

TORSTEN WADSTEIN, Norrköping :

OSTEOSYNTHESIS WITH SCREWS IN MEDIAL FRACTURES OF THE NECK OF THE FEMUR

Since osteosynthesis by employment of a nail has been recognized generally and adopted widely as a suitable method of treatment in medial fractures of the neck of the femur, osteosynthesis with screws has been placed more in the background. The purpose of the present work is partly to present the results of osteosynthesis with screws in 37 cases of medial fractures of the neck of the femur; partly to discuss the advantages and drawbacks of this method as illustrated by the 37 cases. All these patients were treated in the Surgical Clinic of the Linköping Hospital during the period of 1935-37. In all the cases a helicoid screw with a central canal and guide was employed after a method that will be described later on.

Among the many authors who in recent years have reported their experiences with osteosynthesis in fractures of the femoral neck, a few have used a screw instead of a nail. Screwing is by no means a new method, however. As early as 1858 v. Langenbeck was the first to employ it. In 1907 Delbet and his school commenced using screws. Delbet used ordinary carpenter's screws, measuring 7-9 cm. in length (cited after Nyström). Dujarier employed two screws to prevent rotation of the head of the femur. Since 1920, ordinary carpenter's screws have been employed by Martin in New Orleans and his method has been adopted by Brewster who uses two screws that are driven in without guides into two holes drilled beforehand. Brewster has reported healing in 89 % of the cases in a series of 53 patients. Lippmann uses a screw with four threads, which is driven in free-hand under roentgenological control. The screw is of corkscrew type (corkscrew bolt). Geckeler employs two carpenter's

screws and performs the operation under fluoroscopy, with a special guiding arrangement along the neck of the femur. He has reported 50 cases in which the operation on an average has taken 23 minutes, and the average stay in the hospital for the patients has been 24 days; no information is given about the later results.

Krapp also employs ordinary carpenter's screws without a central canal. Hotz (1923) used a long carpenter's screw, which is driven through the acetabulum into the pelvis minor, fixing the fragments of the fracture to each other and the pelvis, femoropelvic fixation (cited after Nyström). Myron O. Henry (1938) drives in a Kirschner guide free-hand, over which he threads a drill, which enters the head of the femur. An extra guide, parallel to the first, is driven in for fixation of the head. The drill and its guide are then pulled out and a rust-proof screw is inserted in the drill canal and this screw extends a few centimeters outside the corticalis, so that the patient avoids lying on that side. The patient is not allowed to put any weight on the leg before six months have passed, or when roentgenography shows a distinct healing. Also this author gives no final results.

In 1938 Marino-Zuco described a similar technique: a guide over which a drill is threaded, reaching to the head of the femur. Then a new drill for the head. A screw is inserted in the drill canal, and the thread of this screw covers the head of the screw, too, on which a nut is placed. An extra guide is used alongside the first one for fixation of the head. Henderson & Macy have reported a special screw construction with a cap-nut and end-plate.

In his monograph on medial fractures of the femoral neck¹ Gunnar Nyström reports that he has used a rust-proof helicoid screw in 25 cases. His technique appears to have been about the same as employed in the present 37 cases of the Linköping material. Without the support of a reexamination of his material, however, Nyström considers the nail preferable to the screw—a view that finds support also in my material.

¹ *Ergebnisse der Chirurgie und Orthopaedie*. Vol. 31, 1938.

Putty employs exclusively a screw of a particular type and with a special technique, with which he claims to have obtained particularly good results.

Technique.

The technique employed in practically nearly all the 37 cases here concerned was as follows: Immediately after admission to the hospital, wire extension is applied, either through the tuberosity of the tibia (20 cases) or through the condyles of the femur (14 cases), or both (2 cases). Traction with adhesion tape was employed in one case. Some authors warn against wire traction through the femoral condyle—for fear of injuring the knee-joint. Still, such injury should not be likely to occur unless the wire is placed so far anteriorly that it passes through the suprapatellar recess. Personally, I have never seen any untoward effect from wire traction through femoral condyles, and I consider it a gain to avoid traction by way of the knee-joint.

The interval between the accident and the operation has varied a good deal, but for all 37 cases it was on an average 17 days, and for the last 20 cases, 12 days.

