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THE RESULTS OF TENDON SUTURE OF THE HAND

A Review of 500 Patients

By

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INTRODUCTION

The treatment of tendon lesions of the hand has always been a major problem for the medical profession.

This is due to several reasons:

In the first place clear indications pointing to primary or secondary sutures have never been formed.

Secondly there are relatively few surgeons who have mastered the technical difficulties associated with tendon sutures.

Finally, the follow-ups seem to indicate that the results in many cases are poor, and generally speaking this is in accord with the experiences of the majority of surgeons.

However the indications for tendon suture as well as the evaluation of the results have very much varied during the course of time. After the emergence of antiseptics a number of publications appeared telling of successful tendon sutures (*König, Küster, Nicoladoni,* and more). *Haegler* believed in his time that the suturing of the flexor tendons was such a simple operation that it could be performed by the local practitioner. Other authors of a later date (*Bunnell*) have claimed that the prognosis of the tendon suture is exceedingly poor, especially within certain regions of the hand. The countless number of suggestions aiming at technical improvements of the suturing methods point to the same conclusion.

The surveys which have so far been published are based on fairly heterogeneous material and unfortunately do not always permit a clear evaluation of the results. They partly derive from certificate material and questionnaires and on information from insurance companies

(*Dubs, Kiaer, Fleischer-Hansen*, and more). They consist partly also of such small series, that no reliable statistical conclusions can be drawn (*O'Shea, Närvi, Haegler, Müller*, and more). An exception is *Trautner*'s publication from Copenhagen in 1946: an investigation of 272 patients treated mainly by primary tendon suture.

The purpose of the present article is, to contribute to a more uniform treatment of open tendon sutures of the hand.

At the Surgical and out-patient department of Drammen Hospital a large number of hand injuries, is treated every year. The reason is that the town and neighbouring districts of Drammen form one of the largest centres of the timber-felling and forestry industry in the country. One would also assume therefore that the form of the lesions would be different from that seen in the normal series culled from the town, and with the passage of time the impression received has been that the majority of tendon injuries are either pure cuts (axe injuries) or dilacerations (machine injuries). The series confirmed this—see below. This further involved the question whether a difference could be demonstrated in the prognosis of tendon injuries corresponding to the differing forms of lesion.

THE SERIES

During the period 1940–1950, 734 tendinosutures were performed upon 510 patients in the Surgical and Out-patient Department of Drammen Hospital. 10 patients are not included in the series (6 patients are dead, 2 have left the country and 2 could not be reached). In all 500 patients were re-examined on whom 724 tendon sutures were performed (see Table 1). The series does *not* include open tendon injuries

TABLE 1
The Series.

Type of tendon	No. of patients	Number of tendon suture		
		Primary	Secondary	In all
Flexor tendon	218	298	20	318
Extensor tendon	282	340	66	406
Total	500	638	86	726

which were treated conservatively (plaster, splints or other immobilisation). The number of tendon sutures which this article demonstrates should be large enough to permit conclusions to be drawn from the results. Table 2 shows a comparison between this series and some of the

TABLE 2
Earlier investigations.

Investigator	Year	No. of patients	Number of tendon sutures		
			Flexor	Extensor	Total
Haegler	1896	100	35	65	100
Just	1923	120	126	84	210
Närvi	1926	102	?	?	130
O'Shea	1939	123	71	52	123
Trautner	1946	259	"111"	"148"	376
The author	1954	500	318	406	724

largest series which have hitherto been published. It is not the author's intention to discuss each one of these publications in detail, but merely to draw attention to the fact that the number of extensor and flexor lesions in some of the series, in *Trautner*'s amongst others, refer to the number of *patients*, not to the total number of tendon lesions.

Treatment was administered partly in the operative department, partly in the policlinic (see Table 3). Most of the extensor tendon lesions were treated by the policlinic staff, but most of the flexor tendons were sutured in the operative department. This fact could well be expected, but it must be borne in mind when the results are evaluated.

Age and sex distribution exhibit the same variations well known in other publications and will not be mentioned here.

The manner in which the injury was inflicted is of much interest —see Table 4. It is striking how completely axe and saw blade lesions are in the ascendant; they form together almost 70 % of all the lesions. The distribution is typical: the axe hits the extensor tendons (timber fellers), while the saw blade damages the flexor tendons. This occurs to a large extent in the smaller saw-mills when the hand pushes the timber log towards the saw blade.

In a series based on town-dwellers (*Trautner*) axe and saw blade lesions were found to form only about 6 % of the total, while cuts from fragments of glass were the most frequent lesions (about 45 %).

