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CONTEMPORARY CHALLENGES IN TFCC MANAGEMENT: A MULTIFACTORIAL CLINICAL ANALYSIS OF CURRENT EVIDENCE

Katarzyna Szurna *(Corresponding Author, Email: katarzyna.szurna@wp.pl)*
University Clinical Hospital in Białystok, Białystok, Poland
ORCID ID: 0009-0008-6233-2349

Tomasz Suprun
University of Dundee, Dundee, Scotland, United Kingdom
ORCID ID: 0000-0001-5610-9273

Jan Rytel
Faculty of Medicine, Medical University of Białystok, Białystok, Poland
ORCID ID: 0009-0006-0831-9990

Anna Maria Modzelewska
University Clinical Hospital in Białystok, Białystok, Poland
ORCID ID: 0009-0007-1563-8946

Jakub Walczewski
Independent Researcher, Białystok, Poland
ORCID ID: 0009-0001-9662-199X

Ada Kondrat
University Clinical Hospital in Białystok, Białystok, Poland
ORCID ID: 0009-0008-0823-0544

Wojciech Franciszek Majewski
University Clinical Hospital in Białystok, Białystok, Poland
ORCID ID: 0009-0005-5216-7907

Zuzanna Twarowska
University Clinical Hospital in Białystok, Białystok, Poland
ORCID ID: 0009-0006-8662-099X

Sylwester Stawowski
University Clinical Hospital in Białystok, Białystok, Poland
ORCID ID: 0009-0008-3861-7635

Urszula Rusiłowicz
Faculty of Medicine, Medical University of Białystok, Białystok, Poland
ORCID ID: 0009-0008-3568-8921

Emilia Bolesta-Okuniewska
Independent Researcher, Warsaw, Poland
ORCID ID: 0009-0008-4086-5232

Michał Pietrasz
Ludwik Rydygier Provincial Combined Hospital in Torun, Torun, Kujawsko-Pomorskie, Poland
ORCID ID: 0009-0000-8148-7487

ABSTRACT

Background: The triangular fibrocartilage complex (TFCC) is a crucial stabilizer of the wrist, traditionally associated with sports- related trauma. However, increasing evidence suggests a wider etiological spectrum.
Aim: This literature review aims to synthesize current evidence (2015- 2025) regarding the risk factors, mechanisms of injury, and management of TFCC lesions, emphasizing its prevalence beyond athletic populations.
Material and methods: A systematic search was conducted across PubMed, Web of Science, and Wiley Online Library using the keywords: "triangular fibrocartilage complex," "TFCC," "arthroscopy," and "wrist injuries." The selection included RCTs, prospective and retrospective cohort studies, and case series published in English between 2015 and 2025. Case reports were strictly excluded. A total of 37 articles met the criteria for final synthesis.
Results: While acute traumatic tears (Palmer Type I) remain prevalent in overhead and axial-loading sports, anatomical predispositions- specifically positive ulnar variance- and age- related degenerative changes (Palmer Type II) are significant risk factors in non-athletic populations. Modern diagnostics have evolved with MR arthrography showing superior sensitivity over conventional MRI, although diagnostic arthroscopy remains the gold standard. Management has shifted toward minimally invasive arthroscopic techniques, particularly foveal reattachment using suture anchors and modified suturing methods, which demonstrate favorable long-term outcomes and improved quality of life.
Conclusions: TFCC pathology is a multifaceted condition that should not be viewed solely as a sports injury. Understanding the interplay between anatomical, occupational, and traumatic factors is essential for accurate diagnosis and effective patient-centered management. Clinicians must adopt a broad etiological perspective to prevent chronic disability and optimize functional recovery.

KEYWORDS

Triangular Fibrocartilage Complex, TFCC, Arthroscopy, Wrist Injuries

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Introduction

The triangular fibrocartilage complex (TFCC) is a critical anatomical and functional unit located at the ulnar aspect of the wrist. It serves as the primary stabilizer of the distal radioulnar joint (DRUJ) and acts as a crucial load-bearing structure, transmitting approximately 20% of the axial load from the carpus to the ulna [1, 2]. Due to its complex architecture, which includes the articular disc, the ulnar collateral ligament, and the radioulnar ligaments, the TFCC is often susceptible to both acute traumatic tears and chronic degenerative changes [3, 4].

