

Characteristics and management of flexor tendon graft disruption

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Summary—In order to define the proper management of patients with disruption of a flexor tendon graft, 220 consecutive flexor tendon grafts were reviewed. Patients were divided into two groups—those who did not require a silastic rod prior to tendon grafting (89 grafts) and those who did require a silastic rod prior to tendon grafting (131 grafts). The incidence of tendon graft disruption for these two groups was 1.1% and 7.6%, respectively. Based on an analysis of these 11 graft disruptions, a method of management was devised. The literature is reviewed regarding the incidence and method of management of disrupted flexor tendon grafts.

Complications following flexor tendon graft include haematoma, infection, development of stiff joints, failure of the tendon to glide and disruption of the graft. Many reports are available regarding functional evaluation after grafting, but none addresses in depth the management of a disrupted tendon graft.

Materials and methods

Two hundred and twenty consecutive flexor tendon grafts performed in 193 patients from 1973 to 1984 were reviewed. Patients were divided into two groups: Group I—those who did not require a silastic rod prior to tendon grafting (78 patients with 89 flexor tendon grafts); and Group II—those who require a silastic rod prior to flexor tendon grafting (115 patients with 131 flexor tendon grafts). There were 63 (81%) males in Group I and 105 (91%) males in Group II. In Group I the ages ranged from 2 to 73 years—mean 28 and median 24 years. In Group II the ages ranged from 5 to 69 years—mean 30 and median 27 years. Most grafts were performed in the 19 to 30 years age group (Fig. 1). All grafts were performed by or under the direction of the attending staff. The hand and wrist were totally immobilised for 3 to 4 weeks, after which therapy was begun in the Milliken Hand Rehabilitation Center. Complete office and rehabilitation records were maintained on each patient. Therapy was standardised, but patient participation outside the Center was uncontrollable. Our therapy regimen has been presented in depth previously (Weeks and Wray, 1976).

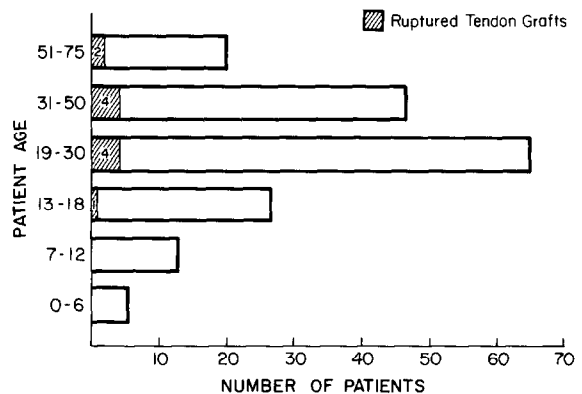


Fig. 1

Figure 1—Age distribution of patients with tendon grafts.

Characteristics of graft disruptions

Incidence. In Group I (no silastic rod prior to grafting) there was one rupture in 89 grafts—a 1.1% incidence. In Group II (a silastic rod was implanted prior to grafting) there were 10 ruptures in 131 grafts—a 7.6% incidence. All ruptures occurred in males (ages ranging from 13–58 years). Nine ruptures were confirmed by subsequent surgery—two refused surgery. There were no ruptures in the grafts performed before the age of 12 years. The distribution of the fingers treated in Groups I and II is shown in Figure 2.

The initial cause of the tendon injury. The initial injuries resulting in tendon laceration are listed in

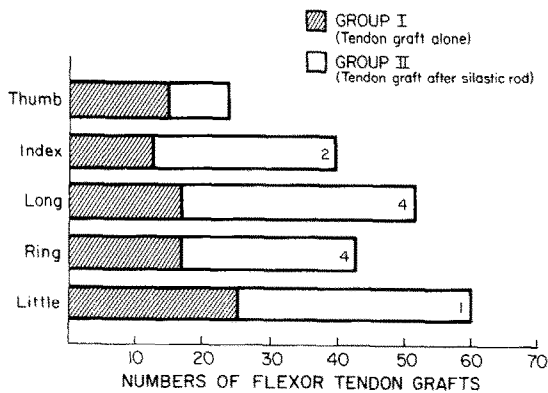


Fig. 2

Figure 2—Fingers involved in flexor tendon grafts.

Table 1. All were associated with a laceration (knife, saw, gunshot wound, or brick) except one patient who sustained an electrical burn. The latter required several procedures to obtain skin coverage and supple joints prior to tendon grafting.

