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Hand carpometacarpal joint instability in elite boxers: injury characteristics, surgical technique, and outcomes

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**Abstract:**

Purpose: We describe a single-surgeon's experience of managing hand carpometacarpal joint (CMCJ) instability in elite boxers, focusing on injury characteristics, surgical technique, and outcomes.  
Methods: This prospective cohort included consecutive elite boxers undergoing surgery for hand CMCJ instability between 2009-2021. Diagnosis was mostly clinical with imaging reserved if equivocal. CMCJs were accessed via longitudinal incisions either between index/middle rays, and additionally ring/little. As the CMCJs were exposed, often marked deficiency in the CMCJ ligamentous capsule was seen. The articular surfaces were decorticated to cancellous bone with autogenous bone graft impacted. The CMCJ's were fixed in extension using various methods, with memory staples now preferred. Outcomes included radiographic fusion, return to boxing, and complications.

Results: 40 hands had surgery in 38 boxers. In total, 101 CMCJs were fused, with an average of 2.53 joints per patient. Patients were mainly young (mean age 24.1 years) male (37/38) with the trailing hand more commonly affected (trailing hand 87.5%, leading hand 12.5%). The most frequently fused CMCJ was the index (97.5%, n=39), then middle (95%, n=38); ring (45%, n=18); and little (15%, n=6). 82% (31/38) of patients returned to the same level of boxing at a median of 8 months from surgery (range 3-27 months). Three patients had revision surgery for non-union, a median of 9.4 months after initial surgery (range 3.2-133.1 months): two for index/middle and one for the little CMCJ. All three revisions fused and returned to boxing at the same level, although the little CMCJ required a second bone graft and fixation.

Conclusions: This represents the largest series of hand CMCJ instability in elite boxers treated surgically. The lead surgeon has developed and described a robust technique for treating these injuries. Patients can achieve full recovery and most can return to boxing at the same level with little risk of complications.

Type of Study: Level 4 Case-series

---Manuscript Draft---

**Response to Reviewers:**

Powered by Editorial Manager® and ProduXion Manager® from Aries Systems Corporation
31 January 2022

Professor Brent Graham
Editor-in-Chief: Journal of Hand Surgery

Re: Hand carpometacarpal joint instability in elite boxers: injury characteristics, surgical technique, and outcomes

Dear Prof Graham,

Thank you for re-considering our manuscript on our retrospective study of carpometacarpal injuries amongst elite boxers. We have addressed your comments, tracked on the manuscript, and have uploaded it as well as a clean version,

Yours sincerely,

Mr David Bodansky FRCS
Orthopaedic Registrar
On behalf of the authors
Abstract

INTRODUCTION

Purpose

We describe a single-surgeon’s experience of managing hand carpometacarpal joint (CMCJ) instability in elite boxers, focusing on injury characteristics, surgical technique, and outcomes.

METHODS AND MATERIALS

This retrospective cohort included consecutive elite boxers undergoing surgery for hand CMCJ instability between 2009-2021. CMC joint instability is usually clear on clinical examination using a ‘seesaw’ test. All cases had a plain radiograph and in equivocal cases for instability advanced imaging such as MRI or ultrasound scan was performed. Diagnosis was mostly clinical with imaging reserved if the clinical evaluation was equivocal. CMCJs were accessed via longitudinal incisions either between index/middle rays, and additionally ring/little. As the CMCJs were exposed, often marked deficiency in the CMCJ ligamentous capsule was seen. The articular surfaces were decorticated to cancellous bone and with autogenous bone graft impacted. The CMCJs were fixed in extension using various methods, with memory staples now preferred. Outcomes included radiographic fusion, return to boxing, and complications.

RESULTS

Forty hands had surgery in 38 boxers. In total, 101 CMCJs were fused, with an average of 2.6 joints per patient. Patients were mainly young (mean age 24.1 years), male (37/38) with...
the trailing hand more commonly affected (trailing hand 87.5%, leading hand 12.5%). The most frequently fused CMCJ was the index (97.5%, n=39), then middle (95%, n=38); ring (45%, n=18); and little (15%, n=6). There were 82% (31/38) of patients who returned to the same level of boxing at a median of 8 months from surgery (range 3-27 months). Three patients had revision surgery for non-union, a median of 9.4 months after initial surgery (range 3.2-133.1 months): two for index/middle and one for the little CMCJ. All three revisions fused and the patients returned to boxing at the same level, although the little CMCJ required a second bone graft and fixation.

**DISCUSSION**

**Conclusions**

This represents the largest series of hand CMCJ instability in elite boxers treated surgically. The lead surgeon has developed and described a robust technique for treating these injuries. Patients can achieve full recovery after treatment of CMCJ instability, and most can return to boxing at the same level with little risk of complications.

**Type of Study:** Level 4, Therapeutic Case-series
Hand injuries are the commonest type of injury sustained by amateur and professional boxers. This increased risk of hand injury is to be expected given the high forces transmitted through a clenched fist. A recent study detailing hand injuries in elite boxers over 8-years reported that the commonest hand and wrist injury sustained was hand carpometacarpal joint (CMCJ) instability. The authors reported CMCJ instability accounted for 22% of all hand and wrist injuries in their series, and this was the diagnosis with the longest duration of training time lost at a mean of 54 days (total 2,009 training days lost in the cohort).

Only 5 degrees of sagittal movement occurs at the index and middle finger CMC joints due to the interlocking bony architecture. Here, the index CMCJ articulates with a ‘V’ shaped facet of the trapezium and smaller facets for the capitate and trapezoid (4). The middle finger metacarpal interlocks radially, with the index metacarpal and articulates with a ‘V’ shaped facet of the capitate. In comparison, 30 degrees of sagittal movement occurs at the ring and little finger CMC joints, articulating against two flatter facets on the hamate (4).