TABLE 3

Where treated	No. of patients	Number of tendon sutures		
		Flexor	Extensor	Total
Operative Department	201	216	136	352
Out-Patient Department	299	102	270	372
Total	500	318	406	724

TABLE 4
Type of lesion.

Method of injury	No. of patients	Number of injured tendons		
		Flexor	Extensor	Total
Axe	175	34	221	255
Saw blade lesions (circle saw, tenson saw)	148	171	64	235
Knife	64	52	47	99
Glass	52	44	18	62
Crushing	12	2	12	14
Sickle	18	9	12	21
Subcutaneous ruptures	16	0	16	16
Other causes	15	6	16	22
Total	500	318	406	724

Throughout the whole of this series the manner of injury is distinguished by clearly uniform features. There are other factors, however, which contribute to differentiate the series e.g. the different methods by which the injuries are treated. This is due to the different material used for suturing, different operative techniques, and the varying abilities of the doctors. Most of the tendon sutures were carried out by assistant doctors on duty (with varying experience and qualification) or by permanently appointed policlinic doctors, and a lesser number by the senior assistant doctor. Usually a simple Bunnell suture was performed with silk or flax. On the whole the series will not illustrate a clearly defined technique in suturing. Nor is this intended. The purpose is to present the results of that tendon surgery which is pursued at *a Norwegian Hospital possessing in general a good surgical standard and efficiency.*

FOLLOW-UP PROCEDURE

The follow-up examinations took place during the course of the year 1951 and the spring of 1952. The observation period varied from 11½ years, to 2 years, on an average 5¾ years.

Out of the 500 patients included in the series the author re-examined personally 478 patients with 696 tendon injuries: all those with flexor tendon lesions, in all 218, and 260 patients with extensor tendon lesions. 22 patients with a total of 28 extensor tendon injuries were examined by the patients' own doctors. The procedure was the same in all cases, since the methods pursued in the re-examination here were forwarded to the doctor concerned. It was above all the *function* of the injured finger which was examined: each individual finger joint under-

went active and passive stretching and bending, in the metacarpophalangeal joints and in the wrist joint. In contrast to *Trautner* the author has *list the result of each single finger* not the hand as a whole---for many suffered several tendon lesions simultaneously, some with both flexor and extensor lesions from the same injury. One might well foresee that the result of the treatment would vary according to the finger, and the follow-up confirmed this.

Mobility was partly examined by measuring the angle corresponding to the size of the arc of movement, since the circumference of the finger was traced on paper in its furthest positions. Likewise the distance in mms. was measured from the digital pulp to both the distal hand line and to the proximal part of the hollow of the hand. Furthermore a comparison with the healthy finger on the other hand was made, in order to ascertain the strength of the stretching and bending of the injured finger. The tabulation of all the angles and distance estimates, however, was so far from clear and was so difficult to evaluate that a clinical judgement of function was considered to be the only rational approach in the presentation of the results. *By successful result is meant complete or approximately complete recovery of tendon function; by unsuccessful result is meant no tendon function at all, while a satisfactory result signifies a tendon function about half the normal.*

Finally a careful investigation was made into the sensibility of all cases, into possible vasomotor disturbances and into the appearance and position of the scars. No importance was attached to these factors, however, unless they had an effect upon the function of the injured tendon. Lastly all case-histories were checked and perhaps supplemented.

THE RESULTS

Table 5 shows the results of the examination evaluated according to the method mentioned above. A well-known characteristic will at once be noticed: the relatively large number of successful primary tendon sutures of extensor tendons and the many poor results with flexor tendons. In this series the difference is greater than in most of the others; in particular there is a striking number of unsuccessful sutures of:

Flexor tendons. These are the most interesting, and a more exact localisation of the site of the tendon sutures is therefore necessary, see Table 6. The black area on the diagram represents "no man's land". That is, the region from the insertion of m. flexor digitorum sublimis to the distal line in the hollow of the hand, or that part of the hand where both the superficial and the deep finger flexors have a common

TABLE 5

The results after primary and secondary tendon suture.

	Unsuccessful	Fairly Satisfactory	Successful	Total
Primary tendon suture:				
1) Flexor tendons	*188*	86	24	298
2) Extensor tendons	34	92	*214*	340
Secondary tendon suture:				
1) Flexor tendons	11	8	1	20
2) Extensor tendons	12	22	32	66
Total	245	208	271	724

tendon sheath. *Here there was only one solitary successful primary suture,* and this occurred on the thumb where we only have one flexor tendon. Of the 3 fairly satisfactory results 2 were similarly sited on the thumb, while altogether *94* were failures. Distally to "no man's land" the results were also very poor, although not so extreme, whilst the further proximal sutures were much better.

