody (including ourselves) ever thought of resecting the obstructing fibula.

It cannot be maintained in the three other cases of connective tissue pseudarthrosis that the anil brought clear cut advantages.

The fracture due to gunshot injury, 5 months old, which was described in detail in another place (HAEBLER, a.a.O.,page 36, Ill. 7) and which was nailed because the lateral displacement could not be compensated for otherwise, had not solidified when the nail was removed 5½ months later, but healed quickly after the resection of the fibula. In this case also one had omitted to resect the fibula. This was the reason why the introduction of the nail into the distal fragment was particularly difficult even after the exposure of the fracture site and there was a gap of several millimeters at the fracture cleft. The fracture was pushed together to a certain but insufficient extent when the limb was used. The nail penetrated closely to the talo-crural joint. If the obstructive fibula, which was responsible for the delayed healing had not made a further pushing together impossible, the nail would probably have perforated the joint and caused additional complications.

Even in the 7 months old fracture of Ill. 103 (Table Nr. 13) in which a beginning pseudarthrosis was suggested by the X-ray picture, we are inclined to think that a simple resection would have fitted the purpose better and lead to a quicker healing. In the operation there was found only connective scar tissue between the fracture ends which also closed the marrow cavities. In this case it was likewise omitted to resect the fibula and when the nails were removed 4 months after the operation because a dark colored discharge indicated rust defects, the fracture had not yet solidified (Ill. 103b). (The nails had oxydized at the fracture site). The wounds closed soon after the nails had been removed but the fracture solidified only after 4 more months to such an extent that the walking cast could be replaced by an UNNA bandage (Ill. 103c).



a b c

Illustration 103

a) Seven month old fistulating gunshot fracture of the leg. The fibula is healed. Open nailing. Sclerotic connective tissue observed between the two fragments had to be removed during this operation. Non-operative re-fracture of the fibula. (Pictures were destroyed).

b) Four months after the operation. Removal of the nail because blackish secretum indicated the existence of rust, which was true. The fracture is movable. Therefore further plaster casts were applied.

c) Eight months after the nailing. Four months after the extraction of the nail the fracture was bridged over by bone and the wounds were closed. A quicker healing would probably have been obtained with a resection of the fibula and non-operative reduction.

I maintain that those 4 fractures would have satisfactory solidified if one had resected the fibula and if a non-operative reduction had been performed with subsequent application of walking casts, because we had not to deal in these cases with genuine pseudarthroses but with an unhealed fracture. To prove this statement I wish to point to Ill. 104 which resembles Ill. 103 very much and in which it seems fully justified to diagnose a pseudarthrosis. This "pseudarthrosis" solidified after the resection of the fibula and 6 weeks in a plaster cast, to such an extent that it could be placed in an UNNA bandage. The patient could perform his duties 8 weeks after the resection. This is one example out of a great number, because we have, in consideration of our bad experience in the case shown in Ill. 102, confined ourselves at first to resection of the fibula. Apart from cases having very serious defects we have always been successful.

On the basis of our experience we therefore might say, in contrast to our previous statements that a nailing is only to be performed in old tibia fractures due to gunshot in bad position, the wounds of which have just healed, if we have to deal with a transverse or short oblique fracture in the median third, in which a stabile osteosynthesis may be expected with certainty. Even if these conditions are fulfilled, the greatest reserve is indicated and it is recommended to perform the nailing only if one does not succeed in obtaining a satisfactor position by non-operative measures after the resection of the fibula.

The wounds must be drained. It is better to not suture the skin. An additional plaster cast is necessary until the infection hazard is definitely overcome.

In all other old tibia fractures due to gunshot injury the nailing should NOT be performed. They will become solid as a rule by a resection of the fibula with subsequent position at rest by walking cast, if one succeeds in bringing the fragments to a proper abutment.

If healing fails to come, supporting apparatuses are indicated and one of the time honored pseudarthrosis operation should be performed (bone graft or MATTI's operation) if at least one year has elapsed after the definite closure of the wounds.

The nailing of the old fistulating tibia fracture due to gunshot injury should not be performed even though a pseudarthrosis exists or is imminent. The nailing does not bring any advantage but it does constitute an additional hazard of complications which can be avoided without the nail.

The double nail is particularly susceptible to corrosion by the suppuration and this type of nail therefore further sustains the suppuration (foreign body) and it obviously favors the formation of sequestra.

Illustration 104c could not be reproduced as the negatives were not available.

a b c

Illustration 104

a) 1½ year old gunshot fracture of the tibia. Diagnosis according to the X-ray: "Pseudarthrosis". The fibula is healed and the wounds have been closed for more than one year.

b) Six weeks after the resection of the fibula with subsequent treatment in a walking cast. Marked formation of callus. The fracture is clinically healed. The patient was released from the hospital with an UNNA's bandage.

c) Ten weeks after the operation. Bony healing of the fracture. The shortening amounts to ½ cm. All joints are freely movable.

Since we have to deal in the tibia mostly with connective tissue pseudarthroses, the resection of the fibula with subsequent application of walking cast will as a rule bring quick healing (apart from defect pseudarthroses). The fibula resection constitutes a minor and simple operation and should therefore be tried before any more serious operation is performed. If the resection does not show the desirable result, one should wait until the wounds have healed for about one year and then perform a bone graft without nail.

c) Fractures of the humerus due to gunshot injuries.

BOEHLER (in Technique of the treatment of bone fractures, Ed. 9-11, Vol. 3, Vienna 1944, page 1986) advises against the marrow nailing of pseudarthroses of the humerus because it does not bring any advantages (epsecially with respect to callus formation) over other methods and because it failed in case of atrophic bone, just as the bone graft, and because of the greater hazard in case of an infection (which might spread over the whole marrow cavity due to the nail).

In our 47 cases of marrow nailing operation of old fractures of the upper arm due to gunshot injuries an osteomyelitis occurred in three cases, namely in a three months old fistulating fracture, in a 19 months old pseudarthrosis, the wounds of which had been closed for 5 months and in a 2½ year old pseudarthrosis which was operated upon 13 months after the healing of the wounds. All these patients were not treated in our clinic and the spreading of the infection was without any doubt due to deficiencies of the technique, above all to the delayed opening of the wound.

In the already described (HAEBLER a.a.O. Page 175, Ill. 75) still fistulating fracture the neurolysis of the radialis had been performed together with the nailing. The wound of the neurolysis and the wound of the olecranon were sutured. The wound at the fracture"was closed by approximation suture and tamponaded." Although the temperature rose and marked swellings took place, the neurolysis wound was only opened 4 days after the operation and the entrance wound at the olecranon only after 7 days, when an abscess already threatened to break through. The nail was much too short and had no hold in the proximal fragment.

In the 19 months old pseudarthrosis in the median part (see HAEBLER a.a.O. page 43, Ill. 12) in which a severe infection and erysipelas had developed 10 months before on the occasion of the splintering, the osteosynthesis was apparently stabile, but the wound had been sutured and only a small drain

was placed into the wound for 24 hours, "because of the persisting soft part cavity in the extended arm". In this case it was again omitted to open the wounds in proper time in spite of a marked swelling of the arm and although an "abundant" amount of serous liquid came out of the suture stitches after the removal of the suture. Even active movement exercises were instituted and an attempt was made to keep the inflammation down by alcohol cataplasma, (swellings and redness of the skin). Finally 16 days post-operative an abscess broke through. That the infection spread under these averse conditions into the distal fragment is quite natural (nailing had been performed by approach from the distal side). Fortunately, the nail had a firm hold, so that a severe inflammation was avoided, sequestra did not develop and the loosened structure of the bone soon subsided and the fracture became solid.

Also in the case of a two year old defect pseudarthrosis the osteosynthesis proved to be instabile. Confident in the fact that the wounds had healed one year before, the site was primarily sutured and the drain was removed after 24 hours in spite of still existing fever. Here again valuable time was lost by the administration of sulfonamides and the application of cataplasma and although the fever was steadily on the increase, the wounds were widely opened only 10 days post operative, when the presence of the abscess was quite obvious.

The spreading of the infection into the marrow can be avoided with certainty if the wounds are immediately widely opened in case an infection occurs, even if the osteosynthesis is not completely stabile. (See Ill. 106).

A primary closure of wounds is always hazardous in old fractures due to gunshot injuries, because one is never on the safe side with regard to infections even if the fistulae are closed for more than 1 year. Among 8 of that type of pseudarthroses only 4 healed primarily.

On the other hand 3 out of 5 fractures healed without infection, which had been nailed 3 to 5 months after the closure of the fistulae and sutured primarily with adequate drainage. The postponement of the operation apparently does not bring any advantages.

The suppuration was, if no osteomyelitis occurred, in all cases very tedious in which the wounds had not been opened widely and if one was satisfied instead with a simple drain. In contrast to this, 6 pseudarthroses which had been operated upon 4 to 6 weeks after the healing of the wounds, healed per secundam and much quicker, because we renounced the skin suture (the wounds were thoroughly drained), only the musculature over the bone was held in the proper place by a few stitches.

