Digital function following flexor tendon repair in Zone II: A comparison of immobilization and controlled passive motion techniques

The performance of 50 consecutive digits in 37 patients was analyzed following flexor tendon repair in Zone II. Twenty-five digits were managed by 3½ weeks of immobilization followed by a program of gradually increased motion; 25 other digits by intermittent passive motion initiated within the first 5 days with active flexion commenced at 4½ weeks. Results were graded according to the percentage of return of motion at the proximal and distal interphalangeal joints. There were four ruptures in the immobilization group with no excellent results, 12% being rated good, 28% fair, and 11% poor. In the digits managed by early mobilization there were 36% excellent, 20% good, 16% fair, 24% poor; there was one rupture in this group. Early passive motion appeared to be an effective technique to improve the results of flexor tendon repairs in this area.

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Although there has been almost universal conversion to primary flexor tendon repair within the digital fibro-osseous tunnel, controversy still exists as to the benefit of early mobilization techniques designed to control or modify adhesion formation.

While most authors agree that the results in zone II[1] are consistently worse than those in other anatomic areas,[2–4] abstracting meaningful information for comparison of results in this zone is both confusing and difficult. Factors which influence these results include the technique and skill of the surgeon, the type of tendon repair, suture material, the presence of associated injuries, the length of immobilization following tendon suture, and the type of mobilization program utilized. Variations in these factors will invalidate any effort to compare digital performance following tendon repairs in this zone.

A multiplicity of classification systems based either on the proximity of the digital pulp to the distal palmar crease or a summation of the degrees of active flexion at each joint further hinders the comparison of results.[1, 5–14] No single tightly focused study exists to substantiate that early postoperative mobilization provides better final digital function than immobilization until tendon healing has occurred.

This study is an effort to create a relatively pure sample by limiting the digits under consideration to those with acute flexor tendon injuries in zone II, managed by a single surgeon, without associated injuries, with the exception of the interruption of digital neurovascular structures. Nearly identical repair techniques and suture materials were used in all cases, and each of the two postoperative regimens was closely monitored.

Material

The performance of 50 consecutive digits in 37 patients was analyzed following flexor tendon repair in zone II. Twenty-five digits were managed by 3½ weeks of protective immobilization prior to the initiation of a gradual motion program. Twenty-five additional digits were managed by a carefully supervised regimen of intermittent passive motion initiated within the first 5 postoperative days according to a modification of the method described by Duran and Houser.[13]

Surgical technique

All repairs were carried out by the same surgeon and, except for occasional small variations in the method of tendon repair, the surgical technique was the same in

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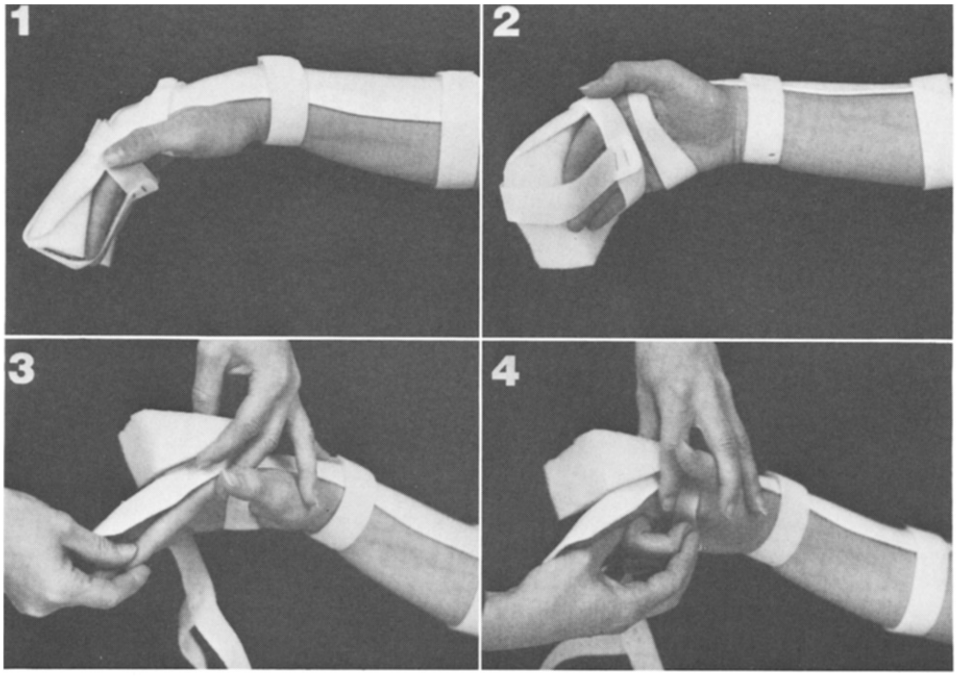

