MDCT Arthrography Features of Ulnocarpal Impaction Syndrome

Michel D. Crema1
Monica D. Marra1
Ali Guermazi1
Frank W. Roemer1,2
Klaus Bohndorf2
Nabil Jomaah3

OBJECTION. The aim of this article is to present the imaging patterns of ulnocarpal impaction syndrome (Palmer class II lesions) on MDCT arthrography.

CONCLUSION. MDCT arthrography is an excellent tool for imaging patients with clinically suspected ulnocarpal impaction syndrome, allowing identification of the spectrum of findings and proper classification according to Palmer class II (degenerative) lesions, which directly affects management.

Ulnocarpal impaction syndrome is a degenerative condition caused by increased load transmission through the ulnar aspect of the wrist. The triangular fibrocartilage complex (TFCC) has three major functions [1, 2]: It acts as a cushion for the ulnar carpus that carries approximately 20% of the axial load of the forearm, it is the major stabilizer of the distal radioulnar joint, and it is a stabilizer of the ulnar carpus. The lunotriquetral ligament stabilizes the lunate and triquetrum and has dorsal, volar, and membranous components. Although the volar component is the thickest and strongest part, both dorsal and volar are important in resisting distraction [3]. Repetitive and increased loading of the ulnar aspect of the wrist caused by conditions such as congenital positive ulnar variance, distal radius fractures, premature physeal closure of the distal radius, Madelung’s deformity, and radial head resection will lead to degeneration of the TFCC and ulnocarpal and distal radioulnar joint. Positive ulnar variance is usually present; however, cases with neutral and negative ulnar variance have been described [4]. Clinical symptoms include ulnar wrist pain, swelling, and limitation of motion. Movements that increase ulnar variance (firm grip, pronation, ulnar deviation of the wrist) often exacerbate symptoms. Relief of symptoms is typically obtained with rest [5, 6].

The aim of this article is to present the specific degenerative patterns of ulnocarpal impaction syndrome on MDCT arthrography and to classify these changes according to the Palmer system [7] of degenerative lesions of the TFCC and the ulnocarpal and distal radioulnar joints (Palmer class II lesions).

MDCT Arthrography

Direct MR arthrography is considered the reference standard imaging method for detection of TFCC lesions [8–11]. Literature on the diagnosis of ulnocarpal lesions with MDCT arthrography is sparse. However, the spatial resolution available with modern MDCT is significantly higher than that of MRI. MDCT arthrography of the wrist is highly accurate in detecting intrinsic ligaments and triangular fibrocartilage (TFC) lesions, showing results comparable to those of direct MR arthrography [12–14]. In a recent report, Moser et al. [15] showed that MDCT arthrography was more accurate than MRI and MR arthrography in the detection of TFCC tears, lunotriquetral ligament tears, and cartilage abnormalities. MDCT arthrography is a powerful diagnostic tool for the detection of wrist disorders when MR arthrography is contraindicated or MRI is not available. Our standardized protocol consists of a triple injection (midcarpal, distal radioulnar, and radiocarpal joints, successively) of iodine contrast material (Hexabrix 320 [ioxaglate meglumine], Mallinckrodt) under fluoroscopic guidance (1–2 mL in the midcarpal and distal radioulnar joints, and 2–3 mL in the radiocarpal joint). However, the arthrography protocol is shortened to a double or single injection when a communication of two or three compartments is seen during fluoroscopy after the first or second injection. We then performed
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a high-resolution protocol at 64-MDCT (Somatom Sensation, Siemens Healthcare) with neutral forearm rotation (0.4-mm slice thickness; 0.2-mm gap; 120 kV; 200 mA; pitch, 0.9; field of view, 144 mm; reconstruction kernel, B75f). Reconstruction in the axial, sagittal, and coronal planes is then performed (1.5-mm slice thickness; 1.5-mm gap; field of view, 144 mm).

