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FROM THE DEPARTMENT OF SURGERY
(HEAD: CURT FRANKSSON, M.D., PROFESSOR)
SERAFIMERLASARETTET, AND THE DEPARTMENT OF CLINICAL
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SUBCUTANEOUS PARTIAL RUPTURE OF THE ACHILLES TENDON

by

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Translated from the Swedish

by

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To Monna

Contents

Preface

Achilles heel — the athlete's vulnerable spot — gave the impulse to this investigation.

Curt Franksson inspired, criticized, and set the pace from start to finish.

Lennart Widén encouraged me and provided facilities for the neurophysiological examinations.

Anders Persson carried out the electromyographic examinations and analysed these and the operative findings.

Erik Lindgren interpreted the X-ray findings.

Hans Nordenstam analysed the histological material.

Torgny Sjöstrand encouraged and supported the work.

Stefan Jacobson's, Elin Köpman's, and Bertil Wallerman's photographic skill lent colour and shape to the work.

Lars Glassér's old Dalecarlian country-house provided an inspiring and peaceful working-place.

The investigation was supported financially by Folksam Insurance Company and the "Poliklinikkommittén" of the Swedish Sports Federation.

Thus, it was possible to carry out the work reported in the following.

Introduction

Subcutaneous partial rupture of the Achilles tendon has been regarded as an uncommon injury (see the following). In a short period of time, however, the author has diagnosed this condition relatively often. The object of this investigation was to throw light on the nature of the injury and to present a new method (by electromyography) for diagnosing the condition.

Definition

Subcutaneous partial rupture of the Achilles tendon refers here to a tear involving a varying number of fibres in the free portion of the Achilles tendon, usually leaving most fibres intact. To distinguish clinically a partial rupture from a complete rupture is not difficult, because plantar flexion of the foot does not occur on Thompson's test (1960) — manual compression of the triceps-surae belly — if the rupture is complete. Absence of this reflex is pathognomonic for complete rupture of the Achilles tendon.

The Achilles tendon is formed by the fusion of fibres from the medial and lateral bellies of the gastrocnemius and the soleus. The partial rupture of the tendon can involve a greater or smaller section of

1) the medial portion of the tendon
2) the lateral portion of the tendon
3) the central or the soleus portion of the tendon
4) all three portions of the tendon, as in some central ruptures, but most of the tendon fibres remaining intact.

Histologically, the partial rupture is characterized by devitalized tendon tissue with frayed fibrous structure, and around these areas granulation tissue, which, according to the age of the rupture, is transformed into more or less tendon-like connective tissue.

History

Complete subcutaneous rupture of the Achilles tendon was first described by Paré in 1575 and has since been described by several authors, for instance Petit in 1724, af Acrel in 1759, and Arner & Lindholm in 1959. The last-named authors presented a study of 92 patients operated on for subcutaneous Achilles-tendon rupture, which was complete in all the cases. They hold that isolated partial rupture of the free portion of the Achilles tendon does not occur or is, at least, extremely rare.

Arner & Lindholm (1959) state that of all the published cases of so-called partial rupture which were explored operatively only one (Kolb & Salem 1953) could, from the functional standpoint, possibly be regarded as partial. On the basis of his observations in a series of 240 cases from the Böhler Clinic in Vienna, all being cases of complete Achilles-tendon rupture, Schönbauer (1955, 1966) questions the existence of the partial rupture.

Kolb & Salem (1953) report 2 cases of Achilles-tendon rupture treated by operation; in one case the rupture involved half the tendon. The rupture may possibly be judged as partial in the other case as well. According to Kolb & Salem, the reason why only a small number of partial ruptures have been described would be that, because of the clinical methods of examination, a difference between "strain" — "zerrung" — and partial rupture of the tendon cannot be definitely established. They also state that it is difficult to diagnose a partial rupture clinically. Ignorance of this injury, however, can lead to deterioration or complete rupture, as a result of unsuitable treatment (forced exercise, massage).

Wedel (1954) and van de Kamp (1954) each described a case of partial Achilles-tendon rupture. In Wedel's case there was a medial intact tendon remnant, the "thickness of a wool thread", 2 mm in thickness. Schönbauer (1955) believes that both cases were misinterpreted and that in both of them the intact portion of the tendon consisted of the plantaris tendon, which, according to Alker (1957), can descend medial as well as in front of, behind, and lateral to the Achilles tendon.

In 1960 Solheim reported a series of 76 cases of complete and 1 case of partial rupture; the latter was initially treated conservatively for 5 months

without any effect. Operation revealed a rupture of half the tendon with calcium deposits. In 1964 Lanz described a case of partial spontaneous transverse rupture of the Achilles tendon, 2 cm above the insertion, in a 62-year-old woman. He also discussed the question whether or not the Achilles tendon always ruptures completely. In Lanz's opinion, the diagnoses in the published cases of partial rupture treated conservatively cannot be regarded as confident and he considers that the sporadic cases treated operatively and published as partial ruptures must be viewed very critically. According to Baetzner (1957), individual bundles of tendon fibres can rupture at different levels and thus simulate partial ruptures. Lanz considers that exposure of the whole tendon is necessary in order to prove that a true partial rupture has occurred.

Present series

The series comprises 24 patients who over the 4-year period 1964—1967 were examined for Achilles-tendon injuries at the Department of Surgery and the Physiotherapy Department at Serafimerlasarettet in Stockholm (Tables I—III) and who had undergone operation for the injury at least 1 year previously (see below).* It will be seen from Tables II and III that all the patients, excluding one (no. 3), engaged in some form of sport. The explanation of this is that the author is physician to the Swedish Amateur Athletic Association and to football and ice-hockey teams of top-class players. In this capacity I came into direct contact with 13 patients. The other 11 were referred to me because of my interest in sports injuries; 6 patients were referred from hospital physicians or private practitioners in the Stockholm area and 5 from hospital physicians outside the Stockholm area. Nine cases were by the referring physician diagnosed as "achillotendinits" and 2 as rupture of the gastrocnemius muscle.

The distribution by sex and age is shown in Table I. It will be seen that there is only one woman (case 9). The patients can be divided into a lower age-group of 19—29 years, including champion athletes alone (Table II)

TABLE I

Age and sex distribution

Age (years)	Men	Women	Total
19	1	0	1
20—29	10	0	10
30—39	1	0	1
40—49	8	0	8
50—59	1	1	2
60—65	2	0	2
Total	23	1	24

* I have operated upon a further 15 patients, but as the observation period in these cases is less than 1 year, they are not included here.

TABLE II

Champion athletes

Case no.	Age yr	Occupation and branch of sport	Causal violence	Interval between rupture and operation
1	24	Engineer, medium-distance runner	Spurt in a 3000-metre race	6 months
2	25	Policeman, skier	Excessive weight-bearing on foot in grappling with a drunkard	1 month
4	29	Engineer, ice-hockey player	Pulled up suddenly at ice-hockey	7 weeks
6	29	Electrician, footballer	Tripped over at work	8 months
14	24	University student, long-distance runner	Barefoot running	6 months
15	22	Buyer, hurdler	Slipping	4 months
18	27	Farmer, long-distance runner	Spurt in a 10,000-metre race	5 days
19	28	Engineer, cross-country runner	Tripped over tree-root	12 months
22	22	Student of technology, sprinter	Violent push-off at a 100-metre race	3 months
23	23	Gymnastics master, medium-distance runner	Training; pressure of shoe stiffener	6 months
24	19	Office clerk, medium-distance runner	800-metre race on wooden floor	8 months

and a higher age-group of 38—65 years, comprising various kinds of athletes* (Table III). The latter group includes the only patient who was not an athlete (case 3) but who was physically very active.

The following intervals had elapsed between operation and examination:

1 year — 11 cases
2 years — 10 cases
3 years — 3 cases

* In the following the term "athlete" will refer to a person who performs strenuous physical exercise 2—3 times a week.

TABLE III

*Athletes**

Case no.	Age yr	Occupation and branch of sport	Causal violence	Interval between rupture and operation
3	46	Electrician	a) Blow of reinforcing iron bar b) Stumbled on a wooden board	18 months (partial) 2 days (complete)
5	42	Engineer, skier	Sudden push-off in the cold	12 months
7	51	Carpenter, footballer	Joggling after training	12 months
8	40	Electrical fitter, orienteerer, skier	Cycling uphill	14 months
9	54 ♀	Engineer, cross-country runner, gymnast	Slipped during cross-country running in the mountains	6 weeks
10	65	Colonel, walking	Slipped on kerb	2 weeks
11	44	District manager, allround orienteerer	Tripped over on kerb	7 weeks
12	42	Manager, cyclist, skier	Caught foot; butted on calf by ram	5 months
13	38	Engineer, handball player	Handball match	10 weeks
16	63	Foreman, athlete	a) Physical exercises b) Jumped to dodge traffic on crossing street	7 weeks 4 weeks
17	47	Engineer, allround sportsman, orienteerer, skier	a) 1500-metre run b) Skiing	10 years? 2 months
20	43	Bank clerk, orienteerer	Cross-country race	9 months
21	45	Taxi driver, track-and-field athlete	a) Road race b) Football c) 400-metre run	7 months 2 months 1 day

Occupation and form of athletics will be seen from Tables II and III. A striking fact is that heavy manual labour is represented by only 2 cases (farmer and carpenter) as against white-collar and similar occupations by 22 cases.

The branches of athletics are mostly of the track-and-field type, cross-country running, orienteering, and skiing, all of which call for greater fitness and require more intense and lengthy running practice with resulting greater strain on the Achilles tendon. Team sports (football, ice-hockey, handball) are represented by only 3 cases.

In view of the fact that diminished perfusion with impaired oxygen supply to the tendon tissue has been discussed as a causative factor in devitalization of the Achilles tendon (Wuscheck, Kempe & Arent 1966), the haemoglobin values were studied and the following results were obtained:

Hb =	· 11.9 g per 100 ml	2 cases
	12.7—13.9 g per 100 ml	6 cases
	14.0—15.0 g per 100 ml	15 cases
	16.7 g per 100 ml	1 case

It will be seen that the haemoglobin value was below the lower limit of normal range — 12.0 g per 100 ml — in 2 cases (nos. 17 and 18).

Aetiology

Subcutaneous rupture of the Achilles tendon has been attributed to pathological processes in the tendon tissue and/or trauma. Rupture of a pathologically changed tendon can result from insult, which is so slight that the patient himself does not notice it, so-called spontaneous rupture (Christensen 1954). Several authors, from Friaques (1891) to Boyd (1945), have described numerous factors that lower the strength of the tendon, such as syphilis, gonorrhoea, tuberculosis, uratic arthritis, and pyogenic infections. Other causes are tendinitis, suggested by Malbec (1935) and Silfverskiöld (1941), and tumours and cysts, by Christensen. Repeated minor traumata, particularly in certain occupations, would also lead to rupture of the small vessels with accompanying impaired circulation, which could predispose to later ruptures (Albrecht 1925, Bate 1951, Wachs 1951, Borsay 1952). Oral steroid treatment (Lee 1961, Gjone 1962, Melmed 1965, and others) and local steroid injections in connection with trauma (Lee 1957) have also been discussed as aetiological factors.

Of the above-listed causal factors, steroid injections and trauma played a part in the present series of cases.

Steroid injections

Since Hollander (1951) published his work on the beneficial anti-inflammatory effect of locally injected hydrocortisone in bursitis and tendinitis, this treatment has been widely used in achillotendinitis, not least in sports injuries. Wrenn, Goldner & Markes (1954), in an experimental study on dogs, report on the effect of cortisone on the healing process and the tensile strength of the tendon after severing of the tendon and subsequent suturing. They found that daily intramuscular administration of 10 mg of cortisone per kg body-weight for 3 weeks prevented excessive formation of peritendinous fibrous tissue, but it did not prevent end-to-end healing of the tendons. On weight-bearing exercise it was found that the strength in the sutured area of the tendon was consistently lower than in the control cases. Although the tendon, treated with cortisone for 3

weeks, was 40 % weaker than in the controls, the healing in both the cortisone and the control group was adequate for normal tendon function.

Asboe-Hansen (1956) and Zachariae (1966), in studies of the local effect of corticosteroids, emphasize that these drugs inhibit new formation of connective tissue and produce an anti-inflammatory effect, but may cause increased degeneration and necrosis of the tissues.

Only in 3—4 of the published cases of partial subcutaneous rupture of the Achilles tendon can the diagnosis probably be regarded as confident. As my material from the Department of Surgery at Serafimerlasarettet over the period 1964—1966 includes 24 cases of partial rupture, the question arises whether these could be complications of local steroid treatment of achillotendinits, this treatment being relatively widely used during this period of time. The series has therefore been analysed with respect to the number of local steroid injections before and after the occurrence of suspected rupture and the interval of time between injection and rupture (Table IV).

It will be seen from Table IV that intra- or peritendinous corticosteroid injection had been given:

Before rupture	6 cases
Before and after rupture	4 „
After rupture	8 „
Neither before nor after rupture	6 „

Accordingly, 14 patients had not received any steroid injection before the rupture. Out of the 10 patients who had been given local steroid injection before the rupture 2 (nos. 5 and 6) had received one injection about 1 year before the rupture and had had no trouble from the Achilles tendon during this period of time, in spite of intense activity. It is therefore hard to believe that the injection in these cases could have been of any aetiological significance. In Cases 2, 4, 10, 19, 21, and 23 the injection which caused relief of symptoms was given 2—4 months before the partial rupture. In at least 4 of these cases the local symptoms present at the time of the injection were in a part of the tendon other than the site of rupture. Patients nos. 11 and 23 received one steroid injection 5 and 6 weeks, respectively, before the injury and were free from symptoms until they sustained the rupture.

Histological examination of the surgical cases showed no difference in the picture between the steroid-treated and the non-steroid-treated patients, with the possible exception of Case 22, in which the devitalized tendon tissue was found to contain a few small defined necrotic areas with

TABLE IV

Corticosteroid treatment in partial ruptures of Achilles tendon

Case no.	Diagnosis	Before rupture		After rupture	
		Number of steroid injections	Interval between injection and rupture	Number of steroid injections	Interval between rupture and injection
1	Tendinitis	0	—	1	3 months
2	Tendinitis	2	3 months	0	—
3	Tendinitis	0	—	3	6 months
4	Tendinitis	2	2 months	0	—
5	Tendinitis	1	1 year	9	2 weeks
6	Tendinitis	1	1 year	1	3 weeks
7	Tendinitis	0	—	2	1 week
8	Tendinitis	0	—	9	1 week
9	Partial rupture	0	—	0	—
10	Tendinitis	1	4 months	0	—
11	Tendinitis	1	6 weeks	2	11 days
12	Partial rupture	0	—	0	—
13	Partial rupture	0	—	0	—
14	Achillobursitis	0	—	3	2.5 months
15	Tendinitis	0	—	1	3 months
16	Tendinitis	0	—	5	10 day
17	Partial rupture	0	—	0	—
18	Partial rupture	0	—	0	—
19	Tendinitis	1	11 months		
		1	3 months	1	2 weeks
20	Partial rupture	0	—	0	—
21	Tendinitis	2	2 months	0	—
22	Tendinitis	1	5 weeks	0	—
23	Tendinitis	1	3 months	0	—
24	Tendinitis	0	—	1	10 days

a suggestion of dystrophic calcification. The appearance of parts of the areas resembled that of thopus.

It will be seen from the above account that just over half the patients had not received steroid injections before the rupture. In the rest, the time-relationships, among other factors, argue against the possibility that the steroid injections would have been of direct aetiological significance. They might have played a part by relieving the patient of the symptoms attending a small rupture or some other injury of the Achilles tendon, and so allowed increased weight-bearing on the tendon, thus being concerned in causing the clinically manifest rupture.

Trauma

The Achilles tendon can be ruptured by direct or indirect violence. It is believed that rupture can occur when the violence is applied at right angles to a tense tendon (Kolb & Salem). Indirect violence is considered to be the more common cause. Arner & Lindholm, in analysing the causes of complete rupture, distinguished between three main types of indirect violence:

1) Pushing off with the weight-bearing forefoot flexed in a plantar direction while extending the knee joint, for instance at the start of a sprint, in running, and in some types of jumps. In this coordinated movement the calf muscle is maximally contracted;

2) Sudden and unexpected violent dorsiflexion of the ankle when the foot is in an intermediate position, for instance in slipping on a stair, or stumbling into a hole; the patient falls forward and the heel sinks down suddenly. In this type of violence the calf muscle is usually moderately contracted and becomes maximally contracted in the sudden reflected and uncontrolled movement;

3) Violent dorsiflexion of the foot flexed in a plantar direction, for instance on jumping or falling from a height. The calf muscle is strongly contracted and the sudden violence to the foot leads to marked stretching of muscle and tendon.

The Achilles tendon, being one of the strongest tendons of the body, takes a load of about 240 kg at ordinary walking and of about 600 kg at running. The load may amount to 900 kg at very swift running (Carlsöö 1968). Arner, Lindholm & Orell (1959), in their series of 74 cases of complete rupture examined histologically noted degenerative changes in the tendon in all the cases, even in those of the patients operated on only a few hours after the injury (see also Davidsson 1956). They attributed the histological changes to impaired blood supply. Angiographic and microangiographic studies by Lagergren & Lindholm (1959) have shown that the most frequent site of rupture of the Achilles tendon is the segment least vascularized, namely 2—3 cm above the insertion of the tendon. Arner & Lindholm give the following explanation of the Achilles-tendon rupture: Training and increased activity of a muscle lead to hypertrophy and increased vascularisation of muscular tissue (Petrén, Sjöstrand & Sylvén 1936), and probably also of tendon tissue, during an athlete's active years. If these are followed by inactivity, degenerative changes will occur in the tendon tissue with resulting impaired tensile strength. Ricklin (1962) states that the elasticity diminishes rapidly after age 30, with progressing

obliteration of the vessels of the tendon. Degeneration and fragmentation of the tendon fibres will reduce the tensile strength of the tendon.

Ricklin also maintains that in highly active athletes exhaustion is a factor that plays an important part in causing structural changes in the Achilles tendon with resulting greater tendency to rupture. A comparison is inevitably made with the insufficiency fractures of the fibula, which are largely on the same level as the Achilles-tendon ruptures and which occur relatively often in champion athletes during periods of hard training. As regards the aetiology of these fractures, they have been attributed, for instance, to a change in the submicroscopical bone crystals and dissolution of the tissue connecting them (Henschen 1936).

On the basis of Cummins' (1949) observation that the tendon fibres from the gastrocnemius and the soleus converge as the descend, while rotating, toward the insertion on the calcaneus, Christensen (1954) suggested that in running and jumping there occurs a saw-like friction between the tendon fibres, especially in persons in whom there is not satisfactory coordination between the three muscle-tendon portions. This would explain why the tendon often ruptures in untrained athletes.

Present series

The series of cases of partial rupture of the Achilles tendon, numbering altogether 24, can be divided into two groups, one comprising 11 active champion athletes between 19 and 29 years old, who were training almost daily all the year round. The other group consisted of 13 athletes, including one woman, whose ages ranged from 38 to 65 years. The majority of the latter group had never given up sports completely. Several of them were still very active, taking part in, for instance, orienteering races and the Vasa Ski Race (skiing competition over a distance of 85 km).

The first group cannot be regarded as representative of Arner & Lindholm's theories, as all of them were in their most active period of athletics. Four were, or had recently been, members of the Swedish international athletic team, the youngest one, 19 years old, being a member of the junior team and considered to be one of our most promising medium-distance runners. The others were champion ice-hockey players, footballers, and track-and-field athletes — medium-distance and long-distance running. The mean age was 25 (24.8) years. It was of course difficult to establish the exact time that had elapsed between the injury and the operation at which specimens for histological examination were taken, as some of the patients reported several injuries. In one case, however, the exact interval of 5 days could be established. After careful history-taking and analyses

of the reported traumata, the approximate time interval could be fairly well ascertained.

Some data in the most active group are set out in Table II. Table III shows data from the athlete group, but it should be noted here that most of these patients had, in fact, never given up sports entirely.

In those cases in which a long time had elapsed between the injury and the author's first examination of the patients, it was difficult to establish the nature of the trauma. With due reservations, the distribution of the causal violence, according to the Arner-Lindholm scheme (their group 3 not being represented), can be listed as follows:

Group 1	*14 cases*
(start of sprint, running)	(nos. 1, 2, 5, 7, 8, 13, 14, 16, 17, 20, 21, 22, 23)
Group 2	*10 cases*
(slipping)	(nos. 3, 4, 6, 9, 10, 11, 12, 15, 18, 19)

The series includes one case in which direct violence was applied to the tendon. In the rest of the cases the patients were able to specify one or several similar types of indirect violence as the cause of the rupture.