Fig. 1. Dorsal orthoplast splint immobilizes the wrist in moderate flexion and the digits in a balanced position *(1)*. Digital extension is prevented by a dorsal foam wedge *(2)* and a twice-daily passive motion program permitting nearly complete interdigital joint extension *(3)* and flexion *(4)* is carried out by the patient for 4½ weeks.

Table I. Patient group

	Immobilization	*Passive early motion*
Age (yr)	22.1	24.6
Time to repair (days)	2.2	2.6
Follow-up (days)	160	125
Tendons severed:		
FDP (alone)	3	8
FDP + FDS	22	17

all cases. The digital wound was extended proximally and distally and exposure gained by resecting a small portion of the fibro-osseous canal. This defect in the tunnel was usually expanded to allow for full unimpeded amplitude of the tendon repair. Retrieval of proximal tendon ends was carried out either by the use of a small tendon forceps or by a palmar incision through which a probe or catheter could be passed to deliver the tendons back into the digit. The position of the proximal tendon stump was temporarily maintained by the use of a small transverse trapping needle. Tendon repair was carried out with either a modified Bunnell crisscross or a modified Kessler technique, with the suture knot being buried at the site of tendon juncture. The flattened distal ends of the superficialis slips were usually repaired with horizontal mattress sutures, and additional fine interrupted or running sutures were used to tidy up the sites of both tendon junctures.

Suture of digital nerves was carried out at the time of tendon repair, and no attempt to repair the digital sheath was made during the time period covered by this study. In no cases were local steroids utilized nor were silicone membranes interposed at the time of primary repair.

Postoperative management

In the immobilization group, the wrist was positioned in moderate flexion and the digits in a balanced position for 3½ weeks, following which active and passive flexion and active extension were permitted for an additional 2 weeks. At 5½ weeks passive extension was allowed, and dynamic splinting was employed when necessary to overcome contractures.

At 2 to 5 days in the early mobilization group (Fig. 1) a dorsal orthoplast splint immobilized the wrist in moderate flexion and the digits in a balanced position. Digital extension was prevented by a dorsal foam wedge, and a twice-daily passive motion program permitting nearly complete interdigital joint extension

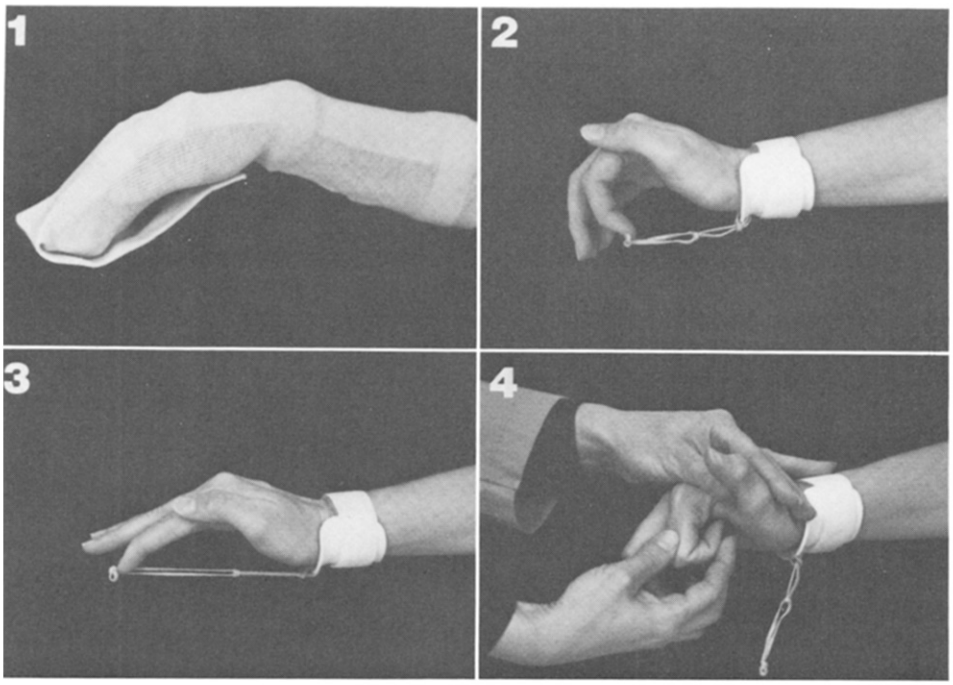

Fig. 2. During the first 4½ weeks a protective stockinette covering is used between exercise periods *(1)*. At 4½ weeks a simple wrist cuff rubber-band assembly is employed *(2)* with gentle active extension and flexion *(3)* and passive flexion exercises *(4)* encouraged.