A formation of sequestra was observed in none of the 11 cases in which the healing of the wounds took place less than five months prior to the operation, although there were a few comminuted fractures among these cases.

We have nailed 14 pseudarthroses which were 5 to 22 months old regardless of the still existing fistula. As a matter of fact, the wounds were thoroughly drained and left open. Not a single case of osteomyelitis occurred and sequestrum formation was observed in only two cases although the osteosynthesis was not absolutely stabile in all of the cases and in spite of the fact that existing sequestra (which were removed at the same session) were the reason for the fistula suppuration.

We therefore feel justified in denying the possibility of a spreading of the infection into the marrow cavity due to the presence of the nail. We deem this hazard to be completely avoidable and it therefore cannot possibly constitute a factor of contraindication to the marrow nailing of pseudarthroses of the upper arm.

All our cases (33) of pseudarthroses due to gunshot fractures came to a bony healing.

In an 8 months old pseudarthrosis in the distal third, however, a bone graft was performed 5 months after the operation with the nail in position (by one of my very "operation happy" colleagues) (See HAEBLER a.a.O, page 47, Ill. 14). I am not sure whether this was necessary or not.

It must be admitted, however, that the treatment in the hospital was rather tedious and lasted in many cases more than 1 year and the nails were only removed after 6 to 7 months.

The desire to create better conditions, that is better mobility of the joints by adequate movement, was in the first place responsible for this long hospitalization rather than the time required for bony healing (with the exception of suppurations and injuries of the nerves). The nail was left in position in these cases as an additional fixation. The patients so treated were farmed out for work so that the time of the stay in the hospital is not an absolute measure of the unemployability.

The fact, however, that all pseudarthroses came to a bony healing, including some cases with severe atrophy and cases in which a bone graft had previously been performed without much success is clearly in favor of the marrow nailing method and refutes the opinion of BOEHLER.

As a matter of fact the osteosynthesis was stabile in the majority of the cases, at least to such an extent, that the nail did not allow for any lateral movement. This is not always the case in the examples cited by BOEHLER. If the fracture after nailing was still movable

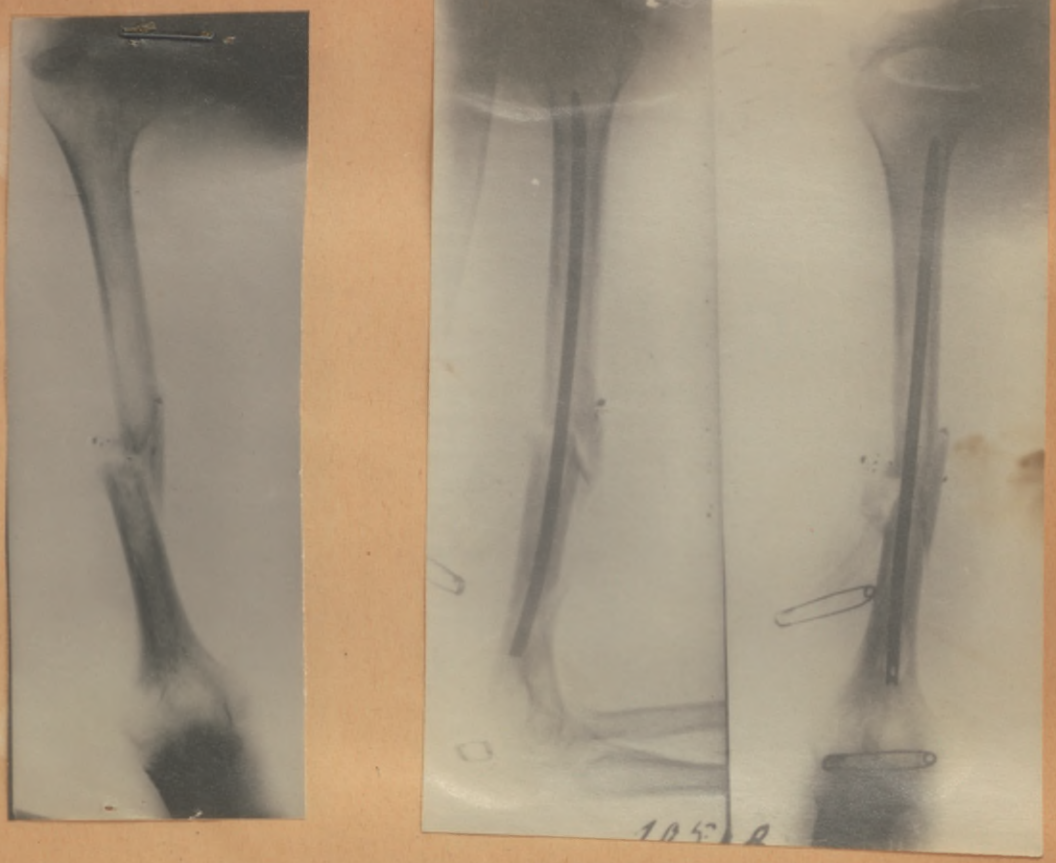
in a longitudinal direction, which happened in several cases, we applied abduction plaster casts and pushed the fracture together at the same time. The arm was elevated above horizontal until the fracture became solid. Such loosenings of the nail occur especially if the nail was introduced by approach from the distal side they do not present any additional hazard if treated properly. It is not sure whether or not a longitudinal wire suture will prevent this distraction. In case of atrophic bone the wire suture is likely to cut through the bone and will then prove hazardous rather than helpful.

This is illustrated by the following examples:

Fractures in the middle third are the most suitable because the nailing will secure a stabile osteosynthesis.

In the 6 months old fracture due to gunshot injury in Ill. 105, the wounds of which had been healed for six weeks, the broken out wedge had not found a junction to the distal fragment. First of all, we have mobilized the fracture under anaesthesia, although it appeared freely movable, and we hoped to be able to perform a closed nailing operation. Since no reaction was observed, we performed the operation 8 days later.

We were not successful in performing a closed nailing. The KIRSCHNER wire used as a guide rod repeatedly slipped off the proximal fragment. The exposure revealed that the marrow cavity was closed by strong callus and that a connective tissue pseudarthrosis existed between the broken out wedge and the distal fragment. The connective tissue between the fracture ends was removed and the proximal marrow cavity was opened by means of an awl. We renounced, however, a resection of the bone. The wounds were properly drained and the musculature at the fracture site, but not the skin, was brought in position by a few approximation stitches. Abduction plaster cast. The osteosynthesis was clinially stabile (Ill. 105). As no fever was observed, the drains were removed after 10 days and movement exercises were instituted 3 weeks post operative. The wounds had healed secondarily 6 weeks after the operation, the plaster cast was removed. The slight gap of the fracture is pushed in by the use of the limb with a slight angulation (Ill. 105c) and has healed 6 months post operative to such an extent that the nail can be removed (Ill. 105d). The patient is detailed to work during the period of movement exercises and on his discharge to the troop there was an extension defect of the



a b

Illustration 105

a) Six month old pseudarthrosis after gunshot fracture in the arm above the elbow. The wounds have been healed for 6 weeks.

b) After the open nailing, during which operation only the connective tissue between the fragments was removed. The osteosynthesis is stabil. The fracture cleft is somewhat gaping. Drainage of the fracture cleft and of the nail insertion site. No skin suture. Abduction plaster cast. The patient started subjecting the limb to exercises 6 weeks after the operation. The plaster cast was removed and the wounds healed per secundam.

c d

Illustration 105

c) Five months after the operation. The fragments were pressed together and they healed with slight angulation in the dorsal direction. Good formation of callus. The nail will be removed.

