Disabling Hand Injuries in Boxing: Boxer’s Knuckle and Traumatic Carpal Boss

Charles P. Melone, Jr., MD, Daniel B. Polatsch, MD*, Steven Beldner, MD

Owing to constant usage with continual exposure to violent forces, the boxer’s hands are exceedingly prone to injury. Numerous reports confirm that hand injuries are highly prevalent among both amateur and professional fighters and may in fact constitute a sport-specific epidemic. Foremost among these injuries is disruption of the metacarpophalangeal (MP) joints of the fingers, traditionally termed boxer’s knuckle. The clenched-fist posture, coupled with the enormous forces generated by punching, render the MP joints or knuckles highly vulnerable to damage. The most frequent and severe type of boxer’s knuckle encountered is extensor hood disruption, with derangement of the longitudinal central tendon and the transversely oriented sagittal fibers. In such cases, prompt surgical repair is necessary to restore integrity of this critical extensor unit, prevent irreparable tissue damage, and maintain optimal joint function.

The second most common but less recognized type of hand injury apt to cause major disability among fighters is disruption with destabilization of the carpometacarpal (CMC) joints of the fingers, the so-called carpal boss. The excessive trauma of boxing, repeatedly transmitted from the MP joints to the base of the metacarpals, is apt to destabilize the normally rigid CMC joints. Acute sprains and contusions of these joints usually respond successfully to conservative measures; however, untreated or recurrent injuries are prone to result in progressive CMC instability characterized by painful periarticular bony hypertrophy, joint subluxation, and articular degeneration. For the debilitating traumatic carpal boss, selective CMC joint arthrodesis constitutes optimal treatment.

KEYWORDS
- Boxer’s knuckle
- Sagittal band
- Extensor hood
- Carpometacarpal boss
- Carpometacarpal joint
- Arthrodesis

Department of Orthopaedic Surgery, Albert Einstein College of Medicine, Hand Surgery Center, Beth Israel Medical Center, 321 East 34th Street, New York, NY 10016, USA

* Corresponding author.
E-mail address: dpolatsch@chpnet.org (D.B. Polatsch).

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This article, focusing on recognition and management of the debilitating boxer’s knuckle and traumatic carpal boss, reviews the key anatomic features of the MP and CMC joints of the hand and, based on the authors’ experience with 47 fighters requiring 54 surgical procedures, describes the pathologic anatomy of these potentially career-ending boxing injuries. Moreover, based on this surgical experience, the article reports operative techniques that have proved successful in most cases. In an effort to enhance safety, emphasis also is placed on prevention of injury. Because sport in general is a major source of injury, preventive measures have become a critical aspect of optimal sports medicine that must be increasingly employed in boxing.

ANATOMY AND PATHOANATOMY

The Metacarpophalangeal Joint Extensor Hood Mechanism: Normal Anatomy

The extensor hood of the finger MP joint comprises the stout, longitudinal central tendon and the left substantive, but equally important, transverse peripheral fibers, termed the sagittal bands (Fig. 1). Integrity of this mechanism permits unimpaired joint function and due to its considerable shock-absorbing capacity, affords protection to the underlying articular surface. An intact extensor hood is essential to successful boxing, whereas traumatic disruption is apt to cause major dysfunction, and requires prompt detection and restoration of the damaged joint.

The dorsally located extensor digitorum communis crosses the center of the MP joint, stabilized within a soft tissue groove. During flexion and extension of the MP joint this central tendon, having no dorsal or volar attachments, glides freely in a longitudinal direction in line with its terminal insertion at the distal phalanx. The central tendon is stabilized ulnarly and radially by the sagittal bands, which originate from the palmar transverse metacarpal ligament and volar plate. Confirming personal observations,4,5 Tubiana and Valentin6 demonstrated that the sagittal fibers attach to the lateral borders of the extensor tendon, with some of the fibers traversing the dorsal aspect of the central tendon and uniting with fibers from the opposite side of the tendon, thereby creating a stabilizing groove for the central tendon. Similarly, Ishizuki,7 in his anatomic study of the extensor mechanism of the long finger, reported that the sagittal bands are divided into thin superficial and thick deep layers. The superficial layer traverses the dorsal aspect of the extensor tendon and the deep layer lies on both sides of the long extensor, forming a central groove that maintains tendon stability. Deep to and separate from the central tendon and the sagittal bands lies the joint capsule of the MP joint, affording additional protection to the articular surface.