Pathology and pathogenesis

The histological changes in subcutaneous complete rupture of the Achilles tendon have been described earlier by, for instance, Kolb & Salem in 1953 (6 cases), Davidsson in 1956 (5 cases), Orell in 1958 (14 cases) and Arner, Lindholm & Orell in 1959 (74 cases). The last-named authors found characteristic degenerative and necrobiotic changes in the tendon tissue in all their cases (see page 20).

Own investigations*

The histological findings are recorded in Table V. The *champion* group (Table II) includes one patient (no. 18) with a partial rupture that was examined only 5 days after the injury. Gross examination showed relatively extensive haemorrhage along the rupture ends. The histological picture of the resected rupture ends was that of devitalized tendon tissue with altered collagen stainability and non-stainable endoplasm areas. Minimal inflammatory cell infiltration was seen in a few places around the vessels as well as slight fibrin exudation. There were virtually no formation of granulation tissue and no signs of newly formed tendon-like granulation tissue.

In the rest of the patients in the champion group — irrespective of the time interval between injury and operation — the histological examination of the resected rupture ends showed partially devitalized tendon tissue with obliterated fibrin structure and in places fraying of the collagen bundles, altered stainability and decolourized poorly stainable or non-stainable endoplasm areas. To the devitalized tendon tissue were attached fine or coarse streaks of loose granulation tissue, rich in collagen and of a thin wavy structure that deviated from the collagen structure of normal tendon tissue. The tendon-like granulation tissue in cases 6 and 19, in which the time interval between injury and operation was 12 months and 8 months, respectively, was highly vascularized and inflammatory infiltrates were seen around the vessels; in some places there were also

* The histological examinations were carried out in cooperation with Hans Nordenstam, prosector at the Department of Pathology, Serafimerlasarettet.

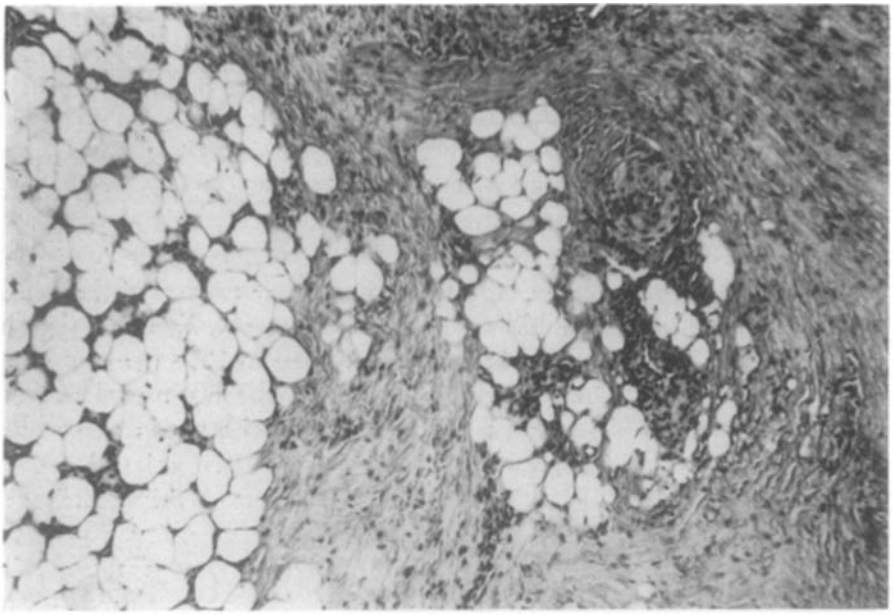

Fig. 1. Transition from peritendinous fatty tissue to newly formed granulation tissue. Areas of chronic cell infiltration. (Haemotoxylin and eosin, x95.)

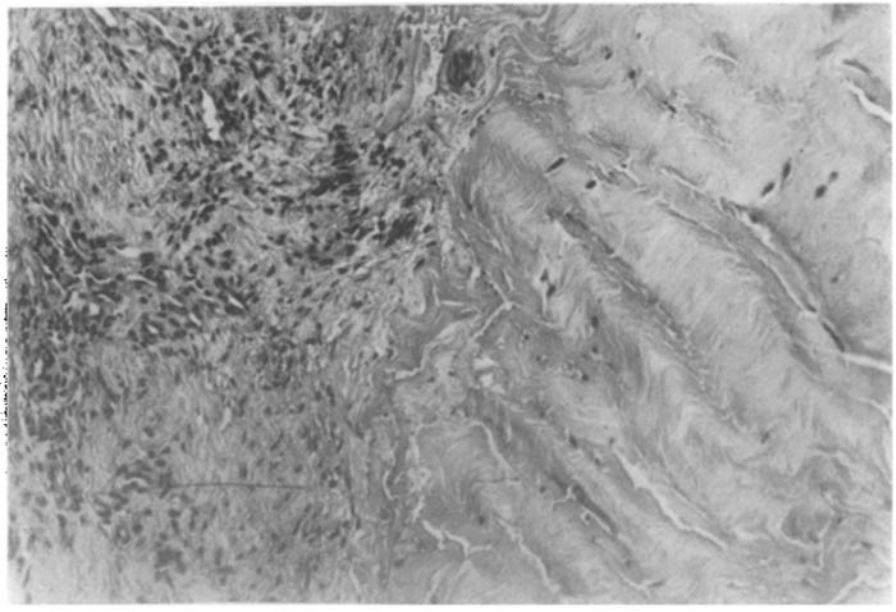

Fig. 2. Transition from devitalized tendon tissue to surrounding sclerosed granulation tissue Sparse inflammatory cell infiltration. (Haemotoxylin and eosin, x95.)

Fig. 3. Devitalized tendon tissue, partly with complete absence of stainable cell nuclei. Fraying of collagen structure. (Haemotoxylin and eosin, x240.)

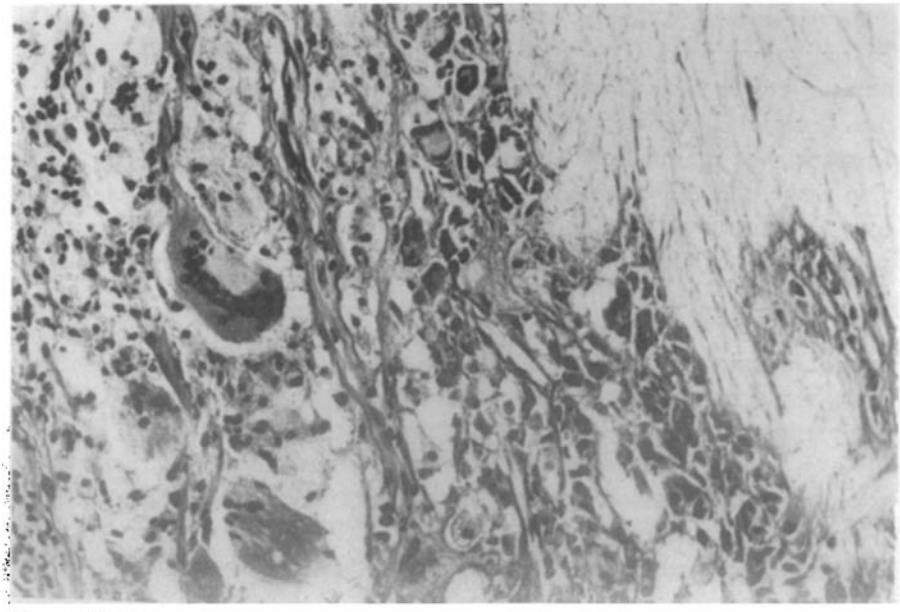

Fig. 4. Highly cellular granulation tissue, showing foreign-body reaction, adjoining an old necrotic area. (Haemotoxylin and eosin, x240.)

large areas of loose granulation tissue poor in collagen. Lymphomonocytic cell infiltration, mainly perivascularly, was seen in all the cases. The degree of inflammation was recorded as minimal to moderate. Some surfaces were coated with a fibrin-like albumin-containing mass (nos. 1, 14, 18, 23, and no. 12 in the athlete group).

In the two cases with the longest history (nos. 6 and 19) histological changes were also seen in the peritenon. The excised peritendinous tissue consisted of fatty tissue showing transformation into newly formed granulation tissue, fairly rich in collagen and of a wavy structure. Inflammatory changes were seen around the vessels. There was no true tendon-sheath structure. No synovial membrane was visible. The picture resembled mainly that of peritenon with fatty tissue and newly formed granulation tissue of tendon-like appearance.

The histological findings in the *athlete group* (Table III) were largely consistent with those in the champion group, in that "the collagen fibres were in places interrupted by granulation tissue, which indicates that partial rupture must be present" (case 9).

In 4 cases (nos. 3, 11, 17, and no. 22 in the champion group) defined areas of necrosis were found in the devitalized tendon tissue. Suggested dystrophic calcification was noted in the necrotic areas. Parts of the areas were almost tophus-like in appearance (nos. 17 and 22).

In patient no. 17, who had a possibly 10-year-old rupture, a history of achillobursitis, and recurrent symptoms of trouble with the tendon 2 months before operation, histological examination showed not only the usual partial devitalization of tendon tissue but also profuse old and new formation of granulation tissue. Here and there, mainly in this granulation tissue, the collagen showed changes most closely resembling myxomatous degeneration. Foreign-body reaction was seen in these areas. This patient had not received any form of steroid therapy, nor any other specific treatment.

In view of the fact that several of the patients had earlier received local steroid injections and that in a few cases operation revealed a few yellowish white deposits in the peritenon, the specimens were also examined for the presence of foreign-body granulomas or deposits of foreign matter, but no such lesions were found in any of the cases. Analysis of the observed deposits at hormone and chemical laboratories did not show any steroid substance.

Inflammatory monolymphocytic cell infiltration perivascularly was seen in all the cases of this group, minimal in the fresh ruptures and more profuse in the older ones. Ingrowth of vessels was occasionally seen in the devitalized tendon remnant.

TABLE V

Gross and histological findings

Case no.	Macroscopically	Histologically						
		Devitalized tendon tissue	Granulation tissue		Inflammatory cell infiltration		Fibrin exudate	
			new	old tendon-like	acute	chronic		
1	xx	xx	x	xx		xx	xx	
2	xx	xx		xx		x		
3	xx	xx		xx		xx	x	N
4	xx	x	x	xx	x	xx	x	
5	(x)	xx		xx		x		
6	xx	xx		xx		x	x	
7	(x)	xx		xx		x		
8	xx	x	x	xx		xx		
9	(x)	xx	x	xx		x		
10	xx	xx	x	xx	x	xx		H
11	xx	xx	xx	xx	x	xx		N
12	xx	xx	x	xx		xx	xx	
13	(xx)	x		xx		xx		
14	(xx)	xx	x	xx	x	xx	xx	H
15	xx	x		xx		x		
16	xx	x		xx		x		
17	xx	x	x	xx	x	xx		N
18	xx	xx	x			x		
19	(xx)	xx	x	xx	x	xx		
20	(x)	xx		xx		x		
21	xx	xx	x	xx	x	xx		H
22	xx	xx	x	xx		x		N
23	x	xx	x	xx		x		
24	x	xx		xx		x		

( ) = Rupture not visible until after incision in tendon
N = Necrosis
H = Haemorrhage

Summary

The histological changes both in the champion group with a mean age of 25 years and in the athlete group with a mean age of 48 years were characterized by devitalized tendon tissue with altered collagen stainability, frayed fibrous structure to which attached granulation tissue converted into more or less tendon-like connective tissue. Newly formed granulation tissue was seen in 14 cases (see Table V). Old tendon-like

granulation tissue was found in all the cases, except no. 18 with a partial rupture of only 5 days' standing. In all the cases there was minimal to relatively profuse perivascular lymphomonocytic cell infiltration as evidence of post-traumatic inflammation.

Acute inflammatory cell infiltration was seen in 7 cases (nos. 4, 10, 11, 14, 17, 19, and 20) and chronic cell infiltration in all the 24 cases.

As regards the time for the histological changes to develop from the acute to the chronic stage, the limit can probably be fixed at about 7 days. After this time it was not possible to determine the age of the rupture. Chronic changes were the predominating histological findings throughout the series.

No vascular changes were demonstrated in the present cases.

In those cases in which the rupture ends are not distinctly visible macroscopically the histological changes associated with a partial rupture of the Achilles tendon may be defined as follows: Devitalization of the tendon tissue, in which the collagen fibres in places have been replaced by granulation tissue.

Symptomatology

Considering the pathology (see the foregoing), the patient would be expected to suffer tenderness over the rupture site and pain on weight-bearing. It will be seen from Table VI that swelling, tenderness, and pain on weight-bearing were, in fact, present in virtually every case. These symptoms occur, however, in several pathological conditions involving this region. The almost invariably experienced stabbing or pricking pain on suddenly increased activity and weight-bearing is more specific to the partial rupture. The pain is probably associated with stretching of the injured tissue.

Some patients complained of stiffness of the tendon in the morning and after they had been sitting still for a long time and also of occasional aching at rest. The stiffness was most marked in cases of fresh rupture and was then probably attributable to oedema and swelling of the ruptured area; in cases of older rupture there was also profuse formation of granulation tissue and adhesions to the peritenon.

In 17 of the present cases the patients complained of weakness of the calf and difficulties in rising on the toes or in controlling the foot when attempting to run. The feeling of weakness can be associated with the loss of function of parts of the muscle-tendon unit and varies with the extent of the rupture. The limiting effect of pain could also be a contributing factor.

The cause of the condition as stated by the patient was trauma, for instance slipping or the like, during athletic exercise (11 cases). Some of the patients regarded the injury as insignificant and not worth mentioning at the time; some had even forgoten all about it by the time they appeared for the first examination. But after careful questioning it was usually possible to discover some insult in the form of excessive weight-bearing. In most cases this had been accompanied by the afore-mentioned shooting, stabbing, pricking, or jarring pain or a sensation of being struck with a whip (23 cases). Some patients described the pain as intense but to many it appeared slight and at first of no importance.

In 8 cases the patients reported a sensation of snapping or tearing of the Achilles tendon. Such an experience is, in fact, consistent with the

TABLE VI

Subjective symptoms

Case no.	Tenderness	Stiffness	Feeling of weakness	Pain on weight-bearing	Sharp pain	Feeling of tear
1	x	x	x	x	x	x
2	x		x	x	x	x
3	x		x	x	x	
4	x	x	x	x	x	x
5	x	x		x	x	
6	x	x	x	x	x	
7	x		x	x	x	
8	x		x	x	x	
9	x		x	x	x	
10	x	x	x	x	x	x
11	x		x	x	x	
12	x		x	x	x	x
13	x		x	x	x	
14	x	x	x	x	x	
15	x			x	x	x
16	x	x	x	x	x	x
17	x	x	x	x	x	
18	x	x		x	x	x
19	x	x		x	x	
20	x	x		x		
21	x		x	x	x	x
22			x	x	x	
23	x			x	x	
24	x			x	x	
Total	23	11	17	24	23	8

true course of events. When distinct, it should give rise to strong suspicion of rupture.

In most cases the tendon injury did not interfere with the patient's work. Only patient no. 3, an electrician, suffered limitation of movement in his work, especially on climbing ladders, because of reduced muscular strength in the plantar flexors of the foot.

The objective symptoms are listed in Table VII. As, in most cases, they were not demonstrated before careful clinical examination, they will be described under that heading (see the following).

Diagnosis

As was mentioned earlier, many authors doubt the existence of partial rupture of the Achilles tendon. Kolb & Salem state, however, that tiredness and insignificant pain are often the only symptoms of partial rupture and that, therefore, the diagnosis is sometimes very difficult, if not impossible.

In the present series of cases the diagnosis was based on:

1) the case-history
2) clinical examination
3) X-ray examination
4) electrophysiological examinations.

The case-history

Data relating to the patient's physical activity are of importance to the diagnosis, as are information concerning lengthy periods of hard training on surfaces that lead to greater demands being placed on the Achilles tendon, such as hard icy roads, wooden floors, etc. Newly added items on the training programme and any injuries are analysed.

The subjective symptoms have been described in the foregoing (Page 29) and are shown in Table VI. The stabbing, jarring, or pricking pain in the Achilles tendon and the feeling of a tear or an audible snap in the region of the tendon give rise to strong suspicion of partial rupture of the Achilles tendon.

Clinical examination

The findings by clinical examination are set out in Table VII. On inspection of the tendon region with the patient standing erect, turning his back to the examiner, and with equal weight-bearing on both feet the injured tendon appeared locally or to the whole of its extent *increased in width* in 23 cases. *Ecchymoses* on the back of the heel extending below both malleoli were seen in the three cases in which the rupture had occurred 1—5 days before the examination. When the patient was standing

Fig. 5. Partial rupture of gastrocnemius component of left Achilles tendon. In the right uninjured leg the contracted gastrocnemius muscle bellies are distinctly seen; muscle tone normal on palpation. The injured leg shows no typical contraction of the gastrocnemius muscle bellies; palpable reduced muscle tone.

on tiptoe with equal weight-bearing on both forefeet, more or less distinct *muscle atrophy* was seen in 14 cases, in 3 involving the medial and in 6 the lateral gastrocnemius belly and in 5 being generalized atrophy of the triceps surae. The circumference of the calf was 1.5—2 cm less than that of the healthy leg. In all the cases in which distinct muscle atrophy was noted at the examination, palpation was believed to reveal reduced *muscle tone*

TABLE VII

Objective symptoms

Case no.	Increase in diameter of tendon plus tenderness on palpation	Defect in tendon contour	Induration of tendon	Muscle atrophy	Reduced muscle tone	Increased dorsal extension	Fluctuation
1	x	x	x	x	x		
2	x	x	x	x	x		
3	—		x	x	x	x	
4	x	x	x			(x)	
5	x		x	x	x	x	
6	x	x	x				
7	x		x	x	x	(x)	x
8	xx		x			x	
9	x		x				
10	x	x	x			x	
11	x		x	x	x	(x)	x
12	x	x	x	x	x	x	
13	xx	x	x			x	
14	x		x	x	x		
15	x		x	x	x	x	
16	x	x	x	x	x	x	
17	xx	x	x				x
18	x		x				
19	x		x	x	x		
20	x		x	x	x	(x)	
21	x	x	x				
22	x	x	x	x	x	(x)	
23	x		x				
24	x		x	x	x		
Total	23	11	24	14	14	8+(5)	3

( ) = < 5°

of the respective belly. Thompson's (1960) test performed with the patient standing on all fours elicited normal plantar flexion in all the cases, though with slightly reduced *muscular strength* in 2 cases when resistance was applied by the examiner's other hand. Increased *dorsal extension in the talocrural joint,* as a sign of lengthening of the muscle and tendon, was noted in several cases. Greatly increased dorsal extension (to 5—15° more

than normal) was present in 8 cases. It was noted in patients with ruptures that involved a relatively large section of the tendon and were of relatively long standing. An increase of dorsal extension to a few degrees more than normal was seen in 5 patients, but such an increase would be within the limits of normal differences in the range of movement between the right and the left ankle joint. With the weight-bearing at walking, etc., after a relatively deep-going partial rupture the thin remaining part of the tendon and its muscle portion will be gradually and increasingly stretched and permanently lengthened, which would explain the increase of dorsal extension.

Palpation of the Achilles tendon was done with the patient supine, the foot flexed in a plantar direction and the knee flexed, and with the patient lying prone or standing on his knees, the foot in mid-position, and standing on his toes. The tendon could thus be palpated right through, relaxed, moderately tense, and maximally tense. A *fusiform thickening* of the Achilles tendon was noted in 23 cases, over an area 2—6 cm (18 cases) and 6—10 cm (6 cases) above its insertion, and corresponding to the rupture site. The thickening involved the whole tendon in 4 cases, in some mainly the medial, the dorsal, or the lateral portion, with marked tenderness on palpation; in 3 cases there was distinct fluctuation. In all the patients (24 cases) palpation of the ruptured tendon revealed an indurated section that was firmer that the normally relatively soft elastic consistence of uninjured tissue. Suspected *dents or small defects* in the tendon contour were also palpated in 9 cases and some *irregularity* in the contour or the peritenon in 2 cases.

X-ray diagnosis

The Achilles tendon is surrounded by loose tissue, mostly fatty tissue, and can therefore be seen in a radiograph. The radiographic appearance of the "Kager triangle", described by Kager (1939), has been regarded as diagnostic of subcutaneous complete rupture of the Achilles tendon. Arner, Lindholm & Lindvall (1959) state that deformation of this triangle, which in lateral views is bounded by the Achilles tendon, the calcaneus, and the deep flexor tendons, is pathognomonic for complete subcutaneous Achilles-tendon rupture, when the tendon contour curves away dorsally from the posterior surface of the calcaneus between the insertion of the tendon and the upper margin of the corner of calcaneus and then proximal to this point deviates ventrally.