The preliminary treatment with wire traction offers the following advantages: Immediate relief from pain for the patient; reposition of the fracture; sufficient time to observe the patient in order to decide whether there might be any contraindication against the operation. The indications were wide, the contraindications narrow. The most important contraindications were, besides physical lesions, advanced senility and mental disturbances. For illustration it may be mentioned that in 1937 a total of 29 patients with medial fracture of the femoral neck were admitted, and 19 of them were operated on. In the remaining 10 cases, operation was resisted from for the following reasons: 4 patients presented wedgeimpaction of the fracture in a good position (age: 50, 79, 83, and 85½ years); 1 refused operative treatment; 1 was suffering from inoperable cancer of the rectum; 1 presented metastases of a tumor; 1 was extremely senile, 82 years old, with incontinence of the urine; 1 was transferred to another hospital; and in 1 case no reason was

recorded. Advanced age has not been considered a contraindication *per se*.

When exact reposition was obtained, and the state of the patient otherwise was fairly good, the operation was performed in the bed. Thus the patient was not transferred to the extension table. In order to facilitate the technique a board was placed under the mattress, for elevation of the pelvis region.

The operation was performed under local anesthesia, sometimes combined with ethyl chloride. The author has injected the anesthetic directly into the fracture with good result and no inconvenience. Spinal anesthesia was employed in one case.

Åkerlund's indicator was attached by means of sutures, parallel with the inguinal ligament. Then the position of the fracture was controlled roentgenographically, and correction was required only in a few cases. After the femur was laid bare below the trochanters, a hole was drilled through the corticalis, about 0.5 cm. in diameter, at the point for the introduction of the guide. A guide was then introduced free-hand by means of Sven Johansson's drill and the position of the guide was controlled by roentgenography in both planes. If its position was not satisfactory, a new guide was introduced alongside the first, and an attempt was made to calculate the angle which the second guide ought to form with the first one, in order to assume the proper position. Most often the direction of the first guide was correct, and only in very few cases was it necessary to employ more than two guides. The guide in the proper position was retained, the other (others) taken out before the introduction of the screw. In most of the cases the guide employed was graded in centimeters by means of holes perpendicular on the long axis (Fig. 1). When these holes are adjusted parallel to the X-rays, it is easy on the roentgenogram directly to read the wanted length of the screw. A drawback of this scheme is that the guide thus becomes fragile, so that it breaks readily—something that happened in a couple of our cases. When the guide is in the correct position, a helicoid screw with a central canal is threaded over it. The screw is made of rust-proof steel, and its thread is high and sharp, and it is threaded only in its tip (Fig. 1). It is driven

in by means of a special chisel until its head enters the hole in the corticalis. While the screw is being driven in, it is necessary continually to watch roentgenographically that the guide is not driven along; if this happens it is pulled back successively. When the screw is in position, the guide is pulled out, and a last roentgenographic control picture is taken. Later I shall discuss the drawbacks of this technique.

After the operation the traction is discontinued, either at once or after a few days, up to one week.

The interval between the operation and the point of time when the patient is allowed to get up has varied greatly, from 13 days to 3 months.

Material.

As in materials from other clinics, the sex distribution of the patients shows a decided preponderance of women. Of the 37 patients concerned here, 10 were men, 27 women. The age distribution over periods of 10 years is given in Table 1.

TABLE 1.

Age and Sex Distribution of the Patients.

Age years	40-50	50-60	60-70	70-80	80-90	
Male	1	3	3	2	1	= 10
Female	0	1	6	13	7	= 27

In this material, advanced age of the patient is relatively more frequent, 23 of the 37 patients belonging to the age-classes of 70-90; 15 were over 75, and 8 were over 80. The average age of the patients at the time of the operation was 71.7 years for the total material, 64.2 years for the men, 74.4 years for the women. The average age for the total number of non-operated patients with medial fracture of the femoral neck was 69.2 years for the men, 73.5 years for the women.

The average age for the total number of patients admitted with pertrochanteric fracture was 73.7 years. Their age and sex distribution is given in Table 2.

TABLE 2.

Age and Sex Distribution of the Patients with Pertrochanteric Fracture of the Femur.

Age (years)	40-50	50-60	60-70	70-80	80-90	90-100	
Male	0	1	6	3	1	0	= 11
Female	0	0	6	6	7	1	= 20

Nyström emphasizes that increasing age is associated with a distinct increase in the relative number of women—something that is plainly evident also from Table 1 and 2.

