Immediate Controlled Active Motion Following Zone 4–7 Extensor Tendon Repair

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ABSTRACT: This article describes a splint management program for zone 4–7 extensor tendon repairs that allows for immediate controlled active motion (ICAM) of the repair and greater arcs of motion for adjacent digits. The splint is designed to relieve tension on the tenorrhaphy by positioning the involved digit in slight metacarpophalangeal joint hyperextension relative to the uninvolved digits with a simple yoke splint designed to control the metacarpophalangeal joints and a second splint to control wrist position. Cadaver and intraoperative trials support this technique, and 140 patient cases managed over 20 years. The majority of patients achieved a rating of excellent for both digital extension and flexion as judged by Miller's criteria. There were very few extension lags and no tendon ruptures. Patients returned to work in the ICAM splint on average in 18 days. The average time to complete the program was seven weeks after repair, and required an average of eight therapy visits. The results of this study demonstrate that the ICAM splinting technique is safe, simple to manage, decreases the morbidity associated with immobilization, is cost effective, and has high patient compliance when compared to other early motion programs.

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*The greatest challenge in treating the hand is to preserve function in all of the structures not directly injured—Wyndell H. Merritt, MD, FACS**

Twenty years ago, this axiom was not being achieved in the hand management of extensor tendon repairs. *Immobilization not mobilization* was the standard procedure following extensor tenorrhaphy in zones 4–7. Not surprisingly, the position that protected the tenorrhaphy often created the need for lengthy rehabilitation to remodel stiff joints and dense tendon adhesions. When therapy failed to achieve acceptable functional results, surgical tenolysis and capsulotomy procedures followed. Since the mid-1980s, many innovative programs have been published which introduced the use of controlled motion for the management of extensor tendon repairs.[1–16] Many of these zone 4–7 extensor tendon programs depend on either a dynamic extension-assist splint or a static splint for the dual-purpose of lessening tension on the repaired tendon by controlling tendon excursion. We have found both of these methods of splinting to be overly cautious and laborious. As an alternative over the past 25 years, we have used the immediate controlled active motion (ICAM) splint program. With our method we have been able to demonstrate that zone 4–7 extensor tenorrhaphies can be simply managed and moved immediately without endangering the repair. This article will 1) provide anatomical and patient studies to support our technique, 2) provide the results of using the ICAM splint program with 140 patients, and 3) describe ICAM splint fabrication and program management.

METHOD AND MATERIALS

Splint Design

The senior author (WHM) conceived the idea for the ICAM splint, originally named the "relative motion splint," in the early 1980s. The first version of the splint consisted of a static wrist splint linked to a static finger yoke-gutter splint. The wrist was positioned in 25–30 degrees of extension and the finger yoke positioned the involved metacarpophalangeal

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(MP) joint in 25–30 degrees more extension relative to the uninjured MP joints. The yoke had an attached finger gutter to immobilize the interphalangeal (IP) joints and was linked to the wrist splint by a strap. The second-edition splint eliminated the link-strap and the finger gutter altogether. In 1986, results of the clinical trial with the second-edition of the splint were presented at the ninth annual meeting of the American Society of Hand Therapists in New Orleans.[2] In their series of 22 patients, Robinson et al.[2] noted that all patients had "full range of motion within five weeks of surgery, joint stiffness was nonexistent and no patient required a therapy program after removal of the splint." Today the ICAM splint is in the third edition (Figure 1). In this edition of the splint the angle of wrist extension was reduced to 20–25 degrees and the position of relative MP joint extension of the involved digit in the yoke was lessened to 15–20 degrees.

Anatomical Trials

Cadaver trials support the concept that the position of the ICAM splint can allow active motion and not put tension on the repair. In these trials, the extensor digitorum communis (EDC) tendon of the long finger was lacerated in zone 5 and not sutured so that minimal tension would produce a gap. When the cadaver wrist was positioned in neutral and a fist simulated, an undesirable amount of tendon gap was observed (Figure 2A). When the yoke component of the ICAM splint was introduced, less tendon gap occurred (Figure 2B). When the wrist was positioned in 20 degrees of extension and the yoke component used, very little tendon gap was noted (Figure 2C).