It should be noted that suturing of the flexor tendons always signifies *suturing of the deep flexor tendon.* Suturing of the superficial tendon was never attempted whether it was injured alone or in combination with the deep tendon.

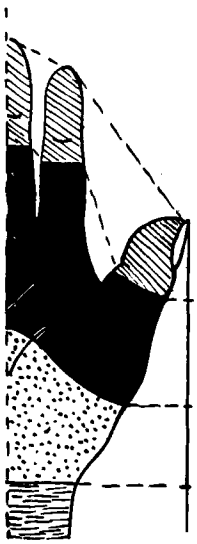

TABLE 6

The results after primary suturing of flexor tendons.

Unsuccessful	Fairly satisfactory	Successful	Total
40	3	3	49
94	3	1	98
24	24	6	54
30	56	14	100
Total *188*	86	24	298

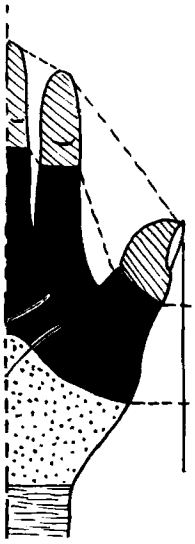

TABLE 7

The results after secondary suturing of flexor tendons.

	Unsuccessful	Fairly satisfactory	Successful	Total
	2	0	1	3
	6	5	0	11
	1	4	1	6
Total	9	9	2	20

Table 7 shows the results of *secondary suturing* (not tendon transplantation) of the flexor tendons. The figures are not large enough for definite conclusions to be drawn, but point clearly in the same direction, i.e., that the tendinosuture in "no man's land" is an operation with a poor prognosis as far as function is concerned. In secondary suturing the conditions ought to be more favourably adjusted for a good result: the skin and subcutaneous tissue are intact and the surgeon in question is quite prepared for an operation of long duration. When the result nevertheless remains no better than after the primary tendon suture, it may intimate that it is the normal anatomical conditions (the tendon sheath and its relation to the tendons) which are not favourable.

The following circumstances support this view: the injuries to the flexor tendons caused by axe cuts would seemingly possess a good prognosis because the dilaceration of the tissue is small and the risk of infection not large. 22 of these 34 injuries struck "no man's land"

TABLE 8

Probable causes of the poor results following primary suture of the flexor tendons.

"Selected" material	61	patients
Infection	17	–
Technical error during operation	34	–
Defective post-operative control	19	–
Lack of tendon function (Adhesions and/or secondary tendon ruptures)	9	–

(more often than not the left index finger), and it emerged that only one of these tendon sutures succeeded, all the others failed. After primary suture of all the 7 axe injuries distal to "no man's land", not one result was successful. This does not indicate a better prognosis in the case of the "clean" injuries.

Is it possible that other factors are the cause, perhaps contributory causes of the poor results? The author has sought to select carefully series which ought to have good prognoses: uncomplicated injuries where only *one* tendon is affected, where no nerve lesion is manifested, no fractures or major injury to the blood vessels, and where the lesion was inflicted with axe or knife. Out of 61 patients who ought to fulfil these requirements there was (see Table 8) a striking number with wound infection: 17 in all, in spite of the supposedly "clean" injuries. Furthermore errors in operative technique were made in at least 34 cases—probably in several more (incorrect auxiliary incisions, too taut thread at the site of the suture, insufficient immobilisation and the like). Small technical niceties are not counted. In 19 cases no controlled check was made on the patient, or the check-up left much to be desired. In 9 other cases the causes of the poor result could not be determined with certainty. It is obviously impossible to ascribe the results solely to one of the causes mentioned, in the majority of cases it was a combination of several. It is difficult to probe into them more closely, and the table is based upon an evaluation according to probability.

TABLE 9

The results after primary suture of the extensor tendons.

Localisation	Unsuccessful	Fairly Satisfactory	Successful	Total
Tendon attachment (transosseous suture)	5	9	5	19
Fingers:				
a) Free tendon (aponeurosis)	7	16	71	94
b) a + capsule injury	7	11	22	40
c) b + top crust of articular surface ...	6	17	17	40
d) a + transverse fracture	5	20	13	38
Hand:				
a) In the tabatière anatomique	4	11	37	52
b) Other tendons of the hand	0	3	19	22
Underarm	0	5	30	35
Total	34	92	214	340

Extensor tendons. In this article the designation extensor tendon also refers to the dorsal aponeurosis of the fingers, which is actually not a normal longitudinal tendon, but an intricately constructed tendon resembling a leaf. Table 5 shows that the prognosis of primary and

TABLE 10
The results after secondary suture of extensor tendons.