Normal Anatomy
To understand the evolution of degenerative changes in ulnocarpal impaction syndrome, knowledge of the normal anatomy of the ulnocarpal joint is essential. For this purpose, we will focus on the horizontal portion of the TFCC, which is the TFC itself, the lunotriquetral ligament, and the articular surfaces of the lunate, ulna, and triquetrum (Figs. 1 and 2).

Palmer Classification of TFCC Lesions
According to Palmer [7], lesions involving the TFCC are classified as traumatic (class I) or degenerative (class II). Palmer class II lesions show the entire spectrum of ulnocarpal impaction syndrome, which generally occurs sequentially as a result of repetitive loading from ulnocarpal abutment affecting the horizontal portion of the TFCC (or the TFC), the ulnar head, lunate, triquetrum, and the lunotriquetral ligament.

Class IIA
The first sign of ulnocarpal degeneration is wear or thinning of the TFC without perforation. Chondral surfaces and the lunotriquetral ligament are intact at this point. Fraying of the proximal or distal aspect of the TFC may be seen at arthroscopy. This sign may be difficult to recognize at MDCT arthrography (Fig. 3).

Class IIB
Progression is observed as additional wear or chondromalacia of the ulnar aspect of the lunate, or of the radial aspect of the ulnar head, or both. Subchondral degenerative marrow changes of the lunate or ulnar head may be seen. Similar changes may be observed at the radial aspect of the triquetrum. No perforation of the TFC is seen at this stage, and no communication between the ulnocarpal and distal radioulnar joints is observed (Fig. 4). At MDCT arthrography, chondromalacia is depicted when cartilage defects are filled with iodine contrast material. Degenerative marrow changes at MDCT are represented by areas of subchondral sclerosis with or without cystic formation.

Class IIC
The third stage shows further progression of degeneration: The TFC becomes perforated. The perforation is located in the thin avascular portion of the TFCC, and communication between the ulnocarpal and distal radioulnar joints is seen (Fig. 5).

Class IID
The fourth stage represents even further progression of degeneration: Evidence of degenerative changes of the articular surface of the lunate and ulnar head (eventually the triquetrum) is observed, the TFC appears to be perforated, and the lunotriquetral ligament is disrupted (class IID). Any component of the lunotriquetral ligament may be affected, and tearing of the dorsal or volar components may lead to lunotriquetral instability. Axial images are useful to separate the components of the lunotriquetral ligament (Fig. 2). Communication between the midcarpal and ulnocarpal joints is seen as well (Fig. 6).

Class IIE
Palmer class IIE lesions are the last stage of the degenerative process with advanced ulnocarpal osteoarthritis and occasionally distal radioulnar osteoarthritis. The TFC is usually entirely absent, and the lunotriquetral ligament is completely disrupted at this stage (Fig. 7).

To summarize the spectrum of ulnocarpal impaction syndrome, first wearing and eventually perforation of the TFC are observed, followed by chondromalacia with or without degenerative marrow changes of the radial aspect of the ulnar head, the ulnar aspect of lunate, and the radial aspect of the triquetrum and disruption of the lunotriquetral ligament (Fig. 8).

A common acquired cause of ulnocarpal impaction syndrome is fracture with shortening of the distal radius, leading to a relatively long ulna. Typical findings of ulnocarpal impaction syndrome are frequently detected in these patients (Figs. 9–11). The MDCT arthrography features of ulnocarpal impaction syndrome may sometimes lack the regular sequence of degenerative changes as proposed in Palmer class II lesions (Figs. 12 and 13). Recognition of these features, which allows prompt diagnosis and management, is more important than the specific classification.