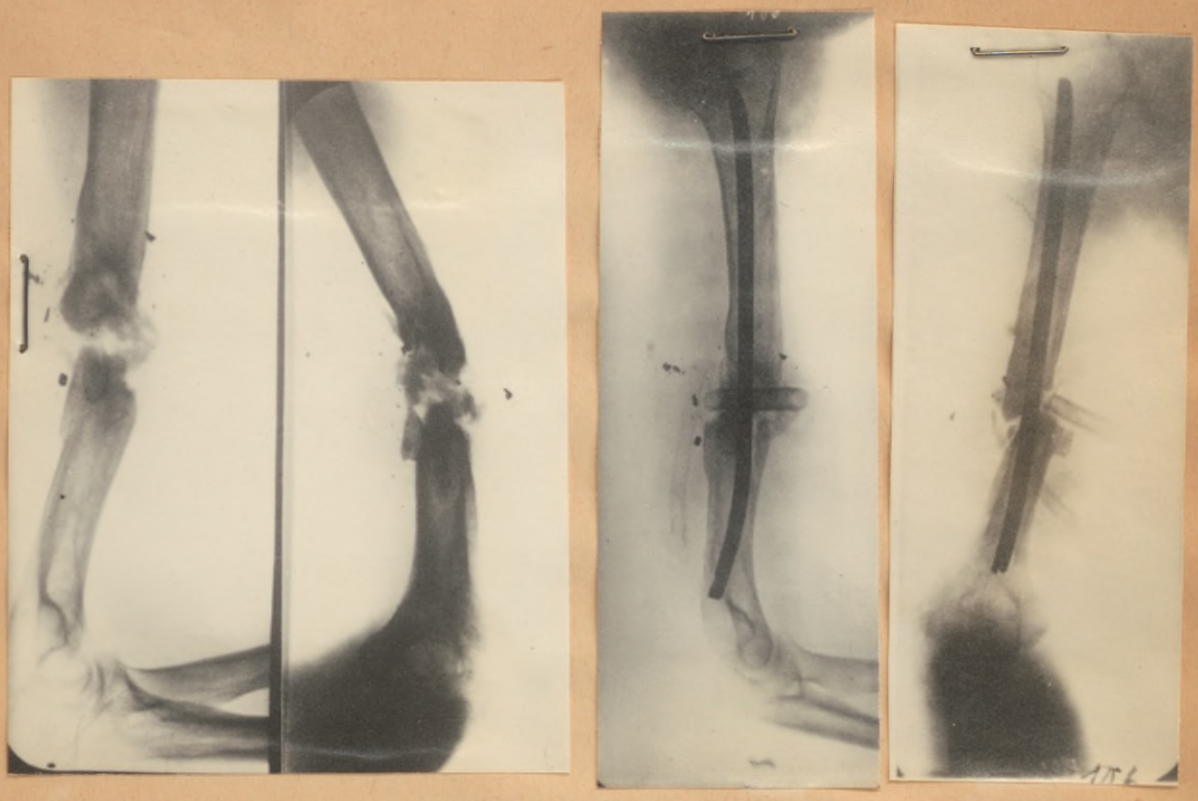
d) Six months after the operation. Bony healing. The defect of elbow extension amounts to 25 degrees. All other joints are freely movable.

elbow joint of 25°. The elbow joint was almost stiff on his admittance. The shoulder was freely movable.

The healing was less uneventful in the case of the 2 year old pseudarthrosis of Ill. 106a, where a bone graft had been performed 9 months after the injury but had not lead to healing. In consideration of the fact that the wound allegedly had healed for more than 1 year, the wounds at the fracture were sutured with application of a drain. The wounds had to be opened three days later because of a rise of temperature. Although an osteomyelitis or a formation of sequestra did not occur, the patient reacted to the movement exercises with fever and pains, so that the plaster cast had to be left in position. As the wound at the fracture continued to fistulate we decided 7 months post operative to remove the nail, although the X-ray picture indicated that the callus formation was not too abundant. (Ill. 106c) The fracture was clinically solid, but still was left in the plaster cast for 6 more weeks (Ill. 106d) when the callus had finally solidified to such an extent that movement exercises could be instituted. The fistulae were completely closed only 11 months after the operation when the patient was discharged from the hospital. The condition of mobility of the joints had not notably improved. This could as a matter of fact hardly be expected in a 2 year old fracture.

One cannot and must not rely upon the solidity of small callus bridges this is demonstrated by the description of the fracture as seen in Ill. 107.

In the nailing of the 8 months old fistulating pseudarthrosis the outer nail had turned by 90°, so that one renounced introducing the inner nail because the fracture appeared to be completely solid (Ill. 107b). Eight days later, the fracture could be moved longitudinally and was somewhat distracted (Ill. 107c). In the abduction cast, the fracture became, after 9 months, so solid by the formation of a sturdy callus bridge, that we removed the nail (Ill. 107d). A refracture occurred 2 months after the removal of the nail due to the physiotherapy. The wounds had healed in the meantime. Since the fracture had not healed after 10 months of treatment by plaster cast (Ill. 107e), I decided to renail the fracture. For this purpose I resected the tapering point of the distal fragment, the callus bridge was freshened and after the nailing which was this time performed by approach from the proximal side, the fracture ends were united by a



a b

Illustration 106

a) 2 year old pseudarthrosis after gunshot fracture. Unsuccessful bone graft 3/4 years after the wounding. The remnant of the graft in the distal fragment is still visible. The wounds have been healed for one year.

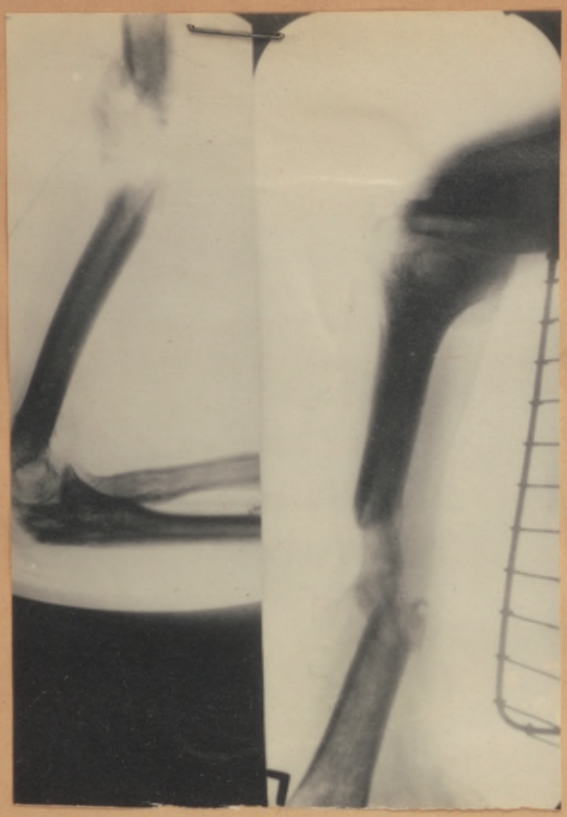
b) After the open nailing. The connective tissue callosities were removed, the tips of the fragments were conservatively resected and a blocking callus bridge was removed. Wound suture with drainage of the fracture site. Abduction cast. Three days after the operation the wounds had to be opened. Subjecting the limb to exercises constantly caused an increase of temperature. Further immobilization by plaster casts.

c d

Illustration 106

c) Six months after the operation. The wounds are still fistulating. Despite the fact that only a small bridge of callus was present the nail was removed. No osteomyelitis. From the clinical point of view the fracture is healed after the extraction of the nail. After that, the patient was kept in the cast for another period of six weeks after which the patient started subjecting the limb to exercises.

d) Eleven months after the operation. Bony healing of the fracture. The fistulae are closed. The flexibility of the joints in comparison to the conditions before the operation is not much better.

