Wyndell merritt immediate controlled active motion (ICAM) protocol following extensor tendon repairs in zone IV–VII: review of literature, orthosis design, and case study—a multimedia article

Mary C. Burns · Brian Derby · Michael W. Neumeister

Published online: 9 January 2013
© American Association for Hand Surgery 2013

The online version of this article (doi:10.1007/s11552-012-9488-z) contains a video, which is available to authorized users.

Abstract

Background Controlled post-operative motion of extensor tendon repairs in zones IV–VII is intended to facilitate tendon excursion and minimize adhesion formation. The Wyndell Merritt “relative motion” digital yoke orthosis provides a low-profile option allowing for immediate controlled active motion (ICAM) of the extensor tendon repair. The addition of a multimedia manuscript demonstrating the manufacturing of the Wyndell Merritt digital yoke orthosis may complement current literature on this topic.

Methods Two case studies demonstrating the use of the Wyndell Merritt ICAM digital yoke orthosis without wrist immobilization following zone V extensor tendon repair are presented. A literature review was completed. A video was produced highlighting fabrication of the digital yoke orthosis as well as video documentation of case study 1.

Results Case study 1 demonstrated mild limitations in metacarpophalangeal (MP) flexion at 5-week follow-up that resolved by 6 weeks. MP hyperextension was attainable for all digits at 5 weeks. Grip strength was comparable to the

contralateral uninjured hand at 10 weeks. The second patient achieved normal composite flexion/extension by 4 weeks. Attainment of normal hyperextension at the MP joints and grip strength for case study 2 was unknown, as the patient was lost to follow-up.

Conclusion The Wyndell Merritt ICAM digital yoke orthosis, fabricated with or without wrist immobilization, appears to facilitate the return of normal extensor tendon function after repair in zones IV through VII while minimizing morbidity to adjacent digits. This protocol provides a safe, low-profile, cost-effective alternative for post-operative treatment of zone IV–VII extensor tendon repairs.

Keywords Wyndell Merritt · Extensor tendons · Orthosis · ICAM

Introduction

In the mid-1980s, post-operative care of the repaired extensor tendon in zones IV through VII began to make a shift from complete immobilization to controlled passive extension protocols in the form of dynamic extension orthotic protocols. These controlled passive protocols allow for protection of the repaired tendon while allowing tendon glide, to prevent adhesions and to increase post-operative flexion and extension. Multiple authors have reported good to excellent results utilizing the various post-operative dynamic protocols as compared to static protocols [2, 3, 5]. Static protocols protect the tenorrhaphy; however, these techniques typically cause significant tenodesis with loss of composite flexion. Due to this loss of flexion, dynamic protocols were introduced for increased tendon glide at the repair site. While dynamic protocols have proven to preserve flexion, the bulkiness of the orthosis tends to interfere with functional use

Electronic supplementary material The online version of this article (doi:10.1007/s11552-012-9488-z) contains supplementary material, which is available to authorized users.

Due to a shift in nomenclature and the Centers for Medicare and Medicaid Services guidelines, the term “splint” has been replaced with the term “orthosis” whenever possible.

M. C. Burns · B. Derby · M. W. Neumeister (✉)
Institute for Plastic Surgery, Southern Illinois University School of Medicine, 747 North Rutledge 3rd Floor, P.O. Box 19653, Springfield, IL 62794-9653, USA
e-mail: mneumeister@siu.edu

[4]. These dynamic orthoses tend to be time consuming, costly to fabricate, and difficult to wear continuously. The “Wyndell Merritt” immediate controlled active motion (ICAM) protocol provides a safe, effective, low-profile, and cost-effective alternative in the post-operative treatment of zone IV through zone VII extensor tendon repairs.