Status of the superficialis tendon. The superficialis was absent in 10 of 11 digits in which the graft disrupted.

Activity at the time of graft rupture. Eight graft ruptures occurred during exercises prescribed by the therapist despite routine thrice-weekly therapy sessions and cautioning by the therapists. Trauma was implicated in two disruptions: both patients fell on the outstretched hand, one from a ladder. One tendon graft disruption was detected when the

button over the fingernail was noted to be missing the morning after surgery.

Time of rupture. Rupture occurred from 1 to 66 days after surgery. One was detected 24 hours after surgery. The time of disruption after the routine three week period of immobilisation was as follows: 1 to 2 days (4 grafts), 14 to 17 days (3 grafts), and greater than 30 days (3 grafts).

Site of disruption. Three ruptures occurred at the site of proximal repair—one in Group I and two in Group II. The remaining eight ruptures occurred at the tendon graft attachment to the distal phalanx—all in Group II (Table 1). In only nine was the site of rupture confirmed at surgery because two patients refused surgery.

Source of tendon. Eight of the ruptured tendons were plantaris grafts and the other three were palmaris longus grafts.

Time from disruption to reoperation. Early exploration was possible in seven cases, but failure to report the incident delayed surgery for 11 and 19 days in two patients.

Method of distal attachment. Ten of the 11 tendon grafts had been attached to the distal phalanx in the following manner. A 4-0 synthetic suture was secured to the tendon graft end using Bunnell's criss-cross method. A drill hole was made through the distal phalanx and nail and the suture passed through the drill hole and tied over a padded button over the nail. The periosteum of the distal phalanx had been removed around the drill hole and the bone roughened where the tendon graft would

Table 1 Patient data

Group	Patient age	Type of injury	Finger	Post-graft		
				Cause of rupture	Day to rupture	Anatomical site
I	21	Knife	Long	Exercise	66	Proximal
II	31	GSW Palm	Index	Exercise	44	Proximal
	13*	Knife	Long	Trauma	45	Proximal
	33	Electrical burn	Long	Technical	1	Distal
	29	Saw	Ring	Exercise	61	Distal
	24	Saw	Index	Exercise	24	Distal
	58	Knife	Long	Exercise	23	Distal
	51	Crush cut	Ring	Exercise	12	Distal
	19	Brick cut	Ring	Exercise	66	Distal
	38	Knife	Ring	Trauma	19	Distal
	35*	Knife	Little	Exercise	40	Distal

*refused surgery

contact the bone. In one rupture the tendon graft had been sutured to the remaining stump of the profundus tendon at the level of the DIP joint using a modified Bunnell suture technique.

Methods of management after graft disruption

The method of management was determined by our findings at the time of surgery. Selection of the method of management will be presented under the Discussion. Management will be discussed below according to the site of graft disruption.

Disruption at the insertion site. Of the eight disruptions at the distal phalanx, four underwent advancement and reattachment of the tendon graft to the distal phalanx using a Bunnell suture passed through a drill hole in the distal phalanx and tied over a padded button. In one patient the tendon graft end was so soft that it could not hold a suture and a further tendon graft was performed. In another, the bed contained dense adhesions which markedly restricted tendon gliding. The disrupted graft was removed and a silastic rod inserted. In one patient, who had electrical burns and had undergone multiple procedures including a cross-finger flap and PIP joint capsulotomy prior to initial grafting, the result was poor. Another patient with an intact superficialis tendon underwent fusion of the DIP joint and the tendon graft was sutured to the superficialis insertion.

Disruption at the proximal repair site. The ruptured graft was completely removed and a silastic rod inserted in one patient. In the other patient the ruptured graft was completely removed and another flexor tendon graft inserted.

Results of management of disrupted tendon grafts

Our results are reported as the sum of total active motion (TAM) at the PIP and DIP joints only (Table 2). Ninety degrees active motion was maintained at the MP joint in all patients. Total active motion was determined by subtracting the loss in active extension from actual active flexion at the PIP and DIP joints and adding the sums. The number of cases is too small to be statistically significant but does give the reader an impression of the results obtainable. Results of distal reattachment cannot be compared to grafting or rod and grafting because circumstances at the time of surgery determine the method of management. An

Table 2

Procedure	Age	Results		TAM
		PIP	DIP	
		Ext/Flex	Ext/Flex	
Distal reattachment	33	-31/38	-22/22	7°
	29	-32/87	-25/50	80°
	24	-16/99	-43/59	99°
	58	+17/73	-43/46	93°
Graft	21	-28/52	-23/23	24°
	19	-18/90	-42/71	101°
Rod/Graft	51	-15/80	-20/53	95°
	31	-42/59	-7/10	20°
Arthrodesis tenodesis	38	-26/93	-15/15	67°

expected 80° to 100° total active motion at the PIP and DIP joints can be used as a guide in counselling patients when discussing possible methods of management.