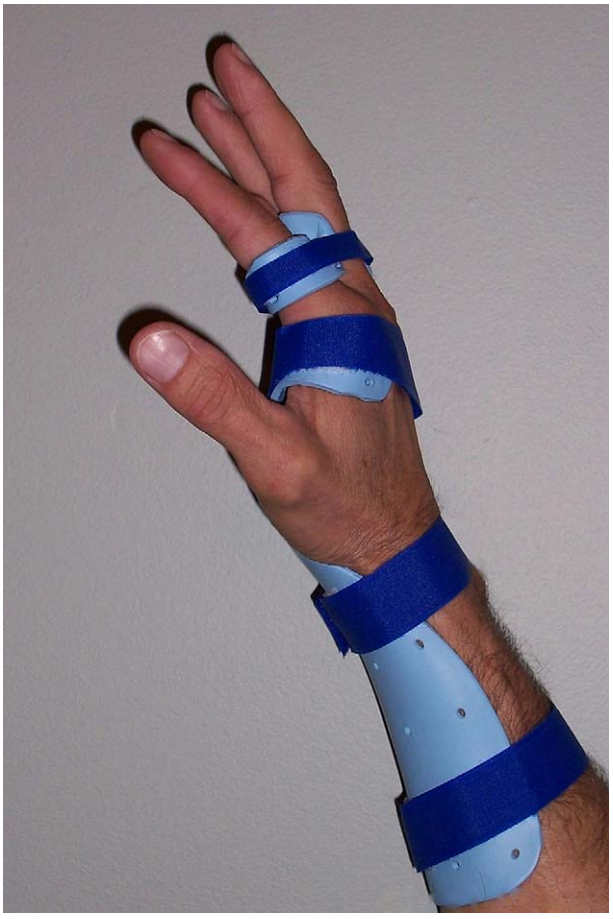

FIGURE 1. *The ICAM splint (third version) with wrist positioned in 20–25-degree extension and the yoke component positions the involved MP joint in 15–20-degree (hyper-) extension relative to the MP joints of the noninjured digits.*

Intraoperative Trials

The cadaver experiment simulated active motion. The next step was to introduce movement through active patient participation. Intraoperative trials allowed direct observation of the effect of the ICAM splint position on a tendon repair with the patient actively moving. These trials involved a patient with a long finger zone 5 EDC laceration. To insure that any tension on the repair could be discerned, a suture that would easily breakaway was used to repair the tendon. A tongue blade was used to simulate the ICAM yoke and the wrist was positioned in neutral by the senior author (Figure 3A). In this position, the patient was asked to make a fist and tension was observed on the repair. To reduce the tension on the repair, the patient's wrist was repositioned to 20 degrees of extension (Figure 3B). In the simulated ICAM position, no tension was observed on the breakaway suture during fist making and active extension of the fingers. Within minutes after these trials, the EDC tendon was repaired, the patient fitted with the ICAM splint, and controlled active motion exercises begun (Figures 3C and 3D).

ICAM Program Management

Therapy management of the ICAM program consists of three phases, which are defined by number of days after repair: phase 1 is 0–21 days post repair, phase 2 is 22–35 days after repair, and phase 3 is 36–49 days after repair.

In phase 1, both components of the splint must be worn continuously. During this phase it is requisite that full active composite finger flexion and extension be obtained within the confines of the splint. Proper measures should be taken to control edema and the vigor of exercise monitored so not to incite the inflammatory response. Scar massage is added to the home program after suture removal. Patients should be instructed to *wear both components of the splint at all times*. Before beginning phase 2, it is important that full active motion be achieved within the limits of the ICAM splint.

In phase 2, the patient is instructed *to wear the yoke at all times.* If, however, the patient is to engage in medium to heavy-duty type tasks, then both