and flexion was carried out by the patient for 4½ weeks. Separate passive exercises for the proximal and distal interphalangeal joints were used in an attempt to separate the profundus and superficialis repair sites.[13]

At 4½ weeks (Fig. 2) a simple wrist cuff with a rubber-band assembly was employed with gentle active extension and flexion and passive flexion exercises were encouraged.[12] Unprotected digital motion was allowed at 5½ weeks, and dynamic splinting was employed as necessary to overcome contractures. Careful monitoring of these postoperative exercise programs was carried out with frequent examination by the physicians and therapists involved.

Patients

Omitted from this study were patients with adjacent fracture, skin loss, or other associated injuries deemed prejudicial to the restoration of tendon function. Concomitant digital nerve interruption in 48% of the digits did not result in deletion from the study group. All results presented in this report precede any tenolysis procedures.

There was little difference in patient age or time to repair between the two groups studied. The average time to follow-up was somewhat longer in the immobilization group (Table I). Severance of the profundus alone in zone II occurred in three of the immobilized digits and eight of those managed by early passive motion, with combined profundus and superficialis severance found in 22 digits and 17 digits, respectively.

Table II. Tendons severed

	Immobilization		*Passive early motion*	
Finger	*No.*	*%*	*No.*	*%*
Index	3	12	6	24
Long	10	40	4	16
Ring	7	28	8	32
Small	5	20	7	28

A breakdown of the tendon severances per digit is shown in Table II.

Methods

In order to grade the digital performance following zone II flexor repair, a combination of existing classifications and the total active motion (TAM) system recommended by the American Society for Surgery of the Hand was used. Because metacarpophalangeal joint motion was normal in all cases, this measurement

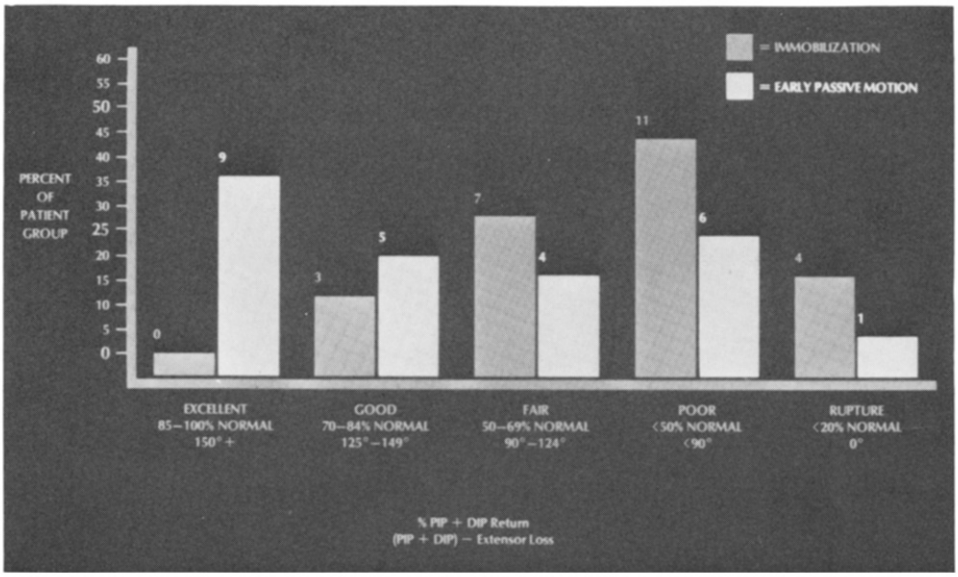

Fig. 3. Results following zone II flexor tendon repair.

