ACUTE SUPPURATIVE TENOSYNOVITIS OF THE FLEXOR TENDON SHEATHS OF THE HAND

A REVIEW OF ONE HUNDRED AND TWENTY-FIVE CASES

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INFECTIONS of the flexor tendon sheaths of the hand present a problem still far from solution. They are of importance because of their frequency, their notoriously poor results, and the likelihood of permanent disability. Little progress has been made in their treatment in recent years. Surprisingly few large series of cases have been reported in the literature with enough follow up reports to give a true picture of the end-results. The most comprehensive reviews in the past have been those of Forssell[1] (1903), Keppler[2] (1912), Cleveland[3] (1924), Garlock[4] (1924), Schiessl[5] (1925), Brofeld[6] (1929), and Deike[7] (1933). In most of these, however, the follow up results were scanty. This review is an attempt to supply that defect. The series includes 125 cases admitted to the wards of this hospital over a 17 year period from 1916 to 1933. The average period of observation after operation was 16 months. A few cases were omitted because of insufficient data or because of an inadequate follow up report. During this period there were seven cases of gonococcus tenosynovitis which were not included in this analysis and which will be discussed only briefly.

Origin of Infection.—Infection may reach the sheath by any one of four routes. It may be introduced by primary direct inoculation as by a puncture wound, by secondary extension from a neighboring infection, by the blood stream, or by lymphatic spread from a more distant focus. None of the cases was infected by the hematogenous route except the seven gonococcus infections which will be discussed separately. Lymphatic involvement of a sheath from a distance must be rare. In spite of a careful search no instance of it was found in this series. Kanavel[8] believed it occurred occasionally following a lymphangitis on the volar surface of the finger. Forssell[1] reported three cases of ulna bursitis following a thumb infection, without suppuration of the radial bursa, which he believed were lymphatic in origin. These cases, however, are not very convincing.

As the hematogenous and lymphatic sources of infection can be eliminated here, the cases fall into two main groups, primary and secondary. The primary group represents those cases in which the infection has been implanted directly into the sheath at the time of injury. The secondary group includes those cases in which the sheath was involved by extension from a neighboring infection, usually an overlying abscess. These two groups differ considerably in their characteristics as will be shown by later comparisons. The

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differentiation between them in this review was not always easy but could usually be made fairly accurately from the type and site of injury, the symptomatology, and the findings at operation. There were 67 primary cases, or 54 per cent, and 58 secondary cases, or 46 per cent.

Trauma.—A history of preceding injury was obtained in 92 per cent of the cases. As shown in Table I a puncture wound was by far the most frequent cause, occurring in 64 cases or 51 per cent. The outstanding feature was the insignificant character of the wound in most cases. Not infrequently the injury was so slight that the patient had difficulty in remembering it. Four of the infections were due to human bites and will be discussed more at length later.

TABLE I

TYPES OF INJURY CAUSING TENOSYNOVITIS

	Cases	Per Cent
Puncture wounds............................	64	51
Lacerations and incised wounds...............	39	32
Unknown.................................	10	8
Contusions...............................	4	3
Burns....................................	4	3
Human bites..............................	4	3
Totals.................................	125	100

Wound of Entrance.—The frequent origin of tenosynovitis from injury at the flexor creases of the fingers has long been recognized. This series adds further emphasis to this site of origin. In nearly half the cases, 59 or 47 per cent, the wound of entrance was in, or close to, the flexor finger crease. The distal finger crease was the one most frequently involved and was by far the commonest site of entrance of infection anywhere on the fingers or hand. It was involved in 41 instances or 33 per cent in this series. The proximal interphalangeal crease was the site of entry in 13 cases or 10 per cent. At the distal and proximal interphalangeal creases the tendon sheaths are more superficial and are free of the thick annular ligaments which at other points bind them to the phalanges. The absence of this fibrous layer beneath the crease makes free motion possible yet at the same time leaves the sheath more vulnerable to injury and infection. The more frequent involvement of the distal crease may be due to its greater exposure to injury and to the fact that of the three creases it lies closest to the tendon sheath. Only a very slight injury or puncture wound in this region may infect it. The metacarpophalangeal crease was implicated in only 4 per cent of the cases. The tendon sheath beneath this crease is quite superficial but is protected by the phalangeal annular ligament which is absent at the other creases. Cases of tenosynovitis due to injury at the creases were mostly primary infections (68 per cent) from direct inoculation.

Tenosynovitis arising from injury or infection elsewhere than from a finger crease occurred in 63 cases or 51 per cent. The most common site

TABLE II

SITE OF WOUND OF ENTRANCE

Site		Cases		Per Cent	
At finger crease	Distal crease....................	41	....	33	
	Middle crease..................	13	....	10	
	Proximal crease	5	....	4	
	Totals.............................	59	....		47
Not at finger crease	Distal closed space...............	23	....	19	
	Middle closed space..............	13	....	10	
	Proximal closed space............	16	....	13	
	Palm..........................	7	....	6	
	Dorsum of hand or finger.........	4	....	3	
	Totals.............................	63			51
Unknown			3	....	2
Totals			125	....	100

was the distal closed space, occurring in 23 cases or 19 per cent of the series. Twenty-one of these 23 cases were of the secondary type. The proximal and middle closed spaces and the palm were less frequently at fault in the order named. The involvement of the tendon sheath secondarily from the distal closed space is of interest and illustrates the two routes of infection that have been emphasized by Auchincloss.[9] In 10 of the 21 cases in which the sheath was thus involved, the infection apparently invaded the end of the sheath directly from the adjacent soft tissues; in the remaining 11 cases, it reached the sheath by way of the shaft of the distal phalanx, the volar sub-tendinous space, and the distal phalangeal joint, usually with an osteomyelitis of both the distal and middle phalanges. The frequency of tenosynovitis secondary to infection of the distal closed space emphasizes the importance of early and adequate drainage of these infections.

Site.—The right hand was involved in 67 per cent of the cases, or twice as often as the left. The difference is obviously due to the greater use of the right hand and the greater chance of injury. The incidence of tendon sheath infection in the different fingers is shown in Table III. The thumb, index, and middle fingers were most often affected, probably in direct proportion to their more general use. The index finger came first. Other

TABLE III

DISTRIBUTION OF CASES OF TENOSYNOVITIS IN FINGERS

	Cases	Per Cent
Thumb.......................	22	18
Second finger..................	44	35
Third finger...................	33	26
Fourth finger..................	17	14
Fifth finger...................	9	7
Totals......................	125	100

reported series of tenosynovitis show a similar incidence, but with the thumb or third finger in first place.

Age and Sex.—There were 68 males and 57 females. The average age was 37, the youngest being five and the oldest 71.

