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FLEXOR TENDON GRAFTS

Results in 95 Cases

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After the technique of free tendon grafting has gradually become so firmly established that the operation is a routine procedure, it has been introduced in several departments all over Denmark. In this connection, it is perhaps of interest to ascertain the results obtained in a department of general orthopaedic surgery by this operation, considered by many hand surgeons a task which makes the utmost demands on the surgeon's skill.

MATERIAL AND METHODS

The present analysis comprises the results of 95 free tendon graftings performed in the Orthopaedic Hospital, Aarhus, during the period 1949–1965. These operations, done on a total of 90 patients, are equally distributed on the digits of the right and left hand. The distribution of the digits is shown in Table 1. The patients ranged in age between 2 and 66 years. 34 patients were younger than 15 and 6 were older than 50. The age distribution is listed in Table 2. On the basis of the manner of injury, the operated digits may be divided into 2 groups, *viz.* digits with uncomplicated clean cuts and digits showing crush injuries and lacerations, often with fractures, articular and nerve damage. Sequelae of previous tendon suture or tendon grafting must be assigned to the latter group.

The tendon grafting was carried out in 18 cases because of injury to the flexor pollicis longus in the tendon sheath and in 76 cases because of injury to both flexor tendons within the fibrous tendon sheaths of the fingers (Bunnell's "no man's land"). Only in one case was tendon grafting done because of an isolated injury to the flexor digitorum profundus, preserving the flexor digitorum sublimis.

Preoperatively, it was endeavoured to obtain a full passive mobility of the finger joints. Union of fractures was awaited, scar formations were corrected, skin grafting was done, and in some cases nerve repair. 70 of the digits were operated upon within the first 4 months after the accident, only 4 more than 1 year after.

The operation was carried out in a bloodless field after disinfection by soap and water. The approach was mid-lateral, in about half the operations dorsal to and in

the other half volar to the nerve-vessel bundle. In some cases this incision was combined with a transverse incision. In the palm the incisions were applied parallel to the natural creases. As a donor tendon we used the tendon of the extensor digitorum longus (pedis) in 62 cases, that of the plantaris longus in 4, and that of the palmaris longus in 28 cases. In one case it is not stated from where the donor tendon was taken. When the tendon of the extensor digitorum longus pedis was used, its distal end was fastened to the tendon of the extensor digitorum brevis pedis.

Table 1. Distribution on the digits of the operations.

	Thumb	2nd digit	3rd digit	4th digit	5th digit
Number of operations	18	20	30	13	14

Table 2. Age distribution of the patients.

Age groups	0–9	10–19	20–29	30–39	40–49	50–59	60–69
Number of patients	18	33	18	8	7	4	2

The fixation of the tendon to the distal phalanx was done in 58 cases by suturing the tapered graft with knotted silk 0000 in a V-shaped cut to the distal stump of the flexor digitorum profundus. In 37 cases the tendon was fastened to a hole drilled into the distal phalanx, using pull-out wire. Proximally the suture was performed as interlacing or fish-mouth suture using silk 0000 (in a few cases wire). The suture line was covered with the lumbricalis muscle. When suturing to the flexor pollicis longus, the suture line was applied as far proximally as possible, but not always in the muscle. Prior to or during the operation, 27 of the 81 injured nerves on the operated digits were repaired. In 2 cases nerve grafting was done. The suturing was done with silk 0000000. During the operation damaged pulleys were reconstructed. Pressure dressing was applied with a plaster cast, and the tendon was kept non-functioning for 3 weeks. Pull-out wires were removed at the end of 4 weeks, and at the same time exercises were started. In some cases showing contractures an elastic traction splint was used for a varying length of time.

Follow-up

Out of a total of 90 patients 72 were examined in their homes. About the others relevant data were found in the case records. 6 had gone abroad, 4 had died of irrelevant causes, one has undergone amputation, one had a stiff, useless finger, and 6 were not seen for other reasons. The follow-up period was between 1 and 18 years, except in 4 cases less than 1 year.

