Ulnar Impaction

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KEYWORDS

- Ulnar impaction
- Ulnocarpal impaction
- Abutment
- Stylocarpal impaction

Ulnar impaction syndrome, also known as ulnocarpal impaction or ulnocarpal abutment, is a common source of ulnar-sided wrist pain. It is a degenerative condition that occurs secondary to excessive load across the ulnocarpal joint, resulting in a spectrum of pathologic changes and symptoms. It may occur in any wrist but is usually associated with positive ulnar variance, whether congenital or acquired. It may be seen after distal radius malunion, radial head excision, congenitally positive ulnar variance, premature physeal closure of the radius, or any condition that causes an increase in the relative length of the ulna. Mechanical abutment of the distal ulna with the carpus often results in pain and progressive deterioration of the triangular fibrocartilage complex (TFCC), as well as pathologic changes in the dome of the ulnar head, the ulnar corner of the lunate, the triquetrum, and the lunotriquetral interosseous ligament (LTIL). The diagnosis of ulnar impaction syndrome is made by clinical examination and is supported by radiographic studies. Surgery is indicated if nonoperative treatment fails. Although a number of alternatives exist, the 2 primary surgical options are ulnar-shortening osteotomy or partial resection of the distal dome of the ulna (wafer procedure). This article discusses the etiology of ulnar impaction syndrome, and its diagnosis and treatment.

BIOMECHANICS

In the ulnar neutral wrist, the ulnocarpal joint bears 18% of the load that crosses the wrist.\textsuperscript{1} The TFCC plays a critical role in transferring this load from the carpus to the ulna. Excision of the TFCC decreases the load transmitted to the ulna by 67%, and the ulna bears only 6% of the total load across the wrist.\textsuperscript{1} An inverse relationship between ulnar variance and TFCC thickness has been demonstrated\textsuperscript{2}; therefore, a thick TFCC is present in wrists with congenital negative ulnar variance, allowing effective transfer of load from the carpus to the ulna. Although it is less common, ulnar impaction syndrome can occur in patients with neutral or negative ulnar variance.\textsuperscript{3}

Forearm pronation and grip both result in a relative increase in ulnar length.\textsuperscript{4–6} In ulnar neutral or negative wrists, this increase in relative length can be enough to create a dynamic positive ulnar variance. In the ulnar neutral wrist, this dynamic positive ulnar variance results in an increase in ulnocarpal load.\textsuperscript{7,8} There is evidence that in some ulnar positive wrists, however, that the dynamic increase in relative ulnar length during pronation and grip leads to dorsal subluxation of the ulnar head, resulting in a decrease in ulnocarpal load.\textsuperscript{8} In ulnar neutral or negative wrists, the phenomenon of dynamic positive ulnar variance with increased ulnocarpal load and the presence of a thicker TFCC explain the occurrence of ulnar impaction syndrome.

Increasing or decreasing the relative length of the ulna has been shown to cause significant changes in ulnocarpal load. In a study by Palmer and Werner,\textsuperscript{1} increasing the length of the ulna by 2.5 mm resulted in an increase in ulnocarpal load to 42% of the total load across the wrist. On the other hand, decreasing the length of the ulna by 2.5 mm resulted in a decrease in ulnocarpal load to only 4% of the total load across the wrist. Resection of a wafer of the distal dome of the

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ulna has also been shown to decrease ulnocarpal load transmission, regardless of initial ulnar variance.\(^9,10\) This decrease in ulnocarpal load is the rationale for the ulnar-shortening osteotomy and the wafer resection in the treatment of ulnar impaction syndrome.\(^11,12\)

PRESENTATION

There is little information known about the demographics and natural history of ulnar impaction syndrome. Because ulnar variance tends to be more positive in Asian individuals than White, the incidence of idiopathic ulnar impaction syndrome may be higher in Asian populations.\(^13–19\) Ulnar impaction syndrome is also more common in patients who have an acquired increase in ulnar variance, such as after a distal radius fracture malunion (Fig. 1). It is possible that with an increased tendency for distal radius fracture fixation, the incidence of acquired ulnar impaction syndrome will decrease. The onset of symptoms is usually insidious and progressive. Patients complain of ulnar-sided wrist pain, and occasionally swelling and loss of wrist motion and forearm rotation. Symptoms are exacerbated by activities that involve forceful grip, pronation, and ulnar deviation. In cases of idiopathic ulnar impaction syndrome, patients do not typically report an acute traumatic event preceding the onset of symptoms. Not all cases of ulnar impaction are symptomatic. Although ulnar impaction is presumably symptomatic in most cases, it is not unusual to see a patient with radiographic evidence of ulnar impaction, but who has minimal symptoms.