Background

In 1978, Wyndell Merritt M.D. did his first cadaver study demonstrating relieved tension on a repaired extensor tendon if the digit with the repaired tendon was positioned in 25–30° more extension relative to the uninjured metacarpophalangeal (MP) joints, due to an essentially single motor system in the limited excursion of extensor tendons [4]. From this cadaver study, Dr. Merritt derived a “relative motion” yoke orthosis, with this position, which allowed for ICAM. This digital yoke orthosis was combined with a wrist orthosis in 25° to 30° extension [4]. Current protocol positions the injured MP joint in 10° to 15° more extension than the uninjured digits. This combination wrist orthosis with digital yoke orthosis allows for full composite active motion of the uninjured digits while allowing 10–15° less MP flexion to the digit with the repaired tendon, thus relieving tension on the extensor tendon repair without the use of dynamics (Fig. 1). Dr. Merritt and his therapists began utilizing this “controlled active” program in the early 1980s, and at about the same time, various “controlled passive” dynamic protocols were being introduced. Howell and Merritt et al. [4] have since reported results equivalent

to or better than dynamic orthotic management utilizing this “controlled active” protocol if initiated within the first 3 days after repair.

Literature Review

Several authors over the years have reviewed this protocol. Saldana [7] presented “Early Relative Motion Rehabilitation of Proximal Extensor Lacerations Using the Wyndell Merritt Splint” at the 1997 American Association for Hand Surgery (AAHS) annual meeting. Saldana claims that the “splint employs the Quadrigia effect through the junctura tendinae to protect the injured finger” [7]. He reports 26 out of 27 excellent results with 1 out of 27 good results. There were no ruptures and no fair or poor results. At the same 1997 AAHS meeting, Merritt and Howell [6] presented a 10-year study, including 180 patients, using this post-operative protocol. They reported 98.5 % normal flexion and 96.2 % of normal total active motion. Recovery was slowest with delayed repair or delayed initiation of the post-operative protocol. Merritt and Howell concluded earlier work use, lower cost, and good or better functional motion than extensor tendon repairs treated with conventional techniques. Sharma et al. [8] utilized an in vitro model to assess the effect of the ICAM orthosis with the wrist immobilized in 25° of extension on zone VI extensor tendon repairs. The authors measured tendon elongation both with and without the “Wyndell Merritt” orthosis on the intact tendon as well as after transection and repair of the extensor tendon in zone VI. The study concluded that “the relative motion splint

Fig. 1 a–c Combination wrist orthosis with “Wyndell Merritt” ICAM digital yoke orthosis allowing for full composite active motion of the uninjured digits while allowing 10–15° less MP flexion to the digit with the repaired tendon, thus relieving tension on the extensor tendon repair without the use of dynamics

reduces the effective strain on intact and repaired zone VI middle finger extensor tendons and supports its clinical use” [8].

In 2008, Berry and Neumeister [1] presented “Analysis of Limited Wyndell Merritt Splint for Extensor Tendon Injuries to Hand Immobilization.” The authors compared two groups utilizing the “Wyndell Merritt” ICAM protocol. Group A was placed in the ICAM digital yoke orthosis only, with no wrist immobilization. Group B was treated with the ICAM yoke orthosis and wrist immobilization. They reported no ruptures in either group with similar range of motion (ROM) comparable to previous studies utilizing the traditional Wyndell Merritt protocol with wrist immobilization. The authors conclude that these results support the use of the hand-based “Wyndell Merritt” ICAM protocol without wrist immobilization (Fig. 2).

Conclusion

Dynamic orthotic protocols have proven effective for the treatment of extensor tendon repairs; however, the dynamic orthosis can be costly to fabricate and is cumbersome, which interferes with functional use. The “Wyndell Merritt” ICAM orthosis and post-operative protocol is a safe and effective alternative to traditional dynamic orthotic protocols. All of the studies reviewed for this article have shown good to excellent results with little risk of tendon rupture or extensor lag. The “Wyndell Merritt” ICAM protocol encourages immediate controlled active motion. The low-profile design is less cumbersome and provides for protected functional use,

which, in turn, can increase patient compliance. The digital orthosis is easier and less time consuming to fabricate which, in turn, will lower overall costs. Fewer therapy visits have also been anecdotally alluded to [4], which also will lower overall cost as well as provide a good to excellent outcome in today’s healthcare environment, which typically limits the number of therapy visits a patient can receive.

