Management of Isolated Capitate Nonunion: A Case Series and Literature Review

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Abstract

Background Isolated capitate nonunion is rare. No consensus on the appropriate treatment for this condition exists.

Case Description We reported two cases of capitate fracture nonunion presenting several months after untreated high-impact wrist trauma. Treatment was delayed as both patients' nonunions were missed on conventional radiographs. Both were ultimately diagnosed with advanced imaging and successfully treated with internal fixation and autogenous bone grafting. The relevant literature pertaining to capitate nonunion was reviewed.

Literature Review Immobilization and internal fixation with bone grafting for capitate nonunion have been described in the literature. Loss of vascular supply and progression to avascular necrosis is a concern after capitate nonunion.

Clinical Relevance We present two cases and review the literature on the diagnosis and treatment of this rare injury to guide management. Internal fixation with autogenous bone grafting could play a role in management for this rare condition.

Keywords

- capitate fracture
- capitate nonunion
- wrist trauma

Isolated fractures of the capitate without dislocation are rare, accounting for less than 1% of carpal fractures,¹ and may pose a clinical and diagnostic challenge.² Most capitate fracture patterns are transverse, although reports have demonstrated oblique fractures.^{2,3} The mechanism of injury may be a direct blow to the wrist, as in a punch, or wrist hyperextension during a fall.^{3,4}

Symptoms can be nonspecific and radiographs can be difficult to interpret, leading to a delay in treatment and ultimately nonunion,^{4–6} posttraumatic arthritis, or avascular necrosis (AVN).⁷ While surgical treatment for delayed and nonunion has been recommended by some authors^{5,6} there is no consensus, and some favor prolonged immobilization.¹ We report two cases of capitate fracture nonunion

presenting several months after untreated high-impact wrist trauma.

Case Report

Case 1

A 31 year-old right-hand-dominant male sustained a left wrist injury while horseback riding overseas. His radiographs were read as negative, and he was diagnosed with a wrist sprain and was managed conservatively. Due to limited range of motion (ROM) and strength 4 months postinjury, he sought consultation. Outside radiographs were reviewed and revealed lucency at the mid-portion of the capitate, suspicious for fracture. Computed tomography (CT) demonstrated a transverse

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Fig. 1 Coronal and sagittal computed tomography scan images 21 weeks postinjury display a transverse distal-to-waist fracture with minimal dorsal displacement.

fracture through the capitate (**Fig. 1**). Magnetic resonance imaging (MRI) demonstrated no fracture healing and a diffuse edema pattern throughout the capitate without ischemia, indicative of nonunion (**Fig. 2**).

Surgical reconstruction with autograft was recommended. The capitate was exposed via a dorsal approach. The nonunion site was debrided to remove fibrous nonunion and sclerotic bony edges until bleeding cancellous bone was visualized. Distal radial autograft was harvested and packed into the nonunion site. Kirschner wires (K-wires) were placed across the nonunion in a distal-to-proximal fashion to reduce the capitate, and two cannulated, headless compression screws were used to stabilize the construct. Retrograde screw orientation was chosen to preserve midcarpal articular cartilage.

Fig. 2 Coronal and sagittal magnetic resonance imaging images from the same time demonstrating no evidence of fracture healing and a diffuse edema pattern throughout the capitate with no evidence of ischemia.

Fig. 3 Sagittal computed tomography at 8 weeks demonstrates nonunion consolidation.

The patient was immobilized for 6 weeks in a short arm cast, followed by gentle ROM exercises. CT scan at 8 weeks showed consolidation of the fracture (**Fig. 3**). At 12 months, radiographs demonstrated no hardware loosening and maintenance of carpal alignment. The patient reported mild discomfort (Visual Analogue Scale [VAS] 1–2, Patient-Rated Wrist Evaluation [PRWE] 7) with full flexion. The patient demonstrated ROM and grip strength of 100% of the contralateral wrist, and returned to all activities without restriction.

Case 2

A 15-year-old right-hand-dominant male was injured when he fell onto an outstretched left wrist while playing football. He reported pain, but was able to continue playing the rest of the season. Due to pain 6 months postinjury, he sought consultation at an outside hospital. Radiographs were interpreted as negative, and he was referred for evaluation of persistent pain. On exam, no edema or effusion was present with mild tenderness to palpation over the carpus. ROM was 80% of his uninjured side. CT showed fracture nonunion of the capitate body oblique in the sagittal plane (**Fig. 4**).