In striking, the fingers are curled into the palm to buttress the thenar and hypothenar eminences and force is transmitted from the metacarpal-phalangeal joints through the CMC joints, up the kinetic chain of the upper extremity (5). When a boxer tires, the radio-carpal joint is prone to collapse into flexion on striking, loading the CMCJ eccentrically, straining the dorsal CMCJ ligaments causing attenuation (6, 7). This may present as pain, instability, or peri-articular osteophyte formation, known as “traumatic carpal bossing” (6, 8-10).
Although surgery is often needed to manage CMCJ instability in boxers who wish to continue competing, little is known about the surgical management and subsequent outcomes in these high-demand athletes, including the ability to return to sport postoperatively. Most literature is from small series, which include fewer than 15 patients and short follow-up periods (4, 10-13). In addition, the recovery time from surgery can be prolonged, up to 12 months (3, 8).

We describe a single-surgeon’s experience of managing hand CMCJ instability in elite boxers. We have focused on the injury characteristics, surgical technique, and outcomes.
Methods

This prospective-retrospective cohort study included consecutive elite boxers undergoing surgery for hand CMCJ instability between 2009 and 2021 in the UK. Elite boxers are defined as those who are either professional boxers or amateurs competing at a national or international level. Referrals were either from the medical team of the relevant amateur national sporting organisation, or in the case of professionals from the boxers themselves. Surgeries were performed by an experienced hand surgeon, with all data prospectively-collected and recorded in an electronic patient database. Institutional approval was obtained for this work and all patients provided informed consent to participate in the study. Patients were included in the study if they were above 16 years and had a closed injury to the CMCJ joint. Patients were excluded if they had concomitant injuries or were unable to consent for treatment.

Clinical assessment and investigations

The clinical presentation of hand CMCJ instability is usually that of pain on impact over the dorsum of the affected CMCJ. It often occurs either following a single forceful punch against an opponent, or a gradual onset of pain following repeated impact while boxing. In the acute setting there is often very little to see on initial inspection with absent swelling and bruising, although one patient presented with a dramatic index to little finger CMCJ dislocation. In the chronic setting there may be carpal bossing. Boxers often seek treatment with pain on impact preventing them from competing. There may also be a reduction in hand grip strength dynamometer readings, compared to baseline and the contralateral side, with 20% reduction indicating pathology (14).

The diagnosis was mostly clinical, with a good history and instability demonstrated on clinical examination. Imaging often does not add much in the presence of a good history.
Radiographs were performed in all cases, with further imaging (dynamic ultrasound, magnetic resonance imaging (MRI), or computerised tomography) reserved for cases where clinical instability was equivocal. As the dorsal ligamentous complex is a thin structure, tears, laxity and oedema can be challenging to assess on cross-sectional imaging.

All patients were preoperatively consented for CMCJ fusion and bone graft. Bone graft was usually harvested from the boxers trailing iliac crest in cases where more than one CMCJ was fused, and the distal radius used as a donor site where less bone graft was required.

**Carpal Seesaw test**

The authors have found a helpful clinical test to localise pain is stressing the CMCJ. Pain, with a soft end-point corroborates the history (14). The CMCJ is stressed to open the articulation dorsally and identify joint laxity and discomfort. In order to do this the examiners thumb is placed into the palm of the boxer at the level of the proximal metacarpal and the examiners index finger placed on the boxer’s metacarpal head with an attempt to depress the head volarily, in an attempt to open the CMCJ dorsally, as a type 1 lever (Figure 1).

**Surgical technique**

All cases were performed under general anaesthesia. A longitudinal straight incision was used over the interval of index and middle CMCJs and additionally ring and little CMCJs as required (Figure 2). The skin flap was carefully elevated off the finger extensor tendons, which were retracted. The extensor carpi radialis brevis and longus tendons are partially elevated off the base of the metacarpals to access the CMCJs. The underlying CMCJ-s are often exposed with absent dorsal ligaments and capsule due to chronic atrophy, or in other cases the capsule is lax (Figure 3). The joints are assessed for instability, and these usually correspond to those...
suggested on preoperative examination. The articular surfaces are removed with a sharp osteotome to the volar cortex exposing bleeding cancellous bone. A small Macdonald retractor can be placed below the metacarpal base to lever up the volar rim to ensure complete decortication (Figure 4). The interval between the index and middle metacarpal bases are also debrided and bone graft inserted to increase the fusion area and prevent longitudinal instability between the index and middle rays. Multiple small 1.6mm K-wire holes are made in the prepared cancellous bone surfaces to encourage healing.

Cancellous bone graft harvested from the trailing hip is impacted into the large defect. The trailing hip is preferred because it is further from the opponent and therefore less likely to be struck with a low blow causing pain after return to competition. Bone graft should be impacted into the debrided joint down to the volar rim filling the void, which can be confirmed on intra-operative radiographs. The prepared joints are then reduced into neutral extension by elevation of the volar metacarpal and fixed under radiographic control. We always attempted to fuse the CMCJ’s in a neutral position to align the MC heads; fusion in flexion at the CMCJ would drop the metacarpal head while in extension would raise the metacarpal head. Early in the series, smooth exposed K-wires were utilised to reduce costs for those self-funding the procedure. This remains an acceptable method of fixation, but the senior author now prefers permanent internal fixation using either headless compressions screws or memory staples, the latter being his latest method. The self-drilling cannulated headless compression screws were inserted in a retrograde manner obliquely across the grafted joints (figure 5). An attempt to criss-cross oblique screws in the index/middle and ring/little seemed to offer the most stable construct. The use of staples for internal fixation is shown in F (figure 5). Before inserting staples, the interval between the bases of the index and middle MC’s is debrided with a sharp osteotome and bone graft impacted. Care must be taken to avoid metalwork insertion and...

