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Supination-outward rotation injuries of the ankle

A CLINICAL AND ROENTGENOLOGICAL STUDY WITH SPECIAL REFERENCE TO THE OPERATIVE TREATMENT

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I *Introduction*

In the autumn of 1958, an active program of treatment for ankle fractures was started at the Department of Orthopaedics, Lund Hospital, on the initiative of its head, Professor Gunnar Wiberg. The incentive to this was the comparatively high frequency of post-traumatic cases of ligamentous insufficiency and arthrosis deformans, which characterized the conservative treatment of fractures, and which could be pointed out in works which had emanated from the same clinic earlier. Practically all fractures in adult patients were subjected to an analysis at operation and efforts to make a careful anatomical reconstruction. This program of treatment has been consistently followed through the years and has also been extended to include purely ligamentous ankle injuries. Conservative treatment has therefore only been used in isolated cases. Special interest has been devoted to the most common injuries, namely, the supination-outward rotation injuries. This work will illustrate the observations and results of surgical treatment of these injuries during the years 1958—1965, with regard to diagnosis, pathological anatomy and therapy. A special surgical method has been devised, based on the use of a special metal staple for fixation of the lateral malleolar fracture and strengthening of the reconstructed anterior tibiofibular ligament.

A close and constructive collaboration has been carried on with the Roentgen-Diagnostic Department II, Lund Hospital. Collaboration has also taken place with the Department of Orthopaedics, Malmö General Hospital, which during the years 1961—1963 referred patients to us, as a result of which, the size of the material was increased.

II *Nomenclature, abbreviations and statistical methods*

Nomenclature

Those ankle injuries arising from outward rotation violence have been differently denominated by different authors. "Abduction", "external rotation", "supination-abduction", "supination-eversion", supination-external rotation" and "supination-lateral rotation fractures" are some of the expressions which have been used. I have chosen the term "supination-outward rotation injuries". It may seem unnecessary to increase the list of names, but the names hitherto used have been subjected to criticism as well as misinterpretation. By using the word "supination" as a link in the name I want to indicate the accordance with Niels Lauge Hansen's nomenclature, signifying that the rotation violence hits the supinated foot. By the term "outward rotation" the etiological trauma, according to my opinion, is given a designation which is unlikely to be misunderstood, and which is idiomatically correct. I have replaced the word "fracture" with "injury", the latter involving both fractures and ligamentous injuries.

Abbreviations

The following abbreviations are used in this work:

SOR-injuries	= supination-outward rotation injuries
Stage IV, LUX-injury	= supination-outward rotation injury of stage IV with luxation of the talus and the whole foot
ATTu	= Anterior tibial tubercle
PTTu	= Posterior tibial tubercle
PTPr	= Posterior tibial process
ATFL	= Anterior tibiofibular ligament
ITFL	= Interosseous tibiofibular ligament
PTFL	= Posterior tibiofibular ligament
TrTFL	= Transverse tibiofibular ligament
ATaFL	= Anterior talofibular ligament
CFL	= Calcaneofibular ligament

Statistical methods

Conventional statistical methods are used for the calculation of the standard error of the mean, the difference between means and the difference between percentage numbers. Statistical significance is described as follows:

$P > 0.05$	= not significant
$0.05 > P > 0.01$	= almost significant *
$0.01 > P > 0.001$	= significant **
$0.001 > P$	= highly significant ***

III *Purpose*

The purpose of the present investigation is to analyse and answer the following questions:

Part I

Is Niels Lauge Hansen's experimental-surgically and roentgenologically based division into stages with well-defined ligamentous injuries and fractures applicable also to the living organism?

Part II

To what extent has the surgical method used in the material, enabled a good joint reconstruction, and how have the primary results of treatment turned out from a clinical and roentgenological point of view?

Part III

Can a consistently accomplished and in its nature carefully defined reconstruction of the ligamentous injuries and the fractures of the ankle, in the future reduce the frequency of ligamentous insufficiency and arthrosis deformans?

Discussion

The following questions have been of interest:
Part I

1. How often does the isolated rupture of the anterior tibiofibular ligament (stage I) occur, and the implications of its clinical and roentgenological diagnosis and differential diagnosis?
2. Is the distal oblique fibular fracture always preceded by a rupture of the anterior tibiofibular ligament, and in what types does this rupture appear?
3. Does the dorsal injury in stage IV-injuries appear in order before or after the medial one?
4. Do stage IV-injuries with intact dorsal structures occur?
5. How does the size of the dorsal tibial fragments vary, and is there any relation between the size of the fragments and the luxation injuries?
6. How often in stage IV-injuries, does a rupture of the deltoid ligament occur, instead of a fracture through the medial malleolus?

Part II

1. How often has one in the present material been able to reconstruct the

ankle mortise anatomically in respect to ligamentous injuries and fractures?
2. How often have pseudarthroses occurred?
3. What are the most common operative complications, and how often have they occurred?
4. Should the large dorsal tibial fragments be subjected to an osteosynthesis, or do satisfactory reduction and retention occur, by the distal oblique fibular fracture being reduced and fixed in the exact position?

Part III

Can in the present material, a clear relationship be pointed out between:
1. poor clinical results of treatment and the occurrence of arthrosis deformans?
2. unsuccessful reconstruction of the joint and the occurrence of arthrosis deformans?

IV *Short historical survey*

Maisonneuve (1840) was the first to describe the mechanism of outward rotation injuries. With the support of experimental-surgical investigations he pointed out the occurrence of two quite different types of fractures of the fibula. When the tibiofibular ligaments remained intact, a distal and oblique fracture of the fibula arose. When the ligaments mentioned ruptured, a high up or subcapitally situated fracture of the fibula occurred. Maisonneuve was of opinion that it was the pressure of the talus on the anterior part of the lateral malleolus that caused the distal fracture which was not accompanied by any ligamentous or aponeurotic damage. He also proved that continued outward rotation of the foot caused a fracture of the medial malleolus or a rupture of the deltoid ligament. Hönigschmied (1877) described 22 cadaver experiments, in which outward rotation of the foot caused the same types of fractures that had been observed by Maisonneuve. He found, however, in 6 cases an avulsion of a bone fragment from the anterior tibial tubercle, i.e., the origin of the anterior tibiofibular ligament. This injury, however, only appeared in combination with the high situated fibular fracture. The distal fibular fracture was not accompanied by any ligamentous injury, but always originated distally to the attachment of the anterior tibiofibular ligament. Hönigschmied also found that the distal fibular fracture was of 3 different types, namely, a long oblique fracture, a short oblique fracture and a combined transverse and oblique fracture. Contrary to Maisonneuve he considered that the

fracture was caused by a powerful pulling action of the posterior talofibular ligament.

Le Fort (1886) described 3 clinical cases of isolated rupture of the anterior tibiofibular ligament, where the attachment in the fibula was detached with a bone fragment. He thought, however, that this type of fracture was caused by pure supination violence. His pupil, le Roy (1887), by cadaver experiments, showed that the anterior tibiofibular ligament at outward rotation of the foot can rupture with avulsion of fragments from the anterior tibial tubercle as well as the anterior part of the lateral malleolus.

Stimson (1892) was the first to prove that the distal oblique fracture of the fibula is preceded by a rupture of the anterior tibiofibular ligament, which, with a bone fragment, is detached from its origin on the anterior tibial tubercle. The same discovery was made by Quenu (1907), who, however, produced outward rotation violence to the supinated foot.

In 1922 Ashhurst & Bromer published their important work on ankle fractures, which for the first time, were given a genetic classification. They consider that the distal oblique fracture of the fibula, which is both intra- and extra-articular, generally shows no or slight displacement, and that in practically every case it is not accompanied by a rupture of the anterior tibiofibular ligament. Ashhurst also considers that the 2nd degree of the outward rotation injury consists of a rupture of the deltoid ligament or a fracture of the medial malleolus, and that the 3rd degree consists of a fracture of the posterior tibial margin. Ashhurst & Bromer's work is to this day widely accepted, both for the classification and for the treatment of ankle injuries. Bishop (1932) totally agrees with the views of Ashhurst & Bromer.

In 1942, Niels Lauge Hansen published his extensive and important work on ankle fractures. On the basis of experimental-surgical and roentgenological studies, he divides up the outward rotation fractures into 2 different groups, which he calls supination-eversion fractures and pronation-eversion fractures. The former occur by outward rotation of the supinated foot and comprise 4 so-called stages. Stage I consists of rupture of the anterior tibiofibular ligament with avulsion of fragments from the anterior tibial tubercle, or from the lateral malleolus, or also from both these places simultaneously. Stage II implies the occurrence of distal oblique fibular fracture. Stage III is characterized by injury to the dorsal part of the tibia in the form of periosteal ligamentous detachment or fracture varying in size, through the part of the bone that is the origin of the posterior tibiofibular ligament and the transverse tibiofibular ligament. Stage IV, finally, implies the occurrence of fracture through the base of the medial malleolus or detachment of the deltoid ligament. Lauge Hansen thus considers that the distal oblique fibular fracture is always preceded by

a rupture of the anterior tibiofibular ligament, and that the fracture of the dorsal tibial margin always precedes the medial injury, which is in glaring contrast to earlier ideas. His views were rapidly subjected to a great deal of criticism, and it was particularly emphasized that the results obtained by cadaver experiments were not applicable to the living organism. In his work on fractures of the posterior tibial margin, Hendelberg (1943) considers Lauge Hansen's stage division to be erroneous. In several cases he can register outward rotation fractures with medial injuries, but with completely intact dorsal structures. In his work, Magnusson (1944) agrees with the classification represented by Ashhurst & Bromer and considers, like Hendelberg, that the medial ankle fracture precedes the dorsal one. He also criticizes Lauge Hansen's conception of supination-eversion, but agrees entirely with him, concerning the injuries of the anterior tibiofibular ligament. Magnusson was the first to make a far-reaching clinical analysis of these ligamentous injuries. Thus he considers that defectively healed anterior syndesmotic injuries, in a high degree promote the occurrence of arthrosis deformans in the ankle.

Danis (1949) divides up the ankle fractures into 4 groups with regard to the position of the fibular fracture in relation to the tibiofibular ligaments. He considers "la fracture interligamentaire", i.e., the distal oblique fibular fracture unaccompanied by a rupture of the anterior tibiofibular ligament, to be the most common type of fibular fracture.

In his monograph on ankle injuries, Bonnin (1950) entirely accepts Hönigschmied's experimental works as well as Ashhurst & Bromer's classification. He, therefore, considers that the anterior tibiofibular ligament never ruptures, but that the distal oblique fibular fracture constitutes the first stage of the outward rotation injury. He gives a system of classification of his own for outward rotation fractures, which he divides up into 3 degrees of severity, in respect to the site of the fibular fracture and the occurrence of so-called tibiofibular diastasis, i.e., rupture of the tibiofibular ligaments. So, although with important fundamental differences, he brings together in one large group, the injuries which Lauge Hansen calls supination-eversion fractures and pronation-eversion fractures, which from a practical point of view creates confusion and lack of clarity. Contrary to Lauge Hansen, Palmer (1950) considers that the dorsal tibial fracture precedes the medial one, while other authors, such as Kristensen (1949, 1956), Biström (1952), Reimers (1953), Proctor (1954), Vasli (1957), Quigley (1959) and Klossner (1962) entirely adopt the classification of the former. Watson-Jones (1955), in conformity with Bonnin, considers that the distal oblique fibular fracture occurs without ligamentous injury and without displacement. Jergesen (1959) highly criticizes Lauge Hansen, whose classification he considers to be "a great measure of speculation", taking into

consideration, only "extrinsic stresses, disregarding the intrinsic ones, due to muscle activity". In conformity with Devlies (1959) and Calvetti (1960) he considers that the distal oblique fibular fracture is not accompanied by a rupture of the anterior tibiofibular ligament. Also Soeur (1961) criticizes Lauge Hansen's cadaver experiments and presents a classification for the malleolar fractures of his own, according to which the distal oblique fibular fracture can arise both by rotation and by plantar flexion. He considers this fracture to occur uncombined with a rupture of the anterior tibiofibular ligament. Rose (1962) is of opinion that Lauge Hansen's genetic classification is the only one acceptable, especially for the reason that it draws attention to the ligamentous injuries accompanying the ankle fractures. He considers, however, that the fracture of the posterior tibial margin has another genesis than that one outlined by Lauge Hansen. Other authors using the classification of the latter are Dinstl & Spängler (1963), Cedell & Wiberg (1962), Cedell (1965), Lauttamus & Solonen (1965) and Burwell & Charnley (1965). On the basis of experimental investigations, Hirsch & Lewis (1965), however, maintain that the different components of an ankle injury more commonly appear simultaneously than in a certain sequence. Weber (1963, 1966), finally, divides the ankle fractures according to the height of the fibular fracture in relation to the tibiofibular syndesmosis, a division as a principle, based on Danis' classification. He considers that the distal oblique fibular fracture is seldom combined with a rupture of the anterior tibiofibular ligament with the exception of the stage IV-injury which in the presence of a dorsal tibial fracture is always combined with a rupture of the ligament mentioned.

From what has been said above, it is clear that supination-outward rotation injuries are subjected to a keen discussion with often controversial opinions, maintained by different authors. Many questions, concerning especially the pathological anatomy of the injuries, are still unanswered and require still more investigation and consideration.

PART I

Clinical and roentgenological diagnosis. Operative studies of capsule, ligament, bone and cartilage injuries

V *Material and methods*

The material in this work includes all those cases of supination-outward rotation injuries operated on at the Department of Orthopaedics, Lund Hospital, in the years 1958—1965. The material has been selected by careful study of roentgenograms and also records and operation notes. The injuries have been classified according to Lauge Hansen for the reason that the author has judged his system to be the best of those available, even if some important questions—as is clear from Chapter III—ought to be subjected to further discussion and investigation. The purpose of the operations has first of all been to reconstruct the injuries, at which efforts have been made to devise as adequate a method as possible. In connection with these operations one has also had the opportunity to analyse the pathologico-anatomical changes of the ankle, which has been made possible, especially as the ligamentous injuries have also been exposed at operation. Practically every patient has been subjected to operative analysis and treatment. Only in a few cases a year one has been obliged to avoid such measures by force of special circumstances, for instance, the presence of severe skin damage and serious somatic disease.

A. Clinical diagnosis

After the customary history taking, the patients have been carefully examined by inspection, palpation and function test. The surgeon on duty has meanwhile filled up a special form of examination with his observations, which has then accompanied the patient to the operating unit, where the operator in question has made a note of the observations at the exploration. Thus one has registered the presence of deformation, swelling, hematoma and skin damage in the form of contusion, nutritive disturbances and penetrating wounds. The joint capsule, ligaments and adjacent skeleton parts have systematically been palpated, and the maximal point of tenderness and possible crepitations have been located. Circulation and nerve

function in the foot have also been tested. Often a cautious stability test has been performed. In ligamentous injuries the maximal point of the indirect pain has often been explored by cautious provocation tests, i.e., displacement of the foot in certain directions. On the basis of the clinical symptomatology a preliminary diagnosis has been made in respect to the type and the stage of the ankle injury.

B. Roentgenological diagnosis

The roentgenological examination of the ankle has been performed according to a modification of the method reported by Bolin (1961); see Fig. 1. Thus the examination has taken place in well-defined projections and, apart from the early part of the patient material, the uninjured ankle has also been subjected to an exactly equivalent examination. 4 standard projections have been used, namely, 1) 0° rotation, 2) 20° inward rota-

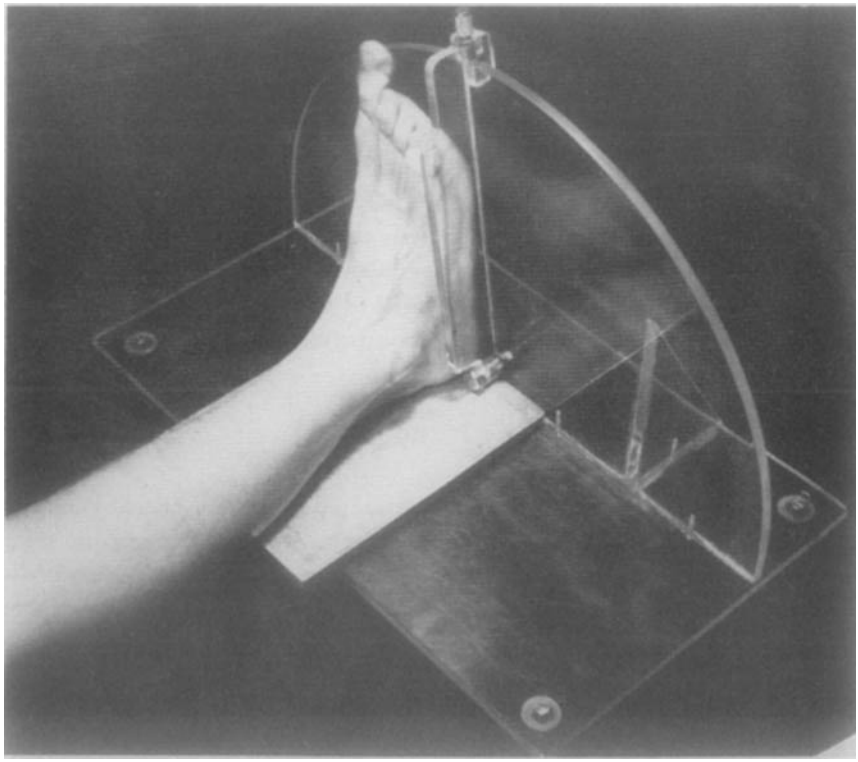


Fig. 1. Device used in the roentgenological examination of the ankle injuries. (From Bolin, H.: Acta radiol. 56, 1961: Fig. 5, p. 443.)

tion, 3) 55° outward rotation, and 4) 85° outward rotation of the leg and the foot. These projections reproduce: 1) the joint between the talus and the medial malleolus, 2) the joint between the talus and the lateral malleolus, 3) the anterior tibial tubercle, and 4) the posterior tibial process, respectively. When necessary, complementary examinations in other projections have been made, especially at the suspicion about the occurrence of a rupture of the deltoid ligament or a fracture through the dorsal part of the tibia. A simultaneous examination of the uninjured ankle has in many cases yielded much valuable information, particularly in respect to the diagnosis of ligamentous injuries. Arthrography has not been used. Stress roentgenograms, i.e., examination of the foot forcibly twisted in various directions have occasionally been used in connection with the diagnosis of ligamentous injuries. In the material, with the exception of the luxation injuries, "the position on admission", i.e., the position of the talus and of the bone fragments in the primary roentgenograms of the patients has not been registered. According to the author's opinion, these roentgenograms do not make an estimation of the severity of the injuries possible as the position of the talus and the bone fragments, during the transport of the patient from the place of the accident to the roentgen examination table, is mostly influenced by many external factors in a positive way.

C. Operative examination

Most of the patients have been explored within 1 to 3 days after admission. Open injuries and several luxation injuries have been treated by emergency operation. The patients have generally been operated on under spinal anesthesia and in a bloodless field. Elderly people and patients with hypertension and with suspected coronary disease have as a rule been operated on under general anesthesia, some under local anesthesia. As a rule a bloodless field has not been used in elderly patients and not in the presence of manifest or suspected obliterating vascular disease. The lateral side of the ankle has been explored through a curved incision over the lateral side of the distal fibula, extending to the anterior tibiofibular ligament and the lateral part of the joint capsule; see Fig. 2. The medial part of the ankle has been explored either through a transverse curved incision or a vertical straight incision across the medial malleolus; see Fig. 3. As a rule, the posterior tibial process has been explored from the lateral incision, which is then placed further dorsally than usual. Occasionally this exploration has also taken place through a separate incision, just laterally to the Achilles' tendon. As neither the clinical nor the roentgenological examination could give a conclusive answer about the stage of the injury, an extended exploration of the joint was made. Thus the deltoid ligament has

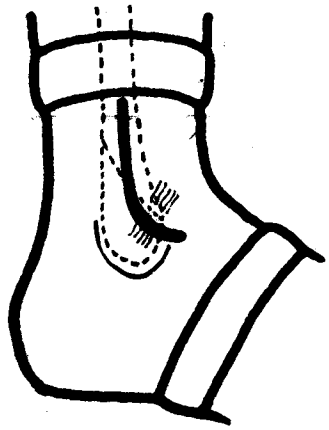


Fig. 2. Lateral operative approach to the talocrural joint.

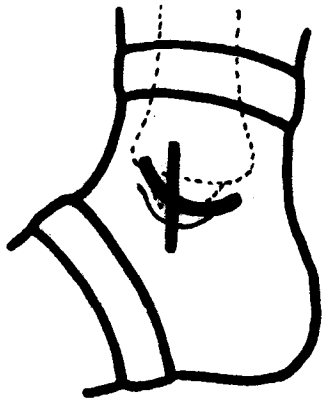


Fig. 3. Medial operative approach to the talocrural joint.

in many cases been explored in order to distinguish an injury of stage II or stage III from an injury of stage IV. In several cases also, the posterior tibial process has been explored, so that information about the character of the dorsal injury has been obtained. The distal oblique fracture has been carefully registered in respect to its origin and length and the displacement of the distal fracture fragment. The anterior tibiofibular ligament has been subjected to a special interest, and the whole ligament has been exposed. The location of the rupture has been registered as well as the presence of avulsion fragments from the anterior tibial tubercle or from the lateral malleolus. The stability in the interosseous tibiofibular ligament has also been tested. On the medial side, one has registered the appearance of the medial malleolar fracture, the occurrence of interposition of soft tissue and the displacement of the malleolar fragment. At the occurrence of a rupture of the deltoid ligament, one has registered its position and extent, i.e., whether

the injury has been partial or total. The joint capsule has been exposed from both incisions, as extensively as possible, and the injuries have been registered. The facets of the talus have been examined, especially in respect to the occurrence of subchondral fractures. In the years 1961—1965, the isolated rupture of the anterior tibiofibular ligament has been subjected to special studies. For this reason a great number of sprained ankles during these years has been operatively explored, at which the lateral ligaments of the ankle have been exposed and the injuries to them have been registered.

D. Presentation of the material

1. *Size of the material in relation to all ankle injuries operated on*

The material in all comprises 417 supination-outward rotation injuries in 416 patients. In all, 735 ankle injuries have been operated on at the clinic during the years 1958—1965, 417 of which have been supination-outward rotation injuries, and 94 injuries involving rupture of the anterior talofibular ligament, often in combination with the calcaneofibular ligament. Disregarding the last-mentioned group, the supination-outward rotation injuries constitute 65.1 per cent of the total number of injuries operated on. Concerning the annual distribution of the different groups of injuries; see Fig. 4. The injuries have been located in the left ankle in 216 and in the right ankle in 201 cases.

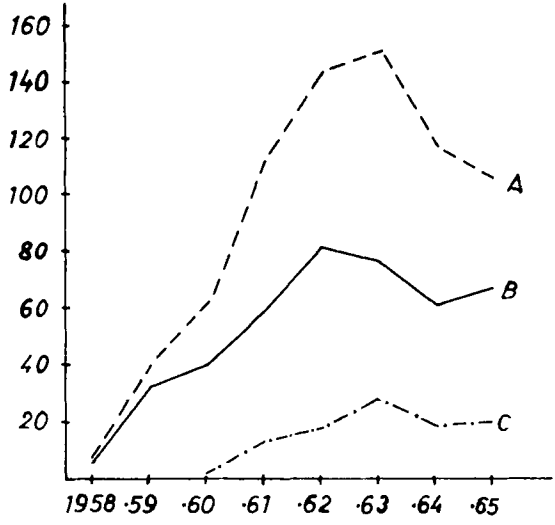


Fig. 4. Diagram showing the correlation between the total amount of operatively treated ankle injuries (curve A), the number of operatively treated supination-outward rotation injuries (curve B), and lateral collateral ligament injuries (curve C) during the years 1958—1965.

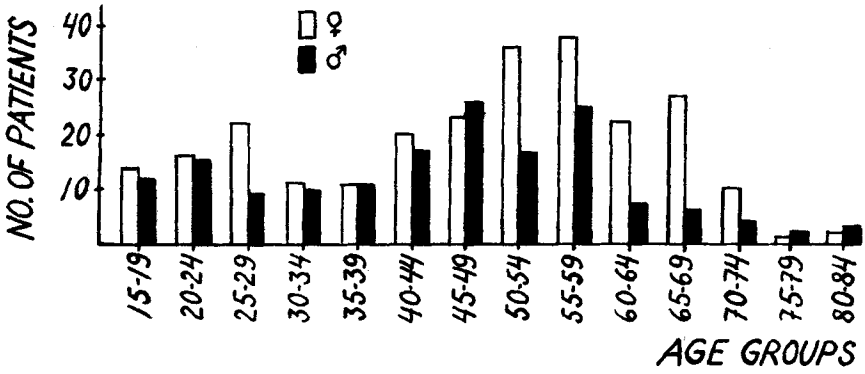


Fig. 5. Sex and age distribution of the patients. Marked predominance of women, especially in the ages of 50 to 70.

2. *Distribution of the patients into sex and age*

The material involves 253 women and 164 men, which means a ratio of 1.5 : 1. The age of the patients varies rather strongly and within wide limits, the lowest age being 15 and the highest 84 years. Patients under 15 have not been included in the material, thus comprising adults only. Concerning the distribution of sex and age, see Fig. 5. The mean age of the whole material amounts to 46.3 ± 16.1 years, of which for the women 47.5 ± 16.1, and for the men 44.3 ± 16.7 years. The mean age of the women, accordingly, is somewhat higher than that of the men, but the difference is not statistically significant. In the ages between 50 and 70 there is a marked predominance of women.

3. *Distribution of the patients into stage*

The distribution of the injuries into different stages can be seen in Table 1. From this table it appears that there is a marked predominance of stage IV

Table 1. Stage distribution of the patients. Correlation to the year of operation.

Year	Stage I	Stage II	Stage III	Stage IV	Total
1958	—	2	1	2	5
1959	—	15	3	13	31
1960	—	16	3	20	39
1961	—	15	2	40	57
1962	2	28	3	48	81
1963	2	23	5	46	76
1964	4	21	3	33	61
1965	3	24	4	36	67
Total	11	144	24	238	417
%	2.6	34.5	5.8	57.1	100.0

and stage II-injuries in the order mentioned, while stage I and stage III-injuries are rather modestly represented. The percentage distribution is: Stage I 2.6 %, stage II 34.5 %, stage III 5.8 % and stage IV 57.1 %.

4. *Correlation between sex, age and stage*

The distribution of the patients in respect to sex, age and stage can be studied in Table 2. From this we conclude that a slight predominance of men is present in stage I, that the women dominate in stage II, that the distribution of sex is equivalent in stage III, and that the women have a a very marked predominance in stage IV. The mean age in stage I is 30.2 ± 10.9 years and in stage II 42.4 ± 16.3 years. In the last-mentioned stage the mean age of the women is 43.5 ± 17.4 years and that of the men 40.8 ± 14.9 years. The mean age of the women, accordingly, is a little higher, but the difference is not statistically significant. In stage III the mean age is 44.2 ± 13.2 years. In stage IV it is 49.6 ± 15.7 years, the mean age of the women being 50.1 ± 15.5 years and that of the men 48.6 ± 16.0 years. Nor is the difference here statistically significant.

The mean age is higher*** in stage II than in stage I and higher*** in stage IV than in stage II. On the other hand, there is no statistically significant difference between stage II and stage III, and not between stage III and stage IV either. Summarily it can be said that stage I-injuries are seen only in young patients, and that the extent of the injuries is greater in patients of advanced age.

Table 2. Correlation between sex, age and stage.

Age	Stage I		Stage II		Stage III		Stage IV		Total		Total
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀+♂
15—19	1	2	7	6	—	1	6	3	14	12	26
20—24	—	1	9	7	—	1	7	6	16	15	31
25—29	1	—	9	3	1	1	11	5	22	9	31
30—34	—	3	4	5	2	—	5	2	11	10	21
35—39	—	—	4	5	—	—	7	6	11	11	22
40—44	—	2	6	4	1	5	13	6	20	17	37
45—49	1	—	8	12	3	1	11	13	23	26	49
50—54	—	—	13	7	1	2	22	8	36	17	53
55—59	—	—	8	8	1	1	29	16	38	25	63
60—64	—	—	4	1	—	1	18	5	22	7	29
65—69	—	—	9	1	2	—	16	5	27	6	33
70—74	—	—	2	—	—	—	8	4	10	4	14
75—79	—	—	1	—	—	—	—	2	1	2	3
80—84	—	—	—	1	—	—	2	2	2	3	5
Total	3	8	84	60	11	13	155	83	253	164	417

Table 3. Stage distribution of the patients during the years 1962—1965, the Malmö patients excluded.

Year	Stage I	Stage II	Stage III	Stage IV	Total
1962	2	28	2	30	62
1963	2	22	5	29	58
1964	4	21	3	33	61
1965	3	24	4	36	67
Total	11	95	14	128	248
%	4.4	38.3	5.7	51.6	100.0

5. *Frequency studies*

The distribution of the different stages of supination-outward injuries in a normal population is difficult to calculate, but it can be roughly estimated. From Table 1 it appears, among other things, that stage I-injuries have not been registered before 1962. For that reason the percentage distribution of these injuries is too low. In the material there are also included many patients who do not normally belong to the reception area. From the Department of Orthopaedics, Malmö General Hospital, we have in the years 1961—1963 received 57 SOR-injuries for treatment, comprising 3 stage II, 2 stage III and 52 stage IV-injuries. The addition of these patients gives the material an over-representation of stage IV-injuries. During the years 1962—1965 the annual distribution of the different stages has been rather uniform. If the Malmö patients from the years 1962—1963 are excluded, one will get a correct distribution of the injuries of the reception area during the above-mentioned period; see Table 3. This material includes 248 patients. The percentage distribution of the stages is: Stage I 4.4 %, stage II 38.3 %, stage III 5.7 % and stage IV 51.6 %. The sex distribution remains unchanged as compared to the whole operation material. There may still be a slight over-representation of stage IV-injuries in the material, as some severe ankle injuries have been transferred to the clinic from hospitals both in the reception area and out of it. The percentage figures obtained could, with consideration of the last-mentioned circumstance, indicate that the normal distribution of the different stages may be as follows: 50 % stage IV-injuries, 40 % stage II-injuries and 10 % stage I and stage III-injuries with a slight predominance of the last-mentioned.

6. *Etiological factors*

At the history taking the patients were thoroughly questioned about the position and the movement of the foot at the moment of the accident. Only 21 patients (5 %) spontaneously stated that the foot had been twisted out-

Table 4. Etiological factors listed in order of frequency.

	No. of cases
1. Slipping on level ground (ice, slippery or wet floor, etc.)	169
2. Slipping or stumbling down from a step	73
3. Sports injuries (Skiing 15, football 10, skating 7, wrestling 5, hand-ball 2, sledging 2, gymnastics 2 and tennis 1 case)	44
4. Traffic accidents (overturned bicycles or motor-cycles, collision with bicycle, motor-cycle or car)	35
5. Stumbling (trapping of the foot on locomotion)	32
6. Fall from a height	26
7. False step on rough ground	21
8. Fits of syncope (epileptic fit, vaso-vagal fit, insulin coma, etc.)	4
9. Other unspecified causes (rare types of trauma)	13
Total	417

wards in relation to the lower leg. 38 patients (9.1 %) stated pure supination violence to be the cause of the injury. The rest, about 85 per cent, could not give any information at all as to how the foot had been displaced at the moment of the accident, especially because the occurrence of the injury was of very short duration. Among the etiological factors, there is a marked predominance of slipping on level ground which occurred in 169 cases (40.5 %). Next thereafter, comes slipping or stumbling down from a steep, 73 cases (17.5 %). In the third place come sports injuries, 44 cases (10.6 %). More detailed information about the etiological factors is given in Table 4.

7. *Comparison with earlier investigations*

Ad 1. The number of SOR-injuries given an account of in this work will probably be the largest hitherto published. Formerly Magnusson (1944) and Proctor (1954) have published materials, comprising 386 and 400 patients respectively, coming next in size. The percentage occurrence of SOR-injuries in the present work, broadly speaking, corresponds to observations made earlier. The percentage figures have in different materials varied between 42.0 and 73.6. Ashhurst & Bromer (1922) report 61.0 %, Bishop (1932) 54.4 %, Lauge Hansen (1942) 68.6 %, Magnusson (1944) 48.8 %, Kristensen (1949) 42.0 %, Biström (1952) 73.6 %, Vasli (1957) 73.6 % and Klossner (1962) 63.0 %.

Ad 2. The distribution of sex among SOR-injuries is very divergent. Lauge Hansen (1942) mentions a slight predominance of women, the ratio between women and men being 1.1 : 1. In his material, Magnusson (1944)

has a slight predominance of men, and the ratio between the sexes here is the reverse, i.e., 1 : 1.1. In a material, comprising only stage III and stage IV-injuries, Biström has a marked predominance of women the ratio being 2.5 : 1. As to the distribution of age, Lauge Hansen (1942) considers that SOR-injuries have a higher frequency in men and a uniform distribution in the different age groups up to the age of 45. After this age a predominance of women is present, at the same time as the frequency of injuries is slowly decreasing. The results in this work do not support this view. There is in almost all age groups a predominance of women, and the frequency of fractures clearly increases after the age of 45. The mean age of the patients in the present work is higher than that in Magnusson's material. He reports a mean age of 42.2 ± 0.8 years, of which for women 44.8 ± 1.2 years and for men 39.8 ± 0.9 years. From this it follows that Magnusson also found a higher mean age for women than for men.

Ad 3. Lauge Hansen (1942) has reported the following distribution of the different stages of SOR-injuries: stage I 4.3 %, stage II 35.0 %, stage III 23.3 %, and stage IV 37.4 %. Compared with this work, there is a good accordance with the percentage distribution of the injuries of stage I and in a certain degree also with that of the injuries of stage II. In Lauge Hansen's work, however, the stage III-injuries have a high representation and the stage IV-injuries a low one. The explanation of this must be that Hansen has divided up his material on a roentgenological basis only, in consequence of which he has happened to place injuries with rupture of the deltoid ligament in stage III. From this it appears that the distribution into stages must be based on both clinical and roentgenological examinations. Magnusson (1944) has divided up his material according to Ashhurst & Bromer, thus using a roentgenological classification. He has a high over-representation of so-called unimalleolar fractures which correspond to stage II in Lauge Hansen's classification. He also has an over-representation of the combination of unimalleolar fracture and fracture of the dorsal tibial margin which then corresponds to stage III in the classification mentioned above. Also these over-representations will probably be due to the fact that sufficient attention has not been paid to the ruptures of the deltoid ligament. In a follow-up material, including 60 patients, Kristensen (1949) has given the following stage distribution: stage I 1.7 %, stage II 28.3 %, stage III 13.3 %, and stage IV 56.7 %. Other materials published, for instance by Biström (1952), Vasli (1957) and Klossner (1962), only deal with so-called severe SOR-injuries, i.e., mainly stage III and stage IV-injuries, and in a certain degree also stage II-injuries.