Table III. Classification system

Group	*PIP + DIP return (%)*	*PIP + DIP minus extensor loss (degree)*
Excellent	85-100	150+
Good	70-84	125-149
Fair	50-69	90-124
Poor	<50	<90

could only bias a true assessment of tendon function as reflected at the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joint levels. It was therefore elected to use the sum of PIP joint and DIP joint flexion (in attempted fist position), minus the extensor lag at these joints, in order to compute a TAM. The percentage of a normal 175° motion at these two joints was determined with the use of the formula:

$$\frac{\text{Active PIP + DIP flexion} - \text{extension lag}}{175^\circ} \times 100 = \text{\% of normal active PIP and DIP motion}$$

and the classification system shown in Table III was devised.

PIP and DIP joint motion greater than 150°, or 85% to 100% of normal, was graded as excellent. Motion between 125° and 149°, or 70% to 84% of normal, was judged good; motion from 90° to 124°, or 50% to 69% of normal, was classified as fair. A functional return of less than 90°, or 50%, was categorized as poor. Although it is somewhat more demanding than most previous assessments, we think that this classification most accurately reflects the recovery of digital function following flexor tendon repair.

Results

There were four (16%) tendon ruptures in the digits in the immobilization category, compared to a single (4%) rupture in the early passive motion group. Excluding the rupture cases, the average TAM of all three joints of the immobilized digits was 168°, compared to 213° in the mobilized fingers.

With the classification system described previously, the results of this study are shown (Table IV, Fig. 3).

In the immobilization category there were no excellent results, 12% good results, and 40% in the good or fair category. Combining poor results with ruptures, there was an overall 60% failure rate. In the early passive motion digits there was a 56% excellent or good performance, with 72% in the excellent, good, or fair categories, and 28% in the poor or rupture groups. The 56% excellent and good results of the passive motion group were statistically significant ($P \leq 0.005$) when compared to the 12% in the immobilized group. Comparison of the excellent, good, and fair groups (72% for the passive motion group and 40% for the immobilized group) was also significant ($P \leq 0.05$).

Results following zone II severance of the profundus alone produced one good and two fair results in the immobilization group. Five excellent results and one

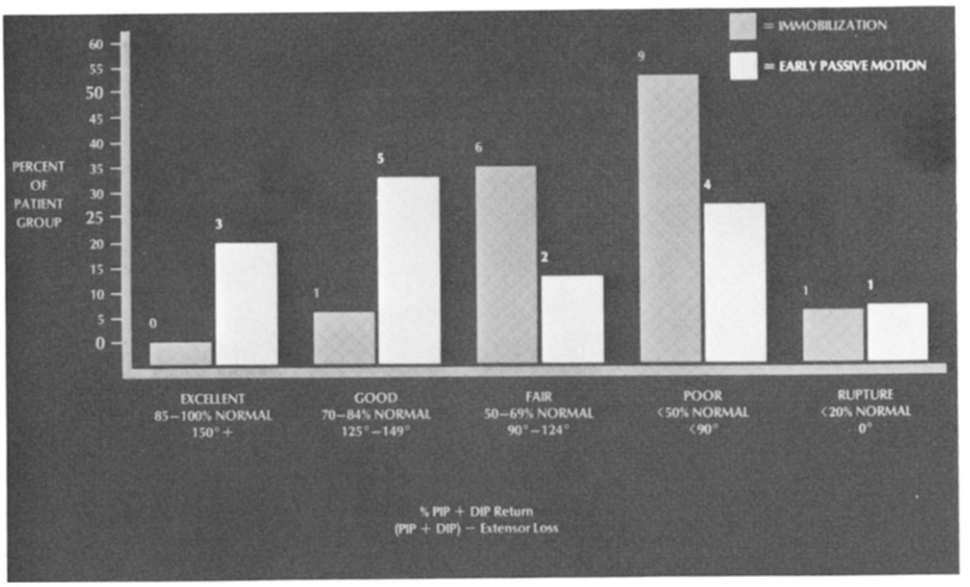

Fig. 4. Results following repair of profundus and superficialis in zone II.

Table IV. Total results

	Excellent	*Good*	*Fair*	*Poor*	*Rupture*	*Total*
Immobilization	0 (0%)	3 (12%)	7 (28%)	11 (44%)	4 (16%)	25
Early passive motion	9 (36%)	5 (20%)	4 (16%)	6 (24%)	1 (4%)	25

Table V. Profundus and superficialis repaired

	Excellent	*Good*	*Fair*	*Poor*	*Rupture*	*Total*
Immobilization	0 (0%)	1 (6%)	6 (35%)	9 (53%)	1 (6%)	17
Early passive motion	3 (20%)	5 (33%)	2 (13%)	4 (27%)	1 (7%)	15

each in the good, fair, and poor categories followed early motion.

