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Traumatic Articular Lesions of the Lunate Fossa Without Corresponding Changes on MRI

David P. Falk, MD[1]
Rikesh A Gandhi, MD[1]
Matthew Winterton, MD[1]
Viviana Serra, MD, MS[1]
Stephen Barchick, MD[1]
David R. Steinberg, MD[1]

[1]Department of Orthopaedic Surgery, University of Pennsylvania, Philadelpha, PA

Abstract

We describe a series of patients with the unusual arthroscopic finding of post-traumatic articular cartilage lesions of the lunate fossa. This is a retrospective observational study of five adult patients with a history of trauma, all of whom underwent diagnostic wrist arthroscopy for chronic wrist pain, who were found to have cartilage lesions in the lunate fossa. All patients appeared to have normal radiocarpal joints on magnetic resonance imaging (MRI). No patient sustained a distal radius fracture. Pre-operative wrist radiographs were assessed for scapholunate (SL) angle, SL gap, lunate-capitate (LC) angle, midcarpal arthritis, and ulnar variance. Arthroscopic photos were compared to pre-operative MRIs. In addition to the cartilage lesions, 4/5 patients were found to have scapholunate ligament injuries. These findings suggest that some patients with poorly-characterized chronic post-traumatic wrist pain may have symptomatic articular cartilage lesions involving the lunate fossa despite normal MRIs. These lesions may be associated with scapholunate injuries.

Introduction

In 1984, Watson and Ballet proposed the concept of scapholunate advanced collapse (SLAC) wrist after reviewing over 4,000 wrist radiographs.[1] In this classic paper, the authors associated scapholunate ligament (SL) injuries with radioscaphoid arthritis that developed in a progressive three-stage sequence: Degenerative changes initially emerge between the tip of the radial styloid and the scaphoid (SLAC I). Changes then continue proximally to affect the entire radioscaphoid joint (SLAC II), followed by involvement of the capitolunate joint (SLAC III).

Notably, the radiolunate articulation is spared in this model, thought to be secondary to the spherical nature of the lunate's articulation in the lunate fossa.[2] Due to this unique shape, the radiolunate joint remains congruent regardless of the position or rotation of the lunate. Thus loads are thought to be equally distributed across the joint and the cartilage surface is preserved.[2,3] The scaphoid fossa, however, is more elliptical. Therefore rotatory or translational instability following SL injury disrupts articular congruence at the radioscaphoid articulation, leading to increased contact pressures and subsequent degenerative changes as seen in the SLAC pattern. [2]

Although this SLAC pattern continues to serve as the basis for the surgical treatment of radiocarpal arthritis [4–6], other patterns are beginning to emerge. These include isolated luno-capitate arthritis [7] as well as radiolunate arthritis associated with SL injuries in the absence of radioscaphoid arthritis. [8] Both of these patterns stand contrary to the classic description of Watson and Ballet.

Over the last several years, we have discovered a cohort of patients with lunate fossa articular cartilage lesions found while undergoing diagnostic wrist arthroscopy for chronic, post-traumatic wrist pain. No patient demonstrated the SLAC pattern, the lesions were not visible on MRI, nor had any patient sustained a distal radius fracture, which are known to be associated with radiolunate arthritis.

The primary purpose of this report is to describe our arthroscopic findings of articular cartilage lesions involving the lunate fossa in patients with chronic, post-traumatic wrist pain with normal imaging studies. A secondary aim to is to discuss potential mechanisms leading to this injury pattern, including a possible association with scapholunate ligament injuries.

Materials and Methods

We performed a retrospective observational study on five adult patients with chronic, post-traumatic wrist pain who underwent diagnostic wrist arthroscopy between 2017-2018 and were found to have articular cartilage lesions involving the lunate fossa. No patient had sustained a distal radius fracture. MRIs were obtained prior to surgical intervention, although these were non-diagnostic. All patients elected to undergo wrist arthroscopy for diagnostic evaluation and possible treatment of persistent symptoms that had failed to respond to conservative measures.

Wrist arthroscopy was performed by the senior author at a large academic medical center. Charts were reviewed for data including sex, age, mechanism of injury, and prior treatments. Radiographs including postero-anterior and

lateral views of the wrist were assessed by a fellowship trained upper extremity surgeon using Sectra IDS7 (Sectra Group, Linköping, Sweden) for scapholunate (SL) angle, SL gap, lunate-capitate (LC) angle, and midcarpal arthritis. Ulnar variance was measured using the central reference point as described by Medoff.[9] Pre-operative MRIs and operative reports were reviewed and compared to arthroscopic images, with particular attention to the integrity of lunate fossa and SL ligament.

