

Relative Motion Splinting

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The history

- Seemingly evolved from the treatment of extensor tendon repairs
 - Started with completely static splinting protocols



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 - Started with completely static splinting protocols
 - Then in the 1980s, progression to various dynamic protocols

Early dynamic splinting for extensor tendon injuries

Earl Z. Browne, Jr., MD, and Christine A. Ribik, OTR/L, Cleveland, Ohio

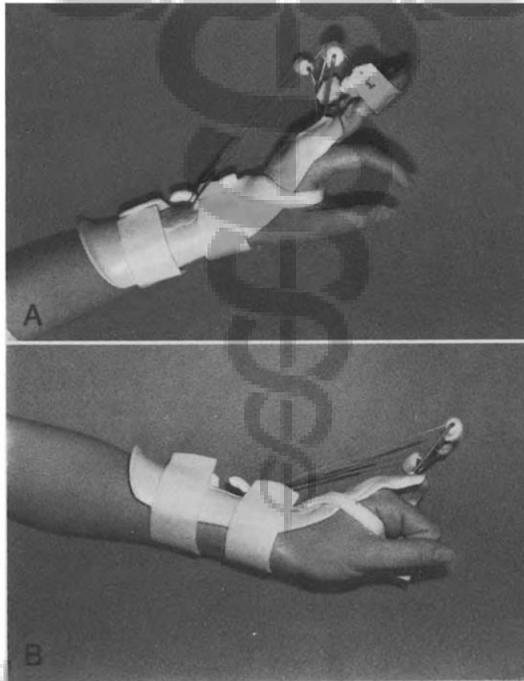


Table II. Treatment protocol

Five weeks of dynamic splinting beginning 3-5 days after repair. Flex 10 times an hour to minimum:
MP 70 PIP 90 DIP 50
Progressive resistance exercise for an additional 5 weeks

Table III. Results

No tendon ruptures
Motion within normal range
All back to work by 10 weeks

Table IV. Results

Complete digit extension	77 of 82
Full fist flexion	52 of 52
Dominant hand grip equal	36 of 36
Secondary tendolysis	0 of 82
Return to work	9.5 wk

The history

- Seemingly evolved from the treatment of extensor tendon repairs
 - Started with completely static splinting protocols
 - Then in the 1980s, progression to various dynamic protocols
 - Then in the 1990s, progression to early active motion protocols

EARLY ACTIVE MOBILIZATION FOR EXTENSOR TENDON INJURIES

The Norwich regime

P. SYLAIDIS, M. YOUATT and A. LOGAN

From the Departments of Physiotherapy and Plastic Surgery, West Norwich Hospital, Norwich, UK

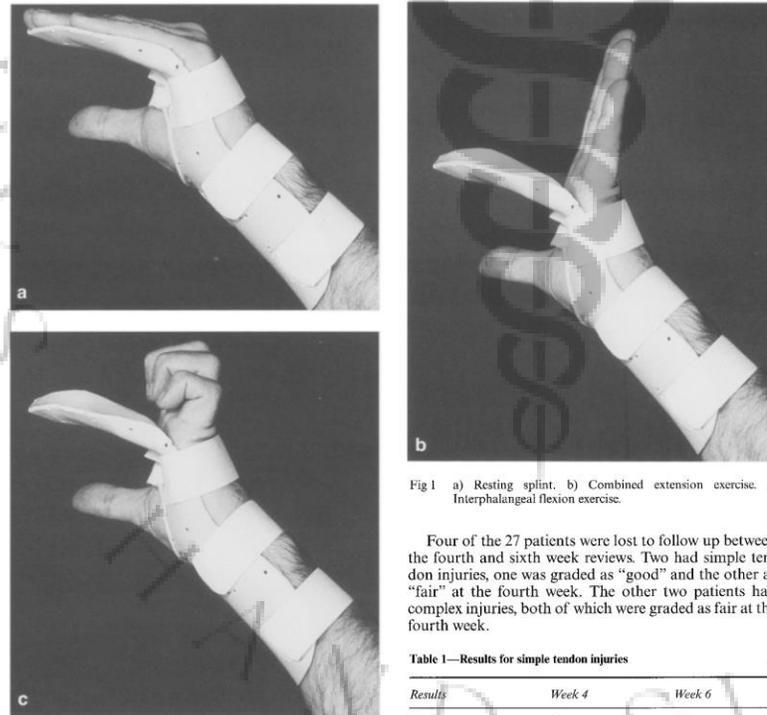


Fig 1 a) Resting splint. b) Combined extension exercise. c) Interphalangeal flexion exercise.