Diagnosis.—Early recognition of tendon sheath infection is of paramount importance. Failure to recognize it at the outset and the consequent delay in operation are probably the main causes of the prevalent poor results. In 31 cases of this series, or 25 per cent, the diagnosis was not made at the first visit to the hospital. In the group with primary infection the diagnosis was missed in only 13 per cent of the cases, but in the group secondarily infected it was missed in 38 per cent and was often not made until after several days' delay (Table IV). The average delay in operation because of error in diag-

TABLE IV

ACCURACY OF DIAGNOSIS IN PRIMARY AND SECONDARY CASES AND IN WHOLE SERIES

	Primary		Secondary		Totals	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Correct diagnosis........	58	87	36	62	94	75
Incorrect diagnosis......	9	13	22	38	31	25

nosis in the primary group was one day, whereas in the secondary group it was over four days. The difference between the two groups is not surprising. In the primary group the classic signs of tendon sheath involvement are usually clear cut. The presence of tenderness localized definitely to the region of the sheath, the flexed position of the finger, and the exquisite pain on passive extension of the distal phalanx, are signs which leave little doubt as to the diagnosis. Of these, localized tenderness over the sheath is by far the most reliable. A wound of entry over the course of the sheath is usually present also. Usually these signs are easy to elicit, except in cases with a partially draining sheath in which they may be obscured because of lack of tension of the exudate in the sheath. Such cases are not an infrequent source of error in diagnosis. In the secondary group the diagnosis is more difficult. Here the presence of infection in the tissues outside the sheath confuses the picture. It is often difficult to decide whether or not the sheath has been invaded, especially in those cases in which only a localized portion of the sheath has been involved, as not infrequently happens. It should be strongly emphasized, however, that when the diagnosis of suppurative tenosynovitis is in doubt, it is usually better to operate than to delay. This point will be discussed subsequently in greater detail.

Classification of Results.—The results in this series of 125 cases were based on an average follow up period of 16 months. In evaluating the end-results, anatomic, symptomatic, and economic factors were considered, but the chief emphasis was placed upon the functional result. The classification into four groups used by Cleveland[3] was adopted with slight modifications.

Group I.—Bad Results.—This group included deaths, amputations, and deformed, stiff, often painful fingers without motion at the interphalangeal joints and little at the metacarpophalangeal joint.

Group II.—Fair Results.—Nearly complete motion at the metacarpophalangeal joint but no active motion at the interphalangeal joints.

Group III.—Good Results.—Complete function at the metacarpophalangeal joint and slight active motion at the interphalangeal joints.

Group IV.—Optimal Results.—An almost complete return of normal function in the finger. There may be very slight limitation of extreme flexion or extension but the finger is practically as useful as before the infection.

Results.—The final results in the 125 cases of this series were discouraging. Over one-third of all the cases fell into Group I. Nearly two-thirds of the cases were in Groups II and III. Only one-sixth regained approximately full function (Table V). These results were similar to those of

TABLE V

A COMPARISON OF RESULTS BY GROUPS

	Group I Bad Results		Group II Fair Results		Group III Good Results		Group IV Optimal Results		
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Totals
Present series.........	44	35	31	25	29	23	21	17	125
Present series (15 cases with tendon necrosis at operation omitted)	34	31	28	25	27	25	21	19	110

Cleveland,[3] whose 57 cases from this hospital were included in the present series. As it seemed perhaps unfair to include very advanced cases, another summary was made omitting 15 cases which showed definite necrosis of the tendon at operation. These results, however, were only slightly better. Other reported series show varied figures. Keppler,[2] Schiessl,[5] and Deike[7] classified their cases according to function into three groups—good, average, and poor. An attempt was made to reclassify our results for comparison. They proved to be very similar to those of Deike, but much poorer than those of the other two authors (Table VI). Perhaps the discrepancy can be partly explained by differences in follow up methods. Schiessl did not

TABLE VI

A COMPARISON OF RESULTS WITH THOSE IN OTHER SERIES

Reclassified into Three Groups

	Poor		Average		Good		Totals
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases
Keppler (1912)........	35	28	13	10	79	62	127
Schiessl (1925)........	19	28	10	14	39	57	68
Deike (1933)..........	106	53	34	17	60	30	200
Present series (re-grouped)............	63	50	27	22	35	28	125

state whether his cases were followed or not. Keppler reexamined about one-half of his cases but did not state the length of follow up. Deike followed only one-third of his series, largely by questionnaire. The cases reported here were followed for an average period of 16 months after operation by actual interview and examination in nearly every case.

Tendon Necrosis.—Gross sloughing of the tendons in whole or in part was very frequent and was noted in 52 per cent of the cases. It was possibly even more frequent but was not recorded. Deike[7] noted it in about one-fourth of his 200 cases. Garlock[4] reported necrosis of the tendon or tendon sheath in 72 per cent of his 42 cases. A comparison between the incidence of tendon slough and the results showed a close correlation between the two. The one case in Group IV showing tendon necrosis was one in which a small portion of the flexor carpi radialis tendon sloughed, leaving no perceptible loss in function. Of the five cases in Group I without tendon slough, four had stiff contracted fingers and one died of sepsis (Table VII).

TABLE VII

INCIDENCE OF TENDON NECROSIS IN THE RESULT GROUPS

	Group I Bad Results		Group II Fair Results		Group III Good Results		Group IV Optimal Results		Totals	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Tendon intact...	5	11	14	45	21	72	20	95	60	48
Tendon sloughed.	39	89	17	55	8	28	1	5	65	52

Necrosis of the tendon was slightly more frequent in secondary than in primary infections, occurring in 55 per cent of the former and 40 per cent of the latter. The infection in the soft tissues outside the tendon sheath, which is present in secondary cases, tends to prolong the infection within the sheath and compromise the tendon.

As later discussion will show, tendon necrosis occurred with about equal frequency in Staphylococcus and Streptococcus infections but much more frequently in mixed infections with two or more organisms.

Bacteriology.—Culture reports were obtained in all but 13 cases. With but few exceptions these were taken at operation. Further cultures were rarely taken. It is probable that secondary contamination with other organisms frequently occurred later and may have influenced the course of the infection. The Streptococcus hemolyticus was the organism most frequently found, and was present in pure culture at operation in 45 cases (36 per cent), and the Staphylococcus in 39 cases (31 per cent). The remaining 28 cases included 13 cases of mixed Streptococcus hemolyticus and Staphylococcus, eight cases in which no growth was reported, five cases of mixed organisms, three of which contained *B. coli*, and two cases of nonhemolytic streptococcus in pure culture. Keppler's[2] series showed a very similar distribution of organisms. In most of the other reported series, however, few if any cultures were reported.