The function of the tendon is reflected in the excursions of the distal phalanx. If the extension defect of the distal phalanx is recorded as the sum total of the extension defects of the three joints and the flexion ability of the distal phalanx as the sum of the excursions in the three joints when the finger is flexed maximally

Table 3.

Tendon grafts in the fingers. 77 cases	Age at operation	Lesion of digital nerves	Extension defect in the distal phalanx	Mobility of the distal phalanx	Mobility in the M.P. joint	Mobility in the proximal I.P. joint	Mobility in the distal I.P. joint	Flexion defect in distal phalanx
Age 2–15 years	14	1	normal					
uncomplicated cases	11	0	10	270	100	105	65	0
(clean cut)	11	2	20	260	100	105	55	0
	15	1	25	235	110	100	25	10
	7	1	5	230	90	100	40	35
	4	0	0	220	90	100	30	50
	9	0	0	190	100	65	25	80
	10	0	25	185	80	85	20	60
	15	2	20	180	90	80	10	70
	4	0	15	180	90	75	15	75
	4	0	30	180	90	60	30	60
	2	0	5	170	60	80	30	95
	14	2	55	165	90	65	10	50
	2	0	5	160	90	60	10	105
	4	0	90	155	90	55	10	25
	10	0	30	145	110	25	10	95
	2	0	0	120	90	25	5	130
	13	2	25	120	90	30	0	125
	10	0	amputated					
Age 2–15 years	7	0	normal					
complicated cases	15	1	0	220	100	90	30	50
	5	1	20	195	100	85	10	55
	7	0	40	170	100	55	15	60
	2	0	25	145	90	35	20	100
	2	0	60	155	90	20	45	55
	13	0	5	120	90	30	0	145
	5	2	80	100	65	30	5	90
	5	1	20	40	20	20	0	210
Age 16–49 years	18	1	10	240	110	70	60	20
uncomplicated cases	19	0	0	225	90	90	45	45
	24	1	0	215	110	80	25	55
	29	0	15	210	110	70	30	45
	19	0	30	210	90	95	25	30
	49	1	10	190	100	90	0	70
	20	1	30	171	80	90	1	69
	17	2	25	170	60	90	20	75

Table 3 (cont.).

Tendon grafts in the fingers. 77 cases	Age at operation	Lesion of digital nerves	Extension defect in the distal phalanx	Mobility of the distal phalanx	Mobility in the M.P. joint	Mobility in the proximal I.P. joint	Mobility in the distal I.P. joint	Flexion defect in distal phalanx
	24	1	35	165	100	60	5	70
	27	1	115	140	120	10	10	15
	19	2	90	140	90	50	0	40
	49	1	5	135	85	40	10	130
	17	1	25	120	90	30	0	125
	22	2	90	115	100	15	0	65
	19	1	25	110	80	30	0	135
	27	1	130	110	90	20	0	30
	18	1	65	105	90	5	10	100
	16	2	170	100	90	5	5	0
	33	1	45	85	70	0	15	140
	22	1	30	80	80	0	0	160
	42	0	105	55	45	5	5	110
Age 16–49 years complicated cases	19	1	20	180	110	70	0	70
	21	0	80	170	90	70	10	20
	28	0	2	170	90	80	0	98
	33	0	0	170	110	60	0	100
	40	2	70	160	90	65	5	40
	18	2	30	160	100	50	10	80
	19	2	25	165	80	70	5	90
	29	1	45	155	100	30	25	70
	31	2	20	150	90	60	0	100
	27	1	40	150	90	30	30	80
	29	1	45	150	70	70	10	75
	18	2	75	145	100	45	0	50
	31	0	75	140	90	40	10	55
	29	1	5	135	110	5	20	130
	19	0	35	125	70	50	5	110
	28	0	2	115	90	25	0	153
	25	2	30	95	90	0	5	145
	39	2	105	90	90	0	0	75
	40	0	45	90	90	0	0	135
	25	2	60	80	80	0	0	130
	22	2	70	70	45	10	15	130
	18		amputated					
	28		re-operated (tendon rupture)					

Table 3 (cont).