Four of the 27 patients were lost to follow up between the fourth and sixth week reviews. Two had simple tendon injuries, one was graded as "good" and the other as "fair" at the fourth week. The other two patients had complex injuries, both of which were graded as fair at the fourth week.

Table 1—Results for simple tendon injuries

Results	Week 4	Week 6
Excellent	11	14
Good	7	8
Fair	8	2
Poor	0	0

Assessment of progress at 4 and 6 weeks was made using the Dargan criteria (Dargan, 1969):

- Excellent: no extensor lag and with flexion of pulps to mid-palm.
- Good: extensor lag $<15^\circ$ with flexion of pulps to mid-palm.
- Fair: extensor lag $16-45^\circ$ or pulp to palm distance <2 cm.
- Poor: extensor lag $>45^\circ$ or pulp to palm distance >2 cm.

Time of return to work was also recorded.

Table 1—Results for simple tendon injuries

Results	Week 4	Week 6
Excellent	11	14
Good	7	8
Fair	8	2
Poor	0	0

The figures refer to 26 tendon injuries in 17 patients. Note that two patients failed to return for review after week 4.

Table 2—Results for complex tendon injuries

Results	Week 4	Week 6
Excellent	6	9
Good	1	2
Fair	8	2
Poor	0	0

The figures refer to 15 tendon injuries in 10 patients. Note that two patients failed to return for review after week 4.

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

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*St Joseph's Hospital Hand Management Center
Elmira, New York*

- 2005, Journal of Hand Therapy
 - the seminal idea for relative motion splinting conceived in the 1980s

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

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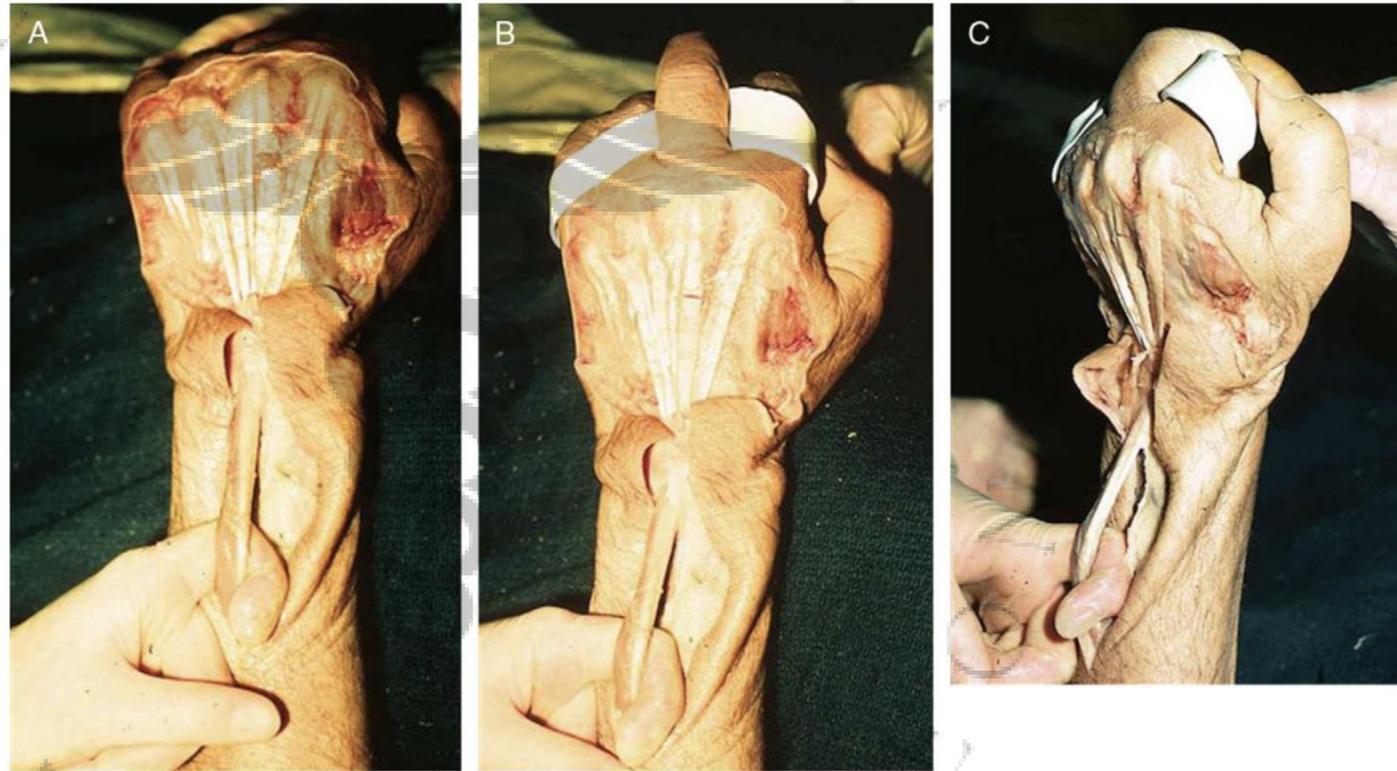