Merritt and Howell [4] advocate initiating the ICAM program within 10 days of the initial tendon repair, with the best results achieved when the protocol is initiated immediately or within 3 days of the initial surgery. While we try to adhere to these guidelines and start the ICAM protocol within 3–5 days, there are times when a patient does not return in this time frame for various reasons, and it may be necessary to begin the program slightly later. We will be presenting two case studies of zone V extensor tendon repair treated with the “Wyndell Merritt” ICAM protocol. The first case was initiated at 7 days post-initial repair with the second case initiated at 11 days post-initial repair. Case study 1 (J.V.) is also presented in the multimedia portion of this paper.

Case Study 1

J.V. is a 20-year-old right-handed male who sustained an oblique laceration of his right long finger extensor digitorum communis (EDC) in zone V, as well as a 100 % laceration to the extensor hood, when a glass bowl fell on his hand. He was transported to the E.R. where exam and X-rays revealed no fractures, dislocations, or foreign bodies. He was then referred to the Southern Illinois University (SIU) plastic

Fig. 2 a–c “Wyndell Merritt” ICAM digital yoke orthosis without wrist immobilization

surgery service for repair of the noted extensor tendon and extensor hood lacerations. The wound was irrigated, and the extensor tendon was repaired with 4–0 nylon, in a figure-of-8 fashion just proximal to the extensor hood. The extensor hood was then repaired, also using 4–0 nylon. Post-repair and closure, the hand was placed in a surgical dressing and a volar plaster half cast with the wrist and digits extended.

J.V. returned for follow-up with the surgeon at 7 days post-operatively. All incisions were clean and dry with no signs of infection, and the patient was referred to the SIU Hand Therapy Center with an order to begin the “Wyndell Merritt” ICAM extensor tendon protocol. Gentle compression was applied to the wrist and digits to control post-operative edema. The patient was fit with a “Wyndell Merritt” ICAM digital yoke orthosis which maintains the long finger in increased extension as compared to the index, ring, and small fingers, with instructions to wear the orthosis at all times. The wrist was not included with this patient. The patient was instructed in full digital active range of motion (AROM) exercises, with the orthosis on, to be done throughout the day. The patient was also advised to passively extend the interphalangeal (IP) joints several times a day due to the natural flexed posturing at the IP joints with this particular orthosis. Precautions were discussed and emphasized, which included no lifting or heavy use of the hand. Video consent was achieved at this time, and the patient agreed to have his progress documented visually via video documentation. A video was taken of this patient’s range of motion with the “Wyndell Merritt” digital ICAM orthosis in place (please see the video portion of this multimedia paper). J.V. was advised to schedule a return appointment at approximately 4 weeks post-op at which time we would start full composite AROM. He was also advised to call sooner if he had any problems, concerns, or questions.

J.V. did not return until 5 weeks post-surgery. Thick hypertrophic scarring was noted on the dorsum of the hand at the level of the injury. Scar massage was done with cocoa butter, and the patient was instructed in home scar massage techniques. This patient was also provided with silicone gel sheeting and a tip-free edema glove for edema control and scar compression. Full composite AROM exercises were initiated, and the patient was advised to wear the orthosis for protection only. Exercises were done, and composite ROM measurements were documented (Table 1). He had good initial range of motion with only mild limitations in MP flexion. J.V. was able to demonstrate MP hyperextension at all MP joints including the injured long finger. Video documentation was again achieved of this initial range of motion and the scar at this time. The patient was sent home with the above home program with precautions to avoid any heavy lifting or gripping with this hand. J.V. was advised to schedule an appointment in 1 week, at 6 weeks post-surgery, to initiate passive range of motion (PROM) if necessary.