EXAMINATION AND DIAGNOSIS

The diagnosis of ulnar impaction syndrome is made on clinical grounds, and is supported by radiographic studies. A complete wrist examination should be performed to rule out other sources of pain such as pisotriquetral arthritis, distal radioulnar joint (DRUJ) arthrosis, extensor carpi ulnaris (ECU) subluxation or tendonitis, or neuritis of the dorsal cutaneous branch of the ulnar nerve. The ulnocarpal stress test was described by Nakamura and colleagues,\(^20\) and involves placing the wrist in maximum ulnar deviation, axially loading the wrist, and passively rotating the forearm through supination to pronation (Fig. 2). A positive test is one in which the patient’s typical pain is reproduced, and is suggestive of ulnar impaction syndrome. Although sensitive for ulnar impaction syndrome, a number of other pathologic processes can result in a positive ulnocarpal stress test, including LTIL injury, TFCC injury (without impaction), and isolated arthritis.\(^21\) The patient will also have tenderness to palpation dorsally just distal to the head of the ulna, and ulnarily just volar to the styloid. The lunotriquetral interval may be tender. If the LTIL is involved, lunotriquetral provocative maneuvers such as the Regan shuck test and the Kleinman shear test may be positive. It is also important to examine the DRUJ for stability and pain, as this will affect

Fig. 1. PA radiograph of the right wrist 6 months after an untreated distal radius fracture. Note the severe positive ulnar variance.

Fig. 2. The ulnocarpal stress test. The examiner places the wrist in maximum ulnar deviation, axially loads the wrist, and passively rotates the forearm from supination into pronation.
surgical decision making. It is also important to compare the affected wrist examination with the contralateral side.

**IMAGING**

As part of a standard wrist series, a neutral rotation posterior-anterior (PA) wrist radiograph should be obtained to determine ulnar variance. These are performed by imaging the wrist with the elbow flexed at 90 degrees and the forearm in neutral rotation. In addition, a pronated grip PA radiograph should be obtained to evaluate for dynamic positive ulnar variance. All views should be evaluated for pathology that could lead to acquired positive ulnar variance, such as a mal-united distal radius fracture or premature arrest of the distal radius physis. Comparison radiographs of the contralateral (unaffected) side are frequently helpful. Radiographs may demonstrate subchondral sclerosis or cystic changes at the dome of the ulna, the proximal ulnar corner of the lunate, or the proximal radial corner of the triquetrum. In severe cases, changes consistent with frank degenerative arthritis, such as osteophyte formation, may be evident at the ulnocarpal joint. The PA radiograph should be examined for DRUJ arthritis, and the slope of the DRUJ should be noted in anticipation of possible ulnar-shortening osteotomy. The lateral radiograph should be evaluated for evidence of dorsal ulnar subluxation. Although not usually necessary, if the diagnosis is unclear magnetic resonance imaging (MRI) provides detailed images of the structures involved, and is useful in detecting occult pathology. In its earliest stages, the involved articular cartilage may develop fibrillation and chondromalacia, which can be detected on MRI. Bone hyperemia or edema, localized to the involved regions, may also be evident. Subtle subchondral sclerosis or cystic changes are also detectable by MRI. MRI, and in particular MR arthrography, is useful for evaluating the integrity of the TFCC and the LTIL. When the diagnosis is in question, MRI is especially useful for evaluating other possible sources of ulnar-sided wrist pain.

**PALMER CLASSIFICATION**

The Palmer classification provides a scheme for categorizing acute and chronic TFCC injuries according to the location and severity of pathology seen on arthroscopy. Class II conditions (IIA through IIE) are degenerative, as opposed to acute TFCC injuries, and represent a spectrum of increasing severity of pathology secondary to ulnar impaction syndrome (Table 1). It should be noted that Class IA injuries, which are acute traumatic central disk perforations, are difficult to differentiate from degenerative perforations secondary to ulnar impaction syndrome.

**TREATMENT**

Nonoperative treatment should be provided initially, particularly in cases of idiopathic ulnar impaction syndrome. This should include 6 to 12 weeks of rest or immobilization, activity modification, nonsteroidal anti-inflammatory drugs, or local corticosteroids. If these modalities fail to work, surgical intervention may be necessary.
adequately treat symptoms, surgical intervention is indicated.

