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Triangular Fibrocartilage Complex Injuries: Anatomy, Pathology, Detection, and Management

Anatomy

The ulnar aspect of the wrist is complicated and difficult to evaluate, requiring a good understanding of the anatomy and biomechanics of the joint.[1] The distal radioulnar joint (DRUJ) and the proximal radioulnar joint (PRUJ) combine to make a bicondylar joint with two convex and two concave surfaces for articulation.[1] Motion at the DRUJ occurs in three separate motions: "(1) rotation about the longitudinal axis of the forearm, (2) dorsal-palmar translation, and (3) proximal-distal translation".[1] Due to this anatomical design, the entire forearm must be assessed rather than the DRUJ itself when an individual has ulnar wrist pain.[1] The stability of the DRUJ relies heavily on other structures since the bony anatomy can only be attributed to 30% of the total stability at the joint.[1] Structures surrounding the DRUJ for stability include the interosseous membrane, the extensor retinaculum, and a variety of ligamentous structures and muscle-tendon units described below.[1] These structures contribute to the composition of the triangular fibrocartilage complex (TFCC), which is located at the ulnar aspect of the wrist and articulates directly with the hyaline cartilage covering the ulnar head.[1]

The triangular fibrocartilage complex (TFCC) is the key stabilizing structure for the DRUJ.[1] The TFCC is described as a three-dimensional structure made up of the triangular fibrocartilage articular disc, the dorsal and palmar radioulnar ligaments, the extensor capri ulnaris subsheath, the ulnar collateral ligament, the

ulnolunate and ulnotriquetral ligaments, and a meniscal homologue.[1,2] The TFCC is an anatomical structure for restraint and control, as well as for transmitting loads at the approximation of the ulna and carpal bones and through the DRUJ.[1] Typically, 82% of the load is transmitted from the carpal bones to the radius and 18% is transmitted to the ulna.[1] In describing the anatomical make up of the TFCC, the dorsal and palmar radioulnar ligaments, whose origins are the dorsal and palmar aspects of the distal radius, respectively, insert to the fovea (separating the ulnar styloid from the ulnar pole on the ulnar head) and assist in joint stability by limiting rotation along the forearm axis and avoiding separation of the joint by restricting translation in a dorsal-palmar direction.[1] The ulnolunate and ulnotriquietral ligaments are integral in their role of controlling translation in a palmar direction.[1] The extensor carpi ulnaris (ECU) tendon subsheath (the muscle-tendon unit in this region) is fixed to the dorsal radioulnar ligament which allows it to assist in providing the DRUJ with dynamic and static stability.[1] The meniscal homologue originates dorsally and attaches volarly, encompassing the area from the dorsal aspect of the distal sigmoid notch and the dorsal aspect of the triangular fibrocartilage disc to the ulnar side of the triquetrum, lunate carpal bones, and the lunotriquetral ligament.[1] This meniscus is not a dense collagenous structure, but rather highly vascularized with the ability to stretch and lengthen due to its loose connective tissue.[1] Similar to knee menisci, the central aspect of the TFCC is avascular while the peripheral aspect is more vascularized with better healing properties.[3] The figure in Appendix A provides a depiction of the TFCC and its surrounding anatomy.[1]

Pathology

A variety of wrist/hand pathologies can affect the TFCC, making clinical evaluation and use of imaging critical in diagnosis.[1,3] For instance, a fracture to the radial head with ulnar styloid implication negatively influences DRUJ stability as it functions to be a "medial anchor for the TFCC".[1] Statistics show that stable fractures to the distal radius lead to an injury of the TFCC in 11-19% of patients whereas unstable fractures can lead to a TFCC injury as high as 40-85% of the time.[1] Another influencing factor at the wrist is the potential of ulnar variance, or the orientation of the distal ulna in comparison to the distal radius[1]. If the ulna is further distal compared to the radius, positive ulnar variance exists (and vice versa for negative ulnar variance).[4] The presence of positive ulnar variance impacts the way in which forces are spread across the joint, increasing the load transmitted at the ulna and TFCC up to 40%.[1,5] This can also lead to ulnar impaction syndrome, effectively increasing the load on the TFCC and causing damage to the articular disc.[1]

Wrist and hand injuries account of 3-9% of all sports-related injuries.[6] Injury to the TFCC frequently occurs in athletes who partake in tennis, golf, hockey, lacrosse, baseball, gymnastics, boxing, and waterskiing due to direct pressure on the hand, repetitive loading, and the forceful rotation essential to these sports.[3,5] Additional risk factors for a TFCC injury include activities requiring a loaded grip with repetitive twisting, pulling, and pronating as seen in the use of heavy equipment and power tools or in some of the aforementioned sports.[5,7] Age is also a risk factor for degenerative TFCC injuries regardless of symptom presentation as TFCC damage can be found in symptomatic and asymptomatic individuals.[8]