Stability of the extensor mechanism also is augmented by the junctura tendinum, connecting the extensors proximal to the MP joints.8 Although variations in the number and location of these intertendinous structures are frequent, three distinct junctura usually can be identified. One juncture is apt to connect the index and long finger extensor tendons and is usually fascial in structure. A second juncture usually is present between the long and ring finger extensor tendons and may be ligamentous or fascial. An additional juncture connecting the ring and small finger extensors typically is tendinous. The presence of the juncturae enhances resistance to central tendon subluxation at the MP joint and these juncturae have been reported to be injured in some cases of extensor hood disruption.9

The bony configuration of the MP joint is also a contributing factor to central tendon stability. The articular surface of the MP joint consists of the eccentrically rounded head of the metacarpal and the matching concavity of the proximal phalanx. This unique contour of the MP joint articular surface induces an ulnar-deviation posture of the fingers as demonstrated by Hakstian and Tubiana.10 The most commonly
injured index and long finger articular surfaces have a 10° to 15° ulnar inclination whereas the less frequently injured ring and small finger MP joints demonstrate lesser degrees of asymmetry. These investigators infer that this skeletal configuration is an additional element predisposing to instability and displacement of the central extensor tendon when MP joint disruption occurs.

**The Extensor Hood Mechanism: Pathoanatomy**

Personal experience with surgical repair of 44 boxer’s knuckles, in 38 fighters, reveals consistent patterns of pathology (see *Fig. 1*). Despite variations in extent and exact location, the characteristic lesion consistently comprised rupture of the sagittal band with subluxation or overt dislocation of the central extensor tendon (*Fig. 2*). Twenty-six sagittal bands were ruptured radially, 10 ulnarly, 4 centrally, and 4 completely (radially, centrally, and ulnarly). Similarly, variation occurred with central tendon subluxation, which was usually displaced in the direction opposite the sagittal
band injury. Significantly, 8 of the 10 ulnar sagittal band ruptures were associated with radial subluxation of the central tendon—a lesion previously reported as rare.$^{11,12}$ Moreover, in the 4 cases of small finger injury, a major central rupture of the sagittal fibers resulted in an unusual derangement of radial displacement of the extensor digitorum communis tendon and ulnar displacement of the extensor digitii quinti tendon.

Capsular tears were observed in 32 of the 44 MP joints. The tear was invariably located beneath the sagittal band rupture and extended for a variable distance across the joint. In no instance did the capsular injury compromise integrity of the collateral ligaments. However, 5 of the joints with capsular tears also demonstrated osteochondral fractures of the metacarpal head articular surface. Albeit small, ranging from 3 to 10 mm in diameter, these cartilage lesions were characteristically located on the dorsal-central contact area of the metacarpal head, also directly in line with the sagittal band rupture. Notably, all osteochondral fractures occurred in chronic, recurrent, and severely disrupted boxers knuckles, previously untreated or treated nonoperatively.

Without treatment and with repeated trauma to the extensor hood, this relatively thin but critical protective cover of the MP joint clearly deteriorates, exposing the underlying and unsheathed articular surface to an increased risk of chondromalacia, osteochondral fracture, and ultimately degenerative joint disease (Fig. 3).

The Carpometacarpal Joint: Normal Anatomy

The CMC joints of the fingers consist of a complex row of articulations formed by numerous uneven facets on the distal aspect of the distal carpal row connecting

![Fig. 2. Disrupted extensor hood with subluxed extensor tendon.](image)

![Fig. 3. Recurrent, untreated injury to the long finger metacarpophalangeal joint resulting in disabling traumatic arthritis.](image)
with the articular surfaces of the base of the metacarpals. The index metacarpal base articulates mainly through its V-shaped facet with the trapezoid as well as its smaller facets at its radial and ulnar sides that articulate with the trapezium and capitatum. The long finger metacarpal articulates via a large triangular facet with the capitatum. This configuration creates a snug mortise-and-tenon connection resulting in utmost stability of the index and long finger metacarpals on the distal carpal row, thereby forming the fixed skeletal unit of the hand.

The ring finger metacarpal articulates by a small flat facet with the capitatum and by a large quadrilateral facet with the hamate. This configuration permits motion, albeit relatively minor, in the sagittal plane in contrast to the rigid index and long finger CMC joints. The small finger metacarpal articulates through a saddle-shaped facet with the hamate, permitting considerable motion of approximately 20° to 30°.