After subcutaneous partial rupture of the Achilles tendon a change in "Kager's triangle" also occurs in some cases (see below, at 3). By infiltra-

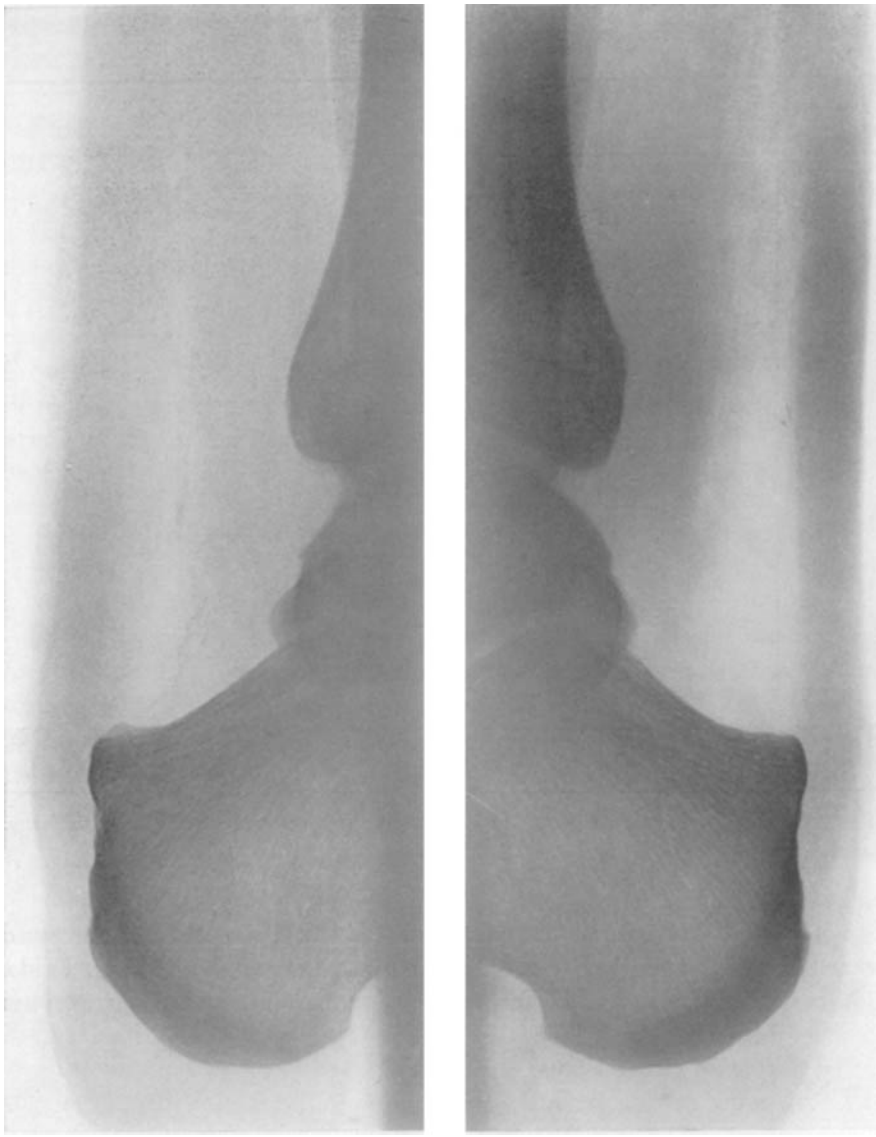

Fig. 6. X-ray findings in Case 19.
Right: Normal Achilles tendon of contralateral side, with "Kager's triangle" displayed as a triangular light part, the base formed by the upper margin of the calcaneus and the sides by the ventral contour of Achilles tendon and the dorsal contours of the deep flexor tendons.
Left: Achilles tendon partially ruptured centrally. "Kager's triangle" reduced and deformed by tendon thickening and soft-tissue infiltration, and the tendon contour irregularly outlined against the fatty space. Small areas of calcification are also seen in the soft-tissue space.

TABLE VIII
X-ray findings

Case no.	Thickening of tendon	Tendon indistinctly outlined	Infiltration	Calcification
1	x			
2	x			x
4	x			
6	x			
8	x	x	x	
10	x			
11	x			
12	x	x	x	
13	x	x	x	
14	x		x	
15	x	x	x	
16		x	x	
17	x		x	
19	x	x	x	x
20	x			
21	x	x	x	
22		x	x	
23		x		
24	x	x	x	
Total	16	10	11	2

In 3 patients with injuries of both Achilles tendons simultaneous X-ray of contralateral tendon showed local thickening but no other abnormalities.

tion into the fatty space it becomes more or less symmetrically narrowed or reduced in comparison with that on the contralateral uninjured side.

X-ray examination was performed in 19 cases. The observed changes are recorded in Table VIII.

The following changes were seen:

1) Local, more or less extensive, thickening of the tendon (16 cases);
2) Tendon contour less distinct than normal and irregularly outlined against the fatty tissue (10 cases);
3) Soft-tissue space infiltrated (11 cases), in some cases round the whole tendon, in others dorsally or only ventrally.

These findings proved to be of value in locating the rupture site, especially when the first superficial inspection of the exposed tendon at operation did not show any obvious change. Exposure of the section of the tendon corresponding to the part showing radiographic changes revealed a

partial rupture situated ventrally in the cross-section of the tendon (case 24).

Soft-tissue X-ray showed in 2 cases (nos. 2 and 19) minor areas of calcification ventral to the Achilles tendon, which were interpreted as calcification of haematomata after rupture. In one of these cases (no. 19), in which the tendon appeared intact on inspection, incision of the tendon revealed a central rupture with calcium incrustation both in the proximal and in the distal rupture ends.

The contour could not be seen in 1 case (no. 14) and therefore the rupture could no be assessed radiographically.

Soft-tissue X-ray is an important part of the examination in cases of suspected partial rupture of the Achilles tendon. In some cases in which neither the clinical nor the electromyographic examination yielded any conclusive evidence of partial rupture the X-ray findings provided a valuable basis for the decision whether or not to operate.

Electrophysiological examinations*

So far as is known, electrophysiological studies of partial tendon ruptures in man have not been described earlier. A preliminary report of the studies in the present cases has been published (Persson 1967) and a more detailed account will be published elsewhere (Persson & Ljungqvist, in the press).

The studies comprised:

1. *Electromyographic recording*

of voluntary activity using concentric needle electrodes in the triceps surae. Cases 2—24 were examined by this method. The amount of such activity was compared between corresponding electrode positions in the healthy and the affected leg and between the lateral and medial gastrocnemius bellies and the soleus muscle of the same leg. To activate the muscle under examination, the patient was told to stand on his toes bearing the weight of the whole body on the leg to be examined.

In cases of partial rupture the amount of motor-unit activity was found to be reduced in the muscle portion whose tendon had been torn. The pattern of activity was also changed. Most of the action potentials recorded were of small or medium amplitude, whereas the large potentials, which always appear at moderate to strong contraction, were lacking (see Fig. 7 A).

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* Performed in cooperation with Ass. Prof. Anders Persson. Department of Clinical Neurophysiology, Karolinska Sjukhuset.

Organic lesion of the peripheral or central nervous systems was not present in these cases. Yet, as was evident from the electromyograms, the patients were unable to perform maximal activation of the muscles. A similar functional disturbance has been shown by Blom & Hagbarth (1966) in muscles of amputation stumps, where the tendons or muscles had been divided. In their cases as well as in ours there was probably a changed proprioceptive inflow from the muscles, which led to a disturbance of the feed back mechanisms. This would be the primary cause of the functional paresis. Pain played no significant part in these cases; none of the patients reported pain from the tendon region on activation of the muscle during the examination. Moreover, inhibition by pain could hardly have produced the observed asymmetry of the electrical activity.

2. *Analysis of the "H-reflex"*

in the gastrocnemius and soleus muscles. This is a proprioceptive muscle reflex mediated via a two-neuron arc (Hoffmann 1922, Magladery et al., 1952), thus being of the same type as the common ankle jerk but, unlike the latter, it is elicited by electrical stimulation of the posterior tibial nerve and not by stimulation of the stretch receptor by tapping the tendon. The magnitude of the reflex response may be said to be a measure of the excitability of the motoneuron. It was recorded electromyographically with surface electrodes over the various portions of the triceps surae. The H-reflex was studied preoperatively in cases 10—24.

The results showed that a rupture that involves the tendon of the gastrocnemius alone, medially or laterally, has no significant influence on the H-reflex. After ruptures of the soleus tendon, on the other hand, isolated or combined with partial or total rupture of the gastrocnemius, there is a significant increase of the H-reflex, the amplitude of the response being 2—3 times larger than in the healthy leg (Fig. 7 C). Such abnormally increased reflexes were noted in cases 18, 19, and 24 and in 2 cases of total rupture. To judge from the results of our studies of total Achilles-tendon ruptures, the increase of the reflex does not occur until some time (a few weeks) after the rupture.

The phenomenon may seem paradoxical; after a tendon rupture the muscle is less stretched than normal and so it would be expected that the muscle spindles should also be lax and that their stimulating influence on the motoneurons of the muscle should be reduced. A *decreased* H-reflex could therefore have been expected. By experiments on animals (Kozak & Westerman 1961) it has been shown, however, that tenotomy is followed by increased afferent activity from the muscle concerned, possibly caused

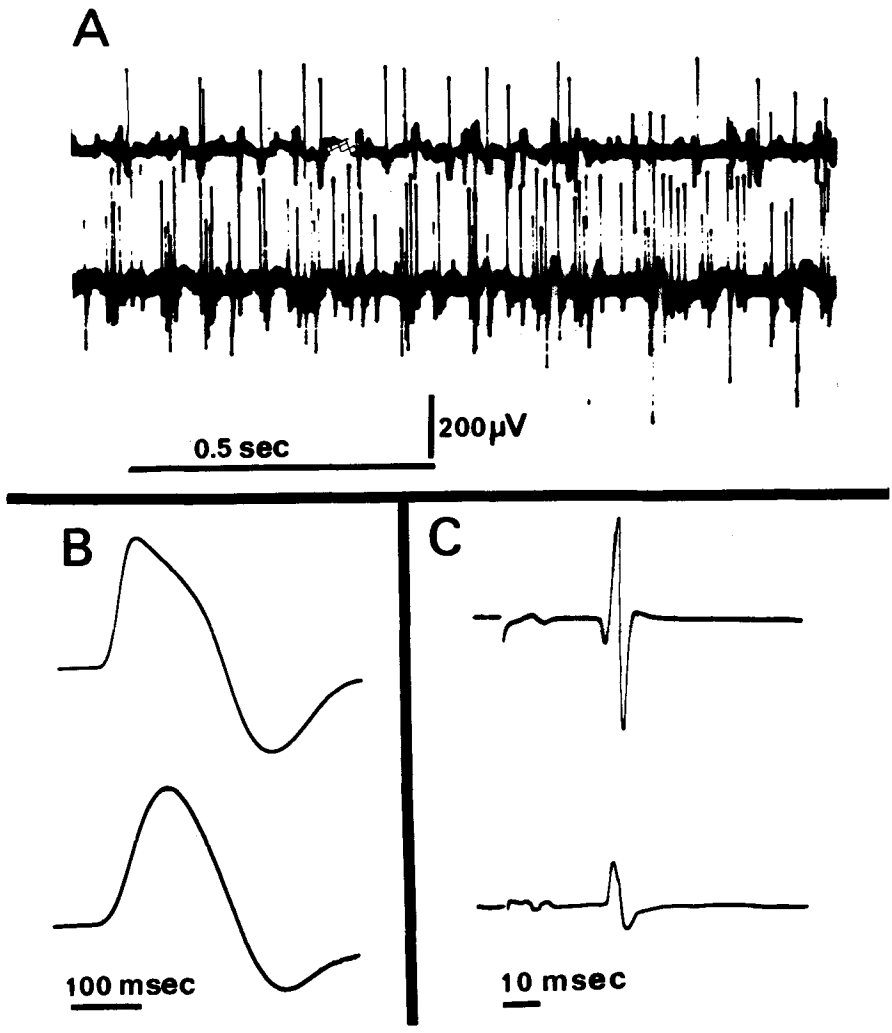


Fig. 7
CASE 24. E.M.G. recordings in a patient with partial rupture of the tendons of the lateral gastrocnemius and soleus muscles.
A: E.M.G. from lateral (upper tracing) and medial (lower tracing) gastrocnemius belly. *B:* Contraction curve, and *C:* H-reflex from the affected (upper tracings) and the healthy leg. Note shortened contraction time, due to rupture of the soleus tendon, and deformed contraction curve due to gastrocnemius rupture.

by a compensatory increase of the activity in the gamma-motoneurons of the muscle, which results in an increase of the monosynaptic response.

The observation that in man the reflex is increased after soleus but not after gastrocnemius rupture may be accounted for by the fact that the soleus muscle is of predominatingly slow "tonic" type.

3. *Analysis of the isotonic contraction curve of the calf muscles*

Muscle twitching was elicited by electric stimulation of the posterior tibial nerve and the plantar flexion of the foot was recorded with a capacitive transducer (Dickinson 1950), which did not interfere with the movement. This examination was made in cases 2—24. The contraction time (the time from the foot of the curve to its peak) was measured and the shape of the contraction curve was analysed. The contraction time for a mixed muscle is of course determined by its slowest component. Accordingly, a significantly shortened contraction time was recorded in cases of rupture of the soleus tendon (Fig. 7 B). Partial rupture of the gastrocnemius tendon, on the other hand, caused deformation of the contraction curve (Fig. 7 B) and prolongation of the contraction time.

The results of the preoperative electrophysiological examinations are set out in Table IX, which also shows the rupture site as revealed by operation. It will be seen from the table that in 19 out of 23 cases the conclusions drawn on the basis of these examinations with respect to the extent and localization of the partial rupture were in very good agreement with the findings at operation. In a further case (no. 6) re-examination of the film showed that the E.M.G. picture clearly indicated lateral rupture, that is, established the correct site. Insufficient experience with the method of examination accounts for the uncertainty in the initial interpretation of the findings in this case.

In cases 8 and 9, in which the electrophysiological diagnosis was in doubt, the rupture involved the whole or part of the soleus tendon. When these patients were examined, analysis of the H-reflex had not yet been introduced, nor were any attempts made at using the needle electrode for selective recording from the soleus muscle. These factors would explain the failure.

The reason why the rupture site in case 15 could not be established, in spite of repeated examinations, is obscure.

All the patients were examined on several occasions postoperatively. At check-ups 3—6 months after operation E.M.G. was normal in all the cases.

The method of electrophysiological diagnosis used in the 23 cases presented in Table IX has since then been applied in a further 15 cases of

TABLE IX

Electromyographic and operative findings

Case no.	Preoperative E.M.G.	Findings at operation		
		Medial	Central soleus	Lateral
1	— (Postoperatively lateral)			1 left
2	Lateral			1 right
3	Lateral			1 right
4	Lateral	(1)		1 left
5	Lateral		(1)	1 left
6	Pathological; probably lateral			1 right
7	Lateral			1 right
8	Uncertain; possibly medial	1	(1)	right
9	Uncertain		1	right
10	Lateral			1 left
11	Medial	1		left
12	Lateral — (soleus?)		(1)	1 left
13	Medial	1		(1) left
14	Lateral		(1)	1 left
15	Pathological but difficult to interpret		1	(1) right
16	Medial	1		right
17	Lateral — (medial?)	1		1 left
18	Central — soleus	(1)	1	left
19	Central — soleus		1	right
20	Lateral			1 left
21	Lateral — medial	1		1 left
22	Medial	1		right
23	Medial	1		right
24	Lateral — soleus		1	1 right
Total	Medial 6 (1) Central 3 (1) Lateral 13 Uncertain 3	8+(2)	5+(4)	14+(2)

Figures in parentheses = Rupture involved only very small part of fascicle or portion of tendon.

operatively verified partial rupture of the Achilles tendon. In every one of these 15 cases the extent and localization of the rupture could be correctly predicted on the basis of the results of the electrophysiological examination.

A further 100 patients with long-standing symptoms located in the region of the Achilles tendon (such as pain, tenderness, and swelling of

varying degree of severity) have been examined. No electrophysiological changes of the type found in partial rupture were demonstrated in any of these cases. The patients who were not operated upon improved on conservative treatment and the condition was classified as "tendinitis".

In another 2 cases E.M.G. showed slight asymmetry of voluntary activity which, in itself, might have been compatible with a small partial rupture. The H-reflexes and contraction curves were normal. At a check-up after some weeks E.M.G. was normal in both cases. By then, the patients were also symptom-free. The question whether these patients had had small partial ruptures cannot be answered. Clinical manifestations and other observations argued against this possibility.

Differential diagnosis

As will be seen from the description of the symptomatology and diagnosis of the partial Achilles-tendon rupture (see Tables VI and VII), the patient's history and the clinical findings are not pathognomonic. The condition can be confused with many other conditions affecting the Achilles tendon and surrounding tissue, such as complete Achilles-tendon rupture, tendinitis, peritendinitis, calcaneal bursitis, periostitis, and insufficiency fractures. These conditions can often be differentiated clinically from a partial tendon rupture by the presence in the latter case of, especially, the jarring pain, feeling of weakness, and muscle atrophy. Further, the increased dorsal extension in the ankle joint is absent in all the other conditions except complete rupture. In most cases the electrophysiological examinations will help in differentiating with certainty a partial rupture from the above-mentioned conditions.

In complete rupture of the Achilles tendon the plantar flexion of the foot at Thompson's test is absent. This absence is pathognomonic and, therefore, complete rupture need not be confused with partial rupture.

The partial Achilles-tendon rupture can sometimes be difficult to distinguish from *achillotendinitis*, whether the latter is in an acute or a chronic stage. Antiphlogistic medication has usually a distinct beneficial effect on the tendinitis, provided that the Achilles tendon is not subjected to any form of increased activity during the treatment. "*Tennis leg*" (Arner & Lindholm 1958) — rupture of the medial gastrocnemius aponeurosis and the muscle belly — can often be confusingly like a partial Achilles-tendon rupture, as the pain can primarily be located in the calf and the Achilles tendon both in partial rupture and in "tennis leg". But in "tennis leg" palpation will reveal transverse, distinct local tenderness

and diastasis or induration over the medial gastrocnemius belly. E.M.G. may also show some abnormalities in these cases, because of limitation of movement by pain, but these changes are not characteristic of the injury, unlike the E.M.G. findings in partial rupture.

Another painful condition affecting the Achilles-tendon region and accompanied by symptoms similar to those of partial rupture is *peritendinitis* — involving not only the Achilles tendon but also the tibialis posterior and the peroneal tendons. Crepitations occur in peritendinitis. The tenderness on palpation is also more extensive and less distinctly localised than in the partial rupture. *Bursitis* of the subcutaneous Achilles bursa and of the calcaneal Achilles-tendon bursa, in particular, can cause pain radiating ventrally-proximally along the Achilles tendon. Bimanual palpation often reveals fluctuation, and this can be further verified by aspiration of exudate on puncturing the bursa.

A possibility that must not be forgotten is that in athletes *periostitis* of the tibia and fibula as well as the not uncommon *insufficiency fractures of the fibula* can give rise to pain — which is initially difficult to locate — in the back of the lower leg and the Achilles-tendon region. Palpation and X-ray examination of the lower leg and E.M.G. will usually be diagnostic in differentiating these conditions from partial Achilles-tendon rupture. Ankle sprain with hyperextension strain and injury of the posterior part of the joint capsule should also be considered in the differential diagnosis.

Treatment

When an Achilles tendon is torn, the extent of the rupture can vary, from a clinically insignificant tear to complete rupture with complete loss of tendon function. Cases of the former type require no treatment, whereas those of the latter result in considerable disability, unless the function of the tendon is restored by surgery. The ruptures here designated as partial fall somewhere between these two extremes.

In those cases in which the results of investigation argue for the presence of relatively small ruptures, the correct procedure would be to try first a period of rest and symptomatic treatment. If the patient still complains of distressing trouble or objective symptoms persist at the end of this period, operation should be performed. If the symptoms are severe and the rupture is assessed as extensive, the primary treatment should be by operation.