Ad 4. In his material, Lauge Hansen (1942) reports a predominance of female patients in stage I, which does not agree with the observations in the present work. 4 out of 7 patients in this stage were at an age under 45.

He reports a male predominance in stage II and stage III, which, again, does not agree with the observations in this work, where in stage II there is a female predominance, and where in stage III the sex distribution is uniform. In stage IV Lauge Hansen reports a marked predominance of women, which well agrees with the observations in the present work. He also states that the injuries of stage IV especially affect women in middle life. This last-mentioned fact has also been reported by Biström (1952).

Ad 5. The distribution of the different stages of the SOR-injuries in a normal population is not to be found in any earlier work. The explanation of this would seem to be that no author before has made so thorough an inventory of the injuries as has been the case in this work.

Ad 6. In his work, Magnusson (1944) mentions that most of the SOR-injuries in his material have occurred by the patients slipping or stumbling. Thereafter follow, in order, road accidents and sports injuries. Biström (1952) has above all, emphasized the important rôle played by the trauma of slipping. Thus he could prove that the majority of these injuries occurred during the winter months. Several authors also report that a very small number of the patients can describe how their foot was displaced at the time of the accident.

VI *Injuries of the anterior tibiofibular ligament*

A. Isolated rupture of the anterior tibiofibular ligament (stage I)

1. *Different types of rupture*

In the medical literature little attention has been paid to the isolated rupture of the anterior tibiofibular ligament (ATFL). In a material comprising 31 "ligamentous" ankle fractures, Lauge Hansen (1949) has described 4 cases of isolated ATFL-rupture, which implies a frequency of about 13 per cent. Bonnin (1950) considers that the isolated ATFL-rupture is the most common ligamentous injury in the ankle, often occurring in combination with a rupture of the calcaneofibular ligament. Palmer (1950) is of opinion that the injury is a common type of ankle sprain. McLaughlin (1959) considers the isolated ATFL-rupture essentially to be a sports injury, and terms it "the skier's sprain". Menelaus (1960) has reported clinical and operative findings in 3 patients. 1 or possibly 2 of them, however, must have had a pronation injury with a simultaneous rupture of the deltoid ligament, to judge from the roentgenograms which show a very great distance between the talus and the medial malleolus. Broström (1966) has

described 25 cases of isolated ATFL-rupture included in a larger material comprising lateral ligamentous injuries.

Isolated ATFL-rupture has in the present material been diagnosed and operated on in 11 cases, including 3 women and 8 men. Of these patients 7 men had a rupture located in the ligament itself. The remaining 4 patients had an avulsion of the ligament from the anterior tibial tubercle (ATTu) with a well-defined bone fragment. All the female patients of the group belonged to this category. Consequently there is in the material no case in which the rupture of the ligament was situated in the fibular attachment, which constitutes the 3rd possibility of the ligamentous injury in question, and which has been proved experimentally among others by Lauge Hansen (1942). The size of the material does not allow any certain conclusions to be drawn from these facts. Much, however, indicates that the occurrence of an ATFL-rupture with a fibular avulsion fragment is promoted in a high degree by a simultaneous distal oblique fibular fracture. This is discussed further in the work.

The frequency of stage I-injuries in the material may seem to be too low. It must, however, be taken into consideration that the majority of the ligamentous injuries affecting the lateral portion of the ankle has reference to the anterior talofibular ligament (ATaFL) and the calcaneofibular ligament (CFL). In the years 1960—1965, 105 total lateral ligamentous injuries have ben operated on, 11 of which were ATFL-ruptures and 94 injuries with rupture of the ATaFL, often in conjunction with partial or total rupture of the CFL. The share of the ATFL-injuries in this material, about 10 per cent, became considerately much smaller than was expected from the beginning. About the same percentage figure has been reported by Broström (1966), who diagnosed the injuries by arthrography. The reason why the isolated ATFL-rupture so rarely occurs is difficult to prove. It may be due to the fact that the ligament is very strong and that trauma, severe enough to rupture it, will also usually fracture the distal part of the fibula.

2. *Clinical diagnosis*

The patients have generally stated pure "supination violence" to be the provoking cause of the isolated ATFL-rupture. At clinical examination, swelling over the anterior portion of the tibiofibular syndesmosis and hemarthrosis, well visible and palpable, have been registered. The patients have stated tenderness on palpation over the ATFL and the lateral part of the ankle. It has been possible to produce indirect pain by forced outward rotation and also by dorsiflexion of the foot. The presence of such indirect rotation pain has been reported earlier by Bonnin (1950), Palmer (1955), McLaughlin (1959), and Broström (1966). Bonnin has also reported in-

direct plantar flexion pain as typical of an ATFL-rupture, and Menelaus (1960), both plantar flexion and dorsiflexion pain.

3. *Roentgenological diagnosis*

One has been able to make a roentgen diagnosis in those isolated ATFL-ruptures in which the ligament has ruptured with an avulsion of a rather large fragment from the anterior tibial tubercle, where the fragment has been well visualized in the roentgenogram, especially in the projection taken with the foot in 55° outward rotation. One has not been able to diagnose ruptures located in the ligament itself by use of plain radiography; nor has it been possible to prove any difference between the injured and the intact ankle at an examination of a patient in exactly accordant projections. The Figures 6, 7, and 8 show roentgenograms of ankles with different types of ATFL-ruptures.

The difficulty in diagnosing the isolated ATFL-rupture by roentgen has been pointed out earlier by several authors. Lauge Hansen (1942) has formed the following criteria for the diagnosis of the injury: 1) irregular contour in the ATTu or in the anterior margin of the lateral malleolus; 2) bone fragments in the soft parts frontally to them, and 3) fracture line through the ATTu. He considers that the injury cannot be established by any form of stress roentgenograms. Hendelberg (1943) has made experi-

Fig. 6. Stage I-injury. Fragments from the anterior tibial tubercle, indicating rupture of the anterior tibiofibular ligament.

Fig. 7. Rupture of the right anterior tibiofibular ligament in the ligamentous substance. No bone fragment and no incongruity can be seen. Left ankle in exactly the same projection for comparison.

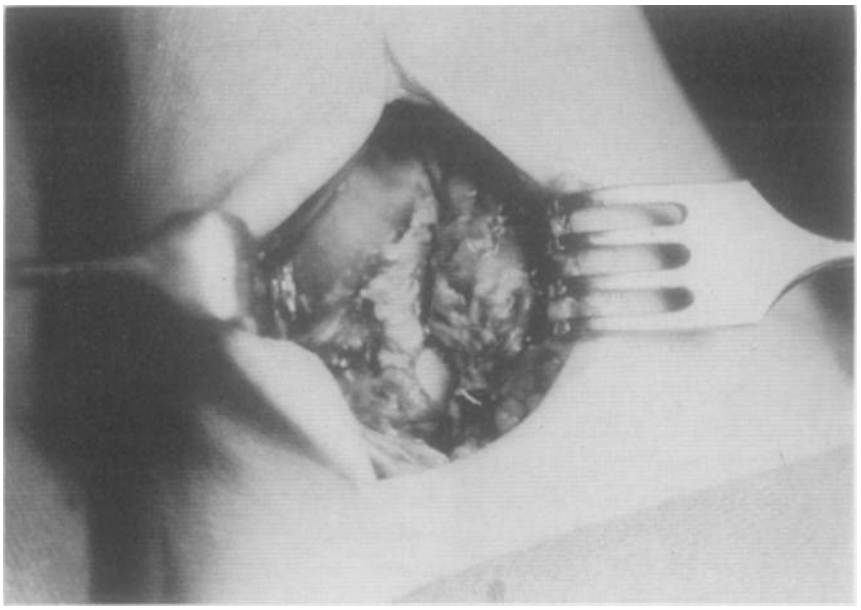
Fig. 8. Stage I-injury with an unusually large fragment from the anterior tibial tubercle.

mental investigations with section of the ATFL and outward rotation of the distal fibula, which was kept in this position by means of a wooden wedge placed in the anterior tibiofibular diastasis that was produced. He did not, however, succeed in establishing any demonstrable difference by examinations with or without a wedge. Also Bonnin (1950) considers the

roentgenological diagnosis to be difficult and the possibilities of diagnosis by provocation to be small. According to his opinion, the clinical symptoms must be decisive of the diagnosis. Berridge & Bonnin (1944) have shown that the isolated ATFL-rupture is diagnosable by arthrography. Broström, Liljedahl & Lindvall (1965) have described 5 arthrographically diagnosed cases of this injury, which also have been operatively explored. However, they consider the method to be uncertain when more than a week has passed after the occurrence of the injury.

4. *Operative examination*

At the operative exploration of stage I-injuries, one will find a localized hemorrhage around the ruptured ligament and, as a rule, a rather small and well-defined ventrolateral capsule rupture. Besides, there will be a moderate hemarthrosis. Of the 11 patients in the material 1 had a large detached bone fragment involving the whole ATTu (see Fig. 8), and 3 had smaller ones. In those 7 patients who had their rupture located in the ligament proper, this rupture was situated somewhere in the middle of it (see Fig. 9). In the 3 patients who had smaller ATTu-fragments, these were displaced a few mm in ventral, lateral, and distal direction. The distal part of the fibula in all the 11 patients lay in quite a normal place in relation to the tibia and no form of anterior diastasis could be demonstrated. In the purely ligamentous ATFL-injuries, one of the ligament portions sometimes proved to be trapped in the space between the tibia and the fibula. Rupture also of the other lateral ligaments could in no case be demonstrated at the explorations. At outward rotation of the foot during the operations, one could see how the distal fibula was displaced a few mm in lateral direction, at the same time as a diastasis, 10—12 mm wide, could be produced between the tibia and the anterior margin of the lateral malleolus. This diastasis, then, was possible, owing to the fact that the distal fibula could be powerfully rotated around an axis, which mainly runs through the interosseous tibiofibular ligament and the interosseous membrane. At both outward rotation and dorsiflexion of the foot, an increased diastasis arose in the ATFL-rupture, which may explain the mechanism behind the indirect ligamentous pain. Other movements could not provoke any obvious displacements between the free ends of the ligament. The indirect pain which Bonnin and Menelaus could produce by plantar flexion of the foot must probably have reference to the rupture of the joint capsule and consequently cannot be specific to an injury to the ATFL. Several authors have made experimental investigations at which they sectioned the ATFL and then measured the size of the anterior tibiofibular diastasis, which arose when the foot was rotated outwards. Ashhurst (1922) has estimated it at 10 mm, Palmer (1941) at 10, Lauge Hansen (1942) at 8 to 9, Hen-



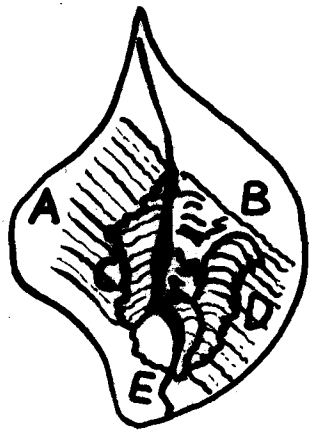
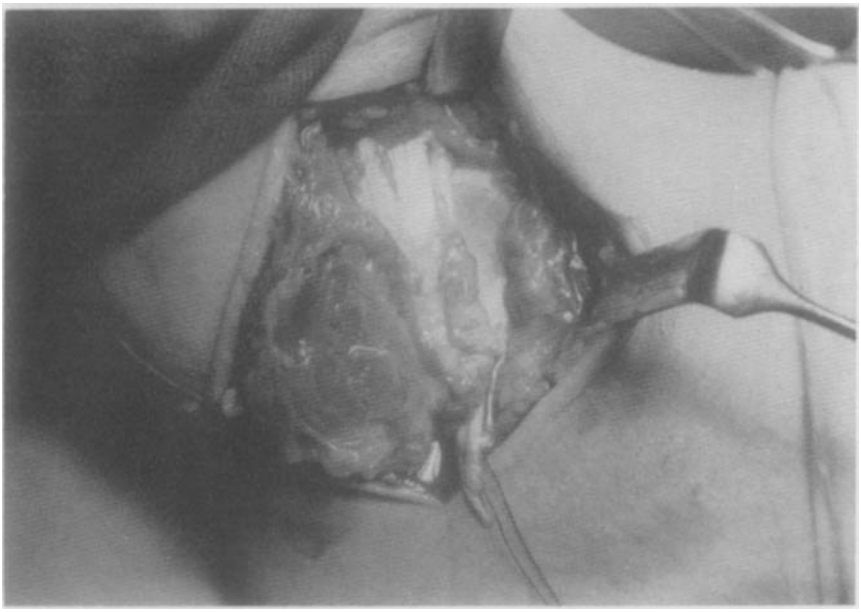


Fig. 9. Isolated rupture of the anterior tibiofibular ligament (left ankle). A. Tiba. B. Fibula. C. Tibial, and D. Fibular portion of the ligament. E. Ventrolateral corner of the trochlea tali and rupture of the joint capsule.

delberg (1943) at scarcely 10, and Bonnin (1950) at 4 mm. Broström (1966) has, at operation, estimated the size of the diastasis at 5 mm.

5. *Differential diagnosis*

The isolated ATFL-rupture is, above all, confused with the isolated ATaFL-rupture. From an anatomical point of view, the ligaments are closely connected with each other, see Fig. 10. The ATaFL is weaker, and more firmly connected with the joint capsule, than the ATFL. The ATaFL originates from the ventrodistal part of the lateral malleolus, just distally to the



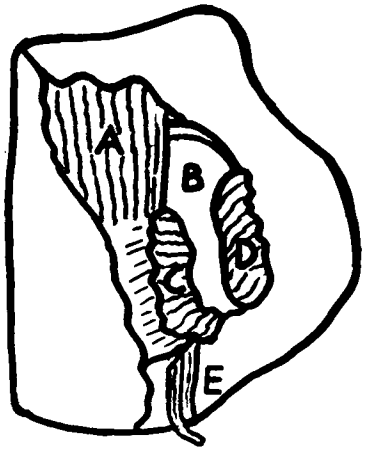


Fig. 10. Anatomical relationship between the anterior tibiofibular and anterior talofibular ligaments (right ankle). A. Anterior tibiofibular ligament. B. Capsule rupture and lateral part of the talus. C. Fibular, and D. Talar portion of the ruptured anterior talofibular ligament. E. Fibular portion of the partially ruptured calcaneofibular ligament.

attachment of the ATFL, and is attached to the lateral side of the collum tali. The ligament easily ruptures when the foot is twisted into powerful supination and inward rotation, and more easily when the foot also is put in plantar flexion. During the years 1960—1965, 94 cases of ATaFL-ruptures have been operated on. In 25 to 30 per cent the ligament rupture mentioned was associated with a partial or total CFL-rupture. Similar materials have been reported by several authors, particularly Broström (1966), who found a combined injury to the ligaments mentioned in about 20 per cent. Most of the 94 patients have stated pure "supination violence" to be

Fig. 11. Rupture of the anterior talofibular ligament of the left ankle. Incongruity in the talofibular joint. Right ankle for comparison in exactly the same projection (20° inward rotation of the foot).

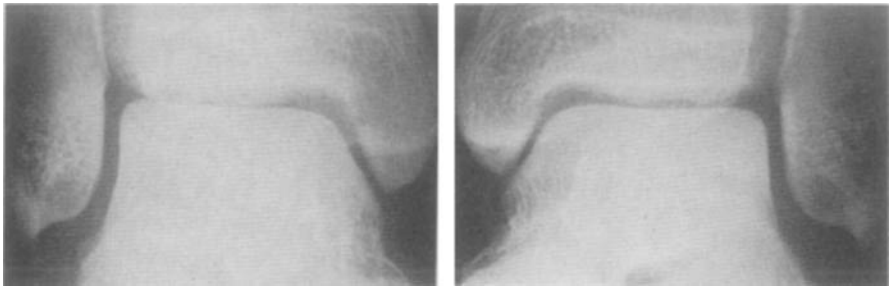


Fig. 12. Same as Fig. 11. In this case there is also a partial rupture of the calcaneofibular ligament.

the cause of the injury. They have had rather pronounced swelling and hematoma ventrally and distally to the lateral malleolus and tenderness on palpation, which has reached its maximum over the actual ligament. Well-palpable hemarthroses have seldom been present. Indirect pain could be provoked by forced supination and inward rotation of the foot. At roentgenological examination, one has only in a minority of cases found fragments emanating from the distal fibula or the collum tali, thus corresponding to the origin and the attachment of the ligament. At a comparative examination of the intact ankle in exactly the same projection, a clear

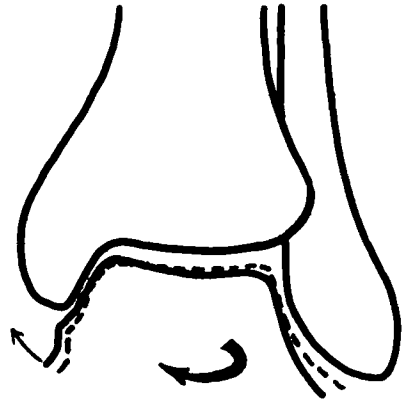


Fig. 13. Talofibular incongruity. Mechanism: The ruptured talofibular ligament gives rise to ankle instability, resulting in slight inward rotation and varus displacement of the talus. The arrows indicate the directions of talar movement.

incongruity, in almost every case, has been demonstrable in the joint between the talus and the lateral malleolus; see roentgenograms, Figs. 11 and 12. This incongruity, appearing still more distinctly at a simultaneous CFL-rupture, is due to the fact that the ATaFL-rupture gives rise to slight instability in the ankle mortise resulting in rotation of the talus in medial direction and also a slight displacement of it in varus direction, see Fig. 13.

The easiest way to convince oneself that the incongruity is due to this displacement of the talus is to make an operative analysis of a case with an isolated ATaFL-rupture. Then one can easily demonstrate the instability as well as the rotation of the talus which the injury can give rise to. The same explanation is also given by some experimental investigations in which a total ATaFL-rupture has been produced. Leonard (1949) who considers the ATaFL to be the most important stabilizing component of the lateral collateral ligament, has, by cadaver experiments, been able to prove that a section of the ATaFL and the lateral portion of the joint capsule can enable talar tilt in varus direction amounting to 10°, when the foot is plantarflexed, whereas the ankle is rather stable in the absence of plantar flexion. Anderson, Lecocq & Lecocq (1952) have made similar examinations and then established instability in both the vertical and the longitudinal axis of the talus with the possibility of tilting up to 6—7°.

The difficulty in distinguishing between an isolated ATFL and an isolated ATaFL-rupture by palpation has been emphasized, among others, by Bonnin (1950). He considers the ATFL to be so sensitive to palpation that, at the occurrence of an injury close to this ligament, it can localize the maximal point of tenderness to itself. During an operative examination of an isolated ATaFL-rupture, one will always find an extensive lateral rupture of the joint capsule, as a rule stopping at the ATFL. It is probably, I suppose, this rupture of the joint capsule that first of all makes the dif-

ferential diagnosis between ATFL and ATaFL-injuries difficult, even to the experienced examiner.

The isolated ATaFL-rupture can, however, be diagnosed by means of other methods, namely so-called anteroposterior stability test, so-called stress inversion radiography, and arthrography. The first-mentioned method is based on experimental examinations performed by Pennal (1943) and Anderson, Lecocq & Lecocq (1952). With section of the ATaFL and the lateral portion of the joint capsule, they were able to prove that the foot could be displaced in dorsoventral direction, thus producing a ventral subluxation of the talus. Anderson, Lecocq & Lecocq could also show that increased plantar flexion of the foot was accompanied by increased dorsoventral instability in the ankle. When the plantar flexion amounted to 20°, they could displace the talus and the foot 7 to 8 mm in ventral direction. If the plantar flexion was increased to 35°, they could in addition to the displacement mentioned also show the possibility for the talus to rotate in medial direction. Staples (1965) and Coutts & Woodward (1965) have accounted for the clinical application of these observations and shown that an ATaFL-rupture gives rise to anteroposterior instability, which can be roentgenologically registered. Staples considers that the examination may be made on fresh ligament ruptures, without anesthesia necessarily being resorted to, provided the examination is made as early as possible after the occurrence of the injury. Swelling, pains, and spasm make an examination without anesthesia impossible. Coutts & Woodward examine fresh injuries after blocking of the peroneal nerve, which method has been described by Ruth (1961). Broström (1966) has also used the anteroposterior stability test in fresh ligamentous ruptures, at which examination has been performed under spinal anesthesia.

Stress inversion radiography implies that the ankle is roentgenologically examined in defined projections with the foot inward rotated and the heel adducted. The method is best adapted for the diagnosis of combined ATaFL and CFL-ruptures even if, as has been shown by Anderson, Lecocq & Lecocq (1952), an isolated ATaFL-injury can make possible the occurrence of talar tilt in varus direction up to 6—7°. The procedure and the practical application of this method of examination, however, have been subjected to much discussion. Its clinical value is disputed, and strongly negative opinions about it have been delivered by Rubin & Witten (1960).

Arthrography is stated in the literature to be a reliable method of proving an ATaFL-rupture. Methods and roentgenological observations have been described by a number of authors, e.g., Wolff (1940), Hansson (1941), Palmer (1941), Hendelberg (1943), Berridge & Bonnin (1944), Lindblom (1952), Arner, Ekengren, Hulting & Lindholm (1957), and Rezek (1958). Broström, Liljedahl & Lindwall (1965) have more systematically employed

Fig. 14. "Isolated fracture of the posterior tibial process" with rupture of the anterior tibiofibular ligament and vertical fracture of the posterior tibial process.

arthrography and published a fairly comprehensive material of ATaFL-injuries.

The 3 now mentioned special methods of the establishment of the isolated ATaFL-rupture, however, have some disadvantages, which make them unsuitable for routine clinical work. Thus they take up time and require assistance from a qualified staff and medical apparatus.

The possibility of proving an ATaFL-rupture by plain radiography, i.e., the establishment of incongruity in the joint between the talus and the lateral malleolus, has not been mentioned in the literature previously. The method is simple and is based on the fact that the ankles of each patient are normally symmetric and, therefore, it requires examination of both the ankles of the patient in exactly the same projections. The occurrence of old defectively healed ligamentous ruptures may, however, reduce the reliability of the method.

A second possibility of confusion with the isolated ATFL-rupture is what in the literature, is mostly termed "isolated fracture of the posterior tibial process". This injury is characterized by a rupture of the ATFL in combination with an intra-articular fracture running vertically and frontally through the posterior part of the distal tibia (see Fig. 14). It is mentioned here, because, as we know, it requires quite another treatment than does the isolated ATFL-rupture. The injury is rare, and at the Department of Orthopaedics, Lund Hospital, it has been diagnosed in only 3 patients

Table 5. Clinical and roentgenological differential diagnosis in ATFL-injuries, ATaFL-injuries and ATFL-injuries combined with fracture of the posterior tibial process.

Ligament injured	Clinical diagnosis	Roentgenological diagnosis	Special methods
ATFL	Moderate hemarthrosis. Max. swelling and tenderness over the anterior syndesmosis. Indirect outward rotation and dorsiflexion pain.	Sometimes, detached fragment from the ATTu or the lateral malleolus (?).	Arthrography.
ATaFL	In most cases slight hemarthrosis. Max. swelling and tenderness over the talofibular joint. Indirect supination and inward rotation pain.	Rarely, detached fragment from the lateral malleolus or collum tali. Incongruity in the joint between the talus and the lateral malleolus.	Arthrography. Anteroposterior stability test. Stress inversion radiography.
ATFL + Posterior tibial fracture	The same as in isolated ATFL-rupture, but often tenderness over the anterior joint capsule, too. Sometimes, swelling and tenderness over the posterior part of the joint.	Vertical fracture through the posterior tibial process.	(Arthrography.)

during the years 1960—1965. Ashhurst & Bromer (1922) found only 1 case among their 300 fractures. Hendelberg (1943) has stated a frequency of 5/223, Biström (1952) 1/322, and Broström, Liljedahl & Lindvall (1964) 18/185 fractures. Lauge Hansen (1942) and Kristensen (1949) have denied its existence as a special type of injury, and want it to be classified among the pronation-outward rotation fractures. Palmer (1941) considers the injury to arise by plantar hyperflexion violence causing an anterior rupture of the capsule and a chisel fracture in the tibia. By arthrography, Hendelberg (1943) showed that the posterior tibial fracture is associated with a rupture of the ATFL, and he considers the injury to result from outward rotation violence. Bonnin (1950) is of opinion that the injury results from plantar flexion of the foot or powerful dorsal displacement of the latter in neutral position. By arthrography, Broström, Liljedahl & Lindvall (1964) have in most of the cases been able to demonstrate an ATFL-rupture but no signs indicating a rupture of the anterior capsule. They therefore consider that the injury cannot be caused

by plantar hyperflexion, but that it deals with an atypical form of SOR-injury of stage III instead, where, the distal oblique fibular fracture for some reason has not occurred.

The 3 cases operated on at the Department of Orthopaedics, Lund Hospital, all had a rupture in the middle of the ATFL and a relatively limited ventrolateral rupture of the capsule. At the clinical examination, the patients had the same symptomatology that characterizes the isolated ATFL-injury. In some case, tenderness on palpation over the posterior portion of the joint could be registered. The establishment of the posterior tibial fragment has been decisive in forming a diagnosis, which has often required several oblique projections at the roentgenological examination as the fractures have shown very slight displacement.

Table 5 shows a collation of the diagnostic criteria and methods available for the establishment of ATFL-injuries, ATaFL-injuries, and ATFL-injuries in combination with fracture of the posterior tibial process.

B. Injuries of the anterior tibiofibular ligament occurring in combination with distal oblique fracture of the fibula in stage II, III, and IV.

1. *Earlier investigations*

As is clear from Chapter IV, the opinions differ widely as to whether or not the distal oblique fibular fracture is combined with a rupture of the ATFL. On the basis of experimental as well as roentgenological examinations, Lauge Hansen (1942) considers that the ATFL is always ruptured when a distal oblique fracture of the fibula is present, and that the ligamentous injury always precedes this fracture. He is of opinion that the ligament ruptures with an avulsion fragment from either the ATTu or the lateral malleolus. In 2 cadaver experiments, Lauge Hansen found that the ATFL was intact in spite of the fibula being fractured in the usual way. He ascribed this to the poor quality of the preparation and the forced outward rotation of the foot not occurring as desired, and therefore he paid no attention to these observations. Lauge Hansen considered that in 60 per cent with certainty, and in 22 per cent in all probability, he could roentgenologically show that the ATFL had ruptured. As has previously been mentioned, he based this diagnosis on the presence of fragments or contour-changes in the ATTu or in the lateral malleolus. Magnusson (1944) re-examined 211 cases of SOR-fractures and could in 157 (75 %) of them roentgenologically point out signs of injuries to the ATFL in the form of sclerosed and torn off fragments from the ATTu or the lateral malleolus, or defects and contour-changes in them. The injuries included 54 pseud-

arthroses and 103 contour-changes. From this Magnusson concluded that all SOR-fractures probably have a rupture of the ATFL. He writes: "There is a certain element of probability that all fractures by external rotation involve injury to the anterior tibiofibular ligament". Later (1965) he declares that the distal oblique fibular fracture is *always* preceded by a rupture of the ligament mentioned.

2. *Different types of rupture and their percentage distribution*

5 main types of ATFL-injuries have been encountered in the present material, namely, rupture in the ligament itself, rupture in the ATTu, with or without an avulsion fragment, and rupture in the fibular attachment, with or without an avulsion fragment. Fig. 15 depicts these main types of injuries. Here it must be pointed out that combined forms are not uncommon, and that the ligament need not in its entirety have connection with the avulsion fragment that has arisen. In the material, 406 cases with distal oblique fracture of the fibula are included, 405 of which have been operated on. The remaining case had such severe skin damage that the exploration of the lateral portion of the ankle was avoided. Among these 405 cases, 389 (96,1 %) were found to have a total ATFL-injury. The distribution of the 5 different main types of injuries can be seen in Table 6. From this table it is clear that rupture located in the ligament itself has a very marked predominance and comprises no less than 254 cases (65.3 %). Next come rupture in the fibular attachment and rupture in the ATTu in that order. Avulsion fragments could be registered in 88 (22.6 %) cases, of which, 67 were women and 21 men. The material yields much interesting information. Especially the great predominance of rupture in the ligament itself is impressive, which type of rupture has not been noticed by Lauge Hansen. Bonnin (1950) considers that a complete rupture of a ligament in its substance is extremely rare, especially in the short ligaments

Table 6. Type distribution of the ATFL-injuries of stage II, III and IV in women and men.

Type of injury	Women	Men	Total	%
A. Rupture in the ligament proper	139	115	254	65.3
B. Rupture in the fibular insertion	58	18	76	19.5
1. with a bone fragment	40	11	51	
2. without a bone fragment	18	7	25	
C. Rupture in the ATTu	41	18	59	15.2
1. with a bone fragment	27	10	37	
2. without a bone fragment	14	8	22	
Total	238	151	389	100.0

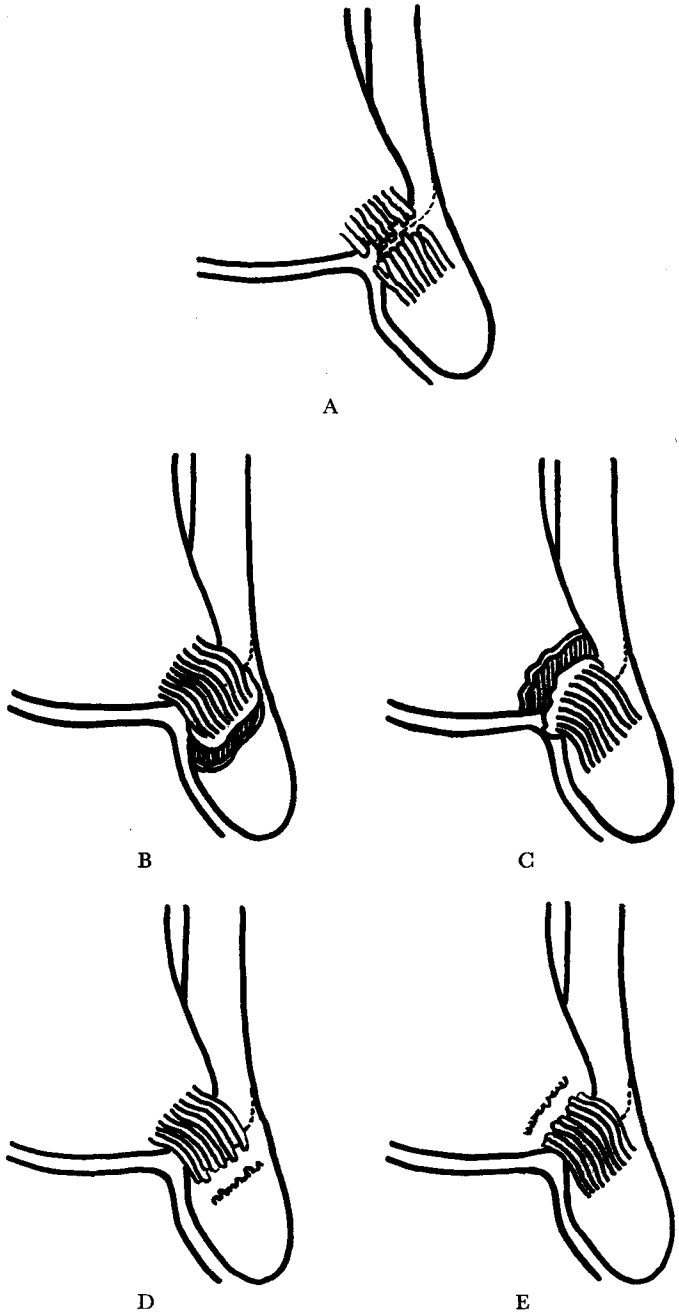


Fig. 15. Different types of rupture of the anterior tibiofibular ligament occurring in combination with distal oblique fibular fracture, arranged in order of frequency. Rupture in the ligament proper (A). Rupture in the fibular insertion with (B), and without (D), a bone fragment. Rupture in the tibial origin with (C), and without (E), a bone fragment.

characterizing the ankle. Watson-Jones (1955) is of the same opinion considering that a ligament, even in severe injuries, does not rupture in its substance but more commonly in its origin or insertion. Weber (1966) considers that the ATFL is seldom injured in its substance. Thus these opinions can be completely confuted by the results in this material. Also Broström (1966) has reported that a ligamentous rupture with an avulsion fragment rarely occurs.

VII *Occurrence of uninjured anterior tibiofibular ligament in combination with distal oblique fibular fracture*

In the present material, the occurrence of intact ATFL in the presence of distal oblique fracture of the fibula has been registered in 16 cases (3.9 %). In these the fracture has originated just distally to the attachment of the ligament in the fibula (see Fig. 16). The oblique fracture was in some cases rather short, but in the majority of the cases it had an ordinary appearance. Among the 16 patients, 12 were women and 4 men. The distribution into different stages was: 6 stage II, 2 stage III, and 8 stage IV-injuries. It is difficult to establish the reason why the ATFL had not ruptured in these cases. It probably deals with variations in the strength of the bone causing the fracture to appear in the weakest part of the fibula, in these cases located in the bone tissue, distally to the attachment of the ligament. One can, therefore, suspect the presence of an osteoporotic factor involved, which to a certain degree can have a protective effect on the ATFL. That an osteoporotic factor may be involved is evidenced by 75 per cent of the patients being women, and that 75 per cent of them were aged above 40. The 16 cases, then, prove that the distal oblique fibular frac-

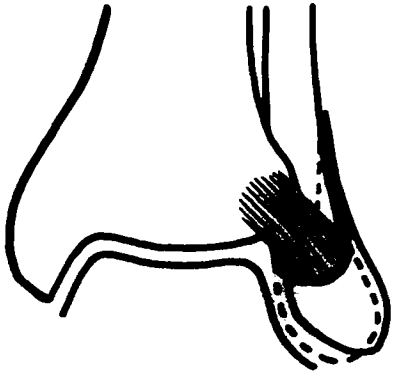


Fig. 16. Stage II-injury with intact anterior tibiofibular ligament, fracture starting below the fibular insertion of the ligament.

ture is not necessarily associated with a rupture of the ATFL, which circumstance confutes the opinion advocated by Lauge Hansen and Magnusson. On the other hand, it is remarkable that so many authors, for instance, Ashhurst & Bromer, Bishop, Bonnin, Watson-Jones, Jergesen, Devlies, Calvetti, Soeur, Willenegger, and Weber, consider that the ATFL seldom or never ruptures in SOR-injuries.