The results were definitely better in the Staphylococcus than in the Streptococcus cases. The mixed Streptococcus hemolyticus and Staphylococcus cases held an intermediate position and appeared to do slightly better than the Streptococcus cases in pure culture but were too few in number for fair comparison. The other instances of mixed infection did poorly. A number of these were very late cases. Those in which no growth was reported did unusually well. Some were very early cases and several may have been unrecognized cases of gonococcus tenosynovitis. The 13 cases in which no culture report was received did extremely poorly (Table VIII). Some were late, advanced cases in which the culture was neglected. The poorer prognosis in the Streptococcus cases is somewhat surprising. Keppler[2] and Cleveland[3] noted this also. This group, however, included most of the very severe spreading infections and most of the bad complications.

TABLE VIII

A COMPARISON OF RESULTS ACCORDING TO BACTERIOLOGY

	Group I Bad Results		Group II Fair Results		Group III Good Results		Group IV Optimal Results		Totals	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Streptococcus hemolyticus...	19	42	13	29	8	18	5	11	45	36
Non-hemolytic streptococcus..	—	—	1	50	—	—	1	50	2	21
Staphylococcus..	10	25	8	21	13	33	8	21	39	3
Streptococcus hemolyticus and Staphylococcus	5	38	2	16	5	38	1	8	13	10
Miscellaneous...	3	60	2	40	—	—	—	—	5	4
No growth......	—	—	1	12	2	25	5	63	8	7
No report.......	7	54	4	30	1	8	1	8	13	10
Totals........	44	35	31	25	29	23	21	17	125	100

The incidence of tendon slough was about the same in both the Streptococcus hemolyticus and Staphylococcus groups. It was much higher in cases of mixed infection with two or more organisms (Table IX).

TABLE IX

A COMPARISON OF THE INCIDENCE OF TENDON NECROSIS WITH BACTERIOLOGY

	Tendon Intact		Tendon Sloughed		Totals	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Streptococcus hemolyticus....	25	56	20	44	45	36
Non-hemolytic Streptococcus.	1	50	1	50	2	2
Staphylococcus..............	21	54	18	46	39	31
Streptococcus hemolyticus and Staphylococcus	5	38	8	62	13	10
Miscellaneous..............	—	—	5	100	5	4
No growth.................	7	88	1	12	8	7
No report.................	1	8	12	92	13	10
Totals..................	60	48	65	52	125	100

The Streptococcus was found more often in primary tenosynovitis than the Staphylococcus. Sixty-nine per cent of the Streptococcus cases were of this kind as compared to 44 per cent of the Staphylococcus cases. Similarly, the Staphylococcus was more frequently present in secondary tenosynovitis.

The exact importance of secondary contamination was not determined. To do this repeated cultures in each case would have been necessary. Its importance, however, is undoubtedly great. Since 1921, especial care was taken in the early dressings to prevent it. The hand and forearm were kept in sterile towels. Dressings were touched only with sterile gloves or instruments. If soaks were used every precaution was taken to keep them sterile as well.

Primary and Secondary Tenosynovitis.—This analysis has already shown that secondary tenosynovitis is more difficult to diagnose and more prone to tendon necrosis than primary tenosynovitis. It is most frequently due to the Staphylococcus whereas primary infections are usually due to the Streptococcus. Further analysis will show that secondary tenosynovitis is more apt to cause a localized type of infection with only a partial involvement of the tendon sheath. Contrary to expectation, a comparison between results in primary and secondary tenosynovitis did not show great differences. Both Cleveland[3] and Iselin[10] have stressed the better prognosis in primary cases. In this series the high incidence of primary cases in Group I was due largely to severe Streptococcus infections which were mainly primary. These were offset, however, by a large number of secondary cases in Group I due to late diagnosis and operation, often with extensive infection adjacent to the sheath. The good showing of the secondary cases in Group III was due largely to the inclusion here of secondary cases with only limited sheath involvement and consequently only slight disability. The larger number of primary than secondary cases in Group IV suggests that the best results can be expected in primary cases treated early.

Results in the Different Fingers.—A comparison of the results of tenosynovitis in the various fingers is of interest in showing that the best results occurred in the thumb and the poorest in the fifth finger. If the results in both Group III and IV are combined, the thumb ranks first in spite of the fact that the radial bursa was involved in every case but one and in spite of the frequent extension of the infection to the ulna bursa. When the infection was limited to the digital sheath and radial bursa, the results were unusually good with eight of the 13 cases falling into Group III. When the infection extended to the ulna bursa, however, the results were all very poor. Seven of the eight cases with this extension had to be placed in Group I. The remaining one had fair function, but only because the extension was limited to the ulna bursa above the wrist. Thus, notwithstanding the danger of ulna bursitis, the results in the thumb were better than in the other fingers. Deike[7] obtained his best results in the fourth finger. The thumb ranked low because of the very high incidence of ulna bursa extension in his cases. The better prognosis in the thumb is due to several factors. Since the thumb has

one less phalanx than the other fingers, a sloughed or adherent tendon causes less functional disability. There is loss of motion in the phalangeal joint only, as other muscles provide motion in the metacarpophalangeal joint. The thumb has also only one flexor tendon in its sheath instead of the two present in the other fingers, which often become adherent to each other after infection. The tendon to the thumb lies for most of its course at a deeper level than the other tendons and is less apt to become attached to the skin after incision. Moreover, involvement of the radial bursa in the palm and above the wrist does not usually cause much additional disability unless the tendon sloughs.

In the fifth finger, the results were poor. This finger has none of the advantages of the thumb. Moreover, it has an extensive sheath which includes the tendons of the three middle fingers and which if infected may cripple them as well. Deike also had his poorest results in this finger (Table X).

TABLE X

END-RESULTS IN THE DIFFERENT FINGER SHEATHS

	Group I Bad Results		Group II Fair Results		Group III Good Results		Group IV Optimal Results		Totals	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Thumb.........	8	36	3	14	9	41	2	9	22	18
Second finger....	16	35	12	27	9	20	8	18	45	36
Third finger.....	11	45	7	21	5	15	10	30	33	27
Fourth finger....	6	37.5	4	25	6	37.5	—	—	16	12
Fifth finger.....	4	44.5	4	44.5	—	—	1	11	9	7

The Bursae.—The radial bursa was involved alone without associated infection of the ulna bursa in 13 cases. In six the whole bursa and digital sheath of the thumb were involved, and in seven cases the digital sheath and bursa in the palm were infected without extension above the wrist. In only one case was the digital sheath of the thumb involved alone without extension upward to the bursa. The bursa was never found infected without the digital sheath. Forssell did not find it to have occurred in his cases or in any of those in the literature. Anatomic studies help to explain this. According to Poirier,[12] the sheath communicates freely with the bursa in 95 per cent of cases. The organisms responsible for these infections were well distributed among the different groups with the Streptococcus hemolyticus the most frequent. As has been shown, the results were surprisingly good with most of the cases falling into Group III. The failure of the infection to extend to the bursa above the wrist in more than half the cases is of interest. I know of no anatomic explanation. It was probably due to the walling off of the sheath by exudate ahead of the infection.