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 AUTHOR RESPONSE: Yes, this is correct as now edited.

Commented [BG11]: That isn’t what figure 5 shows.
 AUTHOR RESPONSE: amended.
irritation incursion into the facet on the trapezoid and fluoroscopy is advised throughout. Internal fixation of the index to middle metacarpal bases is advised to increase the stability. The use of staples for internal fixation is shown (figure 5 and 6). We find memory staples easier to use and are inserted under direct vision across the joint. Headless compression screws require additional small incisions away from the operative site and need to be inserted under careful fluoroscopy. Both methods of fixation are on balance equally likely to have similar union rates.

Tissue planes are closed in layers with dissolvable sutures where possible with dissolvable sutures and immobilisation is maintained for four to six weeks with a below-elbow volar backslab, with free MPJ movement to prevent stiffness in these joints.

Rehabilitation
Rehabilitation is performed under the guidance of a hand therapist or physiotherapist (appendix A). The patient is allowed home in a volar backslab on the same day and is advised to perform gentle active flexion/extension of the MCP, PIP and DIP joints. They are seen within 5 days for a wound check and assessment of edema. A full plaster cast or wrap around thermoplastic splint is fitted at this stage and monitored throughout the immobilisation period. Early gentle active flexion and extension of all MCP/PIP and DIP joints is commenced within the first week to prevent stiffness and promote tendon gliding.

At six weeks, the splint can be changed to a removable neoprene wrist support with a volar rigid reinforcement to allow hand hygiene, scar care and commence gentle active wrist flexion and extension. The splint can be used to provide additional support to the hand/wrist when returning to impact.
Once bony consolidation has been confirmed the patient may commence grip strengthening, focusing on both intrinsic and extrinsic hand-wrist muscles, proprioception and with consideration of the rest of the upper limb and wider kinetic chain. Progressive active hand-wrist loading continues between 8–10 weeks as bony fusion consolidates. A plain radiograph is performed between 8–10 weeks to ensure bony union.

Once bony union has been confirmed radiographically, the boxer can gradually start to resume light impact through the hand. Prior to impact, hand-wrist strength testing is performed, ensuring near full hand-wrist strength is available to prevent the risk of re-injury. Progressing loading in a systematic manner commences with water punching bags, progressing to normal bags (softer to harder), then pads, technical sparring, and eventually open sparring can begin if no adverse reaction is encountered at each stage. In our experience a period of 4–6 weeks is expected from initial impact to full impact in sparring. An off-the-shelf Neoprene wrist brace with a volar metal bar may be useful to allow the athlete to progress sport specific loading strategies.

Data collected

Data were prospectively collected on patient demographics (age, sex, hand dominance, boxing stance), previous treatment (steroid injections and/or surgery), imaging, and injury characteristics (hand, digit(s) injured), and surgical technique (bone graft used, and fixation methods). Outcomes assessed postoperatively including bony union radiologically, return to boxing (and whether this was at the same competition level as previously), any complications, and further surgery.
Results

Patient and injury characteristics

Thirty-eight boxers underwent surgery on 40 hands, with a mean age of 24.1 years (SD 3.2) and 37/38 were male (97%). Thirty-two patients (84%) were right-hand dominant. Four of the six left-hand dominant boxers fought with a southpaw stance (leading with right hand and foot). The remaining 34 boxers fought with an orthodox stance (leading with left hand and foot), including two of the left-handed dominant fighters. The symptom duration before surgery varied, with a median of 14.5 months (range 2-132 months).

Injuries more commonly involved the trailing right-hand. In the 36 injuries seen amongst the 34 orthodox fighters, 31/36 (86%) had right-hand injuries, and 5/36 (9%) had left-hand injuries, including two boxers with bilateral injuries. All the four southpaws had left-hand injuries. All six left-handed boxers required surgery on their left hand, regardless of whether their stance was orthodox or southpaw. The most frequently injured digits amongst the cohort were the striking digits; index (97.5%, n=39), then middle (95%, n=38); ring (45%, n=18); and little (15%, n=6), (table 1). An average of 2.53 joints per hand were injured which needed surgery.

The decision as to which joints to arthrodese was based primarily upon those joints that were painful on punching and had signs of clinical laxity on examination. It is our experience that the boxer can identify those joints that are painful and affected.

All patients had pre-operative radiographs to evaluate bony anatomy. Additional imaging occurred in 20 patients: 12 receiving an MRI, 5 a CT and 3 undergoing an ultrasound scan. Twenty-four hands received an intervention prior to surgery, of which, 19 received a corticosteroid injection prior to surgery and 5 had undergone prior surgical intervention with other surgeons (Table 2). One patient had an acute traumatic dislocation of CMC J 2-4-V and did
not have a steroid injection. This acute dislocation underwent closed reduction and temporary buried K-wire stabilisation on the advice of the senior author at the local hospital by another surgeon and definitive CMCJ fusion several weeks later.

The method of joint fixation evolved during the cohort period, with K-wires used in 8 (20%) hands, compression screws in 16 (40%), and staples in 16 (40%). Autograft was used in all cases: distal radius in 6 and iliac in 34. No bone graft donor site problems were reported.