Irregularities of the TFCC have been reported present in 27% of individuals younger than 30 years of age. The prevalence further increases to 49% of individuals over age 70 with TFCC damage.[8]

Detection

In clinical presentation, individuals will report ambiguous pain on the ulnar side of the wrist, tenderness to palpation, and mechanical symptoms such as clicking or popping with wrist movement.[3] Individuals will also likely complain of weakness, the feeling of giving out, and a loss in the ability to rotate the forearm.[1,6] Many patients will report pain at the ulnar side of the wrist with "powerful rotary hand movement" and lifting heavy objects which can be indicative of TFCC damage.[9] Injury to the TFCC can be classified as Class 1 (traumatic, acute) or Class 2 (degenerative, chronic).[1,3] The traumatic and degenerative classifications can each be further categorized as A-D or A-E (respectively) depending on the location and severity of damage.[1] This categorization is according to Palmer's 1989 classifications, which can then be sub-classified using the Atzei classification complementary to Palmer.[9,10] A traumatic injury is common in individuals who fall with an outstretched hand[3] whereas a chronic injury is typically the result of a previously undiagnosed acute injury with the ligament structures at the DRUJ now incapable of stabilizing the joint.[1] See Tables 1 and 2 in Appendix B for classification details.[11]

As discussed above, diagnosing an injury to the TFCC can be difficult due to the various surrounding structures that could be involved. Obtaining a detailed

history and, in the case of an acute injury, the mechanism of injury are imperative in diagnosing damage to the TFCC.[6] A variety of differential diagnoses are possible with ulnar sided wrist pain. A physical clinical examination is required in an attempt to rule out other causes, first examining the involved and uninvolved wrists to assess for edema or other apparent differences (such as a prominent ulnar head).[6,9] The clinician should evaluate wrist range of motion in all planes (flexion/extension, pronation/supination, and radial/ulnar deviation) and utilize palpation techniques to find the area of maximal tenderness.[6] In order to locate the TFCC, the clinician should "[palpate] at the soft spot on the ulnar wrist between the flexor carpi ulnaris (FCU) and ECU tendons, just distal to the ulnar styloid and proximal to the pisiform".[6] A positive fovea sign is signified if the patient reports severe pain or tenderness at this site, with 95.2% sensitivity in the discovery of an injury to the foveal aspect of the TFCC.[6,9] Using a dynamometer to measure grip strength is helpful, as an individual's grip strength of the involved hand is oftentimes reduced in comparison to the contralateral side due to pain.[6] More specifically, a ratio of grip strength can be measured comparing strength in a supinated position versus a pronated position, as powerful, supinated grip is more likely to cause pain with a TFCC injury.[9] A frequently used clinical evaluation tool is for the clinician to pronate the patient's wrist and combine this with ulnar deviation and axial force to compress the TFCC.[6] If the individual has a torn TFCC, this positive "TFC grind test" will result in a painful click or pop as the lunate carpal bone and head of the ulna impinge upon the TFCC.[6,9] Another test, with 100% sensitivity, is the "press test" requiring the individual to push through the involved hand (with the wrist in

extension) to stand from a seated position. Reported pain (representative of the pain causing the patient to pursue treatment) is considered a positive test.[6,12] The "ulnocarpal meniscoid-test" or the "waiter's test" is completed by passively moving the patient's wrist from extension into ulnar deviation with an axial load; this test has 72.7% accuracy is identifying a lesion to the TFCC if the patient has more pain with this test in a supinated position compared to neutral or pronated positions.[9] Additional clinical testing involves evaluation of the stability of the wrist, as degenerative tears of the TFCC are commonly associated with instability and osteoarthritis of the DRUJ.[6] Using such tests as the "piano key sign" to assess for subluxation of the DRUJ or the "ballottement-test of the distal ulna" to assess for translation of the radius on the ulna, the clinician can better appreciate the degree of instability.[9] In order to develop a complete understanding of the joint, it's important to do this stability testing by applying stress with the wrist in neutral, in a pronated position, and in a supinated position.[6]