Table 1 J.V. treated with the Wyndell Merritt ICAM protocol initiated at 7 days post-op. Active ROM measurements at 5 weeks post-repair of the extensor tendon in zone V of the right long finger. Note good hyperextension at all MP joints including the injured long finger. Mild limitations in MP flexion present

ROM—right	Index	Long	Ring	Small
MP extension	+10	+15	+10	+15
MP flexion	70	65	75	80
PIP extension	0	10	5	15
PIP extension	110	100	105	90
DIP extension	0	0	0	0
DIP flexion	65	75	75	75

J.V. returned for his follow-up appointment at 5 weeks and 6 days post-surgery. The scar on the dorsum of the hand at the level of injury had softened significantly. AROM was measured and documented (Table 2). AROM measured within normal limit (WNL) including full composite MP flexion and full MP hyperextension at all MP joints. It was determined at this time that the initiation of PROM was unnecessary due to full AROM. Therapy putty was used and issued for gripping, rolling, and pinching to assist with regaining grip and pinch strength. Video documentation was again achieved. This patient was sent home with a home exercise program with precautions and instructions to continue to avoid heavy lifting or heavy gripping with the injured right hand. The plan at this time was to recheck J.V. for ROM and grip strength at his next formal surgical follow-up. No formal therapy appointments were scheduled in this time. Instructions were provided to J.V. to call sooner if he noticed any problems or losses of ROM. J.V. returned for follow-up at 10 weeks post-surgery. He continued to demonstrate ROM within normal limits. Grip strength measurements were taken and documented at this visit (Table 3). An average of three trials on the second handle of a Jamar dynamometer revealed grip strength comparable to his uninjured left hand. This patient was seen for a total of four therapy visits with excellent results including range of motion and grip strength within normal limits.

Table 2 J.V. AROM measurements at 5 weeks 6 days post-repair of the extensor tendon in zone V of the right long finger. Full composite flexion and full MP hyperextension present. Excellent gains in total active motion as compared to measurements at 5 weeks post-surgery

ROM—right	Index	Long	Ring	Small
MP extension	+15	+15	+15	+15
MP flexion	80	90	90	90
PIP extension	0	5	5	0
PIP extension	110	100	105	95
DIP extension	0	0	0	0
DIP flexion	80	80	80	80

Table 3 J.V. grip strength measurements taken with a Jamar dynamometer at 10 weeks post-repair of the extensor tendon. Right grip strength WNL as compared to the uninjured left hand

Grip strength	Right	Left
Jamar—2nd handle		
Trial 1	97 lbs	98 lbs
Trial 2	104 lbs	95 lbs
Trial 3	104 lbs	90 lbs
Average, three trials	102 lbs	94 lbs

Case Study 2

Case study 2 is an 18-year-old male who suffered a laceration to his right long finger EDC in zone V. No operative note details were available as this patient's repair was done by a non-SIU community hand surgeon. An order was received for a "Wyndell Merritt" orthosis and protocol at 11 days post-surgery. This patient was seen the same day. The incision was noted to be clean and dry with the stitches already removed. He was fit with a "Wyndell Merritt" ICAM digital yoke orthosis maintaining the right long finger in increased extension as compared to MP extension of the index, ring, and small fingers. Instructions for continual wear of this orthosis were provided. The patient was instructed in AROM exercises, to be done with the orthosis on, to maintain protection of the extensor tendon repair. Precautions were discussed and emphasized, including no heavy lifting or heavy use with the injured hand. The next therapy visit was scheduled at 4 weeks post-surgery to begin full composite AROM without the use of the orthosis.