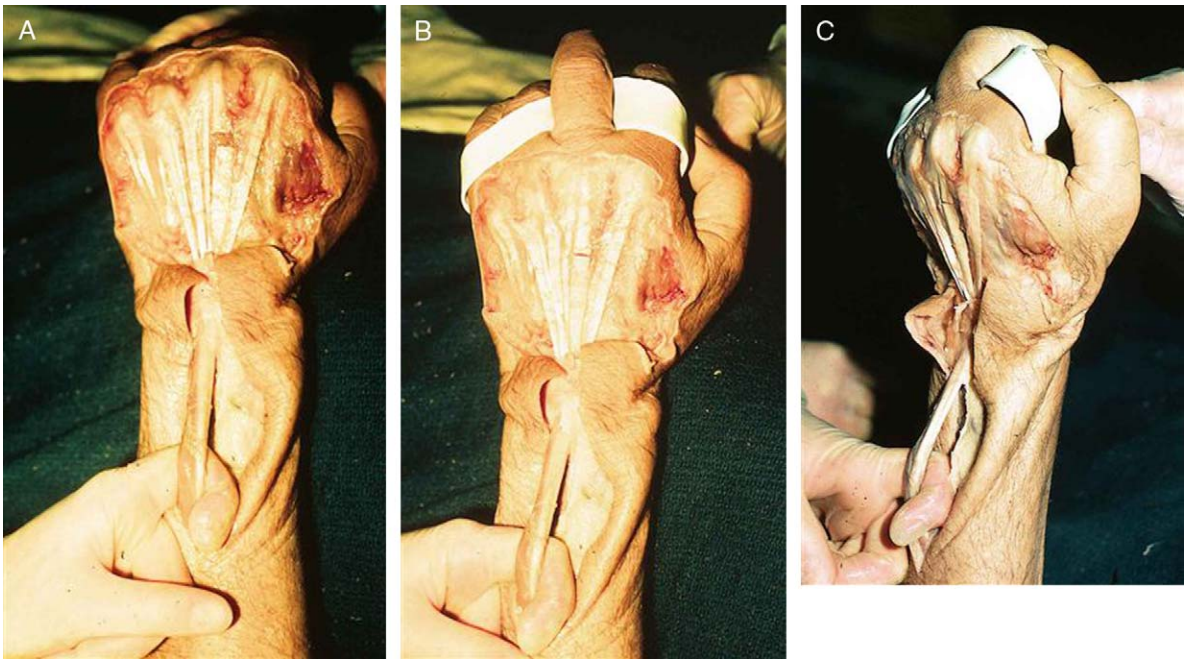

FIGURE 2. *ICAM cadaver trials zone 5 EDC laceration of the long finger that is not sutured. (**A**) Undesired tendon gap with wrist positioned at neutral and fingers fisted during simulated-contraction of the long digital extensors. (**B**) Less tendon gap when ICAM yoke introduced with wrist positioned at neutral and fingers fisted during simulated-contraction of the long digital extensors. (**C**) Further reduction in tendon gap with wrist positioned in 20-degree extension, yoke in position and fingers fisted during simulated contraction of the long digital extensors.*

components are required during those tasks. To prepare for wrist-out activity, the wrist splint is removed for active range of motion wrist exercises. Initially during wrist range of motion, the fingers are held relaxed so not to place too much tension on the repair. If no extension lag develops, exercises are quickly advanced to combine wrist flexion with fisting and wrist extension with digital extension. Once the wrist is moving freely, the wrist splint should be discontinued for light-duty use.

In phase 3, the wrist splint is discarded completely. The finger yoke or a buddy strap is worn during activity. To prepare for yoke-off activity, the yoke is removed for active range of motion exercises. Before completion of this phase, full composite wrist and finger motion should be achieved outside the confines of the ICAM splint.

The frequency of treatment during the initial ten days after repair may require two therapy visits to adjust the splint for changes in edema and to individually instruct the patient in range of motion exercises. We have found that patients need to be followed at least once each week thereafter to assess the fit of the ICAM splint, to individualize instruction, and to advance the program.

Patient Trials

Between 1984 and 1994, all patients referred to Hand Management Specialists in Richmond, Virginia with the diagnosis of zone 4–7 EDC, extensor indicis proprius (EIP), and/or extensor digiti minimi (EDM) tenorrhaphy were entered into the study. A team of occupational and physical therapists experienced in hand therapy treated the ICAM patients. Patient referral sources were received most often from hand surgeons and secondarily from emergency room physicians.

Inclusion Criteria

Acceptance into the ICAM program required that each patient have injury to at least one but not all extensor tendon(s) in zone 4–7. If all EDC, EIP, and EDM tendons were repaired, the patient did not qualify for the ICAM program. Classification as a *simple* tendon injury indicated involvement of one extensor tendon in zone 4–7. Classification as *complex* indicated one or more of the following; multiple tendons, joint involvement, crush injury, and/or tendon repairs delay more than five days after injury. The classification of *complex* was also assigned to any complete tendon laceration in zones 4–7 in which no tenorrhaphy was performed.

Data Analysis

We analyzed data from patients who completed the ICAM program. Completion of the program was operationally defined as participation for at least 21 days from the time of tenorrhaphy. Miller's guidelines were used to categorize the ICAM splint