The ulna bursa was involved alone without associated radial bursitis in eight cases. In three the infection included the fifth finger sheath and the

whole bursa, in three cases it affected the finger sheath and the bursa in the palm only, and in two cases it involved the bursa in the palm and above the wrist without the digital sheath. In two cases the fifth finger sheath was involved without any extension to the bursa. The frequent infection of the digital sheath or bursa without the other may be partly explained on anatomic grounds. Poirier found full communication in only about one-half of his dissections. The others showed either narrowing or complete occlusion. Half of the ulna bursa cases in this series were caused by the Streptococcus hemolyticus in pure culturé. The results were nearly all very poor.

There were ten instances of combined infection of both radial and ulna bursae. These infections are notorious for their severity, rapid spread, and crippling results. Most of the major complications occurred in this group. In nine of these cases the infection spread from the radial to the ulna bursa and in only one did it spread from the ulna to the radial bursa. The frequent extension of the infection from one bursa to the other may be due to actual communication or to their proximity. Poirier found free connection to occur in about one-half of his dissections, usually by way of one or two small intervening bursae. In our series 41 per cent of the radial bursitis cases spread to the ulna bursa and only one case of ulna bursitis spread in the reverse direction. Other authors report a higher incidence. Forssell,[1] Brofeld,[6] and Deike[7] had 85, 76, and 43 per cent respectively of radial to ulna bursa extensions, and 21, 0, and 35 per cent of ulna to radial bursa extensions. Brofeld encountered no instance of ulna-radial bursa spread. The more frequent extensions in these series may be due to a larger number of late neglected cases. The preponderance of spread from the radial to the ulna bursa as compared to that in the reverse direction is noteworthy and has been reported by other authors. No satisfactory explanation, however, has been offered. The involvement of the bursae and finger sheaths was complete in all but two cases. The Streptococcus hemolyticus was present in every case but one. In seven it was recovered in pure culture and in two cases it was combined with the Staphylococcus. This is the organism one would expect in such virulent and wide spread infections. The results were extremely bad. Every case but one fell into Group I.

TABLE XI

RESULTS IN RADIAL AND ULNA BURSAE

	Group I Bad Results		Group II Fair Results		Group III Good Results		Group IV Optimal Results		Totals
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases
Radial bursa.........	1	8	2	15	8	62	2	15	13
Ulna bursa..........	3	38	4	50	—	—	1	12	8
Radial and ulna combined..............	9	90	—	—	1	10	—	—	10

Duration of Tenosynovitis Before Operation and Results.—The average duration of tenosynovitis before operation was 6.2 days. This long period of delay was probably the chief cause of the poor end-results. The average delay before operation in Group IV was 3.4 days as compared to 9.3 days in Group I. This delay was due in part to errors in diagnosis in our own Out-Patient Clinic, but chiefly to delay before coming to the Clinic. A comparison of the cases without tendon necrosis with those with necrosis also showed the importance of the time factor. The average duration of symptoms in the former was 3.6 days as compared to 8.3 days in the latter. The time factor is not, however, the only one; some cases operated upon within 24 hours of the beginning of the infection did badly and others incised after days of delay had nearly perfect function. But these were the exceptions.

TABLE XII

AVERAGE DURATION OF TENOSYNOVITIS BEFORE OPERATION IN THE RESULT GROUPS

	Group I Bad Results	Group II Fair Results	Group III Good Results	Group IV Optimal Results	General Average
Average days duration before operation.........	9.3	5.0	4.6	3.4	6.2

Age and Results.—The effect of age on the results and on the incidence of tendon necrosis was also studied. Cases with poor results tended definitely to fall into an older age group than those with good results. The average age of the cases in Group IV was 30 years as compared to 42 years in Group I, an average difference of 12 years. The frequency of tendon slough also increased with age. Thus the average age of patients without tendon necrosis was 32 years as compared to 42 years among those with necrosis (Table XIII). Patients who developed complications were also slightly older on the average. Those with severe infections such as combined radial and ulna bursa involvement had an average age of 44 years as compared to the general average of 37. Deike,[7] Forssell,[1] zur Verth,[11] and Kanavel[8] likewise emphasized the poorer prognosis in older patients and the greater frequency of sepsis and other complications among them. Deike even claimed that his favorable results only occurred in patients under 30 years of age. Moissejeff[18] attributed this phenomenon to increasing atherosclerotic changes in the tendon in later life.

TABLE XIII

RELATION OF AGE TO TENDON NECROSIS AND END-RESULTS

	Tendon Intact	Tendon Sloughed	Group I Bad Results	Group II Fair Results	Group III Good Results	Group IV Optimal Results
Average age (years)	32	42	42	37	31	30

Recent Versus Older Results.—A comparison of results of cases operated upon in the decade from 1916 to 1925, as compared to a nearly equal number in the eight years from 1926 to 1933 inclusive, was disappointing (Table

XIV). It showed only slight improvement in the more recent group in spite of a campaign for earlier diagnosis, earlier removal of drains, and a more rigid aseptic dressing technic, designed to prevent secondary contamination. The results are still very poor and allow of much greater improvement.

TABLE XIV

A COMPARISON OF RESULTS IN THE 10 YEAR PERIOD (1916–1925) AND 8 YEAR PERIOD (1926–1933)

	Group I Bad Results		Group II Fair Results		Group III Good Results		Group IV Optimal Results		Totals	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
1916–1925......	24	40	15	25	12	20	9	15	60	48
1926–1933......	20	31	16	25	17	26	12	18	65	52

Soaks Versus Moist Dressings.—An attempt was made to compare results according to the type of treatment used after operation. This was found to be difficult because of the wide variety of procedures and the frequent shift from one treatment to another. The chief difference was found to be in the use of sterile hand soaks of saline or boric solution as compared to the use of sterile gauze compresses which were moistened frequently with these solutions without disturbing the dressing. The soaks were given for about 30 minutes every three or four hours. Large deep basins were used in which the whole hand and forearm could be immersed to above the elbow. A third group included those cases in which neither of the above procedures had been carried out consistently and in which Dakin's solution was also frequently used. These were usually late neglected cases.

The results seemed to show the wet dressing procedure to be preferable to the soaks (Table XV). Using the presence or absence of tendon slough as a criterion, the advantage seemed to rest also with the wet dressings. The arguments advanced for the soaks are that they allow earlier finger motion and better cleansing of the wounds. Against them is the difficulty of preventing secondary contamination and the impossibility of maintaining elevation of the hand while in the soak, with consequent congestion of the tissues. It should be emphasized again, however, that, because of the many variable factors and the short duration of the procedure in many cases, the comparison is open to question.