Mortality.

The primary operation mortality was 5 cases out of 37 = 13.5 %. Under this heading I have reckoned all the patients who died during their stay in the hospital even though their death was not directly connected with the operation. The age of the patient, the cause of death and the interval between the operation and death in these 5 cases were as follows: 1) 63½ years, cardiac insufficiency, 26 days; 2) 77 years, sepsis from decubitus, 24 days; 3) 83½ years, pyelitis + bronchopneumonia, 2 months; 4) 88½ years, thrombosis of the mesenteric vein, 10 days; 5) 79 years, probably cardiac insufficiency, 6 days. The mortality was considerably smaller for this group than for two other comparable groups of patients admitted within the same period, namely: non-operated medial fractures of the femoral neck and pertrochanteric fractures of the femur. Of the 22 patients in the first-mentioned group, 7 (*i.e.*, about 32%) died: of the 31 patients in the latter group, 10 (about 32%) died. These patients were treated only with wire traction. The cause of the lower mortality among the operated patients can hardly be difference in age, nor selection of the material; it is more likely to be a greater mobility of the operated patients, resulting in an easier care.

Late Results.

Of the 37 operated patients 5 died in the hospital. Of the remaining 32 operated patients 2 died within 6 months after their discharge from the hospital (one of these showed good

healing of the fracture at the discharge and was since able to walk well; the other showed no healing of the fracture). Of the remaining 30 patients, 19 showed a good result, 11 a poor result (pseudarthrosis). By the term "good result" I mean osseous healing of the fracture and good or fair function of the injured hip. Of these 30 patients only 18 could be reexamined thoroughly, also by roentgenography. Concerning the remaining 12, the information obtained was of such a character that the classification given here can be considered correct. Of the 11 patients with pseudarthrosis, 3 were reexamined; some of them showed a poor healing of the bone even during their stay in the hospital, and in some of them the subsequent information made the presence of pseudarthrosis most likely. In 3 of these cases, however, the functional result was good, notwithstanding the pseudarthrosis. Of the 19 cases recorded under "good result", 15 were reexamined with roentgenography and showed a complete osseous healing of the fracture. The remaining 4 cases were entered in this group of "good results" because the information obtained gave the following data: 1) About $4\frac{1}{2}$ years after the operation the patient is able to walk 2 km. without any difficulty and without the support of a cane; he attends to his work without inconvenience, being on his feet all day long. 2) The patient died 2 years after the operation; at that time he was able to walk 5 km. in the fields and woods without a cane. 3) The patient was subsequently attacked by psychosis and walked restlessly up and down, up and down. Roentgenography 6 months after the operation showed osseous healing. 4) Dead. One year after the operation the patient was able to walk without any inconvenience.

In 18 cases, then, a thorough reexamination of the patients has been possible, including roentgenography, but 4 of them do not meet the established requirement of an observation period of two years (G. Nyström; J. Waldenström). In no case has the observation period been less than 15 months. Thus, in two cases it was 15 months, in two it was over 18 months, in six it was 2- $2\frac{1}{2}$ years, in six cases $2\frac{1}{2}$ -3 years, and in two cases $3\frac{1}{2}$ - $4\frac{1}{2}$ years. In these 18 cases the result has been good in 15, and

pseudarthrosis in 3 (respectively 83 and 17%). These relatively favorable figures concerning the healing of the fractures apply only to the patients who could be reexamined, not to the total material.

Shortcomings of the Technique.

The Guide. We have used a guide graded in centimeters by means of small holes perpendicular on the long axis of the guide as suggested by Hallberg (Fig. 1). These holes make the guide fragile, and it has broken in 4 cases, bent in 2. In 2 of the cases in which it broke, this happened while the screw being driven in and carried the guide along. In one case the guide broke because the central canal of the screw was too narrow. In one case the guide was forced into the pelvis and had to be removed through an extraperitoneal incision. So the perforation of the guide involves a certain risk of breakage, even though it cannot be made responsible for the poor late result in any of our cases.

The Helicoid Screw. It has its advantages as well as drawback. Among the former, it is to be mentioned that it takes a very firm hold in the dense bone structure of the femoral head. As the result of this, when the head of the screw presses against the corticalis the head of the femur is forced against the neck fragment, producing a sort of impaction; but this may go too far, so that the ends of the fracture are crossed.