Conservative treatment

Because of the way in which it was collected, the present series of cases does not include patients with small ruptures and mild transient symptoms. Most of the patients (13 cases) had undergone prolonged (6—18 months) conservative therapy consisting of rest, short-wave, ultrasonic-wave and X-ray treatment, and had received antiphlogistics (Tanderil®, Butazolidin®), local steroid and heparin injections without any noticeable effect. Immobilization in plaster for 3—4 weeks had been tried in 3 cases but produced no improvement. As soon as the Achilles tendon was allowed weight-bearing beyond ordinary walking, symptoms were noted in the form of tenderness, swelling, and shooting or stabbing pain.

Considering the pathology of the injury (see the following) it may be said that restitutio ad integrum by conservative treatment is impossible. There will remain, for instance, the elongation of the tendon which has been described above. The conservatively treated patients in this series also had subjective or objective symptoms of varying degrees of severity which indicated operation.

Operative treatment

The aim of the operative treatment was to restore the muscle-tendon relation so as to re-establish, as near as possible, its normal function.

The operations were carried out under ether anaesthesia (6 cases), extradural anaesthesia (12 cases), spinal anaesthesia (5 cases), or with blocking of the sciatic nerve (1 case). A bloodless field was obtained by compression of the thigh with a pneumatic tourniquet inflated up to a pressure of 550 mm Hg. The patient was lying prone on the operation table.

The Achilles tendon was exposed with a medial curved incision from the insertion of the calcaneus towards the border between the medial and the lateral gastrocnemius bellies. The peritenon was divided in the midline from the calcaneal insertion. After the peritenon had been divided, the changed rupture area could be directly observed in 17 cases, and also in some cases in which the rupture ends were covered with granulation tissue. When the granulation tissue had been removed by blunt dissection or excision, the rupture ends were clearly seen. No definite pathological changes were seen in 7 cases after the peritenon had been divided. The tendon surface looked normal on the whole. The guidance provided by E.M.G. and X-ray as to the rupture site proved valuable in these cases. Careful palpation, manually and by means of instruments, over the suspected sections revealed softer or firmer parts of the tendon, which in some instances showed suggested fusiform thickening. A longitudinal incision of the changed part disclosed, at a depth of a few millimetres, the following types of pathological changes:

a) Cavities, in which the ends of the ruptured tendon were seen lying retracted from one another and coated with haemorrhages and fibrin deposits (3 cases);

b) Soft granulation tissue without tendon structure (2 cases); further exposure revealed the retracted tendon ends and the diastasis filled with the contour-less granulation tissue;

c) Induration and adhesions ventrally on the tendon (2 cases) which concealed ruptures situated ventrally and centrally.

The appearance of the rupture varied greatly, but the following types could be distinguished*:

* The records are taken from the tendon segments mainly affected by the rupture.

	Transverse rupture	Oblique-longitudinal rupture
Medial gastrocnemius portion	3 cases	3 cases
Lateral gastrocnemius portion	6 cases	8 cases
Central soleus portion	3 cases	1 cases
Total	12 cases	12 cases

After the rupture had been located, granulation tissue and devitalized tendon tissue was excised. The continuity of the tendon was then restored by various methods, as seen in Table X. End-to-end suture was used in 8 cases. The operation was especially difficult in those cases in which the rupture was of long standing and the rupture ends were widely separated, while at the same time some lengthening of the non-ruptured tendon portion had occurred. By longitudinal incision into the border between the ruptured and the intact tendon portion the retracted rupture ends were mobilized to assure as satisfactory apposition as possible. In 2 cases, in which this could not be done, the surgeon divided the intact non-ruptured tendon portion and sutured it across the ruptured ends for reinforcement, so as to assure adequate apposition. In 2 cases the tendon was greatly thickened because of granulation tissue and devitalized tendon tissue centrally. After excision the tendon was of normal thickness or slightly thinner than normal. In these cases we did no more than apply suture round the cystic cavity with its exposed tendon walls and draw it sufficiently tight for the excised tendon walls to unite closely.

In longitudinal oblique ruptures and central ruptures side-to-side suture was used in 7 cases.

Suture and plastic repair with a flap were performed in 5 cases. The flap was taken from the common tendon aponeurosis, where it appeared most viable. Thus, if the rupture was laterally situated, the flap was taken from the medial side, and swung over laterally to cover the defect. With a medially situated defect, the procedure was the reverse. Loose connective tissue and any hardened tissue dorsally on the flap was removed so that a fresh tendon surface was obtained. In order that the tendon contour would be as even as possible, the flap was not, unlike Silfverskiöld's or Lindholm's technique, rotated 180°, as this often results in more or less marked thickening of the tendon contour corresponding to the rotation area. The flap was instead turned down without rotation distally with the dorsal freshened-up surface over the tendon defect and sutured.

TABLE X

Method and result of operation

Method of operation	Number	Excellent	Good
End-to-end suture	8	8	
Side-to-side suture	7	7	
Suture plus plastic repair with flap	5	5	
Suture plus plastic repair with plantaris tendon	4	3	1
Total	24	23	1

Suture and plastic repair with the plantaris-longus tendon were used in 4 cases, in which excision of devitalized tendon and granulation tissue had given a larger longitudinal tendon defect centrally, medially, or laterally. The plantaris-longus tendon, which in all the cases extended medially, was loosened at its insertion on the calcaneus and sutured into the defect. When the defect was situated centrally or laterally, it was sutured after tunnelling from the medial side into the defect tendon area.

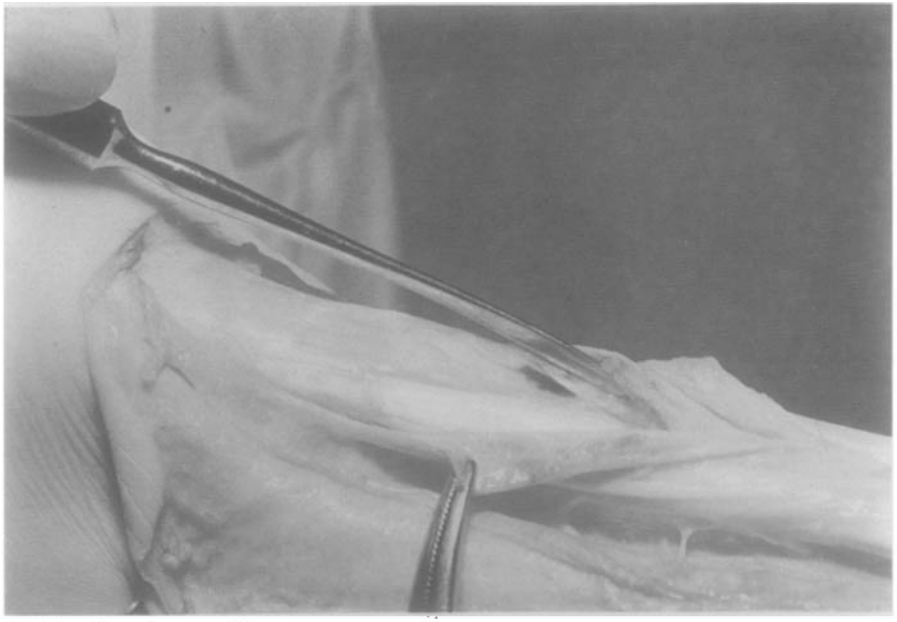
All the tendon sutures were made with synthetic suture material (supramid). Peritenon was sutured with catgut, which was not used furthest distally, however, as the tension will be too great at this point, when the foot is flexed more or less markedly in a plantar direction. After skin suture the foot plus lower leg was immobilized in plaster with the foot moderately or, in some cases, markedly plantar flexed to ensure least possible tension in the suture area.

The patients could be discharged from hospital on the 3rd—7th postoperative day. Before discharge they started to walk about on crutches. On discharge they were instructed to carry out toe exercises in the plaster cast and quadriceps exercises. Three weeks after discharge the patient was recalled for removal of the plaster and the sutures. A new full lower-leg plaster cast was applied, the plantar flexion of the foot being reduced as much as possible. As plantar flexion to 10—15° was used in most cases, it was sometimes necessary to build up the heel slightly. Thereafter the patient was allowed to train walking, gradually without crutches. The plaster was removed 4—7 weeks after operation and the patient was given a cork heel, 1, 2, or 3 cm thick, to wear inside the heel of the shoe for the first two weeks. Remedial gymnastics, consisting of active exercises of the ankle joint and strengthening exercises of the lower-leg and thigh

muscles, were started on the day of plaster removal. They were continued until the range of movement in the talocrural joint was normal after 1—2 months. The patients returned for outpatient check-ups 1—2, 3, and 12 months after plaster removal.

Complications

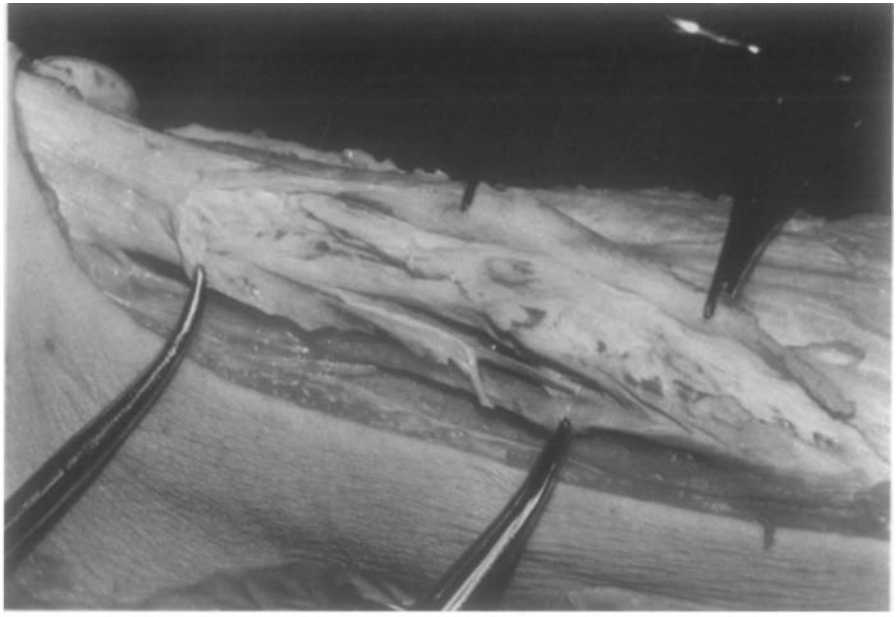
No serious complications occurred. Apart from transient wound secretion without infection (case 19) and slight irritation of the skin over an area of one cm, due to a loosened catgut suture (case 5), all the operation wounds healed by first intention. In 1 case (no. 13) a subcutaneous haematoma or seroma developed after removal of the plaster and had to be punctured four times. However, this did not prevent the patient from starting gradual training 4 months after operation. Some tightness of the gliding tissue round the Achilles tendon and the operation scar was noted in 1 case (no. 4) for the first 4 months after removal of the plaster. A relatively slight tenderness over the grafted area was present for the first few postoperative months in some of the plastic-repair cases.



CASE 8. Dorsal — medial rupture.

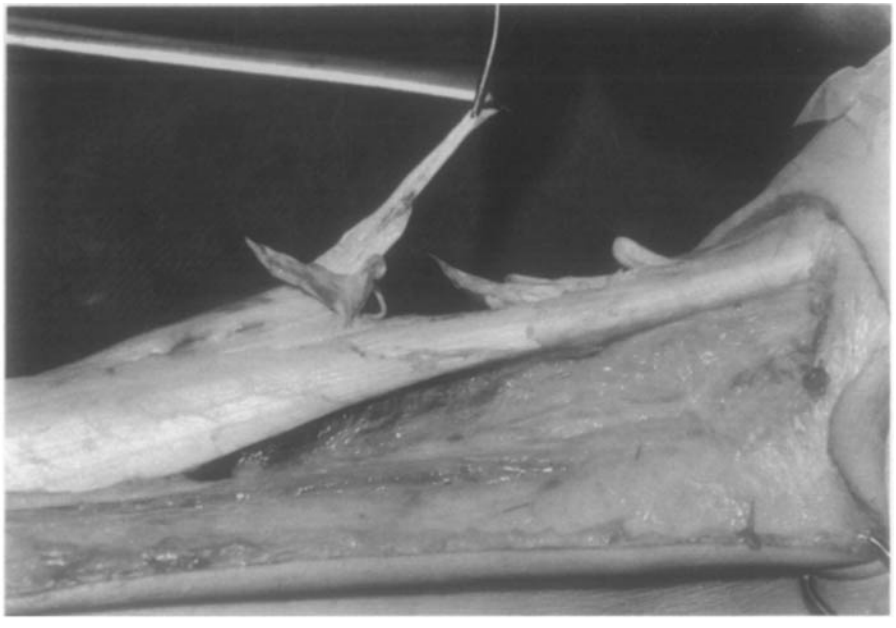
a) Rupture ends enclosed in hardened callous granulation tissue; incision for some distance in the mid-line.

b) After excision of granulation tissue and exposure of the distally rounded-off and the proximally split rupture end.



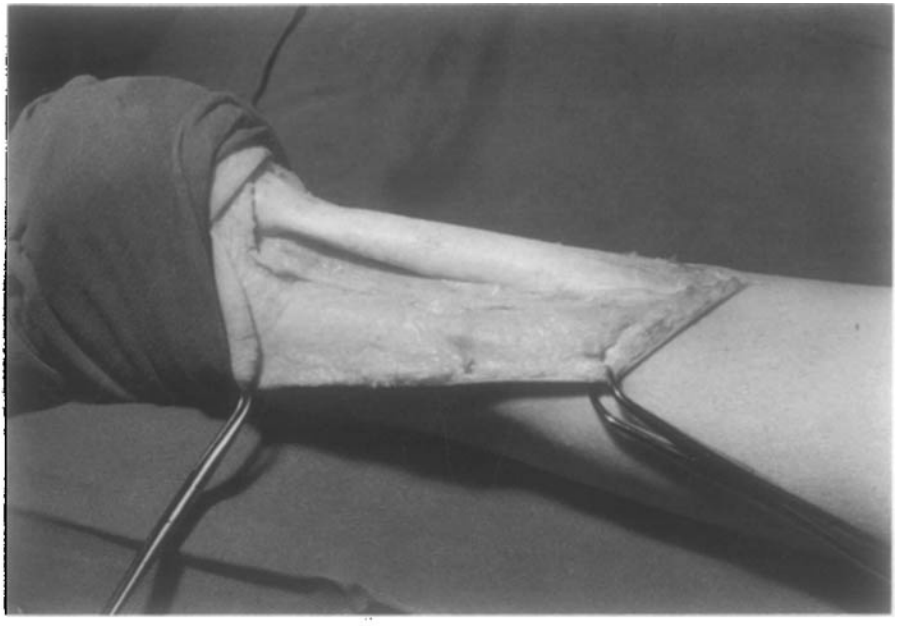
CASE 11. Medial rupture.
a) Granulation tissue and hardened tendon-like tissue partly removed over rupture ends.

b) Rupture ends exposed.



CASE 11. Medial rupture.
c) Lateral intact tendon portion and medial rupture ends.

d) Achilles tendon sutured, using a flap from lateral portion of tendon.



CASE 19. Central soleus rupture.
a) Achilles tendon exposed.

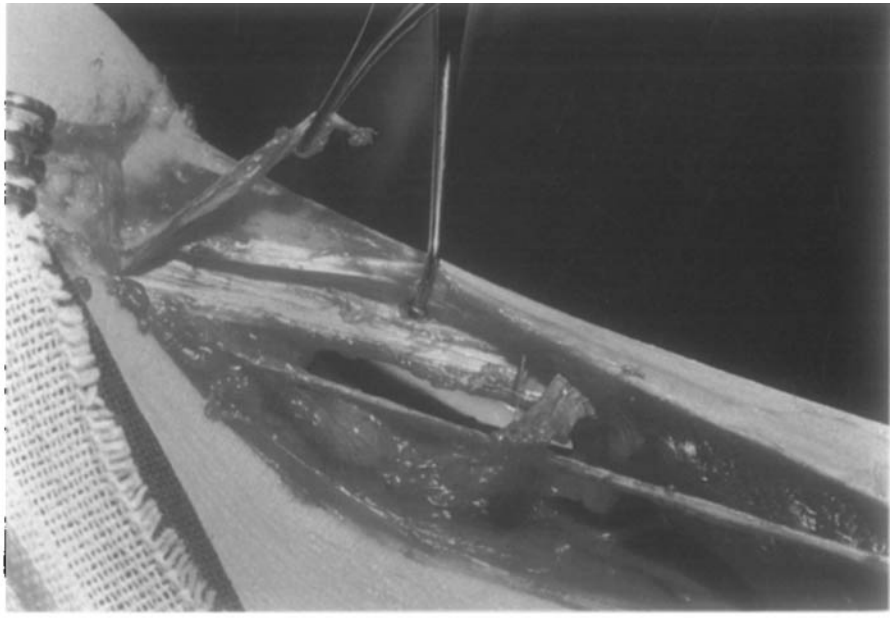
b) Incision into palpably harder part.

CASE 19. Central rupture.
c) Central cystic cavity with granulation tissue, haemorrhages, and fibrin deposits.

d) Central rupture ends after excision of granulation tissue.

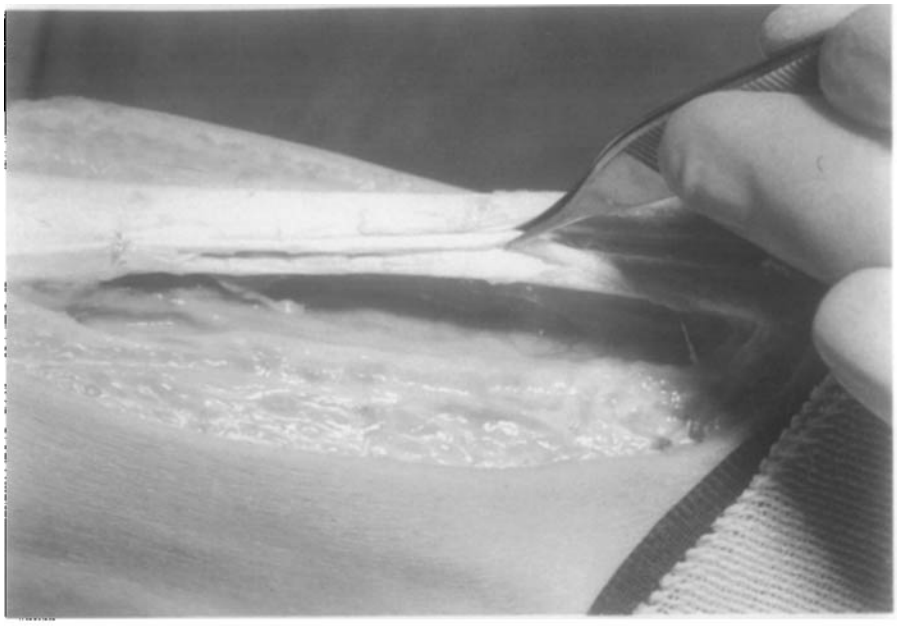
CASE 10. Transverse rupture through the whole lateral tendinous portion of gastrocnemius.

CASE 15. Rupture of soleus portion; rupture ends, rounded off distally, about 1 cm from insertion of Achilles tendon on calcaneus.



CASE 18. 5-day-old central — medial rupture.

CASE 22. Multiple small medial ruptures.



CASE 22. Medial rupture. Plastic repair with plantaris-longus tendon.

CASE 24. Sutured rupture ventrally in lateral portion of gastrocnemius, also slightly involving tendinous portion of soleus.

Results

Kolb & Salem (1953) report that in their series of 2 operatively and 2 conservatively treated cases of partial Achilles-tendon rupture relief of symptoms and normal tendon function were obtained in the two operation cases, in spite of transient fistula formation. With the conservative treatment the end result was satisfactory in 1 case but, as far as can be judged, this patient had a rupture of the gastrocnemius aponeurosis — "tennis leg". In the other case, in which the rupture involved the free portion of the Achilles tendon, fatigability, muscle atrophy, and tenderness on palpation were still present 4 years after the injury.

Conservative treatment

In the present series 13 patients had been treated conservatively for 6—18 months. Rest for 2—6 months and, in 3 cases, immobilization in plaster for 3—4 weeks had not led to improvement. Nor had X-ray and short-wave treatment seemed to improve the condition. Local steroid and heparin injections had caused only temporary alleviation of the symptoms. Every form of increased activity caused increased pain and swelling of the Achilles tendon.

