A Paradigm Shift in Managing Acute and Chronic Boutonniere Deformity

Anatomic Rationale and Early Clinical Results for the Relative Motion Concept Permitting Immediate Active Motion and Hand Use

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Background: We have utilized relative motion splinting for early motion following acute repair of boutonniere injuries, and we have developed nonoperative orthosis-based therapy for the treatment of chronic injuries. We offer our early clinical experience using relative motion flexion splinting for boutonniere deformities and explain the anatomic rationale that permits immediate active motion and hand use following acute injury or repair. For chronic boutonniere deformity, we offer a nonsurgical management method with low morbidity as a safe alternative to surgery.

Methods: Our understanding of the extrinsic-intrinsic anatomic interrelationship in boutonniere deformity offers rationale for relative motion flexion splinting, which is confirmed by cadaver study. Our early clinical results in 5 closed and 3 open acute and 15 chronic cases have encouraged recommending this management technique. For repaired open and closed acutely injured digits, we utilize relative motion flexion orthoses that place the injured digits in 15° to 20° greater metacarpophalangeal flexion than its neighboring digits and otherwise permit full active range of motion and functional hand use maintaining the 15° to 20° greater metacarpophalangeal flexion for 6 weeks. In fixed chronic boutonniere cases, serial casting is utilized to obtain as much proximal interphalangeal extension as possible (at least −20°), and then relative motion flexion splinting and hand use is instituted for 12 weeks.

Results: Our acute cases obtained as good as, or better range of motion than, conventional management techniques, with early full flexion and maintenance of extension without any recurrences. The most significant difference is morbidity, with ability to preserve hand function during healing and the absence of further therapy after 6 weeks of splinting. Patients with chronic boutonniere deformity presented from 8 weeks to 3 years following injury (averaging 31 weeks) and were 15 to 99 years of age (averaging 42 years). All were serially casted to less than −20° (averaging −4°) and maintained that level of extension after 3 months of relative motion flexion splinting. All achieved flexion to their palm, and all met the Steichen-Strickland chronic boutonniere classification of "excellent." There were no recurrent progressive boutonniere deformities in either acute or chronic cases and no instances of reflex sympathetic dystrophy/chronic regional pain syndrome (RSD/CRPS).

Conclusions: Relative motion flexion splinting affords early active motion and hand use with excellent range of motion achieved following acute open boutonniere repair or closed boutonniere rupture with less morbidity than conventional management. Chronic boutonniere deformity will respond to relative motion flexion splinting if serial casting can place the proximal interphalangeal joint in less than −20° extension, and the patient actively uses the hand in a relative motion flexion orthosis for 3 months, recovering flexion. No further therapy was needed in our cases. We believe this management technique should be attempted for chronic boutonniere deformity as a preferable alternative to surgery, which remains an option if needed.

Key Words: active motion, boutonniere disease, hand use, relative motion concept

(*Ann Plast Surg* 2020;84: S141–S150)

Boutonniere deformity has been the most difficult of extensor injury problems, with acute injury management usually requiring 2 to 4 months out of work,[1] and chronic fixed boutonniere deformity, a conundrum that often defies any acceptable correction with surgical or nonsurgical techniques.[2]

THE RELATIVE MOTION "QUADRIGA EFFECT" ORTHOSIS CONCEPT

Four types of digital orthoses are commonly described: static splints, dynamic splints, serial static splints, and static progressive splints.[3] Relative motion splinting differs in that it takes advantage of the relationship between extrinsic motor function of adjacent digit tendons with a shared muscle and the subsequent effect on interphalangeal (IP) function, accomplished by the relationship between adjacent metacarpal (MP) joints. The relative motion concept provides a simple management technique that safely permits finger and wrist active motion without increased tension on the repaired or ruptured tendon.[4] This takes advantage of what Verdan[5] named the "quadriga effect" to explain complications that occur when long extensor tendons are sutured to the profundus tendons over finger amputation stumps, a previously popular technique to provide protection for the phalangeal stump. This problem also exists when IP joints are fused in too much extension, both causing adjacent digits to be unable to fully flex the distal interphalangeal (DIP) joints to the palm because of the relative loss of flexion to the profundus of the sutured or fused digit or, conversely, a flexor profundus tendon repair with greater than 1-cm resection allowing only the repaired digit to be able to flex to the palm due to the shortened relative motion that places slack in the adjacent flexor profundi tendons. The anatomic arrangement causing these complications can be used to advantage.

"Quadriga" is the name the Romans gave their 2-wheeled chariot with equidistant reins used by the charioteer to control the 4 horses during the Roman and Greek chariot races, explaining Verdan's choice of terminology (Fig. 1). In the human hand, this metaphor has the charioteer as the extensor digitorum communis (EDC) and flexor digitorum profundi muscles, and the tendons as the reins. When a tendon from a common muscle is splinted 15° to 20° at the MP joints relative to its adjacent digits, there is alteration of forces from the common muscle, reducing tension on that tendon,[4] and this difference persists throughout total active amplitude of motion because the uninjured adjacent tendons pull the common muscle forward, maintaining laxity in the splinted digit. This phenomenon permits safe active motion and hand use in long extensor tendon repairs and acute sagittal band ruptures by splinting the repaired or ruptured tendons in 15° to 20° greater metacarpophalangeal (MCP) joint extension than adjacent digits for 6 weeks, with good/