TABLE XV

COMPARISON OF RESULTS BETWEEN CASES TREATED WITH WET DRESSINGS AND HAND SOAKS

	Group I Bad Results		Group II Fair Results		Group III Good Results		Group IV Optimal Results		Totals	
	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Wet dressings...	9	26	7	21	8	24	10	29	34	27
Hand soaks.....	26	34	22	29	18	24	10	13	76	61
Miscellaneous...	8	53	4	27	2	13	1	7	15	12

Complications.—There was only one death in this series, a percentage of 0.8. This was a case of Streptococcus hemolyticus infection involving the radial bursa and spreading to the forearm. The patient developed a positive blood culture on the fifth day after operation and died the next day, following a severe hemorrhage from the radial artery. Other authors have found the mortality higher. Klapp,[14] Keppler,[2] and zur Verth[11] had an incidence of between 3 and 5 per cent. Deike[7] had 16 deaths in 200 cases, or a mortality of 8 per cent. These were mostly in old people with sepsis.

Amputation of an arm or finger was performed in 11 cases or 8 per cent. Eight were finger amputations and were thought advisable because of extensive tendon slough and osteomyelitis in six cases and for severe contractures in two cases. One amputation through the midforearm and two through the upper arm were performed because of severe infection. One of the latter was accompanied by recurrent hemorrhage from the radial artery. A stiff finger, if ankylosed in the optimum position of slight flexion, is usually useful; although the two distal phalangeal joints are frequently stiff, the metacarpophalangeal joint usually has some motion. Such a finger is frequently preferable to an amputated stump. The thumb should never be amputated.

Osteomyelitis was a common complication and occurred in 47 cases or 38 per cent, and was often multiple. The middle phalanx was the one most frequently infected, chiefly because of its central position and frequent involvement with a suppurative arthritis of either the proximal or distal phalangeal joint. This bone was involved in 28 cases. Suppurative arthritis was also frequent and occurred in 36 cases or 29 per cent. The distal phalangeal joint was the joint most often invaded. Not only was it involved secondarily to the sheath but it was often the route by which infections of the distal closed space reached the sheath. The proximal phalangeal joint was the joint most often affected secondarily to infection of the tendon sheath. The metacarpal bone and the metacarpophalangeal joint were the least often involved. The Staphylococcus in pure culture was responsible for slightly more cases than the Streptococcus (40 per cent as compared to 26 per cent), and was more prone to involve several bones before the infection was arrested. The results in this group, with complicating osteomyelitis and suppurative arthritis, were very poor, as would be expected, and most of the cases fell into Group I. The figures for the incidence of osteomyelitis and arthritis are open to some question but are approximately correct. It was difficult to be sure of the actual involvement in all cases.

Hemorrhage from the radial artery occurred in two cases. One was associated with severe infection and was largely responsible for the patient's death. The other also accompanied a severe infection and recurred several times, finally necessitating upper arm amputation. In the former the use of Dakin's solution and hard rubber tube drains close to the radial artery may have contributed to the hemorrhage. In both these cases the radial bursa above the wrist had become involved and was drained by a lateral incision

between the flexor carpi radialis tendon and the artery. This incision is more anterior than the one usually made behind the artery and may leave it more exposed to trauma and infection. Kanavel, Deike, and Garlock reported similar complications. Deike and Kanavel had several cases of severe hemorrhage from the ulnar artery as well. Kanavel believes this is the artery usually involved. He emphasizes the danger of severe and even fatal hemorrhage. He believes ligation of the vessel should be done at once and advises against packing the wound or other temporizing measures. Our experience in these two cases confirms his view.

It is of interest that suppurative phlebitis, which occurred only once as a complication, developed in the only case in which Bier's passive hyperemia treatment was tried. This was a toxic case with a severe infection of the radial bursa. Venous constriction was maintained for the first 15 hours after operation by an Esmarch bandage about the upper arm which impeded the venous return but did not obliterate the arterial pulse. A suppurative phlebitis developed later in the median basilic vein and had to be incised. This procedure was formerly extensively used in Germany but in recent years has had fewer supporters. A number of cases of secondary erysipelas have been reported following its use.

There were two cases of gangrene of the terminal phalanx secondary to extensive soft tissue involvement and osteomyelitis. Deike, zur Verth,[11] and others reported similar occurrences in severe and neglected infections due apparently to thrombosis of the vessels in the finger. Deike had ten such cases.

Musculospiral nerve paralysis from the use of an Esmarch tourniquet with temporary wrist drop occurred in two cases. One lasted five months before complete recovery. To prevent this Auchincloss uses at least 18–20 layers of towelling beneath the tourniquet.

One boy, age 8, developed a positive Staphylococcus hemolyticus blood culture after operation and a metastatic osteomyelitis of the femur that had to be drained. Deike had five similar cases, all with foci in the bones of the lower extremity. All of his cases died. In only three of our cases was sepsis proven by positive blood cultures. One has just been mentioned; and of the other two, both due to the Streptococcus hemolyticus, one recovered and the other died following hemorrhage from the radial artery.

It is significant that the Streptococcus hemolyticus was the organism present in most of the cases with severe complications. It was responsible for the only death, all of the upper arm and forearm amputations, two of the eight finger amputations, both cases of secondary radial artery hemorrhage, both cases of local gangrene of the terminal phalanx, the only case of suppurative phlebitis, seven of the nine cases with extension into the spaces of the forearm, four of the five cases of extension to the tendon sheath of the flexor carpi radialis muscle, and the only case with extension to the wrist joint.

Other complications such as involvement of the forearm, the tendon sheath

of the flexi carpi radialis muscle, and the wrist joint will be discussed later with the other extensions of tenosynovitis.

Human Bite Infections.—There were three cases of tenosynovitis secondary to human bites on the dorsum of the hand. In all, the sheath was involved by way of the metacarpophalangeal or interphalangeal joint, and the volar subtendinous space. In only one was the extension of the process to the sheath recognized before the infection was well advanced. All these cases showed extensive tendon slough, osteomyelitis, and suppurative arthritis. In two the finger was amputated. In the third it was advised but not done. The results were all bad. Probably because of the mixed and virulent organisms introduced, these cases are notoriously persistent and disabling. Kanavel and Mason and Koch[15] have recently discussed them at length. Every human bite should be treated with extreme consideration and in most cases admitted to the hospital at once. Mechanical cleansing of the wound should be carefully carried out. Some débridement may be necessary. Incisions should be liberal. Extension to the bones and joint should be watched for and treated accordingly. Unless drainage is adequate there is danger of further extension to the flexor tendon sheath. Because of the presence of anaerobic organisms in the mouth, particularly anaerobic streptococci, spirochaetes, and fusiform bacilli, Meleney[16] advises débridement and flooding of all surfaces of the wound with a creamy suspension of zinc peroxide. This suspension is also used at subsequent dressings.