VIII *Distal oblique fibular fracture occurring in stage II, III, and IV*

A. Different types of fracture. Displacement of the distal fibular fragment

406 cases of distal oblique fibular fractures are included in the material, 405 of which have been operated on. 3 main types of fractures of the fibula have been registered, namely, 1) a short, 2) an "ordinary", and 3) a long oblique fracture; see Fig. 17. Among the 406 fractures there was a marked predominance of the "ordinary" type registered in 349 cases (86.0 %). Next there came the long oblique fracture, registered in 35 cases (8.6 %). The short oblique fracture has been the most uncommon type, registered in 22 cases (5.4 %). The fractures have as a rule begun at the level of the joint between the tibia and the talus. In a few cases the fracture has begun

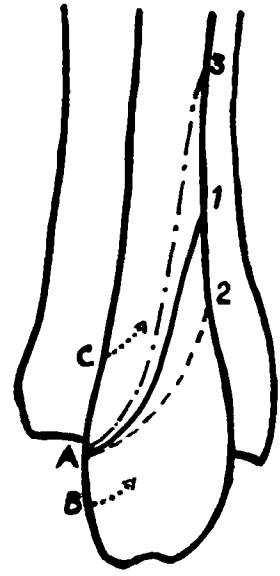


Fig. 17. Different types of fibular fracture.
A-1: "Ordinary" type of fracture. A-2: Short oblique fracture. A-3: Long oblique fracture. B: Fracture starting below the insertion of the anterior tibofibular ligament. C: Fracture above the joint.

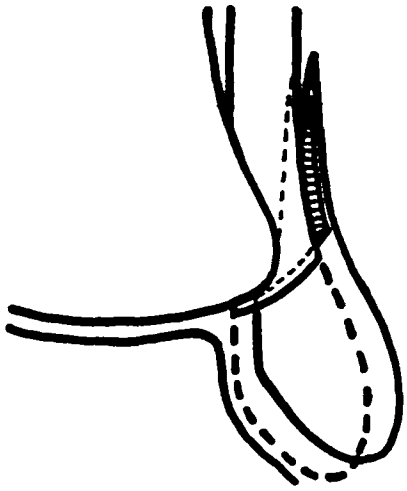


Fig. 18. Distal oblique fibular fracture with displacement of the distal fragment in outward rotation and dorsal, proximal and lateral direction.

somewhat above the joint space and in a few cases below it, in the latter the ATFL often being intact. The 3 main types of fractures on the whole correspond to those pointed out by Hönigschmied (1877), however, with the exception of his combined transverse and oblique fracture.

The distal fibular fragment has as a rule been displaced in outward rotation and in dorsal, proximal and lateral direction (see Fig. 18). The displacement has, of course, been most pronounced in luxation injuries. One has not been able to register any great difference between stage II and stage III-injuries, whereas the injuries of stage IV, because of the medial injury component, have often promoted the occurrence of lateral displacement with accompanying obvious articular incongruity. As to the displacement of the fragment, see also Chapter IX C.

B. The proximal fibular fragment and its relation to the interosseous tibiofibular ligament and the tibia

According to Lauge Hansen (1942), no damage occurs to the interosseous tibiofibular ligament (ITFL) in SOR-injuries, and the proximal fibular fragment remains in its normal place in the tibiofibular incisure. In the present material, however, several cases have been registered, in which the proximal fibular fragment could be displaced up to 0.5—1.0 cm in lateral direction, indicating a distension or a partial rupture of the ITFL. The phenomenon has been most frequently observed in stage IV-injuries, but has also been registered in a few cases of stage II and stage III-injuries. The same observation has been made by Grath (1964). In some cases of stage IV, LUX-injuries, one has also been able to register complete rup-

ture of the ITFL, involving considerable pathological mobility of the proximal fibular fragment. Some authors, for instance, Bosworth (1947), Harris (1947), Fleming & Smith (1954), Fahey, Schlenker & Stauffer (1956), and Meyers (1957, 1965), have reported SOR-injuries in which the proximal fibular fragment has been displaced and fixed behind the posterior tibial tubercle, implying that an injury to the ITFL must be present.

IX *Injuries of stage II*

A. Clinical diagnosis

At the clinical examination, the patients have shown considerable swelling round the distal part of the fibula extending over the anterior syndesmosis and often over the whole joint. On palpation the patients have complained of considerable tenderness over the oblique fracture in its whole extent but also over the ATFL and the anterior portion of the joint capsule. Crepitations corresponding to the fracture have often been registered.

B. Roentgenological diagnosis

The distal oblique fibular fracture has a very characteristic appearance in the roentgenogram. The lateral projection, especially, is decisive of the

Fig. 19. Distal oblique fibular fracture, lateral view.

Fig. 20. Stage II-injury with a typical distal oblique fibular fracture. The anterior tibiofibular ligament is ruptured with the avulsion of a fibular fragment, which is rotated almost 90° in proximal and tibial direction.

diagnosis (see Fig. 19), even if, in frontal projections, especially in 20° inward rotation of the foot one can discern the spiral form of the fracture. See roentgenograms, Fig. 20.

C. Operative examination

Explorative studies of the distal oblique fibular fracture have shown that the distal fracture fragment can present a varying degree of displacement. As a rule, the distal fibular fragment has been outward rotated and displaced in dorsal and proximal direction, involving a shortening in the fracture. The fragment has also often been displaced in a lateral direction resulting in a widening of the ankle mortise. This widening has made a slight lateral subluxation of the talus possible, in spite of the deltoid ligament being intact; see Fig. 21 and roentgenograms Fig. 22. By experimental investigations, Lauge Hansen (1942), Close (1956), and Grath (1960) have shown that the talus can be displaced 2 to 3 mm in lateral direction when the distal part of the fibula has fractured but the deltoid ligament is intact. The same observation has been made in the present material.

In the literature there are widely diverging opinions about the size of the

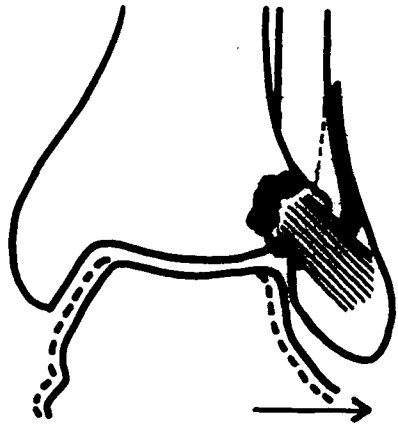
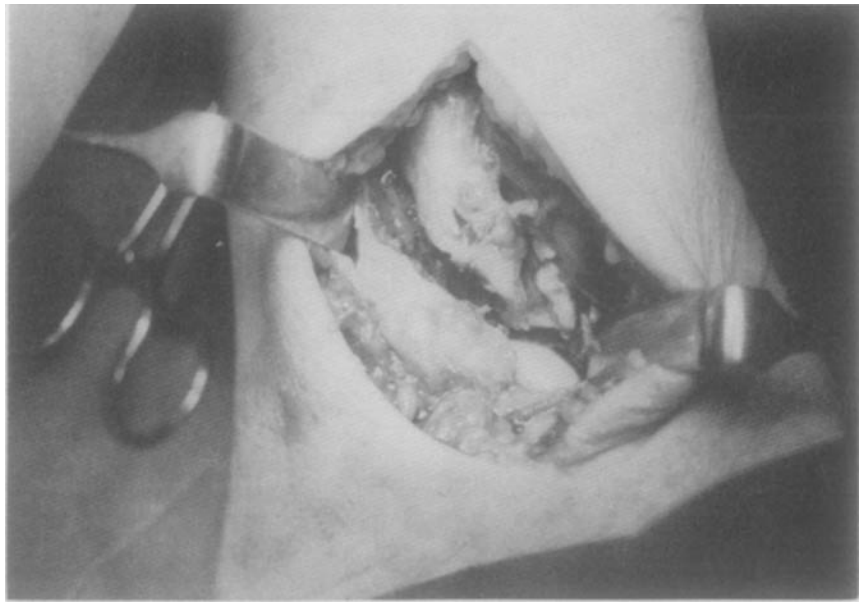


Fig. 21. Stage II-injury with lateral subluxation of the talus.

Fig. 22. Stage II-injury of the left ankle with an increased distance between the medial malleolus and the talus. No injury to the deltoid ligament was found at operation. Right ankle for comparison.

displacement of the distal fibular fragment. Ashhurst & Bromer (1922) consider the distal oblique fibular fracture to be characterized by "little or no displacement", a conception shared by Bonnin (1950), who, moreover, considers the fracture to be stable. Watson-Jones (1955) categorically declares that the fracture does not show any displacement. Lauge Hansen (1942) is of opinion that the distal fibular fragment can be displaced up to 30 to 40° outward rotation. Picaud (1953) has observed that the distal



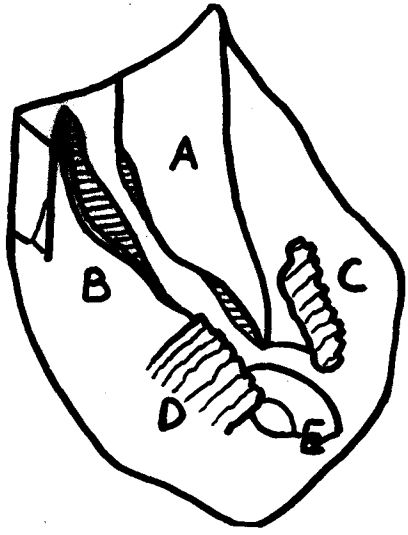


Fig. 23. SOR-injury with distal oblique fibular fracture (right ankle). A. Proximal, and B. Distal fragment of the fibula. C. Tibial, and D. Fibular portion of the ruptured anterior tibiofibular ligament. E. Capsule rupture and ventrolateral part of the trochlea tali.

fragment is displaced in dorsal and proximal direction and in outward rotation, but he has not noticed the lateral displacement. Vasli (1957) has not observed any rotation displacement, but, on the other hand, displacement in dorsal as well as lateral direction and also the possibility for the talus to be subluxated in lateral direction. Soeur (1961) considers the distal fibular fragment to show only a slight displacement. Bolin (1961)

has described all the possibilities of displacement, and Cedell & Wiberg (1962) have particularly emphasized the occurrence of shortening and outward rotation.

The simultaneous injury to the ATFL and the distal part of the fibula gives rise to very pronounced instability in the ankle, especially with regard to the outward rotation of the foot. The instability increases owing to the fact that there is also a rupture of the lateral and ventral part of the joint capsule, see operation picture Fig. 23. In those cases where the ATFL was intact, the instability of the ankle was less pronounced, though, however, obvious. According to the observations made in the present material, an intact ATFL cannot appreciably reduce the instability of rotation but on the other hand better prevent the talus from being subluxated in lateral direction. The rupture of the lateral joint capsule accompanying the distal oblique fibular fracture is in its lower part limited by the ATaFL, which is always uninjured in SOR-injuries.

In 13 cases of stage II-injuries, the deltoid ligament was explored with a view to exclude rupture. These patients had slight clinical symptoms on the medial side, but the roentgenograms showed an increased distance between the talus and the medial malleolus, possibly indicating rupture of the ligament. In 1 patient the posterior tibiofibular ligament has also been explored on the suspicion of rupture, without one's being able to verify the occurrence of this injury.

X *Injuries of stage III*

Patients with a distal oblique fibular fracture and fracture through the posterior tibial tubercle (PTTu) or the posterior tibial process (PTPr) have been grouped in stage III. 24 patients have fulfilled these requirements. 3 of them have been explored on the medial side in order to exclude rupture of the deltoid ligament.

A. Clinical diagnosis

The symptomatology of the patients has in no respect been different from that valid for stage II-injuries. The clinical diagnosis of the posterior tibial fracture has been difficult, and the fracture could only exceptionally be established, and this due to the patients showing swelling and tenderness on palpation over the posterior part of the joint. The same view has been advocated by Hendelberg (1943).

Fig. 24. Stage III-injury with a large posterior tibial fragment. Medial malleolus and deltoid ligament not injured either clinically or at operation.

B. Roentgenological diagnosis

The roentgenological examination is absolutely necessary for the diagnosis of stage III-injuries, at which lateral projections with the foot in at least 85° outward rotation must be used (see Fig. 24). Minor fragments and fragments without displacement often require several different projections to be demonstrable. From a theoretical point of view the dorsal tibial injury may consist of a ligamentous rupture without an avulsion fragment, an injury which cannot be established by plain radiography, and therefore the stage III-injuries may suffer a small under-representation.

C. The posterior tibial fragment and its variations in shape and size

The posterior fracture of the tibia is generally considered as an avulsion fragment originating from injuries of the posterior tibiofibular ligament (PTFL) and the transverse tibiofibular ligament (TrTFL). Some of the fractures are, however, considered as chisel fractures caused by the talus. Palmer (1941) and, before him, Grøndahl (1913) consider two different types of fractures to exist, namely, fracture through the PTTu and fracture through the PTPr, the former supposed to have an almost sagittal extension and to affect the articular surface very little, and the latter to have

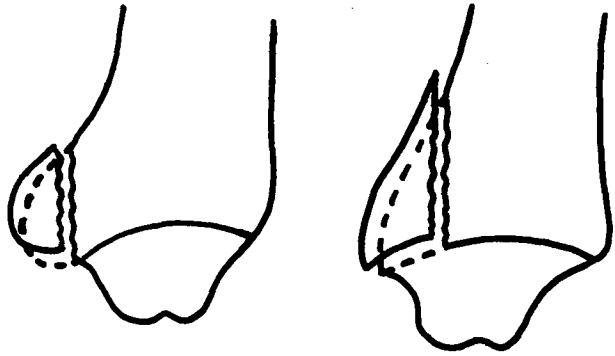


Fig. 25. Different types of posterior tibial fracture.
A. Fracture of the posterior tibial tubercle.
B. Fracture of the posterior tibial process.

a more frontal location and always to be intra-articular. Lauge Hansen (1954), however, considers the dorsal tibial fracture always to be intra-articular, and the TrTFL first of all to be involved in this injury. Accordingly, with the support of both experimental and roentgenological examinations, he does not believe that there can be an isolated extra-articular fracture of the PTTu. In the present material, two main types of posterior tibial fragments have been registered, in appearance agreeing with those reported by Grøndahl and Palmer; see Fig. 25.

Lauge Hansen (1942) considers the posterior tibial fracture to arise by the occurrence of 3 different forces, namely, 1) pressure of the talus on the dorsolateral corner of the tibial articular surface, 2) pressure of the distal fibular fragment in dorsomedial direction, and 3) pulling of the PTFL and the TrTFL in proximal and dorsal direction. Rose (1962), instead, believes that the posterior tibial fragment is produced by a direct pressure effect of the medial part of the trochlea tali.

The size of the posterior tibial fragments has been measured in roent-

Table 7. Classification of the posterior tibial fragments.

Group	Definition
Sh	Shell-shaped, thin bone fragment
1/4	Fragment comprising at most 1/4 of the articular surface.
1/3	Fragment comprising more than 1/4 and at most 1/3 of the articular surface.
1/2	Fragment comprising more than 1/3 and at most 1/2 of the articular surface.

Table 8. Size distribution of the posterior tibial fragments of stage III in women and men.

Group	Women	Men	Total
Sh	1	3	4
1/4	7	8	15
1/3	2	1	3
1/2	1	1	2
Total	11	13	24

genograms taken with the foot rotated $\geq 85°$ outward. This method of measurement will probably be the only available one and must be considered to be inexact, but still sufficient for an estimation of the mutual size of the fragments. In respect to their sizes, the fragments have been divided up into 4 groups, which broadly speaking, are similar to those reported by Hendelberg (1943); see Table 7. Table 8 shows the distribution of the fragments into the different groups, from which it is clear that more than 50 per cent of them are included in group "1/4", and that the remaining fragments have a fairly even distribution among the other groups. The distribution of sex is even, throughout the whole material.

XI *Injuries of stage IV*

A. Fracture of the medial malleolus

The material includes 238 stage IV-injuries, comprising 155 women and 83 men. Of these 238 patients, 174 (73.1 %) had a fracture through the medial malleolus. 126 were women and 48 men.

1. *Clinical diagnosis*

At the clinical examination the patients have shown considerable swelling round the medial malleolus, and maximal palpation tenderness over it. Crepitations could often be established. 3 women had an open fracture with a transverse wound in the soft parts. In 2 women and 1 man, the posterior part of the medial malleolus was connected with the posterior tibial process in one large fragment.

2. *Roentgenological diagnosis*

The medial malleolus has been examined especially in frontal projections. The fractures have generally been horizontal and located at the level of the

Fig. 26. Stage IV-injury with an avulsion fragment belonging to the anterior tibiofibular ligament, distal oblique fibular fracture, horizontal medial malleolar fracture, posterior tibial fracture and dorsal subluxation of the talus.

joint space (see Fig. 26). Some of them have been situated more proximally and have in that case been of a more oblique type, and others have been located at different levels distally to the joint space. Very small malleolar tip fragments have been registered as ruptures of the deltoid ligament. Fissure in the medial malleolus has been registered in scarcely 20 cases.

3. *Operative examination*

The malleolar fragment has as a rule been displaced in lateral and ventral direction, provided a dorsal subluxation of the talus has not been present, in which case the displacement of the fragment has been lateral and dorsal. The medial malleolar fracture can allow the talus considerable possibility of subluxation in a lateral direction; see Fig. 27. The fragment, as a rule, always accompanies the talus when the latter is displaced in a lateral direction, in outward rotation or valgus. The malleolar fragment has in many cases been comminuted. Interposition of soft tissue, namely, fascia, periosteum and ligamentous tissue, has to a very high percentage been registered in the medial malleolar fracture. This phenomenon has been reported by most of the authors who have explored the medial malleolar fracture. Interposition of the posterior tibial tendon, reported by some authors, for in-

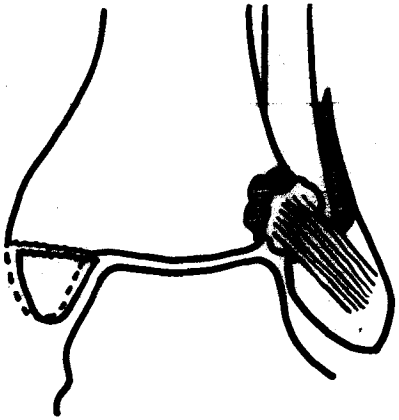


Fig. 27. Stage IV-injury with fracture of the medial malleolus and lateral subluxation of the talus.

stance, Lee & Horan (1943) and Coonrad & Bugg (1954), has not been registered. The joint capsule has in all the cases turned out to be ruptured in its ventromedial portion, the rupture extending from the medial across to the lateral malleolus.

B. Rupture of the deltoid ligament

Rupture of the deltoid ligament has been registered in 64 cases, i.e., 26.9 per cent of the 238 patients with stage IV-injuries. 29 of the patients were women, and 35 were men.

1. *Clinical diagnosis*

The clinical symptoms of the deltoid rupture do not appreciably differ from those of the medial malleolar fracture. Thus the patients have shown swelling of a rather high degree, especially below the medial malleolus, and considerable palpation tenderness over the ligament. With a total ligamentous rupture there has occasionally been a valgus displacement of the foot.

2. *Roentgenological diagnosis*

The deltoid rupture can be roentgenologically diagnosed in those cases in which there is an avulsion fragment from the tip of the medial malleolus, and in those cases in which the talus, owing to the ligamentous insufficiency, has been displaced in valgus position or subluxated in a lateral direction (see Fig. 28). In the latter cases, the distance between the talus and the medial malleolus should, at a comparative examination of the intact ankle, have increased more than 2 to 3 mm; see Fig. 29. In the great majority of the cases there is no displacement of the talus, and therefore the clinical examination must be decisive of the diagnosis, even if a rupture of the deltoid ligament may be suspected of being present when the roent-

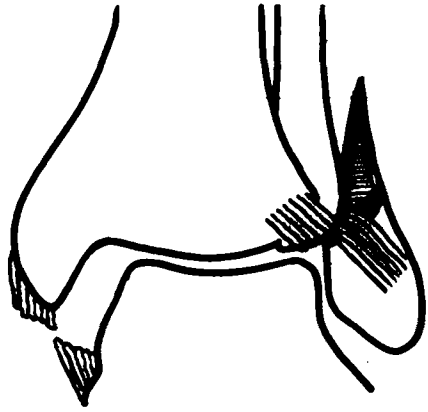


Fig. 28. Stage IV-injury with rupture of the deltoid ligament and lateral luxation of the talus. Fibular portion of the ruptured anterior tibiofibular ligament is trapped in the fibular fracture.

genograms show the presence of a considerable swelling of the soft parts around the medial malleolus. By plain radiography, the distinction of a stage IV-injury from a stage III-injury and in some cases also from a stage II-injury can be very difficult or even impossible. This circumstance has been pointed out earlier by Staples (1960), who emphasizes the importance of clinical examination, and designates the deltoid rupture "the invisible injury". He has accounted for a material involving 110 cases of stage IV-injuries, in which the deltoid rupture has not primarily been diagnosed in 19 cases (17.3 %). Navarre (1962) has also emphasized the importance of the ruptures of the deltoid ligament being diagnosed. The deltoid rupture can also be established by arthrography and stress radiography. Berridge & Bonnin (1944) and Ciccone & Richman (1948) above all recommend stress radiography, at which the ankle is examined with the foot in forced pronation and outward rotation. Kleiger (1956) and Staples (1960) also recommend a stability test, which they perform in lateral and in both anteroposterior and lateral direction, respectively.

3. *Operative examination*

Lauge Hansen (1942) considers the deltoid ligament to rupture with a tearing off of a small bone shell from the medial malleolus. This type of ligamentous rupture has, however, only exceptionally been registered in the present material. Most of the ligamentous ruptures have instead been located in the ligamentous substance and in its proximal part. In not a few cases the rupture has been incomplete, with the posterior portion of the deltoid ligament, i.e., mainly the posterior talotibial part, remaining intact. Observations made, may indicate that the tendon of the posterior tibial muscle has a protective effect on this portion of the ligament, as the incomplete deltoid ruptures have, as a rule, stopped at the anterior part of the tendon.

Fig. 29. Stage IV-injury with rupture of the deltoid ligament. On the frontal view, there is an abnormally large distance between the medial malleolus and the talus, indicating the ligamentous injury. On the 20° inward rotation view and on the lateral view, a fibular avulsion fragment belonging to the anterior tibofibular ligament is clearly visible.

4. Correlation between the frequency of fracture of the medial malleolus and rupture of the deltoid ligament

From what is said above, it is clear that the medial component of the stage IV-injuries in about 75 per cent consists of a fracture through the medial malleolus, and in 25 per cent of a rupture of the deltoid ligament. The sex distribution in the two types of injuries gives much interesting information. Among the women 126 out of 155 (81.3 %) had a fracture, while the corresponding figures for the men were 48 out of 83 (57.8 %). This implies that the women had fracture 4 times more often then they had ligamentous rupture, whereas the men had a fairly even distribution of the two types of injuries. The difference is statistically highly significant. The great difference between the two sexes is certainly due to the presence of an osteoporotic factor involved promoting the occurrence of fracture in women.

C. Frequency, size and displacement of posterior tibial fragments

In 16 (6.7 %) of the 238 stage IV-injuries one was not able roentgenologically to establish a fracture through the posterior part of the tibia. The distribution of sex was even, 9 women and 7 men. 5 of these cases have been explored, at which 2 patients were found to have quite intact dorsal structures and 3 to have incomplete ruptures of the PTFL and the TrTFL. The findings thus verify that the dorsal tibial injury can consist of a ligamentous rupture without the presence of an avulsion fragment. The absence of both dorsal fracture and ligamentous rupture has earlier been reported by Hendelberg (1943). The explanation of this absence may be that the ankle joint is subjected to a combined trauma. Accordingly, an established stage II-injury might, for instance, be subjected to secondary pronation violence causing a medial injury but leaving the dorsal structures uninjured.

The 222 cases in which a posterior tibial fragment has been diagnosed have been grouped in the way stated for the stage III-injuries, and the distribution into these 4 groups can be studied in Table 9. From this table it is clear that there is a predominance of the small fragments. Only 42 instances (18.9 %) have a size exceeding one fourth of the articular surface. The sex distribution is 31 women and 11 men implying a predominance of women.

The tibial fragments have generally been displaced in dorsal and proximal direction, but in a few cases only in dorsal direction. In the luxation-injuries, the displacement of the posterior fragment has in most cases been severe.

Table 9. Size distribution of the posterior tibial fragments of stage IV in women and men.

Group	Women	Men	Total
Sh	28	19	47
1/4	90	43	133
1/3	19	8	27
1/2	12	3	15
Total	149	73	222

D. Luxation injuries

1. *Correlation to sex and age*

Luxation injuries, i.e., stage IV-injuries with dorsolateral dislocation of the talus and the whole foot, have been registered in 97 patients, 64 of whom were women and 33 men. Thus 40.8 per cent of the stage IV-injuries were complicated by luxation, and the women and the men had luxation injuries in about the same proportion, i.e., 41.2 per cent and 40.0 per cent, respectively. With a view to the whole material, the luxation injuries amount to 23.5 per cent, i.e., scarcely one fourth of the total. The medial injury in 75 cases (77.3 %) consisted of a fracture through the medial malleolus. The sex distribution was 57 women and 18 men. Rupture of the deltoid ligament has been registered in 22 patients (22.7 %), comprising 7 women and 15 men. From the figures it is clear that with regard to luxation injuries, it is also applicable that about 75 per cent of the cases have a fracture of the medial malleolus, and about 25 per cent a rupture of the deltoid ligament. While the men have an even distribution with regard to the two injury components the women have a very marked predominance of fracture implying that the osteoporotic factor involved is more pronounced in

Table 10. Sex and age distribution of the patients with luxation injuries.

Age	Women	Men	Total
15—19	3	1	4
20—29	8	4	12
30—39	5	4	9
40—49	11	6	17
50—59	25	7	32
60—69	7	6	13
70—79	5	5	10
Total	64	33	97

the luxation material than in the whole stage IV-material. The difference of sex is statistically highly significant. The men have shown an even distribution in respect to the presence of luxation injuries in different age groups, whereas the women have a maximum in the ages of 40 to 60, see Table 10. 72 of the 97 patients were aged at least 40, implying that in round numbers 75 per cent of the luxation injuries occur at the age of 40 or more. The mean age in the luxation material is 49.1 ± 16.4 years, whereas the mean age of the men is about 2 years higher than that of the women.

2. *Clinical diagnosis*

The clinical symptomatology, as regards the luxation injuries, has been rather uniform. At inspection, one has been able to register diffuse swelling around the ankle, which has been deformed because the talus and the foot have been dislocated in dorsolateral direction. By reason of this the foot has been considerably plantarflexed and the heel proximally displaced. On palpation, the patients have complained of diffuse tenderness over the whole joint, and one has been able to register crepitations, especially over the lateral malleolus. At palpation over the anterior part of the joint, one has been able to feel a decided prominence from the distal part of the tibia. In cases of fracture through the medial malleolus, the proximal tibial fragment has produced a considerable pressure effect on the medial soft parts

Fig. 30. Stage IV. LUX-injury. Severe luxation of the talus and the whole foot in dorsal and lateral direction.

with signs of nutritive disturbances in them. The luxations have sometimes been firmly fixed, in which cases the dorsal dislocation of the talus and the foot has generally been pronounced.

3. *Roentgenological diagnosis*

The roentgenological diagnosis has been easy and has as a rule required frontal and lateral projections only. In the cases which have been examined with remaining luxation of the talus, the joint has as a rule been considerably deranged with dorsal and proximal dislocation of the talus, the posterior tibial fragment, and the malleolar fragments; see roentgenograms, Fig. 30.

4. *Correlation to the size of the posterior tibial fragments*

All the luxation-injuries have been associated with a posterior tibial fragment varying in size. 23 of the 97 luxation-injuries (23.7 %) have had a posterior tibial fragment, the size of which has exceeded one fourth of the articular surface. From this, then, it is clear that there is no established connection between luxation of the talus and large posterior tibial fragments. Of the 23 patients, 17 were women and 6 men, which means a clear predominance of women.

XII *Injuries of the talus*

The occurrence of injuries to the talus in indirect ankle injuries is considered to be rare. Thus Bonnin (1950) considers that the talus, as a rule, is not damaged in SOR-injuries. Changes of osteocondritis dissecans originating from injuries to the lateral corner of the trochlea tali, have been reported in the literature by Ray & Coughlin (1947), Nisbet (1954), Rödén, Tillegård & Unander-Scharin (1954), Mau (1959), and Gschwend (1960). They consider that it is exclusively the lateral changes of the talus that have a traumatic etiology. Ray & Coughlin, however, also describe medial changes of the talus, probably arising from trauma. Weber (1966) has reported both lateral and medial injuries of the talus which appear in supination injuries and supination-outward rotation injuries, respectively. In the present work, injuries to the talus have only exceptionally been registered which, however, in some degree may have been due to the fact that it is only during the last few years that one has begun to look for them systematically. On the lateral side of the trochlea, 2 different types of injuries have been registered, namely, subchondral fractures affecting the ventrolateral corner of the trochlea and a similar injury to the lateral

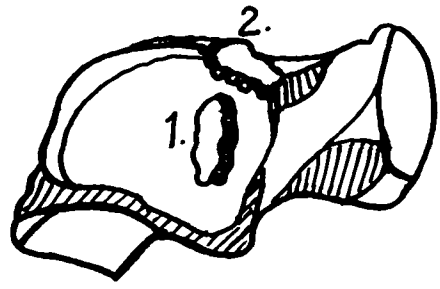
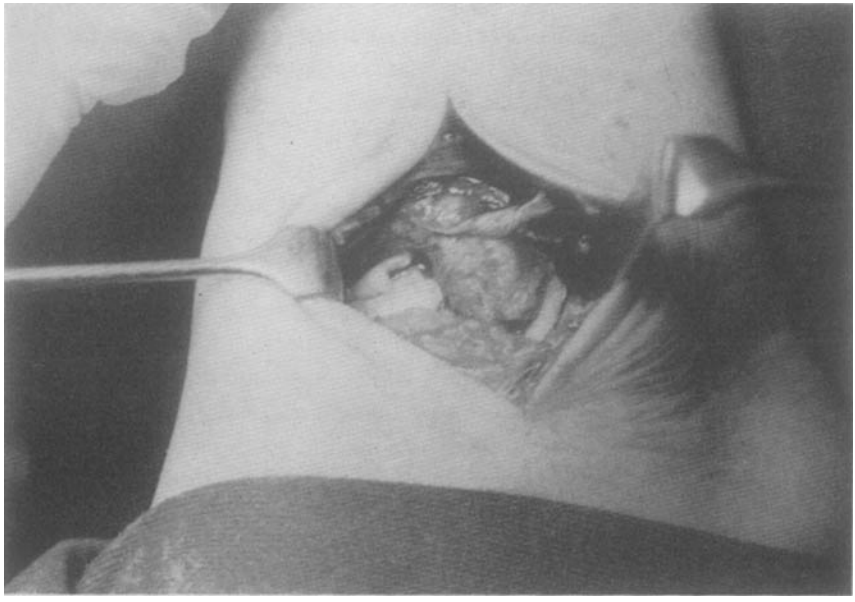


Fig. 31. Subchondral fractures of the lateral part of the talus. 1. Fragment from the lateral articular surface. 2. Fragment from the ventrolateral corner of the trochlea. (For comparison, see Fig. 32 which shows a similar lesion of the ventromedial corner of the trochlea.)



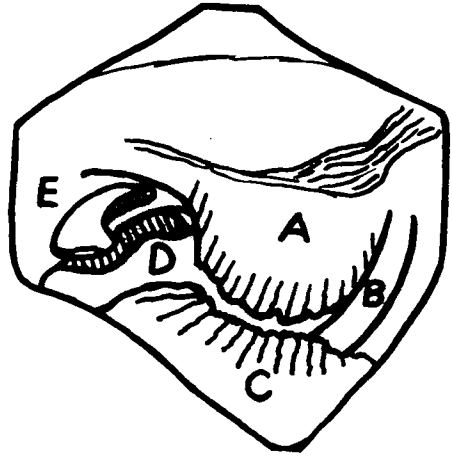


Fig. 32. SOR-injury with rupture of the deltoid ligament (right ankle). A. Medial malleolus and proximal portion of the deltoid ligament. B. Tendon of the posterior tibial muscle. C. Distal portion of the deltoid ligament. D. Capsule rupture and ventromedial part of the trochlea tali. E. Subchondral fracture fragment from the trochlea tali.

articular facet; see Fig. 31. The subchondral fractures which affected the lateral corner of the trochlea had the same location as described by the above-mentioned authors. The injuries which affected the lateral articular facet were located in its anterior part and measured about $2 \times 5 \times 10$ mm in size. The bed of the fragment was always covered with spongy bone. This type of injury is probably caused by a pressure effect from the lateral malleolus when the talus is rotated outwards in the ankle mortise. On the medial side of the trochlea tali, one has registered subchondral fractures of the same type as those affecting the lateral corner. Their appearance can be studied in the operation picture, Fig. 32. The subchondral fractures have not been visible in the roentgenograms. When affecting the corners of the trochlea tali, they have mostly been registered in women with stage IV-injuries.

XIII *Summary*

Clinical, roentgenological and operative examination of 417 supination-outward rotation injuries in adult patients has yielded the following information.

Supination-outward rotation injuries include about 65 per cent of all ankle fractures. They are more common in women than in men, the ratio being 1.5 : 1. In ages above 50 there is a marked predominance of women. Approximately, the injuries consist of 50 per cent stage IV-injuries, 40 per cent stage II-injuries, and 10 per cent stage I and stage III-injuries, with a slight predominance of the last-mentioned. Stage I-injuries affect young patients. The mean age of the patients is higher in stage II than in stage I, and higher in stage IV than in stage II. There is on the other hand, no statistically significant difference between stage II and stage III, or between stage III and stage IV. The higher the patient age, the severer the injury.