This patient returned to therapy at 4 weeks post-surgery with the ICAM orthosis in place, stating that he had worn this protection at all times. Scar massage was done, and the patient was instructed in home scar massage techniques. AROM was measured out of the orthosis and composite

Table 4 Z.S. treated with the Wyndell Merritt ICAM protocol initiated at 11 days post-repair of the extensor tendon in zone V of the right long finger. Active ROM measurements at 4 weeks post-repair. Full composite flexion and composite extension present although no hyperextension measured at this time

ROM—right	Index	Long	Ring	Small
MP extension	0	0	0	0
MP flexion	85	90	90	95
PIP extension	0	0	0	0
PIP extension	110	105	110	95
DIP extension	0	0	0	0
DIP flexion	65	70	65	70

Fig. 3 "Wyndell Merritt" ICAM digital yoke orthosis for long finger EDC repair. This design will be used for repairs of the long or middle finger

AROM measurements were documented (Table 4). AROM was WNL in both composite flexion and full composite extension although hyperextension was not present. Instruction was provided for home AROM exercises with emphasis on isolated EDC exercises as well as lifting fingers off of the table in an attempt to regain MP hyperextension. Due to excellent range of motion, there were no formal return appointments scheduled for hand therapy. He was advised to call if he had any problems or if he noticed any sudden losses in ROM. To this date, this patient has not returned or called with any problems or difficulties. Total therapy for this patient consisted of two visits to the SIU Hand Therapy

Fig. 4 "Wyndell Merritt" ICAM digital yoke orthosis for extensor tendon repair. This design will be used for EDC repair to one of the border digits, the index or small finger

Center with excellent results. Attempts were made at 8 months post-surgery for additional documentation of outcome; however, he has been lost to follow-up.

Multimedia Video Contents

Based on the literature review, the above conclusion, and our own excellent clinical results at SIU School of Medicine, it was decided to put together this multimedia article highlighting the “Wyndell Merritt” ICAM post-operative protocol. An instructional video demonstrating the fabrication of the “Wyndell Merritt” digital yoke ICAM orthosis has been included. This demonstration includes fabrication of the splint for EDC repairs of the long or middle fingers (Fig. 3), as well as an example of the orthosis when the extensor tendon repair is to one of the border digits, the index or small finger (Fig. 4). Also included in the video portion of this paper is the video documentation of range of motion at 7 days post-surgery with the digital ICAM orthosis, as well as range of motion video documentation at 5 and 6 weeks post-surgery for J.V., case study 1, which demonstrates excellent results utilizing the digital ICAM yoke orthosis without wrist immobilization.

Acknowledgments The authors thank Maria Ansley, Scientific Photographer, SIU School of Medicine, Department of Surgery, Division of Plastic Surgery, for photographing all of the figures and for taking and editing all of the video for this multimedia article.

Conflict of Interest The authors declare that they have no conflict of interest.

References

1. Berry N, Neumeister M. Analysis of limited Wyndall Merritt Splint for extensor tendon injuries to hand immobilization. Abstract: Presented at American Association for Hand Surgery annual meeting Beverly Hills, CA Jan 2008. Published: HAND 2008;3(2):170.
2. Browne EZ, Ribik CA. Early dynamic splinting for extensor tendon injuries. *J Hand Surg.* 1989;14:72–6.
3. Evans RB. Early dynamic splinting for extensor tendon injuries. *Hand Clinics.* 1986;2(1):157–69.
4. Howell JW, Merritt WH, Robinson SJ. Immediate controlled active motion following zone 4–7 extensor tendon repair. *J Hand Ther.* 2005;18(2):182–90.
5. Martzon JL, Bozentka DJ. Extensor tendon injuries. *J Hand Surg.* 2010;35:854–61.
6. Merritt WH, Howell JW. Immediate active motion and use following extensor tendon repair using relative motion splinting: a ten year study. Abstract: Presented at The American Society for Hand Surgery Annual Meeting, Phoenix Az. Jan 1998.
7. Saldana MJ. Early relative motion rehabilitation of proximal extensor tendon lacerations using the “Wyndell Merritt” splint. Abstract: Presented at The American Association for Hand Surgery Annual Meeting, Phoenix AZ. Jan 1998.
8. Sharma JV, Liang NJ, Owen JR, et al. Analysis of relative motion splint in the treatment of zone VI extensor tendon injuries. *J Hand Surg.* 2006;31(7):1118–22.