Postoperative outcomes

The median post-operative follow-up time for the cohort was 45 months (range 1.3-147 months). One patient (2.5%) had a superficial K-wire pin site infection treated with oral antibiotics. Three hands (7.5%) had revision surgery for non-union a median of 9.4 months after initial surgery: one at 9.4 months; one at 133 months; and one at 10.3 months. The first two patients fused after their revision procedure. The latter patient who had a revision at 10.3 months following their index surgery required another fusion procedure 12.5 months later (i.e. 22.8 months from the index surgery) which was successful with a further fusion at 22.8 months. Infection was excluded with radiographs and blood tests (including WCC and CRP). We did not identify any common themes factors in the non-union cohort. Two revisions were for index to middle CMCJs and one for the little finger CMCJ. All revisions fused, although the little CMCJ required a second bone graft and fixation. The other 37 hands united on radiographs by a median of 3.8 months (range 1-123 months). There were The range was increased as one patient missed early appointments and returned for another reason. 82% (31/38) of patients who returned to the same competition level of boxing at a median of 8 months from surgery (range 3-27 months). The seven boxers who did not return to the previous level were due to retirement from boxing despite bone union. This was due to a number of factors, including
advancing age, time away from competing and the realisation that the intervention of Covid-
19 pandemic prevented competition for 18 months.
Discussion

CMCJ instability of the hand is a serious injury for boxers that is poorly appreciated. Historically, this injury was career-ending. In all series, including ours, they tend to occur in young males, however we have seen an increase in female boxers as the popularity of the sport among women grows (4). We have presented characteristics of 40 hands with CMCJ instability sustained in 38 elite boxers, as well as detailed our surgical technique and rehabilitation regimen. Furthermore, we have described the clinical outcomes in these patients, including high levels of return to sport at the same level as previously. ADDIN EN.CITE ADDIN EN.CITE.DATA (3, 8).

The dorsal CMCJ anatomy of the CMCJ is predictable with a dorsal ligamentous capsular complex. These dorsal restraining structures usually attenuate with repeated trauma although we have seen two acute traumatic initial events: one with an MRI showing the tear (Figure 7) and the other with complete II-V CMCJ dislocation.

CMCJ instability of the hand is a serious injury for boxers that is poorly appreciated. Historically, this injury was career-ending with a boxer retiring with "weak hands". In all series, including ours, they tend to occur in young males, however we have seen an increase in female boxers as the popularity of the sport amongst women grows (4). An initial corticosteroid injection is reasonable to allow a boxer to return for an important event but ultimately, they require surgery if they wish to continue competition. Instability persists. CMCJ ligament repair or reconstruction has largely been abandoned due to the high forces involved in favour of a reliable, permanent treatment, by way of fusion of the affected joints as described.
In our series, 97.5% of CMCJ injuries involved the longer striking index and middle fingers, which is not surprising given they are the longer striking digits. The Great Britain (GB) Olympic boxing team have over the last 15 years, carefully looked at injury prevention and seen a decrease in CMCJ injuries (2, 3), due to a combination of improved hand wrapping techniques in both training and competition along with more specific strength strategies in the upper limb (2, 3).

Further, many CMC injuries have been successfully managed non-operatively, as compared to more readily opting for surgery, through the introduction of specific monitoring tools to assist prognosis alongside enhanced rehabilitation strategies (15).

The senior author pays particular attention to the clinical assessment rather than imaging although an initial radiograph is mandatory to assess the bony architecture. Patients had received different imaging modalities previously, each with slightly different benefits. An USS allows the assessment for dynamic instability with dorsal CMCJ opening. An MRI can visualise the dorsal ligament and bone edema in the unstable joints, and a CT will demonstrate the dorsal bossing and occasional loose fragment. In these cases, cross-sectional imaging did not add useful clinical information in the presence of a consistent history and examination.

Over the years certain surgical aspects and pearls have evolved. We pay particular attention to bony debridement to the volar rim of both the carpal bone and metacarpal base. We use generous amounts of cancellous bone usually from the iliac crest with no morbidity in our series (n=40). The staples are inserted into the predrilled holes across the CMCJ. We do not create a recess or trough because the cortical bone around the staple leg is needed for fixation.

Dorsally applied memory staples are simple to insert and reduce the risk of trapezoid facet

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AUTHOR RESPONSE
We have made these changes here and throughout. We have used the term “non-operative”.

14
penetration that is of concern with the use of retrograde headless compression screws from the middle metacarpal to the trapezoid.

Our postoperative rehabilitation regime has evolved very little with time. We aim to achieve early full range of motion of the finger joints while the underlying bone heals. Return to impact around 8 weeks after an encouraging radiograph with a gentle load and gradually increasing to full impact at 12-16 weeks if no adverse reaction or pain has ensued.

Our patients experienced good results with all but 7 patients returning to the same competition level of boxing on average by 8 months. Given this large series of patients treated we consider that these represent favourable results with high levels of return to play, thus suggesting the technique used is effective and durable.

There is a paucity of data on this subject, with only three small series involving 15, 13 and 11 cases of CMCJ instability (4, 10, 13). Revision surgery was performed in 3 cases (7.5%) in our series resulting in successful bony fusion in all cases. There were no other complications recorded. The little finger CMCJ non-union was fused successfully after two further attempts with bone graft with no further problems and the patient returned to boxing at the same competition level.