FIGURE 2. ICAM cadaver trials zone 5 EDC laceration of the long finger that is not sutured. (A) Undesired tendon gap with wrist positioned at neutral and fingers fist during simulated contraction of the long digital extensors. (B) Less tendon gap when ICAM yoke introduced with wrist positioned at neutral and fingers fist 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 fist during simulated contraction of the long digital extensors.

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

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

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

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

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

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

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Analysis of Relative Motion Splint in the Treatment of Zone VI Extensor Tendon Injuries

Joy V. Sharma, MD, Ni-Jui Liang, BS, John R. Owen, BS,
Jennifer S. Wayne, PhD, Jonathan E. Isaacs, MD

From the Departments of Orthopaedic Surgery and Biomedical Engineering, Orthopaedic Research Laboratory, Virginia Commonwealth University, Richmond, VA.

- 2006, Journal of Hand Surgery
 - 10 cadaveric extremities tested intact with/without splinting, transected with/without splinting, and repairs with/without splinting
 - Results: reduction of gapping with the yoke/wrist splint in place

Relative motion orthoses in the management of various hand conditions: A scoping review



Melissa J. Hirth B (OT), MSc (Hand & Upper Limb Rehab)^{a,b,c,*}, Julianne W. Howell PT, MS, CHT^d, Lisa O'Brien PhD, B App Sci (OT), M Clin Sci (Hand & Upper Limb Rehab), Grad Dip Ergonomics, Grad Cert Clinical Research Methods^b

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Relative motion splinting

- 2016, Journal of Hand Therapy
 - A review of the relative motion splint
 - The Merritt splint, Wyndell Merritt Splint, Immediate controlled active motion splint, yoke, border digit splint
 - Today this is simplified to:
 - Relative motion flexion splinting
 - Relative motion extension splinting