Nonsurgical and surgical treatment was discussed with the patient, but the family elected surgical reconstruction with bone graft to expedite return to sport. A ligament sparing dorsal capsulotomy was created. The nonunion site

Fig. 4 Coronal and sagittal computed tomography images reveal an oblique proximal-to-distal fracture, suggestive of a shearing mechanism of injury.

Fig. 5 Coronal and sagittal computed tomography images confirm bony healing of the nonunion.

was evaluated and the sclerotic edges were debrided back to bleeding cancellous bone. Distal radius autograft was harvested and impacted into the nonunion site. Two headless cannulated compression screws were inserted retrograde over guidewires to lag the volar fragment to the dorsal fragment. The wrist was immobilized in a short arm cast for 8 weeks, at which point CT confirmed > 80% cortical bridging across the nonunion site (►Fig. 5). Following 4 weeks of therapy, the patient had ROM equivalent to the contralateral side and grip strength of 90% of the contralateral side. He was allowed to return to lifting and pushups and returned to full baseball activity at 4 months.

Discussion

The appropriate treatment for capitate nonunion is controversial, although generally management for this condition relies on cast immobilization versus operative fixation. A review of these two treatment modalities is presented here.

Cast Immobilization

Current literature regarding cast immobilization for isolated capitate fracture nonunion consists of three case reports of three patients. Two reports of successful treatment with cast immobilization have been described^{1,7} (►Table 1).

Table 1 Reported outcomes of nonoperative treatment for capitate nonunion

Author	Publication year	N	Result	Follow-up (wk)	Treatment
De Schrijver and De Smet ⁷	2002	1	Union (X-ray and MRI)	130	Cast immobilization for 10 d followed by a brace for a “few weeks”
De Schrijver and De Smet ⁷	2002	1	Asymptomatic nonunion	56	Cast immobilization for 3 wk followed by a brace for 1 mo
Gümüştas et al ¹	2014	1	Union (X-ray only)	52	Cast immobilization for 3 mo

Abbreviation: MRI, magnetic resonance imaging.

The first case was a 13-year-old male who sustained a fall onto the left wrist. Initial radiographs were deemed negative. The patient was lost to follow-up until representing at 6 months postinjury due to continued pain. Radiographs revealed a transverse capitate fracture with central bony sclerosis. CT scan showed nonunion. Surgical fixation was recommended but the patient elected for nonsurgical management and was treated with a short arm cast for 3 months. At 1 year, the patient regained full strength and ROM, and radiographs confirmed union.¹

The second patient was a 15-year-old male who sustained a right wrist injury after a fall. Initial radiographs were deemed normal, and a cast was applied for 10 days, followed by a brace for a few weeks. The patient had persistent pain 2 months postinjury, and a subsequent bone scan demonstrated high uptake in the wrist with repeat radiographs showing a transverse fracture of the capitate. MRI was highly suspicious for the development of AVN. Immobilization was continued, and 6 weeks later revascularization was evident. At 2.5 years postinjury, the fracture had completely healed on radiographs and MRI.⁷

The final case demonstrated failure of cast immobilization in the treatment of capitate nonunion. The patient was a 19-year-old patient who sustained a right wrist injury while playing rugby. Initial radiographs were deemed normal and patient was placed in a short arm cast for 3 weeks followed by a brace for 1 month for symptomatic management. At 4 months postinjury, the patient had diminished ROM and grip strength with continued pain and swelling. Repeat radiographs were normal, but MRI demonstrated a fracture of the proximal pole of the capitate. Mobilization was then allowed at that point, and MRI 3 months later revealed no AVN of the proximal pole of the capitate with resolution of most of the bony edema. At 13 months, MRI again demonstrated nonunion of the fracture, but the patient was completely asymptomatic and no further treatment was provided.⁷

Operative Management

Recent available literature focuses on operative treatment in the management of capitate nonunion. Still, the evidence for operative management is composed exclusively of case reports (► Table 2).