Extensions of Tenosynovitis.—Extensions of the infection from the sheath to the fascial spaces of the hand occurred frequently. The thenar space was involved in 15 cases: in ten from the second finger, in three from the first finger, in one from the third finger, and once from the fourth finger via the midpalmar space. The midpalmar space was involved four times: once following infection of the third, fourth, and fifth finger sheaths respectively and once following an infection of the palm. The space between the first dorsal interosseus and adductor transversus pollicis muscles was involved four times as a complication of tenosynovitis of the first and second fingers. In three cases it was associated with an abscess of the thenar space and was apparently secondary to it. In one case the thenar space was apparently not involved. These extensions were similar to those described by Kanavel and Deike.

Extension of infection into the soft tissues of the forearm occurred in nine cases. It followed involvement of the radial bursa above the wrist and combined infection of both bursae above the wrist in three cases each. It occurred once after involvement of the ulna bursa alone, and twice from extension of an infection of the thenar space. In no instance did it follow midpalmar space infection. Most of these were markedly toxic cases. The forearm extension in itself added little to the later disability. Six of the cases showed Streptococcus hemolyticus in pure culture, one showed Streptococcus hemolyticus and Staphylococcus, and in the remaining two there was no culture report. Other authors emphasize also the frequency of forearm infection

following radial or ulna bursitis. Deike had 61 cases. All agree that it occurs rarely after thenar space, and almost never after midpalmar space involvement. The best approach to these deep forearm abscesses has been recently discussed by Auchincloss.

Extension to the tendon sheath of the flexor carpi radialus muscle occurred in five instances. In every case it followed involvement of the radial bursa in the palm and above the wrist. In one of these the infection spread from the flexor carpi radialis sheath to the wrist joint and extended between the trapezoid and the second metacarpal bone to the dorsal subaponeurotic space. The patient recovered but was left with a stiff hand and wrist. This was the only case in this series with wrist joint involvement. The Streptococcus hemolyticus was present in the culture of four of the five cases, including the one spreading to the wrist joint. Disability from involvement of the sheath of the flexor carpi radialis muscle was very slight. Involvement of the wrist joint, however, is always a serious complication often necessitating amputation. Deike had four cases, of which one died, two had amputations, and one has a stiff, crippled hand. Both Auchincloss and Deike believe that the usual route of involvement is from the radial bursa to the sheath of the flexor carpi radialis tendon which inserts into the bases of the second and third metacarpal bones.

Extensions from the volar to the dorsal surface of the hand occurred in ten cases. In six of them the route was by way of the lumbrical muscles and the webs. In four instances it led through the joints; once in the proximal phalangeal, twice in the metacarpophalangeal, and once through the carpus. Extension in the reverse direction, from the dorsum to the volar side of the hand, occurred in only three cases. These were all human bite infections, spreading by way of the metacarpophalangeal joint twice and the proximal phalangeal joint once. These cases emphasize the importance of these two routes of deep infection from one side of the hand to the other. Other routes must be very rare. In the fingers the insertion of the deep fascia to the sides of the phalanges and to the skin laterally, tends to prevent spread around the finger by way of the subcutaneous tissues.

Surgical Technic.—The incisions were usually multiple, short, and anterolateral, over the proximal and middle closed spaces in the fingers and a single midline incision over the sheath in the palm. The bursae above the wrist were usually drained by lateral incisions as advocated by Kanavel. The finger incisions were either bilateral or unilateral, and were often given a slight L extension at their distal end for better drainage. Finger incisions lateral to the anterior digital vessels have not been used as they would divide the branches from the vessels to the sheath and tendon and might compromise their nutrition. In only a few advanced cases, with frankly slough-tendons, was a long midline anterior incision across the flexion creases used. Recently Auchincloss has suggested the use of truncated flaps for the finger incisions, one for the proximal and one for the middle closed space. The flap includes all tissues down to the tendon sheath. Its distal end is cut

along the flexion crease. Its sides are cut obliquely to avoid the anterior digital vessels and nerves and extend nearly to the next proximal crease. Its advantage is the better drainage of the sheath. The palmar incision is made as formerly. Ten cases of this series have been incised by this technic with encouraging results. The number is of course too small from which to draw conclusions but the results have been somewhat better than the general average. For deep abscesses extending upward into the interflexor space of the midforearm, the incisions advocated by Auchincloss have been recently used.

Splitting of the anterior carpal ligament, to provide better drainage for suppurative ulna bursitis, was performed on three occasions. These were all advanced cases in which palmar and lateral incisions above the wrist had already been made. All gave poor functional results. Forssell advocated this incision to prevent pressure on the tendons beneath the ligament which he believed was the chief cause of their necrosis. Leibovici and Iselin,[17] on the other hand, condemn this incision. They believe it exposes the tendons without draining the sheath behind them and favors necrosis and contractures. Kanavel advises it only in late cases with necrosis of the tendons or in exceptional instances where excessive pressure on the tendons or on the median nerve is feared. Auchincloss divides the ligament occasionally but believes partial division is often sufficient and prevents prolapse of the tendons.

Duration of Healing and Hospitalization.—The average time required from operation to complete healing was 53 days. Cases without tendon necrosis averaged 36 days, and those with necrosis 71 days, or nearly twice as long. The average period of hospitalization was 22 days, 17 days for those without tendon slough and 26 days for those with it.

Localized Tenosynovitis.—In 24 cases, or 19 per cent, the infection proved to be localized to only a portion of the sheath. This limitation was most common in the first and fifth fingers, probably because of the greater length of these sheaths with their associated bursae. In the fifth finger it may have been due occasionally to an anomalous sheath. In seven cases involving the thumb the infection did not extend to the bursa above the wrist. In the fifth finger the localization occurred in different parts of the sheath and bursa. In the other fingers the localization was about equally distributed between portions of the sheaths in the fingers and the palm. A few of these cases may have been incorrectly classed as instances of localized tenosynovitis when they were really very early infections, incised before the inflammation had had a chance to spread throughout the whole sheath. Such errors were probably rare, however. Klapp and Beck[18] believe that the infection is often temporarily checked in the region of the proximal phalangeal and metacarpophalangeal joints and that the entire sheath is usually not involved unless operation is delayed. Since in all but six of our 24 cases with limited involvement the tenosynovitis was definitely of the secondary type, it seems probable that the limited extent of the tenosynovitis was due rather to the tendency of the sheath to wall off the area of its involvement in the face of a slowly invading infection from without.

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The incidence of tendon slough in these cases was slightly above that for the whole series and was probably due to the high proportion of secondary cases, which are more liable to tendon slough because of the associated infection outside the sheath. The bacteriologic reports in this group are interesting in that they show a much greater frequency of Staphylococcus over Streptococcus. In fact only four cases showed Streptococcus hemolyticus in pure culture. This emphasizes the more localizing features of the former as compared to the invasive characteristics of the latter. The results in these cases proved to be slightly better than those for the whole series. The advantage of the more limited extent of infection more than offset the greater incidence of tendon necrosis.