Received January 9, 2020, and accepted for publication, after revision January 9, 2020.
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Conflicts of interest and sources of funding: none declared.
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ISSN: 0148-7043/20/8402–S141
DOI: 10.1097/SAP.0000000000002307

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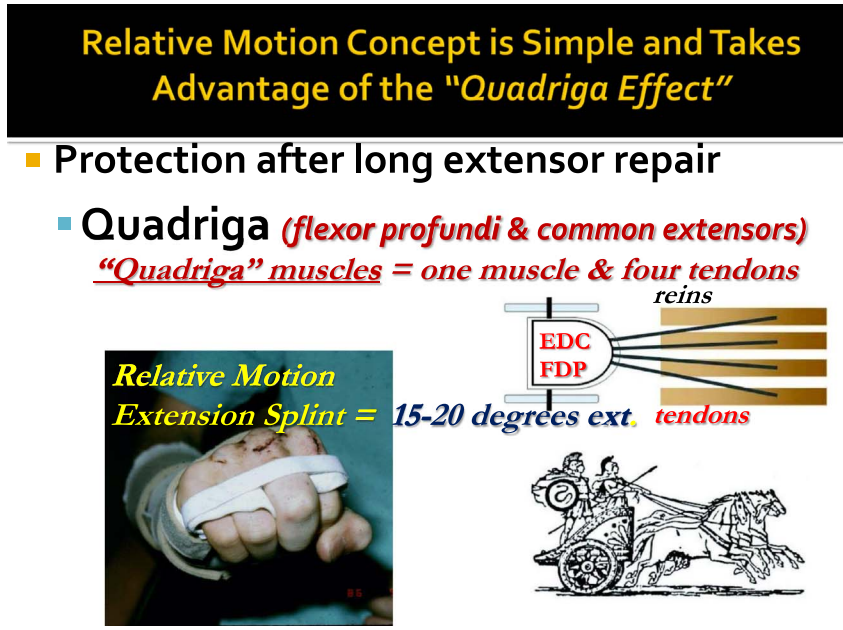

FIGURE 1. Quadriga, illustration of the roman chariot compared with anatomy. full color online

excellent results,[6–9] significantly less morbidity,[10] and no reported ruptures or pain syndromes among 371 cases.[11]

An excellent description of how to make relative motion extension and flexion orthoses is available on YouTube, courtesy of Melissa Hirth, B(OT), MSc (https://www.Youtube.com/watch?v = 30d 0d Q2ZjCA).

ANATOMIC RATIONALE FOR BOUTONNIERE DEFORMITY ORTHOSES: "WINSLOW'S DIAMOND"

The 18th-century Danish-born French anatomist Jacob B. Winslow (1669–1760) described the tendinous rhombus[12] that later became known as "Winslow's diamond." He described the complex dynamic interrelationship between the extrinsic and intrinsic digital extensor mechanisms that encircle the proximal interphalangeal (PIP) joint and are critical to balanced IP extension (Fig. 2). Biomechanical engineers[13,14] have offered computerized, complex mathematical studies of Winslow's diamond relationships, citing the importance of MP and IP finger position on tendon force in the isolated digit, but with little or no attention to the importance of the interrelationship of MCP joint position between adjacent digits.

Boutonniere deformity provides the unique opportunity for an orthosis that provides useful quadriga effect from both flexor and

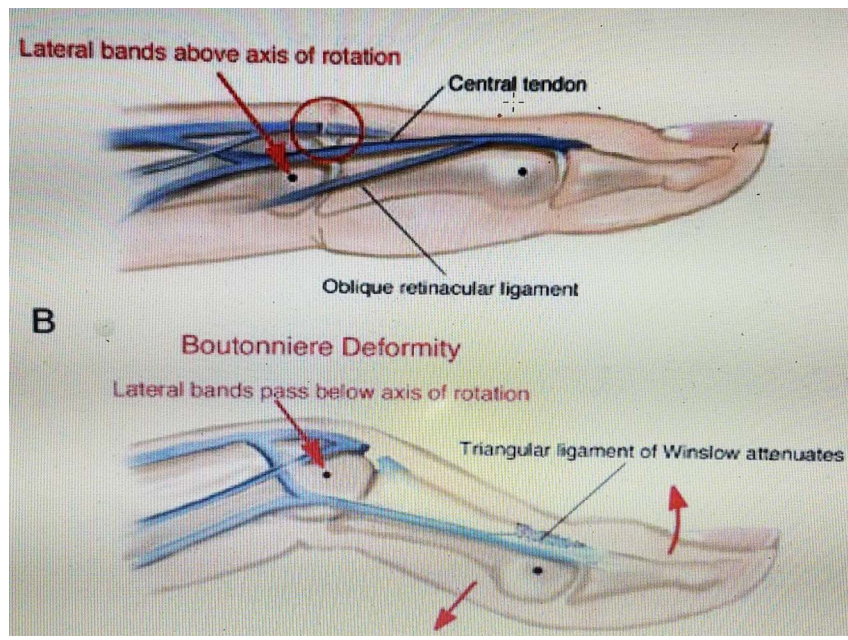

FIGURE 2. Anatomical illustration of Winslow's diamond. Adapted from Yu, Chase, and Strauch. *Atlas of Hand Surgery.* St Louis, MO; Elsevier; 2004:347. full color online