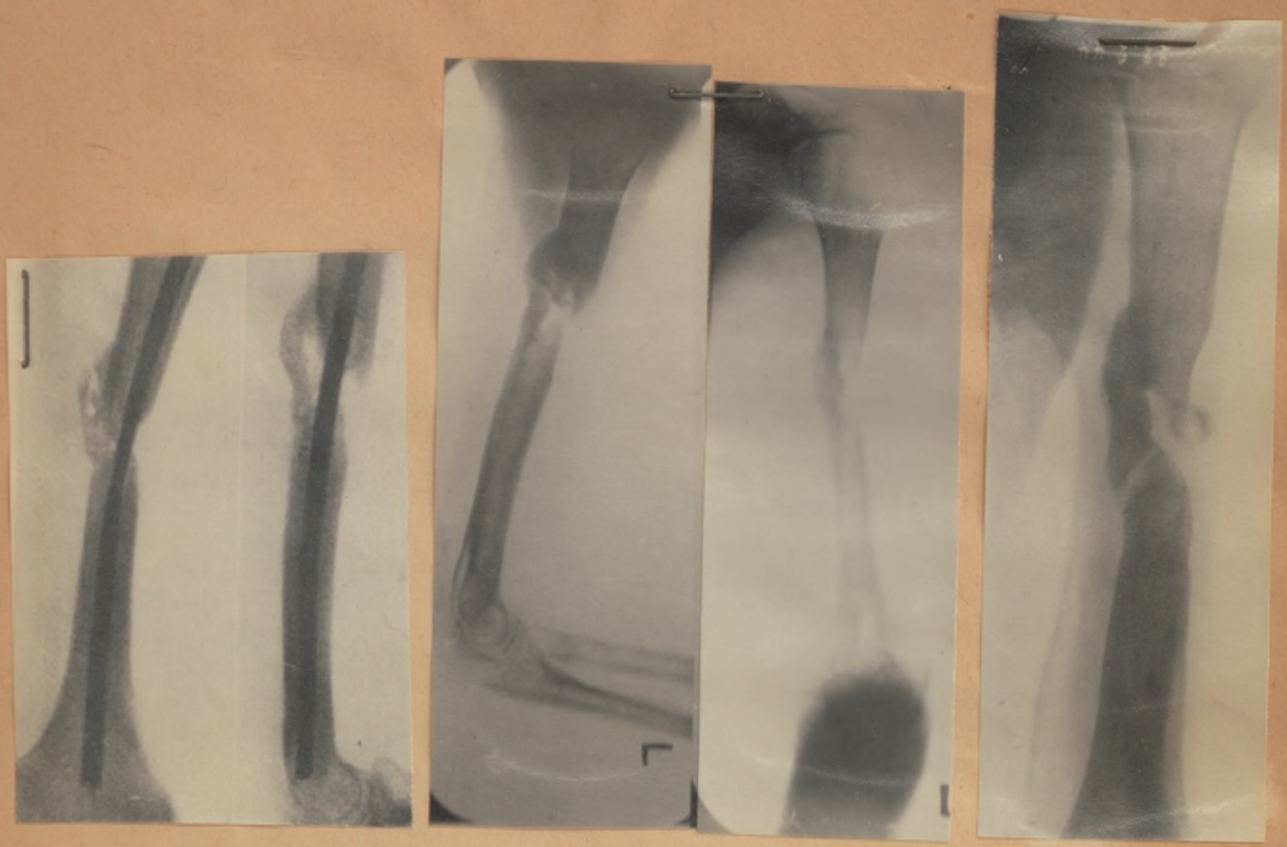


a b

Illustration 107

a) Eight month old fistulating defect pseudarthrosis after gunshot fracture of the arm above the elbow.

b) The same fracture after the nailing. The nail had turned 90° so that the inner nail could not be inserted. The fracture is clinically healed. The wounds were kept open. An arm sling was used.



c d e

Illustration 107

c) Eight days after the operation. Distraction of the fracture. The fragments can be moved up and down in the longitudinal direction. Abduction cast.

d) Nine months after the operation, eight days after the removal of the nail. The fracture healed with a small bridge of callus. Soon after that the fistula at the fracture site healed. Two months after the extraction of the nail a refracture occurred during the medico-mechanical treatment. Application of an abduction cast.

e) 21 months p.op., 10 months after the refracture: Pseudarthrosis between the callus bridge and the distal fragment.


f g

Illustration 107

f) Once again open marrow nailing. The tips of the fragments were resected and the callus bridge was freshened. After the fragments had been pressed together they were held together by means of a wire running in the longitudinal direction. Application of a plaster cast for a period of 10 weeks. Good healing of the wound. The nail was extracted after a period of 6 months. After that a fistula was observed at the fracture site extending to the wire which was removed.

g) Nine months after the second and 2½ years after the first operation. Bony healing of the fracture. The fistulae are closed.

longitudinal wire suture (Ill. 107 f). The nail appeared rather short, however, it was so firmly stuck in the distal marrow cavity that it separated the fracture when driven in farther. The drain wounds healed uneventfully. The plaster cast was removed only 12 weeks later; the nail was withdrawn six months post operative. Then a fistula occurred at the fracture which communicated with the wire suture which was then also removed ; 9 months after the second and 2½ years after the first operation the patient was finally released from the hospital (Ill.107g).

It is not sure whether or not a better result would have been obtained in the first place if the fracture ends would have been resected. We refrained from performing the resection at the first operation because we had to deal with a fistulating pseudarthrosis in which as a matter of fact the protective granualtion tissue should be spared as much as possible with a view of avoiding a medullary infection. If the osteosynthesis is very stabile these pseudarthrosis will become solid even if the fracture ends do not widely abut but are only bridged over by callus splinters as is demonstrated in the following case.

In the 6 months old fistulating pseudarthrosis of Ill. 108a, only two little sequestra were removed on the occasion of the nailing operation, whereas the splinters which were still in connection with the periosteum and partly connected with each other by callus were left in position although they made it impossible to push the fracture together. The nail which was driven in as far as the head gave the fracture a completely firm hold, although the nail lay free in the defect. The musculature over the exposed nail was held in position by an approximation suture. The wounds were properly drained and left open. Abduction splint. The wound at the olecranon healed uneventfully. A small sequestrum was ejected at the fracture site whereupon the fistula closed. 10 weeks post operative motion could be instituted and 1 year post operative the fracture was solid enough, so that the nail could be removed (Ill. 108c). Shoulder joint freely movable, mobility of the elbow joint was 70 to 160°.

The pseudarthroses in the median third are also very suitable for nailing, even if the distal fragment is rather short.

In the 22 months old fistulating pseudarthrosis of Ill. 109, for instance, the fracture had so much solidified after 5 months that the abduction cast could be

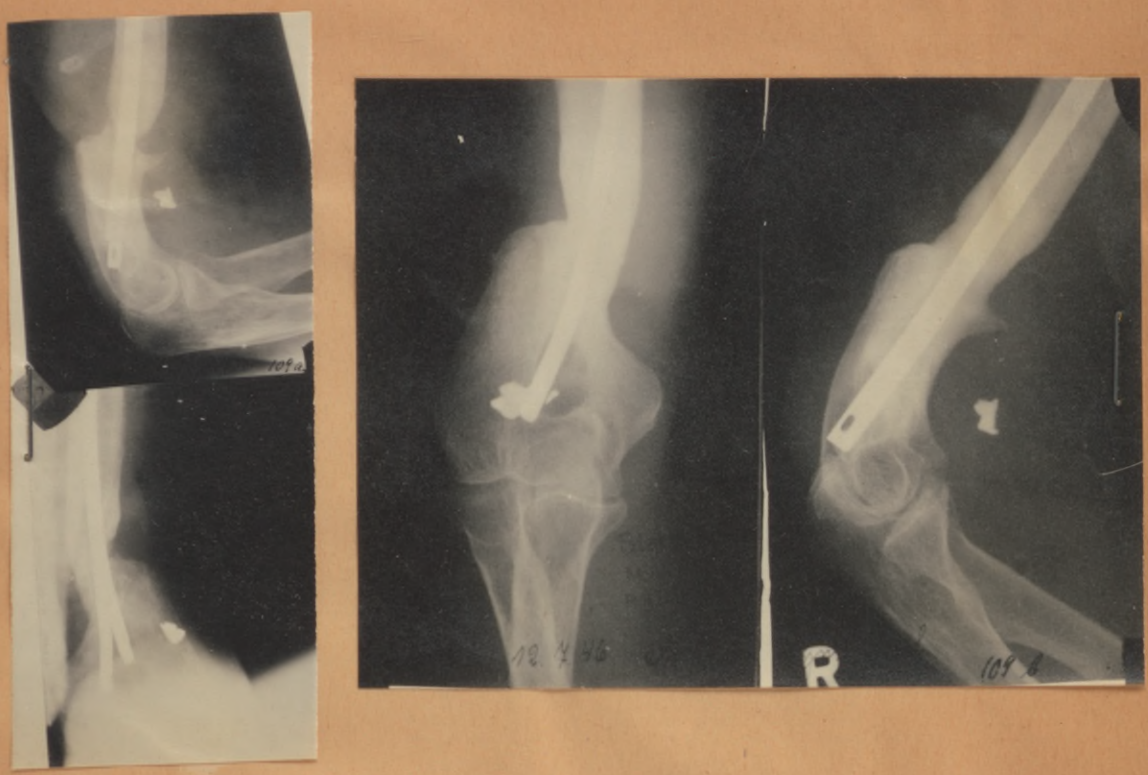
a b c

Illustration 108

a) Six month old fistulating defect fracture of the arm above the elbow after a shell splinter injury. The fracture is freely movable.

b) The same fracture after the nailing, during which only two loose and sequestrated bone grafts were removed. Most of the splinters are covered by callus which prevents the pressing together of the fragments. The nail grants a good hold to the fracture. Abduction splint. The patient began subjecting the limb to exercises 10 weeks after the operation. The splint was removed 12 weeks after operation. 4 months after the operation ambulatory treatment. The patient resumed working 6 months later.

c) One year after the operation. Bony healing of the fracture and removal of the nail. The shoulder joint is freely movable, the motion of the elbow amounts to 70-160 degrees.




a b

Illustration 109

a) Pseudarthrosis after gunshot fracture of the upper arm, 2 months after the nailing. (Pictures taken earlier were destroyed). The fracture cleft is still noticeable, suppuration of the wounds. The nail is exposed in the wound at the olecranon. No osteomyelitis.

b) The same fracture 3 years after the nailing. According to the statements of the patient the inner nail slipped out of the wound 2 years ago. The wounds are healed and the fracture is bridged over by callus.

removed. During all the time the nail was visible in the open wound at the elbow and had here the effect of a very efficient drain so that the wound at the fracture closed relatively quickly. The wound at the elbow healed also but we did not yet remove the nail because the callus appeared to us to be too slight. The patient was then drafted for labor service and I saw him again only 2 3/4 years later because of an abscess at the elbow. The fracture had come to a good bony healing and the nail could be removed on the occasion of the incision of the abscess. The elbow joint was movable between 90 and 160°. This may certainly be called a good result.