The goal of surgery for ulnar impaction syndrome is to decrease the length of the ulna relative to the radius, thereby diminishing the amount of load that crosses the ulnocarpal joint. The 2 primary options for accomplishing this goal are the ulnar-shortening osteotomy and the wafer procedure, both of which have been shown to decrease load across the ulnocarpal joint.\(^1,9-12,27\) Although less well studied, a number of ulnar head excisional osteotomies have been described, all of which effectively shorten the ulnar head while preserving the dorsal cartilage.\(^28-30\)

Depending on severity and symptoms, the presence of coexisting DRUJ arthritis should lead to consideration of procedures that address pathology of both the DRUJ and the ulnar impaction syndrome. Although not the focus of this article, these include endoprosthetic ulnar head arthroplasty, Bowers’ hemiresection interposition technique, matched distal ulna resection, the Darrach procedure, and the Sauve-Kapandji procedure.\(^31-34\) Finally, in cases of acquired positive ulnar variance, the surgeon should consider correcting the underlying problem in the radius, as opposed to shortening the ulna.

**Ulnar-Shortening Osteotomy**

The ulnar-shortening osteotomy was first described by Milch\(^27\) in 1941 (Fig. 4). It remains the gold standard against which other surgeries for ulnar impaction syndrome are compared. Although both ulnar-shortening osteotomy and the wafer procedure reduce ulnocarpal load and effectively treat the symptoms of ulnar impaction, there are some situations in which ulnar-shortening osteotomy should be preferred over the wafer procedure. In a wrist with both positive ulnar variance and a prominent ulnar styloid, correcting the underlying problem in the radius, as opposed to shortening the ulna.

Results after ulnar-shortening osteotomy are good and predictable, with improved Mayo Wrist scores, Disabilities of Arm, Shoulder and Hand scores, range of motion, grip strength, pain, and high satisfaction rates demonstrated in multiple studies.\(^13,38-41\) The most common complications after an ulnar-shortening osteotomy include delayed union or nonunion, and hardware-related
Fig. 4. (A, B) PA and lateral radiographs are shown of a 44-year-old farm wife with pain in the ulnar side of her left wrist. (C, D) T1- and T2-weighted coronal MRI shows typical changes within the lunate suggesting impaction. (E) A photograph taken during arthroscopy demonstrates a large central TFCC tear through which the probe is inserted. Note the chondromalacia of the articular surface of the lunate as well as on the surface of the ulnar head. (F) PA radiograph following the ulnar-shortening osteotomy is shown and demonstrates appropriate correction of the ulnar variance. (G, H) Final radiographs following osteotomy after healing of the ulna are shown.
problems. The nonunion rate is about 5%, but can be exacerbated by a number of factors. Cigarette smoking increases the nonunion and delayed union rate after ulnar-shortening osteotomy, increasing the mean union time from 4 months to 7 months. Smoking is therefore a relative contraindication to ulnar-shortening osteotomy. Delayed or nonunion can also be affected by surgical technique. Copious irrigation during osteotomy should be used to prevent thermal injury to the osteocytes. The periosteum should be carefully preserved during osteotomy. Only as much elevation as is required should be performed. Good compression is essential. Rayhack and colleagues suggested that an oblique osteotomy may improve union time, although other studies show equivalent union times with transverse osteotomies and careful technique. Hardware palpability or pain is common, although newer low-profile plates may decrease this problem. Some surgeons routinely remove the plate 1 to 2 years after osteotomy, although this is not necessary in all patients. Placing the plate on the volar, as opposed to dorsal or ulnar border of the ulna, should also reduce the need for later hardware removal. Furthermore, the volar surface of the ulna is often the flattest and widest. Ulnar shortening should be avoided in patients with DRUJ arthritis, and in patients with a reverse oblique DRUJ slope. In this situation, significant shortening of the ulna may result in abnormal contact between the seat of the ulna and the proximal rim of the sigmoid notch.

It should be noted that ulnar-shortening osteotomy is often combined with wrist arthroscopy (see Fig. 3). This permits direct evaluation of the TFCC, LTIL, and articlar surfaces. It allows debridement of the TFCC perforation or tear, if present. Cartilage flaps on the lunate or triquetrum articular surface can be resected. If LTIL injury is diagnosed, debridement is performed and the joint can be pinned.

The Wafer Procedure

The wafer procedure (partial distal ulnar resection) was described by Feldon in 1992, and involves resection of a thin wafer of the dome of the ulnar head (Fig. 5). Initially described as an open procedure, it can be performed arthroscopically as well. The wafer procedure is effective for decreasing ulnocarpal load and has some advantages over ulnar-shortening osteotomy. Constantine and colleagues compared the clinical outcomes after ulnar-shortening osteotomy and wafer procedure. They found similar results in terms of pain relief and wrist function after both surgeries; however, the ulnar-shortening osteotomy group required more revision operations for painful hardware, and delayed union occurred in some patients. Similar findings have been reported by other investigators. The primary advantage of the wafer procedure is the lack of hardware-related complications, and the avoidance of delayed union or nonunion that can be seen with ulnar-shortening osteotomies. It can also be performed in wrists that have a reverse oblique slope of the DRUJ (see Fig. 5A). As noted previously, drawbacks to the wafer procedure include the 2- to 3-mm limit for ulnar resection and the fact that it does not address stylolcarpal impaction (if present). Furthermore, it does not improve dorsal subluxation of the ulna, and it does not tighten the ulnocarpal ligamentous complex, as does the ulnar-shortening osteotomy. However, in most circumstances it can be an effective treatment for ulnar impaction syndrome, and avoids the hardware complications, delayed healing time, and repeat surgeries that can occur with ulnar-shortening osteotomy.