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extensor extrinsic motor systems simultaneously. First, from the volar side, the profundi provide the key quadriga effect because of the lumbrical muscles arising from the radial side of the tendons. Although controversial,[15] Kaplan[16] and Brand[17] both regarded the lumbrical as the principal extensor of the IP joints. While not as powerful as the interossei, the lumbrical has 4 times the excursion and is more volarly positioned as it passes from beneath the transverse MP ligament, and it may provide sensory feedback regarding positioning of the IP system.[15] Zancolli's electromyographic studies confirm that the lumbrical remains active throughout digital extension, whereas the interossei have intermittent activity during digit extension of the MP and IP joints.[18] This is especially evident with forceful extension due to interossei stabilizing the MP joint, while the EDC increases the forceful pull. This avoids MP hyperextension. Because lumbricals arise from the profundi, placing an MP joint in 15° to 20° greater flexion relaxes that profundus compared with its neighbors because of their common muscle, which subsequently relaxes its lumbrical. In boutonniere deformity, the lumbrical appears to be the principal deforming force pulling the lateral bands below the PIP axis of rotation by attenuating the residual weak, thin, injured horizontal and oblique extensor hood fibers and the stabilizing triangular ligament of Winslow that connects the collateral tendons of the lateral bands as they become the conjoined tendon (Fig. 2). Normally, the triangular ligament and the extensor hood fibers restrain the lateral band/conjoined tendon complex of uninjured digits above the PIP joint axis of rotation as they move laterally and volarly during PIP flexion, even if the central slip is ruptured. When the lateral bands become abnormally positioned below the axis of rotation, intrinsic muscle function causes PIP flexion and DIP hyperextension, unless relaxed in a relative motion flexion orthosis.

Second, the quadriga effect from the dorsal hand arises from the EDC tendons and their important trifurcation proximal to the PIP joint, the central slip inserting into the base of the middle phalanx, and the lateral slips joining the combined interossei and lumbrical tendons (lateral bands) to ultimately form the conjoined tendon that unites distally into the terminal tendon, crossing the DIP joint (Fig. 2). Winslow (1732)[12] described the dynamics of this encircling "diamond" that normally separates and widens when the PIP joint is flexed and the EDC is relaxed, and then with PIP extension relocates medially in a "cinching" fashion as the combined intrinsic and external tendon muscles contract (Fig. 1). However, the lateral slips of the external long extensor tendon are quite capable of extending the IP joints alone without any intrinsic muscle function whatsoever, as evidenced by the fact that with complete ulnar palsy a dorsal blocking orthosis allows full IP extension in the palsied fourth and fifth digits when blocked in MCP flexion relative to the adjacent index and long finger extensors. It can also provide full IP extension with acute boutonniere deformity, provided the slack is compensated by placing the MP joint in 15° to 20° greater flexion, maintaining the lateral bands dorsal to the axis of rotation.

Thus, splinting the boutonniere deformed digit in 15° to 20° relative greater MP joint flexion than adjacent digits relaxes the deforming volar forces that pull the lateral band below the PIP axis of rotation by relaxing the profundus and its lumbrical origin while simultaneously increasing the extrinsic extensor and IP forces via the lateral slips, which encourages medial repositioning of the lateral bands as the PIP and DIP joints are extended (Fig. 3). The difference in these forces will persist throughout an active range of motion as long as the orthosis remains, because of the quadriga effect. Without lumbrical activity but with increased extensor force, the lateral bands remain dorsal to the PIP axis of rotation, and this allows the central slip, the extensor hood oblique and horizontal fibers, and the triangular ligament to spontaneously heal without scar adherence, preserving functional laxity and stability. It is well shown that all 3 of these structures must be divided to create a boutonniere deformity in the cadaver. The advantages of the quadriga effect are demonstrated by creating a boutonniere deformity in the cadaver hand and then pulling the EDC with and without the splint (Video 1, http://links.lww.com/SAP/A470).[19]

FIGURE 3. Ulnar palsy orthosis using the relative motion flexion concept. Only when the adjacent normal index and long digits extend can the EDC attachments to the lateral bands extend the fourth and fifth PIP and DIP joints. full color online

Isolated disruption of the EDC's central slip insertion into the middle phalanx alone does not cause boutonniere deformity, as evidenced by the Fowler procedure, which carefully divides this central attachment from underneath the extensor hood to rebalance the extrinsic-intrinsic relationship for chronic mallet deformity.[20] This procedure does not result in a boutonniere deformity because the surrounding extensor hood and triangular ligament remain uninjured and intact. The initial amount of extensor hood and triangular ligament disruption in acute boutonniere injury will vary, and as long as enough remains intact, the lateral bands initially remain dorsal to the axis of PIP rotation, and the patient continues to be able to extend the PIP joint, but following injury, the volar pull of the lumbrical gradually attenuates these injured structures until the PIP joint "buttonholes" into the deformity, flexing the PIP and hyperextending the DIP joints due to the lateral band relocating below the axis with intrinsic muscle activity. This is why so many patients with boutonniere injury present in the emergency department with what appears to be normal range of motion, only to develop progressive deformity in subsequent weeks, after being misdiagnosed as having an insignificant sprain.