The stage I-injury is rare, most of the injuries affecting men, and the rupture of the anterior tibiofibular ligament is usually situated in the ligament itself without an avulsion fragment being present. Isolated rupture of the anterior tibiofibular ligament occurs in the frequency of only 10 per cent in a material of purely ligamentous injuries. In such a material, on the other hand, rupture of the anterior talofibular ligament often in combination with the calcaneofibular ligament has a great predominance. Isolated rupture of the anterior tibiofibular ligament and isolated rupture of the anterior talofibular ligament can be roentgenologically distinguished, as the latter most often shows an incongruity in the joint between the talus and the lateral malleolus.

According to this material, in 96 per cent of patients, distal oblique fibular fractures are combined with total rupture of the anterior tibiofibular ligament, which in the majority of the cases is injured in the ligament proper and accordingly without avulsion fragments from the lateral malleolus or the anterior tibial tubercle being present. In about 4 per cent, distal oblique fibular fractures are not associated with rupture of the anterior tibiofibular ligament, the fractures most often originating distally to the attachment of the ligament in the fibula. The distal fibular fragment is most often displaced in outward rotation and in dorsal, proximal and lateral direction. The fracture allows a subluxation of the talus in lateral direction amounting to 2 to 3 mm at the occurrence of an intact deltoid ligament resulting in incongruity in the joint. The proximal fibular fragment is generally firmly connected with the tibia, but can in partial or total injuries to the interosseous tibiofibular ligament have pathological mobility. The joint capsule is generally completely ruptured in its anterior portion.

Most of the posterior tibial fragments are small, and seldom exceed one fourth of the size of the articular surface, which is applicable to stage III as well as stage IV and stage IV with luxation. The posterior tibial injury can in stage IV-injuries, and probably in stage III-injuries as well, consist of a ligamentous rupture without the presence of an avulsion fragment. Stage IV-injuries with intact dorsal structures can appear, in which cases the stage IV-injury might possibly be caused by an established stage II-injury being subjected to secondary pronation violence causing a medial injury but leaving the dorsal structures uninjured. In stage IV-injuries, fracture through the medial malleolus occurs in about 75 per cent and rupture of the deltoid ligament in about 25 per cent. In luxation injuries there is a similar distribution. Women have a greater predominance of fracture, whereas men have a fairly even distribution between fracture and ligamentous rupture. Only exceptionally, the dorsal tibial fragment can be combined with the dorsal part of the medial malleolus in one large fragment.

About 40 per cent of stage IV-injuries are complicated by luxation of the talus and the whole foot. There is no established correlation between large posterior fragments and luxation of the talus. Subchondral fractures of the talus occur at the medial as well as the lateral corner of the trochlea. On the lateral side, also the articular facet can be the seat of a subchondral fracture, which probably arises by pressure from the distal fibula, when the talus is rotated outwards in the ankle mortise.

Lauge Hansen's stage distribution is on the whole well applicable to the living organism. In all probability, the posterior tibial injury appears in order before the medial one, as, except for quite intact medial structures, stage III-injuries show exactly the same pathologico-anatomical changes as

stage IV-injuries. The most important objection to be raised to Lauge Hansen's work is that he has not, to a sufficient degree, paid attention to the clinical examination of the ankle injuries as a result of which, for instance, stage IV-injuries with medial ligamentous rupture have been erroneously classified as stage II or stage III-injuries. The operative examination in the present material has also shown divergences from Lauge Hansen's views, especially with regard to the frequency and the pathological anatomy of the injuries to the anterior tibiofibular ligament.

PART II

Method of operative reconstruction. Primary clinical and roentgenological results of treatment

XIV *Earlier methods of treatment*

The literature on ankle injuries and their treatment is very comprehensive. Few problems in traumatology would seem to have been subjected to such a great interest and such diverging opinions as the treatment of the ligamentous injuries and fractures of the ankle. A study of the literature shows that the different authors agree that the best results of the treatment of ankle injuries are obtained by careful joint reconstruction, especially as far as the frequency of arthrosis deformans is concerned. As to the methods and means for good joint reconstruction, the opinions of the different authors are widely divergent. Thus many of them consistently employ conservative treatment implying reduction and fixation in plaster, and resort to operation in those cases only where conservative treatment, in spite of repeated attempts, does not result in acceptable fracture position. Some authors consider that some injuries should be primarily operated on, such as displaced large posterior tibial fragments, displaced medial malleolar fragments, and ruptures of the deltoid ligament, but in other cases they recommend conservative treatment. Other authors, again, in every injury, consistently employ operative treatment with reconstruction of all or almost all the injury components, as they consider that conservative treatment does not allow satisfactory joint reconstruction.

An advocate of the conservative treatment of ankle injuries is especially L. Böhler (1957), who considers that an operation should be performed on defined indications only. Other advocates are Lauge Hansen (1942), Kristensen (1949, 1956), Bonnin (1950, 1965), Portis & Mendelsohn (1953), Fackert (1954), Watson-Jones (1955), Jergesen (1959), Kleiger (1961), Bedogni & Bergami (1962), and Frankel, Mc Cue & Humphries (1963).

Among those pleading for primary operation of injuries to the medial malleolus, the deltoid ligament or the posterior tibial process may be mentioned Felsenreich (1936), Andreesen (1938), Müller (1945), McLaughlin & Ryder (1949), Scuderi & Schrey (1950), Sigel (1951), Cox & Laxson

(1952), Torppi (1954), Trojan (1954), Buck-Gramcko (1955), Dziob (1956), and Braunstein & Wade (1959).

Advocates of operative treatment are Lane (1912), Lambotte (1912), Picot (1923), Sprengell (1942), Lee & Horan (1943), Burgess (1944), Danis (1949), Hachez-Leblanc (1950), Hohmann (1950), Palmer (1950, 1962), Desenfans & Evrard (1952), Picaud & Poucel (1952), Reimers (1953), Proctor (1954), Sturzenegger (1954), de Marneffe (1955), Vasli (1957), Devlies (1959), Calvetti (1960), Willenegger (1961), Soeur (1963), Willenegger & Weber (1963), Denham (1964), Goltermann (1964), Burwell & Charnley (1965), Cedell (1965), and Weber (1966). Plaster for external fixation has generally been employed in connection with operative treatment. Early mobilization after operation has, however, been pleaded for by Müller (1945), Danis (1949), Hachez-Leblanc (1950), Rehn (1953), de Marneffe (1955), Vasli (1957), Willenegger & Weber (1963), Denham (1964), Burwell & Charnley (1965), and Weber (1966). Treatment in plaster after initial postoperative exercise treatment has been employed by Hachez-Leblanc, Vasli, and Burwell & Charnley, whereas the other authors have quite given up the treatment in plaster. Lance & Wade (1965) report negative experiences of not using plaster.

At the operative treatment of the supination-outward rotation injuries, one has particularly endeavoured to reconstruct the medial and dorsal injury components, whereas great importance has not been attached to the lateral one. Thus Cox and Laxson (1952) consider that the lateral malleolar fracture never requires operative treatment. During the last few years, however, more and more attention has been paid to the necessity of a careful reconstruction of the distal oblique fibular fracture. As early as 1949 Danis advanced the view that the fibular fracture is the most important component in an ankle injury, which conception is shared by Picaud (1953), Iselin & de Vellis (1961) and also by Weber (1966), who considers that the medial malleolus may just as well be dispensed with, as far as stability is concerned.

In order to achieve exact reduction and retention of bone fragments in ankle injuries a multitude of osteosynthesis devices has been suggested for use. In the treatment of the distal oblique fibular fracture, one has then made use of cerclage (hemicerclage), plate and screws, tibiofibular screw, fibular screw, Rush pin, intramedullary axial nail, and intramedullary axial screw.

Good experiences of cerclage have been reported by Lambotte (1912), Picot (1923), Wahlheim (1937), Sprengell (1942), Danis (1949), Rehn (1953), Reimers (1953), Rudberg (1953), Proctor (1954), de Marneffe (1955), Picaud & Poucel (1957), Bergkvist et al. (1958), Calvetti (1960), Iselin & de Vellis (1961), Willenegger (1961), Cedell & Wiberg (1962),

Palmer (1962), Soeur (1963), and Cedell (1965). Critical views on using cerclage have especially been expressed by Charnley (1957) and Burwell & Charnley (1965). Sturzenegger (1954) has warned against using cerclage in short oblique fractures.

Plate and screws have been used by Lane (1912).

Tibiofibular syndesmosis screw has been used by Lee & Horan (1943), Danis (1949), Palmer (1950), Vasli (1957), Grath (1960), and Klossner (1962). Critical views on screwing of the syndesmosis have been delivered by Bonnin (1950), Sturzenegger (1954), Close (1956), Willenegger (1961), and Weber (1966) who emphasize that it is deleterious to normal joint function.

Fibular screw has been used by Burgess (1944), Hachez-Leblanc (1950), Desenfans & Evrard (1952), Ewer (1956), Devlies (1959), Jergesen (1959), Navarre (1962), Willenegger & Weber (1963), Burwell & Charnley (1965), Lance & Wade (1965), and Weber (1966).

Rush pin has been used by Hohmann (1950), Braunstein & Wade (1959), Palmer (1962), Dinstl & Spängler (1963), and Wilson & Skilbred (1966). Critical views on using Rush pin have been delivered by Cedell & Wiberg (1962), Willenegger & Weber (1963), Burwell & Charnley (1965), and Lance & Wade (1965).

Intramedullary axial nail has been used by Danis (1949), Sturzenegger (1954), Watson-Jones (1955), and Küntscher (1956).

Intramedullary axial screw has been used by McLaughlin & Ryder (1949), Jergesen (1959), and Denham (1964).

For fixation of posterior tibial fragments, screw, Kirschner wire and metal pin have been used.

Screw has been used by Burgess (1944), Hachez-Leblanc (1950), Hohmann (1950), Scuderi & Schrey (1950), Sigel (1951), Reimers (1953), Buck-Gramcko (1955), Vasli (1957), Braunstein & Wade (1959), Devlies (1959), Klossner (1962), Palmer (1962), Dinstl & Spängler (1963), Willenegger & Weber (1963), Burwell & Charnley (1965), Cedell (1965), Lance & Wade (1965), and Weber (1966).

Kirschner wire has been used by Felsenreich (1932), Nyström (1944) and J. Böhler (1955).

Metal pin has been used by Hendelberg (1943).

Several authors, e.g., Cadenat (1922), Duval & Basset (1923), Perthes (1924), v. Brandis (1939), Danis (1949), Picaud & Poucel (1952), Iselin & de Vellis (1961), Cedell (1965), and Lauttamus & Solonen (1965) have reported that posterior tibial fragments can be exactly repositioned if the distal oblique fibular fracture is fixed in its exact position.

Reimers (1953) and Willenegger (1953) warn against osteosynthesis of posterior tibial fragments considering that the operative trauma may in-

volve a greater risk to the joint, than does a remaining slight displacement.

Medial malleolar fractures have been fixed by screw, metal pin, Kirschner wire, wire loop, and hook plate.

Screw has been employed by Andreesen (1938), Burgess (1944), Müller (1945), Hachez-Leblanc (1950), Desenfans & Evrard (1952), Fackert (1954), Proctor (1954), Buck-Gramcko (1955), Braunstein & Wade (1959), Klossner (1962), Dinstl & Spängler (1963), Willenegger & Weber (1963), Denham (1964), Weber (1966), and Wilson & Skilbred (1966).

Metal pin has been employed by Felsenreich (1936), Wahlheim (1937), Strömberg (1939), Palmer (1941), Hohmann (1950), Vasli (1957), and Cedell (1965).

Kirschner wire has been used, among others, by J. Böhler (1955), and Forgon & Berényi (1958), the latter using a compression device in combination.

Wire loop has been employed by Picot (1923), Felsenreich (1936), Torppi (1954), and Klossner (1962).

Hook plate has been used by Zuelzer (1951) and Picaud (1953).

With regard to their treatment, little attention has been paid in the literature to the injuries to the anterior tibiofibular ligament. Magnusson (1944) reports that ATFL-ruptures with defective healing, especially with formation of pseudarthrosis in ATTu-fragments, give rise to discomfort with pain, swelling, and tenderness located in the anterior tibiofibular syndesmosis. He has also emphasized that an insufficiency in the ATFL gives rise to a persistent widening of the anterior part of the ankle mortise which can allow subluxation movements for the talus in lateral direction resulting in reactive changes in the joint cartilage. He considers that he can prove a statistically significant correlation between defectively healed ATFL-ruptures and the occurrence of arthrosis deformans. Only a few authors treating the distal oblique fibular fracture operatively, mention in their works whether the ATFL-rupture is subjected to any kind of measure. Proctor (1954) mentions suture of the ligamentous rupture concerned. Cedell & Wiberg (1962) suggest careful ligamentous reconstruction in stage II-injuries and recommend suture and strengthening of the ligament with a special metal staple. Palmer (1962) considers it advisable to fix ATTu-fragments with pin and to strengthen ATFL-sutures with staple. Denham (1964) and Goltermann (1964) report suturing of ATFL-ruptures. Cedell (1965) recommends careful reconstruction of the ATFL in stage II, III and IV-injuries. Weber (1966) occasionally fixes large ATTu-fragments with a short screw.

The isolated ATFL-rupture (stage I) has been paid attention to by McLaughlin (1959), who describes nipping of the joint capsule in defec-

tively healed ATFL-ruptures resulting in discomfort with pain and swelling. He suggests "herniorrhaphy". Menelaus (1960) gives an account of 3 instances of ATFL-rupture operated on with suture and transsyndesmosis screw. Rose (1962) considers that ATFL-rupture in young people should be operated on. Cedell (1965) recommends ligamentous reconstruction with suture and staple. Decoulx et al. (1966) consider an ATFL-rupture difficult to suture, and therefore stabilize the ligamentous reconstruction with a tibiofibular bolt. Broström (1966) has reported isolated ATFL-ruptures which have been sutured.

Among supination-outward rotation injuries, especially stage III and IV-injuries have been subjected to operative treatment. On the other hand, one has often been less inclined to operate on stage II-injuries, as they have been considered to have a very good prognosis by conservative treatment of the simplest kind. Watson-Jones (1955) maintains that the stage II-injury should be treated conservatively with early mobilization and the simplest fixation possible. He writes about the distal oblique fibular fracture: "It is a spiral fracture at the level of the inferior tibiofibular joint but without injury of the ligaments of the joint and without displacement." Bonnin (1965) holds the same opinion and considers that operation involves a great risk, and that treatment in plaster will only prolong the duration of the troubles caused by the injury. A different opinion is held by Magnusson (1944) who at follow-up examination of stage II-injuries found discomfort in 35 out of 118 patients (30 %) and also arthrosis deformans in the same frequency. 11 of these patients suffered from constant, and the rest from intermittent discomfort with pain and swelling in the ankle. Treatment of the distal oblique fibular fracture of stage II with walking plaster is recommended by Cox & Laxson (1952) and Soeur (1961). Operative treatment has been recommended by Lee & Horan (1943), Ewer (1956), Picaud & Poucel (1957), Cedell & Wiberg (1962), Cedell (1965), and Lauttamus & Solonen (1965). Cedell & Wiberg have particularly emphasized the risk of arthrosis deformans in cases with remaining incongruity in the joint between the talus and the fibula.

XV *Operative method in the present study*

A. General principles

The purpose of the operative treatment is to make a careful reconstruction of ligament and bone injuries in order to eliminate incongruity and dysfunction in the ankle. The lateral injuries have been judged to be obviously

deleterious to normal joint function, and for that reason a great interest has been paid to the treatment of the ATFL-rupture and the distal oblique fibular fracture. The principles of treatment have been a) exploration of the injuries by incisions of optimum length and location, b) employment of an atraumatic technique of operation, c) fixation or strengthening of the reconstructed injuries by means of osteosynthesis devices, strong, lenient to tissue, and but little spacious, and d) employment of plaster for external fixation.

The distal fibular fracture has been fixed with stainless cerclage wire which has enabled reliable retention of the fracture in the exact position. Rupture of the ATFL has been treated with suture or fragment reposition, after which the reconstruction of the ligament has been stabilized with a special metal staple, the shanks of which have been driven into the bone tissue corresponding to the origin and the attachment of the ligament. Large posterior tibial fragments have generally been fixed by screw and medial malleolar fragments usually by metal pin. Rupture of the deltoid ligament has been carefully sutured.

B. Preoperative treatment and time of operation

The ankle injuries have as a rule been treated preoperatively with elastic support and the foot in elevated position. Preoperative plaster has in the course of years been more and more seldom used, since one has observed that it has often promoted the occurrence of skin damages, probably by a combined action of pressure and heat. Luxation injuries have as a rule been repositioned immediately on the patient's arrival at the hospital and without preceding roentgenological examination to prevent the occurrence of nutritive skin disturbances. Those luxation injuries which, for several reasons, could not be treated by emergency operation, were as a rule treated in preoperative plaster, especially cases with unstable fracture position.

221 patients (53.0 %) were operated on within 1 day after admission, and 132 (31.7 %) within 2 to 3 days. Accordingly, in round numbers 85 per cent of the patients were operated on within 3 days. The remaining patients distribute themselves as follows: 39 were operated on within 4 to 7 days, 21 within 8 to 14 days, 3 within 15 to 21 days, and 1 patient after as long as 35 days. Causes which necessitated postponement of the operations for a longer time were: the presence of skin damage, indication for cardiovascular function tests, the occurrence of other simultaneous bodily injuries with higher priority of treatment, and, conservative treatment having for some time taken place at another hospital within the country or abroad.

C. Operative anesthesia, approach and technique

As has earlier been mentioned, the patients have, as a rule, been operated on under spinal anesthesia and in a bloodless field. Elderly patients and patients with a cardiovascular disease have been operated on under general anesthesia, some under local anesthesia. A bloodless field has not been employed in elderly patients, in patients with a peripheral vascular disease or in patients whose skin has not been in satisfactory condition. The lateral side of the ankle has first been explored, which procedure has been found to facilitate the reconstruction of the injury components located on this side. A curved incision across the distal part of the fibula (see Fig. 2) has, therefore, given good access to the distal oblique fibular fracture, the anterior tibiofibular ligament and the ventrolateral part of the joint capsule. The fracture has cautiously been freed from clots and mesenchymal tissue and also interpositioned periosteal or ligamentous tissue, if any. Operative injury to the periosteum has been carefully avoided with a view not to interfere with the healing of the fracture. The distal fibular fragment has been repositioned by application of extension, ventral displacement, and inward rotation to the foot. The position obtained has been secured by cerclage round the fracture. The cerclage has been found to give good fixation, provided the fracture has not been too short or the bone tissue not too osteoporotic, in which cases one has had to resort to another form of osteosynthesis, usually staple. By section of the transverse crural ligament and by medial displacement of the long digital extensor muscle good access to the anterior tibial tubercle was obtained. The ATFL could, in cases with rupture located in the ligament proper, be sutured; but in cases with rupture located in its origin or attachment, it could only be adapted. Ligamentous fragments have been carefully repositioned, after which the ligamentous reconstruction has been secured with a metal staple, which has also contributed to give very firm fixation of the distal oblique fibular fracture. The staple has been inserted with the foot placed in neutral position or in slight dorsiflexion, with a view not to produce too tight an ankle mortise, making normal dorsiflexion impossible. The lateral joint capsule has been sutured. After that, the medial side of the ankle has been explored through a transverse or vertical incision (see Fig. 3). The medial malleolar fracture has cautiously been freed from clots and mesenchymal tissue and also often occurring interposition of fascia, periosteum, or ligamentous tissue, and has then been exactly repositioned at which one has benefited by exposing also the ventral part of the fracture. The fragment has been fixed by metal pin, exceptionally by screw. Ruptures in the different portions of the deltoid ligament have been carefully sutured. By displacement of the tendon of the posterior tibial muscle in dorsal and

distal direction, one has been able to secure good access to the posterior portion of the ligament. Posterior tibial fractures have generally been operated on from the lateral side of the ankle and often with dorsoventral screw. As a rule, it has not been necessary to make a roentgenological examination in connection with operation, since this offers good view of the injuries. Large posterior tibial fragments have, however, as a rule, required roentgenological examination in lateral projections to establish good articular congruity.

D. The metal staple and other fixation devices used

The metal staple for strengthening of the reconstructed anterior tibiofibular ligament and fixation of the distal oblique fibular fracture has been devised at the Department of Orthopaedics, Lund Hospital. It is made of stainless steel and has two shanks of unequal length, the ends sharpened, so as to enable easy insertion into the bone tissue. The distance between the shanks amounts to about 24 mm. The staple has springy properties. If it is subjected to strong pulling violence, a deformation with an increase of the distance between the shanks will easily take place. Concerning its construction, see Fig. 33. Its correct position corresponding to the origin and the attachment of the ATFL is clear from Fig. 34, which shows a skeletal preparation with a staple inserted. The metal staple was in the beginning not used for the syndesmosis but for fixation of the distal oblique

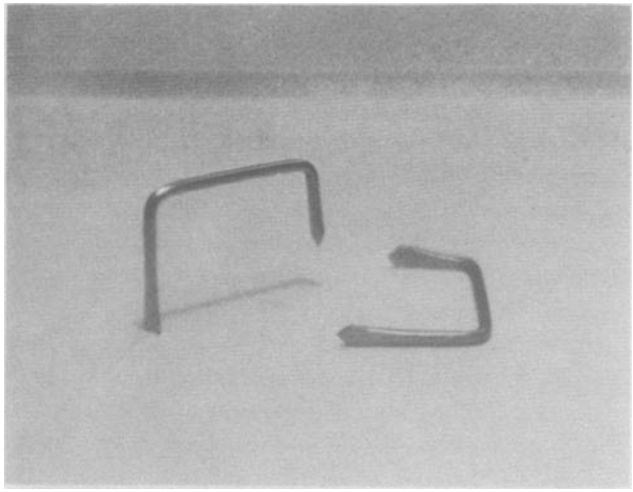


Fig. 33. The syndesmosis staple.

Fig. 34. Skeletal preparation with a syndesmosis staple in the correct position, i. e., corresponding to the origin and insertion of the anterior tibiofibular ligament.

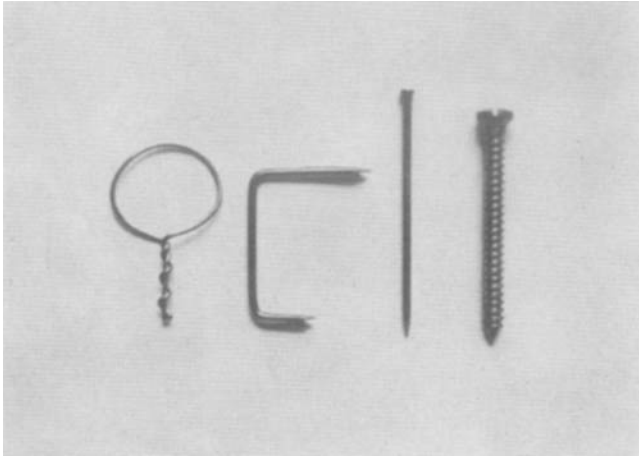
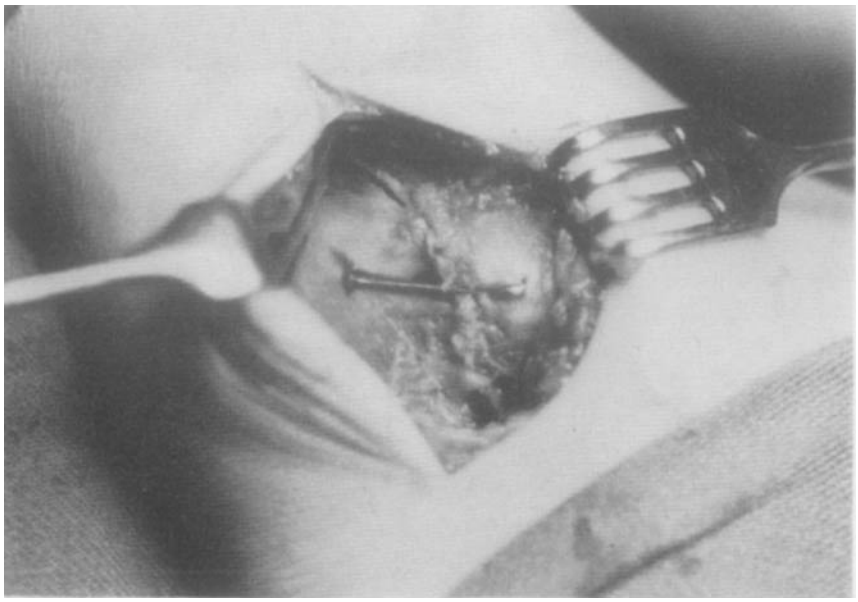


Fig. 35. Fixation devices mostly used in the present material: Cerclage, syndesmosis staple, Palmer pin and vitallium screw.

fibular fracture ("fibular staple"). Then often 2 staples were applied across the fracture positioned about 90° in relation to each other. However, one gradually found that the staple was suitable for strengthening of the anterior syndesmotic ligament ("syndesmosis staple"), particularly in those cases in which the ligamentous reconstruction presented difficulties. In this new position it was also found to be suitable for fixation of the

distal oblique fibular fracture, when the fracture line was short, or when the bone tissue was so osteoporotic that cerclage could not be used.

The metal pins employed for fixation of the medial malleolar fragment have been Rissler pin and Palmer pin. The Rissler pin has in the course of years been abandoned, as it has proved to possess some undesirable properties. Thus it easily breaks small bone fragments, it sometimes slips out and causes a change in the fracture position, and it has not such good metallurgical properties. The Palmer pin has turned out to be more reliable and has only one weak point, namely, too small a head which can cause penetration of the cortical bone and present difficulties at extraction. The



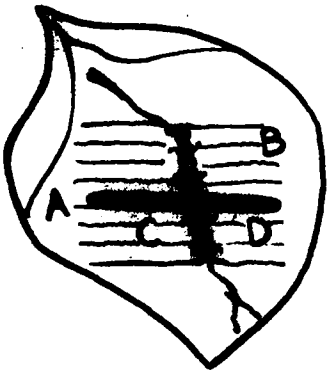


Fig. 36. Reconstructed stage I-injury (left ankle). The anterior tibiofibular ligament is sutured and strengthened by a syndesmosis staple. A. Tibia, B. Fibula, C. Tibial, and D. Fibular portion of the ligament. (Same patient as Fig. 9.)

posterior tibial fragments were in the beginning fixed by wing-screw, but one gradually changed to using a vitallium screw, instead. Fig. 35 shows the 4 types of osteosynthesis devices most often used in the last few years.

XVI *Operative treatment of the different stages of supination-outward rotation injuries*

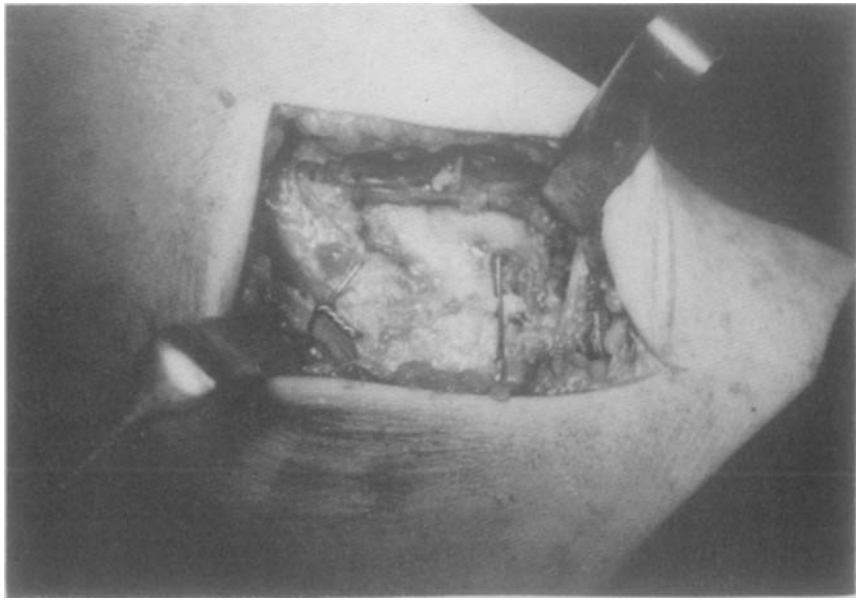
A. Isolated rupture of the anterior tibiofibular ligament (stage I)

The purpose of the operation is to prevent the occurrence of an insufficiency in the anterior portion of the syndesmosis. 7 patients with rupture in the ligament proper have been operated on by suturing of the ligament and strengthening of it with a staple. 4 patients with avulsion fragments from the ATTu have been operated on by reposition of the fragment and fixation of it, in 3 cases by staple and 1 case, a large fragment, by Palmer pin. The Figs. 36 and 37 show a reconstructed stage I-injury, where staple has been used.

Fig. 37. Stage I-injury. The anterior tibiofibular ligament is reconstructed and strengthened by a syndesmosis staple. (Same patient as Fig. 6.)

B. Rupture of the anterior tibiofibular ligament and distal oblique fibular fracture occurring in stage II, III, and IV

The main principle has been exact reduction and fixation of the distal oblique fracture by cerclage. The ruptured ATFL has at the same time been reconstructed by suture or fragment reposition, after which a staple has been applied over the ligament, thus strengthening it and in addition contributing to the fixation of the fibular fracture (see Fig. 38). Short oblique fractures and considerably osteoporotic bone fragments have not been found suitable to be treated by cerclage. In these cases, the ligament has been reconstructed in the usual way and strengthened by staple, after which the fracture has often been fixed with an additional staple applied over the syndesmosis.



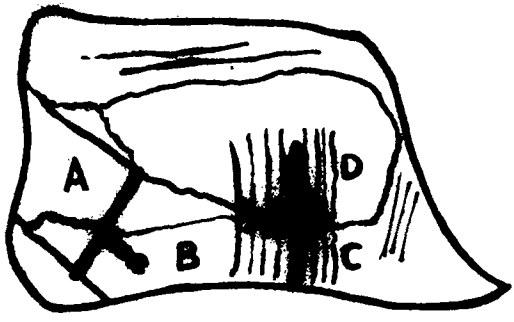


Fig. 38. Reconstructed lateral SOR-injury (right ankle). A. Proximal, and B. Distal fibular fragment. C. Fibular, and D. Tibial portion of the sutured anterior tibiofibular ligament. (Same patient as Fig. 23.)

Table 11. Fixation devices used at the reconstruction of 405 distal oblique fibular fractures.

I.	With syndesmosis staple	329 (81.2 %)
A.	Cerclage+syndesmosis staple	275 (67.9 %)
1.	Cerclage+syndesmosis staple	249
2.	Cerclage+Fibular staple+syndesmosis staple	23
3.	Cerclage+Rush pin+syndesmosis staple	3
B.	Different fixation device+syndesmosis staple *or* syndesmosis staple only	54 (13.3 %)
1.	Syndesmosis staple ×1	18
2.	Syndesmosis staple ×2	26
3.	Fibular staple+syndesmosis staple	7
4.	Rush pin+syndesmosis staple	2
5.	Rissler pin+syndesmosis staple	1
II.	Without syndesmosis staple	76 (18.8 %)
A.	Cerclage	63 (15.6 %)
1.	Cerclage	51
2.	Cerclage+fibular staple	9
3.	Cerclage+Palmer pin	3
B.	Different fixation device	13 (3.2 %)
1.	Fibular staple	13

405 distal oblique fibular fractures have been treated. Table 11 shows how these fractures have been operated on. From the table it is clear that 275 fractures (67.9 %) have been operated on with cerclage and syndesmosis staple, and that 54 fractures (13.3 %) have been operated on with different fixation device and syndesmosis staple *or* syndesmosis staple only. This implies that the syndesmosis staple has been used in a total of 329 cases (81.2 %). The remaining 76 patients have been operated on with osteosynthesis without syndesmosis staple being used. 7 patients in whom the ATFL was uninjured belong to this group.

C. Posterior tibial fragments occurring in stage III and IV

In only 2 of 24 patients with stage III-injury, the posterior tibial fragment has been operated on with osteosynthesis. 1 fragment belonging to group "1/4" was operated on with 1 Rissler pin, and 1 belonging to group "1/3" with 2 Palmer pins. In 15 of 222 patients (6.8 %) with posterior tibial

Fig. 39. Stage IV-injury with a large posterior tibial fragment, fixed by wing-screw.

fracture belonging to stage IV, the fragment was operatively treated (11 women and 4 men). Group "1/3" included 6 and group "1/2" 9 patients. Another 5 cases have been explored for purposes of study in order to find out the position of the posterior fragment after the distal fibular fracture had been fixed. Among the 222 patients only 42 (18.9 %) had a tibial fragment which involved more than one fourth of the articular surface. Of these patients, 15 (35.7 %) were operated on. The main principle has been fixation by screw (see Fig. 39), which has been employed in 8 cases. Of the remaining patients, 3 were operated on with Rissler pin, 1 with staple and 3 with open reduction without fixation.