Discussion

Published reports of flexor tendon grafting were reviewed (Kinmonth, 1947; Littler, 1947; Boyes, 1950, 1955; Posh, 1953; Kyle and Eyre-Brook, 1954; Pulvertaft, 1956; Strandell, 1956; Watson, 1956; White, 1956; Bell *et al.*, 1958; Harrison, 1961, 1969; McCormack *et al.*, 1962; Gaisford *et al.*, 1966; Jaffe and Weckesser, 1967; Thompson, 1967; Goldner and Coonrad, 1969; Boyes and Stark, 1971; Hunter and Salisbury, 1971; Urbaniak and Goldner, 1973; Herndon, 1976; Weeks and Wray, 1976; Honner and Meares, 1977; Hunter and Jaeger, 1977; Stark *et al.*, 1977; Brug and Stedtfeld, 1979; McClinton *et al.*, 1982; Kunzle *et al.*, 1984). The occurrence of flexor tendon graft disruption reported in these series is recorded in Table 3. Fifty-four ruptures were reported in 2363 flexor tendon grafts. There were 16 distal, 1 middle and 25 proximal ruptures, with 12 unspecified sites of rupture. The methods of management in these series are collated and are listed in Tables 4 and 5. Hunter and Salisbury, in their excellent 1971 treatise on technical aspects of flexor tendon grafting, did not discuss the problem. Others, while reporting tendon graft ruptures, did not comment on management (Posh, 1953; Bell *et al.*, 1958; Herndon, 1976). Except in three cases, the outcome of management was reported in descriptive terms such as excellent, good, satisfactory, encouraging

Table 3 Collected series of flexor tendon grafts

Author	Number of grafts	Site of rupture			
		Proximal	Middle	Distal	Unspecified
Boyes, Stark	700	18	—	6	2
Brug, Stedtfeld	50	—	—	1	—
Goldner, Coonrad	22	—	—	1	—
Honner, Meares	100	—	—	2	—
Hunter, Salisbury	74	3	—	—	—
Littler	36	—	1	1	1
Pulvertaft	149	—	—	—	5
Thompson	100	—	—	2	—
Watson	25	—	—	2	4
Weeks, Wray	46	—	—	1	—
White	76	4	—	—	—
	1,378	25	1	16	12
Series Not Reporting Tendon Graft Ruptures	985	—	—	—	—
Total	2,363		54		

Table 4 Management of proximal tendon graft ruptures from collected series

Method of management	Number of patients	Results
Reattachment	9	1 good 6 useful 2 failure
Regraft	2	1 excellent 1 poor
Arthrodesis/Tenodesis	1	1 satisfactory
Unspecified	5	1 fair 1 poor 3 no comment
Refused Repair	8	—

Table 5 Management of distal tendon graft ruptures from collected series

Method of management	Number of patients	Results
Reattachment	7	1 TAM = 240 5 useful 1 failure
Regraft	1	Fair
Unspecified	7	—
Refused Repair	1	—

and poor (Posh, 1953; Boyes, 1955; Pulvertaft, 1956; Strandell, 1956; Bell *et al.*, 1958; Urbaniak and Goldner, 1973; Herndon, 1976; Honner and Meares, 1977; Hunter and Jaeger, 1977). Conse-

quently, it is impossible to draw conclusions about management from this review.

The following comments reflect our approach in the management of a ruptured flexor tendon graft based on the results reported in this paper. The first consideration is the presence or absence of a functioning superficialis tendon in the finger. If present, we recommend fusion of the DIP joint. If necessary, tenolysis of the superficialis tendon may be combined with DIP joint fusion. Postoperatively, active motion is begun immediately at the MP and PIP joints.

If a superficialis tendon is not present, our next preoperative decision is to determine where the disruption occurred. Nine of the 11 ruptures in our series were explored—two had ruptured proximally and seven distally. Physical examination of the remaining two patients suggested that one was proximal and one was distal; however, these were never proven. The site of rupture can be determined by localised tenderness if the patient is seen shortly after the incident. The site of tendon rupture is exposed using the incision made for the initial grafting procedure.