PATIENTS AND METHODS

Diagnosis: Boutonniere Versus Pseudo-Boutonniere

Because so many patients have normal range of motion for days or occasionally even weeks after boutonniere extensor hood and central slip disruption, it is important that emergency personnel understand the clinical tests needed to recognize the disorder. The best treatment for boutonniere deformity is to avoid the deformity. Once fixed deformity occurs, treatment is far more difficult. First, most patients will subjectively know that something is amiss, despite what seems normal range of motion on initial examination. They may complain of weakness, pain, or instability of the PIP joint, which is usually swollen. The Elson test[21] is a good early test and is accomplished by placing the digit flexed at the PIP joint along the edge of a table and then comparing the amount of extension force present at the PIP joint, which will be weak over the middle phalanx due to absence of central slip attachment and then extension at the DIP joint, which does not normally extend in this position but may be felt in boutonniere deformity due to the untethered pull

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through the lateral slips, especially when they are volarly displaced (Figs. 4A, B). This assessment requires subjective interpretation by the examining physician, and the visible, modified Elson test[22] is useful to confirm the findings, placing the injured digit and its normal counterpart in full PIP flexion with the middle phalangeal dorsum firmly against the same digit of the uninjured hand (Fig. 5). If the injured digit has better DIP extension (or any) in that position, boutonniere disruption is likely (Fig. 3). The Boyes test[23] is particularly useful in late deformity, when the lateral bands are volarly displaced and adherent. This examination is done by comparing passive resistance to flexion of the DIP joint while the PIP is maximally extended and then the PIP fully flexed. When there is fixed lateral band volar displacement, passive maximum extension of the PIP joint causes tightening of the lateral bands and DIP resistance to passive or active flexion. However, the DIP joint (if still supple) can be easily flexed when the PIP joint is flexed because tension on the volar displaced intrinsic tendons is relaxed (Video 2, http://links.lww.com/SAP/A471).

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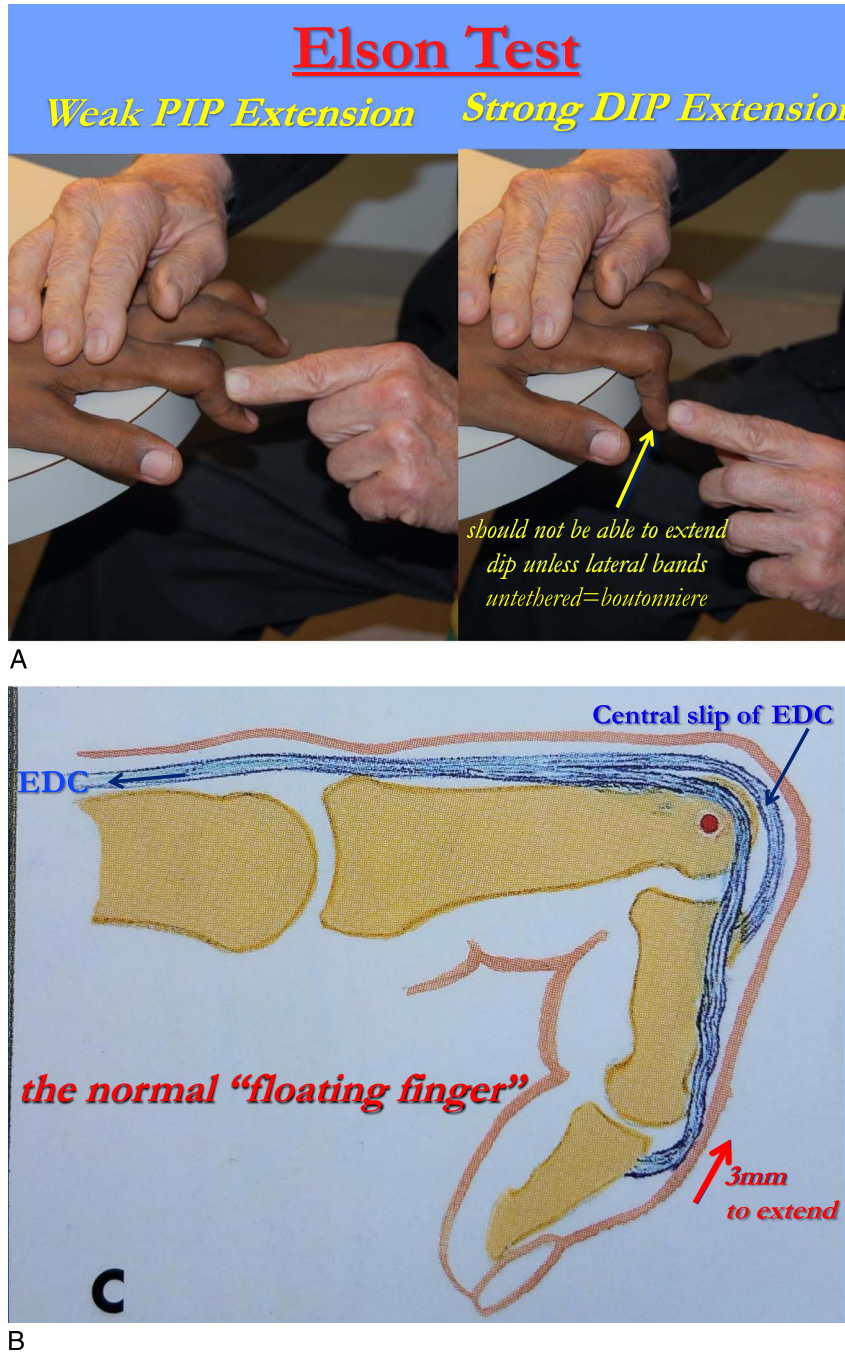