Most boxers with this injury have at some stage received a corticosteroid injection to temporarily alleviate symptoms and allow them to return to competition. Steroid injections have a useful role in the management of this condition and often allow participation in competition until surgery can be scheduled. It is rare that boxers experienced resolution of their symptoms and were able to return to sport without surgery or further treatment.
Injections of local anesthetic alone do not have value as a diagnostic tool in identifying which CMCJs may require arthrodesis as the CMCJ’s all communicate with each other across the hand. A local anaesthetic injection into the index CMCJ will traverse the hand and affect the little CMCJ. We are cautious about operating soon after a steroid injection and prefer a minimum interval of 8-12 weeks between injections and surgery for fusion.

Strengths of this study include it being a large series of elite boxers undergoing surgery under by a single the same surgeon. We have contacted all boxers. Although this cohort may not be reliable responding to surveillance, messages, emails etc, we have been able to accurately track their return to competitions and subsequent activity from online records of professional boxing events (BoxRec.com). While we appreciate this may not be as accurate as face-to-face communication, we are confident their hands are satisfactory as they need to pass a medical from the relevant medical boxing board of controls prior to competing. This cohort of patients is notoriously unreliable in their follow up and BoxRec.com was felt to be a reliable independent indicator of return to full function.

Limitations of this study include the experience and results of one surgeon not being generalisable to all surgeons undertaking these procedures, especially those with limited prior experience. It was not possible to have the same protocol for all the patients given that the operations were performed over 13-years and the surgeon’s protocol evolved over time. Finally, despite having data on time to return to boxing for all patients, validated patient-reported outcome measures were not available, neither were objective data such as grip and pinch strength. However, we consider that these would not add useful information in elite athletes.
Conclusions

This represents the largest series of hand CMCJ instability in elite boxers treated with surgery. The lead surgeon has developed and refined a robust technique for treating these injuries, which has been described in detail. Postoperatively, we recommend that following the surgical techniques and rehabilitation described patients can expect to achieve a full recovery and most can return to boxing at the same level as previously with little risk of complications.


5. Morgan MH, Carrier DR. Protective buttressing of the human fist and the evolution of hominin hands. (1477-9145 (Electronic)).


8. Joseph RB Fau – Linscheid RL, Linscheid RI Fau - Dobyns JH, Dobyns Jh Fau - Bryan RS, Bryan RS. Chronic sprains of the carpometacarpal joints. (0363-5023 (Print)).


Figure legends

Figure 1: Carpal Seesaw test, acting as a type 1 lever

Figure 2: Incisions centred between index and middle rays and between ring and little finger rays

Figure 3: Absent capsule

Figure 4: Elevation of metacarpal base

Figure 5: Fixation with headless compression screws in a 'criss-cross' oblique manner, showing bony union at all fusion sites

Figure 6: Fixation with staples of index, middle and ring finger CMCJs, showing bony union at all fusion sites

Figure 7: Sagittal MRI T2 weighted image showing disruption of dorsal ligamentous complex of the CMCJ

Table 1: Summary of injured CMC joint digits

Table 2: Summary of prior interventions
Hand carpometacarpal joint instability in elite boxers: injury characteristics, surgical technique, and outcomes

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Key words: Boxing, CMCJ, instability, elite athlete
Abstract

Purpose

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METHODS AND MATERIALS

This retrospective cohort included consecutive elite boxers undergoing surgery for hand CMCJ instability between 2009-2021. CMC joint instability is usually clear on clinical examination using a ‘seesaw’ test. All cases had a plain radiograph and in equivocal cases for instability advanced imaging such as MRI or ultrasound scan was performed.

CMCJs were accessed via longitudinal incisions either between index/middle rays, and additionally ring/little. As the CMCJs were exposed, often marked deficiency in the CMCJ ligamentous capsule was seen. The articular surfaces were decorticated to cancellous bone and autogenous bone graft impacted. The CMCJs were fixed in extension using various methods, with memory staples now preferred. Outcomes included radiographic fusion, return to boxing, and complications.

RESULTS

Forty hands had surgery in 38 boxers. In total, 101 CMCJs were fused, with an average of 2.5 joints per patient. Patients were mainly young (mean age 24.1 years), male (37/38) with the trailing hand more commonly affected (trailing hand 87.5%, leading hand 12.5%). The most
frequently fused CMCJ was the index (97.5%, n=39), then middle (95%, n=38); ring (45%, n=18); and little (15%, n=6). There were 82% (31/38) of patients who returned to the same level of boxing at a median of 8 months from surgery (range 3-27 months). Three patients had revision surgery for non-union, a median of 9.4 months after initial surgery (range 3.2-133.1 months): two for index/middle and one for the little CMCJ. All three revisions fused and the patients returned to boxing at the same level, although the little CMCJ required a second bone graft and fixation.

Conclusions

Patients can achieve full recovery after treatment of CMCJ instability, and most can return to boxing at the same level with little risk of complications.

Type of Study: Level 4, Therapeutic
Introduction

Hand injuries are the commonest injury sustained by boxers. This risk of hand injury is to be expected given the high forces transmitted through a clenched fist (1). These injuries lead to the greatest amount of time lost from training and competition (2). A study detailing hand injuries in elite boxers over 8-years reported that the commonest hand and wrist injury sustained was hand carpometacarpal joint (CMCJ) instability (3). The authors reported CMCJ instability accounted for 22% of all hand and wrist injuries in their series, and this was the diagnosis with the longest duration of training time lost at a mean of 54 days (3).

Only 5 degrees of sagittal movement occurs at the index and middle finger CMC joints due to the interlocking bony architecture. Here, the index CMCJ articulates with a ‘V’ shaped facet of the trapezium and smaller facets for the capitate and trapezoid (4). The middle finger metacarpal interlocks radially with the index metacarpal and articulates with a ‘V’ shaped facet of the capitate. In comparison, 30 degrees of sagittal movement occurs at the ring and little finger CMC joints, articulating against two flatter facets on the hamate (4).