Localisation	Unsuccessful	Fairly successful	Successful	Total
Tendon attachment	6	7	3	16
Finger	4	7	15	26
Back of the hand	2	8	14	24
Total	12	22	32	66

secondary suturing of extensor tendons is surprisingly good, better than in the majority of the series which have hitherto been published. The reason may possibly be that in most cases the lesions were caused by an axe and the surgeon therefore had to deal with relatively "clean" injuries. However many of the extensor tendon lesions were complicated, not only by simultaneous nerve lesions, but also by capsule injuries and fractures, particularly when the finger knuckles were struck. As Table 9 shows, several of these complicated tendon injuries seem to have a comparatively good prognosis after primary tendinosuture. This was especially so when the tendon injury was accompanied by a lesion to the joint capsule, possibly also to a smaller or larger area of the articular surface.

With a simultaneous transverse fracture, however, the results were poorer, but not to any degree discouraging.

After secondary suturing of the extensor tendons (Table 10) the results were likewise comparatively good, but not of the same standard as after primary suture. This is due to the fact that the "difficult" extensor lesions were transferred to enable secondary sutures to be performed. Furthermore the total number of the latter was small and consequently they were infinitely more burdened by the unfavourable prognosis of the tendon attachment lesions. In these cases both in primary and secondary sutures the results were poor.

The importance of the time factor to the results obtained after suturing flexor and extensor tendons is difficult to judge. If one considers the different types of lesion (see Table 4), it is not possible in this series to demonstrate any clear division favouring those treated earliest. Irrespective of the nature of the injury the prognosis generally

seems to be independent of the time factor if a limit approaching 7–8 hours is imposed. At Drammen Hospital about 70 % of the injured were treated within the first 6–8 hours, in spite of the great distances: often 200–300 kms.

Nor can it be seen to make any difference to the results whether the patients were treated at the policlinic or at the operative theatre. A reliable comparison is not easy because,—as Table 3 shows—treatment was selective and the favourable and less favourable tendon injuries were distributed respectively. But even if the minor group of flexor tendons treated at the policlinic is studied, together with the minor group of extensor tendon lesions, no clear difference in the results when compared with the whole series can be discovered, either in the one or the other direction.

CONCLUSIONS

With this presentation of the results the author believes that he is justified in setting down the following main lines of treatment for tendon lesions of the hand in departments of general surgery:

Flexor tendons: Primary tendon sutures when the lesion occurs in "no man's land" are to be absolutely discouraged. Distally to "no man's land" no primary suture should generally be performed unless those concerned are skilled in the technique and know in which cases a direct suture should be made, or possibly a tenodesis or arthrodesis in the extremity, or reinsertion of the tendon.

The prognosis of secondary sutures within the same areas is no better and these should not be attempted.

In this part of the hand the aim should, above all, be primary healing of the skin, and then the later reconstruction of the tendon can be passed to a specialist in hand surgery.

Proximally to "no man's land" primary suturing is attempted in uncomplicated injuries to the tendon. When these are accompanied by nerve lesions or fractures the primary tendon suture is generally avoided. As the prognosis for the tendon suture improves the further proximally the lesion is placed, the tendon *can* be sutured primarily in certain cases even with minor complicating injuries, if at the same time these receive adequate treatment.

Extensor tendons: In all cases of uncomplicated extensor tendon lesions and lesions of the dorsal aponeurosis of the fingers primary tendon suture should be attempted. Even in minor lesions of the joint capsule, possibly also of a smaller or larger area of the articular surface a primary tendon suture *can* be ventured upon. In further

complications like transverse fractures or considerable dilaceration of the skin the primary suture is avoided.

SUMMARY

A re-examination was made of 500 patients with altogether 724 tendon lesions of the hand on which primary and secondary tendon sutures had been carried out. The series is notable in that by far the majority of flexor tendon lesions resulted from saw blade injuries (circular saws, band saws, cross-cut saws), while most of the extensor tendon lesions were due to axe injuries. The vast forestry industry provides the reason for this.

The results of the primary tendon sutures of flexor tendons in "no man's land" are extremely poor; this is equally true distally to "no man's land". Otherwise the results on the flexor aspect of the hand are relatively good. On the extensor aspect of the hand and fingers the results following primary suturing are strikingly good, even if the lesion is accompanied by capsule injuries and simple fractures. Secondary sutures give no better results whether the tendon is a flexor or extensor.