FIGURE 4. A, Positive Elson test of the strength of PIP extension (weak) and of extension of the DIP joint (should be none) with PIP flexed. B, Normal laxity of the DIP joint with PIP flexion is due to tethering of the lateral bands to the EDC central slip. full color online

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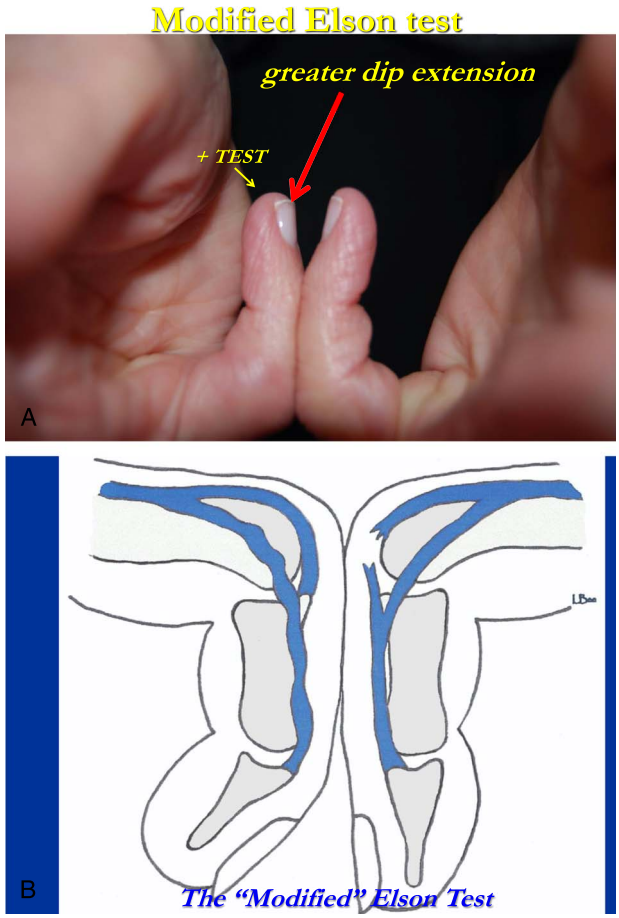

FIGURE 5. A, The modified Elson test provides visual confirmation for DIP loss of laxity and extensibility due to loss of lateral band tethering to the EDC central slip. B, Loss of attachment to the EDC central slip allows extension in modified Elson test. full color online

Pseudo-Boutonniere

When the Boyes and Elson tests are negative but the patient has boutonniere deformity posture, the likely diagnosis is pseudo boutonniere, related to a flexor tendon pulley[24] or volar plate injury[25] causing flexion contracture (Fig. 6). Unfortunately, both late flexor tendon contracture and/or late extensor boutonniere deformity often have fixed DIP stiffness that prohibits accurate clinical testing. Magnetic resonance imaging (MRI) or ultrasound study can confirm whether the deformity originates on the dorsal or volar structures. In general, ultrasound seems preferable if extensor injury is likely,[1] and MRI may better outline the cause of flexor injury (Figs. 7A, B). Following serial casting to neutral in the pseudo boutonniere patient, we prefer a trial of 3 months of dynamic extensor splinting before surgical considerations for pseudo boutonniere patients, because this often proves adequate.

Acute Boutonniere Injury

In early closed boutonniere injury, the deformity may be immediately correctable by placing a pencil, Q-Tip, tongue blade, or even digital pressure (Figs. 8A, B) to block the MP in relatively greater flexion than adjacent digits. Under these circumstances, one can anticipate success using relative motion flexion splinting for 6 weeks and encouraging hand use with the orthosis present 100% of the time. If patients have difficulty maintaining the orthosis during sleep, a separate static gutter orthosis is constructed, maintaining PIP extension for night use, which was necessary in one-third of our cases.

Case Report 1: This 20-year-old college student fell from a balcony 4 days prior to being seen, with a closed boutonniere rupture and full passive motion. Six weeks after relative motion splinting, he recovered full active range of motion.

Open boutonniere repair should be done under local anesthesia with epinephrine, the Lalonde[26] WALANT technique (**w**ide **a**wake **l**ocal **a**nesthesia **n**o **t**ourniquet) because of difficulty correctly restoring the delicate intrinsic-extrinsic balance without the patient's active cooperation. This is especially important when there is avulsion of tissue and affords an opportunity to test the relative motion flexion orthosis as well as the success of repair. The patient is immobilized a few days until acute inflammation subsides and then splinted for 6 weeks with