In striking, the fingers are curled into the palm to buttress the thenar and hypothenar eminences and force is transmitted from the metacarpal-phalangeal joints through the CMC joints, up the kinetic chain of the upper extremity (5). The radio-carpal joint is prone to collapse into flexion on striking, loading the CMCJ eccentrically, straining the dorsal CMCJ ligaments causing attenuation (6, 7). This may present as pain, instability, or peri-articular osteophyte formation, known as “traumatic carpal bossing” (6, 8-10).

Little is known about the surgical management and subsequent outcomes in these high-demand athletes, including the ability to return to sport postoperatively. Most literature is from small series, which include fewer than 15 patients and short follow-up periods (4, 10-13). In addition, the recovery time from surgery can be prolonged, up to 12 months (3, 8).
We describe a single-surgeon’s experience of managing hand CMCJ instability in elite boxers, focusing on injury characteristics, surgical technique, and outcomes.
Methods

This retrospective cohort study included elite boxers undergoing surgery for hand CMCJ instability between 2009 and 2021 in the UK. Elite boxers are defined as those who are either professional or amateur competing at a national or international level. Surgeries were performed by an experienced hand surgeon, with all data collected and recorded in an electronic patient database. Institutional approval was obtained and all patients provided informed consent to participate in the study. Patients were included in the study if there were above 16 years and had a closed CMCJ joint injury. Patients were excluded if they had concomitant injuries or were unable to consent for treatment.

Clinical assessment and investigations

The clinical presentation of hand CMCJ instability is usually pain on impact over the dorsum of the affected CMCJs. It occurs either following a single forceful punch against an opponent, or a gradual onset of pain following repeated impact while boxing. In the acute setting there is often little to see on initial inspection with no swelling or bruising, although one patient presented with a dramatic index to little finger CMCJ dislocation. In the chronic setting there may be carpal bossing.

The diagnosis was is made with a good history and instability demonstrated on clinical examination. Radiographs were performed in all cases, with further imaging (dynamic ultrasound, magnetic resonance imaging (MRI), or computerised tomography) reserved for cases where clinical instability was equivocal.
All patients were preoperatively consented for CMCJ fusion and bone graft. Bone graft was usually harvested from the boxers trailing iliac crest in cases where more than one CMCJ was fused, and the distal radius used as a donor site where less bone graft was required.

**Carpal Seesaw test**

The authors have found a helpful clinical test to localise pain is stressing the CMCJ. Pain, with a soft endpoint corroborates the history (14). The CMCJ is stressed to open the articulation dorsally and identify joint laxity and discomfort. The examiners thumb is placed into the palm of the boxer at the level of the proximal metacarpal and the examiners index finger placed on the boxer’s metacarpal head with an attempt to depress the head volarly, to open the CMCJ dorsally, as a type 1 lever (Figure 1).

**Surgical technique**

All cases were performed under general anaesthesia. A longitudinal straight incision was used over the interval of index and middle CMCJs and additionally ring and little CMCJs as required (Figure 2). The skin flap was carefully elevated off the finger extensor tendons, which were retracted. The extensor carpi radialis brevis and longus tendons are partially elevated off the base of the metacarpals to access the CMCJs. The underlying CMCJs are often exposed with absent dorsal ligaments and capsule due to chronic atrophy, or the capsule is lax (Figure 3). The joints are assessed for instability. The articular surfaces are removed with a sharp osteotome to the volar cortex exposing bleeding cancellous bone. A small Macdonald retractor can be placed below the metacarpal base to lever up the volar rim to ensure complete decortication (Figure 4). The interval between the index and middle metacarpal bases are also debrided and bone graft inserted to increase the fusion area and prevent longitudinal instability.
between the index and middle rays. Multiple small 1.6mm K-wire holes are made in the
prepared cancellous bone surfaces to encourage healing.

Cancellous bone graft harvested from the trailing hip is impacted into the defect. The trailing
hip is preferred because it is further from the opponent and therefore less likely to be struck
after return to competition. Bone graft should be impacted into the debrided joint down to the
volar rim filling the void, which can be confirmed on intra-operative radiographs. The prepared
joints are then reduced into neutral extension by elevation of the volar metacarpal and fixed
under radiographic control. We always attempted to fuse the CMCJ’s in a neutral position to
align the MC heads. Early in the series, smooth exposed K-wires were utilised. This remains
an acceptable method of fixation, but the senior author now prefers permanent internal fixation
using either headless compressions screws or memory staples. The self-drilling cannulated
headless compression screws were inserted in a retrograde manner obliquely across the grafted
joints (figure 5). Care must be taken to avoid metalwork insertion and incursion onto the facet
on the trapezoid and fluoroscopy is advised throughout. Internal fixation of the index to middle
metacarpal bases is advised to increase the stability. The use of staples for internal fixation is
shown (figure 6). We find memory staples easier to use and are inserted under direct vision
across the joint. Headless compression screws require additional small incisions away from the
operative site. Both methods of fixation are equally likely to have similar union rates.

Immobilisation is maintained for four to six weeks with a below-elbow volar backslab, with
free MPJ movement to prevent stiffness in these joints.

Rehabilitation

Rehabilitation is performed under the guidance of a hand therapist or physiotherapist (appendix
A). The patient is allowed home in a volar backslab on the same day and is advised to perform
gentle active flexion/extension of the MCP, PIP and DIP joints. They are seen within 5 days for a wound check and assessment of edema. A full plaster cast or wrap around thermoplastic splint is fitted at this stage and monitored throughout the immobilization period. Early gentle active flexion and extension of all MCP/PIP and DIP joints is commenced within the first week to prevent stiffness and promote tendon gliding.