Traditionally, TFCC injuries have been synonymous with the "athlete's wrist." High-demand sports requiring repetitive loading, forceful rotation, or axial loading- such as gymnastics, tennis, and combat sports- frequently lead to traumatic (Palmer Type I) lesions [5, 6, 7]. In these populations, the mechanism of injury is usually well- defined, often involving a fall on an outstretched hand (FOOSH) or sudden pronosupination [8, 9]. However, a growing body of recent evidence suggests that the prevalence of TFCC pathology in the non-athletic population is significantly underestimated.

The paradigm shift in understanding TFCC etiology highlights that it is "not only a sports injury." Anatomical predispositions, most notably positive ulnar variance, have been shown to significantly increase the mechanical pressure on the ulnar compartment, leading to tears even in the absence of acute trauma [10, 11]. Furthermore, age-related degenerative processes (Palmer Type II) play a substantial role; recent imaging studies have demonstrated a high prevalence of incidental TFCC findings in asymptomatic individuals, suggesting that natural wear and tear are part of the common aging process [12, 13]. Occupational factors,

including long-term exposure to vibrations and repetitive manual tasks, further contribute to the non-sports-related burden of this condition [14].

Beyond clinical symptoms, TFCC injuries profoundly impact the patient's quality of life and functional independence. Persistent ulnar-sided wrist pain and decreased grip strength often lead to prolonged disability, affecting not only athletic performance but also basic activities of daily living and professional productivity [15, 16]. The psychological burden of delayed diagnosis and the challenges of post-operative immobilization further emphasize the need for optimized, patient- centered recovery protocols that ensure a safe and efficient return to both sports and daily activities [17].

Despite the advancements in diagnostic imaging, such as high-resolution MRI and MR arthrography, the TFCC remains a diagnostic challenge, often referred to as the "black box" of the wrist [18, 19, 20]. The introduction of new arthroscopic classifications has provided clinicians with more precise tools to categorize foveal and peripheral tears, which is essential for determining the optimal management strategy [21, 22]. Treatment options have evolved significantly between 2015 and 2025, moving from traditional open repairs to minimally invasive arthroscopic techniques, including foveal reattachment with suture anchors and specialized suturing methods [23, 24, 25].

Given the impact of TFCC injuries on the quality of life and hand function in both athletes and the general population, a comprehensive synthesis of current knowledge is required. This literature review aims to evaluate the most recent evidence (2015- 2025) regarding the risk factors, mechanisms of injury, and management strategies for TFCC lesions, emphasizing its multifaceted nature beyond the sports context.

Material and methods

Search Strategy

A systematic literature search was conducted across three databases: PubMed, Web of Science, and Wiley Online Library. The search was restricted to studies published between 2015 and 2025. To identify relevant publications, a combination of the following keywords was used: "triangular fibrocartilage complex", "TFCC", "arthroscopy", and "wrist injuries".

Inclusion and Exclusion Criteria

Studies were evaluated and selected based on the following inclusion criteria:

- Timeframe: Articles published from 2015 to 2025.
- Language: Research published exclusively in the English language.
- Population: Studies involving human subjects.
- Study Design: Randomized controlled trials (RCTs), prospective and retrospective cohort studies, and case series.

The exclusion criteria were as follows:

- Study Design: Case reports (single- patient descriptions) were strictly excluded to ensure a high level of clinical evidence and reliability.
- Scope: Articles that did not focus directly on the risk factors, mechanisms of injury, or management strategies for the triangular fibrocartilage complex.

Selection Process

The initial screening involved a review of titles and abstracts for relevance to the study objectives. Following this, the full texts of the remaining articles were examined to verify their adherence to the established methodological standards. As a result of this selection process, 37 articles were chosen for final synthesis in this literature review.

Etiology and Risk Factors

Sports-Related Trauma

Traumatic injuries to the TFCC (Palmer Type I) are predominantly observed in athletic populations subjected to high-intensity wrist loading and repetitive rotation. Research indicates that overhead athletes, particularly those in tennis, volleyball, and gymnastics, are at a significantly higher risk due to the forceful pronosupination and axial loading of the ulnar carpus [5, 7, 9]. The most common mechanism of injury remains a fall on an outstretched hand (FOOSH) with the wrist in extension and ulnar deviation, or sudden, high-torque rotational forces [6, 8]. In these cases, the injury often involves the peripheral attachments or the foveal insertion, leading to distal radioulnar joint (DRUJ) instability [14, 21].