Incompletely Drained Tenosynovitis.—In 28 cases, or 22 per cent, the tendon sheaths were not completely incised although the whole sheath was apparently involved at the time of operation. Seventeen of these had to have their inadequate drainage corrected at a later operation. In a few cases the surgeon apparently felt that adequate drainage of the whole sheath was possible through less than the usual number of incisions. In most cases, however, he was misled by the clinical signs to believe that only a portion of the sheath was involved. This occurred especially in very early cases in which the signs were not as yet definite. The most common mistake was failure to drain the palmar portion of the tendon sheath in infections of the second, third, and fourth fingers. This occurred in 13 cases. Failure to drain the radial bursa above the wrist in five instances was the next most frequent error. Of the cases in which the palmar portion of the sheath was not drained there were four with good results and nine with poor results, five of which were later drained in the palm. Cases with adequate incision in the palm, but inadequate incision in the finger, were less frequent and showed about an equal number of good and bad results. From these figures it would seem as if the palmar portion of the sheath was perhaps the most important to drain. For the three middle fingers, Iselin[10] has recently advocated drainage only in the palm. He believes this method drains the dilated proximal part of the sheath where exudate is most apt to collect and avoids injury to the sliding mechanism in the finger. He makes two volar and two dorsal incisions. There were several cases involving the thumb and fifth fingers in which drainage in the finger and palm was successful without necessitating an incision above the wrist. Failure to drain the bursae above the wrist, however, is hazardous because of the danger of extension to the opposite bursa, to the forearm, and even to the wrist joint.

In this group of incompletely drained sheaths, 18 or 64 per cent showed sloughing of the tendon as compared to 52 per cent in the whole series. The end-results in these cases were slightly poorer than those for the whole group.

Uninfected Portions of Tendon Sheaths Contaminated at Operation.— The chief reason for the incomplete incision of sheaths was the belief that the infection was localized and the fear that further incision might contaminate a hitherto uninvolved part. This danger of contamination was accordingly

studied. There were 12 cases in which the sheath infection was definitely localized but in which uninvolved portions were opened at operation. The most frequently uninvolved site in these cases was either the palmar end of the sheath in the three middle fingers or the part of the bursa above the wrist in the first and fifth fingers. Eleven of the 12 cases showed no apparent bad effects from this contamination. The conclusion is that this danger has been overemphasized. When doubt exists as to whether the infection is limited to a part of the sheath or not it is far better to incise the whole sheath even if this may prove to have been unnecessary. There is some difference of opinion as to the best procedure in such cases. Keppler advises making the first incision in the doubtful portion of the sheath and draining the portion definitely infected last. This perhaps lessens the chance of contamination of the uninvolved portion. Kanavel, however, makes his first incision in the sheath where the infection is certain and then carefully incises towards the doubtful portion. The presence or absence of exudate on pressure over the unopened portion of the sheath and the clinical signs before operation help to determine the extent of the incision. This latter method seems preferable. In this way, infections of limited extent are more readily recognized. When real doubt exists, however, it is wiser to incise the whole sheath.

Uninfected Tendon Sheaths Contaminated at Operation.—There is no record of the number of cases wrongly diagnosed as tenosynovitis in which the sheath was incised, found to be uninfected, and remained so. Unless the sheath became infected subsequently the case would not be listed under that diagnosis. There were only four cases in this series which apparently originated in this way. In these instances the incision disclosed no pus within the sheath but some in the subcutaneous tissues close to it. The sheath was undoubtedly contaminated at operation, but would probably have become involved secondarily anyway. Three of these cases showed tendon slough and poor end-results later. In the fourth case the infection remained localized and left the hand with perfect function. This number is surprisingly small and stands in sharp contrast to the large number of cases in which delay from over caution contributed to the poor end-results. It should be emphasized again that when reasonable suspicion of tenosynovitis is present it is far better to incise than to delay. A neglected sheath will give much greater disability than one opened unnecessarily.

Causes of Poor Results.—The end-results have been shown to be poor. Sixty per cent or nearly two-thirds were unsatisfactory and were placed in the lower two groups. Over one-half showed gross tendon slough. I have tried to list the causes of the poor results somewhat in the order of their frequency and importance. Late operation was the chief of these, due not infrequently to delay in diagnosis in our own Out-Patient Clinic but more often to delay before coming to the hospital. Other causes were secondary infection, late removal of drains, incomplete drainage of the tendon sheath, improperly placed incisions, delay in starting active motion of fingers, too early discharge from the hospital, and inadequate supervision of dressings in

the Clinic after discharge. In addition, failure to realize the danger of human bites, neglect of infections of the distal closed space, lack of cooperation on the part of the patient and lowered resistance from associated disease, such as diabetes, should be mentioned. Even when all the causes of poor results were apparently absent, however, the functional result was often poor. The last word has obviously not been said as to the best type of incision, the best method of drainage, and the best postoperative treatment.

Gonococcus Tenosynovitis.—There were seven cases of gonococcus tenosynovitis during this 17 year period which were not included in this series. The diagnosis was made on a positive wound culture in two instances, on a positive smear from the wound in two cases, and on the clinical symptoms, based on the history of an associated polyarthritis, and a positive prostatic smear in the remaining three. All were hematogenous infections. There were two males and five females with an average age of 23. There was no necrosis of the tendon in any case. Healing was uneventful. In one case in which the diagnosis was confirmed at operation by a positive smear from the sheath, the wound was resutured and healed with a perfect functional result. There were no complications. The average time from operation to complete healing was 20 days as compared to 53 days in the cases caused by other organisms. The average period of hospitalization was only 12 days as compared to a general average of 21 days. The results were almost uniformly good. All the cases had nearly perfect function and were classed in Group IV, except one placed in Group III because of slight limitation of motion in the distal phalangeal joint, and one put in Group II because of a slightly adherent tendon.

SUMMARY AND CONCLUSIONS

(1) There were 125 cases of suppurative tenosynovitis in this series followed for an average of over 16 months. Gonococcus tenosynovitis was not included.

(2) Hematogenous infection did not occur in any case. No case was infected from another focus on the hand by way of the lymphatics.

(3) The puncture wound was the most frequent injury causing infection, occurring in 51 per cent of cases.

(4) The flexor finger creases were the most frequent sites of injury causing tenosynovitis, especially the distal crease. A wound at the finger creases should be regarded as a threat to the tendon sheath. The distal closed space was the second most frequent site of origin. Late and inadequate drainage of infections of this space leads frequently to tenosynovitis.

(5) Tenosynovitis was most frequent in the first three fingers of the right hand.