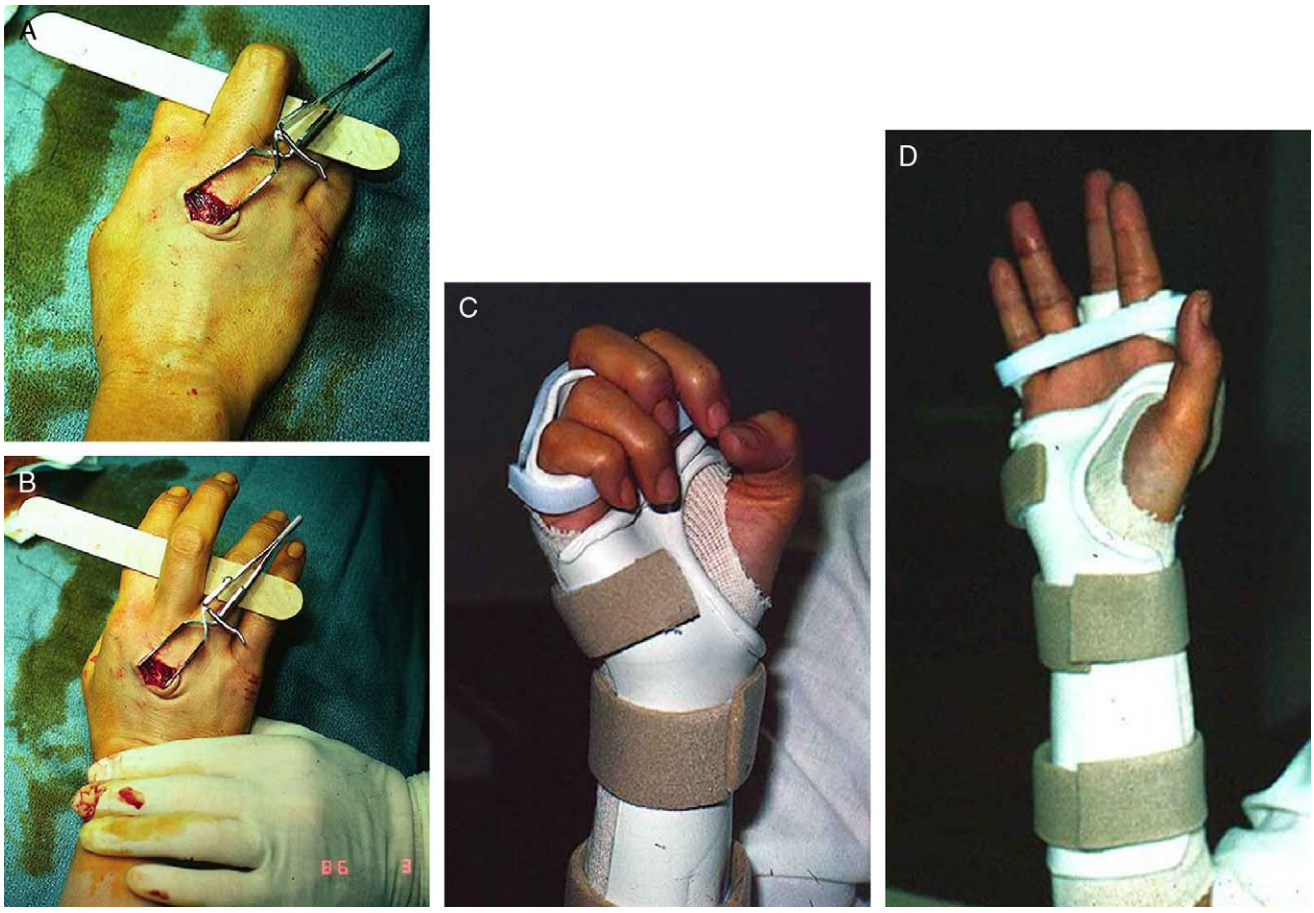

FIGURE 3. *ICAM intraoperative patient trials with breakaway suture in zone 5 EDC laceration of the long finger. (**A**) The patient is actively flexing-extending the digits and tension on the suture is observed with simulated yoke and the wrist positioned in neutral. (**B**) The patient is actively flexing-extending the digits and less suture tension observed with the simulated yoke and the wrist positioned in 20 to 25 degrees of extension. (**C**) The patient demonstrates immediate postoperative controlled active flexion within the ICAM splint. (**D**) The patient demonstrates immediate postoperative controlled active extension within the ICAM splint.*

program results.[17] Miller's guidelines use *active* composite digital extension to rate the results of extensor tendon repairs and *active* composite digital flexion to rate flexor tendon repair results (Table 1). According to these guidelines, an *excellent* result is having no extension lag for extensor repairs or for flexor tendons the flexion range of motion should be restored to normal. A *good* result is defined as a 5-10 degrees extension lag for extensor tendon repairs or for flexor tendons not more that a 20 degrees impairment in terminal flexion. A *fair* result is defined for extensor tendons as an extension lag of 11–45 degrees or for flexor tendons not more than 21–44 degrees impairment in digital flexion. A *poor* result for extensor tendons is an extension lag of more than 45 degrees or for flexor tendons more than 45-degree impairment in digital flexion. For this study we applied both the extensor and flexor tendon criteria proposed by Miller to our data. Additionally, we operationally defined the restoration of ''normal terminal flexion'' as the combined active flexion angles of the MP, proximal interphalangeal (PIP), and distal interphalangeal (DIP) joints of the injured digit subtracted from the combined active flexion angles of the patient's uninjured contralateral finger MP, PIP, and DIP joints. If the resultant flexion difference was less than the contralateral finger then the result was graded by Miller's categories for loss of terminal flexion. When the extension criteria were applied and the result was not excellent, the joint that demonstrated the active extension lag was noted.