Table 2
Clinical indications reported for RM orthoses across the literature

Orthosis category	RME orthoses	RMF orthoses
Protective orthosis	<ul style="list-style-type: none"> ■ ET repair in zones IV-VII^{1-2,3,5,6,8,9-11,12,14,16,17,18-19,20,21,29-31,32-36} ■ Extensor apparatus repair¹⁹ ■ SB disruption <ul style="list-style-type: none"> ○ Acute (<3 wk) and subacute (<6 wk), nonsurgical^{8,13,14,22,33,34} ○ Chronic (>6 wk), nonsurgical²² ○ Acute, postsurgical^{19,32} ○ Chronic, postsurgical^{8,12,14,33,34} ■ Caput ulnae syndrome with tendon ruptures⁸ ■ ET repair and graft^{14,19} ■ ET transfer for rheumatoid ruptures in concert with synovectomies¹ ■ Fight bite with intact tendon and extensor lag¹⁹ ■ Individual MCPJ arthroplasty³⁴ ■ Infection MCPJ with extensor lag¹⁹ ■ Intrinsic tendon transfer to replace IPJ extension^{1,8} ■ Joint replacement with tendon repair or grafting¹ ■ Limit motion of split-skin graft on dorsum of hand^a (Fig. 3) ■ MCPJ and ET soft tissue injury strain¹⁹ ■ Nonrepaired (>50%) ET lacerations/disruption^b ■ Lateral band snapping at PIPJ^c ■ MCPJ collateral ligament injury^d ■ Pain after trigger finger release^e ■ After arthroplasty PIPJ^c ■ Saddle syndrome (interosseous tear)^c ■ Swan neck deformity correction^c ■ Trigger finger^{c, f} ■ Unexplained pain about MCPJ or dorsum of hand^d 	<ul style="list-style-type: none"> ■ Central slip laceration^{29,32,33} ■ Boutonniere <ul style="list-style-type: none"> ○ Acute, nonsurgical^{1,8,14,32-35,37} (Figs. 4A and 4B) ○ Open acute, postsurgical^{1,8} ○ Chronic, nonsurgical^{1,8,14,32,33,37} ○ Chronic, postsurgical^{1,8} ■ Digital nerve repair^{1,14,33,34,37} ■ Flexor tendon repair^{1,8,14} ■ Interosseous tears^{14,33,34,37} ■ Lateral band sprain/tear^c ■ MCPJ volar plate^c ■ After arthroplasty PIPJ^c ■ Unexplained pain in palm of hand^d
Exercise orthosis	<ul style="list-style-type: none"> ■ Address flexor lag^{33,37} ■ Address MCPJ extension lag^{15,32,36} ■ After MC fracture^{15,32} ■ After ET laceration³⁸ ■ Not detailed³⁶ ■ Regain IPJ flexion³⁶ ■ Regain PIPJ flexion^{14,15,32} ■ Adhered flexor tendon^c ■ Persistent PIPJ extensor lag after release of chronic tenosynovitis, collagenase, and surgical release of Dupuytren contractures^g ■ PIPJ stiffness after chronic trigger finger release^g ■ After PIPJ arthroplasty to address PIPJ stiffness^c 	<ul style="list-style-type: none"> ■ Regain active PIPJ extension^{8,36,39,40} ■ Address long ET lag^{33,37} ■ Address PIPJ extension lag¹⁴ ■ After crush/MC fracture³² ■ After ORIF MC fracture³⁶ ■ After proximal phalanx fracture and tendon repair to improve central slip activity¹⁹ ■ After gunshot wound to the MC¹⁵ ■ Regain active IPJ extension³⁶ ■ Regain active MCPJ flexion^{15,32,36} ■ After arthroplasty PIPJ^c ■ Stiff PIPJ^c
Adaptive orthosis	<ul style="list-style-type: none"> ■ After C5-C6 discectomy^{15,32} ■ Improve MCPJ alignment ■ MC head fracture,^{15,32} RA after arthroplasty,¹⁵ RA imbalances (Figs. 5A-5D),³² Parkinson disease with ulnar deviation, and ET subluxation¹⁵ ■ Preoperative functional orthosis RA ET ruptures¹⁹ ■ Reduce PIPJ subluxation in early swan neck deformity³⁶ ■ Lateral band snapping at PIPJ^c ■ Pain after trigger finger release^h ■ Pain in hand of unknown origin^h ■ Swan neck deformity correction^c ■ Trigger finger, limit tendon excursion^f 	<ul style="list-style-type: none"> ■ Address MCPJ alignment and RA imbalances³² ■ Ulnar nerve palsy MCPJ hyperextension¹⁵ ■ Pain in hand of unknown origin^h

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Table 3
Summary of scoping review findings

Indication for orthosis	Available evidence	Degree of relative extensor or flexion	Orthosis design
<p>1. Protective orthosis</p> <p>a. ET repair zones IV-VII</p> <p>b. SB disruption</p> <ul style="list-style-type: none"> ○ Acute and subacute, nonsurgical ○ Chronic, nonsurgical ○ Acute, postsurgical ○ Chronic, postsurgical <p>c. Other, including:</p> <ul style="list-style-type: none"> - Boutonniere <ul style="list-style-type: none"> ○ Acute, nonsurgical ○ Chronic, nonsurgical ○ Chronic, postsurgical ○ Open acute, postsurgical - Caput ulnae syndrome with tendon ruptures - Central slip repair - Digital nerve repair - Extensor lag - Flexor tendon repair - Interosseous tears - MCPJ or PIPJ arthroplasty - MCPJ volar plate/collateral ligament injury - Partial ET laceration - Skin graft - Tendon transfer/tendon grafting 	<p>11 studies; 371 patients suggest ample evidence to use RME after zone IV-VII ET repair</p> <p>Most evidence recommends use of combined RME and wrist orthoses for ET repairs in zones IV-VII, although growing indications that the wrist orthosis may be unnecessary in zones IV-VI. Benefits of overnight resting orthosis not proven</p> <p>2 studies successfully managed nonsurgical nonrheumatoid SB injuries with RME without a wrist orthosis</p> <p>Single-case study combined ET zone IV EDC and central slip in 2 fingers demonstrated versatility of RM use and did not use a wrist orthosis</p> <p>Emerging evidence for RM use in boutonniere, interosseous tears, and digital nerve repairs with video case studies documented</p> <p>No patient data on RM use after flexor tendon repairs</p>	<p><i>Long ET repairs:</i> 15°-20° relative MCPJ extension of injured digit to noninjured has been recommended vs 20°-25°, which is substantiated</p> <p>Unknown relationship between the degrees of relative MCPJ extension needed to protect the repair to wrist position or zone of injury or the amount of tendon shortening with repair. These factors may be best answered on a case-by-case basis during a WALANT procedure</p> <p><i>SB injury:</i> 25°-35° RME has been documented</p> <p>Expert opinion suggests 15°-20° RME</p> <p>Expert opinion proposes visual checking tendon recentralizes and note the patient's pain response to determine adequate position</p> <p><i>Other:</i> No studies</p>	<p>All studies molded a thermoplastic strip to fabricate RM orthoses</p> <p>Caution: use firm thermoplastic not soft material to fabricate the RM orthosis because the former has supportive data</p> <p>Therapist and patient preference seem to dictate choice of the original 4- or 3-finger design, thermoplastic type and thickness, Velcro or self-secured closure, options for border digits balance or injured finger only in relative extension</p> <p>A self-secured-solid thermoplastic orthosis may be more user-friendly for drying after shower than a perforated Velcro-secured design</p> <p>A Velcro-secured design can be fit adjusted as edema changes</p>
<p>2. Exercise orthosis</p>	<p>6 cases incorporated RM into orthosis design and exercises at 3 wk to decrease > 30° PIPJ extensor lag after metacarpal or proximal phalanx fracture, closed, and open reduction</p>	<p>The degree of RME/RMF is not critical because the orthosis is used to manage stiffness or lag developed in healing fractures</p>	<p>A soft or thermoplastic material may be used to design the orthosis; however, the efficacy of the soft material to provide adequate blocking force is unknown</p>
<p>3. Adaptive orthosis</p>	<p>Finger alignment and balance can be improved by application of a RM orthosis as documented in before and after photographs for various hand conditions such as RA</p>	<p>An individualized patient-centered approach is advised. For each patient, several functional orthoses may be needed to discover the best relative position for a variety of tasks. The most important design tool is critical thinking and listening to the patient</p>	<p>Therapist and patient preferences determine if a soft or rigid orthosis effectively supports function</p>