Wrist arthroscopy was performed using a 2.7 mm 30-degree arthroscope via the standard portals, with 12 pounds of distraction applied across the wrist. The first joint assessed during diagnostic arthroscopy was the radioscaphoid joint. Cartilage lesions were assessed under direct visualization. SL injuries were scored according to the Geissler grading system.[10] In all cases, chondral lesions of the lunate fossa were debrided back to stable borders. SL injuries, when present, were debrided or, for Geissler I injuries, underwent shrinkage with a radiofrequency probe.

Post-operatively, symptoms were assessed via qualitative data from patient-reported outcomes obtained from the electronic medical record. All patients had at least two post-operative appointments, with an average duration of follow-up was 11.5 months (range: 2 to 31 months).

The study was approved by the institutional review board at our institution.

Results

Among the patients in this study, two were female and three were male, with an average age of 41 (range: 35–58) at the time of surgery (Table 1). Median time from injury to surgical intervention was 3 years (range: 0.5–15 years). All patients suffered from chronic, post-traumatic radial and/or mid-dorsal wrist pain secondary to falls on outstretched hands (n = 2), motor vehicle accidents (n = 2), or motorcycle accidents (n = 1). Non-operative treatments included activity modification (n = 5), bracing (n = 4), thumb spica casting (n = 1), and steroid injection into the wrist joint (n = 1). Watson's test was negative for 4/5 patients in the study.

One patient had sustained a scaphoid waist fracture during their initial trauma several years prior to evaluation in our clinic (Patient 1), although radiographs and MRI at the time of our evaluation showed complete healing. No other patient sustained a fracture. MRIs for 5/5 patients were non-diagnostic, though an incidental finding of possible triangular fibrocartilage complex (TFCC) tear was suspected in 2 patients. Otherwise, no specific pathology was described that correlated with the patients' location of pain.

Pre-operative radiographs demonstrated SL angles within normal limits (30-60 degrees) for 3/5 patients (Table 2). 0/5 patients had SL gap $>$ 3 mm on static radiographs. LC angle was within normal limits (0-15 degrees) for 4/5 patients. No patient showed evidence of midcarpal arthritis. 3/5 patients were found to have ulnar positive variance and 2/5 with ulnar negative variance.

Radiographs and MRIs were grossly unremarkable at the radiocarpal joint (Figures 1 & 2). During wrist arthroscopy all patients were found to have radiocarpal synovitis along with an isolated articular lesion in the lunate fossa.The degree of cartilage damage ranged from partial thickness defects

Table 1. Demographics

Subject	Age(yrs)	Sex	Mechanism of Injury	Treatments
Patient 1	35	F	Fall off Motorcycle/Vespa	- Thumb spica cast - Activity modification
Patient 2	39	M	Motor-vehicle collision	- Activity modification - Bracing
Patient 3	36	F	Motor-vehicle collision	- Steroid injection (wrist) - Activity modification - Bracing
Patient 4	58	M	Fall on outstretched hand	- Activity modification - Bracing
Patient 5	38	M	Fall on outstretched hand	- Activity modification - Bracing

Table 2. Radiographic Parameters & Geissler Grades

Subject	SL Angle	SL Gap >3 mm?	LC Angle	Midcarpal Arthritis?	Ulnar Variance	SL Tear
Patient 1	62*	No	10	No	+2.0 mm	Geissler 1
Patient 2	46	No	24*	No	+2.4 mm	Geissler 2
Patient 3	52	No	13	No	+2.6 mm	-
Patient 4	63*	No	2	No	−1.4 mm	Geisler 2
Patient 5	52	No	13	No	−1.0 mm	Geissler 1

*Indicates value is outside normal limits

Figure 1. Postero-Anterior and Lateral radiographs of the left wrist of Patient 3, with no evidence of SL laxity or radiocarpal arthritis. Ulnar positive variance is present.

Figure 2. Representative coronal (3D fast gradient echo) MRI image of the left wrist of Patient 3, with normal appearance of the radiocarpal joint. There is no evidence of a cartilage lesion involving the lunate fossa.

in three patients (Figure 3) to full-thickness injuries in two patients (Figure 4). These full-thickness injuries were not immediately apparent, as the cartilage initially appeared to have irregularities or undulations. However, simple manipulation revealed these to be unstable lesions with delamination or lack of adherence to the underlying subchondral bone. All lesions were transverse in orientation (i.e. perpendicular to the orientation of the camera), and associated with delamination and fissuring (Figure 5). 4/5 patients were also found to have scapholunate ligament injuries, two of which were Geissler I with the remainder being scored as Geissler II. 2/5 patients had central TFCC tears.