At six weeks, the splint can be changed to a removable neoprene wrist support with a volar rigid reinforcement to allow hand hygiene, scar care and commence gentle active wrist flexion and extension.

Once bony consolidation has been confirmed the patient may commence grip strengthening, focusing on both intrinsic and extrinsic hand-wrist muscles, proprioception and consideration of the rest of the upper limb and wider kinetic chain. Progressive active hand-wrist loading continues between 8-10 weeks as bony fusion consolidates. A plain radiograph is performed between 8-10 weeks to ensure bony union.

Once bony union has been confirmed radiographically, the boxer can gradually start to resume light impact through the hand. Progressing loading in a systematic manner commences with water punching bags, progressing to normal bags (softer to harder), then pads, technical sparring, and eventually open sparring can begin if no adverse reaction is encountered at each stage. In our experience a period of 4-6 weeks is expected from initial impact to full impact in sparring.

Data collected
Data were collected on patient demographics (age, sex, hand dominance, boxing stance), previous treatment (steroid injections and/or surgery), imaging, and injury characteristics (hand, digit(s) injured), and surgical technique (bone graft used, and fixation methods). Outcomes assessed postoperatively included bony union radiologically, return to boxing (and whether this was at the same competition level as previously), any complications, and further surgery.
Results

Patient and injury characteristics

Thirty-eight boxers underwent surgery on 40 hands, with a mean age of 24.1 years (SD 3.2) and 37/38 were male (97%). Thirty-two patients (84%) were right-hand dominant. Four of the six left-hand dominant boxers fought with a southpaw stance (leading with right hand and foot). The remaining 34 boxers fought with an orthodox stance (leading with left hand and foot), including two of the left-handed fighters. The symptom duration before surgery varied, with a median of 14.5 months (range 2-132).

Injuries more commonly involved the trailing right-hand. In the 36 injuries seen among the 34 orthodox fighters, 31/36 (86%) had right-hand injuries, and 5/36 (9%) had left-hand injuries, including two boxers with bilateral injuries. All the four southpaws had left-hand injuries. All six left-handed boxers required surgery on their left hand, regardless of whether their stance was orthodox or southpaw. The most frequently injured digits were the striking digits; index (97.5%, n=39), then middle (95%, n=38); ring (45%, n=18); and little (15%, n=6), (table 1).

The decision as to which joints to arthrodese was based primarily upon those joints that were painful on punching and had signs of clinical laxity on examination. It is our experience that the boxer can identify those joints that are painful and affected.

All patients had pre-operative radiographs to evaluate bony anatomy. Additional imaging occurred in 20 patients: 12 receiving an MRI, 5 a CT and 3 undergoing an ultrasound scan. Twenty-four hands received an intervention prior to surgery, of which, 19 received a corticosteroid injection prior to surgery and 5 had undergone prior surgical intervention with other surgeons (Table 2). One patient had an acute traumatic dislocation of CMCJ II-V and did
not have a steroid injection. This acute dislocation underwent closed reduction and temporary
buried K-wire stabilisation and definitive CMCJ fusion several weeks later.

The method of joint fixation evolved during the cohort period, with K-wires used in 8 (20%)
hands, compression screws in 16 (40%), and staples in 16 (40%). Autograft was used in all
cases: distal radius in 6 and iliac in 34. No bone graft donor site problems were reported.

**Postoperative outcomes**

The median post-operative follow-up time for the cohort was 45 months (range 1.3-147
months). One patient (2.5%) had a superficial K-wire pin site infection treated with oral
antibiotics. Three hands (7.5%) had revision surgery for non-union a median of 9.4 months
after initial surgery: one at 9.4 months; one at 133 months; and one at 10.3 months. The first
two patients fused after their revision procedure. The latter patient who had a revision at 10.3
months following their index surgery required another fusion procedure 12.5 months later (i.e.
22.8 months from the index surgery) which was successful. Infection was excluded with
radiographs and blood tests (including WCC and CRP). We did not identify any common
factors in the non-union cohort. Two revisions were for index to middle CMCJs and one for
the little finger CMCJ. All revisions fused, although the little CMCJ required a second bone
graft and fixation. The other 37 hands united on radiographs by a median of 3.8 months (range
1-123 months). There were 82% (31/38) of patients who returned to the same competition level
of boxing at a median of 8 months from surgery (range 3-27 months). The seven boxers who
did not return to the previous level were due to retirement from boxing despite bone union.

This was due to a number of factors, including advancing age, time away from competing and
the realisation that the Covid-19 pandemic prevented competition for 18 months.
Discussion

CMCJ instability of the hand is a serious injury for boxers that is poorly appreciated. Historically, this injury was career-ending. In all series, including ours, they tend to occur in young males, however we have seen an increase in female boxers as the popularity of the sport among women grows (4).

The dorsal CMCJ ligamentous capsular complex usually attenuates with repeated trauma although we have seen two acute traumatic initial events: one with an MRI showing the tear (Figure 7) and the other with complete II-V CMCJ dislocation.

An initial corticosteroid injection is reasonable to allow a boxer to return for an important event but ultimately, they require surgery if instability persists. CMCJ ligament repair or reconstruction has largely been abandoned in favour of a reliable, permanent fusion of the affected joints.