RESULTS

Seventy-three percent or 140 patients completed the ICAM splint program between 1984 and 1994. Eighty-seven percent of these patients were male. Occupations varied though manual laborers were in the majority. The dominant hand was involved in 86% of the patients. The average patient age was 34 years (range 11–77 years). The most common zone of injury was in zone 5 (112 patients), followed by zone 4 (14 patients), zone 6 (nine patients) and zone 7 (five patients). The long finger was most often involved (36%), followed by the index (35%), ring (19%), and small (10%) fingers. Simple tendon injuries occurred

TABLE 1. **Miller's Criteria for Rating Tendons after Repair**

Miller's Criteria	*Excellent*	*Good*	*Fair*	*Poor*
Active extension lag	None	5–10°	11–45°	>45°
Terminal flexion loss	None	<20°	21–45°	>45°

in 89 patients and complex tendon injuries in 51 patients. In our series all injuries which involved zone 7 were rated as complex. Average days from injury to tendon repair were 2.3 (range 0–21 days). Average days from surgical repair to ICAM splint program entry were 3.6 days (range 0–23 days).

Results specific to Miller's guidelines regarding active extension losses involving the MP and/or PIP joints on discharge of our 140 patients are summarized in Table 2. Categorization of excellent or no extension lag was achieved in 114 patients. Categorization of good or 5-degree to 10-degree extension lag occurred in 21 patients. Categorization of fair or extension lag of 11–44 degrees was observed in five patients. There were no results classified as poor or greater than 45 degrees extension lag.

Active extension lags involved the MP joint except for in two patients rated as good, who had lags at the PIP joint. All patients with MP extension lag were rated as complex injuries. MP extension lag was 5 degrees in 15 patients and 10 degrees in four patients, 15 degrees in four patients, and 25 degrees in one patient.

Results specific to Miller's guidelines regarding terminal flexion on discharge of our 140 patients are summarized in Table 2. Categorization of excellent or no loss of terminal flexion occurred in 111 patients. Categorization of good or less than 20-degree loss of terminal flexion was noted in 20 patients. Categorization of fair or 21–45-degree loss of terminal flexion was recorded in nine patients. There were no patient results categorized as poor or greater than 45-degree loss of terminal flexion.

At discharge, 11 patients lacked 5–10 degrees of composite flexion, five patients lacked 15 degrees of composite flexion and three patients lacked 20 degrees of composite flexion, and nine patients had 25–35-degree loss of composite flexion.

Grip strength at the time of discharge averaged 85% of the opposite uninjured hand. For the majority (86%) of the cases, the injured hand was the dominant hand. Patients were discharged on average at 49 days (range 21–138 days) after tenorrhaphy. Return to work time averaged 18 days after repair. The average number of therapy visits were 8.1 (range 2–27). There were no complications such as ruptured tendons, infections, or pain syndromes, and to our knowledge no secondary surgeries such as tenolysis or capsulotomies have been required.

TABLE 2. **Results of the ICAM Splint Program in 140 Patients Rated by Miller's Criteria**

ICAM Splint Program (N = 140)	*Excellent*	*Good*	*Fair*	*Poor*
Active extension lag	114	21	5	0
Terminal flexion loss	111	20	9	0

DISCUSSION

There are two decades worth of literature replete with mathematical formulas, cadaver studies, and extensor tendon rehabilitation splint programs that try to give us insight into the actual millimeters of excursion safe and functionally necessary for extensor tendons not to adhere or rupture.[4,7,12,18] Evans and Burkhalter's[4] formula and intraoperative observations are the basis of their program which positions the wrist in 40–45 degrees of wrist extension and limits MP joint motion to 30 degrees. When splinted in this position these authors have suggested that 5 mm of tendon glide occurs in zones 5–7.[4] We do not deny that their splint position is safe; however, we have made evident that extensor tendons can tolerate more movement without risk to the repair. Our preliminary report in 1986 with the second edition of the ICAM splint clearly showed that zone 5–6 tendon repairs tolerated more excursion with all joints freely moving except the wrist, which was positioned in 25–30-degree extension and the involved finger MP joint limited by 25–30 degrees. Not long afterward, our cadaver and intraoperative studies provided evidence that even less wrist extension (20–25 degrees) and less relative MP extension (15–20 degrees) was safe. Unquestionably the safety and tolerance of zones 4–7 extensor tenorrhaphies to more motion and more tendon excursion has been confirmed in our present report. The cadaver work of Minamikawa et al.[18] lends further support to our experience. These investigators found that for any tendon excursion to take in zones 3–8 during simulated passive extension and active grip the position of the wrist had to be at neutral. When the wrist was positioned in 30-degree extension, little tension was seen on the long finger EDC tendon in zone 6, minimal tension in zone 5, and redundant tendon buckling occurred in zones 7–8. Furthermore, to obtain tendon excursion in zones 7–8, the position of the wrist had to be at less than 21 degrees of extension and full unrestricted finger motion was essential.[18] Nonetheless, our results do not provide answers to exactly how many millimeters of tendon excursion occurs within the ICAM splint for various zones or exactly how many millimeters of tendon excursion is truly necessary to produce optimal results.