Recent case reports utilize hardware including headless compression screw fixation. Yoshihara et al⁵ reported a case of a 17-year-old male who sustained a rugby injury with negative radiographs. After 4 months of continued pain, MRI identified a capitate nonunion. The patient underwent open reduction and internal fixation (ORIF) through a dorsal approach. The fracture was repaired using two headless compression screws in a proximal to distal (anterograde) trajectory, with iliac crest bone grafting. Three months postoperatively, the patient demonstrated healing with full return of strength and ROM. Gehrmann et al⁶ reported a case of capitate fracture nonunion diagnosed with CT scan due to persistent pain at 5 months after a fall onto the hand. The patient was treated with ORIF using screw fixation and iliac crest bone grafting. The authors reported excellent results and bone healing at 3 months. Cooney and Stuart⁸ presented a 16-year-old male with capitate nonunion after delayed presentation secondary to a rugby injury. Operative treatment included an anterograde compression screw with bone graft, and the patient demonstrated healing on radiographs.

One limitation in the treatment of capitate fractures is diagnosis of the injury at initial presentation. As evidenced by the literature, nonunions are frequently the result of improper initial treatment due to difficulty in diagnosis. Ability to recognize these injuries on plain radiographs is limited. As there is no reported consensus on diagnostic criteria for capitate nonunion, we recommend fractures greater than 3 months out from injury be recognized as nonunions, as has been similarly suggested for scaphoid nonunion.⁹ Future work should focus on diagnosis through physical examination and imaging at initial presentation.

Another concern for nonunion of the capitate is loss of blood supply and progression to AVN after fracture.¹⁰ Capitate AVN following nonunion has been variably described as low signal intensity and edema on MRI, and with unspecified radiographic and histologic changes.^{7,10,11} The risk of AVN has been attributed to a retrograde blood supply to the proximal pole of the capitate supplied through a single intraosseous vessel.¹⁰ Recent data suggests the capitate is well perfused and receives its vasculature in a retrograde fashion, although up to 70% of proximal poles are directly supplied by volar capitate ligaments.¹¹ These findings may

Table 2 Reported outcomes of operative treatment for capitate nonunion

Author	Publication year	N	Result	Follow-up (wk)	Treatment
Rand et al ⁴	1982	2	1 Union, 1 partial union	52	Curettage and “keyed iliac bone graft,” midcarpal arthrodesis
Yoshihara et al ⁵	2002	1	Union	52	ORIF with screw and iliac cancellous bone graft
Gehrmann et al ⁶	2009	1	Union	12	ORIF with screw and cancellous bone grafting
Cooney and Stuart ⁸	2013	1	Union	16	ORIF with screw and bone graft
Vander Grend et al ¹⁰	1984	5	Union	?	3 curettage and cancellous bone grafting, 2 scapholunocapitate arthrodesis

Abbreviation: ORIF, open reduction and internal fixation.

explain why capitate proximal pole AVN, although suspected in several of the patients detailed in the literature, went on to heal. They may also suggest that current imaging assessments do not sufficiently correlate with histologic necrosis, as has been recently demonstrated for scaphoid AVN.¹²

In our experience, bone grafting in conjunction with a retrograde screw construct works well in the treatment of a transverse/short oblique fracture pattern. By placing the screws in a distal-to-proximal fashion, we are able to avoid any potential damage to the capitate–lunate articulation, while still allowing placement of screws perpendicular to the fracture plane for maximal compression across the nonunion site. Given the high rate of posttraumatic arthritis in this patient population, placement of hardware through the capitate–lunate articulation is undesirable. This small adaptation to the previously described anterograde method serves as an alternative that might potentially reduce these arthritic changes. More oblique fractures necessitate different screw orientations to generate fracture compression, but can still result in excellent healing and clinical outcomes.

Currently, there is no standardized treatment for capitate fracture nonunion. The finding that all three nonoperatively treated nonunions in the literature were skeletally immature is likely only incidental given the small number of cases reported and may not represent a treatment modality recommendation for this patient age group. However, operative internal fixation with autogenous bone grafting appears to be a viable treatment option, especially in patients with higher functional demands. Furthermore, diagnosis of fracture nonunion is challenging given limited ability to identify this injury on plain radiographs. In this case series, internal fixation with grafting offered advantages to cast immobilization after considering risk for AVN and functional demands. Additionally, usage of a retrograde screw construct avoided introduction of hardware into the capitate–lunate articulation, which would otherwise risk posttraumatic arthritis. Given the lack of consensus regarding diagnosis and management of capitate fracture nonunion, further clinical studies conducted with a larger cohort of patients would provide

stronger evidence to determine a proper diagnostic and therapeutic protocol for this condition.

Note

This investigation was performed at Hospital for Special Surgery and Stanford University Medical Center.

Conflict of Interest

None.

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