The open wafer procedure involves a longitudinal incision centered over the DRUJ. The extensor retinaculum is incised along the course of the extensor digit quinti, which is retracted to the side. The joint capsule is then incised longitudinally, and then ulnarly across the dome of the ulna just proximal to the TFCC. Care must be taken to preserve the TFCC distally. Subperiosteal reflection in an ulnarward direction allows visualization of the ulnar head and the base of the styloid. The distal 2 to 3 mm of the ulnar dome is removed with a sagittal saw. It is important to protect and maintain the palmar and dorsal radioulnar ligament insertion at the fovea and at the base of the ulnar styloid. The TFCC is debrided from the undersurface. A layered closure is performed. The patient is placed in a sugar tong splint, which is converted to a removable wrist cock-up brace at 2 weeks. Active motion is allowed time, but full activity does not resume until 8 weeks postoperatively.

The arthroscopic wafer procedure involves sufficient resection of the dome of the ulnar head, using an arthroscopic burr, such that the impaction is relieved. Initially, the TFCC is debrided with a shaver to a smooth, stable edge. Chondromalacia of the lunate surface can also be treated with the shaver. After the TFCC perforation is debrided in patients with Palmer class IIC or higher lesions, the dome of the ulna is accessed through the perforation. Typically 2 to 3 mm of ulnar head removal is sufficient; however, in cases of significant ulnar positive variance, more resection would be necessary. Care must be taken to excise the ulnar head area of impaction entirely. Adequate exposure for this can be
performed by pronating and supinating the forearm during the wafer procedure. This will reveal areas of the head that may need further resection. In addition, the use of intraoperative fluoroscopy will confirm that an appropriate amount of ulnar head has been removed (see Fig. 5C). Although some would advocate preserving the TFCC and converting to an open wafer procedure in patients with class IIA or IIB lesions, in which a TFCC perforation is not present, Tomaino and Elfar\(^26\) report good results in these patients by resection of the central articular disk, followed by wafer resection. They note that resection of the central disk may contribute to unloading the joint, and also treats the fibrillation on the innervated undersurface of the TFCC.

**Stylocarpal Impaction**

A variant of ulnar impaction syndrome is that of stylocarpal impaction (Fig. 6). Differentiating this from ulnar impaction is important, as a wafer procedure would be an ineffective treatment for stylocarpal impaction. If ulnocarpal impaction and stylocarpal impaction are both present, an ulnar-shortening osteotomy should be performed. Tomaino and colleagues\(^35\) reported a series of 5 patients who were treated for stylocarpal impaction. All underwent arthroscopy to rule out concomitant ulnar impaction syndrome. An ulnar styloid resection was performed at its base just distal to the TFCC insertion, with good results. All patients in this series had negative ulnar variance ranging from \(-3\) to \(-7\) mm, and had styloid

![Fig. 5.](image-url)
processes that were greater than the normal length of 3 to 6 mm. Stylocarpal impaction occurs more commonly in wrists with negative ulnar variance, in which the styloid has excessive length.\textsuperscript{35}

**SUMMARY**

Ulnar impaction syndrome is a common source of ulnar-sided wrist pain. It is most common in ulnar positive wrists, whether congenital or acquired, but can occur in ulnar neutral or negative wrists. Therefore, patients should be evaluated for dynamic positive ulnar variance. If the diagnosis is unclear, MRI is the most useful imaging modality. The ulnocarpal stress test should reproduce the patient’s symptoms, and other sources of pain should be ruled out. Treatment requires decreasing the length of the ulna relative to the radius. In cases of acquired positive ulnar variance, treatment of the underlying cause in the radius should be considered, such as in distal radius malunion. In idiopathic ulnar impaction syndrome, the mainstays of surgical treatment are the ulnar-shortening osteotomy and the wafer procedure. Both operations are reliable in treating ulnar impaction syndrome. But because each operation has unique advantages and disadvantages, neither is ideal in every clinical situation and decision making must be individualized.

**REFERENCES**