D. Fracture of the medial malleolus and rupture of the deltoid ligament (Stage IV)

The main principle in the treatment of medial malleolar fractures has been fixation by metal pin (see Fig. 40). 150 out of 174 fractures (86.2 %) were operated on, 148 of which with osteosynthesis, and 2 with open reduction without fixation. The remaining 24 patients were not operatively treated because of the occurrence of nondisplaced fracture through the malleolus or poor skin vitality in combination with good fragment position. Rissler pin has been used in 87 cases, Palmer pin in 35, Rissler pin + Pal-

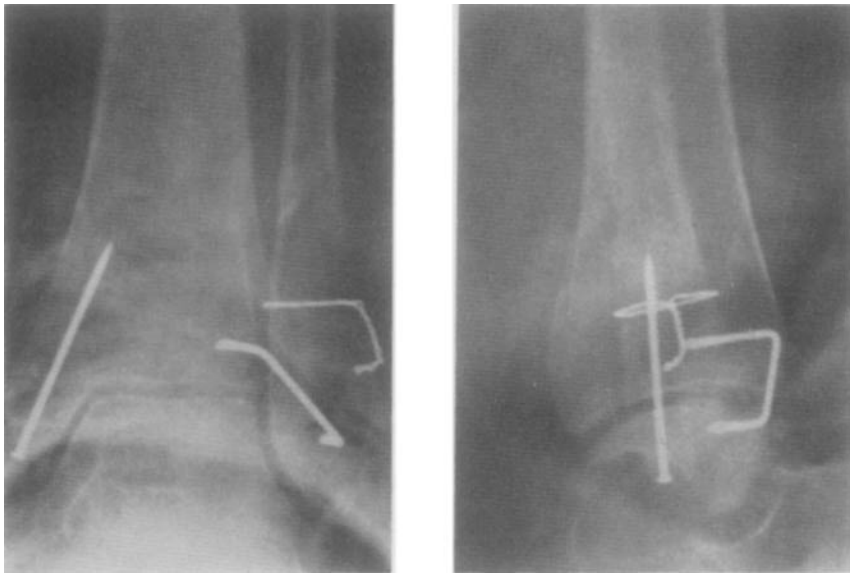


Fig. 40. Stage IV-injury reconstructed with Palmer pin in the medial malleolar fracture. The posterior tibial fragment in the exact position without any special measure of treatment. (Same patient as Fig. 26.)

mer pin in 4, Rissler pin+staple in 2, Palmer pin+staple in 3, screw in 12, and staple alone in 5 cases.

54 deltoid ruptures out of 64 (84.4 %) were operated on with suture. The remaining cases were not operatively treated because of the occurrence of skin damage in combination with a correct position of the talus or small nondisplaced malleolar tip fragments.

XVII *Time of immobilization in plaster*

All patients have immediately postoperatively been supplied with a padded lower leg plaster immobilizing the foot in neutral position in respect to dorsoplantar flexion and also to pronation-supination. Exception has been made for those stage III and IV-injuries with posterior tibial fragments, in which these fragments have not been treated by osteosynthesis. In these cases, the foot has occasionally been immobilized in slight dorsiflexion, with a view to try to achieve better retention of the tibial fragment. The patients have, as a rule, not been allowed to weight-bear in the plaster during the main part of the time of treatment. So-called walking plaster has been

Table 12. Differences between the mean times of immobilization in plaster of patients operated on in 1958—1962 and 1963—1965, respectively. There are highly significant differences between the two groups in injuries of all stages.

Material	Stage	Total	Mean time of immobilization in plaster, in weeks
	II	75	7.7 ± 1.8
1958—1962	III	12	9.8 ± 2.1
(208 patients)	IV	121	9.2 ± 1.9
	II	68	5.7 ± 1.3
1963—1965	III	12	6.0 ± 1.3
(194 patients)	IV	114	8.1 ± 1.6

allowed in about 40 to 50 per cent of the cases during the last 2 to 3 weeks of the time of immobilization. After completed treatment in plaster the patients have been prescribed elastic bandage, movement and walking-exercise, and, in cases of edema and discomfort with swelling and pain, treatment with diuretics and antiphlogistics, respectively.

Stage I-injuries. Of the 11 patients operated on, 5 have been treated in plaster for 5 weeks, 5 in plaster for 6 weeks, and 1 in plaster for 7 weeks.

Stage II-injuries. Of 144 patients operated on, 1 male patient broke off treatment in the course of time in plaster. The mean time of immobilization in plaster for the 143 patients was 6.7 ± 1.9 weeks.

Stage III-injuries. All the 24 patients operated on completed the treatment in plaster. The mean time of immobilization in plaster was 7.9 ± 2.5 weeks.

Stage IV-injuries. 235 out of 238 patients completed treatment. 1 woman died in the course of treatment in plaster of some other disease, 1 woman was an American citizen and continued her treatment in her native country, and 1 man was treated at another hospital, where, in spite of great efforts, his records could not be traced. The mean time of immobilization in plaster for the 235 patients was 8.7 ± 1.2 weeks. No difference between luxation and nonluxation injuries could be registered.

From the above it is clear that the length of time of immobilization in plaster has been directly proportional to the severity of the injuries, i.e., the stage I-injuries have had the shortest and the stage IV-injuries the longest time of immobilization. The length of time in plaster has in the course of years successively become shorter and shorter. This tendency has been most noticeable from the year 1963 onwards. If the material is divided up into two groups, one of which includes patients operated on in the years 1958—1962 and the other including patients operated on in the years

1963—1965, one will find that the mean time of immobilization in plaster has become essentially shorter in the latter group with statistically highly significant difference; see Table 12. The shortening of the time in plaster has, according to experiences made, not yielded poorer results of healing, but has rather facilitated the functional training of the patients.

XVIII *Hospital time and sick-leave*

Hospital time

Only 1 of the 417 patients in the material has been operated on as an outpatient. 195 out of 416 patients (41.7 %) have been treated as inpatients for up to 7 days. Of the remaining patients 173 have been treated as inpatients for 8 to 14 days and 48 for more than 14 days. Long hospital times have been due to multiple injuries, the necessity of preoperative skin treatment or cardiological function test, complications of treatment and, particularly concerning elderly patients, socio-medical factors. The hospital times have in the course of years successively decreased in length, which can be seen in Fig. 41. The cause of this is that the postoperative period through the years has had a more favourable course. It is possible that also

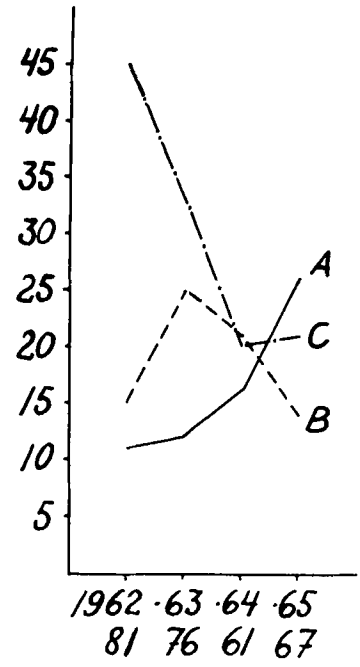


Fig. 41. Diagram showing the continuous reduction of hospital times during the years 1962—1965. Curve A: ≤ 5 days, curve B: 6—7 days and curve C: 8—14 days of treatment in hospital. The vertical figures stand for numbers of patients, the second horizontal line of figures stands for the total amount of supination-outward rotation injuries operated on each year.

the shortage of hospital beds may to some degree have affected the length of the hospital times.

Sick-leave

One has been able to calculate the sick-leave for the patients not belonging to the categories studying people and pensionaries who because of their low level of income are generally not included in the Sick Benefit. 58 such patients embodied in the material have therefore been eliminated. Besides, 4 patients have been disregarded who for reasons earlier mentioned have broken off treatment. One has therefore been able to estimate the sick-leave for a total of 355 patients, for a great many of them by means of records from other hospitals, where the after-treatment has taken place.

Stage I-injuries. 9 patients had a mean sick-leave amounting to 10.1 ± 4.2 weeks.

Stage II-injuries. 119 patients had a mean sick-leave amounting to 13.5 ± 4.0 weeks, of which for women about 2 weeks longer than for men. 3 patients with extreme sick-leave (28, 33, and 36 weeks) have been excluded, because other simultaneous diseases or socio-medical factors for the most part had caused the long sick-leave.

Stage III-injuries. 21 patients had a mean sick-leave amounting to 14.1 ± 5.4 weeks. 3 patients with extreme sick-leave (40, 57, and 63 weeks) have for reasons mentioned above been excluded.

Stage IV-injuries. 198 patients, 80 of whom with luxation injuries, had a mean sick-leave amounting to 20.2 ± 4.2 weeks, of which for women, from 1 to 2 weeks longer than for men. 2 patients with extreme sick-leave (45 and 62 weeks) have been excluded, as the sick-leave, in conformity with above, was not caused by the ankle injury alone.

Table 13. Differences between the mean sick-leaves of patients operated on in 1958—1962 and 1963—1965, respectively. There is a highly significant difference between the two groups in stage II, a significant difference in stage III but no significant difference in stage IV.

Material	Stage	Total	Mean sick-leave in weeks
	II	64	15.3 ± 3.8
1958—1962	III	10	17.3 ± 5.1
(178 patients)	IV	104	21.1 ± 8.3
	II	55	11.4 ± 3.1
1963—1965	III	11	11.2 ± 4.0
(160 patients)	IV	94	19.3 ± 6.8

The sick-leaves have in the course of years successively become shorter. If those patients operated on in the years 1958—1962 and 1963—1965, respectively, are divided up into 2 different groups, one will find that the mean sick-leaves for the stage II- and the stage III-injuries have decreased with statistically highly significant and significant difference, respectively. For the stage IV-injuries, again, there is no statistically significant difference between the mean sick-leave in the two groups; see Table 13.

XIX *Complications of the operative treatment*

A. Survey of the different complications in the present study

The following complications of the operative treatment have been registered.

Wound infection: 11 patients (2.6 %). 9 patients had mild infections and 2 patients infections of medium severity. Osteitis or osteomyelitis developed in none of them. 3 patients had delayed infection with latent periods up to 6 months after operation. 10 patients had their infection located in the lateral wound, and 1 patient had an infection in the lateral as well as the medial wound.

Necrosis of the wound edges: 9 patients (2.2 %). 3 slight and 6 severe instances have been registered, the last-mentioned with the development of slowly healing skin ulcers, from 1×1.5 to 2.5×2.5 cm in size. 6 patients had necrosis in the medial wound, 1 patient in the lateral, and 2 patients in both wounds.

Among the 20 patients who had wound infection or necrosis of the wound edges, 3 suffered from diabetes, and 1 patient from hemiplegia after a cerebral hemorrhage. As a rule, the patients were advanced in age and had severe ankle injuries. Thus 16 patients had stage IV-injuries, 8 of which with luxation. 1 patient had a stage III-injury, 2 patients had a stage II-injury, and one patient a stage I-injury.

Pressure ulcer from the plaster: 3 patients. 1 patient had a slight heel necrosis (a woman aged 72 with a stage IV-injury), 1 patient had an ulcer, 2.5×2.5 cm in size, over the dorsal part of the foot (a woman aged 45 with a stage IV, LUX-injury) and 1 patient had an ulcer, 2×3 cm in size, just below the popliteal space (a woman aged 68 with a stage IV-injury).

Among other complications the following may be mentioned: 1 instance of thrombophlebitis (4 weeks after operation), 2 instances of deep venous thrombosis (3 and 4 weeks, respectively, after operation), 2 instances of

pulmonary embolism (4 weeks and 2 months, respectively, after operation, both nonfatal), 1 instance of pleurisy (3 days after operation), and 1 instance of AP-bleeding (3 weeks after operation, treated at another hospital).

B. Discussion and comparison with earlier investigations

Several authors have emphasized the risks of complications in surgical treatment of ankle injuries. Thus Cave (1965) emphasizes the risks of sepsis, nonunion, malunion, circulatory damage, nerve injury, and soft tissue injury. He warns against operating on patients with diabetes, circulatory insufficiency and poor nutritive condition. He also warns against spacious osteosynthesis devices. Lance & Wade (1965) insist upon restriction when one is going to operate on patients of advanced age, with diabetes, markedly impaired circulation or poor condition of the skin. Stevens (1964) has made an investigation about the occurrence of postoperative infections at orthopaedic operations and has found that the frequency in different investigations varies between 1.7 and 5.4 per cent. His own material comprises 1287 cases, 4.35 per cent of which were complicated by infection. He considers the occurrence of infections to be promoted by a traumatic technique of operation, long times of operation, and an undiscriminating use of antibiotics. He does not find any increased frequency of infection in elderly patients or patients with diabetes. The frequency of complications varies with different authors. Vasli (1957) has reported intra-articular infection in 4 cases (2.2 %), superficial necrosis of the wound edges in 36 cases (19.5 %), osteomyelitis in 1 case, thromboembolism in 1 case, and peroneal nerve paresis due to pressure of the plaster in 2 cases. He employed prophylactic antibiotic therapy in his patients. Klossner (1962) reports infection in 8 per cent, of which 1 osteomyelitis in spite of the fact that most of the patients were given prophylactic treatment with antibiotics. Burwell & Charnley (1965) have reported the following complications in 135 ankle fractures operated on: 8 instances of wound infection (6 %), 2 instances of sepsis, 1 vascular injury resulting in amputation, and 2 instances of fatal pulmonary embolism.

The frequency of complications in this material must be characterized as very low and the complications as mild. All of them have healed and have probably only in a very small degree affected the final outcome, even if they have considerably increased the time of treatment. They have especially affected elderly patients with severe ankle injuries. It is worth noting that no case of established bone infection has been registered in the whole material. The frequency of complication is lower than what has been reported in other investigations.

XX *Primary clinical results. Classification of the patients*

One has been able to estimate the primary clinical result in 413 of the 417 patients operated on. The result is defined as equal to the condition of the patient when he can be discharged from treatment and take up work again. The primary result of the individual patient is often difficult to estimate and must be based on both the patient's subjective symptoms and the examining surgeon's observations at discharge. The primary result is influenced by many factors, especially occupation and social status. Thus many patients can take up work early in spite of some remaining troubles, whereas others must have practically completely recovered from their injury.

In respect to the primary clinical result, the patients have been divided up into 3 groups, namely, "good", "medium", and "poor" results.

A good result indicates that the patient is symptom-free or almost symptom-free, i.e., has remaining slight swelling or very slight pain and tiredness only on exertion, that the range of motion exceeds 50 per cent of normal, and that the capacity for work is normal.

A medium result implies persisting moderate swelling, pain and tiredness on exertion, a range of motion below 50 per cent of normal and on the whole normal capacity for work.

A poor result implies persisting severe discomfort of pain, swelling and stiffness, the occurrence of unilateral limp, deformity or flat-foot and persisting disability with reduced capacity for work.

The classification on the whole agrees with that which Kristensen (1956) employed in his follow-up examinations.

Table 14. Primary clinical results of injuries of stage II, III and IV. Correlation to the year of operation.

Stage and groups		-58-59	-60	-61	-62	-63	-64	-65	Total
II	Good	17	16	13	26	22	21	24	139
	Medium	—	—	1	2	1	—	—	4
	Poor	—	—	—	—	—	—	—	—
III	Good	4	1	1	3	4	3	4	20
	Medium	—	2	—	—	—	—	—	2
	Poor	—	—	1	—	1	—	—	2
IV	Good	15	15	35	42	43	31	35	216
	Medium		4	3	4	2	2		15
	Poor	—	1	1	1	—	—	1	4

The primary clinical result for the different stages was the following:

Stage I: 11 patients. All "good".

Stage II: 143 patients. 139 "good" (97.2 %), and 4 "medium" (2.8 %).

Stage III: 24 patients. 20 "good" (83.4 %), 2 "medium" (8.3 %), and 2 "poor" (8.3 %).

Stage IV: 235 patients. 216 "good" (91.9 %), 15 "medium" (6.4 %), and 4 "poor" (1.7 %). Of these patients 96 had luxation injuries. 84 were "good" (87.5 %), 9 "medium" (9.4 %), and 3 "poor" (3.1 %).

The whole material: 413 patients. 386 "good" (93.4 %), 21 "medium" (5.1 %), and 6 "poor" (1.5 %).

The distribution of "good", "medium", and "poor" results in relation to the year of operation is given in Table 14.

The primary clinical result has not with certainty been influenced by the time elapsed between the accident and the operation. Thus, of 27 patients with "medium" and "poor" clinical results only 5 had been operated on later than 3 days after the accident.

XXI *Primary roentgenological results of reduction*

A. Earlier classifications

From a roentgenological point of view the ankle fractures are in view of treatment usually divided up into 3 different groups, namely, "good", "medium", and "poor" results of reduction. Kristensen (1949) has compiled a scheme in which he gives an account of the size of the fragment-displacements tolerable within the different groups. The scheme has been employed especially in Scandinavian literature and has been modified by Biström (1952), Vasli (1957), Klossner (1962), and others. The differences between these authors' classifications are shown in Table 15. Characteristic of these classifications is the toleration of rather great displacements in the fractures, particularly with regard to the posterior tibial fragments.

B. Classification used in the present study

The author has worked out a classification of his own which demands stricter repositioning of the lateral and medial malleolar fragments and the posterior tibial fragment than that of the above-mentioned authors. The reason for this is that in operative treatment of ankle injuries one should strive for as accurate joint reconstruction as possible. The author's scheme includes 3 groups, namely, "anatomical", "good", and "poor" results of

Table 15. Comparison of the classifications of roentgenological results of reduction used by Kristensen, Biström, Vasli and Klossner.

Bone fragment	Group	Kristensen (1949)	Biström (1952)	Vasli (1957)	Klossner (1962)
Lateral malleolus	Good	No lateral displacement. Dorsal displacement ≤ 2 mm.	No lateral or medial displacement.	Dorsal displacement < 2 mm.	Dorsal, ventral, proximal or distal displacement ≤ 2 mm.
	Medium	Lateral displacement ≤ 2 mm. Dorsal displacement 2—5 mm.	Lateral or medial displacement ≤ 2 mm.	Dorsal displacement 2—5 mm.	Dorsal, ventral, proximal or distal dicplacement 2—5 mm. Widening of the mortise < 2 mm.
	Poor	Lateral displacement > 2 mm. Dorsal displacement > 5 mm.	Lateral or medial displacement > 2 mm.	Dorsal displacement > 5 mm. Lateral displacement.	Displacements and widening of the mortise larger than above. Rotation, angulation or lateral displacement.
Medial malleolus	Good	No lateral displacement. No angulation. Dorsal and ventral displacement and fracture diastasis ≤ 2 mm.	No lateral or medial displacement.	Dorsal and ventral displacement and fracture diastasis < 2 mm.	Dorsal, ventral, proximal or distal dicplacement ≤ 2 mm.
	Medium	Dorsal and ventral displacement and fracture diastasis 2—5 mm. Medial displacement ≤ 2 mm.	Lateral or medial displacement ≤ 2 mm.	Dorsal and ventral displacement and fracture diastasis 2—5 mm.	Dorsal, ventral, proximal or distal displacement 2—5 mm. Widening of the mortise < 2 mm.
	Poor	Displacements larger than above. Lateral displacement. Angulation.	Lateral or medial displacement > 2 mm.	Displacements larger than above. Medial and lateral displacement.	Displacements and widening of the mortise larger than above. Rotation, angulation or lateral displacement.
Posterior tibial margin	Good	Fragment > thin shell: Displacement ≤ 2 mm.	Fragment ≤ 1/4 of the articular surface. Displacement ≤ 2 mm.	Fragment > 1/4 of the articular surface. Proximal displacement < 2 mm.	Fragment ≥ 1/4 of the articular surface. Proximal displacement ≤ 2 mm.
	Medium	Displacement 2—5 mm.	Fragment > 1/4 of the articular surface. Displacement ≤ 2 mm.	Proximal displacement 2—5 mm.	Proximal displacement 2—5 mm.
	Poor	Displacement > 5 mm.	Fragment > 1/4 of the articular surface. Displacement > 2 mm.	Proximal displacement > 5 mm.	Proximal displacement > 5 mm. Displacement of the talus.

Table 16. The author's classification of roentgenological results of reduction.

Component of injury	Anatomical	Good	Poor
Distal fibular fragment	No displacement.	Slight rotation.	Lateral and/or dorso-proximal displacement. Marked rotation. Valgus position.
Medial malleolar fragment	No displacement.	Slight rotation. Dorsal or ventral displacement ≤ 1 mm.	Dorsal or ventral displacement ≥ 1 mm. Lateral or medial displacement. Marked rotation. Valgus position.
Deltoid ligament rupture	No displacement of the talus.	No displacement of the talus.	Lateral displacement or valgus position of the talus.
Posterior tibial fragment	No displacement.	Fragment ≤ 1/4 of the articular surface with proximal and/or dorsal displacement ≤ 2 mm.	Fragment ≤ 1/4 of the articular surface with proximal and/or dorsal displacement > 2 mm. Fragment > 1/4 of the articular surface with proximal and/or dorsal displacement.

reduction, see Table 16. "Anatomical" refers to such a result of reduction, where in the roentgenograms the talus has a correct position in the mortise, and where all the bone fragments seem to have resumed their original position. Small deficiencies in the bone substance due to compression or comminution in the fractures have thereby not been paid regard to. Rotational displacement in the fractures is paid more attention to than in classifications earlier published. By comparison with exactly adequate projections of the uninjured ankle, it has been possible roughly to estimate the size of the rotation of the malleolar fragments. Differences in the reproduction of the joints between the talus and the lateral and the medial malleolus of the two ankles have thereby given the information that the malleolar fragments must have happened to assume a certain rotational displacement. Valgus position in fractures has been registered in frontal projections and implies, according to the definition, a deviation of the distal fracture fragment in lateral direction in regard to the long axis of the bone. If several fracture components are involved in an injury, the worst fracture position has determined the group to which the injury is to be referred. Displacements of the talus have always been registered as "poor" results.

C. Results

The roentgenological result of treatment has been calculated for all the stage I, II, III, and IV-injuries in the material, in all 417 patients. The whole roentgen material for each patient has been carefully studied, and the result of treatment has been estimated on the basis of it. The primary roentgenological result for the different stages was:

Stage I-injuries: 11 patients, all "anatomical". Only 4 of the patients had roentgenological changes preoperatively (ATTu-fragments). The stage I-injuries are therefore of very little interest in this connection.

Stage II-injuries: 144 patients. 123 "anatomical" (85.4 %), 17 "good" (11.8 %), and 4 "poor" (2.8 %).

Stage III-injuries: 24 patients. 18 "anatomical" (75.0 %), 4 "good" (16.7 %), and 2 "poor" (8.3 %).

Stage IV-injuries: 238 patients. 136 "anatomical" (57.2 %), 41 "good" (17.2 %), and 61 "poor" (25.6 %).

All stage II, III, and IV-injuries: 406 patients. 277 "anatomical" (68.2 %), 62 "good" (15.3 %), and 67 "poor" (16.5 %).

If each fracture component is studied separately, the following result will be obtained.

1. *Distal oblique fibular fracture occurring in stage II, III, and IV*

a) *Stage II-injuries:* 144 fractures. 123 "anatomical", 17 "good", and 4 "poor". 17 fractures had a slight outward rotation displacement, and 4 a slight valgus displacement.

b) *Stage III-injuries:* 24 fractures. 20 "anatomical", 2 "good", and 2 "poor". 2 fractures had a slight outward rotation displacement and 2 a slight valgus displacement.

c) *Stage IV-injuries:* 237 fractures (1 fracture not operated on because of the patient's skin damage). 197 "anatomical", 24 "good", and 16 "poor". In the last-mentioned group, 14 had a valgus displacement, and 2 a slight lateral displacement of the distal fracture fragment.

In all, 405 distal oblique fibular fractures have been operated on. The roentgenological result was: 340 "anatomical" (84.0 %), 43 "good" (10.6 %), and 22 "poor" (5.4 %). No pseudarthrosis was registered. 1 delayed union occurred (a woman with a stage II- injury).

2. *Posterior tibial fracture occurring in stage III and IV*

17 patients have been operated on, 14 of whom with osteosynthesis and 3 with open reduction without fixation. The size distribution of the fragments was: group "1/4" 1 patient, group "1/3" 7, and group "1/2" 9 patients. The roentgenological result was: 10 "anatomical" (58.8 %), 1

"good" (5.9 %), and 6 "poor" (35.3 %). The 6 "poor" results included those 3 tibial fragments repositioned without fixation and 3 tibial fragments involving more than one third of the articular surface which healed with 1 mm proximal displacement. If only the 14 cases treated by osteosynthesis are considered, the result is: 10 "anatomical" (71.4 %), 1 "good" (7.1 %), and 3 "poor" (21.5 %).

As has been mentioned earlier, many authors are of opinion that the posterior tibial fragment can generally be repositioned by the distal oblique fibular fracture being fixed in the exact position. In consequence of this, it has been of great interest to evaluate the result of treatment for those posterior tibial fractures not operated on. In all, 229 such cases have been studied, 22 of which were stage III-injuries and 207 stage IV-injuries. The roentgenological result was: 169 "anatomical" (73.8 %), 41 "good" (17.9 %), and 19 "poor" (8.3 %). From this it is clear that more than 90 per cent of the fractures have obtained a satisfactory position. If a similar investigation is made of the tibial fragments involving more than one fourth of the articular surface, i.e., group "1/3" and group "1/2", the result, however, will be different. Of a total of 31 such fragments, 11 (35.5 %) will be "anatomical", 2 (6.5 %) "good", and 18 (58.0 %) "poor", implying that only 42.0 per cent have healed in a satisfactory position. If a comparison is made between the posterior tibial fragments operated on with osteosynthesis and those not operated on, the size of all involving more than one fourth of the articular surface, one will find the following: 9 out of 13 (69.2 %) tibial fragments operated on have obtained an anatomical position, while only 11 out of 31 (35.5 %) tibial fragments not operated on have obtained this result. The difference between the two groups is statistically significant.

3. *Fracture of the medial malleolus and rupture of the deltoid ligament (stage IV)*

150 fractures of the medial malleolus have been operated on, 148 of which with osteosynthesis and 2 with open reduction without fixation. The roentgenological result was: 119 "anatomical" (79.3 %), 3 "good" (2.0 %), and 28 "poor" (18.7 %). The whole material includes 174 medial malleolar fractures, 24 of which have not been operated on because of the occurrence of medial skin damage and nondisplaced fractures. Among the 150 fractures operated on, 1 pseudarthrosis (0.7 %) has been registered. The patient was a man with a fibrous pseudarthrosis causing no discomfort. Among the 24 malleolar fractures not operated on, 2 pseudarthroses (8.2 %) developed which corresponds to the frequency in other conservatively treated materials (Magnusson, 1944, 8.1 %, Kristensen, 1949, 4.7 %, and Biström, 1952, 11.7 %). In this group one has also registered 1 sec-

ondary displacement, i.e., a fragment displaced in the course of treatment. It was a woman aged 80 who had a displacement of the malleolar fragment in valgus direction. Among the 28 patients with "poor" results, there was in 15 a lateral displacement of the medial malleolar fragment (12 patients had a displacement of 1 mm, 2 a displacement of 2 mm, and 1 a displacement of 3 mm). In 13 patients there was a slight valgus position of the medial malleolar fragment.

54 ruptures of the deltoid ligament have been operated on. 10 have not been subjected to reconstruction because of the occurrence of skin damage in combination with a correct position of the talus or small non-displaced tip-fragments from the medial malleolus. 2 of the patients operated on recovered with a slight valgus position of the talus, indicating ligamentous insufficiency. Of the 10 patients not operated on, 1 had a valgus displacement of the talus.

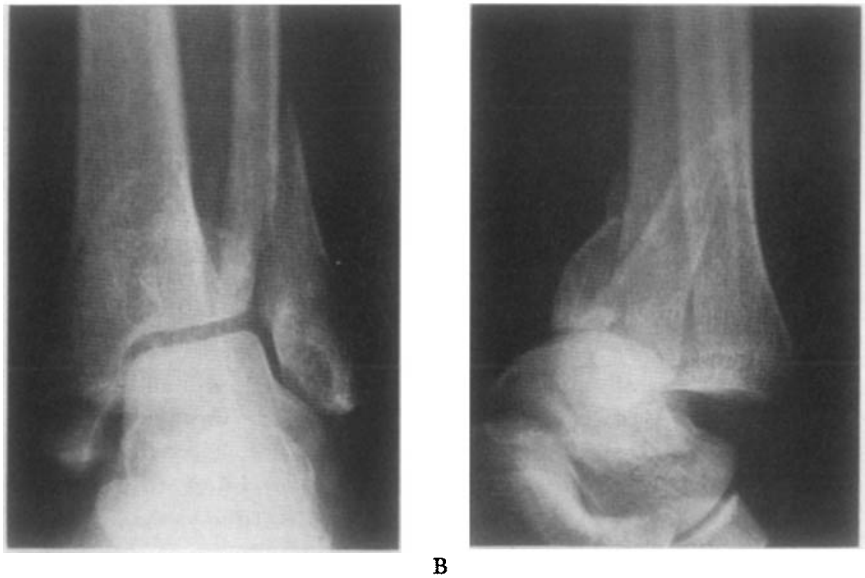
D. Discussion

From what is said above, it is clear that, in supination-outward rotation injuries of stage II, III, and IV, the ankle could be reconstructed anatomically in nearly 70 per cent and satisfactorily in about 15 per cent more. The greater the number of the injury components, the more difficult it has been to perform the reconstruction. Consequently, the stage IV-injuries could be anatomically reconstructed in scarcely 60 per cent, and poor result was obtained in about 25 per cent. If the material is grouped according to Kristensen's scheme instead, considerably better figures will be obtained, namely, 346 "good" (85.2 %), 32 "medium" (7.9 %), and 28 "poor" (6.9 %).

The causes of one's not being able to reconstruct the ankle injuries anatomically in more than scarcely 70 per cent can, of course, be diverse. The factors, above all, playing a rôle are the surgeon's skill and the choice of method of operation and osteosynthesis devices. The first-mentioned would seem to have been the most important factor. The injuries in the material have been operated on by no less than 18 different surgeons, almost all of whom initially had but little experience of the method of operation. Besides, several of them had not had the opportunity of operating on so many injuries as to obtain a good technique. If the patients are divided up into 2 different groups comprising those operated on in the years 1958—1962 and 1963—1965, respectively, one will find throughout, better results of treatment in the last-mentioned group, see Table 17. It should, however, be pointed out that the percentage differences are not statistically significant.

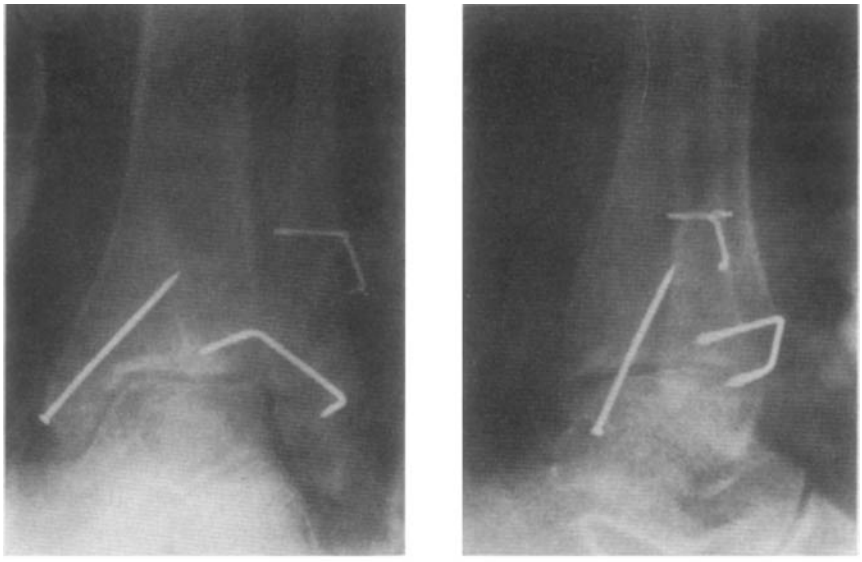
The choice of osteosynthesis devices does not seem to have affected the

A



B

Fig. 42. Woman, aged 51, who sustained an ugly stage IV, LUX-injury in July, 1966 (B). By chance she had an ankle roentgen in 1961, when a rheumatoid arthritis was diagnosed. (A). The patient was operated on with resulting good joint reconstruction (C). At follow-up examination in February, 1967, she was symptomfree and the ankle had, with the exception of a slight irregularity in the posterior part of the tibia, the same roentgenological appearance as before accident (D).



C

D

Table 17. Differences between primary roentgenological results in patients operated on in 1958—1962 and 1963—1965, respectively.

Roentgenological results of reduction	1958—1962	1963—1965
Anatomical	138 (65.4 %)	139 (71.3 %)
Good	30 (14.2 %)	32 (16.4 %)
Poor	43 (20.4 %)	24 (12.3 %)
Total	211 (100.0 %)	195 (100.0 %)

results of treatment negatively. This view is supported by, among other things, the low frequency of secondary displacement and pseudarthrosis. The cerclage has proved to have no deleterious effect on the healing of the fibular fracture. Only one delayed union has been registered. In no case the cerclage has fractured in the course of treatment. The syndesmosis staple has prevented the occurrence of secondary fibular fracture displacement and also the formation of pseudarthrosis in fragments belonging to the ATFL; nor has fracture of the syndesmosis staple in the course of treatment been registered. The Rissler pin has shown some disadvantages, and has, among other things, caused pseudarthrosis in 1 patient by slipping out and causing a diastasis in the malleolar fracture. Neither the Palmer pin nor the vitallium screw has had any established deleterious influence on the healing of the fractures.

XXII *Correlation between primary clinical results and primary roentgenological results of reduction*

To ascertain whether or not there is any correlation betwen the primary clinical results and the primary roentgenological results of reduction, the "good", "medium", and "poor" clinical results among the stage II, III, and IV-injuries in the material have been studied from a roentgenological point of view. Of 375 patients with "good" clinical results, 257 (68.5 %) had "anatomical", 60 (16.0 %) "good", and 58 (15.5 %) "poor" roentgenological results. Of 21 patients with "medium" clinical results, 13 (61.9 %) had "anatomical, 2 (9.5 %) "good", and 6 (28.6 %) "poor" roentgenological results. Of 6 patients with "poor" clinical results, 3 (50.0 %) had "anatomical", and 3 (50.0 %) "poor" roentgenological results.

Of 273 patients with "anatomical" roentgenological results, 257 (94,1 %)

had "good", 13 (4.8 %) "medium", and 3 (1.1 %) "poor" clinical results. Of 62 patients with "good" roentgenological results, 60 (96,8 %) had "good", and 2 (3.2 %) "medium" clinical results. Of 67 patients with "poor" roentgenological results, 58 (86.6 %) had "good", 6 (8.9 %) "medium", and 3 (4.5 %) "poor" clinical results.

The best information is given by the distribution of the "poor" roentgenological results into the different clinical groups. 58 out of 375 patients (15.5 %) with "good" clinical results, 6 out of 21 patients (28.6 %) with "medium" clinical results, and 3 out of 6 patients (50.0 %) with "poor" clinical results thus had "poor" roentgenological results of reduction. The percentage differences are statistically highly significant. There is, therefore, in the material an established correlation between the primary clinical results and the primary roentgenological results of reduction.

