Triangular Fibrocartilage Complex Tears
A Review

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Abstract
Triangular fibrocartilage complex (TFCC) tears are a common source of ulnar sided wrist pain. Originally described by Palmer, in 1981, as a complex of several structures, our understanding of the anatomy and the function of the TFCC has been refined by histologic studies. The TFCC plays an important role in load bearing across the wrist as well as in distal radioulnar joint (DRUJ) stabilization. A thorough knowledge of the anatomy as well as the Palmer classification system helps to guide treatment options.

Ulnar sided wrist pain is a common problem seen by hand surgeons. It has been considered, in the past, to be the “low back pain” of the wrist. As knowledge of the anatomy of the ulnar side of the wrist has evolved, so has our ability to treat specific disorders causing pain in the location. There are a multitude of lesions that can cause ulnar sided wrist pain as part of the differential including instability, arthritis and fractures, among other conditions (Table 1).

Careful attention to the history and physical examination will help to establish the diagnosis. Typically, the patient has ulnar sided wrist pain with pain and/or clicking on pronation/supination. Conventional radiographs as well as magnetic resonance imaging (MRI) also can be helpful in diagnosis. Treatment of triangular fibrocartilage complex (TFCC) tears is based on the differentiation between chronic and acute injuries, as well as their anatomic location. Advances in arthroscopic surgery have not just expanded but opened a new chapter in the treatment of TFCC tears.

Anatomy
The TFCC was described by Palmer and Werner1 as a homogenous structure composed of an articular disc, dorsal and volar radioulnar ligaments, a meniscus homologue, the ulnar collateral ligament (UCL), and the sheath of the extensor carpi ulnaris (ECU). The TFCC originates at the dorsal and volar edges of the sigmoid notch and inserts onto the ulnar styloid base both vertically and horizontally. The TFCC also inserts onto the lunate and triquetrum as the ulnolunate and ulnotriquetral ligaments. The ulnolunate and ulnotriquetral ligaments are volar structures that originate from the TFCC and not the ulna itself. The insertion onto the 5th metacarpal was termed the ulnocollateral ligament, but it is unclear if this ligament truly has a function in stabilizing the wrist, or whether the ECU subsheath is more important clinically. Nakamura and colleagues2 point out that the UCL, which is a thickened joint capsule ulnarly, did not have strong attachments to the ulnar styloid, while the ECU subsheath had a firm connection to the ulnar fovea. Based on the strength of the attachments, as well as the laxity of the UCL, the ECU subsheath is probably a more important stabilizer of the ulnar side of the wrist. In addition, there is a constant perforation of the meniscus homologue, named the prestyloid recess, that should not be interpreted as a tear at arthroscopy or on MRI evaluation.

The TFCC is supplied by dorsal and palmar radiocarpal branches of the ulnar artery as well as the anterior interosseous artery. The microvasculature of the TFCC is very similar to the meniscus, with a rich peripheral supply to
A careful history and physical examination is critical to diagnosing a TFCC tear. Typically, there is a history of ulnar sided wrist pain, possibly with mechanical clicking during pronation/supination activities. There may have been a history of a fall onto a pronated, outstretched extremity; a rotational injury to the forearm; an axial load to the wrist, or, uncommonly, a distraction injury to the ulnar side of the wrist. In addition, if the patient is complaining of discomfort with pronation/supination, but without other complaints, the problem is more likely a tear in the articular disk. If the patient complains of more constant pain with activities of daily living, and has a more limited range of motion, this is more likely to be associated with a peripheral destabilizing tear of the TFCC. The best place to palpate the TFCC is between the ECU and the FCU, distal to the styloid and proximal to the pisiform. In this soft spot of the wrist, there are no other structures than the TFCC. A provocative test, the ulnar grind test, involves dorsiflexion of the wrist, axial load, and ulnar deviation or rotation. If this maneuver reproduces the patient’s pain or mechanical symptom, a TFCC tear should be suspected.