Imaging should be considered if clinical evaluation indicates TFCC pathology.[13] However, due to the size and organization of the entire TFCC structure, diagnosis is difficult even using magnetic resonance imaging (MRI) which is a key tool in evaluating soft tissue abnormalities.[2] Typically, the initial imaging that occurs when an individual presents with vague wrist pain is plain radiographs, though the sensitivity of this form of imaging alone is deficient in detecting injury to the TFCC.[14] Plain radiographs are valuable, though, in identifying ulnar variance and the presence of osteoarthritis in the DRUJ.[15] When using an MRI for wrist pathology, especially for a small, detailed structure like the TFCC, it is recommend to use

sequences with high-spatial-resolution.[2] Magnetic resonance arthrography (MRA), which requires an intra-articular injection to the wrist of dilute gadolinium contrast for better imaging, is considered to be an accurate tool in the assessment of the TFCC.[2] The use of the contrast injection enlarges the joint capsule for a more direct image.[2] In addition, axial traction during MRA further increases the joint space for easier discovery of TFCC injuries.[16] An MRA is more appropriate in evaluating ulnar sided wrist pain, provides the clinician with more information on the integrity of the TFCC structure, and has 94.6% sensitivity in recognizing central tears and 93.3% sensitivity in recognizing peripheral tears.[2] However, it does cost more than a traditional MRI.[2] Also, due to the intra-articular injection, the patient is at increased risk for pain, infection, bleeding, or a reaction to the dilute gadolinium contrast.[2] If an MRI is contraindicated or not a viable option, a computed tomography (CT) arthrogram is recommended as it is the more sensitive and accurate diagnostic tool in identifying injury to the TFCC.[13] A more invasive method of diagnosing injury to the TFCC is through wrist arthroscopy, which continues to be seen as the gold standard and preferred method for conclusive diagnosis and subsequent treatment.[11,17] During the arthroscopic procedure, examination techniques such as the hook, ballottement, and push-off needle tests can be administered.[18]

Management

Treatment of a TFCC injury can be administered in a surgical or non-surgical manner. With a traumatic tear of the TFCC, the individual progresses through three stages; the acute phase occurs for the first two weeks, the subacute phase lasts the

next 2-6 weeks, and the chronic phase is considered to be anything after 6 weeks post injury.[15] Even with a tear of the TFCC, if the DRUJ is stable, then conservative or non-operative treatment should be considered as the first intervention technique.[3,19] The most common conservative management technique is to immobilize the patient's involved wrist in a cast or splint for 4-6 weeks.[19] Statistics show that 40-50% of patients who undergo 4-6 weeks of conservative management for ulnar wrist pain have a natural healing response of the TFCC, though this is heavily dependent on the location of the injury.[19] Due to the blood supply orientation of the TFCC, a tear to the vascularized peripheral 20% is more likely to heal via treatment in a conservative manner than the avascular central portion.[19] A corticosteroid injection into the DRUJ and medication such as non-steroidal anti-inflammatory drugs could also be considered in the conservative management phase.[15] One particular study evaluated the effectiveness of the WristWidget brace, which does not impact motion or upper extremity function but rather acts to stabilize the wrist by approximating the radius and ulna to allow for healing.[19] The study found that an asymptomatic return to function occurred and the individual's ability to bear weight was improved after wearing the brace for 12 weeks.[19] The generalizability of the WristWidget brace in conservative management for all TFCC injuries requires further research, but conservative treatment is found to be a valid first step and should be utilized prior to surgical intervention, particularly during the subacute and chronic phases of healing.[15,19]

If the DRUJ is unstable and/or conservative management fails in reducing the patient's pain and improving function, then surgical intervention is recommended

earlier rather than later.[3,19] One particular retrospective study found the incidence of surgical intervention after at least four weeks of conservative immobilization to be 43% among individuals with a clinical diagnosis of a TFCC injury.[20] The specific classification of the TFCC injury can further indicate the most appropriate surgical intervention.[13] Refer to Tables 1 and 2 in Appendix B for more detail.[11] Due to the heterogeneity of TFCC tears and their various presentations, the clinical assessment and classification of severity are critical in establishing a plan of care.[10] Typically a tear to the central portion can be debrided arthroscopically allowing the individual to return to activity within 1-2 months.[3] On the other hand, a peripheral tear will likely undergo repair (using a variety of open or arthroscopic techniques) requiring the postoperative use of a Muenster cast for six weeks and subsequent strengthening, effectively prolonging the return to sport date to 3-4 months after intervention.[3,19] In both cases, 90% good-to-excellent results have been reported.[3]