A helicoid screw driven into the head of the femur is able to stand a considerable strain without being pulled out—something I have tried out experimentally on two autopsy preparations. After the screw was driven in it was submitted to a load exceeding 100 kg. without being displaced. Here it is to be mentioned that also an ordinary carpenter's screw of size No. 8 takes a very firm hold in the femoral head; in 3 cases it was able to withstand a load of 50 kg. without being displaced.

Owing to the great resistance which the screw meets in the femoral head, there is a certain risk that the head may rotate with the screw. If this happens, the ligamentum teres is twisted or torn off; besides, the fragments of the fracture may be ground to pieces against each other.

Undoubtedly such a rotation took place in one of our cases, probably in two more. In these three cases, no healing was obtained. That rotation of the head does not take place more often (as far as I have been to ascertain) has been due to the circumstance that we have aimed to place the screw eccentrically in the head and also that in several cases we have used two guides, one for the screw and one for fixation of the head while the screw is driven in. With a central location of the screw—*i.e.*, in the central axis of the femoral head—the head cannot avoid rotating. If location of the screw is eccentric enough, the

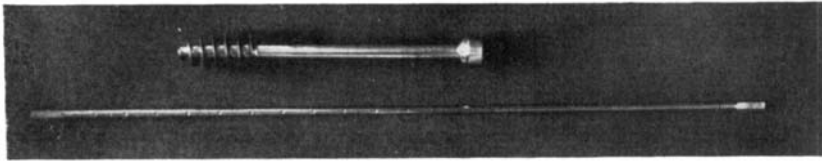


Fig. 1.

head cannot rotate because then it has not enough space to swing in the acetabulum. The extraordinarily great force of this rotary effect of the screw can be fully appreciated when one drives a helicoid screw into a femoral head that one holds in the hand. In order to study its course *in situ*, I made the following experiment: In the case of a woman, 80 years old, with a fracture of the femoral neck, who died immediately after admission, without being submitted to any treatment, the entire hip-joint and proximal one-third of the femur were dissected out together. The joint was opened on the anterior surface so that both fragments of the femoral neck could be seen plainly. The fracture was set precisely and kept in this position. The guide was introduced, and then the screw. When the screw had been driven into the femoral head a couple of turns, the head began to rotate, although the screw had been placed eccentrically somewhat anteriorly to the axis. The screw further rotated, besides around its own axis, eccentrically round the axis of the head, too, making thus a wide rotating motion in the femoral neck, breaking down the brittle interior of this bone. The screw was very

firmly lodged in the head of the femur. Evidently this type of screw implies a considerable risk of rotation of the femoral head, resulting eventually in injury to the neck. In one case the screw broke near the threads, but the healing of the fracture proceeded satisfactorily, probably because the shaft of the screw

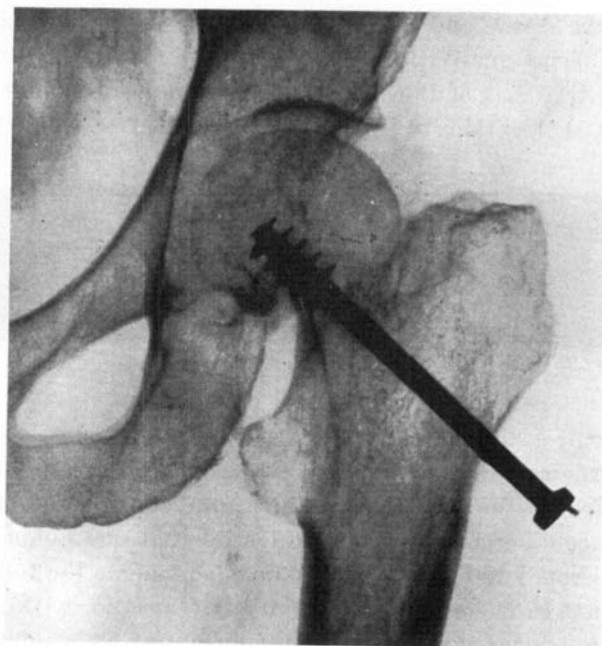


Fig. 2.

was lodged firmly in the head of the femur, rendering the same service as a nail.