XXIII *Summary*

Supination-outward rotation injuries have earlier to a great extent been conservatively treated, i.e., by reduction and fixation in plaster. In the course of years, however, the operative treatment has been more and more employed. The literature on ankle injuries and their treatment is very comprehensive, and the opinions of the different authors often widely diverge as to therapy. The operative treatment of supination-outward rotation injuries has particularly aimed at reconstruction of stage III and IV-injuries, whereas stage II and especially stage I-injuries have been paid little attention to in view of treatment. The literature on the treatment of ruptures of the anterior tibiofibular ligament, both those isolated and those combined with distal oblique fibular fractures, is very rare. While many authors have shown a great interest in the treatment of the distal oblique fibular fracture, they have seldom referred to the rupture of the anterior tibiofibular ligament generally associated with it. The authors who have recommended operative treatment of supination-outward rotation injuries have based their conception on the fact that the best results of treatment will be obtained if the joint is reconstructed as completely as possible. They then emphasize that also very slight displacements in fractures and ligamentous injuries can be deleterious to joint function, and that good joint reconstruction cannot be obtained by closed methods of treatment.

The treatment of the supination-outward rotation injuries in this material aims at careful operative reconstruction of ligament and bone injuries to prevent the occurrence of incongruity and dysfunction in the ankle. Important principles of treatment have been to use an atraumatic technique

of operation, strong osteosynthesis devices, lenient to tissue and but little spacious, and plaster for external fixation. The distal oblique fibular fracture has been fixed by cerclage and a special metal staple, the last-mentioned at the same time stabilizing the reconstructed anterior tibiofibular ligament. Medial malleolar fractures have been fixed with metal pin, and deltoid ruptures have been sutured. Large posterior tibial fragments have been fixed by screw. The following cases have been operatively treated: 11 out of 11 isolated ruptures of the anterior tibiofibular ligament, 405 out of 406 distal oblique fibular fractures, 150 out of 174 medial malleolar fractures, 54 out of 64 deltoid ruptures, and 17 out of 246 posterior tibial fractures.

The length of time of immobilization in plaster has been directly proportional to the severity of the injury, i.e., the stage I-injuries have had the shortest and the stage IV-injuries the longest time of immobilization. The mean time of immobilization in plaster has in the course of years been successively reduced for stage II, III and IV.

Also the length of the sick-leave has been directly proportional to the severity of injuries. The mean sick-leave has in the course of years been reduced for stage II and III, but not for stage IV.

The complications of treatment have been few and of fairly mild nature. Wound infection has been registered in 2.6 per cent and necrosis of the wound edges in 2.2 per cent. Osteitis or osteomyelitis has not occurred. The complications have especially affected elderly patients with severe ankle injuries.

With regard to the primary clinical result, the patients have been divided up into 3 groups, namely, "good", "medium", and "poor" results. For 413 patients the primary result was as follows: 386 (93.4 %) "good", 21 (5.1 %) "medium", and 6 (1.5 %) "poor". The poor results were found among the stage III and IV-injuries.

The patients have in respect to the roentgenological result been divided up into 3 groups, namely "anatomical", "good", and "poor" results of reduction. The author has worked out a stricter classification than any earlier used. Special attention has been paid to the occurrence of rotation displacement of malleolar fragments. For 406 patients with stage II, III, and IV-injuries, the primary roentgenological result of reduction was: 277 (68.2 %) "anatomical", 62 (15.3 %) "good", and 67 (16.5 %) "poor". Of 405 distal oblique fibular fractures, 22 (5.4 %) were "poor". 1 delayed union but no pseudarthrosis was registered. Of 150 medial malleolar fractures, 28 (18.7 %) were "poor". Only 1 pseudarthrosis (0.7 %) was registered. Of 229 nonoperated posterior tibial fragments only 19 (8.3 %) had unsatisfactory position. A closer examination shows that the poor results are applicable to tibial fragments comprising more than one fourth of

the articular surface. Large posterior tibial fragments operated on with osteosynthesis had significantly better position than those not operated on. The figures indicate that posterior tibial fragments comprising less than one fourth of the articular surface do not require any special operative measure and are given a satisfactory position by the distal oblique fibular fracture being repositioned and fixed. There is in the material an established correlation between the primary clinical results and the primary roentgenological results of reduction.

PART III

Late clinical and roentgenological results of operative treatment. Comparison with late results of non-operative treatment

XXIV *Introduction and purpose*

In order to ascertain the late results of the operative treatment of the supination-outward rotation injuries, included in the material, a follow-up examination of the patients operated on in the years 1958—1961 was made. An observation time comprising at least 5 years was chosen because the author wanted to find out whether also slight incongruities and fragment displacements in the ankle could result in the development of symptoms of insufficiency and arthrosis deformans, provided sufficiently long time had elapsed since the injury had healed. An important reason was also that the results of the follow-up examination were to be compared with those which Magnusson (1944) obtained in his material of conservatively treated fractures, where the period of observation totalled 5 to 6 years. In the years 1958—1961 a total of 132 patients were operated on. In all, 100 of them (75.8 %) were subjected to a complete clinical and roentgenological follow-up examination. Of the remaining 32 patients, 7 had died and 4 had moved out of the country or to so distant places in Sweden that one could not expect them to attend the examination. 11 patients could not be found because of incomplete addresses. 10 patients did not submit to a follow-up examination, 5 of them because of illness and 5 for lack of time or interest. Of the 5 patients who could not attend the follow-up examination because of illness, 1 stated that he suffered from a serious somatic disease and was mostly confined to bed. 2 patients stated pronounced nervous symptoms. 1 patient suffered from senile dementia and 1 patient from chronic alcoholism. 11 of the 32 patients not followed up were questioned about the condition of their injured ankle by telephone (10 cases) and by letter (1 case). Of the 7 patients who had died, 4 were women and 3 men. 2 of them died of complications of diabetes, 1 of cerebral hemorrhage, 1 by suicide, while the others died from causes unknown. 5 of these 7 patients were more than 60 years old. 1 patient had a stage II-injury, and 6 patients had stage IV-injuries, 3 of which were luxation injuries.

XXV *Presentation of the follow-up material*

A. Distribution of the patients into sex, age, and stage

The sex and age distribution of the patients in the follow-up material is shown in Fig. 43. The material includes 58 women and 42 men, which means a ratio of 1.4 : 1. The men have a predominance in the age group 25—29 years, and the women in the age group 55—59 years. The stage distribution can be studied in Table 18, from which it is clear that the material includes 38 stage II-injuries (38.0 %), 7 stage III-injuries (7.0 %), and 55 stage IV-injuries (55.0 %). 21 patients (21.0 %), 14

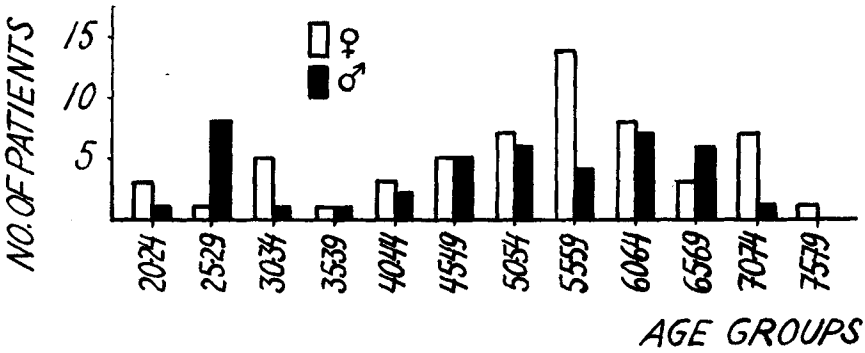


Fig. 43. Sex and age distribution of the patients in the follow-up material.

Table 18. Distribution of the follow-up patients into sex, age and stage.

Age	Stage II		Stage III		Stage IV		Total		Total
	♀	♂	♀	♂	♀	♂	♀	♂	♀+♂
20—24	2	1	—	—	1	—	3	1	4
25—29	1	3	—	1	—	4	1	8	9
30—34	2	—	—	1	3	—	5	1	6
35—39	1	—	—	—	—	1	1	1	2
40—44	1	1	—	—	2	1	3	2	5
45—49	1	3	—	—	4	2	5	5	10
50—54	2	3	1	—	4	3	7	6	13
55—59	3	1	—	2	11	1	14	4	18
60—64	3	4	—	—	5	3	8	7	15
65—69	1	1	—	1	2	4	3	6	9
70—74	3	1	1	—	3	—	7	1	8
75—79	—	—	—	—	1	—	1	—	1
Total	20	18	2	5	36	19	58	42	100
%	38.0		7.0		55.0		100.0		100.0

women and 7 men, had luxation injuries. Stage I-injuries are not included in the material, because no such injuries were registered in the years 1958—1961. The sex distribution is even in stage II, whereas the men have a slight predominance in stage III, and the women a marked predominance in stage IV. The mean age in stage II is 49.9 ± 15.7 years, in stage III 52.3 ± 16.8 years, and in stage IV 53.1 ± 13.2 years, of which for luxation injuries 57.0 ± 10.5 years. The mean age of the whole material is 51.8 ± 14.4 years, of which for women 53.5 ± 14.0 years and for men 49.5 ± 14.9 years.

B. Observation time

The observation time has for no patient been less than 5 years. The mean observation time for the whole material is 5.7 ± 0.6 years, of which for stage II-injuries 5.8 ± 0.7 years, for stage III-injuries 5.8 ± 0.7 years, and for stage IV-injuries 5.6 ± 0.6 years.

C. Comparison with those patients not followed up and with the total material

The sex and stage distribution of the 32 patients not followed up can be studied in Table 19. From this it is clear that the ratio ♀ : ♂ = 1.9 : 1, and that 31.3 per cent are stage II-injuries, 6.2 per cent stage III-injuries, and 62.5 per cent stage IV-injuries. 9 patients (28.1 %) had luxation injuries. The mean age of the patients amounts to 53.3 ± 18.6 years. At a comparison with the 100 patients subjected to follow-up examination, one will find that the differences between the two groups, with respect to the sex distribution and the mean age of the patients, and the degree of severity of the injuries, are not statistically significant. This implies that the 100 follow-up patients well represent all the patients operated on in the years 1958—1961. If the follow-up material is compared with the total material of 417 patients, one will find an equivalent sex distribution and, if the stage I-injuries are grouped together with the stage II-injuries, an almost equal stage distribution (see Table 1). Also the mean age at accident and

Table 19. Sex and stage distribution of 32 patients without follow-up examination.

Sex	Stage II	Stage III	Stage IV	Total
Women	6	2	13	21
Men	4		7	11
Total	10	2	20	32
%	31.3	6.2	62.5	100.0

the frequency of luxation injuries are quite equivalent. The follow-up material is, accordingly, from a statistical point of view representative of the total material, and therefore the results of treatment in the follow-up material must be considered to be roughly applicable also to this material. However, I want to discuss this further in the work.

XXVI *Methods of examination*

A. Clinical examination

In each patient, one has carefully registered subjective symptoms of pain, swelling, stiffness, tiredness, instability or weakness, which symptoms have been correlated to the normal activity and to exertions of different kinds. The patient's ankle has been subjected to a careful clinical examination, at which a comparison with the uninjured ankle has always been made. One has studied the patient's walking capacity, especially in respect to the normal position and movement of the foot and the presence of a limp. One has also registered the presence of edema or local swelling over ligaments or skeletal parts, adjacent to the joint, and the appearance of the operation scars. Ligaments and skeletal parts, adjacent to the joint, have been systematically palpated, and tenderness, if any, has been registered. The malleolar size and the calf size have been measured at corresponding points in both legs. The presence of flat-foot has been registered. The strength of the calf muscles has been roughly tested, among other things, by asking the patient to walk on his toes. One has made a careful measurement of the active and passive range of motion in the talocrural joint as well as in the subtalar joints. Exact measurements of pronation and supination have, however, been difficult to accomplish. The measurements have been performed by means of a goniometer and under standardized conditions.

B. Roentgenological examination

Both ankles have been examined according to a modification of the method reported by Bolin (1961), i.e., the same method given an account of earlier in this work. One has registered the presence of displacements of the talus, malleolar fragments and posterior tibial fragments, pseudarthrosis, ligamentous calcification, bony bridging in the syndesmosis, the condition of the osteosynthesis devices and the occurrence of "reactive" changes in the osseous tissue caused by them, and also arthrosis deformans with reduction of the height of the joint space, changes in the subchondral osseous tissue, and marginal deposits.

XXVII *Classification and presentation of the results of the follow-up examination*

A. Subjective results

The patients have with respect to their subjective symptoms been distributed into 3 groups, namely, "good", "medium", and "poor" results.

A "good" result denotes that the patient is completely symptom-free or has rarely quite negligible symptoms of slight pain, swelling, stiffness or tiredness and then only after extra exertion.

A "medium" result implies moderate symptoms of pain, swelling, stiffness or tiredness after exertion, but no reduced capacity for work and in most cases normal capacity for exercise and sports.

A "poor" result implies severe symptoms of pain, swelling, stiffness or tiredness, expecially on exertion, and, as a rule, reduced capacity for work, necessitating a change from heavy to lighter work. No or but little sporting activity possible.

The distribution of the patients into the different groups can be studied in Table 20. From this it is clear that 88 (88.0 %) patients had "good", 6 (6.0 %) "medium", and 6 (6.0 %) "poor" results. Among the 88 patients with "good" results, 47 were women and 41 men. The 6 patients with "medium" results consisted of 5 women and 1 man. All the 6 patients with "poor" results were women. There is, accordingly, a pronounced female predominance in inferior subjective results of treatment.

The stage II-injuries could be characterized as "good" results in 36 of 38 cases (94.7 %), the stage III-injuries in 6 of 7 cases (85.7 %), and the stage IV-injuries in 46 of 55 cases (83.6 %). "Medium" results occurred in stage II in 1 instance (2.7 %) and in stage IV in 5 instances (9.1 %). "Poor" results were registered in stage II in 1 instance (2.7 %), in stage III in 1 instance (14.3 %), and in stage IV in 4 instances (7.3 %). Stage IV is, accordingly, responsible for 9 of the 12 cases (75.0 %) with "medium" and "poor" results. The patients were completely symptom-free

Table 20. Late subjective results in correlation to sex and stage.

Subjective results	Stage II ♀	Stage II ♂	Stage III ♀	Stage III ♂	Stage IV ♀	Stage IV ♂	Total ♀	Total ♂	Total ♀+♂
Good	18	18	1	5	28	18	47	41	88
Medium	1	—	—	—	4	1	5	1	6
Poor	1	—	1	—	4	—	6	—	6
Total	20	18	2	5	36	19	58	42	100

in 25 of 38 cases (65.7 %) in stage II, in 5 of 7 cases (71.4 %) in stage III, and in 23 of 55 cases (41.8 %) in stage IV, i.e., in 53.0 per cent of the whole material. The percentage difference between stage II and stage IV is here statistically almost significant, while there is no statistical difference between either stage II and III or stage III and IV.

24 of the 88 patients (27.3 %) with "good" results were under 45 years of age. Among the 6 patients with "medium" results, only 1 patient (16.7 %), a woman, was under 45 years of age. Of the 6 female patients with "poor" results, also only 1 patient (16.7 %) was under 45 years of age. The percentage difference is not statistically significant.

Among the 11 patients questioned about the condition of their ankle by telephone or by letter, 8 stated that they had completely recovered, 2 were only slightly and 1 moderately inconvenienced. The 10 patients, 6 women and 4 men, who, therefore, could be registered as "good" results, distributed themselves as follows: 3 stage II-injuries, 1 stage III-injury, and 6 stage IV-injuries, 1 of which was a luxation injury. The patient with a "medium" result was a woman with a luxation injury. Thus, in all, 111 out of 132 patients (84.1 %) could be judged with regard to their subjective symptoms. Of these patients 98 (88.3 %) had "good", 7 (6.3 %) "medium", and 6 (5.4 %) "poor" results.

B. Objective results

In estimating the objective result, one must pay attention to a multitude of factors concerning the appearance and the function of the ankle. To classify patients on the basis of a series of observations made at examination can often be difficult, and the classification will clearly be somewhat artificial. However, the patients have again been divided up into 3 groups, namely, "good", "medium", and "poor" results. The classification used can be studied in Table 21. For each patient 8 different factors have been subjected to special examination. The estimation has been strict in so far that the occurrence of *one* poor quality has resulted in the patient's being classed as a "poor" result.

The objective results of the 100 follow-up patients can be studied in Table 22, from which it is clear that 59 patients (59.0 %) have obtained "good" results, 38 (38.0 %) "medium" results, and 3 (3.0 %) "poor" results. There is among the "good" results an even sex distribution, while the "medium" results occur twice as often in women as in men. The 3 "poor" results all have reference to female patients.

The "good" results occur in stage II in 31 of 38 patients (81.6 %), in stage III in 4 of 7 patients (57.1 %), and in stage IV in 24 of 55 patients (43.6 %), in which, for luxation injuries, in 7 of 21 patients (33.3 %).

Table 21. Classification of late objective results.
(+) and (−) means increase and decrease, respectively.

Components	Good	Medium	Poor
Gait	Normal	Normal	Limp
Malleolar size, (+)	0—1 cm	1—2 cm	> 2 cm
Calf size, (—)	0—1 cm	1—2 cm	> 2 cm
Ligament tenderness	None	Slight	Marked
Dorsoplantar flexion (—)	0—15°	15—30°	> 30°
Pronation-supination (—)	0—10°	10—20°	> 20°
Pes transverso-planus	None	Slight	Marked
Pes plano-valgus	None	Slight	Marked

Table 22. Late objective results in correlation to sex and stage.

Objective results	Stage II ♀	Stage II ♂	Stage III ♀	Stage III ♂	Stage IV ♀	Stage IV ♂	Total ♀	Total ♂	Total ♀+♂
Good	14	17	1	3	15	9	30	29	59
Medium	6	1	1	2	18	10	25	13	38
Poor	—	—	—	—	3	—	3	—	3
Total	20	18	2	5	36	19	58	42	100

"Medium" results occur in stage II in 7 instances (18.4 %), in stage III in 3 instances (42.9 %), and in stage IV in 28 instances (50.9 %), in which, for luxation injuries, in 12 out of 21 patients (57.1 %). The 3 "poor" results all pertained to stage IV-injuries, 2 of which were luxation injuries. The percentage difference between stage II and stage IV is statistically highly significant as regards "good" results, and statistically significant as regards "medium" results.

If the different factors forming the objective results are subjected to a closer study, one will find some observations which can be of interest to note. Slight limp has occurred in 3 patients. An increase of the malleolar size of 0.5 to 2 cm has been registered in 66 patients, 41 women and 25 men, see Table 23. Atrophy of the calf amounting to 0.5 to 2 cm was seen in 36 patients, 26 women and 10 men, see Table 24. Tenderness on palpation corresponding to the ATFL was registered in 9 female patients, 2 of whom with stage II-injuries, and 7 with stage IV-injuries including 3 luxation injuries. Tenderness on palpation corresponding to the deltoid ligament could be demonstrated in 11 patients, 10 women and 1 man, who distributed themselves as follows: 2 stage II-injuries, 1 stage III-injury and 8 stage IV-injuries, 5 of which were luxation injuries. 50 per cent of the

Table 23. Increase of malleolar size. Correlation to sex.

Increase in cm	Women	Men	Total
0.5	9	9	18
1.0	24	10	34
1.5	3	1	4
2.0	5	5	10
Total	41	25	66

Table 24. Decrease of calf size. Correlation to sex.

Decrease in cm	Women	Men	Total
0.5	7	2	9
1.0	14	6	20
1.5	4	2	6
2.0	1	—	1
Total	26	10	36

Table 25. Decrease of range of dorsoplantar flexion. Correlation to stage.

Decrease in degrees	Stage II	Stage III	Stage IV	Total
0	24	3	23	50
0—15	14	4	28	46
15—30	—	—	3	3
>30	—	—	1	1
Total	38	7	55	100

patients had a dorsoplantar flexion range corresponding to that of the uninjured ankle, and 46 patients had a decrease of this range of motion with 15 degrees at the most, see Table 25. 46 patients had a pronation-supination range completely corresponding to that of the uninjured ankle, and 36 patients a decrease of this range of motion with 10 degrees at the most, see Table 26. From the table it is clear that the stage IV-injuries are responsible for the majority of the great restrictions of motion. Unilateral pes transverso-planus could be demonstrated in 5 patients, 2 of whom women with stage IV-injuries, and 3 men, 1 with a stage II-injury and 2 with luxation injuries. On the other hand, no case of unilateral pes plano-valgus could be demonstrated among the 100 patients.

A comparison between the primary and the late clinical results of the patients might be of certain interest. If the follow-up results are classi-

Table 26. Decrease of range of pronation-supination. Correlation to stage.

Decrease in degrees	Stage II	Stage III	Stage IV	Total
0	18	4	24	46
0—10	19	1	16	36
10—20	1	2	15	18
Total	38	7	55	100

fied in the same way as the primary results, one will find that 86 (86.0 %) patients had remained unchanged, 5 (5.0 %) were better, and 9 (9.0 %) had worse results at the follow-up examination. Of 91 patients who primarily had "good" results, 83 (91.2 %) still had "good" results, while 7 (7.7 %) had "medium" results and 1 (1.1 %) a "poor" result. Of 7 patients, who primarily had "medium" results, 1 (14.3 %) still had a "medium" result, while 5 (71.4 %) had "good" results and 1 (14.3 %) a "poor" result. 2 patients who primarily had "poor" results still had "poor" results. Those 5 patients, who had improved from "medium" to "good", all had stage IV, LUX-injuries.

From the figures it is clear that, in the course of years, the clinical results of this material have changed to a slight degree only. The primary results, therefore, can give good information about the future function of the injured ankle of the patients.

C. Roentgenological results

From a roentgenological point of view the follow-up patients, in conformity with the primary material, have been distributed into 3 groups, namely, "anatomical", "good", and "poor" results. The classification is, however, in some respects different, as far as the follow-up material is concerned. When an ankle injury has healed, it is often very difficult to establish and, above all, measure, slight displacements of malleolar fragments. Also displacements in posterior tibial fractures can gradually be levelled and thereby be little conspicuous. For that reason, the classification of late roentgenological results should, according to my opinion, be stricter than the classification of roentgenological results of reduction, as otherwise the follow-up results, at a comparison, will appear to be too good. At the estimation of the late roentgenological results, pseudarthrosis and other deviations from the normal healing must also be considered. For that reason I have made up a different classification for the follow-up results, especially with regard to the medial malleolar fracture and the posterior tibial fracture, for which, at the estimation of the primary results, some slight displacements were

Table 27. Classification of late roentgenological results.

Component of injury	Anatomical	Good	Poor
Distal fibular fragment	No displacement.	Slight rotation.	Lateral and/or dorso-proximal displacement. Marked rotation. Valgus position. Pseudarthrosis.
Medial malleolar fragment	No displacement.	Slight rotation.	Lateral, medial, dorsal or ventral displacement. Marked rotation. Valgus position. Pseudarthrosis.
Deltoid ligament rupture	No displacement of the talus.	No displacement of the talus.	Lateral displacement or valgus position of the talus.
Posterior tibial fragment	No displacement.	Fragment $\leq 1/4$ of the articular surface with proximal displacement ≤ 1 mm.	Fragment $> 1/4$ of the articular surface with proximal displacement. Pseudarthrosis.

Table 28. Late roentgenological results in correlation to sex and stage.

Roentgenological results	Stage II ♀	Stage II ♂	Stage III ♀	Stage III ♂	Stage IV ♀	Stage IV ♂	Total ♀	Total ♂	Total ♀+♂
Anatomical	14	18	1	4	21	10	36	32	68
Good	5	—	—	1	7	6	12	7	19
Poor	1	—	1	—	8	3	10	3	13
Total	20	18	2	5	36	19	58	42	100

accepted as "good" results. The classification can be studied in Table 27. For comparison, see Classification of roentgenological results of reduction, Table 16.

The result of the roentgenological follow-up examination can be studied in Table 28. From this it is clear that 68 patients (68.0 %) have "anatomical" results, 19 (19.0 %) "good" results, and 13 (13.0 %) "poor" results. While the sex distribution is even among the "good" results, the women have a slight and a considerable predominance, respectively, among the "medium" and the "poor" results.

The stage II-injuries could be recorded as "anatomical" results in 32 of

38 cases (84.2 %), the stage III-injuries in 5 of 7 cases (71.4 %), and the stage IV-injuries in 31 of 55 cases (56.4 %). "Good" results occurred in stage II in 5 cases (13.1 %), in stage III in 1 case (14.3 %), and in stage IV in 13 cases (23.6 %). "Poor" results could be registered in stage II in 1 case (2.6 %), in stage III in 1 case (14.3 %), and in stage IV in 11 cases (20.0 %). Accordingly, 11 of the 13 "poor" results (84.6 %) pertain to stage IV-injuries. The percentage difference between stage II and stage IV is for "anatomical" results statistically significant and for "poor" results almost significant, whereas the remaining percentage differences are not statistically significant. Accordingly, the "anatomical" results are to be found especially among the stage II-injuries, which was also the case with the subjective and the objective "good" results.

There is a good accordance between the follow-up material and the total material with regard to the percentage distribution of the different result groups. Thus, the total material had "anatomical" results of reduction in 68.2 per cent, "good" results of reduction in 15.3 per cent, and "poor" results of reduction in 16.5 per cent.

In the follow-up material no pseudarthrosis could be established. Extraction of osteosynthesis devices was carried out in 44 patients distributing themselves among 14 stage II-injuries, 2 stage III-injuries, and 28 stage IV-injuries. 4 out of 20 syndesmosis staples left in position proved to be fractured, 1 in the tibial and 3 in the fibular shank. Fracture of cerclage, metal pin or screw, left in position, could not be established and nor the presence of "reactive" changes in the osseous tissue around them, neither. Bony bridging in the syndesmosis was registered in 3 patients with stage IV-injuries. 5 patients had calcifications in the syndesmosis, 2 with stage II-injuries, 1 with a stage III-injury, and 2 with stage IV-injuries. 4 patients with stage IV-injuries had calcifications corresponding to the deltoid ligament. 12 patients, 5 of whom had been operated on with syndesmosis staple, had rather small contour-changes in the ATTu or in the anterior margin of the lateral malleolus.

XXVIII *Correlation between subjective, objective, and roentgenological results*

A good accordance between the subjective, the objective, and the roentgenological results in a follow-up material including conservatively as well as operatively treated ankle injuries has previously been reported by Kristensen (1949, 1956), Biström (1952), Vasli (1957), Klossner (1962), Stö-

Table 29. Correlation between late subjective and objective results.

	Objective results			
Subjective results	Good	Medium	Poor	Total
Good	59	29	—	88
Medium	—	6	—	6
Poor	—	3	3	6
Total	59	38	3	100

ren (1964), Burwell & Charnley (1965), Weber (1966), and others. It has therefore been of interest to investigate whether the same observations could be made in the present follow-up material.

A. Subjective and objective results

The correlation between subjective and objective results can be studied in Table 29. Of 88 patients with "good" subjective results, 59 (67.1 %) had "good" objective results, while 29 (32.9 %) had "medium" objective results. 6 patients with "medium" subjective results had also, all of them, "medium" objective results. Of 6 patients with "poor" subjective results, 3 had "medium" and 3 "poor" objective results.

59 patients with "good" objective results had also, all of them, "good" subjective results. Of 38 patients with "medium" objective results, 29 (76.3 %) had "good", 6 (15.8 %) "medium", and 3 (7.9 %) "poor" subjective results. 3 patients with "poor" objective results had also, all of them, "poor" subjective results.

From the figures it is clear that there is a very good accordance between the subjective and the objective results in the material.

B. Subjective and roentgenological results

The correlation between subjective and roentgenological results can be studied in Table 30. From this it is clear that of 88 patients with "good" subjective results, 63 (71.6 %) had "anatomical, 17 (19.3 %) "good", and 8 (9.1 %) "poor" roentgenological results. Of 6 patients with "medium" subjective results, 3 had "anatomical", 1 "good", and 2 "poor" roentgenological results. Of 6 patients with "poor" subjective results, 2 had "anatomical", 1 "good", and 3 "poor" roentgenological results.

Of 68 patients with "anatomical" roentgenological results, 63 (92.6 %) had "good", 3 (4.5 %) "medium", and 2 (2.9 %) "poor" subjective re-

Table 30. Correlation between late subjective and roentgenological results.

Subjective results	Roentgenological results			
	Anatomical	Good	Poor	Total
Good	63	17	8	88
Medium	3	1	2	6
Poor	2	1	3	6
Total	68	19	13	100

sults. Of 19 patients with "good" roentgenological results, 17 (89.4 %) had "good", 1 (5.3 %) "medium", and 1 (5.3 %) "poor" subjective results. Of 13 patients with "poor" roentgenological results, 8 (61.5 %) had "good", 2 (15.4 %) "medium", and 3 (23.1 %) "poor" subjective results.

The figures indicate that there is a very good accordance also between the subjective and the roentgenological results in the material.

C. Objective and roentgenological results

The correlation between objective and roentgenological results can be studied in Table 31. Of 59 patients with "good" objective results, 48 (81.4 %) had "anatomical", 8 (13.5 %) "good", and 3 (5.1 %) "poor" roentgenological results. Of 38 patients with "medium" objective results, 19 (50.0 %) had "anatomical", 10 (26.3 %) "good", and 9 (23.7 %) "poor" roentgenological results. Of 3 patients with "poor" objective results, 1 had "anatomical", 1 "good", and 1 "poor" roentgenological result.

Of 68 patients with "anatomical" roentgenological results, 48 (70.6 %) had "good", 19 (27.9 %) "medium", and 1 (1.5 %) "poor" objective results. Of 19 patients with "good" roentgenological results, 8 (42.1 %) had "good", 10 (52.6 %) "medium", and 1 (5.3 %) "poor" objective results.

Table 31. Correlation between late objective and roentgenological results.

Objective results	Roentgenological results			
	Anatomical	Good	Poor	Total
Good	48	8	3	59
Medium	19	10	9	38
Poor	1	1	1	3
Total	68	19	13	100

Of 13 patients with "poor" roentgenological results, 3 (23.1 %) had "good", 9 (69.2 %) "medium", and 1 (7.7 %) "poor" objective results.

These is accordingly in the material a good accordance between the objective and the roentgenological results.

XXIX *Post-traumatic arthrosis deformans of the ankle*

The frequency of post-traumatic arthrosis deformans usually holds an advanced position in the estimation of the results of treatment of ankle injuries. The frequency as well as the severity of arthrosis deformans varies considerably in different materials, because of different selections of patients, different methods of treatment, and different estimations made by different examiners. In most cases these factors make a comparison between the results of treatment in different clinical materials impossible.

In the roentgenograms arthrosis deformans of the ankle is characterized by a reduction of the height of the joint space, unevennesses in the articular surface, sclerosis and thinning-cysts in the subchondral osseous tissue, and marginal deposits arising from enchondral ossification.

The pathological anatomy of the post-traumatic arthrosis deformans of the ankle has been described by Hohmann (1929), Bergstrand (1944), and others.

As regards the etiology of the post-traumatic arthrosis deformans of the ankle, Beck (1930) emphasized the importance of preventing the occurrence of joint incongruity, as it can give rise to a state of irritation resulting in arthrosis deformans. Felsenreich (1937) considers mechanical injuries to the joint cartilage, nutritive disturbances in the joint cartilage, traumatically based joint incongruities, and disturbances in the cerebrospinal and autonomic innervation of the joint to be of importance for the development of arthrosis deformans. He particularly emphasizes the importance of nonunion in ruptures of the deltoid ligament and fractures of the medial malleolus which results in valgus position of the talus with increased strain on the joint cartilage between the talus and the fibula. He also emphasizes that especially elderly people run the risk of sustaining nutritive disturbances in the joint cartilage. Finally he considers step formation in the articular surface of the tibia, faulty weight-bearing and primary mechanical cartilage injuries to be a common combination of causes of the development of arthrosis deformans after ankle injuries. Lewis & Graham (1940) consider "loss of the continuity of the weight-bearing surface of the tibia, widening of the joint mortise, and alteration of the weight-bearing planes" to be the etiology of arthrosis deformans of the ankle. Bergstrand (1944)

considers not only cartilage injuries but also functional strain on this injured cartilage to be necessary for the development of arthrosis deformans on the whole. Palmer (1941, 1944) considers arthrosis deformans of the ankle to arise by articular dysfunction, e. g. incongruity between the articular components, faulty weight-bearing and changed sliding after ligamentous injuries. He considers that the ankle, as regards function, is perhaps the most sensitive joint of the body, and that the talus must have the correct position in the mortise after fractures as well as ligamentous injuries, at which also slight displacements of fragments and slight widening of the mortise cause incongruities. Magnusson (1944) is of opinion that persisting widening of the anterior tibiofibular syndesmosis occurring in defectively healed ATFL-injuries allows subluxation movements for the talus resulting in reactive articular changes. By cadaver experiments, Breitenfelder (1957) has shown that a 2 to 3 mm dorsal displacement of the distal fibular fragment rotates the vertical axis of the talus about 10 degrees outwards, resulting in alteration of the weight-bearing planes of the ankle. By similar investigations, Willenegger (1963) has been able to prove that slight displacements of the talus in the mortise, e.g., a 2 mm linear lateral displacement and a displacement of the vertical axis of the talus in 2 to 4 degrees outward rotation, will result in a considerably reduced surface of contact between the tibia and the talus. The increased strain on the joint cartilage in this surface of contact can successively lead to the development of arthrosis deformans.

It has often been emphasized that certain injury components have a more potentially deleterious influence on ankle function than others. Thus Hendelberg (1943) has emphasized the rôle played by the posterior tibial fragment and considers that large fragments involve a greater risk of arthrosis deformans than small ones. Most of the authors have correlated the occurrence of arthrosis deformans to displacements in fractures through the medial malleolus and the posterior tibial process, while it has generally been considered that there is no correlation between arthrosis deformans and displacements in distal oblique fibular fractures. Thus Kett, Aichner & Wesseli (1965) consider that the lateral malleolar fracture does not require anatomical reduction.

Among the authors who have reported a clear relationship between the roentgenological result of reduction and the frequency of arthrosis deformans, may be mentioned Kristensen (1949, 1956), Biström (1952), Vasli (1957), Willenegger (1961), Klossner (1962), Navarre (1962), Burwell & Charnley (1965), Willenegger & Weber (1963), and Weber (1966).

Some authors, for instance, Cox and Laxson (1952), have emphasized the great importance of nutritive injuries for the occurrence of arthrosis deformans of the ankle.