In an attempt to refine the comparison between the immobilization and passive early motion groups, all isolated profundus repairs or those repairs of the profundus tendon in which the superficialis tendon was excised were deleted; only those cases in which both the profundus and superficialis had been repaired were studied. The same criteria for evaluation were utilized and the results are shown (Table V, Fig. 4).

Forty-one percent of the 17 combined profundus and superficialis repairs managed by immobilization fell in either the good or fair categories; 59% were considered failures. Of the 15 fingers treated by early passive motion following repair of both tendons, 53% achieved either excellent or good results; 66% fell in the excellent, good, or fair categories. Thirty-four percent of this group were considered failures. Comparison of the excellent and good results in the two groups (53% in the passive motion group and 6% in the immobilized group) was significant ($P \leq 0.01$).

Five digits were treated by profundus tendon repair and superficialis tendon excision in the immobilized group; four went on to a poor result and one ruptured. Two digits in the early passive motion group were managed by profundus repair and superficialis excision, resulting in one excellent and one good result.

Discussion

This study compares the performance of zone II flexor tendon repairs managed either by immobilization for 3½ weeks before the initiation of motion or by a

technique of early postoperative passive digital mobilization. The elimination of a number of variables inevitably prejudicial to the results in other studies allowed a more valid comparison of digital function following the repair methods evaluated in this report.

Digital performance following flexor tendon repair followed by 3½ weeks of immobilization yielded no excellent final results and only 12% in the good classification. Forty percent could be classified as good or fair, but 60% of the repairs resulted in a poor functional return. Of those digits managed by early passive motion, 56% went on to an excellent or good result, and there were only 28% in the poor category. This would appear to give supporting evidence that techniques which permit early gliding of tendon repairs may produce substantially better results than those using an immobilization method.

There were four ruptures following the initiation of motion in digits managed by immobilization compared to only one rupture in those digits in which the early passive motion technique was utilized. Lister et al,[12] had only two ruptures in 60 digits following their early mobilization technique. Duran and Houser[13] described two initial ruptures (assumed by the authors to be the result of too vigorous a program) with only two ruptures occurring in the next 25 digits utilizing the passive motion regimen. This reduced rupture rate in the mobilized digits would tend to substantiate the tensile strength studies of Mason and Allen,[15] which indicate that a tendon repair gains tensile strength when submitted to tension at the repair site. Perhaps the improved digital function seen following early passive mobilization in this study is due not only to the creation of less limiting adhesions but also to the improved tensile strength of the tendon repair at an earlier stage of healing.

An accurate comparison of these data and previously reported studies is almost impossible due to the wide variation of techniques utilized and assessment methods. Our results tend to corroborate those reported by Duran and Houser[13] utilizing the passive technique and Lister et al.[12] employing early active extension.

Duran and Houser reported 80% of normal active motion after the zone II disruption. This would place their average result in the good or excellent category described in this report and would indicate the superiority of this technique in their hands.

Lister and Kleinert reported that 75% of the flexor tendon repairs in zone II produced excellent or good results utilizing their technique which permitted early active extension. However, the criteria for good and excellent in that study were less demanding than those reported in this series. The excellent and good classifications of the Lister-Kleinert study would be included in the excellent, good, and fair categories described here. This would indicate a very similar final result when compared with the 72% excellent, good, or fair rating that resulted from early passive mobilization in this study.

The number of cases managed by profundus repair and superficialis excision (five in the immobilized group and two in the early motion group) was too small to allow any valid comparisons with those digits which had repair of both tendons. Previously reported studies[3, 12] suggest that better digital performance can be expected following repair of both tendons and no contradictory evidence is submitted in this report.

Summary

The improved performance apparently produced by techniques which allow early motion of a tendon following repair in this area are encouraging, but the 28% poor results seen in this study still fall far short of the desired objectives.

An attempt has been made to eliminate many of the variables found in other studies.

A method for the evaluation of digital performance following flexor tendon repairs is described which eliminates the almost always normal metacarpophalangeal joint measurement.

This study of results of zone II flexor tendon repairs provides a meaningful comparison between the performance of early postoperative mobilization and immobilization methods. It would appear that early passive motion is an effective adhesion-limiting technique and can substantially improve the results of flexor tendon repairs in this troublesome area.

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