In one case the screw bent when weight was placed on it. This patient was allowed to get up too early, 17 days after the operation, and the fracture failed to heal. As to the length of time during which the patient ought to be confined to bed—that is, what role the rest in bed plays in the healing of the fracture—no definite evidence is furnished by this material. This period varies considerably in both groups. In the 11 cases with pseudarthrosis this period was at last months in six cases (over 3

months in 3 cases) and in the remaining five cases it was respectively, 17, 21, 31, 37 and 50 days. In the 19 cases with healing of the fracture, this period was two months in 7 cases, 30-50 days in 4, and 13-27 in 8. The last-mentioned figures appear rather to indicate that the length of the confinement to

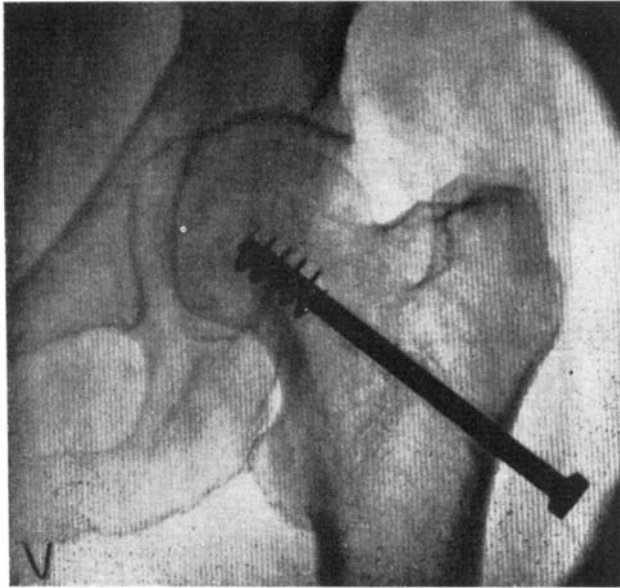


Fig. 3.

bed plays no particular role in the healing of the fracture. In the literature, on the other hand, there seems to be a tendency to keep the patients in bed longer after operation. Most of our patients were allowed to commence exercising in the go-cart, shortly after they got up.

Naturally it is rather difficult to decide what may have been the cause or causes of the failure of healing in some of the 11 cases with pseudarthrosis, whereas the cause of this is obvious in other cases. As an indisputable cause of the failure, the following circumstances may be mentioned: 1) in 1 case, in wound infection with sequestration of the screw; 2) in 1 case (psycho-

sis), a new traumatic injury to the same hip; 3) in 3 cases, more or less complete emigration of the screw from the femoral head. As pointed out by Nyström, employment of a helicoid screw by no means ensures against the last-mentioned complication—no more than does employment of nail. 4) in 1 case, the



Fig. 4.

cause of the failure was rotation of the femoral head under the operation. 5) as possible causes, the following are to be mentioned: probably rotation of the femoral head in 2 cases; excessive compression or crossing of the fragments in 2 cases; in 1 case, bending of the screw when the patient was allowed to get up too early.

The 18 reexamined cases were analyzed as to the following points:

1. Osseous healing of the fracture.
2. Distribution of the fractures on Pauwels' three groups.

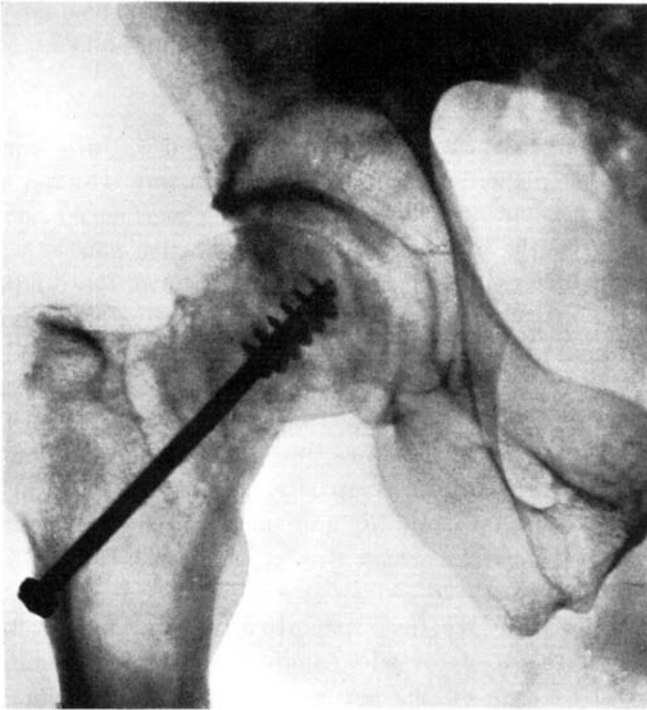


Fig. 5.