In our series, 97.5% of CMCJ injuries involved the longer striking index and middle fingers. The Great Britain (GB) Olympic boxing team have over the last 15 years, carefully looked at injury prevention and seen a decrease in CMCJ injuries due to a combination of improved hand wrapping techniques in both training and competition along with more specific strength strategies in the upper limb (2, 3). Further, many CMC injuries have been successfully managed non-operatively, through the introduction of specific monitoring tools to assist prognosis alongside enhanced rehabilitation strategies (15).

The senior author pays particular attention to the clinical assessment rather than imaging although an initial radiograph is mandatory to assess the bony architecture. Patients had
received different imaging modalities previously, each with slightly different benefits. An USS allows the assessment for dynamic instability with dorsal CMCJ opening. An MRI can visualise the dorsal ligament and bone edema in the unstable joints, and a CT will demonstrate the dorsal bossing and occasional loose fragment. In these cases, cross-sectional imaging did not add useful clinical information in the presence of a consistent history and examination.

We pay particular attention to bony debridement to the volar rim of both the carpal bone and metacarpal base. We use generous amounts of cancellous bone usually from the iliac crest. The staples are inserted into the predrilled holes across the CMCJ. We do not create a recess or trough because the cortical bone around the staple leg is needed for fixation. Dorsally applied memory staples are simple to insert and reduce the risk of trapezoid facet penetration that is of concern with the use of retrograde headless compression screws from the middle metacarpal to the trapezoid.

Our postoperative rehabilitation regime has evolved very little with time. We aim to achieve early full range of motion of the finger joints while the underlying joint fuses. Return to impact around 8 weeks after an encouraging radiograph with a gentle load and gradually increasing to full impact at 12-16 weeks if no adverse reaction or pain has ensued.

Our patients experienced good results with all but 7 patients returning to the same competition level of boxing on average by 8 months, suggesting the technique used is effective and durable.

There is a paucity of data on this subject, with only three small series involving 15, 13 and 11 cases of CMCJ instability (4, 10, 13). Revision surgery was performed in 3 cases (7.5%) in our series resulting in successful bony fusion in all cases. There were no other complications
recorded. The little finger CMCJ non-union was fused successfully after two further attempts with bone graft with no further problems and the patient returned to boxing at the same competition level.

Most boxers with this injury have at some stage received a corticosteroid injection to temporarily alleviate symptoms and allow them to return to competition. Steroid injections have a useful role in the management of this condition and often allow participation in competition until surgery can be scheduled. It is rare that boxers experienced resolution of their symptoms and were able to return to sport without surgery or further treatment.

Injections of local anesthetic alone do not have value as a diagnostic tool in identifying which CMCJs may require arthrodesis as the CMCJs all communicate with each other across the hand. A local anaesthetic injection into the index CMCJ will traverse the hand and affect the little CMCJ. We are cautious about operating soon after a steroid injection and prefer a minimum interval of 8-12 weeks between injections and surgery for fusion.

Strengths of this study include it being a large series of elite boxers undergoing surgery by a single surgeon. We have been able to accurately track their return to competition and subsequent activity from online records of professional boxing events (BoxRec.com). While we appreciate this may not be as accurate as face-to-face communication, we are confident their hands are satisfactory as they need to pass a medical from the relevant medical boxing board of controls prior to competing. BoxRec.com was felt to be a reliable independent indicator of return to full function.

Limitations of this study include the experience and results of one surgeon not being generalisable to all surgeons undertaking these procedures, especially those with limited prior
experience. It was not possible to have the same protocol for all the patients given that the operations were performed over 13-years and the surgeon’s protocol evolved over time. Finally, despite having data on time to return to boxing for all patients, validated patient-reported outcome measures were not available, neither were objective data such as grip and pinch strength.


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8. Joseph Rb Fau - Linscheid RL, Linscheid RI Fau - Dobyns JH, Dobyns Jh Fau - Bryan RS, Bryan RS. Chronic sprains of the carpometacarpal joints. (0363-5023 (Print)).


**Figure legends**

Figure 1: Carpal Seesaw test, acting as a type 1 lever

Figure 2: Incisions centred between index and middle rays and between ring and little finger rays

Figure 3: Absent capsule

Figure 4: Elevation of metacarpal base

Figure 5: Fixation with headless compression screws in a ‘criss-cross’ oblique manner, showing bony union at all fusion sites

Figure 6: Fixation with staples of index, middle and ring finger CMCJs, showing bony union at all fusion sites

Figure 7: Sagittal MRI T2 weighted image showing disruption of dorsal ligamentous complex of the CMCJ

Table 1: Summary of injured CMC joint digits

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<table>
<thead>
<tr>
<th>Joints</th>
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<tr>
<td>Index</td>
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<tr>
<td>Index, Middle, Ring</td>
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<td>Index, Middle, Ring, Little</td>
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</tr>
<tr>
<td>Ring, Little</td>
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<td><strong>Total</strong></td>
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</table>

*Table 1: Summary of injured CMC joint digits*
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<th>Previous intervention</th>
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<tr>
<td>Injection x1</td>
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<td>Injection x2</td>
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<td>Injection x3</td>
<td>2</td>
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<tr>
<td>Injection x5</td>
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<tr>
<td>Debridement (elsewhere)</td>
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<tr>
<td>Failed dorsal ligament CMCJ repair and K wire</td>
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</tr>
<tr>
<td>Injection x1, then MUA and K wire for trauma</td>
<td>1</td>
</tr>
<tr>
<td>MUA and K wire for traumatic acute 2-4 CMCJ subluxation</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>24</strong></td>
</tr>
</tbody>
</table>

*Table 2: Summary of prior interventions*
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