In this type of fracture special attention must be paid that the nail is introduced exactly at the upper edge of the fossa olecrani and that its end is bent a little bit, so as to avoid the distal fragment from slipping of the nail (See Ill. 115). If these points are observed special measures as for instance the spiral spring proposed by MAATZ will not be necessary. If the nail is not introduced exactly in the middle in the hope that it will this way obtain a firmer hold in the spongiosa one risks splitting the bone and in that case the osteosynthesis will be the more instabile.

It is recommended to nail fractures due to gunshot injuries, especially if they are still fistulating by approach from the distal side because of the ever present infection hazard in this type of fracture. By a distal approach the entrance spot of the nail will be the deepest point and the nail will guarantee a perfect drainage if the wound is left open.

This will hardly be possible in case of fractures in the proximal third, because of the hazard that the nail will slip out of the head and cause a pseudarthrosis as actually happened in the fracture due to gunshot injury shown in Ill. 110 which had been nailed (not in our clinic) immediately after the injury and which came to us for treatment one year later. We obtained a healing by means of a staircase shaped freshening and wire suture.

We and many others have attempted to nail such pseudarthroses by approach from the proximal side and complications occurred in each of these cases.

Two pseudarthroses, the wounds of which had healed for two months respectively one year, became infected and resulted in tedious suppurations with perforations towards the fossa olecrani respectively infection of the bursa subdeltoida. In two other fistulating pseudarthroses, the distal atrophic fragment was split once without sequelae and in the other case it came to an infection of the elbow joint.

Illustration 110

1 year old gunshot fracture which had been nailed immediately after the injury. A splint was used for a period of 13 weeks. The old nail canal is clearly noticeable in the head, out of which the tip had slipped. In this way a pseudarthrosis developed. The marrow nailing operation is not indicated for gunshot fractures located so proximally.

Although all these pseudarthroses came to a bony healing, it must be said that the nail did not bring any advantage whatsoever. There is a more simple means; which is more likely to be successful especially in atrophic bone: The distal fragment is slightly pointed and pushed into the spongiosa of the head. Then an abduction cast is applied. This may also be done if the fracture is still fistulating. In that case one must beware that no wire suture is used which willalways cut the atrophic bone and cause the resorption of the fracture ends and the result will be a faulty healing.

The Illustrations 111 - 113 demonstrate the above facts.

The main advantage of the marrow nailing method with regard to old fractures due to gunshot injuries of the humerus in which an uneventful healing is not assured lies in the fact that it can be performed when the wounds are still suppurating. We have nailed 14 times under these circumstances, three times with very severe suppurations and the results are set forth in table VIII.

It is not surprising that a formation of sequestra occurs in this type of fracture which could not be avoided by any conservative method especially when dealing with severely comminuted fractures. It appears relevant to us that an osteomyelitis occurred only in one instance and this could have been avoided.

It is important that only the sequestra are removed during the operation, the splinters, however, will as a rule be left in position and freshening will be avoided. The splinters are useful and their removal would be synonymous with a destruction of the protective granulation dam. It is important also that the osteosynthesis be stabile, that the wounds be properly drained, that neither the entrance site of the nail nor the wounds be sutured to avoid a collection of the infectious secretion.

The nailing is to be performed if possible by approach from the distal side to avoid collections of secretions in the marrow cavity. The nail will then constitute an ideal drain and its entrance site will be the deepest point.

If the nailing is exceptionally performed by approach from the proximal side (Ill. 114) it will be necessary to apply an abduction cast and to elevate the arm above the horizontal until the infection period is overcome.

With reference to what has been said already to the point (HAEBLER a.a.O.,page 34, Ill. 5 and 6) we abstain from giving more illustrations. Only one nailing will be described because it typically demonstrates that conditions may arise in case of an atrophic bone which must be given special consideration.

# TABLE VIII.

Marrow nailing of intensely purulent and fistulating old Fractures of the upper arm due to gunshot injury.

| | Number | Bony Healing | with | | Average stay in the hospital Days | Final Result *) | | |
|---|---|---|---|---|---|---|---|---|
| | | | Format. of sequestra | Osteomyelitis | | I | II | III |
| Intensely purulent fractures, moderately splintered, 6 days to 9 weeks old | 3 | 3 | 1 | - | 115 | 2 | 1 | - |
| fistulating fractures 4-8 weeks old, without extens. splintering | 3 | 3 | 1 | - | 98 | 3 | - | - |
| , comminuted fractures | 2 | 2 | 1 | - | 150 | 2 | - | - |
| 10 - 16 weeks old, without ext. splintering | 4 | 2 | 3 | 1 | 210 | - | 1 | 2 |
| , comminuted fractures | 2 | 2 | - | - | 156 | - | 2 | - |

*) I - entirely free mobility of the joints, no shortening

II - Slight angulation or impediment of the joint EM ≤ 20 per cent

III - More important angulation or impediment of the joint EM > 25 per cent

a b c

Illustration 111

a) 15 month old pseudarthrosis after gunshot fracture. The wounds have been healed for 7 months. Serious bone atrophy.

b) The same fracture after the nailing. Drainage of the wounds which were closed by approximation sutures. The osteosynthesis is stabil. Application of an abduction cast. The drainage was removed 14 days later and the patient began with exercises with the abduction cast open. Fistulation of the wounds.

c) The same fracture 4 months after the operation. It seems to be bridged over by good callus. The wounds are still fistulating. Removal of the cast. The patient complained about pains at the fracture site three weeks after that. Therefore another abduction cast was applied which was split. Continued fistulation of the wounds.

d e f

Illustration 111

d) The same fracture 5 months after the operation. Another distraction is observed. Further fistulation of the wounds. After that the fragments were pressed together and an abduction plaster cast was applied. Ambulatory treatment. 9 months p.op. the fistulation of the wounds had not yet subsided. The fracture is healed from the clinical point of view. The X-ray is similar to Illustration 111 c. Additional plaster casts.

e) 13 months after the operation an abscess at the elbow was observed. The callus which bridges over the fracture is thin but stabil. The nail had penetrated the fossa olecrani. It became visible during the incision of the abscess and therefore it was removed. Additional plaster casts. 14 months after the operation the plaster cast was removed.

f) 20 months after the operation. The wounds finally closed and the fracture is stabil. The shoulder can be raised up to the horizontal line. Motion in the elbow is 60-150 degrees.

a

b

Illustration 112

a) One year old fistulating pseudarthrosis after a gunshot fracture with formation of a sequestrum. The sequestrum was removed. The distal end of the fragment was conically sharpened. After that it was inserted into the spongiosa of the proximal fragment which had previously been refreshened with a curette. Drainage of the wound with the skin kept open. Abduction cast. The wounds are healed 8 weeks after the operation. Removal of the plaster cast 6 months after the operation. The fracture is stabil from the clinical point of view. 8 days later a fistula broke open in the operation wound out which a small sequestrum was cast off. After that the wound closed.

b) 7½ months p.op. The fracture is healed. In the elbow joint the impediment of extension amounted to 10 degrees, all the other joints are freely movable.