3. Necrosis of the femoral head. Arthritis.
4. Behavior of the screw: position, bending, etc.; reaction of the bone round the screw.

1. Good *osseous healing* was found in 15 cases, pseudarthrosis in 3.

Two cases in which the bony union of the fragments took place rather late are of some interest. One of these patients, a woman,

66 years old shows that a good final result *may* be obtained in spite of unsatisfactory alignment of the fragments. Attempts at reduction of the fracture were not successful, the shaft of the femur stayed in outward rotation and upward displacement, so that the surfaces of the fragments were not in contact over more than one-half of their extent. Nevertheless, the fracture healed firmly, and three years after the operation, the roentgenograms showed that a practically new neck of the femur had been formed. (Figs. 2 and 3.)

The other case was that of a man, aged 52, who was first treated with plaster cast for 4 months, during which a pseudarthrosis developed. The operation was performed nearly 5 months after the accident. The post-operative course was uneventful, with excellent healing of the fracture. Reexamination, 2½ years after the operation: good mobility; he is able to walk 10 km. without any inconvenience (Figs. 4 and 5).

2. Pauwels' three groups. Group I comprises the cases in which the line of the fracture and the horizontal plane form an angle of less than 30°. Group II comprises the cases in which this angle is greater than 30° and smaller than 70°. Group III comprises the cases in which this angle exceeds 70°. Obviously the border cases can be estimated only approximately, in particular because the fracture line often is not straight but irregular. Of the 15 cases with complete healing, 5 belonged to Group III, 3 were on the border of this group, 6 belonged to Group II, and 1 was on the border between Groups I and II. Of the 3 cases with pseudarthrosis, 2 belonged to Group III, 1 to Group II. All 18 cases were typical varus fractures, after Nyström's classification (Böhler's adduction fracture); there was no valgus fracture, after Nyström's classification (Böhler's abduction fracture). Of all these 37 operated cases, one might possibly be designated as valgus fracture with wedge-impaction; but the impaction loosened under the treatment of the patient at home, and at the operation, 3 months later, the fracture was completely loose. The remaining 36 cases had to be reckoned

as varus fracture with separated fragments and upward displacement and upward rotation of the femur.

3. *Necrosis of the femoral head. Arthritis.* As no roentgenological control of these 18 patients took place from their discharge to their reexamination, it is impossible at any rate to decide whether there might have been some necrosis of the femoral head with subsequent healing. Among the 15 cases with solid union, 12 showed no evidence of any necrosis of the femoral head, whereas 3 presented changes that may be taken as suggestive of previous necrosis of the head. Of the 3 cases with pseudarthrosis 2 showed typical necrosis of the head with sequestration, and in 1 case the head had undergone almost complete absorption.

Arthritis or, more correctly, arthrosis deformans appears not to have been any common complication after operation. Of the 15 cases with complete healing, only 1 showed pronounced changes, but hardly more than on the non-operated side; 4 showed slight changes still a little more conspicuous than before the operation; and 10 showed no changes of this kind. The three cases with pseudarthrosis showed slight changes, similar to those in the first-mentioned operated case.

4. *Behavior of the screw* as to its final position and the surrounding reaction of the bone. Among the 15 healed cases the screw had kept its original good position in 12 while the screw was discharged in 1, broken in 1, and projecting 3 cm. outside the corticalis in 1. In the last-mentioned case the femoral neck had been shortened through absorption, but finally the fracture had healed satisfactorily. Nyström emphasizes the importance of the point: that the screw is not threaded in its entire length, but only at the tip, for then it is able to "follow along" if the femoral neck is shortened instead of forming the diastase that probably would result if it were firmly lodged in the corticalis by means of the screw thread.

In the 3 pseudarthrotic cases the screw had emigrated from the femoral head in 2, and was broken in 1. Among the 17 cases

in which the screw was retained, 9 showed no reaction of the surrounding bone, whereas 6 showed slight sclerosis and 2 marked sclerosis round the screw with "periostitic" deposits on the corticalis.