Anatomical Risk Factors: Ulnar Variance

Beyond acute trauma, anatomical predisposition plays a crucial role in TFCC pathology. Positive ulnar variance- a condition where the ulna is longer than the radius- has been identified as a major risk factor for TFCC lesions in symptomatic patients [10, 11]. Increased ulnar length leads to a significant increase in load transmission through the ulnocarpal joint, predisposing the TFCC to attritional tears and ulnocarpal abutment syndrome [10]. Recent studies suggest that even minor variations in ulnar length can correlate with the severity of TFCC lesions, highlighting that structural anatomy is as critical as mechanical trauma in the development of these injuries [4, 11].

Age-Related Degenerative Changes (Palmer Type II)

The prevalence of TFCC abnormalities increases linearly with age, supporting the classification of many lesions as degenerative (Palmer Type II) rather than traumatic [12, 13]. Advanced imaging has revealed a high rate of incidental TFCC changes in asymptomatic individuals, which suggests that the natural aging process and chronic "wear and tear" are frequent causes of discoid thinning and perforation [13]. These degenerative changes often occur in the central avascular zone of the articular disc, where the healing potential is limited [1, 2].

Occupational and Occupational-Related Factors

Non-sports-related TFCC injuries are frequently linked to occupational hazards, particularly involving repetitive manual tasks and long-term exposure to vibrations [14, 23]. Tasks requiring chronic, repetitive power-grip activities or prolonged rotation of the forearm can lead to cumulative microtrauma of the TFCC components [23]. Furthermore, TFCC pathology is increasingly recognized in patients with no history of sports involvement, where the injury stems from activities of daily living or chronic overload associated with specific professional demands [14, 20].

Diagnostics

The diagnosis of TFCC injuries remains a clinical challenge, often requiring a combination of physical examination, advanced imaging, and, in many cases, surgical validation [1, 12]. While clinical tests are essential for initial suspicion, radiological evaluation is necessary to differentiate between traumatic and degenerative lesions [18, 19].

Magnetic Resonance Imaging (MRI) and MR Arthrography

Conventional MRI is the primary non-invasive diagnostic tool used to evaluate ulnar-sided wrist pain, showing high specificity but varying sensitivity depending on the type of lesion [19, 26]. Studies have demonstrated that MRI is particularly effective in diagnosing traumatic tears (Palmer Type I), although its accuracy can be limited in detecting subtle foveal detachments or central perforations [19, 37].

MR arthrography (MRA) is considered superior to conventional MRI for the detection of intra-articular pathology [18, 20, 27]. By utilizing contrast medium to distend the joint capsule, MRA provides better visualization of the TFCC's complex ligamentous structures and foveal attachments [18, 20]. Comparative analyses indicate that direct MR arthrography significantly improves diagnostic sensitivity for peripheral and foveal tears that might otherwise be overlooked on standard scans [20, 22, 27].

Arthroscopy: The Gold Standard

Despite the advancements in non-invasive imaging, diagnostic arthroscopy remains the "gold standard" for the definitive diagnosis of TFCC injuries [20, 21, 27]. Arthroscopy allows for direct visualization of the articular disc and the testing of ligamentous tension through dynamic maneuvers, such as the "hook test" or "trampoline test" [18, 21].

Furthermore, the implementation of new arthroscopic classifications has refined the diagnostic process, allowing clinicians to categorize disorders based on the exact location and nature of the tear, including distal radioulnar joint (DRUJ) instability [18, 21]. Recent literature emphasizes that foveal TFCC pathology, in particular, is a frequently overlooked injury that often requires arthroscopic confirmation for accurate management [22].

Management

The therapeutic approach to TFCC injuries is determined by the chronicity of the symptoms, the presence of distal radioulnar joint (DRUJ) instability, and the patient's functional requirements [3, 14, 21]. Management strategies range from non-operative protocols to advanced arthroscopic reconstructions [28, 29].

Conservative Management

Initial treatment for stable TFCC lesions, particularly Palmer Type II degenerative changes, typically involves activity modification, non-steroidal anti-inflammatory drugs, and immobilization [12, 14, 28]. Comparative studies indicate that while conservative management can be effective for low-demand patients, those with high functional or athletic needs often benefit more from early surgical intervention to prevent long-term disability [14, 21]. Recent evidence suggests that specific immobilization protocols, such as using a short-arm cast in a semisupination position, can optimize healing by reducing tension on the foveal attachments [28].