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Relative Motion Splint: Active Motion After Extensor Tendon Injury and Repair

Wyndell H. Merritt, MD

J Hand Surg Am. 2014;39(6):1187–1194.

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FIGURE 4: Unrestricted work and recreational activities are encouraged in the splint.

The future of
relative motion
splinting

Relative Motion Flexion Splinting for Flexor Tendon Lacerations: Proof of Concept

HAND

2019, Vol. 14(2) 193–196

Bryan Chung¹, David T. W. Chiu¹, and Vishal Thanik¹

- 2019, Journal of Hand
 - 4 fresh frozen cadavers, 25 cycles of maximum flexion/extension
 - Repaired with simple 6-0 interrupted suture
 - In all 4 hands, elongation was restricted to less than 1.3 mm in repaired tendon in the RMFS compared with elongation >2 mm in the nonsplinted condition
 - All repairs had suture breakage and repair rupture without the RMFS

SAMUEL E. GALLE, MD
HAND SURGEON

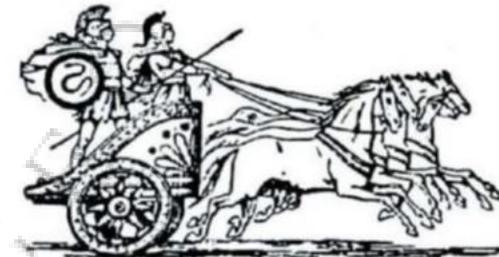
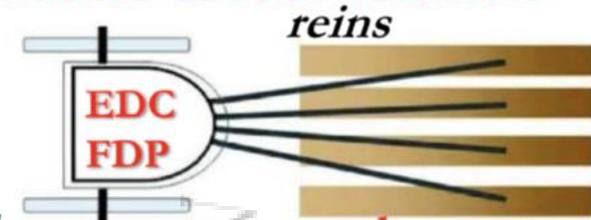
- The current state of care...

Relative Motion Concept is Simple and Takes Advantage of the "Quadriga Effect"

- Protection after long extensor repair
 - **Quadriga** (*flexor profundi & common extensors*)
"Quadriga" muscles = one muscle & four tendons



15-20 degrees ext. tendons



PHWE & RMS



FIGURE 8. A, A tongue blade, pencil, or even finger pressure may allow full IP extension in an early Boutonniere rupture with deformity. Immediate placement of relative motion flexion (RMF) orthosis for 6 weeks results in full range of motion (B). full color online

PHWE & RMS

48yr woman with 6 mo. fixed flexion contracture that is painful and has decreased flexion as well; misdiagnosed as “volar plate injury” or “occult fx”; “unresponsive to hand therapy”



poor initial ROM when first placed in relative flexor motion splint due to chronic inflammation and pain, but recovered “excellent” ROM by 3 months



serially casted to -5 degrees (three weeks)