The position of the wrist is not the only difference in our program from others. The ICAM yoke is

fashioned to allow full immediate composite digital flexion-extension minus the 15–20 degrees of MP joint motion of the involved digit(s). Minimikawa and colleagues[18] observed in cadavers that blocking flexion (i.e., fisting) was not necessary if the wrist was positioned in 30 degrees of extension. We strongly believe that use of the yoke has allowed us to reduce the extended position of the wrist to enhance tendon excursion and still safely move zone 4–7 repairs. Minimikawa et al.[18] also noted that when the wrist was positioned in 30-degree extension tendons in zones 3–8 became redundant proximal to the MP joint. The ICAM yoke positions the involved MP joint in 15–20-degree extension/hyperextension, which may renew the redundancy and unload the repair (Figure 4). Another possible role of the ICAM yoke may be that it harnesses the extension force of the juncturae tendinum and the adjacent fingers. Because the yoke links the noninjured digits to the injured digit these noninjured digits may act as a ''dynamic-assist'' during finger extension, again to unload the tendon repair (Figure 4).

We have gleaned from our 20-plus years of ICAM experience that more motion has not increased the frequency of extension lag or made tendon repairs more vulnerable to rupture. One hundred-fourteen or 81% of our patients had no extension lag; there were no ruptures, and overall 96% of our patients had good to excellent results. Our worst result was in a single patient who had a 25-degree extension lag; this injury was described as complex and created by a chain saw. At the time measurements were taken the repair was approximately seven weeks old, and splinting had just been discontinued. Khandwala et al.[16] and Stuart[19] have documented spontaneous long-term improvement in the final outcome following extensor tendon repair, so we suspect that many of our early patient results improved over time.

When our results are compared with the results from other studies that restrict more motion and/or used dynamic extension splinting, our overall ratings are equal or better.[4–16] In 1990, Newport et al.[10] used Miller's classification to grade their zone 5–8 repairs. Their patients were managed by static splinting and achieved 63%/83% excellent/good results. Today, the majority of studies that use dynamic extension assist or static splints with controlled motion report at least 90% excellent/good results. Newport et al.[10] suggested that many patients have more difficulty regaining functional fisting than struggle with residual extension lags. We did not find this to be true, as the majority of our patients achieved excellent composite terminal flexion results at seven weeks after repair. We strongly believe that using the ICAM yoke to start composite fisting and digital extension immediately preserved these functions.

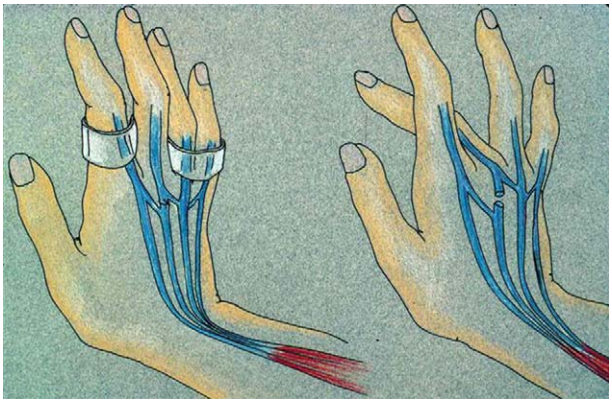

FIGURE 4. *ICAM yoke links the injured digit to the noninjured digits. The yoke may function to unload the repair and harness extension forces during active motion.*

The average time post repair to discharge was seven weeks after tenorrhaphy. We believe this timeframe to be extremely reasonable given today's healthcare requirements. Walsh et al.[11] reported an average discharge time of nine or ten weeks post repair in their preliminary study. Evans[12] reported the time of discharge for her patients to be between four and 12 weeks. Khandwala et al.,[16] who used an active motion program, reported that on average their patients were discharged after eight weeks of therapy if no further improvement was noted and the patient was satisfied.

Seventy-three percent of the patients who entered the ICAM program completed it. The 140 patients who completed the program participated for at least 21 days from the time of tendon repair. Reasons for attrition that were noted on medical record review included various insurance issues and self-discharge when doing well, as the patient believed there was no need to continue in a supervised program. Patients who did not complete the program discharged themselves either after the first or second visit which was within the first ten days of treatment or during phase 3 of the program after the wrist splint had been discontinued. Khandwala and colleagues[16] also reported about a 30% noncompliance rate. These authors emphasized that a fair number of individuals who sustain this type of injury are young, male, and noncompliant, and further pointed out that studies of this nature are done to critique the effect of the technique on those who used it not those who did not.[16]

To our knowledge, there have been no complications such as ruptured tendons, infections or pain syndromes as a result of using the ICAM program. Allieu et al.[5] reported three ruptures before splinting; Khandwala et al.[16] had one rupture with the dorsal extension splinting and two ruptures with their active motion palmar block splint technique. As far as we are aware, no secondary surgeries such as tenolysis have been required by our patients. We have encountered minor clinical challenges that

appeared to be due to referral of patients later than ten days after repair. Some hands referred late were already exhibiting stiffness, overwhelming edema, and adhesions limiting range of motion. We advocate initiating the ICAM program within ten days of repair, and our best results were achieved when started immediately or within three days of the tenorrhaphy. Infrequently, just as with any other acute injuries, there were patients who began to use their hand too vigorously, triggering a generalized inflammatory reaction or local suture irritation.