Tendon grafts in the fingers. 77 cases	Age at operation	Lesion of digital nerves	Extension defect in the distal phalanx	Mobility of the distal phalanx	Mobility in the M.P. joint	Mobility in the proximal I.P. joint	Mobility in the distal I.P. joint	Flexion defect in distal phalanx
Age 50 and over uncomplicated	52	0	20	150	90	40	20	100
Age 50 and over complicated	50	2	20	145	90	55	0	105
	60	2	15	125	110	15	0	130
	66	1	20	90	80	10	0	160
Isolated injury to flexor digitorum profundus	25	2	30	205	90	90	25	35

with the wrist in a position of function, the flexion defect of the distal phalanx may be calculated as 270° (normal mobility) subtracting (extension defect + flexion).

The results are listed in tables stating for each case the age at the time of operation and whether the tendon injury co-existed with injury to 1 or 2 digital nerves. The individual cases are arranged according to the results obtained. The age groups 2–15 years, 16–49 years, and older than 50 years are listed separately, and each age group is divided into 2 sub-groups, depending upon whether there was a case of a clean cut without complicating injuries or whether there was a crush injury and/or complicating injuries.

In recording the operated thumbs the table gives the total extension defect in the distal and proximal phalanges, the excursion in the proximal joint and the excursion in the distal joint. In addition, the latter is stated in degrees. Because of the difficulty in recording the mobility of the carpo-metacarpal joint accurately in degrees, the restriction of the spread of the interstice (measured from the tip of the thumb to the tip of the index finger—compared with the other hand) was measured and so was the distance from the pulp of the thumb to the base of the little finger during opposition.

RESULTS

In assessing the results for the 4 fingers Littler's criteria were used (excellent = 240° flexion + full extension, good = 180°). It was found that in the age group 2–15 years (clean cuts) there were 11/19 = 57 per cent good results; in the same age group, but with complicating injuries, there were 3/9 = 33 per cent good results. In the age group 16–49 years (clean cuts) there were 6/21 = 27 per cent good results,

Table 4. Tendon grafting to flexor pollicis longus (18 cases).

	Age (years)	Lesion of digital nerve	Extension defect in proximal joint + Extension defect in distal joint	Mobility in the distal joint in degrees	Mobility in the distal joint in degrees	Mobility in the proximal joint in degrees	Distance in cm from the pulp of the thumb to base of the little finger in oppostition	Lack of full spread in the first interstice measured in cm
Uncomplicated cases	19	0	0	45	0/45	45	1	0
	5	0	–15	45	–15/30	25	1½	1½
	7	0	0	45	0/45	25	1½	1½
	13	0	20	70	20/90	70	0	?
	14	0	–10	0	–10/–10	45	1	0
	21	1	0	15	0/15	40	2	4
	19	1	0	45	0/45	60	0	4
	20	1	0	10	0/10	45	1½	0
	46	2	10	30	–20/10	15	3	0
	15	2	5	15	5/20	20	1½	3½
Complicated cases	39	2	–10	35	0/35	45	1	0
	10	2	0	45	0/45	35	1	2½
	36	1	10	15	0/15	15	1	3½
	33	0	15	55	10/65	30	0	3
	19	0	0	20	0/20	20	3	3
	48	2	no active movement				5	12
Age 50 years and over	52	1	0	35	0/35	35	1	0
	60	2	20	5	0/5	25	1	3½

and in the same age group with complicating injuries 1/23 = 4 per cent good results. In the over-50 group there were a total of 0/4 = 0 per cent good results. In the one case having grafting for an isolated injury to the flexor digitorum profounds the result was good. In the 18 cases treated by grafting to the flexor pollicis longus the results were in 3 cases better and in 4 cases equally good as if no operation had been performed; the remainder were poorer.