a b c

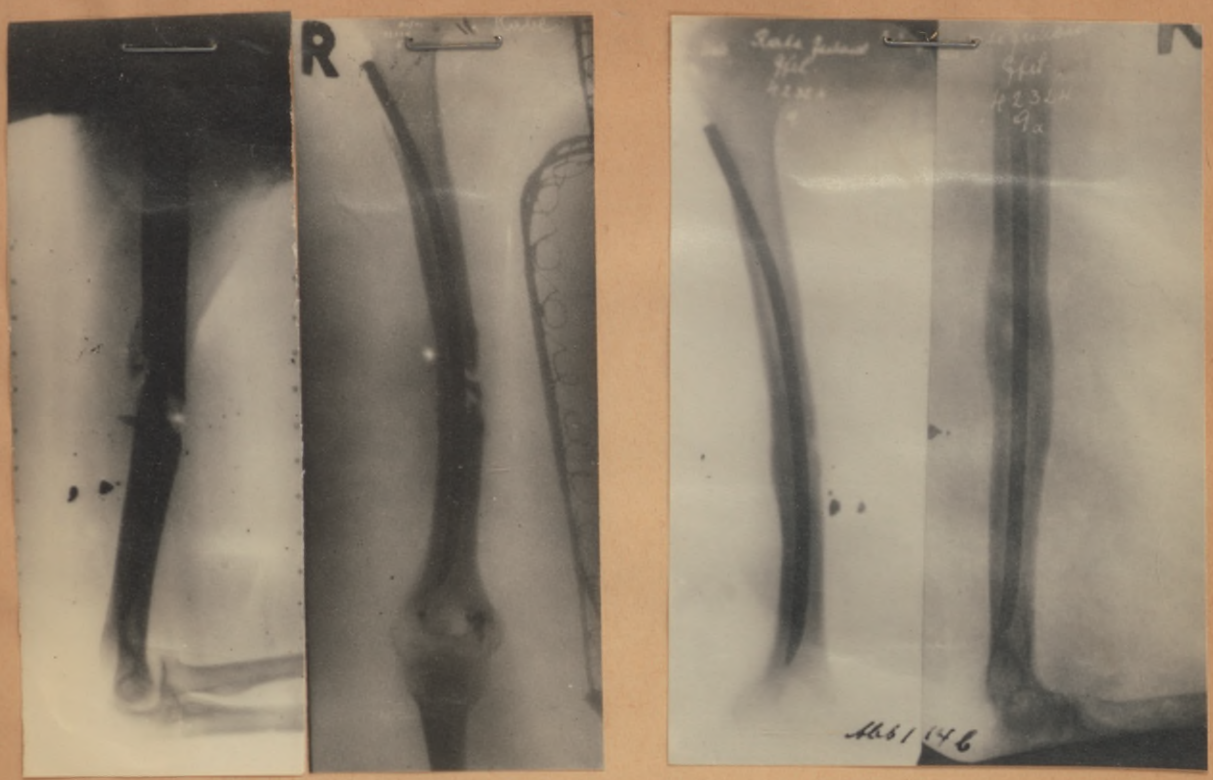
Illustration 113

a) Three year old pseudarthrosis of the arm above the elbow after gunshot fracture. A bone graft had been made one year before. The suppurating wounds have been healed for 8 months. The previously planned nailing operation was not made because the bone would become too short by the necessary freshening of its ends. Therefore only the distal fragment was freshened and inserted into the proximal marrow cavity. It was kept in place with two wire loops. Application of a plaster cast.

b) The same fracture after the operation. Primary healing of the wound.

c) Five months after the operation. Despite the fact that a primary healing had been obtained, and the limb was constantly immobilized, another pseudarthrosis had developed which was due to the resorption of the atrophic bone caused by the wires.

The question whether or not a healing would have been obtained without the wire suture cannot be answered. It would have been better to take a possible shortening into account and to nail the fracture. It certainly would have been successful because a stabil osteosynthesis was possible. Now the patient declines further operations.




a b

Illustration 114

a) Five week old fistulating fracture of the arm above the elbow after nailing. The osteosynthesis is stabil. An abduction cast was applied.

The wounds which had been kept open, healed without delay and per secundam, within four weeks. After that the patient started subjecting the limb to exercises. Removal of the plaster cast after a period of 2 months. The patient was released to his unit for garrison duty three months after the operation.

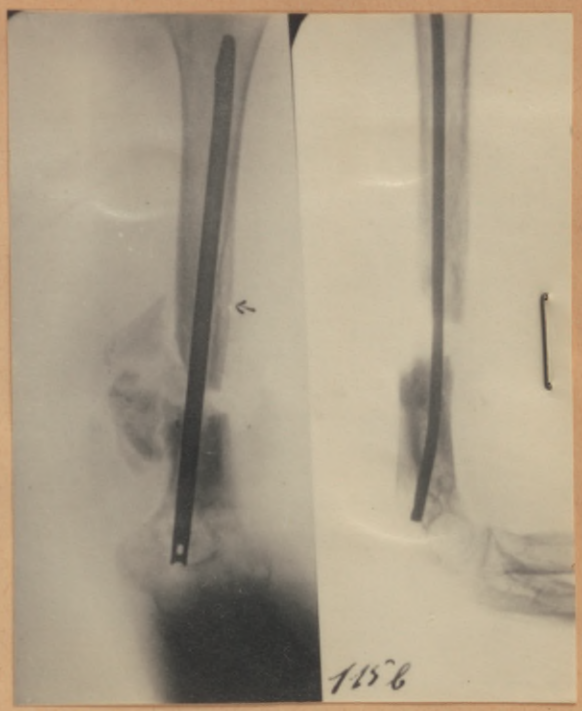
b) Six months after the operation. Bony healing of the fracture and extraction of the nail. All joints are freely movable.

In the nailing of the 16 weeks old fistulating comminuted fracture of Ill. 115a, the nail stuck in the corticalis when driven into the proximal marrow cavity. It was withdrawn and the point was slightly angulated whereupon it could be easily driven in and came into a good position. After that the fracture was still movable in a longitudinal sense (Ill. 115b). For this reason the inner nail was also driven in but the fracture could still be distracted. We pushed it together strongly and applied an abduction cast. The X-ray control which we always perform after the application of plaster casts revealed that the distraction was still existing and that the nail had penetrated through the corticalis into the soft parts at the spot which is clearly visible in Ill. 115b and c. When we removed the nail the point of which was palpable throughan incision, the outer nail slipped out of the distal fragment. Therefore we used another nail which was 2 centimeters longer. The end of this nail was given the shape of the letter S to assure a firm hold in the proximal fragment. The nail now reached up to the spongiosa of the head. A piece of bone had broken out at the flexor side of the distal fragment which had to be removed because it was bare of periosteum. The fracture could now be easily adapted, but the nail did not have a proper hold and was, therefore, fixed by wire loops. The position was now satisfactory but the fracture could still be distracted (Ill. 115d). Considerable pressure was exercised from the side of the elbow and an abduction cast was applied. The wounds which were left open came to an uneventful secondary healing and the fracture had solidified, 4 months post operative to such an extent that movement exercises could be instituted (Ill. 115e). The patient was transferred 4 weeks later into a special hospital because of a paralysis of the radialis. The nail was then removed 8 months after the operation after a suture of the nerve had been done. X-ray pictures are missing. The shoulder joint was freely movable, elbow movable 90 to 170°.

It may be seen in the table that the result of the treatment is the better the earlier the operation is performed. Nevertheless we advise a careful consideration of the indication in every case.

In summary we wish to say:

The marrow nailing method is very successful in the treatment of pseudarthroses of the humerus due to gunshot injuries and has proved superior to all other methods if a stabile osteosynthesis can be achieved. This is the case



a b

Illustration 115

a) 16 week old fistulating comminuted gunshot fracture in the arm above the elbow. The nail was inserted in the wrong way. Fractures of this kind should be nailed only from the distal side.

b) Even after the insertion of the outer nail the fragments could be moved in the longitudinal direction. The nail had jammed in the proximal marrow cavity and probably had pierced the bone at that spot (!).

c d e

Illustration 115

c) At the same spot the inner nail had pierced the bone and penetrated the soft parts. During its extraction through an incision made at the spot where the nail tip was palpable, the outer nail slipped out of the distal fragment.

d) After the second operation with a longer nail which is somewhat angulated at its end. It is held in place by means of a wire loop because a part of the distal fragment had broken off. An abduction cast was applied because the fragments are still distractable. The wounds are kept open. Good healing.

e) Four months after the operation. The fracture is bridged over by callus to a large extent and it is clinically healed. The nail was removed four months later.

in all fractures situated distal to the line defining the boundary between the proximal and median third.

It is not necessary to wait with the nailing 9 months after the closure of the wounds, it can be performed when the wounds are still fistulating. The nailing is to be performed as a rule by approach from the distal side. In the further course of the treatment special attention must be paid to a possible distraction of the fracture due to a loosening of the nail. If this occurs the fracture must be fixed in an abduction cast in an elevated position of the arm (above horizontal). An additional longitudinal wire suture may prevent the distraction its use, however, is not permissible in case of fistulating pseudarthroses or atrophic bone. In these cases its use may be hazardous because the wire might cut the bone and cause resorption.

The nailing is not indicated in case of fractures due to gunhsot injuries located in the proximal third. In case of pseudarthroses in this area with atrophic bone it fits the purpose better if the distal fragment is sharpened and pushed into the spongiosa of the head. This can be done even if the wounds are still fistulating. Wire suture must be avoided in this case under all circumstances because it would lead to resorption of the bone.

If the wounds have healed in these pseudarthroses for more than 9 months and if the calcarous contents of the bone are satisfactory, the pseudarthrosis is freshened in the shape of a staircase and a wire suture is applied.

The nailing of the <u>fistulating</u> old fracture of the upper-arm is permissible only if a completely stabile osteosynthesis can be expected.

The nailing should only take place if the formation of callus is insufficient and if a pseudarthrosis is imminent or if the formation of sequestra necessitates the exposure of the fracture site anyhow. The nailing should be performed in these cases as a rule by approach from the distal side. Fistulating fractures of the upper arm located above the boundary of the proximal and median third should always be excluded from nailing because the nail will not find a proper hold in the proximal fragment.

In case of a <u>severe suppuration</u> the stabile osteosynthesis by means of the marrow nail should be performed only exceptionally if one does not succeed with the usual conservative methods to put the fracture at rest in such a way that the infection can be efficiently fought.

d) Pseudarthroses of the Forearm

We did not see our way clear to nail old fractures of the forearm as long as they were still fistulating. As we have seen the hazard that the nail will penetrate the thin corticalis of the bone is already great even if the course of the healing is aseptic. In case that a pseudarthrosis occurs or is already existing it must be foreseen that large areas of the bone become necrotic and that a defect pseudarthrosis will possibly ensue.