5/5 patients noted symptomatic and functional improvement following arthroscopic debridement.

Discussion

This case series suggests that a subset of patients with chronic, post-traumatic wrist pain with no corresponding radiographic or MRI findings may have a symptomatic lesion involving the lunate fossa. The transverse orientation of the lesion in association with delamination, fissuring, and radiocarpal synovitis is further suggestive of a chronic injury (Figure 5). In our cohort, the lesion frequently appears to be associated with SL injuries. While cartilage damage can often be expected in patients with a history of intra-articular distal radius fracture, we could not find descriptions of isolated pre-arthritic lunate fossa lesions in our review of the literature.

We propose that a possible mechanism leading to this injury pattern revolves around the integrity of the SL

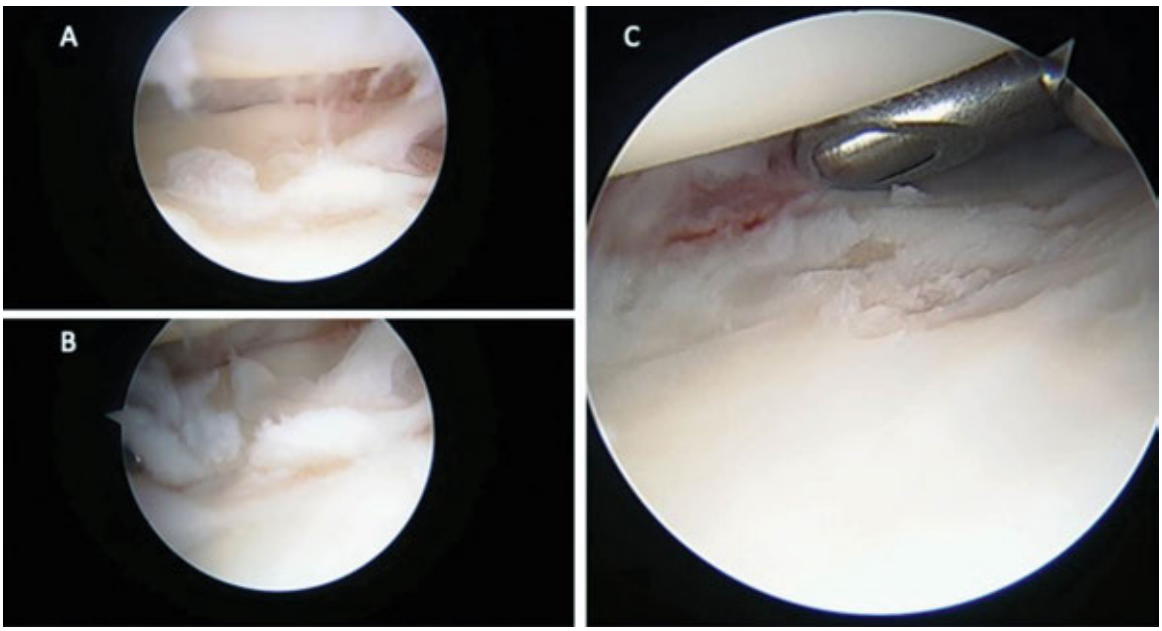

Figure 3. Arthroscopic images of the lunate fossa from Patient 3 from the 3, 4 portal**. (A)** Appearance of the lunate fossa upon insertion of the arthroscope; **(B)** Cartilage manipulation with probe, showing delamination of the unstable cartilage; **(C)** During debridement with shaver, ultimately resulting in a partial thickness lesion with stable borders.