The conclusion is that in departments of general surgery it should as a rule be abstained from primary tendon suture in "no man's land" and distally to "no man's land". Surgeons may carry out the primary tendon suture however proximally on the flexor aspect of the hand and in the majority of the extensor tendon lesions.

Secondary *tendon repair* ought to be transferred to a specialist in hand surgery.

RESUME

Il a été procédé au réexamen de 500 malades ayant au total 724 lésions des tendons de la main chez lesquels il avait été pratiqué des sutures primaires et secondaires des tendons.

Cette série est notoire du fait que de loin la majorité des lésions du tendon fléchisseur provenaient de coupures de scies (scies circulaires, scies alternatives), tandis que la plupart des lésions des tendons extenseurs étaient dues à des accidents de hache. L'étendue de l'industrie forestière en fournit la raison.

Le résultat des sutures primaires des tendons fléchisseurs pratiquées dans le "no man's land" sont extrêmement piètres; ceci est également vrai distalement au "no man's land". Autrement les résultats de l'aspect fléchisseur de la main sont relativement bons. Sur l'aspect extenseur de la main et des doigts, les résultats de la suture primaire

sont remarquablement bons, même si la lésion est accompagnée de blessures de la capsule et de fractures simples. Les sutures secondaires ne donnent pas de meilleurs résultats suivant qu'il s'agit de tendons fléchisseurs ou extenseurs.

La conclusion est que dans les Services de chirurgie générale, on doit s'abstenir, en règle générale, de la suture primaire du tendon dans le "no man's land" et distalement au "no man's land". Le chirurgien doit opérer la suture primaire du tendon, de quelque manière que ce soit, proximalement à l'aspect fléchisseur de la main et dans la majorité des lésions du tendon extenseur.

Il convient de renvoyer les réparations secondaires des tendons à un spécialiste de la chirurgie de la main.

ZUSAMMENFASSUNG

500 Patienten mit insgesammt 724 Sehnenverletzungen der Hand, an denen primäre und sekundäre Sehnennähte ausgeführt worden waren, wurden nachuntersucht. Diese Gruppe von Patienten ist bemerkenswert, da weitaus die Mehrzahl der Beugesehnenverletzungen durch Sägen (Rund- und Kreuzschnittsägen) hervorgerufen waren, während die meisten der Strecksehnenverletzungen durch Unfälle mit Äxten entstanden. Die ausgedehnte Holzschlagung in den Wäldern ist die Ursache dieser Erscheinung.

Die Ergebnisse der primären Naht der Beugesehnen in "Niemannsland" sind äusserst schlechte. Dasselbe gilt für das Gebiet distal von "Niemannsland". Im übrigen sind die Ergebnisse an den Beugesehnen der Hand verhältnismässig gut. Die Ergebnisse nach primärer Naht der Strecksehnen der Hand sind erstaunlich gut, selbst wenn die Verletzung mit Beschädigung der Gelenkskapsel und einfachen Brüchen verbunden ist. Sekundärnaht gibt keine besseren Resultate weder an Beuge-oder Strecksehnen.

Die Schlussfolgerung ist, dass man im allgemeinchirurgischen Abteilungen in der Regel von primärer Beugesehnennaht im "Niemannsland" und distal davon absehen sollte. Der Chirurg kann jedoch die primäre Sehnennaht im proximalen Bereiche der Beugeseite der Hand und in der Mehrzahl der Strecksehnenverletzungen ausführen. Sekundäre Sehnennaht sollte an den Spezialist für Handchirurgie gewiesen werden.

REFERENCES

Bunnell, Sterling: Surgery of the Hand, J. B. Lippingcott, Philadelphia, 1948.
Dubs, J.: Correspond.-Blatt f. Schweizer Aertzte. 1919: 49: 1938.
Fleischer-Hansen, C. C.: Nord. Med. 1941: 9: 88.

Haegler, Carl S.: Beitr. z. klin. Chir. 1896: 16: 90 and 307.
Kiær, Sven: Acta Orthopaed. Scand. 1932: 2: 2002.
Küster, E.: Zentralbl. f. Chir. 1877: 4: 783.
König: Zentralbl. f. Chir. 1874: 1: 129.
Müller, Oswald: Beitr. z. klin. Chir. 1923: 128: 754.
Närvi, E. J.: Acta Chir. Scand. 1926: 60: 1.
Nicoladoni, C.: Wien. med. Wschr. 1880: 30: 1413.
O'Shea, Maurice C.: Surgery. 1939: 83: 346.
Trautner, Kjæld: Aabne Senelesjoner, A/S Axelholm, København, 1946.