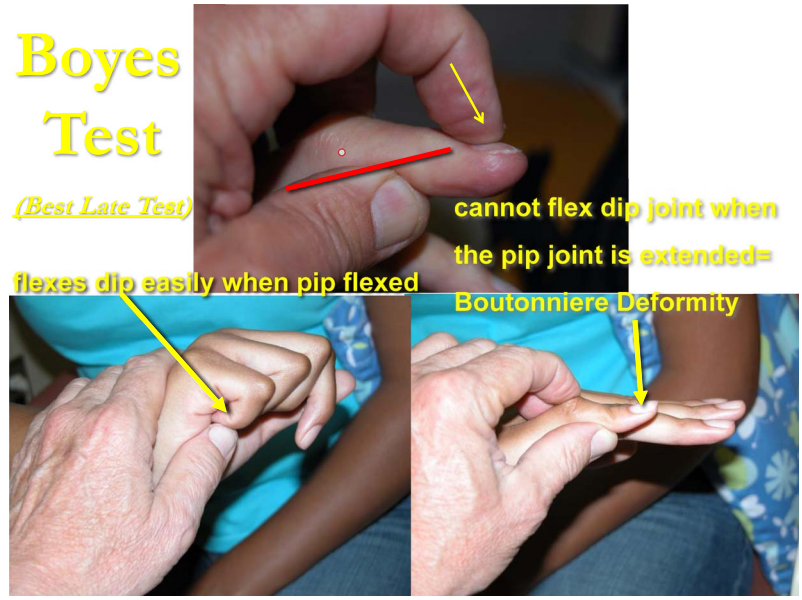

FIGURE 6. A positive Boyes test occurs when the lateral bands become adherent laterally and restrict passive and active DIP flexion with minimum PIP flexion. Seen more frequently in late cases with deformity. full color online

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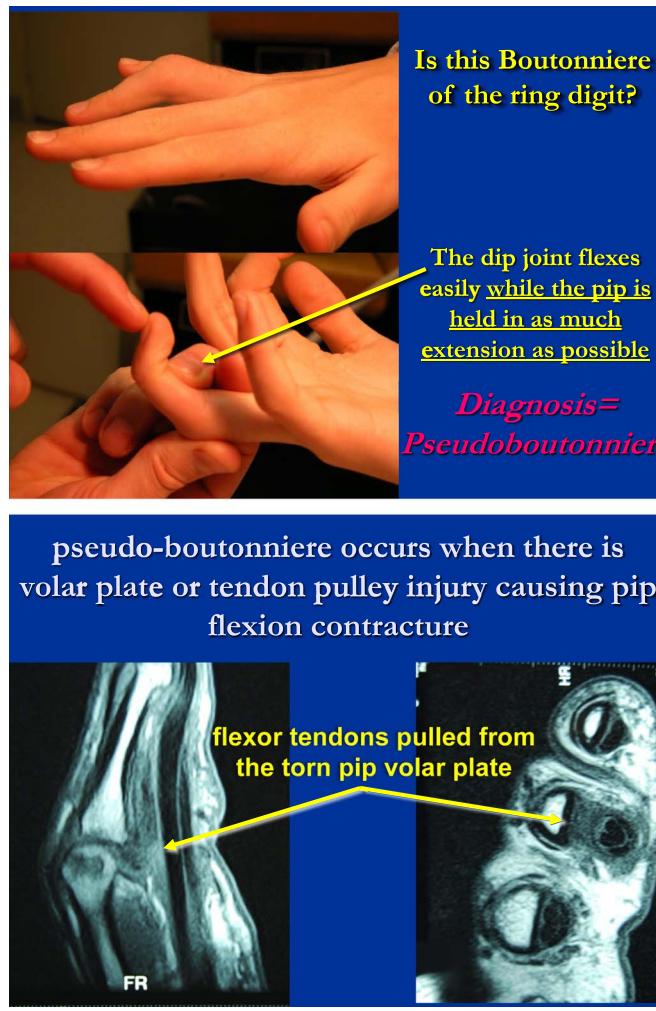

FIGURE 7. A, Negative Boyes test can rule out Boutonniere deformity when DIP passively flexes easily while PIP is as extended as possible. Diagnosis is pseudo-Boutonniere deformity due to flexor injury as seen on MRI (B). full color online

encouragement to recover full range of motion except for the 15° to 20° less MCP extension (Video 2, http://links.lww.com/SAP/A471).

Chronic Boutonniere Deformity

All patients with fixed PIP flexion contracture should be serially casted into as much PIP extension as possible before any other definitive treatment protocol. Once maximum PIP extension is achieved (none worse than −20° in our cases), we use relative motion flex ion orthoses for a full 3 months, encouraging early return of full flexion and functional use in the splint as soon as possible.

Case Report 2: Our first chronic boutonniere patient (2005) was a self-employed 38-year-old insect exterminator who previously refused treatment for closed injury because he felt he could not work with his fifth digit immobilized. He was referred 1 year later with a progressive −55° fixed flexion contracture and requested surgical correction, but without immobilization. We negotiated an agreement for 2 weeks' PIP immobilization and in that interval were able to serially cast to −20° and then used relative motion flexion splinting for 3 months, which he said was easily compatible with his work. After splinting, he disappeared for 3 years but returned for an unrelated problem, still maintaining full flexion and −20° PIP extension (Fig. 9). Subsequently, we have preferred this method of management for all our chronic boutonniere patients. He represents our worst result, because we have been able to serially cast our other patients to better extension, and all recovered functional flexion while in the splint.

Case Report 3: A 48-year-old woman fell 6 months before referral with a swollen, painful PIP joint that had loss of flexion within 2.5 cm from her palm, and a −35° PIP joint-loss of extension. She had been previously diagnosed as having an "occult fracture," and later on as having "volar plate injury," and was characterized as "unresponsive to hand therapy." Initial examination revealed a fixed PIP contracture with positive Boyes test, and after 3 weeks of serial casting, she achieved a −5° contracture and was then placed in a relative motion flexion splint with encouragement for hand use. Her initial range of motion was limited, but within a month, she improved her flexion to the palm and maintained extension in the splint. She had a Strickland and Steichen "excellent" result after her splint was discontinued (Fig. 10), with her extension preserved and full flexion at a 2-year follow-up (Video 3, http://links.lww.com/SAP/A472).