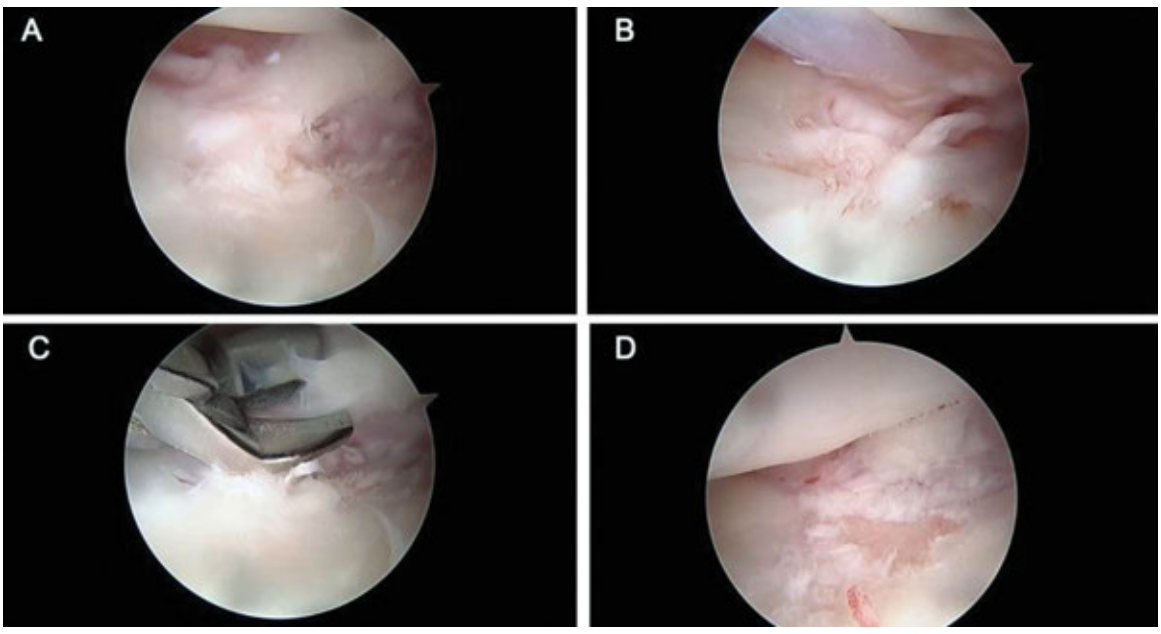

Figure 4 Arthroscopic images of the lunate fossa from Patient 1 obtained from the 3, 4 portal. **(A)** Appearance of the lunate fossa upon insertion of the arthroscope; (**B)** Following debridement with a shaver alone, the full-thickness depth of lesion is not yet appreciated; **(C)** Manual debridement of the abnormal cartilage, demonstrating its lack of adherence to underlying subchondral bone. **(D)** Lunate fossa at completion of debridement, revealing a full-thickness lesion.

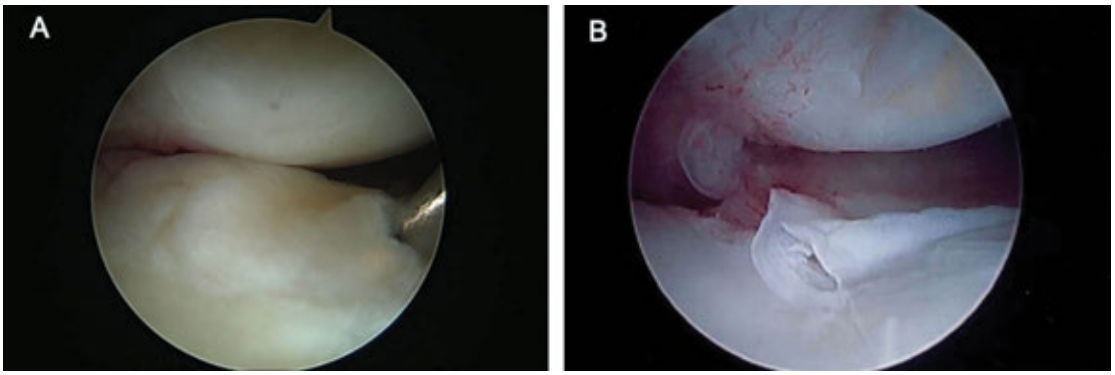

Figure 5. Arthroscopic images of the lunate fossa obtained from the 3, 4 portal upon initial arthroscope insertion in two different patients. **(A)** Patient 4: Undulating cartilage about the volar half of the lunate fossa, with probe lifting up the loose edge due to loss of adherence of articular cartilage to underlying bone. **(B)** Patient 5: Delamination and fissuring of the cartilage about the volar aspect of the lunate fossa. The lesion is transverse in orientation, nearly perpendicular to the arthroscope

ligament. Given that 80% of our patients were found to have SL ligament injuries on arthroscopy, we propose that they are either directly or indirectly associated with the lunate fossa lesions. Under the pretense of a direct association, we hypothesize that the force from the blunt trauma that caused the initial SL ligament injury simultaneously drove the lunate into the lunate fossa, causing a shearing injury to the articular cartilage. Alternatively, it is possible that the force from the initial traumatic event injured the SL ligament in isolation, and over time the lax SL ligament indirectly allowed for repetitive micro shearing of the lunate on the lunate fossa.