The purpose of repairing a tear to the peripheral aspect of the TFCC is to "re-establish the anatomy and attachments of this complex structure to relieve patients' pain", as the peripheral portion is critical in stabilizing the DRUJ.[10] Without surgical intervention, the patient is at risk for long-term instability of the DRUJ leading to cartilaginous deterioration and possible osteoarthritis.[10] Many studies have been completed in assessing the effects of various surgical techniques; an open repair method reportedly demonstrated 79% satisfaction while an arthroscopic outside-in technique found satisfaction as high as 93% with a reduction in pain and improvement in function.[10] It's important to consider the impact of positive ulnar variance on TFCC injuries, as many of these individuals report unsatisfactory

outcomes after surgery.[21] An operative procedure (ulnar-shortening osteotomy) can be completed to decrease the risk of impingement or stress on the TFCC and to "help maintain the mechanical integrity of the [DRUJ]".[21] However, an ulnar-shortening osteotomy (USO) can only assist with DRUJ stability if ulnocarpal integrity is intact and the radioulnar ligaments are not impaired.[21] If an individual has an unstable tear of the TFCC, a USO will not impact the integrity of the DRUJ.[21] In comparing arthroscopic debridement (AD) to arthroscopic peripheral repair (AR) of the TFCC in combination with a USO, patients who undergo an AR in conjunction with a USO produce a more stable DRUJ with superior clinical outcomes in comparison to those patients who receive an AD with a USO.[21]

Soreide et al. (2016) concluded that wrist arthroscopy is the best method in assessing the integrity of ligaments, cartilage, and the entire TFCC structure at the DRUJ.[10] In looking at the long-term effects of surgical intervention for tears to the peripheral aspect of the TFCC, arthroscopic repair using an outside-in suture method demonstrated good results (according to a median Mayo Wrist Score of 85, on a scale of 30-100) at follow-up 20 years postoperatively.[10] It's important for the clinician and patient to understand that if the TFCC injury is not repaired in a reasonable amount of time, and chronic pain and instability are persisting, a reconstruction may be required which yields a success rate of approximately 80%.[15]

Conclusion

As knowledge and understanding of the TFCC have significantly increased in recent years, the research has important clinical implications.[10] The current

research significantly helps clinicians in determining the appropriate plan of care for TFCC management, yet more research is always needed to further improve the ability to diagnose and treat injuries, diseases, and different pathologies. This is particularly true in the case of finding effective conservative TFCC treatment options that could prevent the need for surgery. The myriad techniques for clinical examination are critical, in conjunction with imaging, in the diagnosis of a TFCC injury and the classification systems assist in deciding the best treatment. The data on TFCC injury management includes results for a range of individuals, from young athletes with traumatic injuries to older adults with more degenerative damages, allowing for more relevant application to the general population regarding choice of treatment. As a clinician, it's important to address the impairment(s) from the TFCC damage, but the patient should be treated in a holistic manner through appropriate education on the injury and consultation regarding plan of care. The research above suggests a bout of conservative management can be effective through the use of bracing or casting to reduce pain and improve function prior to undergoing surgical management. However, if further intervention is required via surgery (in hopes of avoiding a full reconstruction), the outside-in arthroscopic technique to repair the TFCC is currently noted to have the most successful outcomes long-term.