Numerous palmar and dorsal ligaments contribute to the stability of the CMC joints but have considerable variability in their location and number. The dorsal ligaments are substantially stronger than their palmar counterparts and whereas the index and long finger CMC joints typically have two supporting ligaments, the less stable ring and small finger CMC joints usually have one. Additional stability of the CMC joints is provided by the radial and longitudinal interosseous ligaments spanning the index, long, and ring finger articulations. The intermetacarpal joints located at the base of the 4 metacarpals are stabilized by numerous intermetacarpal and interosseous ligaments that also provide support to the CMC joints, most prominently those of the index and long fingers.

Dynamics stabilizers of the CMC joints include the extensor carpi radialis longus and extensor carpi radialis brevis tendons inserting at the dorsal aspect of the base of the index and long finger metacarpals, respectively; the extensor carpi ulnaris tendon attaching to ulnar aspect of the small finger metacarpal; the flexor carpi ulnaris tendon via its pisometacarpal ligament extension inserting onto the palmar aspect of the small finger metacarpal; and the flexor carpi radialis tendon with its strong attachments to the base of the index and long finger metacarpals.

The Carpometacarpal Joint: Pathoanatomy

The rigid bony architecture coupled with the substantive static and dynamic soft tissue restraints of the index and long finger CMC joints serve to direct, absorb, and stabilize load transmission from the fingers to the wrist. Nonetheless, with excessive, often violent forces such as those encountered in boxing, CMC instability is apt to occur and result in a major compromise in hand function (Fig. 4). With repetitive transmission of pathologic forces from the metacarpals to the CMC joints, periarticular hypertrophic bone spurs develop with concomitant articular subluxation and degeneration. With increasing chronicity, a painful bony mass progressively enlarges at the base of the index and long finger CMC joints, resulting in the classic and disabling traumatic carpal boss (Fig. 5).

AUTHORS’ PREFERRED MANAGEMENT

Most hand injuries in boxing undoubtedly can be successfully managed by nonoperative measures. However, a clear consensus exists that the MP joint extensor hood disruption or boxer’s knuckle, and the symptomatic traumatic CMC boss are optimally treated by surgical methods. For these usually chronic and always severe injuries, conservative treatment is an unrealistic option for the competitive boxer whose expectations are a successful recovery with a rapid return to competition.
Boxer’s Knuckle: Diagnosis and Operative Treatment

These surgical lesions are readily detected by an accurate description of injury, a precise physical examination, and supplemental high-quality radiography. Rarely are specialized imaging studies necessary. Characteristic features of the complete MP joint extensor hood disruption include marked swelling; decreased joint motion, often with an extensor lag; central tendon subluxation, accentuated by flexion of the joint; and a palpable, markedly tender gap at the site of sagittal band rupture. Radiography, including tangential views (Brewerton) of the joint, occasionally demonstrate metacarpal head subchondral cysts, highly suggestive of the occurrence of MP joint osteochondral fracture (Fig. 6).

Operative techniques

In our experience with 38 professional fighters, having incurred 44 boxer’s knuckles, regardless of the interval between injury and surgery, direct repair of these lesions has been possible and consistently successful (Fig. 7). Because a midline incision directly over the apex of the metacarpal head is apt to result in a painful obtrusive scar with additional impairment, a curved incision, avoiding the prominence of the knuckle, affords preferential exposure. Following extensor tenolysis and sagittal band debridement, the location and extent of soft tissue disruption is clearly visualized. The extensor mechanism is precisely coapted with the joint positioned in 60° to 70° of flexion, permitting a tension-free repair that subsequently will not restrict joint mobility. However, capsular tears, if present, are debrided but not repaired thus...

Fig. 4. Repetitive transmission of detrimental forces of the MP joints to the carpometacarpal (CMC) joints is prone to cause traumatic carpal boss formation.

Fig. 5. Radiograph demonstrating traumatic metacarpal boss characterized by periarticular hypertrophic spur formation with concomitant articular degeneration.

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avoiding an excessively tight soft tissue closure prone to result in a highly detrimental loss of joint flexion. Although some reports advocate dorsal capsule repair, the risk of MP joint dysfunction is excessive, whereas without repair no functional deficits have been observed. In contrast to capsular tears, osteochondral fractures require precision repair. Debridement and drilling of these lesions, occasionally augmented with capsular flap resurfacing, are critical to promote fibrocartilage ingrowth with preservation of articular integrity. The sagittal bands are repaired with strong, absorbable sutures following which the central tendon is relocated and secured in its midline groove, thereby restoring tendon stability at the extremes of both extension and flexion. Postoperatively the reconstructed joints are immobilized in 60° to 70° of flexion for 6 weeks, following which an intensive program of hand therapy is pursued. Punching is permissible when the knuckle demonstrates thorough wound healing with a pain-free, full arc of motion, and the hand regains near-normal strength, a period of recovery ranging from 8 to 12 weeks.