Case Report 4: The importance of intrinsic balance is represented by a 40-year-old patient (Fig. 11) with chronic supple boutonniere deformity 6 months after emergency department repair of a box cutter laceration that gradually led to progressive boutonniere deformity with associated DIP joint hyperextension. Even in the relative motion flexion orthosis, he could not fully extend his PIP joint unless the DIP joint hyperextension was blocked. His 3-month program therefore included relative motion flexion orthosis of the MP and extension blocking

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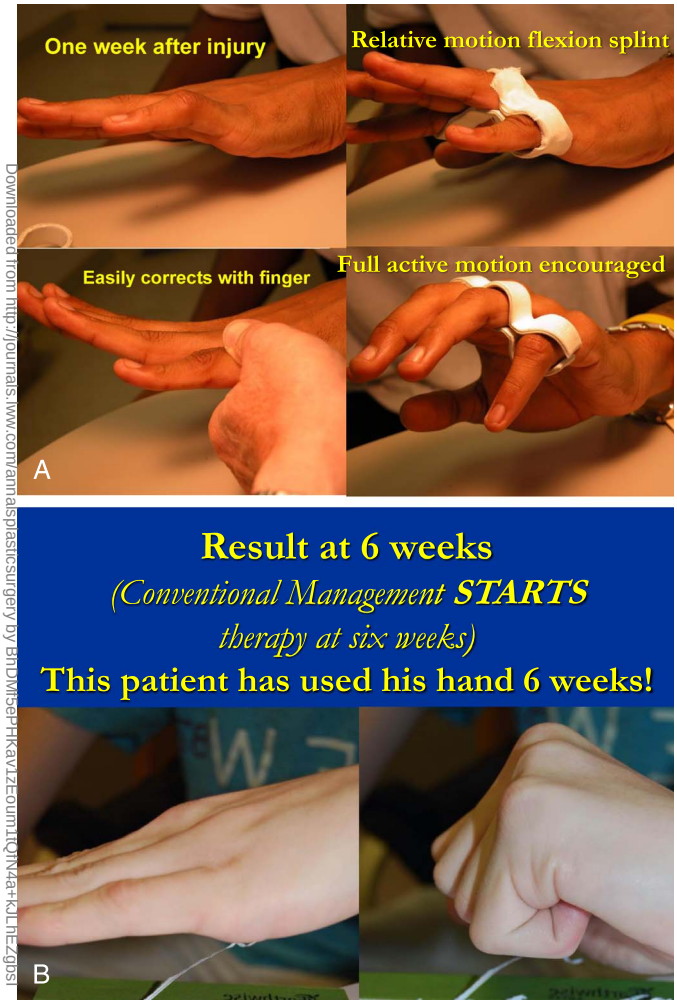

FIGURE 8. A, A tongue blade, pencil, or even finger pressure may allow full IP extension in an early Boutonniere rupture with deformity. Immediate placement of relative motion flexion (RMF) orthosis for 6 weeks results in full range of motion (B). full color online

orthosis of the DIP, with otherwise full motion, which proved successful after 3 months.

RESULTS

There were no patients with recurrent boutonniere deformity in this series of acute and chronic boutonniere cases. Furthermore, patients were encouraged and able to resume normal active hand use in activities with the orthosis present at all times. There were 9 women and 14 men.

Most of our cases were chronic, likely because of the senior citizen status of the surgeon, being exempt from emergency calls. There were 15 chronic patients and 8 acute, with only 3 of these open repairs. The initial PIP joint flexion contracture averaged −29°, and the average improved PIP joint range of motion following splinting was 35.9°, because several chronic patients improved flexion as well as extension.

The cases averaged 31 weeks to treatment, varying from 8 weeks to 3 years, and required an average of 2½ weeks of serial casting, followed by 3 months of relative motion flexion splinting and hand use. Visits to the therapist averaged 7.5 times, with therapy ending after splinting, except for a 2- to 3-week follow-up to be sure extension was maintained. However, the surgeon has followed some patients up to 10 years. Two additional patients not included in the series quickly redeveloped flexion deformity after serial casting and were found to have pseudo boutonniere deformity on MRI; they were successfully treated with dynamic extension splinting for 3 months. A 92-year-old patient with Parkinson disease also was not included because he could not tolerate relative motion flexion splinting and had to be immobilized. Otherwise, compliance in this user-friendly orthosis seemed excellent, although a 15-year-old with a 3-year history of chronic boutonniere supple deformity confessed he took his splint off when playing drums for his school band. Nonetheless, he maintained full PIP joint extension after 3 months of splinting and recovered his DIP joint flexion (case 3).