DISCUSSION

The operative results reported in the literature have been recorded partly by measuring the excursions in degrees and partly by measuring

the restriction of movement, stated as the distance from the finger pulp to the distal crease of the hand and the distance from the finger nail to the level of the metacarpal bone, in maximum flexion and maximum extension of the finger. At times, the two methods have been combined. It is common to both modes of recording that they are suited rather for comparing the operative results in uniform materials than for affording a consistent characteristic of the individual material. Modes of recording which state the results in centimetres give too favourable results in cases of small hands with short fingers. A total excursion measured in degrees gives no information about the distribution of the mobility of the individual joints, or about the site in the joint concerned in which the movement takes place. Both bear relation to finger function. Complete recording of these factors is difficult to survey, both when tabulated and illustrated in diagrams.

Recording the mobility of the thumb in degrees involves the difficulty that it is hard to obtain an accurate measure of the excursion of the movement in the carpo-metacarpal joint. Many surgeons use the excursion in the distal joint as a measure of tendon function. However, it is well-known that the position in the proximal joint influences the extent of the excursion, and moreover the thumb may often be extended in the proximal and distal joints, while there is a decrease in the width of the first interstice in maximum extension and abduction in the carpo-metacarpal joint. This factor is of importance to thumb function. In the present study, therefore, the author decided to record the decrease in the width of the first interstice while simultaneously recording the excursion of movements in the joints in degrees.

The results were most favourable in the group having clean cuts, and better in the under-15 age group than in older patients. In patients over 50 years of age the results were poor. Tendon function does not appear to be dependent upon whether nerve injury is present in the operated finger, and it could not be demonstrated that better results were obtained in some categories of fingers than in others. If operation is performed within the first months after the accident, the operative results appear to be identical. One patient had the operation several years after the original trauma, and the result was poor. Furthermore, the importance of who performs the operation has been demonstrated. As Fullbright lecturer, the late American Professor H. Allen operated upon a number of patients of all preoperative categories, with good results in two-thirds.

In assessing the functional result, however, one should not rest con-

tent with paying regard to the isolated tendon function. As far as function is concerned, an extension defect and restricted width of the first interstice give rise to more complaints than does a flexion defect.

Moberg et al. have correctly pointed out the role of sensibility, and in particular tactile gnosis, in hand function. The patients often complain that a stiff finger is in the way, but the fact is that they are unable to orientate this finger unaided by vision. A finger which does not have full sensibility on the apposition surface is not used if another finger, with normal sensibility, is available. Only in one out of the 29 cases of nerve repair (in a child) did the sensibility prove near-normal, with a 2-point discrimination of less than 4–5 mm, and even in this case the patient did not use the finger, an index finger, for precision grip. The remaining patients showed varying degrees of hyp- and dys-aesthesia, somewhat better than in cases where the nerve had not been repaired. In all cases but one there was protection sensibility, both in cases where the nerve had been repaired and in others where it had not. In 4 of the cases treated by pulley reconstruction, the pulley had given way, leaving the tendon like a sail on the volar aspect of the finger.

Actual operative complications were observed partly in connection with the operation proper, and partly in removing suited donor tendons. In the former group there were 3 cases of taut volar scars, 2 cases of injury to functioning finger nerve, 1 case of injury to the ulnar nerve (pressure by a Pean forceps), and in 1 case posttraumatic dystrophy. In addition, there was a case of granuloma on the finger pulp left by a pull-out wire, and a cleft thumb nail after drilling of the tendon into the distal phalanx.

The complications in removing donor tendons comprise 3 cases of annoying "drop toe", 4 cases of annoying paraesthesiae on the foot through many years, 2 cases of transient paraesthesiae in the area innervated by the median nerve, and one case of neuroma affecting the cutaneous branch of the radial nerve.

It is evident from the above that our results are poorer than they ought to have been. In the literature there are reports of up to 90 per cent good results in the best risk categories. The surgeons have been experienced, the technique has been the current one in hand surgery at the time of the operation, and physiotherapists, ergotherapists, as well as an up-to-date bandage workshop have been available.

In 1950 *Boyes* published a material of free tendon grafts divided into groups of about 25 treated in each year. This analysis showed that of the patients from the first year less than 50 per cent could flex up to

1½ inches from the distal crease of the hand and that 2 operations were complete failures, while among the patients from the last year of analysis 86 per cent had the above-mentioned function. This result was attained without any change in technique except that the surgeon had acquired greater skill.