(6) Errors in diagnosis caused delay in operation in 25 per cent of the cases and occurred in 13 per cent of those with primary tenosynovitis, and in 38 per cent of the cases of secondary tenosynovitis. The delay averaged one day in primary cases and four days in secondary cases. The accompany-

ing infection in tissues adjacent to the tendon sheath made the diagnosis more difficult in the secondary cases.

(7) The end-results were poor. They were classed in four groups based primarily on function. Over one-third of the cases were in the poorest group. Nearly two-thirds were in the lower two groups. Only 17 per cent had complete or nearly complete function. The exclusion of 15 advanced cases with tendon necrosis at operation made very little improvement in the results.

(8) Gross necrosis of the tendon occurred in 52 per cent of cases.

(9) The Streptococcus hemolyticus was present at operation in pure culture in 36 per cent of cases, the Staphylococcus in 31 per cent. Results were somewhat better in the Staphylococcus cases. Mixed infections usually did poorly.

(10) The best results were found in the thumb and the poorest in the fifth finger.

(11) Primary tenosynovitis occurred in 67 cases, or 54 per cent, and secondary tenosynovitis in 58 cases, or 46 per cent. The results in the two groups were about the same. Unless localized to a portion of the tendon sheath, however, secondary tenosynovitis gave a much poorer prognosis. Secondary tenosynovitis was more apt to have tendon necrosis. Primary infections were most frequently caused by the Streptococcus and secondary infections by the Staphylococcus.

(12) There were 13 cases of radial bursitis, eight cases of ulna bursitis, and ten cases of combined infection of both radial and ulna bursae. All but one of the combined infections spread from the radial to the ulna bursa. Most of these cases were due to the Streptococcus hemolyticus.

(13) The average duration of tenosynovitis before operation was 6.2 days. It was nearly three times as great in Group I as in Group IV.

(14) The prognosis became definitely poorer with advancing age. Tendon necrosis also became more frequent.

(15) Sterile wet dressings of saline or boric solution seemed to give better results after operation than sterile hand soaks.

(16) There was one death, a mortality of 0.8 per cent. There were three arm and eight finger amputations. Osteomyelitis occurred in 38 per cent of cases. The middle phalanx was most frequently involved. Suppurative arthritis was most frequent in the distal phalangeal joint. The Streptococcus hemolyticus was the responsible organism in most of the severe complications.

(17) There were three cases of tenosynovitis secondary to human bites on the dorsum of the fingers and hand. All showed poor functional results.

(18) Extensions to the thenar space occurred in 15 cases, to the mid-palmar space in four cases, to the forearm in nine cases, and to the wrist joint in one case. Extension from the volar to the dorsal side of the hand occurred in ten cases; in six by way of the lumbricals and webs, and in four through

the phalangeal or metacarpophalangeal joints. Extension from the dorsum to the volar side occurred only in the three human bite infections.

(19) The average period from operation to complete healing was 53 days. It was twice as long in the cases with tendon necrosis as in those without.

(20) Localized tenosynovitis occurred in 19 per cent of cases. Most of these were secondary infections. The results in these cases were somewhat better than the average.

(21) In 22 per cent of cases the tendon sheath was incompletely drained. Over half of these had to be operated upon again. The results in these cases were poorer than the average.

(22) Uninfected portions of sheaths contaminated at operation did not influence the results appreciably. In doubtful cases it is wiser to incise the whole sheath.

(23) Only four cases of tenosynovitis were due to contamination of an uninfected sheath at operation. In all these cases the infection lay close to the sheath and probably would have involved it later. In doubtful cases of tenosynovitis it is much wiser to operate than to delay.

(24) Delay before operation is probably the most important cause of the poor results.

(25) Gonococcus tenosynovitis occurred in seven cases during this period. All were hematogenous. There was no tendon necrosis or other complication. The results were all unusually good.

REFERENCES

[1] Forssell, W.: Klinische Beiträge zur Kenntnis der akut septischen Eiterungen der Sehnenscheiden der Hohlhand besonders mit Rüchsicht auf die Therapie. Nord Med. Arkiv., 1903, hft. 3, No. 14, 1; hft. 4, No. 19, 55.

[2] Keppler, W.: Zur Klinik der Sehnenscheidenphlegmone unter besonderer Blerücksichtigung der Stauungsbehandlung. Deutsch. Ztschr. f. Chir., 115, 63, 1912.

[3] Cleveland, M.: Suppurative Tenosynovitis of the Flexor Muscles of the Hand. Arch. Surg., 7, 661, 1923.

[4] Garlock, J. H.: Infections of the Hand. Surg., Gynec., and Obst., 39, 165, 1924.

[5] Schiessl, M.: Inzision in den natürlichen Falten der Hand—ein Beitrag zur Behandlung der Sehnenscheiden- und Schwielen-phlegmone. Münch. med. Wchnschr., 72, 1728, 1925.

[6] Brofeld, S. A.: Über das Panaritium. Duodezim (Helsingfors), 45, 849, 1929. Absti. Zentralorgan für die ges. chir. und ihre Grenzgebiete., 48, 783, 1930.

[7] Deike, H.: Sehnenscheidenpanaritien der Hand, ihre Behandlung und ihr Spätschiksal. Brun's Beitr. z. klin. Chir., 158, 461, 1933.

[8] Kanavel, A. B.: Infections of the Hand. Sixth Ed., Lea and Febiger, Philadelphia, 1933.

[9] Auchincloss, H.: Surgery of the Hand. Nelson's Loose-leaf Surgery, 3, 459, 1927.

[10] Iselin, M.: Tenosynovites digitales. Schweiz. med. Wchnschr., 13, 1159, 1932.

[11] Zur Verth, M.: Das Panaritium. Ergebnisse der Chir. und Orthopädie., 16, 653, 1923.

[12] Poirier, P.: Traite d' anatomie humaine. 2, Masson et Cie, Paris, 1896.

[13] Moissejeff, A. J.: Ueber Alterserscheinungen in den Sehnen. Münch. med. Wchnschr., 68, 1538, 1921 (Rep. Med. Soc., St. Petersburg and Moscow Path. Soc., St. Petersburg, October. 13–15, 1921).

[14] Klapp, R.: Die Behandlung der Sehnenscheidenphlegmone. Berlin. klin. Wchnschr., **45,** 725, 1908.

[15] Mason, M. L., and Koch, S. L.: Human Bite Infections of the Hand. Surg., Gynec., and Obst., **51,** 591, 1930.

[16] Meleney, F. L.: Zinc Peroxide in the Treatment of Microaërophilic and Anaërobic Infections. ANNALS OF SURGERY, **101,** 997, 1935.

[17] Leibovici, R., et Iselin, M.: Traitement des phlegmons des gaines carpiennes par les incisions laterales et discontinues. Journal de Chir., **37,** 358, Paris, 1931.

[18] Klapp, R., and Beck, H.: Das Panaritium. S. Hirzel, Leipzig, 1923.