Selection of the method of management for a distal disruption is determined by answering the following questions: (1) Will the tendon end hold a suture or is it too soft? (2) Must tendon length be sacrificed to obtain tendon which will hold a suture? (3) Does the tendon graft glide when distal tension is applied to the graft? It is assumed that the tendon graft was initially inserted under proper tension, thus at exactly the right length. If one must resect

more than 5 to 10 mm of tendon graft to get to a level where the tendon has the consistency to hold a suture, then the graft will be too short and the finger severely flexed. Placement of a suture in a more proximal position will of necessity shorten the graft. Next, one must determine if the tendon graft glides when tension is placed on the graft. It is important to determine whether or not the graft is relatively free within the finger and palm. If it is not freely movable, then removal of the graft should be considered. How much should the tendon graft slide? At 6 weeks after tendon grafting, the average tendon graft glides approximately 50% of its normal excursion (Weeks and Wray, 1976). At 12 weeks after tendon grafting, the tendon glides approximately 75% of its normal excursion (Bell *et al.*, 1958). If tendon graft gliding is inadequate or if excessive lengths would have to be sacrificed, then the decision must be made whether a second tendon graft or a rod should be inserted. This decision is made empirically. Since tendon graft rupture is infrequent, relevant data must be reported in subsequent series and collated with this series to permit establishment of a scientific basis for management.

Evaluation of the proximal disruption is very similar. One must determine if the tendon ends will hold a suture, if the tendon length will have to be sacrificed, so making the graft too short, and if the graft glides adequately when proximal tension is applied. In our experience proximal rupture was associated with extensive tissue destruction, necessitating either a flexor tendon graft or a rod and subsequent grafting. In no instance were we able directly to repair a proximal rupture.

When should a flexor tendon graft be used?

A second tendon graft is our next choice of management if direct repair cannot be accomplished. A graft should be considered if the ruptured tendon ends will not hold a suture, if tendon length must be sacrificed or if the tendon graft fails to glide when tension is placed on the graft.

When should a rod and subsequent tendon grafting be considered?

A rod should be considered when tension on the tendon graft results in minimal tendon gliding. Thus, use of a rod is determined by the extent of the adhesions around the ruptured tendon graft. At six weeks the adhesions should allow 50% of normal tendon excursion.

Time of immobilisation after management of graft disruption.

A final consideration is how long the hand should be immobilised after distal reattachment, direct repair or flexor tendon grafting. Immobilisation after repair of a tendon rupture in our series varied from 12 to 30 days. When distal attachment was possible, the period of immobilisation was 12, 13, 16 and 17 days respectively. Our results are recorded according to the time of rupture and the period of immobilisation after repair (Table 6). Two patients

Table 6 Patient management (time in days)

Age	First immob.	Time to rupture	Delay	Second immob.	Result	
<i>Distal reattachment</i>						
33	1	1	0	17	7°	
29	26	61	2	12	80°	
24	23	51	3	16	99°	
58	20	23	4	13	93°	
<i>Tendon graft</i>						
21	23	66	11	23	24°	
19	33	66	4	12	101°	
Age	First immob.	Time to rupture	Time to		Second immob.	Result
			Rod	Graft		
<i>Rod graft</i>						
51	13	13	2	107	26	95°
31	27	44	19	145	30	20°

undergoing an immediate graft were immobilised 12 and 23 days respectively. If a rod was used before regrafting, then the fingers were immobilised between 26 and 30 days after rod removal and flexor tendon graft insertion. Immobilisation after rod graft is straightforward and needs no further comment. We are concerned in this paper with determining the optimum period of immobilisation after distal reattachment, direct repair or immediate tendon graft. The numbers provided in our series are too small to be statistically significant. Arbitrarily, we decided immobilisation should be shortened because of the adhesions which had already formed around the tendon graft proximal to the site of distal reattachment. Our best results were obtained if immobilisation was limited to 12 to 16 days (Table 6). Thus, we recommend mobilising the finger for 14 days after repair. By flexing the distal phalanx passively while actively exercising the flexor tendon graft to flex the MP

and PIP joints, tension can be placed on the adhesions about the proximal portion of the flexor tendon graft without stressing the attachment to the distal phalanx.

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