On a biochemical level, *in vitro* studies have demonstrated that application of a shearing force to articular cartilage can increase the production of reactive oxygen species, promoting chondrocyte death secondary to oxidative damage.[11] Regardless of the direct or indirect hypothesis, we propose that injury to the SL ligament allows the lunate to apply an abnormal shear force on the lunate fossa, leading to focal articular cartilage lesions.

Classically it is thought that there is a spectrum of SL injury severity, ranging from occult (with no radiographic findings on static radiographs) to SLAC arthritis.[12] A dynamic phase exists between these two ends of the spectrum, characterized by SL angle $>$ 60 with SL gapping $>$ 3 mm on stress radiographs.[12] In the context of the patients in this series, it is interesting to note that only 2/5 patients with SL injuries had SL angles $>$ 60 and 0/5 patients demonstrated SL gapping $>$ 3mm. Unfortunately stress radiographs were not available for these patients, though it is possible these may have shown some degree of dynamic instability given the arthroscopic findings.

Although the classic SLAC pattern of radiocarpal arthritis with sparing of the radiolunate joint remains widely accepted today [13], it is important to note that additional patterns have emerged that stand contrary to this dogma. Most pertinent to our report is a study by Lane et al. that evaluated 21 wrists in patients with radiolunate arthritis without radioscaphoid arthritis. Although the majority of patients in that study demonstrated SL gapping $>$ 3 mm on static XRs, the authors identified a subgroup of $\pm$ patients "that demonstrated radiolunate arthritis in isolation—that is RL joint space narrowing with no RS narrowing and no SL widening".[8] Notably 5/6 of the patients in this subgroup had wrists with SL Angle $>$ 60, consistent with SL laxity.

While it could be inferred that the patients in our case series represent a unique subset of patients who could go on to develop isolated radiolunate arthritis as described by Lane et al., there are two major differences between our studies. First, none of the patients with radiolunate arthritis were "particularly symptomatic," meaning that their symptoms were controlled with conservative measures alone. Second, no patient with radiolunate arthritis presented to clinic following an episode of acute trauma. These two characteristics differ from the patients in our series, all of whom underwent surgical treatment for pain refractory to conservative measures for symptoms that developed from a known traumatic event. Despite these differences, both studies shed light on a unique subset of patients with SL instability and pathology localized to the radiolunate joint—the articulation thought to be spared in the SLAC pattern as described by Watson and Ballet.

Although we only focused on limited post-operative results, such as patient-reported pain levels and functional improvement, our goal was not to describe definitive treatment for this problem. Rather, the primary purpose of this paper was to bring attention to a potential cause of post-traumatic wrist pain in the setting of normal MRI findings and no history of distal radius fracture. Nevertheless, all patients experienced significant pain relief. It is unknown whether this was due to chondral debridement or SL shrinkage, though others have shown improved functional outcomes and pain resolution following electrothermal shrinkage of SL ligament injuries.[14,15]

Moving forward, it is critical for hand surgeons to consider articular lesions of the lunate fossa as a potential cause of chronic dorsal and/or radial-sided wrist pain in patients with a remote history of trauma. The atypical presentation of patients in this series, including the absence of diagnostic findings on physical exam or advanced imaging helps to explain the lengthy delay from injury to diagnostic arthroscopy. Having failed to respond to conservative management, diagnostic arthroscopy was utilized as a treatment of last resort.

This study has several limitations, the first of which is small sample size. We felt it important to publish these early results given their potential significance, as this lesion has yet to receive attention in the literature. Another limitation is the presence of concomitant intra-articular wrist pathology beyond SL ligament injury, including 40% with TFCC tears and 1 prior scaphoid fracture. While some of this pathology

may have contributed to the patients' symptoms, the TFCC tears, for example, would not explain the predominantly radial or middorsal pain endorsed by our patients. Similarly, while the scaphoid fracture may have caused radial-sided wrist pain following the acute episode of trauma years prior to presentation in our clinic, this patient's MRI demonstrated complete healing of the fracture. Moreover, the scaphoid fracture in itself would not explain a cartilage lesion in the lunate fossa given that the scaphoid does not articulate with the lunate fossa.

Conclusion

In conclusion, patients with chronic radial and/or middorsal wrist pain after trauma with no corresponding lesion on MRI may have a symptomatic articular lesion involving the lunate fossa.These lesions appear to be associated with scapholunate ligament injuries without producing the typical SLAC pattern of wrist pathology.We believe the mechanism may be through either a direct shearing force that occurred at the time of injury, or repetitive microtrauma from scapholunate laxity.

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