In Table IX we give a survey on the nailed pseudarthroses of the forearm.

5 pseudarthroses of both bones of the forearm, the wounds of which had healed from 4 weeks to 9 months, came - with one exception - to a bony healing.

This failure in case number 5 is due to improper technique.

We had to deal with a genuine pseudarthrosis at the radius with fibrous cartilage. (Ill. 116a). Since the defect at the ulna was about 3 centimeters, the bone ends of the radius were resected to the same extent in the sound bone. Hereafter the fracture ends of the ulna did not yet come to a wide abutment, the freshened bone ends were still at a distance of about 1 centimeter and we considered this result as good enough. When the nails were driven in there was still a gap in the ulna. We intended to avoid a further resection and were of the opinion that it would be sufficient to bring the two bone ends together by means of a wire loop. In order to be on the safe side against longitudinal displacement a longitudinal wire suture was also applied (Ill. 116b). A wound infection at the ulna occurred, the point of the distal fragment sequestrated and the result was a new defect pseudarthrosis of the ulna, whereas the radius came to a bony healing (Ill. 116c). After sequestrum and wire had been removed, the fistula closed soon and the radius nail could be removed 5 months post operative. 6 months post operative the patient could be discharged from the hospital. Since the function of the limb was not seriously hampered by the ulna pseudarthrosis we abstained from further intervention.

The ulna nail was too short and did not find the necessar hold in the distal marrow cavity, this is clearly visible in Ill. 116b. So it finally came to the penetration of the point into the corticalis, to an angulation (in spite of the plaster cast) and probably to a gradual fracture and sequestration of the point of the fragment which was held in place at the very end by a wire loop.

T A B L IX

## Marrow Nailing in Case of Pseudarthroses after fractures of the forearm due to gunshot injuries.

| Nr. | Type of Fracture | Injury dating back | Wounds healed since | Type of Intervention | Healing of Wounds | Total time of treatmt. | Result | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Pseudarthrosis of ulna and radius after comminuted fracture in the middle of the shaft. | 7 months | 12 weeks | Marrow nailing of ulna and radius osteosynthesis stabile | Wound infection, formation of sequestra | 263 days | III as before nail. | Radius nail introduced by mistake into the elbow joint, is withdrawn no infec.of joints.S.Ill. 117 |
| 2 | Contact pseudarthrosis of ulna and radius in the middle of the shaft, treated without success 6 months before with wire suture | 9 months | 7 months | Exposed nailing of the ulna with removal of wire. Closed nailing of the radius | Primarily | 68 days | II | |
| 3 | Contact pseudarthrosis of the radius, ulna healed with angulation, middle of the shaft | 10 months | 9 months | Resection of the ulna, freshening of the radius, nailing of the radius. KIRSCHNER wire used for the ulna because of a very narrow marrow cavity | Primarily | 150 days | II | |
| 4 | Defect pseudarthrosis of the radius, proximal third -Pseud. of the ulna below the olecran. Wired unsatisfactorily 9 month before, wound infection | 12 months | 4 weeks | Nailing of the ulna, stabile in spite of short nail. 3 months after nailing bone graft of the radius | Primarily slight wound infection | 280 days | II | See HAEBLER, a.a.O. Page 40, Ill. 10 |
| 5 | Defect pseud. of the ulna, contact ps. of the radius, middle of shaft. | 14 months | 7 months | Resection of the ulna, freshening of the ulna. Nailing of both bones, wire loop at the ulna, ulna nail, too short | Infection, coronary sequestrum at ulna | 285 days | IV | Poor technique, see Ill. 116 |
| 6 | Defect ps. of the radius, distal third, comminuted fract. dist. Luxation of the ulna (Madelung) | 5 months | 3 months | Resection of the ulna, marrow nailing, with longitudinal wire suture | Primarily | 180 days | III | Ulna not far enough resected, therefore, MADELUNG's deformity |
| 7 | Distal luxation of the ulna with healed comminuted defect fract. of the radius | 8 months | 4 months | Resection of the ulna, marrow nailing, p.op. good position | Primarily | 140 days | IV function not improved. | In spite of plaster cast renewed sublux.of ulna with distraction of the site of resection. |
| 8 | Pseud.of the ulna, middle of shaft, luxation of the head of the radius (Monteggia), Treat. unsuccessfully 8 months before with LANE's plate | 12 months | 10 months | Thorough resection of head of the radius, marrow nailing of the ulna. | Primarily | 90 days | I | Cast removed 4 weeks p.op. Movement exercises |
| 9 | Defect pseudarthrosis of the ulna, middle of distal third, abt. 4 centimeters | 4 months | 3 months | Nailing and grafting of tibia chip which is fixed by wire loop | Wound infection with tedious fistulation, no formation of sequestra. | 368 days | IV | Pseudarthrosis between the graft and the distal fragment |
| 10 | Defect Pseud. of the ulna in the middle of the shaft defect abt. 1 cm. | 16 months | 10 months | Marrow nailing and tibia graft which is only fixed by periosteum sutures. Nail too short. | At first primarily, after 5 weeks suppuration and ejection of graft, bone sequestrum | more than 1 year. | IV | Defect larger than before the operation. |

a b c

Illustration 116

a) 14 month old pseudarthrosis of the forearm after a gunshot fracture. The wounds have been closed for 7 months.

b) The same fracture after the nailing. A piece 3 cms. long has been resected from the radius. After that the freshened ends of the ulna can stand one upon the other for an area of 1 cm. Due to the fact that after the insertion of the nails the cleft is still gaping, the fragments are fixed by means of a wire loop. In order to prevent distraction of the radius a wire which runs in the longitudinal direction was used. The ulna nail is too short. The wounds were sutured but they had to be opened again because an infection developed.

c) Three months after the operation. The radius is bridged over by good callus. The osteosynthesis of the ulna was not stabil. Consequently another angulation occurred and the fracture slowly increased with the sequestration of the tip of the distal fragment. Final result: Defect pseudarthrosis of the ulna.

On the basis of our experience we wish to warn emphatically against an additional wire loop. An angulation cannot be avoided by this wire loop if the osteosynthesis is not stabile, the bone will rather slip out of the loop and if an infection occurs resorption in the area of the wire and formation of sequestra is imminent especially in case of atrophic bone. Only the longitudinal wire suture is justified as it avoids distraction. It should be applied as widely as possible (wider than is shown in the illustration). In case of atrophic bone, however, we consider the longitudinal wire suture likewise as hazardous.

If one wants to avoid an excessive resection it will be preferable in these cases to nail the radius first (as has been described by HAEBLER a.a.O.,page 40, Ill. 10) and to wait after the application of a plaster cast until the radius solidifies and only then to proceed to a bone graft of the ulna.

In the other cases of pseudarthroses of both bones, the results are satisfactory. The osteosynthesis was stable in all these cases and this is an important factor to the final healing result.

That the treatment is prolonged by an infection as in case Nr. 1 is quite natural. It is important to note that the pseudarthrosis healed satisfactorily in spite of the infection and in spite of the badly comminuted fracture (Ill. 117)

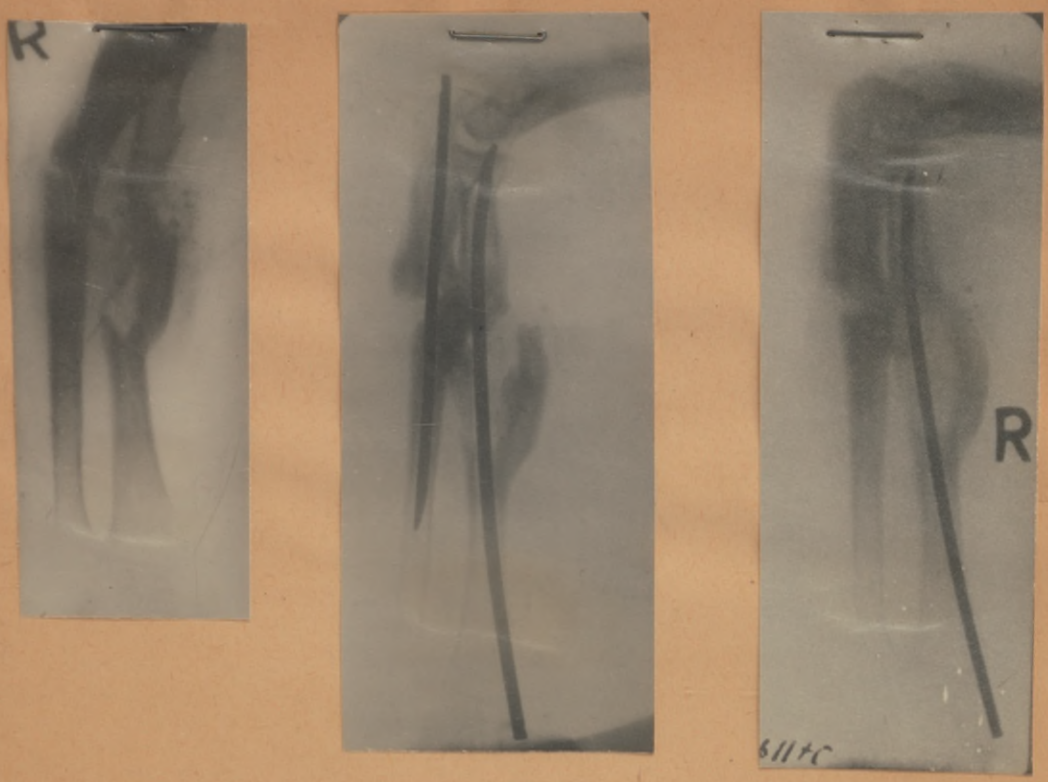
At the operation the radius nail had by mistake been driven in as far as the elbow joint (Ill. 117b). An infection could be avoided because the wounds were opened widely in proper time so that a collection of secretion could not occur and because the osteosynthesis was stabile.