On comparison of the results obtained in the present material with the results presented by Sven Johansson, Böhler, Felsenreich and others, it is plainly evident that osteosynthesis with nail after Sven Johansson's method is preferable to the employment of a screw with the technique here described. My material covers a period of 3 years, 1935-37. In the following years my experiences in this field were gained entirely by osteosynthesis ad modum Sven Johansson, and these experiences fully corroborate my view about the superiority of the nail to the helicoid screw.

SUMMARY

An account is given of osteosynthesis with a helicoid screw in 37 cases of medial fracture of the neck of the femur.

The technique is described and criticized, with special reference to the helicoid screw and the guide that is graduated in centimeters by means of holes perpendicular on the long axis of the guide.

Of the 37 patients, 7 died within six months after the operation. Of the remaining 30 patients, 19 showed healing of the fracture, and 11 presented pseudarthrosis.

In 18 cases reexamination was carried out from $1\frac{1}{4}$ to $4\frac{1}{2}$ years after the operation.

These cases are analyzed as to the result of the healing, necrosis of the femoral head and arthritis deformans.

The author considers osteosynthesis with nail ad modum Sven Johansson preferable to osteosynthesis with screw after the method here employed.

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DISCUSSION

Nyström, G.:

The experiences presented by Wadstein are quite in keeping with those we gained already several years ago in Uppsala with screws of essentially the same type as mentioned here. According

to our experiences the results obtained with screws were rather worse than better than those obtained with nails. The worst drawback of the screw is that it may rotate the femoral head—and in one of our cases this rotation exceeded a complete turn—and it is easy to imagine what will happen then to the blood supply through the ligamentum teres and the remnants of the capsule which in many, perhaps most, cases are still forming a sort of connection between the two fragments.

The advantages which the screw is claimed to offer—that it is able to press the fragments firmly against each other—is more or less illusory, at any rate with employment of screws of the type mentioned here. In the roentgenogram that was presented to illustrate the strong clenching of the fragments as favorable to the healing, even in unsatisfactory reduction of the fracture, it is seen quite plainly that no such clenching has taken place, as the outer end of the screw with head extends about 2 cm. outside the corticalis. The threaded part of the screw is naturally located entirely within the head of the femur, and if then the smooth shaft projects from the corticalis, the screw cannot effectuate any compression of the fragments. Such compression can take place only if the length of the screw is adjusted so well that the head of the screw presses against the corticalis, while the threaded part is located entirely within the femoral head.

The requirement concerning compression of the fragments will be met more readily if—as is the case with the screws we use in Uppsala—the outer part of the shaft of the screw is threaded so that, when the threaded tip of the screw has been placed in the desired location in the femoral head, a nut can be screwed on to the threaded part of the end so that it rests firmly against the corticalis.

But even when a good compression of the fragments is obtained at the time of the operation, it will hardly take long before this compression becomes illusory, on account of the superficial necrosis of the fragments that normally takes place. Whether the fixation of the fragments is accomplished by means of a nail or a screw with its winged part located entirely within

the femoral head, the fragments will be pressed against each other successively as the necrotic layer undergoes absorption, and thus the screw would hardly offer any advantage.

The unfavorable result—with pseudarthrosis in 3 cases as against osseous union in 15—reported for the material here discussed might be accidental on account of the small size of the material. But the indisputable risk of rotation of the femoral head as well as these practical experiences do not speak in favor of the method as employed here. And I feel I ought to warn against its employment. In the past three years I have employed the so-called multiple spiking with 3 light, non-canalized wing-nails, the total weight of which corresponds to a Smith-Petersen nail, and which I introduced without any guiding-pin. Recently the nails have been made somewhat heavier, however, in order to avoid the inconvenience that might arise the nails are too thin, so that one of them may break—something which hitherto has not jeopardized the alignment of the fragments in any case, as only one spike has broken so far, or this has not happened until the healing of the fracture was in progress.

Our results, which have not been published yet, appear to give similar percentage of healing as obtained with Sven Johansson's technique. As far as I am able to remember, among 30 odd cases which we have followed up for more than two years, pseudarthrosis has occurred only in one, where it was associated with necrosis of the head of the femur—a phenomenon that may occur even under conservative treatment.