DISCUSSION

It is difficult to accurately compare results of conventional management techniques for acute boutonniere deformity. This complexity is pointed out in a *Journal of Plastic and Reconstructive Surgery* CME review by Soni et al,[1] concluding that morbidity, risks, cost, and final results after 6 months favor static immobilization as the management method of choice. However, Evans[27] controlled active short-arc motion[25] and the dynamic splinting methods clearly afforded earlier return of motion and function, indicating the value of early active motion. All of these conventional management methods require intense hand therapy, whether cautiously instituted early or after 6 weeks' immobilization, with an average of 2 to 4 months off work. Relative motion flexion splinting affords the opportunity to continue hand use, usually compatible with return to work during splinting, and minimal to no

FIGURE 9. One-year progressive fixed Boutonniere −55° contracture (A) refusing immobilization more than 2 weeks obtained −20 with serial casting (B) and used hand at work in orthosis for 3 months (C) maintaining −20° (D) even after 3 years (E). full color online

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FIGURE 10. A 48-year-old woman 6 months after injury with a painful fixed PIP contracture who had been misdiagnosed and immobilized with loss of flexion and extension (A) was serially casted to almost neutral (B) and then had RMF orthosis and encouraged to use her hand (C) and recovered and excellent range of motion at 3 months, maintained at 2 years (D). full color online

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FIGURE 11. A and B, Chronic but supple Boutonniere not fully corrected in RMF orthosis unless DIP hyperextension blocked (A). Excellent range of motion after 3 months in both orthoses. full color online

additional therapy after the orthosis is discontinued. In fact, once full flexion was achieved in the orthosis, the most common reason for our patients to return to therapy was for repair of broken splints. This circumstance led the therapist to provide a prophylactic spare splint from the outset for obviously active patients.

Conventional chronic boutonniere deformity treatment techniques have proven a conundrum. Late surgical correction with fixed PIP contracture has notoriously unpredictable results, usually poor, from a variety of proposed surgical procedures. However, the alternative of prolonged static immobilization has significant morbidity with frequent stiffness, possibly due to extensor hood adherence and PIP joint ankylosis. Perhaps the most revealing surgical report was by Steichen et al,[2] in the *Difficult Problems in Hand Surgery* text. They reported results following Elliott-type reconstructions in 35 patients with contracture for 8 weeks or more. They developed a chronic boutonniere grading system in which 90° of flexion and −20° extension of the PIP joint were considered "excellent," 80° of flexion and −30° extension were "good," 70° flexion and −40° extension were "fair," and patients with less than 70° of flexion and worse than −40° of extension were "poor." Their 4 worst prognostic findings were (1) inability to passively correct the PIP contracture to completely neutral preoperatively (92% fair/poor); (2) late closed rupture more than a few months; (3) previous local surgery; and (4) older patients (21–45 years of age had 67% fair/poor result; older than 45 years had 80% fair/poor result). Best results (65% good/excellent) were in patients whose preoperative active extension was −30° or better, whereas those whose initial active extension was between −31 and −60° had 73% fair/poor result, even though they could passively extend to neutral. More than three-fourths were younger than 33 years, but even among these there were only 56% with good to excellent results, and of those older than 33 years, 82% had fair/poor result. Because of these results, the authors recommended no surgery for patients who could extend to −30 or better, because one-third of these were worse after surgery. They also recommended against operating on anyone who did not achieve full passive PIP extension preoperatively (92% fair/poor) and were pessimistic about older patients.

Among our chronic boutonniere cases, we had many who would therefore appear prognostically unfavorable for surgery, including older patients (average 42 years and up to 99 years), most with deformity for longer than 3 months (average 40 weeks), and several who had greater than −30° initial PIP joint contracture, but we did not have the adverse results described in Steichen and colleagues'[2] surgical cases. In fact, all our patients who completed use of the relative motion flexion orthosis fit into their "excellent" grading category.

Once serial casting is achieved, this active motion management technique for chronic boutonniere does not greatly interfere with hand function and does not obviate the possibility of later surgery; we therefore propose it be attempted as an attractive initial alternative to surgery. Eventually, we expect a patient who cannot be serially casted to −20° PIP extension. In such a case, we would propose a single surgical procedure to release the volar plate, collateral, transverse, and oblique retinacular ligaments; relocate the lateral bands dorsally; and stabilize them by tendon graft reconstruction of the triangular ligament (the author has previously preferred flattened plantaris encircling the lateral bands), all done under local anesthesia with epinephrine and no tourniquet to ensure proper balance, followed by 6 weeks of relative motion flexion splinting.

However, thus far, we have not found this necessary. Whether surgical or nonsurgical treatment is planned, all chronic boutonniere patients with fixed contracture need serial casting until full passive PIP extension is achieved, if possible. As soon as maximum extension (−20° or better) is obtained, our approach has been to proceed with long-term relative motion flexion splinting for 3 months. It is possible the splinting interval could be shortened if ultrasound or MRI determined the lateral bands were successfully relocated above the PIP axis of rotation earlier, but the morbidity of the splint seems so minimal we have not pursued this approach. Others who use relative motion splinting for chronic boutonniere deformity prefer a more prolonged program by continuing full PIP immobilization after serial casting until full active DIP joint flexion has been achieved before instituting relative motion splinting (Lalonde DH, Higgins A, personal communication, 2016), believing this indicates relocated lateral bands and makes using the relative motion flexion orthosis safer. Only continued experience will clarify the optimum program for these patients, but relative motion flexion splinting for chronic boutonniere deformity should

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represent an improvement in management and a worthwhile attempt prior to surgical considerations.

CONCLUSIONS

Relative motion flexion splinting provides a safe management technique for acute open and closed boutonniere deformity, with lower morbidity, less time off work, and reduced need for intense hand therapy, and may possibly afford better long-term range of motion recovery. Relative motion flexion splinting also offers a nonsurgical, low-morbidity approach for chronic boutonniere deformity and likely represents a paradigm shift in the management of this difficult group of patients.

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