CONCLUSION

Our results suggest that both simple and complex zone 4–7 EDC, EIP and EDM tenorrhaphies should be moved immediately using the ICAM splint management program. We are pleased with the simplicity of the three phases of the program supported by the use of a low-profile two-part splint. Our results graded by Miller's criteria were 96% excellent and 93% good. Fisting and active digital extension is preserved through immediate controlled active motion. Extension lags at the MP and IP joints were rare; none of these required further surgery. Grip strength was 85% of the uninjured hand. The average time of return to work in the ICAM splint was 18 days. Discharge from the program averaged seven weeks after tenorrhaphy and required an average of eight therapy visits.

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APPENDIX

Fabrication of the ICAM Splint

The splint consists of two components, a wrist splint and a finger yoke. Both parts are custom-made from thermoplastic splint material (Figure 1). Before fabricating the ICAM splint components, remove any bulky dressings that may impede motion of any finger at the MP, PIP, and DIP joints. Replace the bulky bandages with light wound dressing and a light self-adhesive compression wrap. If the wound is on the finger or the fingers are edematous, apply the dressings before fitting the yoke. During the fabrication process it is critical to keep in mind that harmful tension is taken off the tenorrhaphy by positioning

the wrist and fingers in passive composite extension. At no time should the wrist/fingers be allowed to fall into flexion.

To fabricate the ICAM splint, obtain the proper dimensions by using the patient's opposite wrist and hand. This is easier and doesn't put the tenorrhaphy at risk. The wrist splint extends two-thirds the length of the patient's anterior forearms and ends in the palm proximal enough to allow full MP joint flexion. The pattern for the wrist splint is shown in Figure 5. The finger yoke is cut from a separate piece of the thermoplastic material. The width of the yoke is approximately the distance between the proximal and middle digital flexion creases of the involved finger. The length of the yoke is approximately one and one-half times the girth of the hand across the MP joint level. (Figure 5)

To mold the wrist splint, position the wrist in 20–25 degrees of extension. During this process be sure to have the patient or an assistant maintain the wrist in extension. A pencil woven between the fingers can be used to position the involved finger(s) MP joint(s) in 15–20 degrees greater extension relative to the other digits. It is critical not to lose the protected position of the involved finger(s). Next fabricate the finger yoke. Place the patient's elbow on the table, hand up with the pencil still maintaining the finger position just as they would be in the yoke. When molding the yoke hyperextension of the involved MP joint(s) is 15–20 degrees more extension relative to the uninjured digit's MP joints. For a long finger EDC repair, place the thermoplastic strip at its midpoint on the volar aspect of the long finger proximal phalanx. Have the patient remove the pencil and use his opposite hand to maintain the position of the long finger MP joint. Drape one end-length of the strip over the dorsal surface of the ring and little fingers and the other end-length over the dorsal surface of the index finger proximal phalanx. Passively position the injured long finger MP joint in 15–20 degrees more (hyper) extension than the other finger MP joints. Mold the strip up around both the ulnar and radial sides of the long finger to form a trough. Mold and contour the ends of the strip that lie over the dorsal aspect of the uninjured fingers. These finger MP joints should be in 15–20 degrees *less* extension than the injured MP joint. Continue to wrap and contour the strip around the volar aspect of the index on one side and the ring and little fingers on the other side. The ends of the yoke strip should now be on the volar aspect. This will leave a gap between the ends of the yoke to allow for adjustment. After allowing the yoke to cool, carefully remove the finger yoke, and have the patient passively support the injured digit(s) in composite extension or replace the pencil. After smoothing the edges and securing the Velcro™ adhesive hook reapply the finger yoke. Secure and snug the Velcro™ loop strap. To check the fit of both parts of the splint together, ask the patient to flex and extend the MP joints with the IP joints extended. Refer to Table 3 for directions to configure the finger yoke when other finger(s) are injured.