Treatment
Treatment of patients with ulnocarpal impaction syndrome depends on the clinical symptoms and the classification of lesions. Options include observation only, conservative care (rest, immobilization, antiinflammatory medication, and joint restriction), and surgical measures. A period of 6–12 weeks of conservative care should be provided before considering surgery [16]. The objective of surgery is to decrease the load-sharing through the ulnar carpus by ulnar recession or shortening. When there is no perforation of the TFC (classes IIA and IIB), the open wafer procedure (resection of the distalmost 2–3 mm of the dome of the ulnar head) or the ulnar shortening osteotomy (excision of a slice 2–3 mm wide of the ulnar shaft with rigid fixation) are surgical treatment choices [17]. When there is perforation of the TFC without significant osteoarthritis (classes IIC and IID), arthroscopic débridement of TFCC tears combined with arthroscopic ulnar wafer resection may be considered. Class IIE lesions are usually managed with more complex procedures such as complete or partial ulnar head resection (Darrach procedure [18]) or arthrodesis of the distal radioulnar joint with distal ulnar pseudoarthrosis (Kapandji-Sauvé procedure [19], usually performed when distal radioulnar osteoarthritis is present).

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Fig. 1—Normal anatomy of ulnocarpal joint. 
A, Drawing shows coronal view of normal ulnocarpal joint involving ulnar head (U), ulnar aspect of lunate (L), and radial aspect of triquetrum (T). Triangular fibrocartilage (TFC, dotted arrow) separates ulnocarpal joint from distal radioulnar joint. Lunotriquetral ligament (solid arrow) separates ulnocarpal joint from midcarpal joint. 
B, MDCT arthrography coronal view in 42-year-old man obtained after triple-compartment injection shows normal aspect of TFC (asterisk) with its radial (black arrow) and ulnar (dotted arrow) attachments. Lunotriquetral ligament (solid white arrow) is intact. Note normal chondral surfaces at ulnar aspect of lunate and radial aspects of ulnar head and triquetrum. No communication is seen between midcarpal, ulnocarpal, and distal radioulnar joints.

Fig. 2—Normal anatomy of ulnocarpal joint in 43-year-old man. 
A, MDCT arthrography sagittal view obtained after triple-compartment injection shows intact triangular fibrocartilage (arrows) separating ulnocarpal and distal radioulnar joints. 
B, Axial view shows intact dorsal (D) and volar (V) components of lunotriquetral ligament (arrows).
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Fig. 3—Palmar class IIA lesion.
A, Drawing shows Palmer class IIA lesion: thinning of triangular fibrocartilage (TFC) (arrow) without perforation. Articular surfaces are intact. L = lunate, U = ulnar head, T = triquetrum.
B, Ulnocarpal impaction syndrome with neutral ulnar variance in 28-year-old woman. This MDCT arthrography coronal view obtained after triple-compartment injection shows thinning of TFC (white arrow) without perforation; TFC is still separating ulnocarpal and distal radioulnar joints. No chondromalacia is evident. Obliquely oriented linear partial tear is seen on ulnar side of TFC (black arrow).

Fig. 4—Palmar class IIB lesion.
A, Drawing shows Palmer class IIB lesion: thinning of triangular fibrocartilage (TFC) and chondromalacia with or without subchondral marrow changes (arrows). Three joint compartments are still separated by TFC and lunotriquetral ligament. L = lunate, U = ulnar head, T = triquetrum.
B, Ulnocarpal impaction syndrome with neutral ulnar variance in 51-year-old woman. This MDCT arthrography coronal view obtained after triple-compartment injection shows thinning without perforation of TFC (black arrow) associated with focal chondral erosion and subchondral sclerosis at ulnar aspect of lunate (white arrow).

Fig. 5—Palmar class IIC lesion.
A, Drawing shows Palmer class IIC lesion: After chondromalacia of articular surfaces, degenerative perforation of triangular fibrocartilage (TFC) occurs, leading to communication between ulnocarpal and distal radioulnar joints (arrow). L = lunate, U = ulnar head, T = triquetrum.
B, Ulnocarpal impaction syndrome with positive ulnar variance in 45-year-old woman. This MDCT arthrography coronal view obtained after double-compartment injection shows relatively large perforation of TFC and communication between ulnocarpal and distal radioulnar joints (black arrow), associated with chondral erosion at ulnar aspect of lunate (solid white arrow). Chondral erosions at radial aspect of ulnar head are also present (not shown). Note intact lunotriquetral ligament (dotted arrow).
Fig. 6—Palmar class IID lesion. 
A, Drawing shows Palmer class IID lesion: After chondromalacia and perforation of triangular fibrocartilage (TFC), disruption of lunotriquetral ligament occurs (arrow), leading to communication between all three wrist articular compartments. L = lunate, U = ulnar head, T = triquetrum.
B, Ulnocarpal impaction syndrome with neutral ulnar variance in 59-year-old man. This MDCT arthrography coronal view obtained after single-compartment injection shows perforation of TFC (black arrow) and disruption of lunotriquetral ligament (white arrow), with communication between midcarpal, ulnocarpal, and distal radioulnar joints. Note chondral erosions at ulnar aspect of lunate and radial aspects of ulnar head and triquetrum.