Operative treatment

The length of stay in hospital was 3—7 days. The results after this period of time will be seen in Tables X and XI. The disability period was wholly dependent upon the patient's occupation. Three young university students were able to resume studies within 1—2 weeks after operation. Three office clerks returned to work after 3 weeks wearing walking plaster. Six patients returned to work within 6—7 weeks, after removal of the walking plaster. Another 6 patients with more strenuous and active type of work returned to it within 2 months. Five patients with heavy or highly active type of work were unable to return to work for 3—5 months. The oldest patient (aged 65, no. 10) resumed half-time work within 2 months

TABLE XI
Results

Function	1—2 wk	3—4 wk	6—7 wk	2 mo.	3—5 mo.	6—11 mo.	1 yr	Total
Return to work	3	3	6	6	6			24
Walking on flat ground			14	10				24
Commenced athletic exercises			1	14		9		24
Complete recovery				12		9	3	24

but, because of the special nature of his occupation, was not able to resume full-time work until 5 months after operation.

The ability to walk on flat ground, which of course is essential in most normal activities, was recovered within 7 weeks in most and within 2 months in all the cases.

In the group of champion athletes all, excluding 2, resumed training activities in running, football, and ice-hockey. Patient no. 22 was able to do high jumps of 1.80 m but after hard sprint training he had diffuse pain from the non-operated portion of the Achilles tendon; E.M.G. at several check-ups showed no abnormalities, however. Patient no. 14 did not resume his training activities, but the main reason was that he gained weight during the long period of rest and partly lost interest in champion athletics. All the patients in the "athlete" group resumed their sports activities, such as competing in the Vasa Ski Race, long-distance running, orienteering, gymnastics, football, and handball.

Half the patients had fully recovered, subjectively and objectively, within 2 months of the operation and all of them had done so within 1 year.

Case 2 is an example of the ability of the Achilles tendon to take great loads. Once or several times each season for 3½ years this patient returned after periods of hard training with symptoms of over-exertion in the form of synovitis of the knee joint, tenobursitis alternatingly of the right and the left trochanter, and ankle sprain, but without any complaints of trouble from the Achilles tendon after operation. Patient no. 8 completed a 30-km competitive cross-country race 5 months after operation without any adverse reaction from the Achilles tendon.

It will be seen from the account of the results that the forms of conservative treatment used produced no beneficial effects. As was mentioned under Treatment, conservative treatment by rest and heat may be

justified in cases in which the rupture is judged to be very small. If the result is not satisfactory or if such treatment is clearly unlikely to succeed, operation should be performed.

The operative methods that were tried in these patients led to complete healing in all the cases within a reasonable period of time. With the above-said exceptions, the author therefore recommends operative treatment of partial rupture of the Achilles tendon.

Summary

Subcutaneous partial rupture of the Achilles tendon has been regarded as an unusual injury. Many authors have questioned its existence. Only in 3 or 4 of the published cases of partial Achilles-tendon rupture can the diagnosis be considered confident. During a short period of time (1964—1967), however, using a new method of examination (by electromyograhy) I have been able to diagnose and treat by operation 24 such cases at the Department of Surgery, Serafimerlasarettet, Stockholm.

Subcutaneous partial rupture of the Achilles tendon refers here to a tear of a varying number of fibres in the free portion of the Achilles tendon, most of the fibres usually remaining intact. Clinically, the partial Achilles-tendon rupture can be differentiated from complete rupture by Thompson's test — manual compression of the triceps-surae muscle belly — in that plantar flexion of the foot does not occur if the rupture is complete. Absence of this reflex is pathognomonic for complete rupture of the Achilles tendon.

The present series comprises 24 patients, who had undergone operation for the injury at least 1 year previously. All of them engaged in some form of sport and the majority had sustained the injury during sports activities. The patients can be divided into two age-groups, one of 19—29 years, including champion athletes alone, and one of 38—65 years, comprising various kinds of non-champion athletes and including the only woman patient.

Of the aetiological factors described in the literature, steroid injections and traumata played a part in this series of cases. The steroid injections were probably of no direct aetiological significance; they might have played a part by relieving the patients of the symptoms attending a small rupture or some other injury of the Achilles tendon and so allowed increased weight-bearing on the tendon, thus being concerned in causing the clinically manifest rupture.

The nature of the trauma was analysed and it was found that the patients could be divided by the causal violence into one group (14 cases) in which the partial rupture had occurred at running and one group (10 cases) in which the insult was due to slipping or the like. The earlier

theories proposing that the subcutaneous complete Achilles-tendon rupture occurs in athletes during periods of inactivity could not be verified in the group of champion athletes with partial ruptures, who were all in their most active periods of athletics.

The histological changes both in the "champion athlete" and in the "athlete" group were characterized by devitalized tendon tissue with altered collagen stainability, frayed fibrous structure to which attached granulation tissue converted into more or less tendon-like connective tissue. Acute inflammatory cell infiltration was seen in 7 cases and chronic inflammatory cell infiltration in all the 24 cases. The histological changes associated with a partial rupture of the Achilles tendon may be defined as devitalization of tendon tissue, in which the collagen fibres in places have been replaced by granulation tissue.

The diagnosis was based on the case-history, clinical examination, X-ray examination, and electrophysiological examinations.

Data concerning lengthy periods of hard training on surfaces that lead to great demands being placed on the Achilles tendon are of great importance. Newly added items on the training programme and any injuries are analysed. Besides swelling, tenderness, stiffness, and pain on weight-bearing, which also occur in tendinitis, the patients complained of stabbing, jarring, or pricking pain in the tendon on suddenly increased activity and of weakness in the calf muscles. The pain and the weakness are probably symptoms specific to partial Achilles-tendon rupture. Eight patients also reported a sensation as of a tear or an audible snap in the tendon region.

The clinical examination, with the patient standing on his toes placing equal weight-bearing on both forefeet, showed more or less distinct muscle atrophy (14 cases) of one or both of the gastrocnemius bellies and reduced muscle tone there. Increased dorsal extension in the talocrural joint, as a sign of lengthening of the muscle and tendon, and palpable dents or small defects in the tendon contour should give rise to suspicion of partial Achilles-tendon rupture.

X-ray examination was performed in 19 cases and showed the following changes: 1) Local, more or less extensive, thickening of the tendon (16 cases); 2) tendon contour less distinct than normal and irregularly outlined against the fatty space (10 cases), and 3) infiltration into the soft-tissue space (11 cases). Owing to this infiltration, a change had also occurred in the "Kager triangle", which was seen symmetrically narrowed and reduced in comparison with that on the contralateral uninjured side.

The electrophysiological examinations showed:

1) Reduction of the amount of motor-unit activity in that part of the muscle with ruptured tendon;

2) Increased H-reflex response in cases of rupture of the soleus tendon, in other cases normal H-reflexes;

3) Shortened contraction time in cases of rupture of the soleus tendon. Increased contraction time and change of the configuration of the contraction curve in cases of rupture of the gastrocnemius tendon.

As regards the differential diagnosis, the partial Achilles-tendon rupture can be confused with complete rupture, tendinitis, peritendinitis, calcaneal bursitis, periostitis, and insufficiency fractures of the fibula or tibia. In most cases the clinical and the electrophysiological examinations will help in differentiating with certainty a partial rupture from the above-said conditions.

Out of the 24 patients, the majority (13 patients) had undergone long-term (6—18 months) conservative therapy consisting of rest, short-wave, ultrasonic-wave, and X-ray treatment, antiphlogistics (Tanderil®, Butazolidin®), local steroid and heparin injections, and immobilization in plaster without any noticeable effect.

The aim of the operative treatment was to restore the muscle-tendon relation so as to re-establish, as near as possible, normal function. After exposure of the Achilles tendon with a medial curved incision and division of the peritenon, the rupture site could be clearly seen in 17 cases. In 7 cases the rupture site could not be located until after longitudinal incision of the Achilles tendon over a suspected section with palpable softer or firmer parts and, in some instances, fusiformly thickened. After the rupture site had been located, granulation tissue and devitalized tendon tissue was excised. The continuity of the tendon was then restored by various methods, namely end-to-end suture (8 cases), side-to-side suture (7 cases), suture and plastic repair with a flap (5 cases), and suture and plastic repair with plantaris-longus tendon (4 cases).

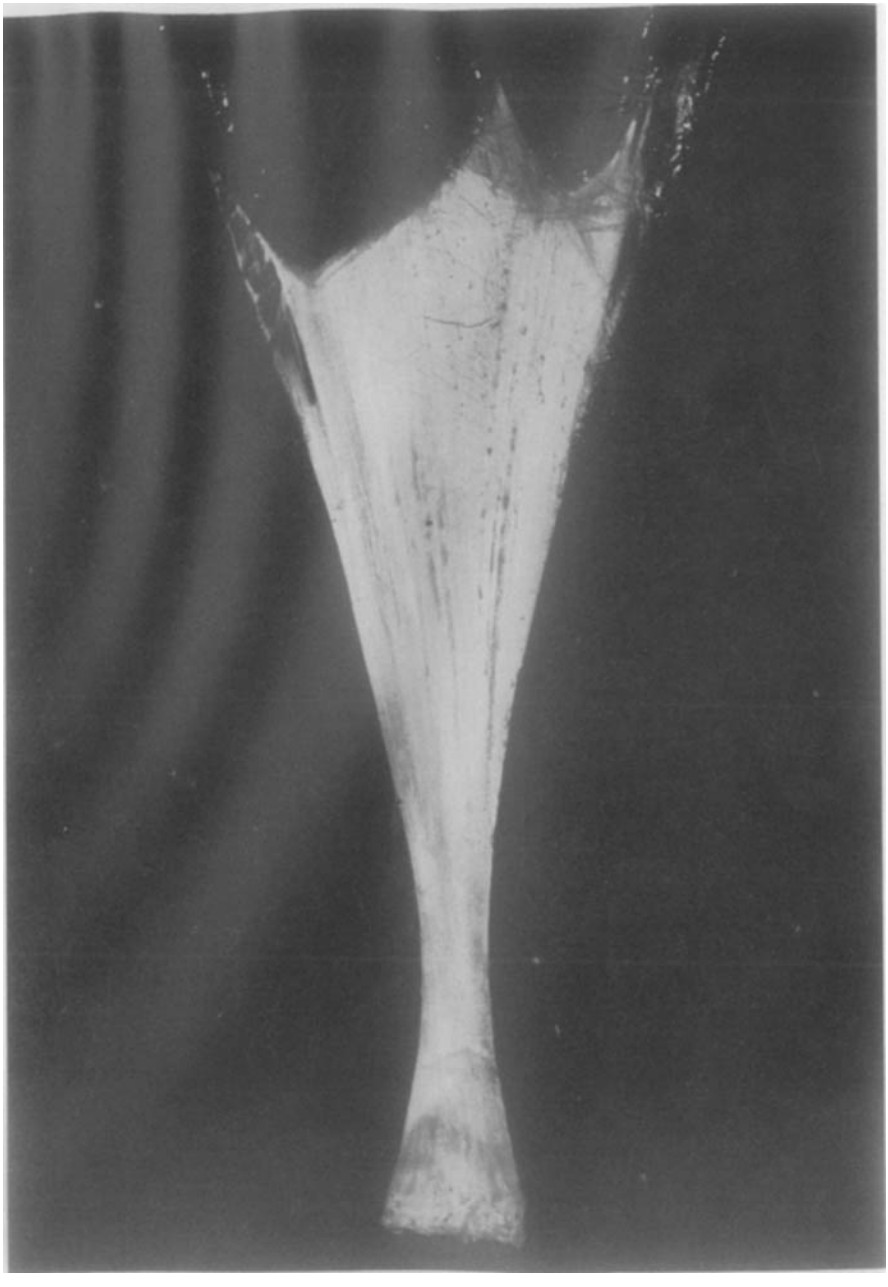
Postoperatively the foot plus the lower leg was immobilized in plaster with the foot plantar flexed for 3 weeks. Thereafter the sutures were removed and the patient wore walking plaster for another 3 weeks. Active exercises were started immediately after the operation and were continued after plaster removal until the range of movement in the talocrural joint was normal.

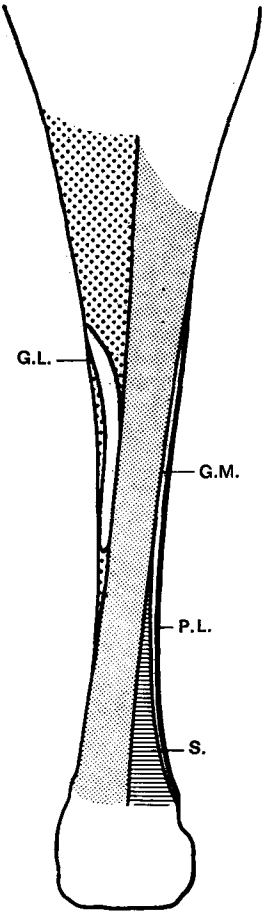
The disability period varied from 1 week to 5 months. It was wholly dependent on the patient's occupation. The majority (18 patients) re-

turned to work within 2 months. The ability to walk on flat ground was recovered within 7 weeks in most and within 2 months in all the cases. All but 2 of the champion athletes resumed full training, but these 2 carry on relatively high sports activities, as do all the "athletes". Half the patients had fully recovered, subjectively and objectively, within 2 months and all of them had done so within 1 year.

Fig. 8.

Right Achilles tendon. The tendon fibres from the medial gastrocnemius belly, descending distally, follow an increasingly lateral course toward the insertion on the calcaneus, where they make up the lateral part of the Achilles tendon. The medial segment of the Achilles tendon is at the insertion made up of tendon fibres from the soleus component. This accounts for the rotation which is characteristic of the course of the Achilles-tendon fibres and which has been described by Cummins (1949) and Rosate (1964). Centrally, the Achilles tendon is made up mainly of soleus fibres. Ventrally, its medial segment is made up of soleus fibres and its lateral segment of fibres from the lateral gastrocnemius. See further the schematic drawings (after Rosate) in the case-report.





CASE 1. A 24-year-old engineer and medium-distance runner, who before the trauma had had tendinitis of the left Achilles tendon of 3 months' duration.

Trauma (6 months before operation): At the spurt in a 3000-metre race he felt a snap in the region of the left calf. He rested from training activities for 2 months. On stepping on a threshold he felt the snapping again in the region of the left Achilles tendon.

Treatment: Local injection of a steroid just over 2 months after first trauma, an antiphlogistic (Tanderil®), and rest; no response.

Subjectively (6 months after trauma): No discomfort in daily life; the slightest effort to increased activity caused pain and tenderness of Achilles tendon. Training impossible.

Objectively: Swelling and tenderness on palpation 5 cm above insertion of tendon. Marked atrophy, impaired muscle tone, and tenderness on palpation over lateral belly of gastrocnemius.

Preoperative E.M.G. not performed.

Operation (6 months after trauma): Oblique rupture just over 10 cm above insertion through lateral portion of tendon to border of medial part. Granulation tissue found in the gap. Excision with end-to-end suture.

Histologically: Devitalized tendon tissue without areas of stainable endoplasm. Collagen frayed and decolourized. Ingrowth of unspecific granulation tissue.

Return to work: 7 weeks.

Postoperative E.M.G. (2½ months): Voluntary activity sparser than normal. No difference between medial and lateral bellies of gastrocnemius.

Outpatient check-up: (4½ months): Subjectively, no great discomfort. He trained 5 times a week, running maximally 10 km. Objectively, adequate function of tendon.

Postoperative E.M.G. (4½ months): Voluntary activity greatly increased, but slight asymmetry between lateral and medial bellies of gastrocnemius.

Outpatient check-up: (14 months): Subjectively no complaints. Training 6 times a week. Interval — running 200—800 metres. Long-distance running, maximally 20 km. Objectively, operation wound healed normally; the atrophy of lateral belly of gastrocnemius barely observable.

Postoperative E.M.G. (14 months): Normal.

Result (4 years after operation): No troubles whatsoever with Achilles tendon. Training regularly 5 times a week for fast and long-distance running over 10—20 km.

G.L. = Gastrocnemius lateralis
G.M. = Gastrocnemius medialis
S. = Soleus
P.L. = Plantaris longus

CASE 2. A 25-year-old policeman and skier, who for the last 17 months had had recurrent bursitis, myositis of the gastrocnemius, and achillotendinitis on the left side.

Treatment: Rest, an antiphlogistic (Tanderil®), local application of Butazolidine ointment, five injections of heparin and six of a steriod, only two of the latter being given in the Achilles tendon itself and its insertion. The last injection given 3 months before the trauma.

Trauma: On pressing his right foot down hard for support while grappling with an unruly drunkard, he had experienced intense sharp pain in the Achilles tendon of that foot.

Subjectively: Able to walk but rising on the toes painful.

Objectively: 2—3 cm above insertion Achilles tendon thicker ventrally; tenderness on palpation and slight depression of tendon contour 10 cm above insertion. Marked atrophy and impaired tone of lateral belly of gastrocnemius.

X-ray: Shadow of calcium deposit immediately above the calcaneus (calcification in haematoma).

Preoperative E.M.G.: Voluntary activity much sparser laterally than medially.

Operation (6 weeks after trauma): Tranverse and longitudinal rupture of lateral part of tendon from 3 cm to 10 cm above insertion. Excision with end-to-end suture (side-to-side).

Histologically: Devitalized tendinous tissue without areas of stainable endoplasm. Slight ingrowth of granulation tissue. Areas of slight perivascular inflammation.

Postoperative E.M.G. (3 months): No definite abnormalities.

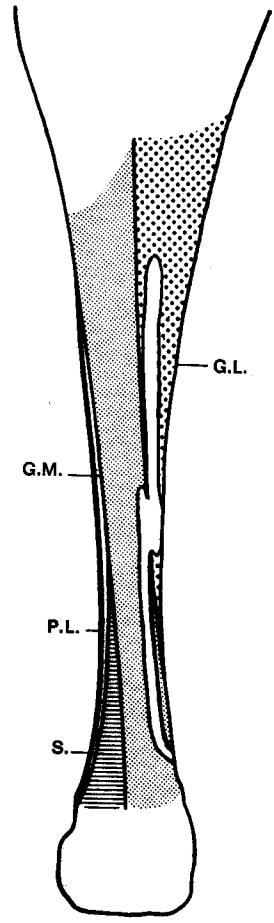
Outpatient check-up (3 months): Using an arch support because of some anterior-arch trouble. Achilles tendon felt normal. Occasionally slight tenderness. Operation scar normal. Tendon function normal.

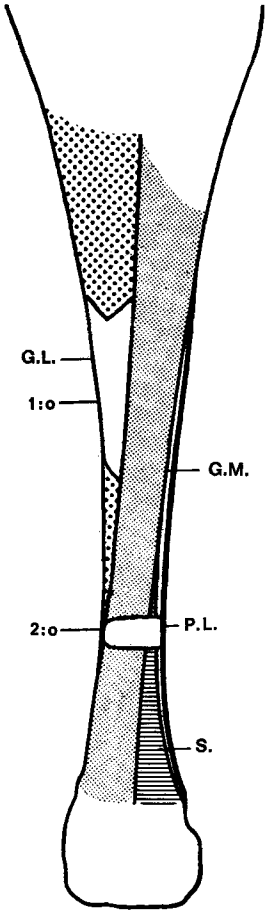
Return to work: 3 months.

Outpatient check-up (7 months): Synovitis due to local over-exertion of right knee-joint after intensive running exercise. Achilles tendon normal.

Outpatient check-up (1 year and 7 months): Trochanteric tenobursitis on left side after long-distance running (30 km). Achilles tendon normal on palpation.

Result: Fully active throughout the racing seasons 1—3 years after operation. Belongs to the Stockholm top-class athletes. District champion. Took part in the Lidingö race (cross-country running 30 km); runs for practice 2—2½ hours three times a week; skis 50 km without any trouble with Achilles tendon.





CASE 3. A 46-year-old electrician, who frequently had to climb ladders.

First trauma (1½ years before operation): Sustained a blow of a reinforcing iron bar against right Achilles tendon, after which he had troubles in the form of increasing tenderness and thickening over the tendon for 1½ years.

Treatment: An antiphlogistic (Tanderil®); short-wave treatment. After local steroid injection within 6 months of the trauma the swelling diminished.

Subjectively (1½ years after trauma): Difficulties in rising on his toes and climbing ladders. Felt stabbing pain in the tendon on getting on to a chair.

Objectively: Right Achilles tendon thinner than left one because of depression in tendon contour laterally and above insertion. Dorsal extension in talocrural joint increased to 10° more than normal. Generalized atrophy of gastrocnemius.

Preoperative E.M.G.: Volitional activity much less laterally than medially.

On the waiting list for operation of lateral partial rupture of Achilles tendon.

Second trauma (6 weeks after objective examination and 2 weeks after E.M.G.): Stumbled on a board at building site and felt something like a violent blow from behind.