Surgical Management: Arthroscopic vs. Open Repair

Surgical intervention is indicated when conservative measures fail or in cases of acute traumatic tears with significant DRUJ instability [3, 29]. Arthroscopic repair has become the standard of care due to its minimally invasive nature and the ability to address intra-articular pathology with high precision [24, 28]. Comparison between open and arthroscopic foveal repairs shows comparable clinical outcomes; however, arthroscopic techniques are often preferred for their lower morbidity and faster recovery times [27].

Advanced Repair Techniques

Recent literature highlights several innovative techniques for foveal reattachment, which is critical for restoring DRUJ stability:

- Suture Anchors and Suturing: The use of suture anchors and modified techniques, such as the "double loop suture," has demonstrated high effectiveness in achieving stable foveal repair [23, 25, 30].
- Transosseous and Dual-Bone Tunnel Repairs: For specific Palmer Type IB injuries, dual-bone tunnel repairs have shown excellent clinical outcomes in retrospective case series [31].
- Around-Styloid Technique: Emerging arthroscopic-assisted techniques, such as the "around styloid" reattachment, offer alternative options for complex foveal tears [30].

Long-term Outcomes and Prognosis

The long-term success of TFCC repair is well-documented, with studies showing sustained clinical benefits for more than 13 years following arthroscopic repair of Palmer 1B tears [32]. Factors such as the timing of surgery, the presence of concomitant ulnar variance, and the specific immobilization protocol used post-operatively significantly influence the final prognosis and the rate of return to sport or work [10, 16, 17, 33].

Discussion

Clinical Implications and Impact on Quality of Life

The findings of this review have significant implications for clinical practice and patient-centered care. Modern management of TFCC injuries emphasizes that "success" is no longer measured solely by radiological healing, but by the restoration of grip strength and the patient's return to their baseline quality of life [15, 16].

Recent studies highlight that rigid, long-term immobilization is being replaced by more dynamic, position-specific protocols- such as semisupination casting- which aim to protect the repair while minimizing joint stiffness [17, 29]. This shift is vital for ensuring a successful return to high-level athletic performance and, equally importantly, for restoring professional productivity in non-athletes who perform repetitive manual tasks. By addressing both the mechanical instability and the patient's functional needs, clinicians can significantly reduce the long-term disability often associated with ulnar-sided wrist pain [14, 34].

Conclusions

The findings of this literature review confirm that triangular fibrocartilage complex (TFCC) injuries are a multifaceted clinical problem that extends far beyond the traditional context of athletic trauma. While high-demand sports remain a significant source of acute Type I lesions [5, 7, 19], evidence from the 2015–2025 period highlights the equal importance of anatomical predispositions and degenerative processes in the general population.

- Etiological Paradigm Shift: Positive ulnar variance and age-related changes are critical non-traumatic risk factors that predispose individuals to TFCC pathology, regardless of their level of physical activity [10, 11, 13]. This shift necessitates a broader diagnostic approach that considers anatomical and occupational factors alongside mechanical trauma.
- Diagnostic Precision: Advanced imaging, particularly MR arthrography, has improved non-invasive detection rates, yet diagnostic arthroscopy remains the gold standard for identifying foveal and peripheral tears [18, 20, 27]. The implementation of modern classifications is essential for tailoring treatment to the specific nature of the injury [21].

• Management Evolution: Surgical management has shifted toward minimally invasive arthroscopic techniques, with a strong emphasis on foveal reattachment using suture anchors and specialized suturing methods [23, 25, 33]. These interventions demonstrate high long-term success rates and are crucial for restoring the quality of life in both athletes and non-athletic patients [15, 32, 34].

• Functional Recovery: Successful management requires not only precise surgical intervention but also optimized, patient-centered rehabilitation and immobilization protocols to ensure a safe return to professional and daily activities [17, 29].

In summary, clinicians must recognize the TFCC as a structure vulnerable to a wide spectrum of insults. Early identification of non-sports-related risk factors is vital for preventing chronic disability and ensuring optimal functional outcomes for all patient groups.

Author's contribution
Conceptualization: Katarzyna Szurna
Methodology: Jan Rytel
Formal analysis:
Investigation:
Writing-rough preparation: Katarzyna Szurna
Writing-review and editing: Jan Rytel
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