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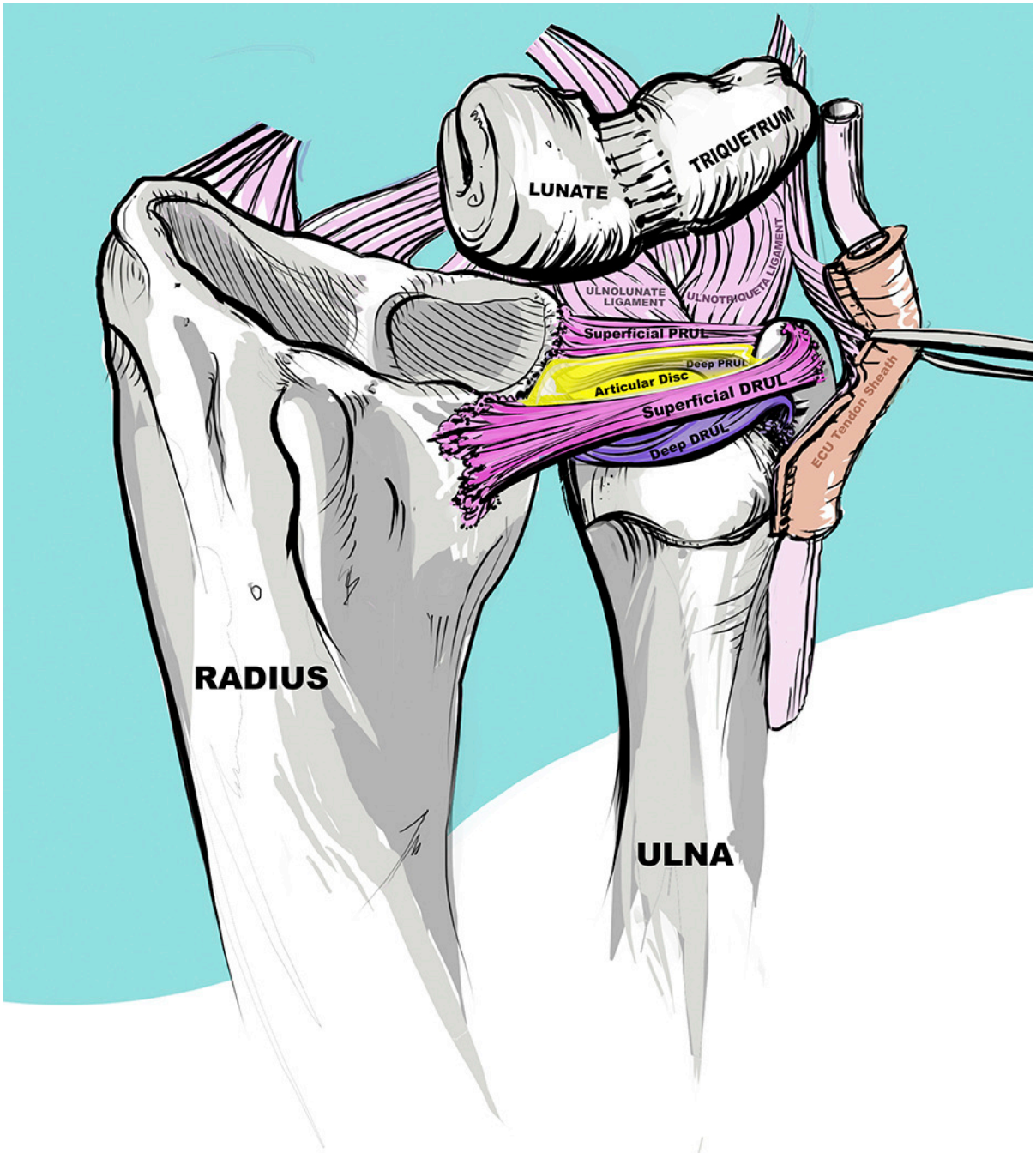
Appendix A

Figure 1: Anatomy of the distal radioulnar joint (DRUJ) and triangular fibrocartilage complex (TFCC)[1]



PRUL = palmar radioulnar ligament; DRUL = dorsal radioulnar ligament; ECU = extensor carpi ulnaris.

Appendix B

Table 1: Palmer Classification for TFCC Injury[16]

Type of tear	Location of tear	Treatment recommendation
Traumatic		
1A	Tear in horizontal or central portion	Debridement
1B	Tear from distal ulna insertion ± ulnar styloid fracture	Repair
1C	Tear with ulnocarpal ligaments disrupted Tear of ulnolunate and ulnotriquetral ligaments	Controversial, open repair or reconstruction
1D	Tear from insertion at radius	Repair or debridement
Degenerative		
IIA	TFCC wear but no perforation	Scope to confirm that the TFCC is intact, then ulnar shortening
IIB	TFCC wear but no perforation; chondromalacia of lunate or ulnar head	Scope to confirm that the TFCC is intact, then ulnar shortening
IIC	Central perforation of TFCC Chondromalacia of lunate or ulnar head	Debridement of the TFCC and wafer procedure Alternative ulnar shortening
IID	Central perforation of TFCC; chondromalacia of lunate or ulnar head; perforation of LT ligament	Debridement of the TFCC and LTL, chondroplasty, possibly arthroscopic reduction and internal fixation of LT interval if unstable and/or ulnar shortening
IIE	Central perforation of TFCC; perforation of LT ligament; ulnocarpal arthritis	Debridement of joint or open salvage

Table 2: Atzei Classification for TFCC Injury[16]

Class	DRUJ instability	Affected TFCC part	TFCC healing	DRUJ cartilage	Treatment
1	None/slight	Distal	Good	Good	Suture
2	Mild/severe	Distal + proximal	Good	Good	Foveal reattachment
3	Mild/severe	Proximal	Good	Good	Foveal reattachment
4	Severe	Proximal	Poor	Good	Reconstruction
5	Mild/severe	–	–	Poor	Salvage