In case of a Monteggia-injury of the ulna fracture, with luxation of the head of the radius it will be useless to perform an osteosynthesis in case of an imminent faulty healing of the ulna and to reduce the head of the radius only by a non-operative procedure.

Even if the marrow nail is used for this purpose, it cannot be avoided that the head of the radius slips out and the ulna nail will break or perforate the bone. The radius luxation must be reduced by operation and thereupon the ulna will be nailed. A healing can be achieved by these measures (See HAEBLER a.a.O.,page 2016, Ill. 4199 - 4212).

A LANE's plate will never be sufficient for this purpose, especially not if it is fixed as is shown in Ill. 118a with only two screws.

If the luxation existed already for a long time, the reduction by means of an operation will not suit the purpose, Even in case of a bony healing there would be considerable impediments in the elbow because the cartilage of the head of the radius is so severely affected that it will




a b c

Illustration 117

a) Seven month old pseudarthrosis of the forearm after gunshot fracture. The wounds have been closed for 12 weeks.

b) The same fracture after the open nailing of the two bones. The radius nail has penetrated into the elbow joint. It was drawn back. The osteosynthesis was stabil. Three days after the operation the temperature increased and an infection of the sutured wounds developed at the radius. The wound was immediately widely opened. Several sequestra were cast off.

c) The same fracture 7 months after the operation. Bony healing. The ulna nail was removed 4 weeks ago. The wound at the radius is still fistulating. Extraction of the nail. Soon after that the fistula closed.

become necrotic and a connective tissue deformation or calcification of the capsules will be the final result. The only way out then is the resection of the head of the radius. If it is performed widely enough and if the pseudarthrosis of the ulna is united by the marrow nail after appropriate freshening, a good healing will be achieved with an almost free mobility of the joints, even if the nail is somewhat too short as in Ill. 118. An additional wire is not required since the radius is no longer obstructing.

If the head of the radius is resected too sparingly, the longitudinal wire will not be of any use and the result will be either a distraction and faulty healing or a fracture of the nail (See HAEBLER a.a.O.,page 2019, Ill. 4213-4222).

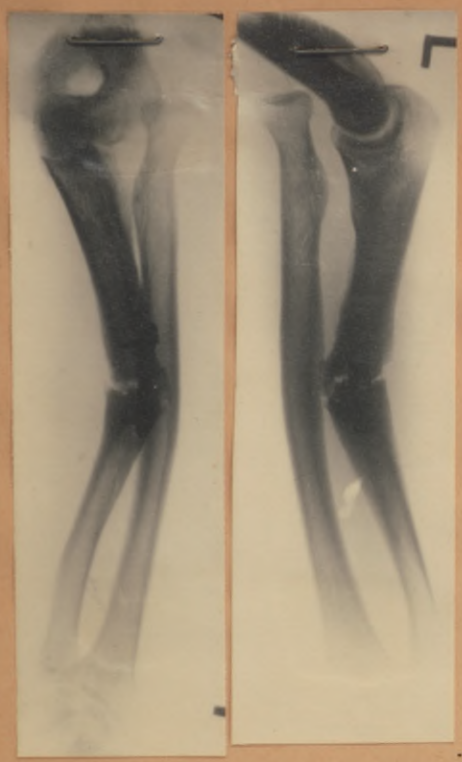
We suggest to neither resect the ulna in defect pseudarthroses of the radius with luxation in the distal radio-ulnar joint nor to nail both bones after the resection. If one resects too sparingly as in Ill. 119, a new luxation will be likely to occur and if an infection occurs especially in case of a nailing of both bones, the final state is possibly worse than before. Most of these fractures will solidify because the obstructive effect of the ulna is annulled by the distal luxation .

If the fracture of the radius has solidified and if the function of the wrist is seriously hampered by a luxation of the ulna in the distal radio-ulna joint it will be useless to resect the ulna in the shaft and use the marrow nail. As we have seen in a case which was not treated in our clinic the scar shrinking at the wrist joint will cause a new distraction of the site of the resection and a new pseudarthrosis will ensue in spite of a plaster cast. It is indicated in these cases to resect the styloid process of the ulna.

In two cases of defect pseudarthrosis of the ulna a bone graft with additional marrow nailing has been performed. The idea that the nail might favor by the position a so secured healing in of the graft is quite obvious and this procedure has been recommended lately by several authors. BOEHLER, however, refutes it because he is of the opinion that the graft is impeded in its nutrition by the destruction of the marrow.

In our two cases of ulna pseudarthroses it also came to an infection and faulty healing, although the osteosynthesis was stabile in both cases.

In consideration of the fact that two other cases of tibia pseudarthroses which were not operated in our hospital also resulted in faulty healings we refrained from further experiments in that direction. Particularly with the forearm the plaster cast assures an adequate position at rest if it is left in position long enough (for at least 12 weeks) and the idea that the nail in position might interfere with the nutrition of the bone is by no means far fetched. As a matter of fact zones of resorption



a b c

Illustration 118

a) 12 month old pseudarthrosis of the ulna with a central luxation of the radius (Monteggia). The wounds were healed 2 months after the injury. Four months after the injury operative reduction of the radius and fixation of the ulna by means of a LANE's plate. It does however not find sufficient hold because it was held by only one screw on each side. Another luxation of the ulna and a pseudarthrosis developed.

b) After the operation. The cartilage of the radius head was entirely destroyed and because of a defect in the ulna which had occurred during a previous operation an extensive resection of the radius head was made. The connective tissue callosities of the ulna were removed and a marrow nail was inserted. The nail had jammed in the callus of the distal fragment so much that it was impossible to insert it any further. Consequently it had to be cut. In spite of the fact that the nail was too short the osteosynthesis was stabil. Primary healing of the wound, application of a plaster splint for a period of 4 weeks, followed by exercises. Release of the patient to his unit 8 weeks after the operation.

c) Six months after the operation; Bony healing of the fracture. No rarefactions round the nail tip to be observed. Rotation is limited by ¼. All other joints are freely movable.

are usually to be seen at the wire loops when a graft is used. Our patient material is not large enough to draw definite conclusions but since we have had good results - the same as BOEHLER - with the bone graft without marrow nail we are inclined to avdise against the additional marrow nailing. It does not bring an appreciative advantage to compensate for the additional hazard.

## SUMMARY:

The marrow nailing brings important advantages in pseudarthroses due to gunshot fractures of both bones of the forearm if a stabile osteosynthesis can be achieved. It is necessary to resect wide enough to assure a wide abutment of the bones.

The attempt to achieve this abutment by additional wire loop is hazardous. This might cause, in case of an infection, a gradual fracture and a formation of sequestra at the bone ends especially so if the osteosynthesis is not fully stabile and if the bone is atrophic.

Only a longitudinal suture is of service if the calcareous content of the bone is satisfactory. It must be applied widely enough. In case of a really stabile osteosynthesis it can usually be dispensed with.

In defect pseudarthroses of one bone the bone graft is the treatment of choice. An additional marrow nailing is rather not performed because it might interfere with the nutrition of the graft. One must also advise against the resection of the second obstructing bone with subsequent marrow nailing of both bones. This method is less certain than the bone graft.

In case of an imminent pseudarthrosis following a Monteggia injury it will be necessary besides the nailing of the ulna to reduce the luxation of the head of the radius by operation to avoid a faulty healing or a fracture of the nail.

If the luxation existed for more than 6 months it will be necessary besides the nailing of the ulna pseudarthrosis to resect the head of the radius. The resectio must be wide enough to prevent the radius from becoming obstructive again.

In case of an old luxation in the distal radio-ulnar joint (MADELUNG) the resection of the styloid process will bring better results than the resection of the shaft of the ulna with subsequent nailing.