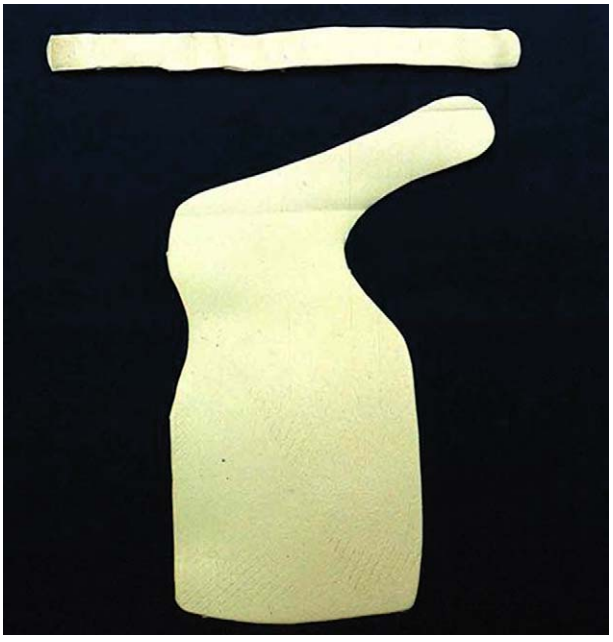
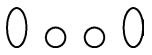
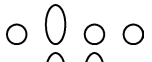
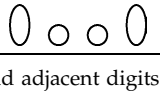


FIGURE 5. *Pattern cutouts of thermoplastic for ICAM wrist splint and yoke.*

TABLE 3. **Configuration of the ICAM Finger Yoke When a Single Finger is Involved.**

Index	*Long*	*Ring*	*Small*	*Yoke Configuration*
XX	O	O	X	
O	XX	O	O	
O	X	XX	O	
X	O	O	XX	

The dorsal position of the tendon repair (XX) and adjacent digits within the finger yoke. In some cases, the (X) dorsal position of an uninjured finger maintains balance of the yoke. The dorsal position is defined as 15–20 degrees more MP joint (hyper-) extension than the (O) uninjured finger(s) MP joint(s).
XX = finger with the tendon repair is held in a position dorsal or in more MP joint extension by the yoke; O = finger(s) is held in a position volar or in less MP joint extension by the finger yoke; X = additional finger held in a position dorsal position or more MP joint extension to balance the yoke.

Editorial Comments: *Wyndell H. Merritt, MD, FACS*

After our first cadaver study in 1978, and the development of the first cumbersome metal splint (made by Maureen Hardy, PT, MS, CHT and Sandy

Robinson, OTR/L, CHT), we quickly became convinced that a ''relative motion splint'' permitting ICAM was a superior method of managing repaired long extensor tendon lacerations. We noted, along with others, that immobilization techniques characteristically cause a loss of flexion rather than extension,[10] and that dynamic passive techniques preserve flexion but interfere with functional use, and require close supervision. Thus, this active motion method is better.

I enjoyed the opportunity to work closely with Juli Howell and the other therapists next door to my office, and I greatly appreciate their collective work in proving the value of this relative motion splint technique. We both followed and reviewed these cases treated with the relative motion technique over greater than ten years, but with somewhat of a different perspective regarding evaluation of results.

Because of the reported loss of flexion as the most common complication, and the reality that ''normal'' people have great variation in their measured total active motion, I used the same data as Howell and others, but preferred to evaluate the functional results of the repaired digit to its ''normal'' counterpart on the other hand. This is a method suggested by Newport et al.[10] The results evaluated in comparison to the contralateral uninjured hand demonstrated that our patients treated with relative motion averaged approximately 98% of their normal flexion and 96% of their total active motion (including hyperextension) by six weeks after repair.

These results are better than other reported immobilization techniques and are equivalent or better than dynamic splinting management. However, these values were better only in patients repaired and/or splinted within 48 hours. Patients treated with a delay in repair and/or splinting were not much better than those reported with immobilization techniques, with the most common deficit in function being a loss of hyperextension. Therefore, the timing of repair and splinting appear to be critical variables. While Juli's technique for comparison is different than my own, her defined results also demonstrate the efficacy of this treatment method.

I have always preferred the term ''relative motion splint,'' although it does indeed permit ''immediate (controlled) active motion'' because I am convinced the mechanism that permits use of this technique is relaxation of tension on the repaired tendon due to an essentially single motor system in the limited excursion of extensor tendons. This provides success through the ''relative motion'' of the neighboring tendons supporting the repaired tendon through a single motor unit. A few years ago, Miguel Saldana compared this management method in a randomized fashion with dynamic splinting. He used standard range of motion measurements for the two groups and found that both techniques produced ''excellent'' results.[20] However, Dr. Saldana found the relative motion/ICAM technique to be far more user-friendly. Therein lies the great value of this method. Use of a splint that permits immediate active motion and function, allows the patient to continue normal activities, requires less therapy supervision, and the patient is less apt to remove this than a cumbersome splint that interferes with function. It has proven to be particularly valuable in patients at high risk for tendon adhesion, such as rheumatoid extensor tendon rupture and complex injury that is likely to produce unfavorable scar. We have also used this concept for sagittal band rupture.[21]

I am particularly grateful to Juli Howell, Sandy Robinson, and their fellow therapists for improving this splinting technique over the years, and finally documenting its efficacy and bringing it to our attention. Try it—you'll like it!