With the number of free tendon graftings indicated every year in this country, each hospital will have only a very few cases.

In Ugeskrift for Læger No. 35, 1967, it is concluded in an editorial that nerve repair must be considered a task for specialists and that this will be even further accentuated by the constant advances in suturing technique.

The present analysis supports the view that free tendon grafting, just like nerve repair, must be considered a task for specialists, which ought to be centralized in a few departments. Only in this way is it possible to acquire and maintain the experience and routine necessary to obtain good results.

SUMMARY

The results of 95 free tendon graftings are reported. 18 were to the flexor pollicis longus, 76 were done in injuries to the flexor digitorum profundus and sublimis, and one in the case of an isolated injury to the flexor digitorum profundus in the tendon sheath. By the criteria of Littler, there were 57 per cent good results in uncomplicated cases (clean cuts) and 33 per cent in complicated cases in the age group 2–15 years. The corresponding values in the age group 16–49 years were 27 per cent and 4 per cent respectively. In the over-50 group the values were 0 out of 4. Among 18 cases of grafting to the flexor pollicis longus the function of the thumb had, all considered, improved in 7. The mode of recording and the role of complicating injuries in the functional result are discussed. Operative complications of importance occurred in 16/95. The surgeon's share in the operative result is established.

It is concluded that free tendon grafting is a task for specialists which ought to be centralized in special departments.

RESUME

Les résultats de 95 greffes libres de tendons sons rapportés. 18 ont été pratiqués pour le long fléchisseur du pouce, 76 à la suite de lésion du fléchisseur profond les doigts et un dans le cas d'une lésion isolée du fléchisseur profond les doigts dans la gaîne du tendon. D'après les

critères de Littler, les résultats ont été bons dans 57 pour cent des cas sans complications (coupe nette) et dans 33 pour cent des cas compliqués dans le groupe d'âge de 2 à 15 ans. Les données correspondants dans le groupe d'âge entre 16 et 49 ans ont été respectivement 27 et 4 pour cent. Dans le groupe des personnes de plus de 50 ans, les données ont été 0 sur 4 cas. Parmi 18 cas de greffes du long fléchisseur du pouce, la fonction a été améliorée chez 7 malades, tout pris en considération. Il est discuté du mode d'observation et du rôle des lésions compliquées pour le résultat fonctionnel. Des complications opératoires importantes ont été observées dans 16 des 95 cas. La question de l'habileté du chirurgien pour le résultat opératoire est établie.

Il est conclu que la greffe libre des tendons doit être réalisée par des spécialistes que l'on devrait centraliser dans des services spéciaux.

ZUSAMMENFASSUNG

Die Ergebnisse von 95 freien Sehnentransplantationen werden berichtet. 18 wurden am Flexor pollicis longus, 76 bei Beschädigung des Flexor digitorum profundus und sublimis und eine bei einer isolierten Beschädigung des Flexor digitorum profundus in der Sehnenscheide vorgenommen. Gemäss der Beurteilung nach Littler wurden 57 Prozent gute Resultate bei den unkomplizierten Fällen (reine Schnittwunden) und 33 Prozent bei komplizierten Fällen in der Altersgruppe 2–15 Jahre erhalten. Die entsprechenden Werte in der Altersgruppe 16–49 Jahre waren 27 Prozent, beziehungsweise 4 Prozent. In der Gruppe über 50 Jahre waren die Werte 0 bei 4 Patienten. Von 18 Fällen mit Transplantation zum Flexor pollicis longus war die Funktion des Daumens in 7 gebessert. Die Art der Darstellung und die Rolle von komplizierenden Schäden auf das funktionelle Endresultat werden besprochen. Operative Komplikation von Wichtigkeit traten in 16/95 Fällen auf. Der Anteil des Chirugens in den operativen Ergebnissen wird festgestellt.

Man schliesst, dass freie Sehnenverpflanzung eine Aufgabe für Spezialisten ist, die in besonderen Abteilungen zentralisiert sein sollte.

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