Objectively: Complete rupture of tendon with diastasis 4—5 cm above insertion. Thompson's test did not elicit plantar flexion of foot.

Operation (1½ years after first trauma and on the day after second trauma): 1) Old rounded-off partial rupture of lateral portion of tendon; proximal end of rupture retracted just over 5 cm from distal end, which was slightly more irregularly rounded; 2) Fresh rupture with haemorrhages and torn tendon fibres through medial and soleus portions of tendon. Plastic repair by Silfverskiöld's method (modified).

Histologically: Devitalized tendon tissue with altered collagen stainability and poorly visible fibrous structure.

Postoperative E.M.G. (7 weeks): Sparse volitional activity in bursts, mainly medially.

Return to work: 11 weeks.

Outpatient check-up (13 weeks): Normal range of movement and tendon function. Able to rise on his toes for the first time in just over 1½ years.

Postoperative E.M.G. (3½ years): Fully normal.

Result (3½ years after operation): Able to climb ladders, etc., without difficulties; no trouble with Achilles tendon.

CASE 4. A 29-year-old engineer and ice-hockey player with a 3-year history of recurrent tendinitis of left Achilles tendon.

Treatment: Heparin injection. Local steroid injection 4 months and 2 months before trauma led to temporary improvement. An antiphlogistic (Tanderil®).

First trauma (7 weeks before operation): During an ice-hockey match he pulled up suddenly — to avoid an object on the ice — and felt a jarring pain in left Achilles tendon.

Subjectively (5 weeks after trauma): Swelling and pain on walking up and down stairs; unable to rise on his toes.

Objectively: Minor defect in tendon contour laterally 2—3 cm above insertion, with a rounded-off thickening distally, which was tender to palpation. Dorsal extension in talocrural joint increased to a few degrees more than normal.

Preoperative E.M.G.: Decreased volitional activity laterally.

On waiting list for operation.

Second trauma (8 days after examination): Tripped on stairs and felt a tear in Achilles tendon.

Objectively: A distinct depression in Achilles tendon laterally 3—4 cm above insertion but tendon intact medially. Thompson's test gave plantar flexion.

X-ray: Soft-tissue space around tendon was infiltrated.

Operation (7 weeks after first trauma):

1. Old rounded-off rupture laterally in lateral portion of tendon;
2. Fresh oblique rupture with haemorrhages in lateral portion of tendon, also involving a small part of medial portion.

Plastic repair by Silfverskiöld's method (modified).

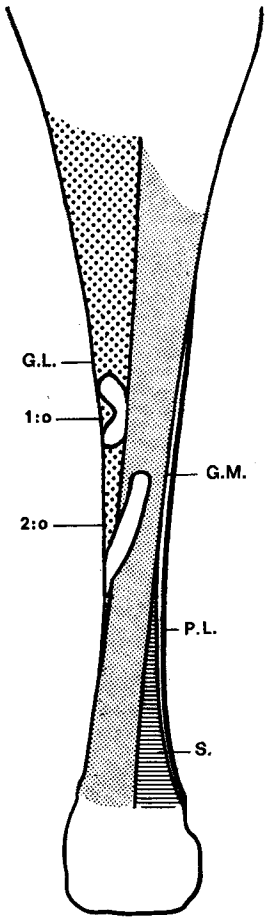
Histologically: Partially devitalized tendon tissue and still vital tendon tissue with altered collagen stainability and frayed fibrous structure. In places, tendon transformed into granulation tissue with sparse unspecific inflammatory cell infiltration.

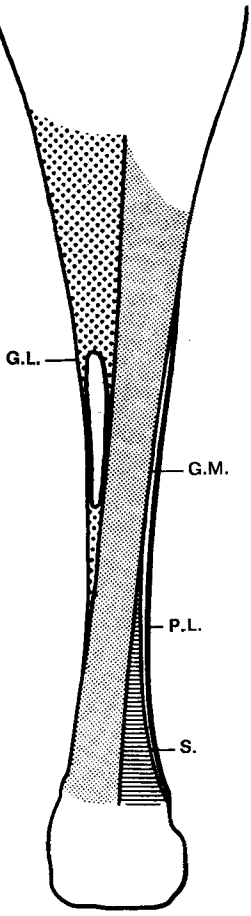
Return to work: Resumed his studies 10 days after operation.

Postoperative E.M.G. (4 months): Normal.

Outpatient check-up (6 months): Some tightness in gliding tissue around Achilles tendon and operation scar for first 4 months after removal of plaster. Operation scar normal.

Result: Fully active at ice-hockey every season for 3 years after operation and has suffered no tendon troubles whatsoever.





CASE 5. A 42-year-old engineer and allround athlete, who 1 year before the trauma had been given a local injection of a steroid for tendinitis of the left Achilles tendon, after which he had been free from symptoms for 1 year.

Trauma (12 months before operation): On sudden start at —20°C in the Vasa Ski Race (85 km) he felt a burning pain in left Achilles tendon. Persisting trouble with tendon.

Treatment: Six heparin and 9 local steroid injections. An antiphlogistic (Tanderil®), ultrasonic-waves, and rest for 2 months had no effects over a period of 11 months.

Subjectively (11 months after trauma): Pain in Achilles tendon on movement; tendon felt swollen and "clotted" in the night; no trouble in his daily activities.

Objectively (11 months after trauma): Thickening about 10 cm above insertion of tendon with tenderness on palpation over this area. Atrophy of 1.5 cm of calf, but no difference between lateral and medial bellies of gastrocnemius. Slightly increased dorsal extension.

Preoperative E.M.G.: Voluntary activity fairly good but somewhat less laterally, though not sufficiently so to give rise to suspicion of rupture on the basis of E.M.G.

Operation (12 months after trauma): Fusiform thickening 6—7 cm above insertion with a laterally darker tendinous streak, one cm in length, and adhesions ventrally in this area. Exposure revealed a cystic cavity, 5 cm long, with a few thin ruptured tendon fibres; the walls showed partly obliterated tendon structure. Excision up to normal tendon tissue; side-to-side suture.

Histologically: Areas of split devitalized tendon tissue with newly formed tendon-like granulation tissue.

Outpatient check-up (4 weeks): Plaster removed after 4 weeks. Operation wound slightly irritated over an area of one cm. Catgut suture, which had loosened, was removed. Pain in plantar aponeurosis. Arch-support for pain in calcaneus spur.

Return to work: 6 weeks after operation.

Outpatient check-up (6 weeks): Subjectively no complaints. No tenderness on palpation over operating field. Operation wound normal.

Postoperative E.M.G. (6 weeks): Normal.

Outpatient check-up (6 months): In full training, but after running for about 1½ hours he noticed symptoms of tenobursitis of knee-joint but had no troubles whatsoever with Achilles tendon.

Outpatient check-up (7 months): After cross-country running he had stabbing pain in region of right calf; small partial rupture of gastrocnemius.

Postoperative E.M.G. (7 months): Completely normal.

Result: (2 years and 9 months): Fully active in skiing and training without any troubles whatsoever.

CASE 6. A 29-year-old electrician, football, bandy, and ice-hockey player, with a history of recurrent tendinitis of both Achilles tendons for 3 years. Local steroid injection 1 year before the trauma had relieved the symptoms during the bandy and ice-hockey season. As the condition was aggravated after football training practice, E.M.G. was performed but showed no definite abnormalities.

Trauma: (9 months before operation and 2 weeks after above-said E.M.G.): Stumbled at work and felt a sharp sudden pain in right Achilles tendon.

Treatment: Short-wave and X-ray; an antiphlogistic (Tanderil®), Hirudoid and Butazolidine ointment, heparin injections, local steroid injection enabled the patient to play bandy and ice-hockey in the winter, but not football.

Subjectively (8 months after trauma): Sharp pain in right Achilles tendon on increased activity. He had to walk with stiff foot.

Objectively: Laterally, a good 2 cm above insertion, a tear was suspected in Achilles-tendon contour, which proximal to this site was thickened and tender to palpation.

Preoperative E.M.G. Interpretation difficult; possibly slightly sparser voluntary activity in the lateral part of the right gastrocnemius.

X-ray: Right Achilles tendon slightly thickened 5 cm above calcaneus.

Operation (8 months after trauma): Peritenon adherent to subcutis. Laterally, 3—5 cm above insertion, several small ruptures relatively superficially. Plastic repair with a flap from medial common aponeurosis.

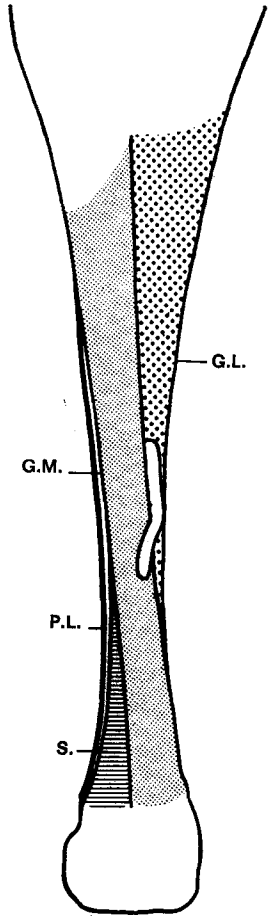
Histologically: 1) Peritenon with newly formed granulation tissue of tendon-like type. 2) Devitalized tendon tissue and newly formed tendon-like granulation tissue.

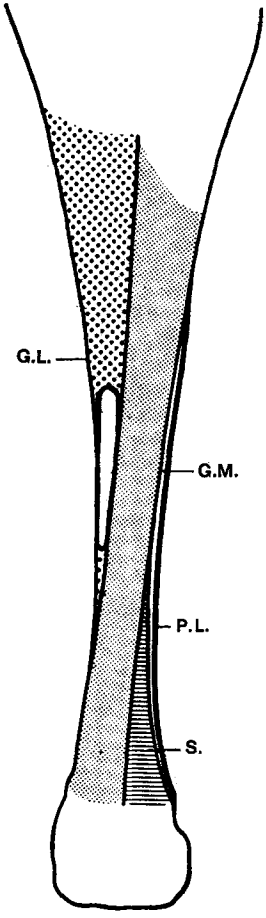
Return to work: 2 months.

Outpatient check-up (3½ months): At first some stiffness in the morning. Some tenderness over operation area. Operation wound normal. He had commenced training.

Postoperative E.M.G. (3½ months): No definite pathological changes. No asymmetry.

Result (2 years after operation): Played in a football match 5 months after operation. Had been fully active in football and regained his old swiftness. No troubles with right Achilles tendon but had had an injury of collateral ligament in right knee, trochanter tenobursitis, and partial semimembranous rupture. Operation wound satisfactory. No tenderness on palpation. Right Achilles tendon slightly thicker than left one. Fully satisfactory muscle-tendon function. Normal range of movement in ankle joint.





CASE 7. A 51-year-old carpenter and footballer.

Trauma (1 year before operation): While kicking a football against a brick wall and joggling, he felt intense pain in right Achilles tendon and then had difficulties in walking.

Treatment: Two local steroid injections 1 week after trauma. Rest; an antiphlogistic (Tanderil®). Immobilisation in plaster for 3 weeks. Elastic bandage.

Subjectively (11 months after trauma): Tenderness and difficulty in walking up and down stairs.

Objectively: Thickening with fluctuation and tenderness on palpation 3—4 cm above insertion of tendon. Muscle atrophy with reduced tone laterally. Dorsal extension in ankle joint slightly increased.

Preoperative E.M.G.: Voluntary activity somewhat less laterally.

X-ray: Achilles tendon slightly thickened over an area about 4 cm in length 2 cm proximal to calcaneus.

Operation (1 year after trauma): Fusiform thickening 3—4 cm above insertion, of opaque appearance laterally. Longitudinal incision in softer part revealed a cystic cavity in lateral portion of tendon with granulation tissue and partly obliterated tendon structure. Excision; end-to-end suture.

Histologically: Devitalized tendon tissue with frayed fibrous structure; poor stainability in endoplasm areas and altered collagen stainability. To this tissue attached streaks of newly formed granulation tissue, rich in collagen and of finely streaked and wavy structure, which differed from that of normal tendon tissue.

Outpatient check-up (2 months): Occasionally slight pain. Operation scar normal. Strength in foot and lower leg not quite normal; return to work therefore postponed.

Outpatient check-up (2½ months): Subjectively and objectively virtually free from symptoms.

Return to work: 2½ months after operation.

Postoperative E.M.G.: (4½ months): Normal.

Result (2 years after operation): Climbs scaffolds. Heavy weight-bearing on Achilles tendon — wheeling loads of mortar. Plays tennis. No trouble whatsoever with the tendon.

CASE 8. A 40-year-old electrical fitter and allround athlete.

Trauma (14 months before operation): While cycling up a 400-metre long hill, standing on the pedals, he felt violent pain in right Achilles tendon. Before this incident he had had a period of training, running 2400 km and cycling 100 km. After trauma tendon painful for 14 months.

Treatment: Heparin and steroid injections on 9 occasions. An antiphlogistic (Tanderil®). Immobilization in plaster and 3 weeks of hospital care.

Subjectively: Stabbing pain on increased activity but also aching at rest, accentuated after an effort to run in the Vasa Ski Race; after skiing 50 km he was unable to walk.

Objectively: Right Achilles tendon twice as thick as left one, with fusiform thickening 3—4 cm above insertion; intense tenderness on palpation over this area and possibly slight incongruence of contour medially and dorsally. Dorsal extension in talocrural joint increased to 15° more than normal.

Preoperative E.M.G.: No definite abnormalities but slight difference in comparison with E.M.G. 6 weeks previously. Reduced voluntary activity in the medial part of gastrocnemius.

X-ray: Right Achilles tendon twice as thick as left one, unclearly outlined; soft-tissue infiltration.

Operation (14 months after trauma): Dorsally, Achilles tendon furrowed centrally, with small haemorrhages, and enclosed in hardened callous granulation tissue. Dorsal-medial partial rupture with rounded-off rupture ends. End-to-end suture and plastic repair with a flap turned over from lateral normal tendon fascicle.

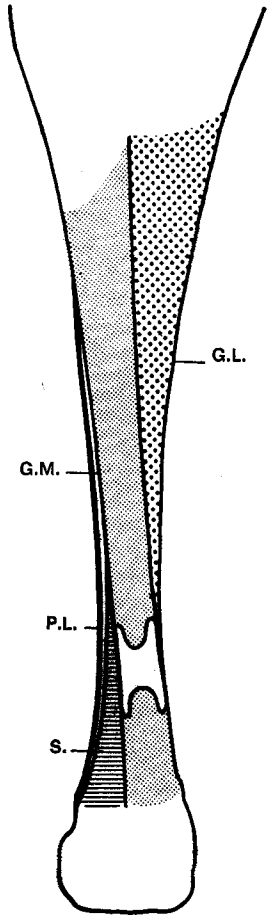
Histologically: Partly devitalized tendon tissue with decolourized collagen and here and there formation of granulation tissue.

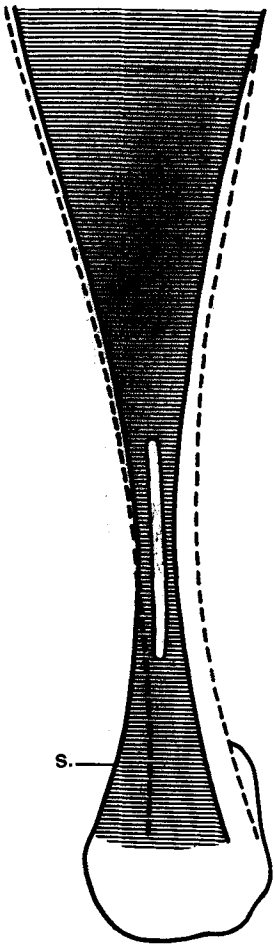
Postoperative E.M.G. (6 weeks): Normal.

Return to work: 6 weeks after operation.

Outpatient check-up (5 months): He had just completed the Lidingö Race, cross-country running 30 km, without any troubles with Achilles tendon. Operation scar normal. No tenderness on palpation.

Result (2½ years after operation): Another Lidingö Race and two Vasa Ski Races after operation. Trained running on hard road the following seasons, 1600—1750 km. Employed as a gymnastics master, on duty for 7 hours every day. No trouble whatsoever with Achilles tendon.





CASE 9. A 54-year-old woman engineer and athlete, who had been operated on for subcutaneous complete rupture of left Achilles tendon in 1946.

Trauma: During a cross-country run she slipped on a stone and felt a sharp pain in right Achilles tendon.

Treatment: Rest.

Subjectively: Weight-bearing painful; difficulty in walking up and down stairs. Stabbing pain on increased activity. Aching at rest.

Objectively (1 months after trauma): Diffuse thickening of Achilles tendon 3—4 cm above insertion and tenderness on palpation of this area as well as slightly further proximally. After increased weight-bearing by walking up and down a flight of stairs, the tenderness was localized distinctly laterally.

Preoperative E.M.G.: Fairly good voluntary activity, slightly reduced laterally. Shape of contraction curve deviated from normal; slightly prolonged duration. Pathological finding not wholly characteristic but suspected to be evidence of rupture.

Operation (1 month after trauma): Achilles tendon seemed to be intact but a longitudinal incision over an area of opaque appearance revealed a cystic cavity with haemorrhages and two torn tendon ends united by granulation tissue. Excision up to healthy tendon tissue, resulting in a cavity, 10—12 cm long. Side-to-side suture.

Histologically: Partially devitalized tendon tissue with poorly stainable endoplasm areas and reduced collagen stainability. Granulation tissue formed in places. Minimal inflammatory cell infiltration. The continuity of collagen fibres here and there broken by granulation tissue, which indicated the presence of partial rupture.

Outpatient check-up (2 months): Subjectively no complaints. Operation scar normal. No tenderness on palpation.

Postoperative E.M.G. (2 months): Normal.

Return to work: Just over 2 months after operation.

Result: During the first 2 postoperative years she was able to carry on various forms of sports; downhill skiing; physical exercises twice a week with ½ hour of cross-country running each time. No trouble whatsoever with Achilles tendon.

CASE 10. A 65-year-old colonel and athlete, who had had medial tendinitis of left Achilles tendon for 4 months. E.M.G. negative. After local steroid injection medially only, about 3—4 cm above insertion, he had been symptom-free until injury occurred.

Trauma: Stepping side-ways on his foot, he slipped on the kerb and felt stabbing pain in the calf.

Subjectively (3 days after trauma): Unable to rise on the toes because of pain.

Objectively: Tenderness on palpation and oedema about 10 cm above insertion; a dent in tendon contour laterally. Dorsal extension in talocrural joint increased to 5—10° more than normal.

Preoperative E.M.G.: Volitional activity much less in left than in right gastrocnemius muscle. Asymmetry with fewer motor units laterally than medially. Prolonged contraction time.

X-ray: Left Achilles tendon thickened.

Operation (2 weeks after trauma): Haemorrhages and partial rupture laterally 10 cm above insertion; rupture involved greater part of lateral tendon fascicle with diastasis of 3—4 cm between rupture ends, distally ensheathed by tendinous callus. Excision; end-to-end suture. Medially tendon structure fully normal.

Histologically: Devitalized tendon tissue showing altered collagen stainability and frayed fibrous structure. Slight tendency to formation of granulation tissue. Signs of fibrin exudation around areas of devitalized tendon tissue.

Outpatient check-up (2 months and 10 days after operation): Subjectively, virtually symptom-free. Operation scar normal.

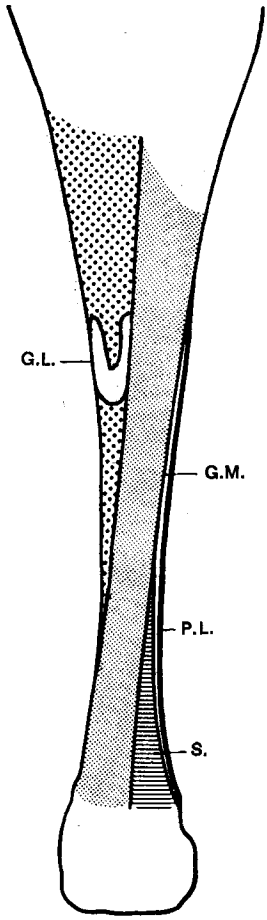
Return to work: 50 % 2 months after operation.