As to the beginning of the post-traumatic arthrosis of the ankle, there are various opinions. Lange (1933) has described cases in which arthrosis deformans made its appearance 2 to 3 years after the time of accident. Felsenreich (1937) is of opinion that arthrosis deformans can be seen in the roentgenograms 1 to 2 years after injury. Hendelberg (1943) considers arthrosis deformans to appear after 3 years at the earliest. Trojan (1954) has reported cases in which arthrosis deformans has not begun until 10 years and more after injury, whereas Klossner found the same frequency of arthrosis deformans in patients who were examined 3 and 7 years, respectively, after their injury. Willenegger (1961) considers that, in patients with poor result of treatment, signs of arthrosis deformans can be seen as early as 1 1/2 years after injury. Weber (1966) has reported that he has already found early signs of arthrosis deformans in SOR-injuries after 1 year's time of observation.

The frequency of post-traumatic arthrosis deformans of the ankle is probably influenced by several different factors, e.g. the patient's sex and age and the type and severity of the ankle injury. Lewis & Graham (1940) have published a material comprising 18 patients in whom severe arthrosis deformans had developed after conservative treatment of fractures. 12 of these patients were women and 14 of them aged between 35 and 56. 12 patients had so-called trimalleolar fractures. Magnusson (1944) considers advanced age to promote the occurrence of arthrosis deformans of the ankle. Biström (1952) found that women in middle life suffer changes of arthrosis deformans more often than others, an observation also made by Klossner (1962), who, moreover, observed that the frequency of arthrosis deformans increased with severe injuries. Contradictory opinions have been expressed by Kristensen (1956) and Burwell & Charnley (1965) who consider that the patient's age and the severity of the injury, contrary to the result of reduction, do not affect the endresult.

The connection between arthrosis deformans and subjective symptoms has not been quite established. Magnusson (1944) is of opinion that there is no clear connection between the two factors. Vasli (1957), Frankel, McCue & Humphries (1963), and Stören (1964) also hold the same view. Hendelberg (1943) asserts positively that pronounced functional discomfort is accompanied by pronounced arthrosis deformans and vice versa. Willenegger (1961) considers a connection to exist but that arthrosis deformans in spite of early beginning, involves relatively late subjective discomfort for the patient. Klossner (1962) is of opinion that mild arthrosis deformans does not affect the subjective symptoms of the patient, whereas marked arthrosis deformans always involves severe subjective symptoms.

XXX *Arthrosis deformans occurring in the present follow-up material*

A. Classification

Magnusson's classification (1944) has been used in graduating the changes of arthrosis deformans of the ankle. Thus 4 degrees have been used, namely, (+), +, ++, and +++, see Table 32.

B. Frequency and correlation to sex, age and stage

Arthrosis deformans was registered in a total of 23 patients, 17 women and 6 men, implying a predominance of the first-mentioned. The changes were moderately pronounced, and the distribution among the 4 different degrees was 13, 8, 1, and 1, respectively. Accordingly, pronounced arthrosis deformans had developed in only 2 patients. Only 2 of the 23 patients (1 woman and 1 man) with arthrosis deformans were under 40 years of age. The mean age of the women was 50.5 ± 7.1 years and that of the men 48.5 ± 14.8 years. The differences of age are not statistically significant. A 55-year old woman with a stage II-injury had arthrosis deformans of degree (+), and a 48-year old woman with a stage III-injury arthrosis deformans of degree +. The remaining 21 patients had stage IV-injuries, 13 of which were luxation injuries. Concerning the sex distribution of these patients and the distribution of the changes of arthrosis deformans in respect to severity, see Table 33.

Thus the frequency of arthrosis deformans for stage II is 1/38 (2.6 %) for stage III 1/7 (14.3 %), for stage IV 8/34 (23.5 %), and for stage IV, LUX 13/21 (61.9 %). In stage IV, 15 out of 36 women (41.7 %) and 6 out of 19 men (31.6 %) had arthrosis deformans. In stage IV, LUX, 10

Table 32. Classification of arthrosis deformans according to Magnusson.

Degree	Roentgenological changes in the joint
(+)	Slight reduction of the joint space and slight formation of deposits on the joint margins.
+	More pronounced changes than mentioned above, possibly with the addition of a sclerotic configuration within the subchondral osseous tissue of the tibia.
++	The joint space only about half as high as that of the uninjured side and rather pronounced formation of deposits.
+++	The joint space has quite or almost disappeared.

Table 33. Degree distribution of arthrosis deformans in women and men in stage IV and stage IV, LUX.

Degree of arthrosis deformans	Stage IV ♀	♂	Stage IV, LUX ♀	♂	Total ♀	♂
(+)	1	3	7	1	8	4
+	2	—	3	2	5	2
++	1	—	—	—	1	—
+++	1	—	—	—	1	—
Total	5	3	10	3	15	6

out of 14 women (71.4 %) and 3 out of 7 men (42.9 %) had arthrosis deformans. There is, accordingly, in stage IV a greater percentage frequency of arthrosis deformans in women, but the difference of sex is not statistically significant. It has been difficult to determine the time of the beginning of arthrosis deformans. In patients with luxation injuries, one has in some cases been able to demonstrate arthrosis deformans roentgenologically from 1 1/2 to 2 years after injury.

C. Correlation to body-weight and occupation

Of the 23 patients with arthrosis deformans 4 women were moderately overweight, 2 with arthrosis deformans of degree (+) and 2 of degree +. 1 man with arthrosis deformans of degree (+) was considerably overweight. In all, overweight was proved in only 5 of 23 patients, and therefore there is in this material no established correlation between overweight and arthrosis deformans.

In order to ascertain whether the patients with arthrosis deformans had averagely heavier work than the other patients, their working conditions were carefully studied. Then 5 women turned out to be employed in work requiring much standing and walking and often heavy lifting. Their occupations were shop-assistant, bathing-woman, ironing-woman, auxillary-nurse, and gardener. The same working conditions were established in 3 men, whose occupations were store-man, farmer and gardener. Thus only 8 of 23 patients with arthrosis deformans were employed in work heavier than that of the average. Of the 5 above-mentioned women, however, 4 had "poor" subjective results, 3 "poor" objective results, and 3 "poor" roentgenological results which may possibly be indicative of the presence of a certain connection between the kind of work and the result of treatment and also the frequency of arthrosis deformans.

XXXI *Correlation between subjective results, roentgenological results and arthrosis deformans*

The connection between subjective symptoms and arthrosis deformans and between the roentgenological result of treatment and arthrosis deformans is of great clinical interest. As has previously been mentioned, the opinions are divergent as to the connection between subjective symptoms and arthrosis deformans, whereas it is generally considered that good roentgenological results are characterized by low frequency of arthrosis deformans. It has for this reason been of interest to investigate, whether there is any connection between the components mentioned in this material. To avoid misunderstanding, I want to point out here that the roentgenological result, according to its definition, only has relevance to the reconstruction of the different injury components and, therefore, has no reference at all to the occurrence of arthrosis deformans.

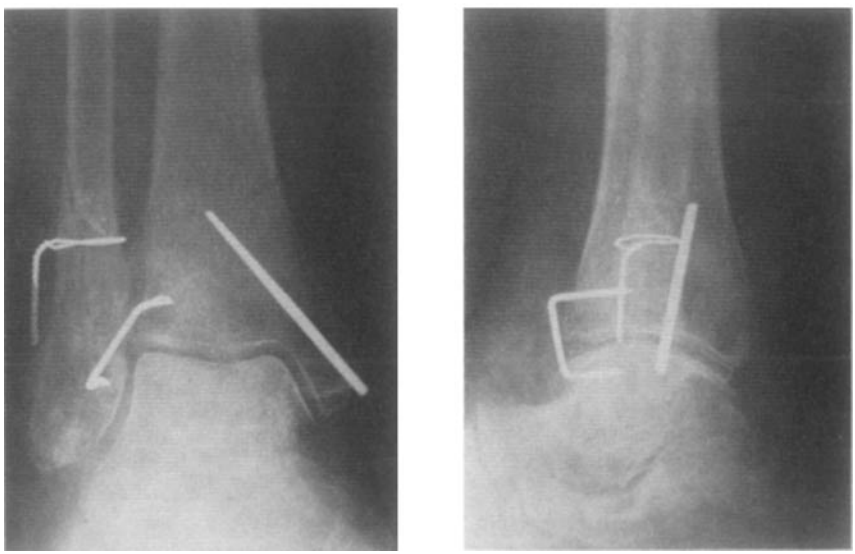
A. Subjective results and arthrosis deformans

The correlation between the subjective results in women and men and the degree of arthrosis deformans can be studied in Table 34. 15 of the 23 patients with arthrosis deformans (65.2 %) had "good" subjective results, 3 (13.1 %) had "medium" subjective results, and 5 (21.7 %) "poor" subjective results. In view of the whole material, arthrosis deformans could be established in 15 out of 88 patients (17.0 %) with "good" subjective results, in 3 out of 6 patients (50.0 %) with "medium" subjective results, and in 5 out of 6 patients (83.3 %) with "poor" subjective results. The percentage differences are statistically highly significant, and there is, there-

Table 34. Correlation between late subjective results and degree of arthrosis deformans in women and men.

Degree of arthrosis deformans	Subjective results							
	Good		Medium		Poor		Total	
	♀	♂	♀	♂	♀	♂	♀	♂
(+)	6	4	2	-	1	-	9	4
+	3	2	1	-	2	-	6	2
++	-	-	-	-	1	-	1	-
+++	-	-	-	-	1	-	1	-
Total	9	6	3	-	5	-	17	6

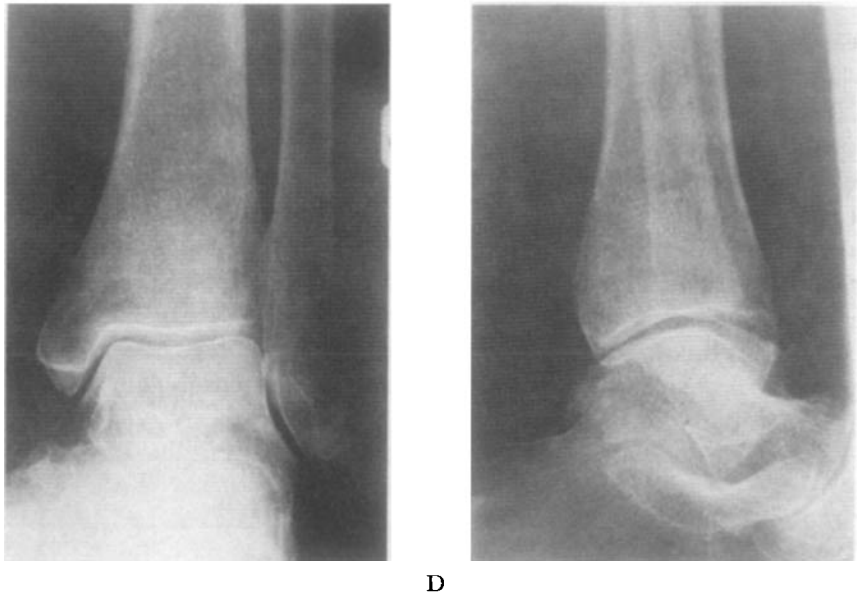
A



B

Fig. 44. Woman, born in 1889, who sustained a stage IV-injury to her right ankle in January, 1961 (A). Operated on with ligament reconstruction, syndesmosis staple, cerclage and Rissler pin (B, March, 1961). At follow-up examination 5 years later she was completely symptom-free and had no arthrosis deformans (C, March, 1966). Left ankle for comparison (D).

C



D

fore, in the material, an established correlation between subjective symptoms and arthrosis deformans.

B. Roentgenological results and arthrosis deformans

The correlation between the roentgenological results and the degree of arthrosis deformans can be studied in Table 35. From this it is clear that 9 of the 23 patients with arthrosis deformans (39.2 %) had "anatomical", 7 (30.4 %) "good", and 7 (30.4 %) "poor" roentgenological results. In view of the whole material, arthrosis deformans could be established in 9 out of 68 patients (13.2 %) with "anatomical" results, in 7 out of 19 patients (36.8 %) with "good" results, and in 7 out of 13 patients (53.8 %) with "poor" results. The percentage differences are also here statistically highly significant. There is, therefore, in the material, an established correlation between the roentgenological result and arthrosis deformans.

In order to ascertain whether posterior tibial fragments which had healed with persistent displacement could be supposed to be of importance for the development of arthrosis deformans, the primary roentgenological result of all the stage IV-injuries in the follow-up material was studied. One then found that 6 of the 55 patients had no posterior fragment, and that 1 of these 6 patients had arthrosis deformans. Accordingly, 49 patients, 20 of whom with arthrosis deformans, could be studied. In 15 of these 49 patients, the posterior tibial fragment had healed with remaining proximal displacement, amounting to 1 to 2 mm. Of these 15 patients, 10 (66.7 %) turned out to have arthrosis deformans. Among the 34 patients in whom the posterior fragment had healed without displacement, 10 were also found to have arthrosis deformans, which corresponds to 29.1 per cent. The percentage difference between the two groups, 37.6 per cent, is statistically almost significant, implying that displaced posterior fragments are more often accompanied by arthrosis deformans than are nondisplaced ones.

Tabl 35. Correlation between late roentgenological results and degree of arthrosis deformans.

Degree of arthrosis deformans	Roentgenological results			
	Anatomical	Good	Poor	Total
(+)	5	4	4	13
+	2	3	3	8
++	1			1
+++	1			1
Total	9	7	7	23

In order to investigate what importance the size of the posterior tibial fragments could have for the development of arthrosis deformans, these fragments were divided up into 2 groups comprising $\leq 1/4$ and $> 1/4$ of the articular surface, respectively. One then found that 4 out of 15 patients (26.7 %) with large displaced posterior fragments had arthrosis deformans, while only 3 out of 34 patients (8.8 %) with large nondisplaced fragments had arthrosis deformans. A similar division of the small fragments was made at which 6 out of 15 patients (40.4 %) with displaced fragments, and 7 out of 34 patients (20.6 %) with nondisplaced fragments were found to have arthrosis deformans. This implies that patients with large displaced posterior fragments have arthrosis deformans 3 times as often as patients with large nondisplaced fragments, and that patients with small displaced posterior fragments have arthrosis deformans twice as often as patients with small nondisplaced fragments. Because of the small size of the material, the percentage differences are, however, not statistically significant.

XXXII *Comparison of subjective results, roentgenological results and frequency of arthrosis deformans in patients operated on with and without the use of the syndesmosis staple*

As has previously been mentioned in Part II, all the patients in the present material have not been operated on with syndesmosis staple. In the follow-up material, patients operated on with syndesmosis staple and patients operated on without syndesmosis staple happened to be almost equal in number, namely, 49 and 51, respectively. For this reason an investigation was made to ascertain whether the staple could be supposed to have any favourable or unfavourable effect on the subjective and the roentgenological results of the patients and on the occurrence of arthrosis deformans.

"The staple material" included 30 women and 19 men distributing themselves among 13 stage II-injuries, 4 stage III-injuries and 32 stage IV-injuries, 11 of which were luxation injuries. "The nonstaple material" included 28 women and 23 men distributing themselves among 25 stage II-injuries, 3 stage III-injuries, and 23 stage IV-injuries, 10 of which luxation injuries. "The staple material", accordingly, with regard to percentage, includes more female patients and more stage IV-injuries than "the nonstaple material". The mean age in "the staple material" is also about 3.5 years higher than that in "the nonstaple material", whereas the mean observation time is 5 to 6 months longer in the last-mentioned material.

Table 36. Late roentgenological results in 49 patients operated on with the use of the syndesmosis staple. Correlation to sex and stage.

Roentgenological results	Stage II ♀	Stage II ♂	Stage III ♀	Stage III ♂	Stage IV ♀	Stage IV ♂	Total ♀	Total ♂
Anatomical	6	5	1	3	14	8	21	16
Good	1	—	—	—	2	2	3	2
Poor	1	—	—	—	5	1	6	1
Total	8	5	1	3	21	11	30	19

Table 37. Late roentgenological results in 51 patients operated on without the use of the syndesmosis staple. Correlation to sex and stage.

Roentgenological results	Stage II ♀	Stage II ♂	Stage III ♀	Stage III ♂	Stage IV ♀	Stage IV ♂	Total ♀	Total ♂
Anatomical	8	13	—	1	7	2	15	16
Good	4	—	—	1	5	4	9	5
Poor	—	—	1	—	3	2	4	2
Total	12	13	1	2	15	8	28	23

At a comparison between the subjective results of the two materials, one will find no established difference. Thus the distribution of "medium" and "poor" subjective results was 5 in "the staple material" and 7 in "the non-staple material", respectively.

The roentgenological result of the patients in "the staple material" can be studied in Table 36, from which it is clear that of 49 patients 37 (75.5 %) had "anatomical", 5 (10.2 %) "good", and 7 (14.3 %) "poor" results. The roentgenological result of the patients in "the nonstaple material" can be studied in Table 37, from which it is clear that the corresponding figures are 60.8 %, 27.4 %, and 11.8 %. The greatest difference between the materials is to be found in stage IV, where "anatomical" results in "the staple material" amounted to 68.8 % compared to 39.1 % in "the nonstaple material".

Arthrosis deformans was observed in 12 patients in "the staple material", 1 with a stage II-injury and 11 with stage IV-injuries, and in 11 patients in "the nonstaple material", 1 with a stage III-injury and 10 with stage IV-injuries. The stage IV-injuries in "the staple material" had arthrosis deformans in 11 out of 32 cases (34.4 %), and in "the nonstaple material"

in 10 out of 23 cases (43.5 %). Among 20 patients with their staple still left in position, only 1 was found to have arthrosis deformans. It was a woman with a stage IV-injury who had an arthrosis deformans of degree +.

Summarily it can be said that patients in stage IV, operated on with syndesmosis staple, with regard to percentage, have a higher frequency of anatomical reconstructions and a lower frequency of arthrosis deformans than patients in this stage operated on without syndesmosis staple. The difference is, with regard to the roentgenological result, statistically almost significant. The results indicate clearly that the syndesmosis staple enables a more exact joint reconstruction and that it has no deleterious effect on the ankle, even in those cases where it is left in position.

XXXIII *Comparison of the late results of conservative treatment with those of the present follow-up material*

A. Short survey of Magnusson's material of nonoperated supination-outward rotation fractures

1. *Distribution of the patients into sex, age and stage*

In his dissertation, Magnusson (1944) gave an account of a material of conservatively treated supination-outward rotation fractures including 386 patients, of whom 183 were women and 203 men. Of these patients 211 (54.6 %) were followed up. 102 were women and 109 men. The mean age of the patients was 47.5 ± 1.0 years, of which for women 49.8 ± 1.6 years and for men 45.5 ± 1.5 years. The mean observation time was about 6.1 years, of which for women 5.4 and for men 6.9 years. The stage distribution was roentgenologically based and comprised 5 different groups of fractures, namely, "unimalleolar fractures", "unimalleolar fractures with fracture of the posterior tibial margin", "bimalleolar fractures", "bimalleolar fractures with fracture of the posterior tibial margin", and "fractures with luxation of the ankle joint". The groups comprised 118, 29, 20, 33, and 11 patients, respectively. If the patients are re-grouped into the different stages used in the present material, stage II will comprise 118 (55.9 %), stage III 29 (13.8 %), and stage IV 64 patients (30.3 %). This re-grouping can only be approximate, as Magnusson's "unimalleolar fractures" and "unimalleolar fractures with fracture of the posterior tibial margin" comprise an unknown number of cases with rupture of the deltoid ligament. Because of this, stage II and III in Magnusson's material will be somewhat overrepresented at the expense of stage IV.

2. *Method of treatment. Immobilization and treatment times*

The conservative treatment of fractures in Magnusson's material implied reduction with inward rotation of the foot and fixation by padded or unpadded plaster. The mean time of immobilization in plaster varied between 27.4 ± 1.3 days (stage II-injuries) and 44.2 ± 2.2 days (stage IV-injuries). The mean treatment time varied between 51.1 ± 2.5 days (stage II-injuries) and 91.8 ± 8.7 days (stage IV-injuries).

3. *Comparison of Magnusson's material with the present follow-up material*

The differences between Magnusson's follow-up material and the present follow-up material with respect to the number of patients, their sex and stage distribution, mean age, mean times of observation, and mean times of immobilization in plaster can be studied in Table 38. From this it is clear that there is an even sex distribution in Magnusson's material, whereas the women have a clear predominance in the present material. His material has a predominance of stage II-injuries, whereas the present material has a predominance of stage IV-injuries. The percentage differences for the stage II and the stage IV-injuries are statistically significant. The mean time of observation in the two materials is almost equivalent. The mean time of immobilization in plaster in Magnusson's material is shorter than that in

Table 38. Comparison of Magnusson's follow-up material with the present follow-up material.

Factors	Magnusson's material	Present material
Number of patients	211	100
Ratio ♀ : ♂	102 : 109 = 1 : 1.1	58 : 42 = 1.4 : 1
Stage II	118 (55.9 %)	38 (38.0 %)
Stage III	29 (13.8 %)	7 (7.0 %)
Stage IV	53 (25.1 %)	34 (34.0 %)
Stage IV, LUX	11 (5.2 %)	21 (21.0 %)
Mean age at follow-up examination	47.5 ± 1.0 years	51.8 ± 14.4 years
Mean observation time	About 6.1 years	5.7 ± 0.6 years
Mean time of immobilization in plaster		
Stage II	27.4 ± 1.3 days	54.6 ± 9.8 days
Stage III	42.5 ± 16.1 days	63.7 ± 16.1 days
Stage IV	44.2 ± 2.2 days	63.0 ± 13.3 days
Stage IV, LUX	51.1 ± 3.2 days	65.1 ± 15.4 days

the present material. It should also be observed that the patients in Magnusson's material have been allowed to weight-bear in the plaster earlier than those in the present material, and that the time of treatment in his material cannot be compared with the sick-leave in the present follow-up material, as the terms would seem to have a different meaning.

B. Differences between the late results of Magnusson's material and those of the present follow-up material

1. *Late subjective and objective results*

In his follow-up material, Magnusson has no strict classification of the subjective results. He uses the word "discomfort" as a common term for "pain, tiredness, weakness or insecurity in the ankle joint". The discomfort of the patients is stated to be "constant or intermittent", in the latter case the discomfort appearing "after exertion, unaccustomed movements and the like". Nor does Magnusson, as far as the objective symptoms are concerned, use any particular strict classification, and, in conformity with his estimation of the subjective symptoms, he does not use any distribution into, for instance, "good", "medium" or "poor" results. It is, therefore, not easy to make a comparison between the results in Magnusson's material and those in the present material. It has, however, been possible for the author to recalculate the results in the present follow-up material so as to be applicable

Table 39. Differences between late subjective and objective results of stage II-injuries in Magnusson's material and the present material.

Components	Magnusson's material (118 patients)	Present material (38 patients)
Subjective results		
Discomfort		
Constant	11 (9.3 %)	—
Intermittent	24 (20.4 %)	7 (18.9 %)
Objective results		
Swelling & edema	17 (14.4 %)	9 (23.7 %) (malleolar size + ≥ 1 cm)
Tenderness ATFL	16 (13.6 %)	2 (5.3 %)
Atrophy of the calf (≥ 1 cm)	4 (3.4 %)	7 (18.9 %)
Pes plano-valgus	10 (8.5 %)	—
Pes transverso-planus	—	1 (2.6 %)

Table 40. Differences between late subjective and objective results of stage III-injuries in Magnusson's material and the present material.

Components	Magnusson's material (29 patients)	Present material (7 patients)
Subjective results		
Discomfort		
Constant	4 (13.8 %)	1 (14.3 %)
Intermittent	9 (31.0 %)	1 (14.3 %)
Objective results		
Swelling & edema	7 (24.1 %)	2 (28.6 %) (malleolar size + ≥ 1 cm)
Atrophy of the calf (≥ 1 cm)	3 (10.3 %)	1 (14.3 %)
Pes plano-valgus	3 (10.3 %)	—

Tabl 41. Differences between late subjective and objective results of stage IV-injuries in Magnusson's material and the present material.

Components	Magnusson's material (64 patients)	Present material (55 patients)
Subjective results		
Discomfort		
Constant	7 (10.9 %)	2 (3.6 %)
Intermittent	15 (23.4 %)	17 (30.9 %)
Objective results		
Swelling & edema	25 (39.1 %)	37 (67.2 %) (malleolar size + ≥ 1 cm)
Atrophy of the calf (≥ 1 cm)	7 (10.9 %)	14 (25.5 %)
Pes plano-valgus	9 (14.1 %)	—
Pes transverso-planus	—	4 (7.3 %)

to the classification used by Magnusson, and therefore a real comparison can be made. The Tables 39, 40, and 41 show the differences between the subjective and the objective results of stage II, III, and IV-injuries in Magnusson's follow-up material and in the present follow-up material. Table 42 gives a collation of the differences involving the whole materials. From the table it is clear that in Magnusson's material there are more patients with constant discomfort from their ankle injury than in the

Table 42. Differences between late subjective, objective and roentgenological results of stage II-, III- and IV-injuries in Magnusson's material and the present material.

Components	Magnusson's material (211 patients)	Present material (100 patients)
Subjective results		
Discomfort		
Constant	22 (10.4 %)	3 (3.0 %)
Intermittent	48 (22.7 %)	24 (24.0 %)
Objective results		
Swelling & edema	49 (23.2 %)	48 (48.0 %) (malleolar size + ≥ 1 cm)
Atrophy of the calf (≥ 1 cm)	14 (6.6 %)	22 (22.0 %)
Pes plano-valgus	22 (10.4 %)	—
Pes transverso-planus	—	5 (5.0 %)
Roentgenological results		
Pseudarthrosis in the ATTu	54 (25.6 %)	—
Contour-changes in the ATTu	103 (48.8 %)	10 (10.0 %)
Pseudarthrosis of the medial malleolar fracture	5/62 (8.1 %)	—
Displacement of posterior tibial fragment	20/73 (27.4 %)	9/56 (16.1 %)

present material. The difference is statistically almost significant. As to the late objective results the table shows that atrophy of the calf, probably due to differences in the length of time of immobilization in plaster, is much more common in the present material than in Magnusson's material. The difference is statistically highly significant. There is, on the other hand, in Magnusson's material unilateral pes plano-valgus in such a great number that the difference between the two materials is statistically almost significant.

2. *Late roentgenological results*

Nor does Magnusson, when discussing the roentgenological results, use any detailed classification of his patients. There is, accordingly, in his material no classification of good or poor results. There are rather scanty reports on, for instance, the displacements of the fracture fragments. About the 118 cases of "unimalleolar fractures" Magnusson writes that "in all cases the fibular fracture healed without marked dislocation". Changes in the ATTu

were demonstrated in 82 cases (69.5 %), of which 27 were pseudarthroses and 55 contour-changes.

The same opinion about the healing of the fibular fracture that was applicable to the "unimalleolar fractures" was also applicable to the 29 cases of "unimalleolar fractures with fracture of the posterior tibial margin". Changes in the ATTu were demonstrated in 23 cases (79.3 %) of which 7 were pseudarthroses and 16 contour-changes. The posterior fragments appeared in 2 types, partly shell-shaped fragments which were not considered to be intra-articular and partly large fragments involving the tibial articular surface. 7 fragments belonged to the former group and the rest, 22 fragments, to the latter group. Among these last-mentioned fragments, 14 showed no displacement, 3 an irregularity in the articular surface, and 5 a proximal displacement amounting to 2 mm.

In 20 cases of "bimalleolar fractures", the fibular fracture had healed "without very great dislocation". All the cases had injuries to the ATTu, consisting of 10 pseudarthroses and 10 contour-changes. 5 medial malleolar fragments healed with displacement and 1 pseudarthrosis in the medial malleolus was registered.

In 33 cases of "bimalleolar fractures with fracture of the posterior tibial margin", the fibular fracture had healed "without any perceptible dislocation". 24 cases (72.7 %) had injuries to the anterior tibiofibular ligament consisting of 6 pseudarthroses and 18 contour-changes. No less than 31 of the 33 posterior fragments were intra-articular. 12 fragments were found to be displaced at the follow-up examination. 4 of them had not primarily been repositioned, and 8 had been displaced during the time of treatment. 3 instances of pseudarthrosis in the medial malleolus were registered, and in 3 instances the medial malleolar fragment had healed with displacement.

Of the 11 "fractures with luxation of the ankle joint", 8 had injuries to the ATTu. 4 of them were pseudarthroses and 4 contour-changes. 1 pseudarthrosis in the medial malleolus was registered, and 1 medial malleolar fracture healed with displacement. In 2 cases the medial injury consisted of rupture of the deltoid ligament. All the 11 luxation injuries had a posterior fragment. 3 fragments showed step-formation at the follow-up examination.

About the 64 stage IV-injuries in Magnussons's follow-up material, it can summarily be said that 20 pseudarthroses could be demonstrated in the ATTu (31.3 %), that the fibular fractures healed without any great displacement, that 9 medial malleolar fractures healed with displacement (14.5 %), that 5 pseudarthroses in the medial malleolus (8.1 %) were registered, and that 15 posterior tibial fragments were found to be displaced (34.1 %).

From what is said above, we conclude that a comparison between the roentgenological results in Magnusson's follow-up material and the present follow-up material is to a certain degree possible. There is in Magnusson's material a relatively high frequency of pseudarthrosis in the ATTu (25.6 %) and the medial malleolus (8.1 %) (see Table 42), whereas in the present material, no pseudarthrosis in the ATTu or the medial malleolus could be registered, certainly owing to the exact and stable reconstruction enabled by the operative method used.

3. *Frequency of arthrosis deformans*

The frequency of arthrosis deformans in Magnusson's material can be studied in Table 43, where a comparison with the frequency of arthrosis deformans in the present material is also made. In this table it can be seen that Magnusson among his stage II-injuries has a frequency of arthrosis deformans amounting to 29.7 per cent compared to 2.6 per cent in the present material. The difference is statistically significant. In stage III the corresponding figures are 62.1 per cent and 14.3 per cent, respectively. The difference is statistically almost significant. In stage IV, the figures are 79.2

Table 43. Differences between frequency of arthrosis deformans of stage II-, III-, IV- and IV, LUX-injuries in Magnusson's material and the present material.

Stage	Frequency of arthrosis deformans	
	Magnusson's material	Present material
II	35/118 (29.7 %)	1/38 (2.6 %)
III	18/29 (62.1 %)	1/7 (14.3 %)
IV	42/53 (79.2 %)	8/34 (23.5 %)
IV, LUX	9/11 (81.8 %)	13/21 (61.9 %)
Total	104/211 (49.3 %)	23/100 (23.0 %)

Table 44. Differences between degree distribution of arthrosis deformans in Magnusson's material and the present material.

Degree of arthrosis deformans	Magnusson's material	Present material
(+)	85 (81.7 %)	13 (56.6 %)
+	15 (14.4 %)	8 (34.8 %)
++	4 (3.9 %)	1 (4.3 %)
+++	—	1 (4.3 %)
Total	104 (100.0 %)	23 (100.0 %)

per cent and 23.5 per cent, respectively. The difference is statistically highly significant. In stage IV, LUX the percentage difference, 19.9 per cent, is not statistically significant. As a total, there is in Magnusson's material a frequency of arthrosis deformans amounting to 49.3 per cent compared to 23.0 per cent in the present material. The difference is statistically highly significant. Table 44 shows the distribution of arthrosis deformans with regard to the degree of severity in Magnusson's material and the present material. There is in Magnusson's material a lower degree of severity. The percentage difference for the mild forms, i.e., degree (+) and degree +, is statistically almost significant.

XXXIV *Discussion*

To make a comparison between the results of conservative and operative treatment of ankle injuries is often very difficult. In this work, the author has tried to compare the late results of a material of operatively treated supination-outward rotation injuries with those of Magnusson's material of conservatively treated similar injuries. Both materials derive from the same hospital and consequently from the same reception area. The interval between the materials amounts to more than twenty years. It is of great importance that there is no form of selection in the two materials. Thus, one has consistently used conservative and operative treatment of the ankle injuries.

The comparison is, however, rendered difficult by the fact that the clinical as well as the roentgenological results have not been classified in an equivalent way, as the author in his material, contrary to Magnusson, has made a detailed classification of the results of treatment. Nor are the materials quite comparable with regard to the sex, age and stage distribution of the patients, which to a high degree, can influence, for instance, the frequency of arthrosis deformans. Magnusson has an even sex distribution in his material, whereas the women are predominant in the present material, which circumstance, according to experience, should involve an apparent disadvantage to the present material with regard to the results of treatment as well as the frequency of arthrosis deformans. The mean age in the present material is higher than that in Magnusson's material, but the difference, about 4 years, is perhaps not so great as to affect the results to any high degree. The materials differ very markedly with regard to the stage distribution. Magnusson has a predominance of stage II-injuries in his material, while stage IV-injuries predominate in the present material, which circumstance involves a clear disadvantage to the latter material.

Magnusson has a certain over-representation of stage II-injuries ("unimalleolar fractures") at the expense of the stage IV-injuries, because he has divided up his material on a roentgenological basis, on account of which ruptures of the deltoid ligament have happened to be unregistered. He has, however, observed this, as, at the follow-up examination of the stage II-injuries, he found 13 cases with roentgenological changes indicating that rupture of the deltoid ligament must have occurred primarily. He also found 6 cases in which injury to the posterior tibial process must have occurred primarily. These circumstances consequently prove that the clinical result of the stage II-injuries has been erroneously worse and the frequency of arthrosis deformans erroneously higher. If one makes a re-calculation, taking Magnusson's above-mentioned follow-up observations into consideration, the frequency of arthrosis deformans for the stage II-injuries can be reduced to about 18 per cent, while it will correspondingly increase for the stage IV-injuries to about 83 per cent. This re-calculation will not affect the significant differences between the two materials to any high degree.

The times of immobilization in plaster differ obviously in the two materials and are in Magnusson's material rather short, especially for the stage II-injuries. Magnusson has also stated them to be insufficient. It is difficult to decide what effect the difference in the mean time of immobilization, about 3 weeks, has had on the result of treatment and on the frequency of arthrosis deformans in the two materials. As far as the present material is concerned, the immobilization times have probably been unnecessarily long, which can be confirmed by the fact that a successive reduction of them has not involved any disadvantage to the results of treatment.