Radiographs should include zero rotation posterior-anterior (PA) and lateral views. The PA, which is shot with the arm abducted to 90° and the forearm in neutral rotation, is the best view to measure ulnar variance. In addition, a pronated grip PA can show increased ulnar variance, which may impact treatment decisions. Tomaino found only 42% agreement between arthrographic and final arthroscopic diagnoses in the setting of chronic wrist pain. Schers and coworkers found that arthrography only diagnosed 50% of the TFCC tears found later at arthroscopy in a series of 39 patients. The utility of MRI in diagnosis is controversial. Potter and colleagues found MRI to have a sensitivity of 100%, a specificity of 90%, and an accuracy of 97%. The accuracy of localizing tears was 92%. These results may be, in part, due to the dedicated surface coil, the small field of view (8 cm), small (1 mm) slices, and the high resolution MRI used (1.5T). The ability of the MRI to diagnose peripheral tears has been questioned recently by Haims and associates, who found a sensitivity of 17%, a specificity of 79% and an accuracy of 64%. In addition, the experience of the musculoskeletal radiologist also plays a diagnostic role. Blazar and coworkers showed the difference between a senior and a junior attending, with 83% and 80% accuracy in diagnosing a tear, respectively, and a 69% vs. 37% accuracy in localizing the tear. MRI does seem to be a useful adjunct to history and clinical examination, but may not be as useful in determining the location of the tear.

**Classification and Treatment**

Palmer devised a classification system to guide treatment of TFCC tears in 1989. The main division is between traumat-
matic type I and atraumatic (degenerative) type II tears. It is useful to think of the degenerative tears as a spectrum of ulnocarpal abutment.

Type IA (Avascular articular disc) tears are the most common. If immobilization fails in the acute period, arthroscopic debridement provides good relief. Since the articular disc is avascular, there is little chance for healing with repair, thus debridement is the treatment of choice. How much of the TFCC can be debrided safely? Adams\textsuperscript{14} showed the central two-thirds could be debrided, leaving a 2 mm to 3 mm peripheral rim without significant kinematic changes.

The other type I tears are peripheral in nature and should be suspected if there is a loss of the “trampoline effect” described by Hermansdorfer and Kleinman.\textsuperscript{15} The normal TFCC has a rebound when palpated with a probe. If that rebound is lost, a peripheral tear is probably present. With this in mind, the remainder of the traumatic peripheral tears are as follows:

Type IB (Base of the styloid) tears can be treated with immobilization for several weeks if caught acutely. If conservative management fails, an open or arthroscopic repair should be performed. The rich vascularity of the periphery of the TFCC offers a highly favorable environment for healing.

Type IC (Carpal detachment) tears involve the ulnotriquetral or ulnolunate ligaments, volarly. If immobilization fails, an open or arthroscopic repair can be performed. Whichever approach is used, the ulnar nerve should be protected due to its proximity.

Type ID (detachment from the radius) tears involve an avascular area of the TFCC as well. Debridement of the central portion of the radial attachment has been performed with good results.\textsuperscript{16} Despite the vascularity of the radial attachment, good results equal to IB repairs have also been shown in arthroscopic repair.\textsuperscript{17} The correct treatment for ID lesions is still being debated.

There are multiple options for arthroscopic repairs. Inside-out repairs using zone specific cannulas or Tuohy needles have been described. There are also outside-in repairs, using Mulberry knots, such as described by Zachee and colleagues.\textsuperscript{18} There has also been a report of an all-inside repair using a meniscal fastener.\textsuperscript{19}

Degenerative tears are a spectrum of ulnocarpal impaction or excessive loading of the ulnar side of the wrist due to positive ulnar variance. It is in this situation that the pronated grip PA radiograph may be helpful in diagnosing a dynamic impaction. Type II tears are an additive type of classification; each successive subtype adds one more finding. Type IIA tears involve thinning of the articular disk without frank perforation. Type IIB tears involve the same thinning with chondromalacia of the lunate or ulna. These patients generally do not have mechanical symptoms, since there is no frank perforation nor a flap to cause the clicking. Fulcher and Poehling\textsuperscript{20} advise that arthroscopy is not indicated in type IIA and IIB lesions. Instead, they recommend that these lesions should be viewed as ulnar impaction and treated with ulnar shortening to decrease the load across the ulnar carpus and the TFCC. Minami and associates\textsuperscript{21} reported poor outcomes following simple arthroscopic debridement of degenerative TFCC tears associated with ulnar positivity. However, treatment options are evolving, and many of the IIA and IIB lesions are being treated in the same fashion as type IIC lesions.