**Traumatic Carpal Boss: Diagnosis and Operative Treatment**

Preoperatively, traumatic CMC boss demonstrates the classic features of a painfully large and tender bony prominence with or without cyst formation overlying the index and long finger CMC joints. Although these digits are the most common sites for traumatic bossing, any or all of the CMC joints may be involved. Tangential radiographs characteristically display hypertrophic bone formation adjacent to, and occasionally overlying, a widened CMC joint space. With increasing chronicity, an enlarging bony mass may completely obliterate degenerative CMC joints.

Our experience includes 9 professional boxers with 11 symptomatic bosses, all of which were treated by CMC joint arthrodesis (Fig. 8). In 8 cases the index and long finger CMC joints were the site of fusion, whereas in 3 the arthrodesis included all 4 finger CMC joints. Although wedge resection of the unstable CMC joints has been advocated for painful carpal bossing, an inordinate risk of recurrent instability with further joint deterioration precludes this procedure as a viable option for the competitive boxer.

**Operative techniques**

The CMC joints are approached through a transverse incision directly over the carpal boss (Fig. 9). Attention is immediately directed toward identifying and protecting the
branches of the radial sensory nerve as well as those dorsal cutaneous branches of the ulna nerve. The long digital extensor tendons and the radial wrist extensor tendons are retracted, clearly exposing the carpal boss. The prominent metacarpal bases are visualized and frequently demonstrate subluxation from the adjacent carpal trapezoid, capitate, and hamate articulations. Associated ganglion cysts are excised and subperiosteal dissection exposes the deranged joints. All hypertrophic bone is excised and the involved joints are thoroughly decorticated, completely removing the damaged articular cartilage and subchondral bone. A healthy cancellous trough is created, extending from the radial aspect of the index CMC joint to the ulnar aspect of the most ulnarly affected joint. The thoroughly decorticated and cancellous surfaces of the metacarpals and carpals are precisely coapted and maintained under compression, as multiple 0.062 Kirschner wires are passed percutaneously from the radial

Fig. 7. (A) Boxer’s knuckle of the third MP joint with ulnar subluxation of the central extensor tendon. (B) Curved incision over the MP joint. The prominence of the metacarpal head is avoided. (C) Surgical pathology. Radial sagittal band disruption with ulnar subluxation of central extensor tendon and underlying capsular tear. The metacarpal head is exposed. (D) Radial sagittal band is repaired and the central extensor tendon centralized over the metacarpal head. (E, F) Centralized extensor tendon and full active range of motion is achieved postoperatively.
aspect of the wrist across the volar aspect of the fusion site, thus affording preliminary stabilization.

A cortical cancellous slot graft along with an abundance of cancellous autograft is then harvested from the outer wall of the iliac crest. The cancellous graft is first inserted and compressed into the trough, ensuring an abundance of healthy bone bridging the fusion site. The slot graft is then carefully sculpted to fit the trough and is first wedged beneath the proximal edge of the metacarpals and then, as the fusion site is distracted, beneath the distal edge of the carpus. The site is then firmly compressed and the insertion of additional 0.062 Kirschner wires ensures secure stabilization. A solid arthrodesis with precise bone graft insertion and accurate wire fixation is confirmed radiographically; the Kirschner wires are bent, cut, and left protruding through the skin.

The capsular tissues are then imbricated and repaired with absorbable sutures. In cases with soft tissue deficiency, a tendon transfer employing the distal half of the insertion of the extensor carpi radialis longus can be advanced dorsally and ulnarly to the insertion of the extensor carpi radialis brevis. The transferred tendon reinforces the capsular tissues and provides not only static but also dynamic stability to the fusion site. The skin wound is closed over a small drain.

The wrist and MP joints are mobilized postoperatively for 6 to 8 weeks or until radiographic union is clearly evident. Once the fusion is solid, the Kirschner wires are removed in the office and an intensive program of hand therapy is initiated. Rehabilitation with alleviation of pain and restoration of mobility and strength sufficient to resume competition requires a period of approximately 6 months.