If a comparison between the results of treatment in Magnusson's material and the present material is made, one will on several points find percentage differences speaking in favour of the latter material. From a statistical point of view there are in the present follow-up material fewer patients with constant subjective symptoms from the injured ankle and considerably lower frequency of arthrosis deformans in all the stages with the exception of the luxation injuries. These differences are much the more remarkable as the present material is burdened by a predominance of female patients, a higher mean age among the patients, and a predominance of severe injuries. The great difference in the frequency of arthrosis deformans could reasonably be due to the fact that the injuries in the present material have been treated according to an operative method which has allowed good and stable joint reconstruction, especially by the use of the syndesmosis staple. Of great interest here is the correlation between defectively healed ATFL-ruptures and arthrosis deformans, which has been asserted

by Magnusson. In the present material in which the ATFL-ruptures have been carefully reconstructed, no pseudarthrosis in the ATTu could be registered, which circumstance, according to the above-mentioned hypothesis, might explain the decreased frequency of arthrosis deformans. The fact that arthrosis deformans, in spite of this ligamentous reconstruction, occurs in a frequency of about 20 per cent, must, I suppose, when discussing the causes of arthrosis deformans, involve the necessity of taking into due consideration also the other injury components and the reconstruction of them.

Even if the follow-up material because of its composition, from a statistical point of view, is representative of the total material, this does not necessarily involve that its results of treatment are applicable also to the last-mentioned material. Though the results of treatment of the follow-up material must be considered very good, the late results may, however, be expected to be still better for those patients belonging to the latter half of the material. In addition to clinical observations made, there are several reasons speaking for the truth of such an assertion. Most of the results of the follow-up material consequently pertain to patients operated on during a period when the operative method was being devised, and the surgeons had not obtained sufficient experience for the operations. Nor was the syndesmosis staple in the beginning used at the reconstruction of the lateral injury components, but it gradually found consistent use, whereby better results of reconstruction could be achieved. As has earlier been mentioned, also the primary clinical and roentgenological results have successively been better. As regards the primary clinical results in those patients operated on in the years 1958—1961 and 1962—1965, respectively, the number of "medium" and "poor" results (see Table 14) amounted to 13 of 132 (9.8 %) and 14 of 285 (4.9 %) cases, respectively, implying a percentage predominance of inferior results of treatment in the first-mentioned group of patients. From a roentgenological point of view there are also percentage differences in respect to the primary result. Thus the patients in the follow-up material had "anatomical" results in 63.0 per cent, "good" results in 17.0 per cent, and "poor" results in 20.0 per cent, while the corresponding figures for the 306 stage II, III, and IV-injuries not followed up, were 69.9 per cent, 14.7 per cent, and 15.4 per cent. The percentage differences are, however, not statistically significant. Also the sick-leave has successively decreased which indicates that the results of treatment have gradually become better.

XXXV *Summary*

In order to ascertain the late results of the operative treatment of the supination-outward rotation injuries in this material, those patients operated on in the years 1958—1961 (132 patients) were subjected to a follow-up examination with an observation time of at least 5 years. 111 of them (84.1 %) could be judged with respect to their subjective symptoms, and 100 (75.8 %) could be subjected to a complete clinical and roentgenological follow-up examination. From a statistical point of view, the follow-up material with respect to sex, age, and stage distribution, proved to be representative of all those 132 patients operated on in the years 1958—1961 as well as the 417 patients of the total material.

With regard to the subjective result of treatment, the patients have been divided up into 3 groups, namely, "good", "medium", and "poor" results. 88 per cent of the patients had "good", 6 per cent "medium", and 6 per cent "poor" results. The best results were obtained in the stage II-injuries, 94.7 per cent of which had "good" results. The worst results were obtained in the stage IV-injuries, of which 83.6 per cent, however, had "good" results.

Also with respect to the objective result of treatment, the patients have been divided up into the corresponding 3 groups. 59 per cent of the patients had "good", 38 per cent "medium", and only 3 per cent "poor" results. Here also the best results were obtained in stage II and the worst in stage IV.

During the observation time the clinical results of treatment have changed to a slight degree only, which means that the primary clinical results can give good information about the future function of the injured ankle of the patients.

From a roentgenological point of view the patients have been divided up into 3 groups, namely, "anatomical", "good", and "poor" results. With regard to medial malleolar fractures and posterior tibial fractures the classification has been stricter than that one used for the primary results of reduction, because, in a healed ankle injury, it is often difficult to establish and measure slight fragment displacements, and displacements in posterior tibial fractures are successively levelled and thereby not very conspicuous. 68 per cent of the patients had "anatomical", 19 per cent "good", and 13 per cent "poor" results. No pseudarthrosis was registered.

There has been a very good accordance between the subjective, the objective and the roentgenological results. Women had generally worse results of treatment than men.

The post-traumatic arthrosis deformans of the ankle is discussed with respect to etiology, beginning, and correlation to the patient's sex and age

and the severity of the ankle injury. Arthrosis deformans in the present material was classified according to Magnusson. It was registered in a total of 23 patients, of whom 17 were women and 6 men, implying a predominance of the first-mentioned. Only 2 of the patients, both women, had severe changes. 21 of the patients were more than 40 years old, and the mean age of the women was somewhat higher than that of the men. The frequency of arthrosis deformans in stage II was 2.6 per cent, in stage III 14.3 per cent, in stage IV 23.5 per cent, and in stage IV, LUX 61.9 per cent. Arthrosis deformans could be demonstrated in only 15 out of 88 patients (17.0 %) with "good" subjective results, in 3 out of 6 patients (50.0 %) with "medium" subjective results, and in 5 out of 6 patients (83.3 %) with "poor" subjective results. The figures imply that there is a significant correlation between subjective symptoms and arthrosis deformans. Arthrosis deformans could further be demonstrated in only 9 out of 68 patients (13.2 %) with "anatomical" roentgenological results, in 7 out of 19 patients (36.8 %) with "good" roentgenological results, and in 7 out of 13 (53.8 %) with "poor" roentgenological results. The figures imply that there is a significant correlation between the roentgenological results of reconstruction and arthrosis deformans. A significant correlation was also established between arthrosis deformans and posterior tibial fractures, healed with displacement. At a comparison between displaced and nondisplaced posterior tibial fragments, one could find that, with regard to percentage, large fragments were more often accompanied by arthrosis deformans than were small ones.

Of the 100 follow-up patients about 50 per cent had happened to be operated on with, and about 50 per cent without, the use of the syndesmosis staple. An investigation showed that patients in stage IV, operated on with syndesmosis staple, had a significantly higher frequency of anatomical reconstructions and, with regard to percentage, a lower frequency of arthrosis deformans than patients in this stage, operated on without syndesmosis staple.

The results of treatment in the present follow-up material have been compared with the results of treatment obtained by Magnusson (1944) in a follow-up material of conservatively treated supination-outward rotation fractures. The comparison was difficult as the clinical as well as the roentgenological results were not equivalently classified. The materials are not comparable, either, as the sex, age and stage distribution of the patients is so different as to involve a clear disadvantage to the present material. Besides, there are also differences with respect to the length of the times of immobilization in plaster in the two materials. From a statistical point of view, there are, in comparison with Magnusson's material, in the present follow-up material fewer patients with constant subjective symptoms from

the injured ankle and a considerably reduced frequency of arthrosis deformans in all the stages with the exception of the luxation injuries. The causes of the reduced frequency of arthrosis deformans are discussed, at which the author emphasizes that this reduction must depend on the operative method used, which, especially thanks to the syndesmosis staple, enables good and stable joint reconstruction. The results of treatment are valued, at which the author emphasizes that they can probably be exspected to be still better for those patients belonging to the latter half of the total material.

XXXVI *General summary and conclusions*

Part I deals with the clinical and roentgenological diagnosis of supination-outward rotation injuries in adults and the joint changes registered at operative exploration of these injuries. For summary, see page 62.

Part II deals with the operative method used in the reconstruction of supination-outward rotation injuries and the primary clinical and roentgenological results of this treatment. For summary, see page 97.

Part III deals with the late clinical and roentgenological results of treatment in most of those patients operated on in the years 1958—1961. The results are compared with the late results of conservative treatment (Magnusson, 1944). For summary, see page 137.

With the support of operative observations made and results of treatment obtained in this material and experiences reported on in other investigations, the following summing-up can be made as to the operative indications for supination-outward rotation injuries of the ankle.

Stage I-injuries. Strong indication for operation at the occurrence of a roentgenologically visualized bone fragment, originating in the ATTu or the lateral malleolus. With conservative treatment there is probably a great risk of pseudarthrosis formation resulting in symptoms of insufficiency from the anterior part of the tibiofibular syndesmosis (Magnusson, 1944). A rupture located in the ligamentous substance should have a good prognosis with conservative treatment, provided the injury is treated with immobilization in plaster for at least 6 weeks. The advantage of an operation also of this type of ligamentous injury is, that one obtains a reliable healing of the ligament (Clayton, 1959), and that the length of the immobilization time can be essentially reduced, especially if the ligamentous suture is stabilized by a syndesmosis staple.

Stage II-injuries. The ATFL-rupture and the distal oblique fibular fracture should, with regard to treatment, be considered a unit. Strong indication for operation at the occurrence of a roentgenologically visualized bone fragment belonging to the ATFL and/or displacement of the distal fibular fragment in lateral, dorsal, or proximal direction, or in outward rotation. An oblique fracture without displacement and combined with a ligamentous rupture without a visible bone fragment would seem to have a good prognosis with conservative treatment, provided the immobilization in plaster is of sufficiently long duration. The advantage of operation also in these cases is probably, in conformity with the above, that the healing of the ligament is ensured and, besides, that secondary fragment displacement is prevented. By operation also, laterally situated free cartilage or bone fragments can be established and removed. Also the time of immobilization can probably be reduced, if the injury is operatively treated.

Stage III-injuries. The same indications as those for stage II-injuries should be applicable. Posterior tibial fragments in size involving more than one fourth of the articular surface and showing proximal displacement should be subjected to osteosynthesis, while small bone fragments do not generally require special operative measures.

Stage IV-injuries. The same indications as those for stage II-injuries should be applicable to the lateral injury components and the same indications as those for stage III-injuries to the posterior tibial fragments. Strong indication for operation on the medial side in all those cases which, in the roentgenograms, show displaced medial malleolar fracture and in all those cases which show signs of rupture of the deltoid ligament with either marked clinical symptoms or, in the roentgenograms, a pathologically large distance between the medial malleolus and the talus. If there is any uncertainty as to the occurrence of a ligamentous rupture, an operative exploration should be performed. With conservative treatment the medial malleolar fracture involves the risk of pseudarthrosis formation, as soft parts are, as a rule, interpositioned in it. Operation also enables the establishment and the removal of medially situated free cartilage or bone fragments and, besides, a reduction of the immobilization time.

The luxation injuries will probably always require operative treatment. Even if, at conservative as well as operative treatment, the frequency of arthrosis deformans is high, possibly due to the occurrence of mechanical as well as nutritive injuries to the joint cartilage, it can be reduced by exact joint reconstruction.

With regard to the stable fixation of the injuries in this material, enabled by the operative method used, the times of immobilization in plaster might be further reduced. The patients would thereby be able to start their movement-exercise earlier, which would probably reduce the frequency of

atrophy of the calf and remaining restriction of the range of motion in the ankle. This procedure might also be supposed to lead to some reduction of the time of treatment and, therefore, accelerate the patient's return to work. The author does not consider a complete elimination of the treatment in plaster to be advisable. In the postoperative period the plaster is probably valuable for the patient, as it can reduce pain and promote the normal healing of the wound. Also later on during the treatment the plaster would seem to be of value for the healing of injuries to the joint capsule and of such sutured ligamentous ruptures in which the suture, contrary to stage I-injuries, cannot be subjected to any stabilizing procedure.

Attempts aiming at further reduction of the time of immobilization in plaster have been started.

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References

Anderson, K. J., Lecocq, J. F. & Lecocq, E. A. 1952. Recurrent anterior subluxation of the ankle joint. J. Bone Jt. Surg. 34 A, 853.

Andreesen, R. 1938. Mangelhafte Knochenneubildung bei Innenknöchelbrüchen, ihre Verhütung und Behandlung. Zentralbl. Chir. 65, 2213.

Arner, O., Ekengren, K., Hulting, B. & Lindholm, Å. 1957. Arthrography of the talo-crural joint. Anatomic, roentgenografic and clinical aspects. Acta chir. scand. 113, 253.

Ashhurst, A. P. C. & Bromer, R. S. 1922. Classification and mechanism of fractures of the leg bones involving the ankle. A. M. A. Arch. Surg. 4,51.

Beck, A. 1930. Zur Frage der operativen Behandlung der Luxationsfraktur des Fussgelenkes. Deutsche Ztschr. f. Chir. 228, 289.

Bedogni, C. & Bergami, P. L. 1962. Le fratture trimalleolari. Arch. ortop. LXXV, 105.

Bergkvist, A., Hultengren, N., Lindholm, Å. & Lindvall, N. 1958. Circumferential wire fixation of the lateral malleolus for fractures at the ankle. Acta chir. scand. 115, 476.

Bergstrand, H. 1944. Arthritis deformans, etiologi och behandling. I. Patologisk anatomi. Nord. med. 21, 61.

Berridge, F. R. & Bonnin, J. G. 1944. The radiographic examination of the ankle including arthrography. Surg. Gynec. Obstet. 79, 383.

Bishop, P. A. 1932. Fractures and epiphyseal separation fractures of the ankle. Am. J. Roentgenol. 28, 49.

Biström, O. 1952. Conservative treatment of severe ankle fractures. A clinical and follow-up study. Acta chir. scand. Suppl. 168.

Bolin, H. 1961. The fibula and its relationship to the tibia and talus in injuries of the ankle due to forced external rotation. Acta radiol. 56, 439.

Bonnin, J. G. 1950. Injuries to the ankle. William Heinemann Medical Books Ltd, London.

Bonnin, J. G. 1965. Injury to the ligaments of the ankle. J. Bone Jt. Surg. 47 B, 609.

Bosworth, D. M. 1947. Fracture-dislocation of the ankle with fixed displacement of the fibula behind the tibia. J. Bone Jt. Surg. 29, 130.

v. Brandis. 1939. Zur blutigen Behandlung schlecht stehender Knöchelbrüche. Arch. orthop. u. Unfall-Chir. 39, 659.

Braunstein, P. W. & Wade, P. A. 1959. Treatment of unstable fractures of the ankle. Ann. Surg. 149, 217.

Breitenfelder, H. 1957. Der lange Drehbruch des äusseren Knöchels. Spätschäden und ihre Verhütung. Verh. Deutsch. Orthop. Ges. Beiheft Zeitschr. Orthop. 88, 333.

Broström, L. 1966. Sprained ankles. Diss., Stockholm.

Broström, L., Liljedahl, S.-O. & *Lindvall, N.* 1964. Isolated fracture of the posterior tibial tubercle. Aetiologic and clinical features. Acta chir. scand. 128, 51.

Broström, L., Liljedahl, S.-O. & *Lindvall, N.* 1965. Sprained ankles. II. Arthrographic diagnosis of recent ligament ruptures. Acta chir. scand. 129, 485.

Buck-Gramcko, D. 1955. Zur metallischen Osteosynthese im Bereiche des oberen Sprunggelenkes. Arch. orthop. u. Unfall-Chir. 47, 211.

Burgess, E. 1944. Fractures of the ankle. J. Bone Jt. Surg. 26, 721.

Burwell, N. H. & *Charnley, A. D.* 1965. The treatment of displaced fractures at the ankle by rigid internal fixation and early joint movement. J. Bone Jt. Surg. 47 B, 634.

Böhler, J. 1955. Gekreuzte Bohrdrähte, ein einfaches Prinzip der Osteosynthese. Arch. orthop. u. Unfall-Chir. 47, 242.

Böhler, L. 1957. Kritik der operativen Behandlung von Knöchelbrüchen. Verh. Deutsch. Orthop. Ges. Beiheft Ztschr. Orthop. 88, 350.

Cadenat. 1922. Bull. et mém. Soc. nat. de chir. 48, 1094. (Quoted by Hendelberg.)

Calvetti, P. 1960. Trattamento chirurgico delle fratture malleolari. Minerva ortop. (Torino) 11, 565.

Cave, E. F. 1965. Complications of the operative treatment of fractures of the ankle. Clin. Orthop. 42, 13.

Cedell, C.-A. 1965. Outward rotation-supination injuries of the ankle. Clin. Orthop. 42, 97.

Cedell, C.-A. & *Wiberg, G.* 1962. Treatment of eversion-supination fracture of the ankle (2nd degree). Acta chir. scand. 124, 41.

Charnley, J. 1957. Closed treatment of common fractures. Livingstone, Edinburgh.

Ciccone, R. & *Richman, R. M.* 1948. The mechanism of injury and the distribution of three thousand fractures and dislocations caused by parachute jumping. J. Bone Jt. Surg. 30 A, 77.

Clayton, M. L. 1959. Experimental investigation of ligamentous healing. Am. J. Surg. 98, 373.

Close, R. J. 1956. Some applications of the functional anatomy of the ankle joint. J. Bone Jt. Surg. 38 A, 761.

Coonrad, R. W. & *Bugg, E. I. Jr.* 1954. Trapping of the posterior tibial tendon and interposition of soft tissue in severe fractures about the ankle joint. J. Bone Jt. Surg. 36 A, 744.

Coutts, M. B. & *Woodward, E. P.* 1965. Surgery and sprained ankles. (Lateral ligament tears.) Clin. Orthop. 42, 81.

Cox, F. J. & *Laxson, W. W.* 1952. Fractures about the ankle joint. Am. J. Surg. 83, 674.

Danis, R. 1949. Les fractures malléolaires. In: Théorie et pratique de l'ostéosynthèse. Masson, Paris.

Decoulx, P., Decoulx, A., Duquennoy, A. & *Brice, J.* 1966. Reste-t-il encore des indications du boullonage tibio-péronier? Rev. chir. orthop. 52, 405.

Denham, R. D. 1964. Internal fixation for unstable ankle fractures. J. Bone Jt. Surg. 46 B, 206.

Desenfans, G. & *Evrard, H.* 1952. Le traitement chirurgical des fractures du coude-pied. Acta orthop. belg. 18, 303.

Devlies, A. 1959. Résultats éloignés du vissage direct dans les fractures malléolaires par torsion. Acta orthop. belg. 25, 131.

Dinstl, K. & *Spängler, H.* 1963. Über Luxationsfrakturen im Bereich des oberen Sprunggelenkes. Arch. orthop. u. Unfall-Chir. 55, 317.

Duval, P. & *Basset, A.* 1923. Traitement des fractures bimalléolaires. Bull. et mém. Soc. nat. de chir. 49, 1415.

Dziob, J. M. 1956. Ligamentous injuries about the ankle joint. Am. J. Surg. 91, 692.

Ewer, E. G. 1956. Ski fractures of the fibula. J. Bone Jt. Surg. 38 A, 442.

Fackert, S. 1954. Zur operativen Behandlung von Knöchelbrüchen und Pseudarthrosen. Arch. orthop. u. Unfall-Chir. 46, 513.

Fahey, J. J., Schlenker, L. T. & *Stauffer, R. C.* 1956. Fracture dislocation of ankle with fixed displacement of fibula behind tibia. Am. J. Roentgenol. 76, 1102.

Felsenreich, F. 1932. Die percutane Nagelung des sog. Volkmannschen Dreieckes. Arch. klin. Chir. 169, 712.

Felsenreich, F. 1936. Osteosynthese offener und bimalleolärer Verrenkungsbrüche des oberen Sprunggelenkes. Chirurg 8, 959.

Felsenreich, F. 1937. Die Klinik der "Posttraumatischen Arthritis" und verwandter Zustände. Wien. Med. Wchnschr. 87, 1140 & 1163.

Fleming, J. L. & *Smith, H. O.* 1954. Fracture-dislocation of the ankle with fibula fixed behind the tibia. J. Bone Jt. Surg. 36 A, 556.

Forgon, M. & *Berényi, P.* 1958. Technisches zur operativen Behandlung von Malleolar-frakturen und -pseudarthrosen. Arch. orthop. u. Unfall-Chir. 50, 182.

le Fort, L. 1886. Note sur une variété indécrite de la fracture verticale de la malléole externe par arrachement. Bull. gén. de thérap. méd. chir. 110, 193. (Quoted by Lauge Hansen.)

Frankel, C. J., Mc Cue, F. & *Humphries, D.* 1963. Injuries to the ankle. South. M. J. 56, 402.

Golterman, A. F. L. 1964. Diagnosis and treatment of tibiofibular diastasis. Arch. chir. neerl. 16—3, 185.

Grath, G.-B. 1960. Widening of the ankle mortise. Acta chir. scand. Suppl. 263.

Grath, G.-B. 1964. Den typiska låga snedfrakturen på fibula. Nordisk Ortopedisk Förenings 32. Kongress i Helsingfors.

Grøndahl, N. B. 1913. Fractura marginalis posterior tibiae og andre brudkomplicationer ved ankelbrud. Norsk magazin f. lægev. 11, 737.

Gschwend, N. 1960. Zur Häufigkeit und Ätiologie der lateralen Form der Osteochondritis dissecans tali. Arch. orthop. u. Unfall-Chir. 51, 491.

Hachez-Leblanc, M. 1950. Le vissage direct des fractures trimalléolaires basses par torsion, avec diastasis tibio-astragalien. Acta orthop. belg. 16, 307.

Hansson, C. J. 1941. Arthrographic studies on the ankle joint. Acta radiol. 22, 281.

Harris, R. I. 1947. Discussion with Bosworth, D. M. J. Bone Jt. Surg. 29, 135.

Hendelberg, T. 1943. Om brott å bakre tibiakanten vid malleolarfrakturer jämte bidrag till kännedomen om ligament- och kapselskadorna. Acta Soc. Med. Upsal. 49, 1—2.

Hendelberg, T. 1946. The roentgenographic examination of the ankle joint in malleolar fractures. Acta radiol. 27, 23.

Hirsch, C. & *Lewis, J.* 1965. Experimental ankle joint fractures. Acta orthop. scand. 36, 408.

Hohmann, G. 1929. Über Arthritis deformans der Sprung- und übrigen Fusswurzelgelenke. Ztschr. Orthop. 50, 499.

Hohmann, G. 1950. Zur Behandlung der frischen und der veralteten schlecht verheilten Knöchelbrüche. Arch. orthop. u. Unfall-Chir. 44, 271.

Hönigschmied, J. 1877. Leichenexperimente über die Zerreissungen der Bänder im Sprunggelenk mit Rücksicht auf die Entstehung der indirecten Knöchelfracturen. Deutsche Ztschr. f. Chir. 8, 239.

Iselin, M. & *de Vellis, H.* 1961. La primauté du péroné dans les fractures du coude-pied. Mém. Acad. chir. 87, 399.

Jergesen, F. 1959. Open reduction of fractures and dislocations of the ankle. Am. J. Surg. 98, 136.

Kett, K., Aichner, H. & *Wesseli, E.* 1965. Der Einfluss der Reposition des Malleolus lateralis bei der Behandlung bimalleolären Knochenbrüche. Monatsschr. Unfallh. 68—2, 82.

Kleiger, B. 1956. The mechanism of ankle injuries. J. Bone Jt. Surg. 38 A, 59.

Kleiger, B. 1961. The treatment of oblique fractures of the fibula. J. Bone Jt. Surg. 43 A, 969.

Klossner, O. 1962. Late results of operative and non-operative treatment of severe ankle fractures. Acta chir. scand. Suppl. 293.

Kristensen, T. B. 1949. Treatment of malleolar fractures according to Lauge Hansen's method. Preliminary results. Acta chir. scand. 97, 362.

Kristensen, T. B. 1956. Fractures of the ankle. VI. Follow-up studies. A. M. A. Arch. Surg. 73, 112.

Küntscher, G. 1956. Zur Behandlung der schweren Verrenkungsbrüche des oberen Sprunggelenkes. Monatsschr. Unfallh. 59, 295.

Lambotte, A. 1912. The operative treatment of fractures. Brit. M. J. 4, 1530.

Lane, W. A. 1912. Method of procedure in operations on simple fractures. Brit. M. J. 4, 1532.

Lance, E. M. & *Wade, P. A.* 1965. The operative treatment of fracture-dislocation of the ankle joint. Clin. Orthop. 42, 37.

Lange, M. 1933. Über die Behandlung in schlechter Stellung geheilter Knöchelbrüche. Ztschr. Orthop. Chir. Beilageheft 58, 517.

Lauge Hansen, N. 1942. Ankelbrud. I. Genetisk diagnose og reposition. Diss. Munksgaard, København.

Lauge Hansen, N. 1949. "Ligamentous" ankle fractures. Acta chir. scand. 97, 544.

Lauge Hansen, N. 1954. Fractures of the ankle. III. Genetic roentgenologic diagnosis of fractures of the ankle. Am. J. Roentgenol. 71, 456.

Lauttamus, L. & *Solonen, K. A.* 1965. Treatment of malleolar fractures. Acta orthop. scand. 36, 321.

Lee, H. G. & *Horan, T. B.* 1943. Internal fixation in injuries of the ankle. Surg. Gynec. Obstet. 76, 593.

Leonard, M. H. 1949. Injuries of the lateral ligaments of the ankle. A clinical and experimental study. J. Bone Jt. Surg. 31 A, 373.

Lewis, R. W. & *Graham, W. C.* 1940. Secondary osteo-arthritis following fracture of the ankle. Am. J. Surg. 49, 210.

Lindblom, K. 1952. Arthrography. J. Fac. Radiol. 3, 151.

Magnusson, R. 1944. On the late results in non-operated cases of malleolar fractures. I. Fractures by external rotation. Acta chir. scand. Suppl. 84.

Magnusson, R. 1965. Ligament injuries of the ankle joint. Acta orthop. scand. 36, 317.

Maisonneuve, J. G. 1840. Recherches sur la fracture du péroné. Arch. gén. méd. 7, 165 & 435. (Quoted by Bonnin.)

de Marneffe, R. 1955. Indications du traitement orthopédique ou chirurgical dans les fractures malléolaires fermées. Acta chir. belg. 54, 411.

Mau, H. 1959. Die Osteochondrosis dissecans und freie Körper des Sprunggelenkes. Ztschr. Orthop. 91, 582.

Mc Laughlin, H. L. 1959. Injuries of the ankle. In: Trauma. W. B. Saunders Company, Philadelphia.

Mc Laughlin, H. L. & *Ryder, C. T.* 1949. Open reduction and internal fixation for fractures of the tibia and ankle. S. Clin. North America 29, 1523.

Menelaus, M. B. 1960. Injuries of the anterior inferior tibio-fibular ligament. Australian & New Zealand J. Surg. 30, 279.

Meyers, M. H. 1957. Fracture about the ankle joint with fixed displacement of the proximal fragment of the fibula behind the tibia. J. Bone Jt. Surg. 39 A, 441.

Meyers, M. H. 1965. Fracture about the ankle joint with fixed displacement of the proximal fragment of the fibula behind the tibia. Clin. Orthop. 42, 67.

Müller, G. M. 1945. Fractures of the internal malleolus. Brit. M. J. 2, 320.

Navarre, M. 1962. À propos des lésions du ligament latéral interne dans les fractures dites isolées de la malléole externe. Acta orthop. belg. 28, 138.

Nisbet, N. W. 1954. Dome fracture of the talus. J. Bone Jt. Surg. 36 B, 244.

Nyström, G. 1944. A contribution to the treatment of fractures of posterior border of the tibia by malleolar fractures. Acta radiol. 25, 672.

Palmer, I. 1941. Fotledens skador. En översikt. Nord. med. 12, 3167.

Palmer, I. 1944. Arthritis deformans, etiologi och behandling. II. Frakturer och arthrosis deformans. Nord. med. 21, 103.

Palmer, I. 1946. Operativ behandling av syndesmosruptur vid fotledsskador. Nord. med. 29, 349.

Palmer, I. 1950. Malleolarfrakturer och deras behandling. Nord. med. 4, 1593.

Palmer, I. 1962. Öppen behandling av frakturer och ledskador. Almquist & Wiksells Bokförlag, Stockholm.

Pennal, G. E. 1943. Subluxation of the ankle. Canad. M. A. J. 49, 92.

Perthes. 1924. Die hintere Luxationsfraktur im Sprunggelenk. Zentralbl. Chir. 51, 2267.

Picaud, A. J. 1953. Reflexions à propos d'un traitement chirurgical simple des fractures récentes de la cheville. Rev. chir. orthop. 39, 570.

Picaud, A. J. & *Poucel, J.* 1952. D'un traitement chirurgical simple des fractures de la cheville. Marseille chir. 4, 253.

Picaud, A. J. & *Poucel, J.* 1957. Un procédé simple et de sécurité de réduction et contention des fractures de la cheville. Marseille chir. 9, 316.

Picot, G. 1923. L'intervention sanglante dans les fractures malléolaires. J. Chir. 21, 529.

Portis, R. B. & *Mendelsohn, H. A.* 1953. Conservative management of fractures of the ankle involving the medial malleolus. J. A. M. A. 151, 102.

Proctor, H. 1954. Lateral rotation fracture dislocation of the ankle. J. Bone Jt. Surg. 36 B, 148.

Quenu, E. 1907. Du diastasis de l'articulation tibio-péronière inférieure. Rev. chir. Paris 1, 897 & 36, 62. (Quoted by Lauge Hansen.)

Quigley, T. B. 1959. Fractures and ligament injuries of the ankle. Am. J. Surg. 98, 477.

Ray, R. B. & *Coughlin, E. J.* 1947. Osteochondritis dissecans of the talus. J. Bone Jt. Surg. 29, 697.

Rehn, J. 1953. Die Osteosynthese nach Danis. Arch. klin. Chir. 276, 234.

Reimers, C. 1953. Die Brüche des fussnahen Unterschenkelabschnittes. Arch. klin. Chir. 276, 260.

Rezek, J. 1958. Die Arthrographie. Fortschr. Geb. Roentgenstrahlen 89, 319.

Rose, G. K. 1962. Ankle injuries. In: Modern Trends in Orthopaedics, vol. 3, p. 155. Butterworks & Co Ltd, London.

le Roy, M. 1887. De la fracture marginale antérieure de la malléole externe. Thèse de Paris. (Quoted by Lauge Hansen.)

Rudberg, N. 1953. Om fibulaosteosyntes som hjälpmedel vid behandling av vissa fotledsfrakturer. Nord. med. 49, 150.

Ruth, J. C. 1961. The surgical treatment of the fibular collateral ligaments of the ankle. J. Bone Jt. Surg. 43 A, 229.

Rubin, G. & *Witten, M.* 1960. The talar-tilt angle and the fibular collateral ligaments. J. Bone Jt. Surg. 42 A, 311.

Rödén, S., Tillegård, P. & *Unander-Scharin, L.* 1954. Osteochondritis dissecans and similar lesions of talus. Acta orthop. scand. 23, 51.

Scuderi, C. & *Schrey, E. L.* 1950. Posterior lipping fractures of tibia involving the ankle mortise. Etiology, pathology and treatment. Illinois M. J. 97, 310.

Sigel, A. 1951. Unterteilung und Behandlung der Verrenkungsbrüche des oberen Sprunggelenkes mit Abscherung eines hinteren Schienbeinbruchstüches (sog. Volkmannsches Dreieck). Arch. orthop. u. Unfall-Chir. 44, 341.

Soeur, R. 1961. La classification des fractures malléolaires. Son importance pour le traitement. Acta orthop. belg. 27, 537.

Soeur, R. 1963. Les fractures malléolaires. Acta orthop. belg. 29, 85.

Sprengell, H. 1942. Zum operativen Befestigen abgebrochener Knochenenden. Arch. orthop. u. Unfall-Chir. 41, 367.

Staples, O. S. 1960. Injuries to the medial ligaments of the ankle. J. Bone Jt. Surg. 42 A, 1287.

Staples, O. S. 1965. Ligamentous injuries of the ankle joint. Clin. Orthop. 42, 21.

Stevens, D. B. 1964. Postoperative orthopaedic infections. J. Bone Jt. Surg. 46 A, 96.

Stimson, L. A. 1892. Pott's fracture at the ankle. New York J. Med., p. 702. (Quoted by Lauge Hansen.)

Strömberg, N. 1939. Preliminärt meddelande om resultaten av en klinisk-röntgenologisk efterundersökning av malleolarfrakturer. Nord. med. 3, 2957.

Sturzenegger, H. 1954. Über die Behandlung der lateralen Malleolarfraktur mit Subluxation des Talus. Schweiz. med. Wchnschr. 84, 1313.

Stören, G. 1964. Conservative treatment of ankle fractures. Follow-up of 99 fractures treated conservatively. Acta chir. scand. 128, 45.

Torppi, P. 1954. Osteosynthesis of medial malleolus by using a loop of steel wire. Ann. chir. et gynaec. Fenniae 43, 451.

Trojan, E. 1954. Die Behandlung der Knöchelbrüche mit Abscherung eines grossen hinteren Schienbeinkeiles. Ztschr. Orthop. 84, 636.

Wahlheim, T. 1937. Intraarticular malleolar fractures. A survey. Acta chir. scand. 79, 166.

Vasli, S. 1957. Operative treatment of ankle fractures. Acta chir. scand. Suppl. 226.

Watson-Jones, R. 1955. Fractures and joint injuries. Ed. 4, E. & S. Livingstone Ltd. Edinburgh & London. Vol. 2.

Weber, B. G. 1966. Die Verletzungen des oberen Sprunggelenkes. In: Aktuelle Probleme in der Chirurgie, 3. Verlag Hans Huber, Bern und Stuttgart.

Willenegger, H. 1953. Fragen der operativen Frakturenbehandlung. Arch. klin. Chir. 276, 173.

Willenegger, H. 1961. Di Behandlung der Luxationsfrakturen des oberen Sprunggelenkes nach biomechanischen Gesichtspunkten. Helvet. chir. acta. 28, 225.
Willenegger, H. & *Weber, B. G.* 1963. Malleolarfrakturen. In: Technik der operativen Frakturenbehandlung. Springer-Verlag, Berlin /Göttingen/ Heidelberg.
Wilson, F. & *Skilbred, A.* 1966. Long-term results in the treatment of displaced bimalleolar fractures. J. Bone Jt. Surg. 48 A, 1065.
Wolff, A. 1940. Artrografi av ankelled. Nord. med. 8, 2449.
Zuelzer, J. A. 1951. Fixation of small but important bone fragments with a hook plate. J. Bone Jt. Surg. 33 A, 430.