Type IIC lesions involve a central perforation of the disc in addition to chondromalacia. The treatment for this lesion is either a formal ulnar shortening, or a wafer procedure, originally described by Feldon and coworkers as an open procedure.\textsuperscript{22} This technique of resecting several millimeters of bone down to subchondral bone, in order to unload the TFCC and maintain DRUJ stability, is now being performed arthroscopically. With this technique, the TFCC tear is debrided and the distal ulna is removed with a burr. It seems reasonable to perform this same procedure with regard to type IIA and IIB lesions. Since there is no kinematic problem with debriding the central two-thirds of the disc, one can debride the thinning degeneration of the disc, even if there is no frank perforation, and unload the ulnar side of the wrist with a wafer procedure.

Type IID lesions involve frank perforation, chondromalacia, and lunotriquetral ligament disruption. If there is no frank instability, one may debride the lunotriquetral ligament and perform an arthroscopic wafer resection. If there is frank instability, a formal ulnar shortening should be performed, which in theory may tighten the ulnocarpal ligaments and help stabilize the ulnar carpus. Otherwise, thought should be given to limited arthrodesis in addition to the treatment of the impaction. Type IIE lesions involve perforation of the disc, chondromalacia, lunotriquetral ligament disruption, and ulnocarpal arthritis. This is the endstage that necessitates salvage procedures, such as the Bowers, Sauve-Kapandji, Matched distal ulnar resection, or the Darrach.

**Open versus Arthroscopic Repair**

Hermansdorfer and Kleinman\textsuperscript{15} reported the largest series of open repairs for chronic tears. Patients in this study had a 73% satisfaction rate. Corso and colleagues,\textsuperscript{23} in a multicenter study, showed a 93% satisfaction rate with arthroscopic repairs, and a return to activity at three months. In a study by Haugstvedt and Husby,\textsuperscript{24} 85% of patients stated they would have the surgery again, knowing the outcome. The question of whether arthroscopic repairs hold up over time has not been adequately investigated, but Trumble and colleagues\textsuperscript{25} showed 8/9 radial tears and 4/5 ulnar tears that were repaired arthroscopically were intact when restudied with MRI/arthrography. Arthroscopic repairs are, therefore, a viable option in the treatment of TFCC tears.

In the treatment of degenerative tears, wafer resections and ulnar shortening have been compared by Constantine
and associates. There were no statistically significant differences in postoperative grip strength, motion, or good/excellent results. Almost half (5/11) of the patients with a formal shortening needed plate removal for ECU tendonitis, and 2/11 patients had a delayed union. The open wafer procedure does seem to offer the same good/excellent results with fewer complications. Results of the arthroscopic wafer resection were reported by Tomaino and Weiser on a series of 12 patients. Postoperatively, grip strength improved an average of 36%. Two-thirds (8/12) of patients reported complete resolution of symptoms, and one-third (4/12) of patients reported minimal symptoms at follow up. Arthroscopic debridement of the TFCC along with arthroscopic wafer resection does seem to be a reasonable treatment modality for type II tears.

Summary

The diagnosis of TFCC tears revolves around an accurate history and physical examination to rule out the myriad of other causes of ulnar sided wrist pain. MRI can be helpful in diagnosis, if one uses a high resolution MRI with a dedicated surface coil, a small field of view, and 1 mm slices. The ability of MRI to accurately localize a peripheral tear is questionable, and does seem to be dependent on the experience of the musculoskeletal radiologist reading the films. The Palmer classification helps to organize the different types of TFCC tears, and is divided into traumatic and degenerative categories: AVascular articular disc, IBase of styloid, ICarpal detachment, IRA Dius detachment.

The degenerative tears are characterized as an additive process in terms of pathology, starting with TFCC thinning and ending with ulnocarpal arthritis. Treatment is constantly evolving, and the trend is toward arthroscopic management of all but the IID lesions with frank instability, and IIE lesions with ulnocarpal arthritis. Long-term follow-up studies are needed to document the durability of the repairs, and to find if the short term results will deteriorate over time.

References

25. Trumble TE, Gilbert M, Vedder N. Ulnar shortening combined with arthroscopic repairs in the delayed management