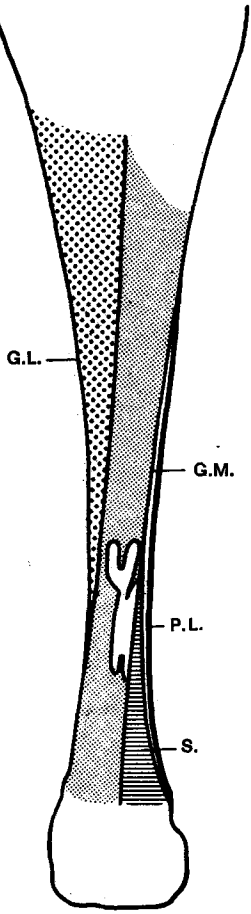
Outpatient check-up (5 months): A tender part laterally 15—20 cm above insertion had troubled him for a month but had cleared up at time of examination. Operation scar normal. No tenderness on palpation. Normal range of movement in ankle joint.

Return to full-time work: 5 months after operation.

Postoperative E.M.G. (5 months): Fully normal.

Result (2 years after operation): Walked fast every day for 1½—2 hours without stopping, half running occasionally. Light physical exercises. No trouble with Achilles tendon after operation.





CASE 11. A 44-year-old district manager and allround athlete, who had had recurrent tendinitis of left Achilles tendon for just over 1 year. Seven months after onset he had been given a local steroid injection; the symptoms had disappeared after 1 week and he had then been symptom-free for 6 weeks, up to the time of the trauma.

First trauma (3 months before operation): Distortion of right ankle joint with excessive weight-bearing on left Achilles tendon.

Treatment: Local steroid injection plus an antiphlogistic (Tanderil®) produced no effect.

E.M.G. (6 weeks after trauma): No abnormalities.

Second trauma (7 weeks before operation): Tripped and made a false step on kerb; felt a violent pain in left Achilles tendon and calf muscle.

E.M.G.: No abnormalities.

Treatment: An antiphlogistic (Tanderil®) plus local steroid injection, but only in medial gastrocnemius part, which was tender on palpation (tennis leg); tenderness over this region disappeared but pain in Achilles tendon persisted.

Subjectively (1 months before operation): Tenderness over lower part of tendon. Incessant pain on walking. Unable to run more than 50 metres.

Objectively: Soft-tissue swelling, tenderness on palpation over tendon and suggested fluctuation medially 5—6 cm above insertion. Atrophy and reduced tone of medial gastrocnemius belly. Slightly increased dorsal extension in talocrural joint.

X-ray: Left Achilles tendon thicker than right one. Probably partial rupture.

Preoperative E.M.G.: Slightly reduced voluntary activity, in the medial gastrocnemius belly.

Operation (3 months after first trauma): Medially, an area of just over 10 cm of Achilles tendon covered with hardened tissue. Exposure revealed three partly oblique tears in medial portion of tendon. Excision; suture plus plastic repair, using a flap from lateral portion.

Histologically: 1) Highly sclerosed tendon-like granulation tissue. Slight inflammatory cell infiltration. Centrally yellowish red collagen bundles, being rests of old tendon tissue with vascularization. 2) Same as above. Profuse vascularization. Lymphomonocytic infiltrates around vessels. Areas of transition from granulation tissue to newly formed tendon-like connective tissue.

Return to work: 4 weeks.

Outpatient check-up: (4 months): After walking for 30—45 minutes he had still some pain on medial side; adhesions? Normal range of movement in talocrural joint. Can rise on his toes without pain. No tenderness on palpation.

Postoperative E.M.G. (4 months): Normal.

Outpatient check-up (10 months): Started training about 7 months after operation. Competing in orienteering contests almost every other day and never over distances shorter than 7 km. Subjectively no complaints. Very occasionally slight pricking, but rapidly passing, sensation in Achilles tendon.

Result (2 years): Subjectively and objectively wholly symptom-free as regards Achilles tendon. Operation scar normal. No muscle atrophy. Some complaints of pain on movement in right shoulder and elbow when playing tennis.

CASE 12. A 42-year-old manager, former speedway driver, and athelete.

Trauma: (5 months before operation): Caught his left foot under a stone and was butted on the calf by a vicious ram. He felt a violent pain above the ankle, as if something and been broken. Interpreted as a muscle sprain.

Treatment: Elastic bandage; rest.

Subjectively (5 months after trauma): Pain above left ankle. Difficulty in walking up and down a flight of stairs. Cannot stand on tiptoes.

Objectively: Depression in Achilles-tendon contour with palpable diastasis, 4 cm in length, in lateral part of tendon. Medially, tendon appeared to be, at least partially, intact at palpation. Atrophy of lateral and medial gastrocnemius. Dorsal extension in talocrural joint increased to 15° more than normal. Thompson's test gave plantar flexion of foot, though with reduced muscular strength.

X-ray: Left Achilles tendon much thicker than right one. Infiltration in fat in front of Achilles tendon.

Preoperative E.M.G.: Greatly reduced volitional activity laterally, possibly also in the soleus.

Operation (5 months after trauma): Hardened tissue enclosed a partial rupture, which involved lateral as well as soleus portions and also part of medial tendon fascicle. Centrally, a plantaris-longus tendon as thick as tip of little finger. So as to achieve satisfatory opposition at suturing, the intact medial fascicle was also divided. Plastic repair using plantaris tendon and turning down of a flap from medial fascicle.

Histologically: Partially devitalized tendon tissue changing into granulation and newly formed collagen-poorer tendon-like tissue. Fairly dense lymphocytic infiltrates surrounded the vessels. The surface of some areas was covered with fibrin fragments.

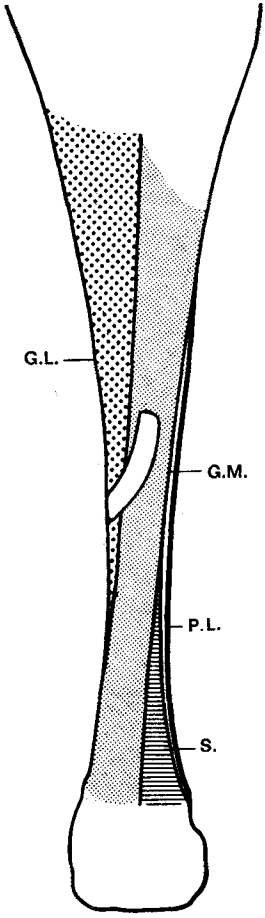
Outpatient check-up (3 months): Subjectively, relatively normal. Operation scar normal. Relatively slight tenderness on palpation over site of repair. Normal range of movement in ankle joint.

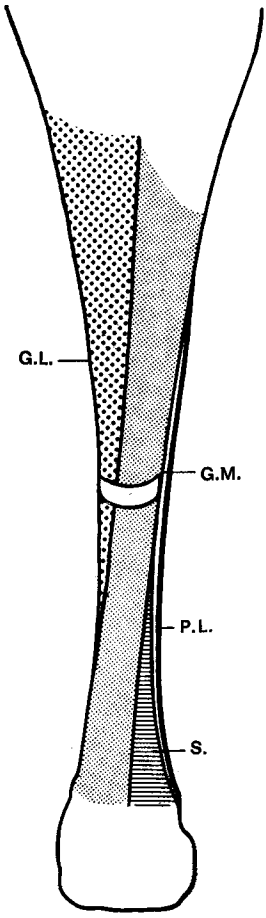
Return to work: 3½ months after operation.

Postoperative E.M.G. planned but not performed until 2 years after operation, as the time did not suit the patient and the foot did not trouble him at all.

E.M.G. (2 years): Completely normal.

Result (2 years): "100 % recovery". Fully active, cycling, skiing, and swimming without any trouble whatsoever with Achilles tendon.





CASE 13. A 38-year-old engineer and handball player.

Trauma: During a handball game he experienced violent pain in left Achilles tendon. Believed that somebody had kicked him; fell down on the floor.

Treatment: Elastic bandage for 3 weeks; plaster for 3 weeks.

Subjectively (6 weeks after trauma): Pain in calf on ordinary walking; had to walk with stiff foot.

Objectively: Marked swelling of lower part of leg and ankle. Achilles tendon greatly thickened and tender to palpation both medially and laterally, a little further than 10 cm above insertion. Depression in tendon contour. Dorsal extension in ankle increased to a few degrees more than normal. Subtotal rupture? Thompson's test gave plantar flexion, though with reduced strength.

Preoperative E.M.G.: Voluntary activity less than normal, mainly medially. When medial needle was pushed deeper — into soleus — definite asymmetry was no longer noted. Probably partial rupture, most likely medially. Neurophysiologically, complete rupture unlikely, as, for instance, the asymmetry of Hoffmann's reflex, seen in complete ruptures, was absent.

X-ray: Achilles tendon could not be defined and, thus, not assessed.

Operation (2½ months after trauma): Hardened and greatly thickened peritenon; haemorrhages. Underneath the peritenon another layer of hardened tissue, at first interpreted as being Achilles tendon. Longitudinal incision in this tissue exposed normal tendon tissue and the site of rupture, which involved both medial and lateral portion of Achilles tendon 3—4 cm above insertion. Soleus portion intact. As excision of all devitalized tendon and granulation tissue left a considerable defect, it was necessary to divide the soleus tendon and let the two parts overlap slightly, so as to ensure satisfactory opposition at suturing, which thus became step-like. A minor defect laterally was covered with a flap from the exposed aponeurosis. It was considered doubtful whether the final result would be as good as those obtained earlier by operation of Achilles-tendon rupture.

Histologically: Devitalized tendon tissue and highly sclerosed granulation tissue of tendon-like appearance. Inflammatory cell infiltration around the vessels.

Outpatient check-up (3 months): Seroma or bursa-like collection developed in the postoperative course and had to be punctured several times. Operation scar normal. Otherwise no troubles with Achilles tendon.

Return to work: 3 months after operation.

Postoperative E.M.G. (6½ months): Fully normal.

Outpatient check-up (1 year and 4 months): He had been skiing in the winter and then trained running without any great discomfort. Objectively, a fusiform thickening with slight fluctuation was palpated dorsally over Achilles tendon 2½—9½ cm above insertion. Operation scar normal; no adhesions. No tenderness on palpation over Achilles tendon. Atrophy of 1 cm of the calf.

Result (1 year and 10 months after operation): Full training; no discomfort.

CASE 14. A 24-year-old university student and champion long-distance runner. He had had trouble with left Achilles tendon for 1½ years, clinically diagnosed as achillotenobursitis. Local steroid injection in the calcaneal bursa relieved the symptoms and enabled him to run races, until he sustained the injury.

Trauma (1½ years before operation): When training barefooted on a golf course he felt a sudden pain in the region of left Achilles tendon immediately above insertion. The pain persisted.

Treatment: Rest; Butazolidine ointment. After 5 months a steroid injection was given locally at the calcaneal insertion and after another 2½ months into the region of the bursa. As no response was noted, dimethyl sulphoxide (DMSO) was tried.

Subjectively (1 month before operation): Pain and tenderness on increased activity. Almost unable to run 50 metres to catch a bus.

Objectively: Achilles tendon distinctly thicker immediately above insertion and tender to palpation laterally. Atrophy of just over 1 cm of triceps surae.

Preoperative E.M.G.: Volitional activity reduced laterally.

X-ray: Left Achilles tendon twice as thick as right one.

Operation (1½ years after trauma): Achilles tendon looked normal on the whole, but 3—4 cm above insertion there was a slightly uneven and raised section. Incision revealed a cystic cavity with two rupture ends and profuse granulation tissue and fibrin. End-to-end suture.

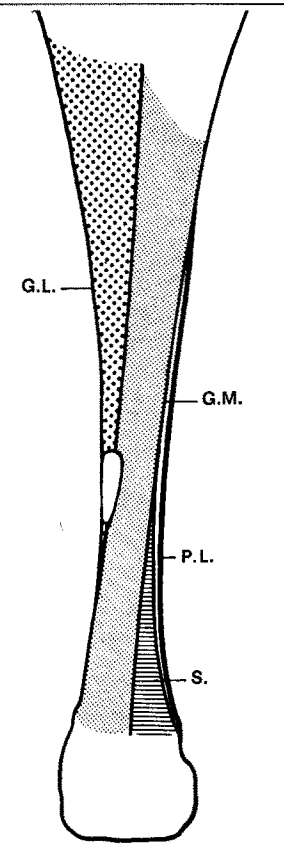
Histologically: Devitalized tendon tissue, partly transformed into and infiltrated by unspecific granulation tissue with newly formed tendon-like connective tissue. Some areas were coated with a fibrin-like mass.

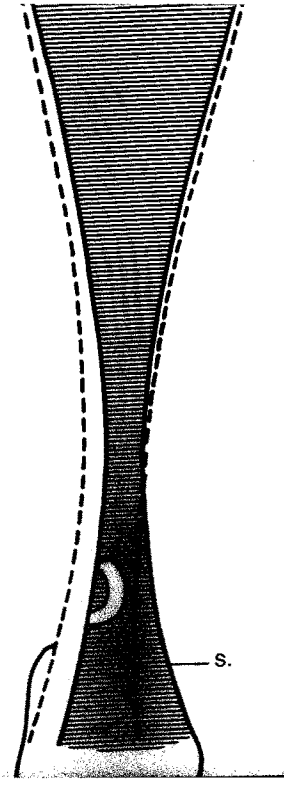
Return to work: 10 days after operation.

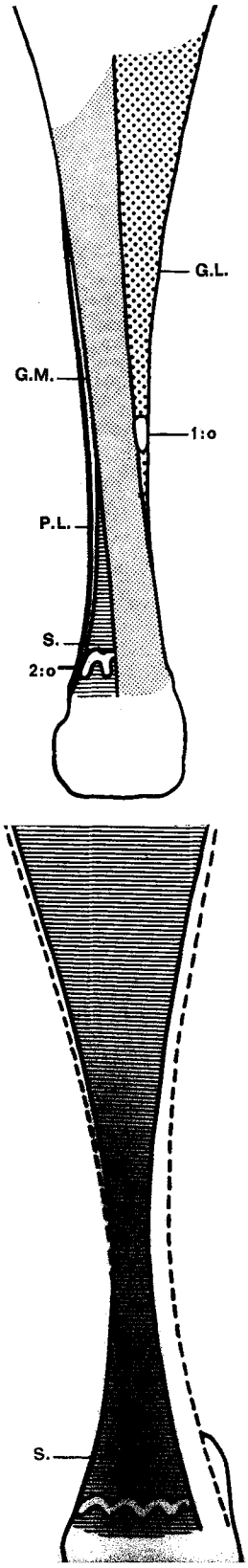
Outpatient check-up (3 months): Subjectively no complaints. Operation scar normal. Full range of movement in talocrural joint.

Postoperative E.M.G. (3½ months): Normal.

Result (2 years): No troubles with Achilles tendon. Training twice a week, running 7—8 km. He had not resumed competitive sports because of studies, among other reasons.







CASE 15. A 22-year-old buyer and champion hurdler with a 1-month history of tendinitis of right Achilles tendon; the condition was relieved by rest.

Trauma: (10 months before operation): During a cross-country run he trod on a stone with accompanying hyperextension of right ankle. Felt as if something had been torn in the Achilles tendon.

Treatment: Relative rest for just over 3 months. DMSO was tried by produced no effect.

E.M.G. (3 months after trauma): Slight reduction of volitional activity. Tendon probably not ruptured. One local steroid injection cleared the condition for 3 months, but the sharp pain returned on increased weight-bearing. Complete rest for a further 2 months.

Subjectively (10 months after trauma): Pain and tenderness over Achilles tendon on exertion and stepping side-ways on the foot. No discomfort at work.

Objectively: Right Achilles tendon increased in width; fusiform thickening and tenderness on palpation laterally about 5 cm above insertion. Atrophy of lateral gastrocnemius belly. Dorsal extension in talocrural joint increased to 5—10° more than normal.

Preoperative E.M.G.: Asymmetry of volitional activity, which was reduced laterally; prolonged contraction time and altered shape of contraction curve. Minor lateral rupture.

X-ray: Right Achilles tendon much thicker than normal above insertion. Oedema in front of insertion.

Operation (10 months after trauma): Rupture of the whole soleus portion and small part of lateral portion of tendon about 1 cm above insertion. End-to-end suture after mobilization and shortening of unruptured part of tendon.

Histologically: Old devitalized tendon tissue and sclerosed granulation tissue resembling normal tendon tissue but having more irregular collagen structure. Moderate lymphomonocytic cell infiltration around the vessels.

Return to work: 3 weeks after operation, wearing walking plaster.

Outpatient check-up (13 months): No trouble with Achilles tendon at sprint rushes, badminton, and physical exercises. Able to run distances of 5 km for 2—3 consecutive days without any discomfort, but after that time Achilles tendon increasingly tender.

Objectively: Operation scar normal. Tendon contour slightly irregular. Slight tenderness on palpation immediately above insertion. No measurable muscle atrophy.

Postoperative E.M.G.: Normal.

Result (2 years): No trouble at all with Achilles tendon. No tenderness after long-distance running.

CASE 16. A 63-year-old foreman and gymnast.

First trauma: During gymnastic exercise practice he felt a snap in right Achilles tendon, after which the tendon was painful on movement and tender.

Treatment: Local steroid injection on five occasions as from 10th day after trauma.

Second trauma (2 months after first one): On running out of the way of a car he felt as though someone had kicked him on the calf 15 cm above insertion of Achilles tendon.

Subjectively: Pain on movement, swelling of tendon. A feeling of weakness on plantar flexion of foot.

Objectively: Defect in medial contour of tendon 7 cm above insertion. Tendon felt thinner than normal on palpation. Atrophy and reduced tone of medial gastrocnemius belly. Dorsal extension in talocrural joint increased to 5—10° more than normal.

Preoperative E.M.G.: Volitional activity much less medially than laterally.

X-ray: Infiltration of the fat at lower portion of tendon, probably due to partial rupture.

Operation (3½ months after first trauma): Transverse rupture of medial portion of tendon about 7 cm above insertion; a layer of hardened tissue found over the site. End-to-end suture.

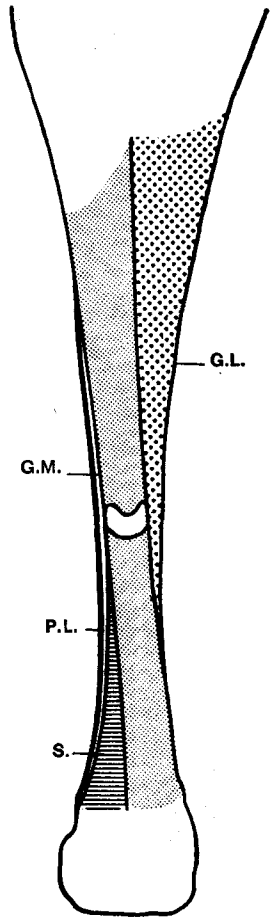
Histologically: Partially devitalized tendon tissue showing transformation into sclerosed granulation tissue, which in parts resembled tendon tissue. Here and there lymphomonocytic cell infiltration.

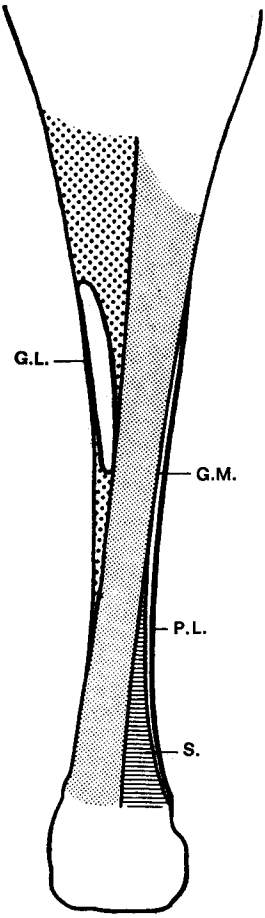
Return to work: 3 months after operation.

Postoperative E.M.G. (3½ months): Volitional activity symmetric. Normal contraction time. Hoffmann's reflexes normal.

Outpatient check-up (1 year and 2 months): Achilles tendon still slightly stiff but otherwise no discomfort. Operation scar normal. Normal strength in foot and calf muscles, though still suggested atrophy of gastrocnemius bellies but normal tone. Range of movement in right talocrural joint same as in left one.

Result (2 years): Subjectively, no trouble with Achilles tendon. Taking daily walks; skiing 10 km or so without any discomfort.





CASE 17. A 47-year-old engineer and allround athlete.

Trauma (10 years before operation): After betting he went, untrained, for a 1500-metre run and felt intense pain in left Achilles tendon. Since then he had two — three spells of recurring trouble every year, in the form of tingling pain.

Treatment: Rest during the most troublesome periods, otherwise no special treatment; no steroids.

Subjectively (2 months before operation): After skiing without sustaining any particular injury he noticed swelling in the region of Achilles tendon and had pain even at rest; stiffness in the morning.

Objectively: Left Achilles tendon much broader and thicker than normal; tendon contour bulged dorsally just above insertion, extending proximally as far as 5 cm below gastrocnemius. Tenderness on palpation most marked laterally.