Fig. 8. Selective carpometacarpal arthrodesis is performed by placing a cortical cancellous slot graft as well as cancellous autograft, usually procured from the iliac crest, into a precisely created cancellous trough at the involved CMC joints.
Authors’ Assessment of Operative Treatment

For both boxer’s knuckle and traumatic carpal boss the outcome of operative treatment has proved consistently favorable. Follow-up evaluation, although difficult to obtain for the competitive boxer, in general has revealed a high level of patient satisfaction, as each athlete experienced relief of pain and recovered digital mobility as well as hand strength commensurate with the needs of a highly competitive boxer, and all returned to unrestricted competition. Three patients initially treated surgically for

Fig. 9. (A) Transverse incision directly over the traumatic carpometacarpal boss with periarticular hypertrophic spur formation and concomitant articular degeneration. (B) Cortical cancellous slot graft as well as cancellous autograft is compressed into the cancellous trough created at the involved CMC joints. The site is then firmly compressed and the insertion of additional 0.062 Kirschner wires ensures secure stabilization. (C) Immediate postoperative radiograph following arthrodesis of all 4 finger carpometacarpal joints. (D, E) Postoperative radiographs demonstrating a solid fusion of all 4 finger carpometacarpal joints.
boxer’s knuckle required additional operative procedures. Two required surgery for osteochondral fractures occurring 2 and 4 years, respectively, after their initial operation. Both of these patients experienced a successful treatment regimen and were able to resume their boxing careers. The third boxer, despite uncomplicated surgery for his MP joint, developed a disabling traumatic carpal boss in the ipsilateral hand that was successfully treated by arthrodesis. Subsequently, he also resumed a successful boxing career.

**PREVENTION OF INJURY**

Nowhere in sports are the hands at a greater risk for injury than in the boxing ring. Because boxing requires continual exposure of the hands to trauma, boxer’s knuckle and traumatic carpal boss are seemingly inevitable consequences. Nonetheless, with recognition of the mechanics as well as the vulnerable sites of injury, preventive measures as applied to other sports can be employed in boxing with an expectant decrease in the occurrence of injury.

Skillful and carefully supervised training is essential to safety. Not only physical conditioning but also hand function should be uncompromised. Flawless, efficient, and potentially less injurious mechanics of punching must be mastered by the fighter, whereas excessive punching should be avoided. Rational methods of taping and wrapping should be precisely contoured to the anatomic configurations of the hand with the objectives of absorbing, diffusing, and diminishing detrimental forces while protecting the vulnerable sites of injury. State boxing commission rules for taping, wrapping, and gloving should be well conceived and carefully formulated with protection as a foremost consideration. Furthermore, commission rules should be standardized so that the hands are continually protected and each fighter is afforded access to beneficial methods of injury prevention.

Custom-fit gloves and flexible casts with increased shock-absorbing capacity are not permissible in boxing matches, but can be provided for training and sparring. Also, the principles of these devices should be incorporated in the design and manufacture of bout gloves as a rational additive measure against detrimental forces incurred by the hand. These protective devices are especially beneficial to the boxer returning to the ring after injury.

The fighter returning from injury requires particularly careful management. Because full recovery is contingent not only on healing of damaged tissues but also on comprehensive rehabilitation of repaired structures, a carefully planned therapy program is essential to a successful outcome. The fighter is continually advised that the recovery of mobility, strength, and endurance essential to a successful competitor is optimally achieved with dedicated rehabilitation that may require several or more months. The fighter also must be continually cautioned against a premature return to competition that is prone to a considerable risk of reinjury.

The boxer’s hands should be constantly monitored by knowledgeable medical personnel for pain and other evidence of potentially disabling trauma. Inflammation, bruising, swelling, and tenderness at vulnerable sites are signs of injury that should be thoroughly evaluated and treated before the fighter is permitted to resume punching. When serious injury is either suspected or detected, consultation with sports medicine specialists is advised.

With increasing recognition and application of preventive measures in boxing, the incidence of hand injuries and the need for operative intervention will undoubtedly diminish.
SUMMARY

The authors advocate operative treatment of the two most debilitating hand-related boxing injuries; namely, boxer’s knuckle and traumatic carpal boss. Recognition of the normal anatomy as well as the predictable pathology facilitates an accurate diagnosis and precision surgery. For boxer’s knuckle, direct repair of the disrupted extensor hood, without the need for tendon augmentation, has been consistently employed; for traumatic carpal boss, arthrodesis of the destabilized CMC joints has been the preferred method of treatment. Precisely executed operative treatment of both injuries has resulted in an expectant favorable outcome, as in the vast majority of cases the boxers have experienced relief of pain, restoration of function, and an unrestricted return to competition. An increasing application of preventive measures to the sport of boxing should decrease the occurrence of injury and the need for operative intervention.

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