Fig. 7—Palmer class IIE lesion (ulnocarpal osteoarthritis) in 80-year-old woman. Ulnocarpal impaction syndrome with positive ulnar variance. Triangular fibrocartilage is completely absent, and large communication between ulnocarpal and distal radioulnar joints is seen in this MDCT arthrography coronal view obtained after single-compartment injection (black arrow). Lunotriquetral ligament is completely disrupted (white arrow), and communication between midcarpal and ulnocarpal joints is also seen. No articular cartilage is detected at ulnar aspect of lunate or at radial aspects of ulnar head and triquetrum. Subchondral bone attrition is seen at ulnar aspect of lunate, and large osteophyte is seen at ulnar head.

Fig. 8—Drawing shows full spectrum of lesions in ulnocarpal impaction syndrome: wearing and eventual perforation of triangular fibrocartilage (TFC) (gray arrowhead); chondromalacia (arrows) of radial aspect of ulnar head (U), ulnar aspect of lunate (L), and radial aspect of triquetrum (T); and disruption of lunotriquetral ligament (white arrowhead).

Fig. 9—Palmer class IID lesion in 68-year-old woman. Ulnocarpal impaction syndrome secondary to fracture of distal radius, with relatively long ulna. This MDCT arthrography coronal view obtained after single-compartment injection shows perforation of triangular fibrocartilage (black arrow) and disruption of lunotriquetral ligament (white arrow), which are associated with chondromalacia of ulnar head, lunate, and triquetrum.
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**Fig. 10**—Palmer class IID lesion in 52-year-old man. Ulnocarpal impaction syndrome secondary to fracture of distal radius, with relatively long ulna. 

A. MDCT arthrography coronal view obtained after single-compartment injection shows large perforation of triangular fibrocartilage and communication between ulnocarpal and distal radioulnar joints (black arrow). Chondral erosion with subchondral sclerosis of ulnar aspect of lunate is seen (solid white arrow). Disruption of lunotriquetral ligament is also shown (dotted arrow). 

B. Axial view shows that disruption of lunotriquetral ligament occurs at its dorsal (D) component (arrows). V = volar.

**Fig. 11**—Palmer class IIE lesion in 56-year-old man. Ulnocarpal impaction syndrome secondary to fracture of distal radius with relatively long ulna. This MDCT arthrography coronal view obtained after single-compartment injection shows perforation of triangular fibrocartilage (black arrow), disruption of lunotriquetral ligament (white arrow), and ulnocarpal osteoarthritis.

**Fig. 12**—Slight positive ulnar variance in 38-year-old woman with ulnar-sided wrist pain without history of trauma. This MDCT arthrography coronal view obtained after double-compartment injection shows large disruption of lunotriquetral ligament (white arrow) and thinned triangular fibrocartilage without perforation (black arrow). No evident chondral erosion is seen, despite subchondral sclerosis at ulnar aspect of lunate (arrowheads). This example cannot be fitted into Palmer class II.

**Fig. 13**—Ulnocarpal impaction syndrome with neutral ulnar variance and no history of trauma in 44-year-old man. This MDCT arthrography coronal view obtained after single-compartment injection shows focal perforation of triangular fibrocartilage (black arrow) and disruption of lunotriquetral ligament (white arrow), which would be considered Palmer class IID lesion. However, no evident chondromalacia or subchondral degenerative marrow changes were observed in this examination.

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