Preoperative E.M.G.: Distinct decrease of volitional activity laterally.

X-ray: Left Achilles tendon markedly thickened. Soft tissues infiltrated.

Operation (10 years after the suspected trauma): Several yellow soft areas of granulation tissue interspersed with tendon-like hardened tissue. Diffuse ill-defined infiltration. Excision of the soft granulation areas and the hardened tendon-like tissue revealed a section extending obliquely laterally-medially, suspected to represent the original site of rupture. Side-to-side suture. Diameter of Achilles tendon shortened by just over one-third. It was considered doubtful whether normal postoperative tendon function would be achieved.

Histologically: Partial devitalization with hyalinization of collagen and fraying of fibrin structure. Profuse formation of fresh and old granulation tissue showing also myxomatous degeneration. Foreign-body reaction seen in these areas. Sparse unspecific inflammatory cell infiltration.

Return to work: 4 weeks after operation.

Outpatient check-up (6 weeks): Operation scar normal. Foot easily raised to mid-position. No tenderness on palpation.

Postoperative E.M.G. (1 ½years): Normal.

Result (1 year and 7 months): No trouble at all with Achilles tendon; "100 % recovery". Full training for last 10 months, running distances of 7—8 km without discomfort.

CASE 18. A 27-year-old farmer and Swedish champion in 10,000 metres.

Trauma (5 days before operation): At the end of a 10,000-metre race in an international competition at a height of 2000 metres in Turkey, possibly stepping sideways on the raised edge of the track he felt sharp stabbing pain in left Achilles tendon and fell down on the track.

Objectively (within a minute of trauma): Distinct tenderness on palpation medially over Achilles tendon; maximal tenderness at calcaneal insertion and junction between soleus muscle and free portion of tendon.

Preoperative E.M.G.: Reduced volitional activity in medial gastrocnemius belly. Asymmetry still more marked when the needle was pushed deeper. Hoffmann's reflex slightly increased.

Operation (5 days after trauma): Haemorrhages beneath peritenon. Medial rupture 5—6 cm above insertion, involving about ¼ of the cross-section of the medial portion of tendon at the border of the soleus muscle. Resection of ruptured ends of tendon and suture with grafting plantaris-longus tendon in the resulting tendon defect.

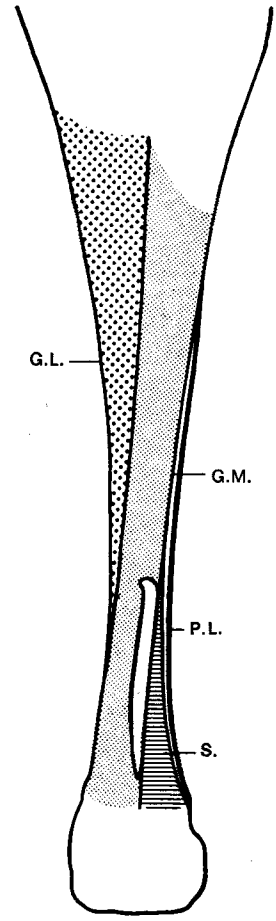
Histologically: Devitalized tendon tissue with altered collagen stainability and non-stainable endoplasm areas. Virtually no granulation tissue. Slight fibrin exudation.

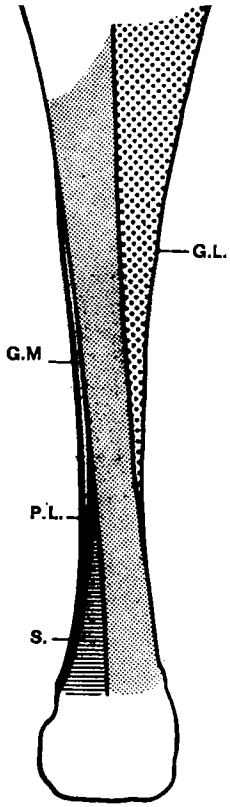
Return to work: 3 months after operation.

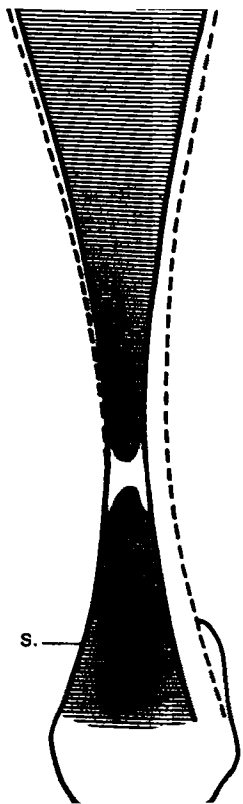
Outpatient check-up (7½ months after operation): Resumed training barely 3 months after operation, running 8 km 4—5 times a week, occasionally 17 km. The main reason for his visit was pain on lateral aspect of left knee. *Diagnosis:* Tenobursitis. No trouble at all with Achilles tendon; operation scar normal. On palpation, Achilles tendon felt slightly thickened over the part into which plantaris tendon was grafted. No tenderness on palpation. Atrophy of calf over 1 cm, but muscle tone normal. Normal range of movement in ankle joint.

Postoperative E.M.G.: Fully normal.

Result (1 year and 7 months): Completed racing season 1 year after operation without any discomfort. Still among topperformers, running 10000 metres in 30 minutes and 20 seconds in a competition for the Swedish Championship, although he did not win it. No trouble at all with Achilles tendon.







CASE 19. A 28-year-old engineer and cross-country runner, who had a history of tendinitis of right Achilles tendon for 2 years. After local steroid injections he was symptom-free for 7 and 3 months, respectively, until he sustained the injury.

Trauma (1 year before operation): During a cross-country run he tripped over root of tree, placing excessive weight on right Achilles tendon, and felt sharp pain in tendon.

Treatment: Rest, DMSO, and one local steroid injection produced no effect. Partial rupture suspected.

E.M.G. (2 months after trauma): No abnormalities.

E.M.G. (5 months after trauma): No abnormalities.

Subjectively (9 months after trauma): Had to give up training; tried skiing, but tendon too painful. Complained of pain on ordinary walking and walking up and down stairs.

Objectively: Thickening and possibly slight irregularity of tendon contour; distinct tenderness on palpation 3 cm above insertion of tendon, most marked medially. Reduced tone laterally; atrophy of calf over 1 cm.

Preoperative E.M.G.: Reduced voluntary activity in soleus and Hoffmann's reflex heightened (150 % of that on left side); central rupture.

X-ray: Right Achilles tendon thickened and poorly outlined; soft-tissue infiltration. Minor areas of calcification in anterior part of tendon.

Operation (1 year after trauma): Achilles tendon looked intact but on palpation thickened at the level of lowermost part of soleus. Incision revealed central rupture with sanguinolent fluid, haemorrhages, and several rupture ends with areas of calcification? Excision; side-to-side suture.

Histologically: Devitalized tendon tissue with obliterated fibrous structure, poorly stainable endoplasm, and altered collagen stainability. Tendon-like granulation tissue, partly with marked inflammatory changes.

Return to work: 6 weeks after operation.

Outpatient check-up (2 months): Subjectively, relatively little discomfort; walked without difficulty. Operation scar normal. No tenderness on palpation. Triceps-surae function normal. Able to rise on his toes.

Postoperative E.M.G. (3 months): Symmetric and normal volitional activity. Hoffmann's reflex and contraction time normal.

Result: (1 year and 5 months): Commenced training 3 months after operation. As he lives in Africa, no final check-up has been made but, according to information, the condition has cleared up completely.

CASE 20. A 43-year-old bank official and orienteerer, with a history of tendinitis of left Achilles tendon for 10 months; no known injury. Had to give up racing.

Treatment: Rest; Butazolidine ointment; no steroid injection.

Subjectively: Pain in left Achilles tendon on movement. Unable to run for more than ½ hour. Tendon painful even on quick walking. Discomfort in the morning.

Objectively: Achilles tendon slightly increased in width. Distinct tenderness on palpation 3—4 cm above insertion, most markedly laterally. Atrophy of calf over 1 cm.

Preoperative E.M.G.: Volitional activity reduced laterally.

X-ray: Left Achilles tendon slightly thicker in upper part.

Operation: A section of tendon, laterally 5—6 cm above insertion, slightly thicker and softer than normal. Longitudinal incision. At a depth of 3—4 mm an oedematous area in which two normal tendon streaks disappeared into tissue of opaque appearance — granulation tissue. Excision; side-to-side suture.

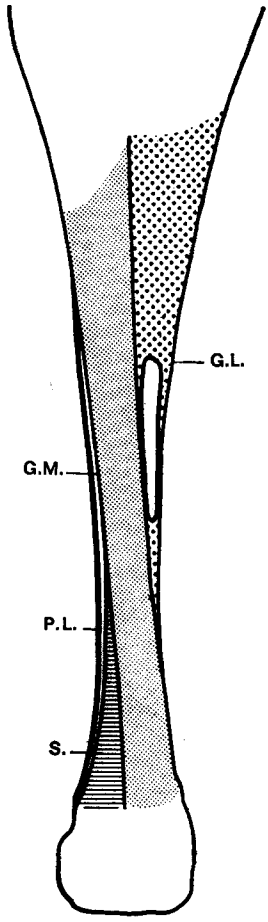
Histologically: Devitalized tendon tissue and mostly newly formed granulation tissue with finely streaked wavy collagen structure, not resembling normal tendon tissue. Some areas of inflammatory infiltration perivascularly.

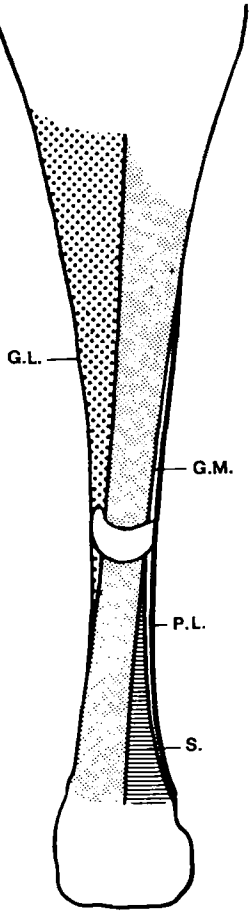
Return to work: 2 months after operation.

Postoperative E.M.G. (5 months): Volitional activity increased but still slightly less than normal, not asymmetric. Further regression.

Outpatient check-up (5 months): Tenderness over Achilles tendon persisted longer than usual. Commenced training but suffered some pain on the following day. Operation scar normal.

Result (1 year and 6 months): No trouble at all with Achilles tendon. Went for orienteering runs every Sunday and on skiis without discomfort.





CASE 21. A 45-year old taxi driver and amateur athlete, who for 7 months had had trouble with his left Achilles tendon following a road race. After local steroid injection on two occasions he had no trouble for 2 months, until the injury occurred.

First trauma (3½ months before operation): On kicking a ball he felt a snap in his left calf, medially. Partial rupture was suspected but E.M.G. showed no definite abnormalities.

Second trauma (2 days before operation): During a 400-metre run he felt violent sharp pain and an audible snapping in the region of left Achilles tendon. He completed the race and was then admitted to Serafimerlasarettet.

Objectively: Transverse indentation in tendon contour and marked tenderness on palpation over tendon 3—4 cm above insertion. Haematoma. Thompson's test gave normal plantar flexion but with slightly reduced strength.

Preoperative E.M.G.: Volitional activity greatly reduced in lateral and medial gastrocnemius bellies. No definite asymmetry. No difference in contraction time between the two legs, but downward deflection of curve markedly prolonged on left side.

Conclusion: Partial rupture, soleus portion should be intact.

X-ray: Achilles tendon thickened locally; its anterior portion poorly outlined against the fatty space.

Operation (2 days after trauma): Bleeding under peritenon towards gastrocnemius bellies. Transverse rupture through medial and lateral parts of tendon, 4—5 cm above insertion, but soleus portion intact. End-to-end suture. The soleus tendon, which was too long after resection of the two rupture ends, was sutured both to the medial and to the lateral side of the already sutured rupture ends.

Histologically: Streaks of devitalized tendon tissue. Sclerosed tendon-like granulation tissue predominated. Both old and fresh haemorrhages. Sparse fresh granulation tissue around haemorrhages and vessels. Minimal inflammatory cell infiltration.

Return to work: 2 months after operation.

Postoperative E.M.G. (4 months): Normal.

Outpatient check-up (9 months): No complaints whatsoever. Trained and competed in track-and-field athletics without any trouble with Achilles tendon. Had noticed slight thickening of tendon contour about 10 cm above insertion but no tenderness on palpation; peritenon possibly slightly thickened in this area. Operation scar normal.

Result (1 year and 3 months): No complaints. Recommenced full training and competing.

CASE 22. A 22-year-old student of technology and international sprinter, who had had tendinitis of right Achilles tendon 4½ months before the operation. After local steroid injection he had been completely free from symptoms during a period of hard training.

Trauma (3½ months before operation): On making a vigorous push off at the start of a 100-metre race he felt an intense jarring pain in the right Achilles tendon. No discomfort in daily life but avoided rising on his toes. Training impossible.

Objectively: Irregular tendon contour medially. Muscle atrophy and reduced tone in medial gastrocnemius belly. Increased dorsal extension in ankle joint.

X-ray: Slightly thickened tendon with oedema towards the fatty space.

E.M.G.: Reduced voluntary activity medially.

Operation: Medially, two rounded-off rupture ends enclosed by granulation tissue. Plastic repair using the plantaris-longus tendon.

Histologically: Devitalized tendon tissue with a few necrotic areas (suggested calcification). Tophus-like sparse granulation tissue.

Return to work: 1 week.

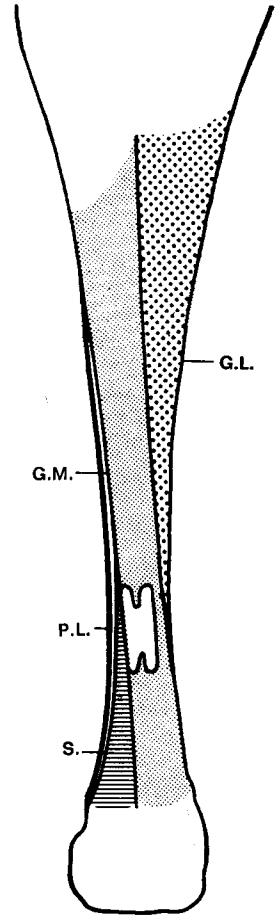
Postoperative E.M.G. (3 months): Normal.

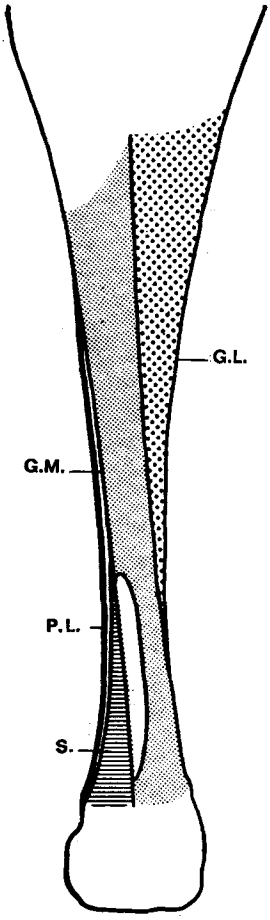
Postoperative E.M.G. (8 months): Normal.

Outpatient check-up (8 months): Gradually increased training. Able to do high-jumping of 1.8 metres, but some diffuse pain on sprint training.

Outpatient check-up (13 months): Probably started too hard training in interval as well as long-distance running; had developed diffuse pain further laterally, which gave rise to suspicion of imminent lateral rupture. Operation scar normal but Achilles tendon felt slightly indurated and had not resumed its normal soft elastic consistence. E.M.G. was still wholly normal.

Result (15 months): He had completed another period of hard training and was free of all symptoms. Training 3—4 days a week, long-distance running over 8—9 km and interval running over 6 times 1000 metres or 300 metres at relatively high tempo. No trouble at all with Achilles tendon.





CASE 23. A 23-year old gymnastics master and medium-distance runner with a 7-month history of tendinitis of right Achilles tendon at insertion laterally. After local steroid injection he was symptom-free for 3 months.

Trauma (3 months before operation): Sharp pain medially in Achilles tendon after training. Persistent pricking pain, probably due to pressure of shoe stiffener while running in training shoes with built-up heels.

E.M.G.: No abnormalties.

Treatment: Rest from training.

Subjectively (1 month before operation): On attempts at training he suffered pain, sometimes so sharp that he could hardly walk.

Objectively: Tendon contour irregular medially a few cm above insertion; tenderness on palpation over this area.

Preoperative E.M.G.: Volitional activity reduced medially. Medial rupture suspected.

X-ray: Dorsal border of fatty space in front of Achilles tendon somewhat indistinctly outlined.

Operation: A thick tendon-like thread extended medially from Achilles tendon, a good 5 cm above insertion, obliquely into the thickened wall of the bursa, to which it adhered. Partial medial longitudinal rupture. Excision; side-to-side suture.

Histologically: Coarse-bundled connective tissue, rich in collagen, only slightly resembling devitalized tendon tissue, and granulation tissue, highly sclerosed and tranformed into tendon-like tissue.

Return to work: 6 weeks.

Outpatient check-up (7 months): Unable to commence training for the first few postoperative months but had cycled instead. Laterally, above insertion, slight thickening which was tender to palpation — peritenon? It had virtually disappeared at the time of examination. Lately he had trained at irregular intervals. Operation scar normal.

Result (13 months): Training 4 times a week, running 10—15 km. No trouble with the right Achilles tendon but some discomfort from the left one.

CASE 24. A 19-year-old office clerk and medium-distance runner.

Trauma (8 months before operation): On running indoors on a hard wooden floor he felt sharp pain in right Achilles tendon.

Treatment: After steroid injection medially at insertion of tendon the tenderness over this area disappeared. The troubles returned, when he commenced training.

Subjectively: Stabbing pain in Achilles tendon on attempts at training and on walking up and down a flight of stairs.

Objectively: Slight swelling of peritenon, fairly intensive tenderness on palpation from insertion of tendon for just over 6 cm in proximal direction. Uncertain whether pain was localised more laterally or more medially. On palpation of relaxed tendon, the point of maximal tenderness was laterally 6—7 cm above insertion. Slight atrophy of lateral gastrocnemius belly.

Preoperative E.M.G. (on two occasions): Some decrease of volitional activity in lateral gastrocnemius belly. Hoffmann's reflex heightened. Shortened contraction time, deformed contraction curve.

X-ray: Right Achilles tendon somewhat thickened.

Operation: Dorsally, Achilles tendon normal. Ventrally, indurated section at junction between soleus muscle and lateral portion of tendon. Removal of granulation tissue revealed a rupture of ventral portion of tendon, 5 cm in length and extending slightly obliquely. End-to-end (side-to-side) suture.

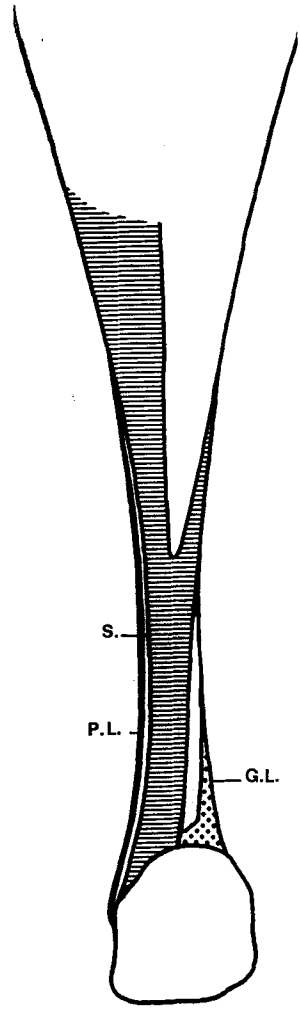
Histologically: Partially devitalized tendon tissue with altered collagen stainability and poor stainability in endoplasm areas. Narrow streaks of newly formed granulaton tissue, rich in collagen and of tendon-like structure. Very sparse monocytic infiltration around some small vessels.

Return to work: 7 weeks.

Postoperative E.M.G. (3 months): Normal. Only slight asymmetry of volitional activity medially-laterally.

Outpatient check-up (3 months): No trouble with Achilles tendon, apart from sensation of cramp in calf muscles on riding a bicycle ergometer. Operation scar normal. No tenderness on palpation. Gradually increased training.

Result (1 year and 1 month): Able to run maximum 20 km without any trouble with Achilles tendon for the first 8—9 months after operation. Then he fell ill with pleurisy. Strength of leg and tendon returned after disk-bar training.



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