ISSN 2218-5836 (online)

World Journal of *Orthopedics*

World J Orthop 2024 February 18; 15(2): 101-200

Published by Baishideng Publishing Group Inc

World Journal of Orthopedics

Contents

Monthly Volume 15 Number 2 February 18, 2024

EDITORIAL

101 Mitochondrial dysfunction in type 2 diabetes: A neglected path to skeletal muscle atrophy

Wu JJ, Xian HM, Yang DW, Yang F

105 Deep learning automation of radiographic patterns for hallux valgus diagnosis

Hussain A, Lee C, Hu E, Amirouche F

MINIREVIEWS

110 Review and update on the management of triangular fibrocartilage complex injuries in professional athletes

Pace V, Bronzini F, Novello G, Mosillo G, Braghiroli L

ORIGINAL ARTICLE

Retrospective Study

118 Mid-term outcomes of a kinematically designed cruciate retaining total knee arthroplasty

Katzman JL, Habibi AA, Haider MA, Cardillo C, Fernandez-Madrid I, Meftah M, Schwarzkopf R

129 Academic productivity correlates with industry earnings in foot and ankle fellowship programs in the United States: A retrospective analysis

Anastasio AT, Baumann AN, Walley KC, Hitchman KJ, O'Neill C, Kaplan J, Adams SB

139 Burden of routine orthopedic implant removal a single center retrospective study

AlOmran AK, Alosaimi N, Alshaikhi AA, Bakhurji OM, Alzahrani KJ, Salloot BZ, Alabduladhem TO, AlMulhim AI, Alumran A

Observational Study

147 Limb Lengthening and Reconstruction Society orthopedic surgeons in the United States: An analysis of geographical distribution, academic, leadership, and demographic characteristics

Hoveidaei AH, Niakan R, Hosseini-Asl SH, Annasamudram A, Conway JD

Prospective Study

156 High rate of clinically relevant improvement following anatomical total shoulder arthroplasty for glenohumeral osteoarthritis

Nyring MRK, Olsen BS, Amundsen A, Rasmussen JV

163 Effect of ankle versus thigh tourniquets on post-operative pain in foot and ankle surgery

Mishra A, Barakat A, Mangwani J, Kazda J, Tiwatane S, Shaikh SMA, Houchen-Wolloff L, Kaushik V

170 Assessment of the effectiveness of weight-adjusted antibiotic administration, for reduced duration, in surgical prophylaxis of primary hip and knee arthroplasty

Okoro T, Wan M, Mukabeta TD, Malev E, Gross M, Williams C, Manjra M, Kuiper JH, Murnaghan J

World Journal of Orthopedics

Monthly Volume 15 Number 2 February 18, 2024

Contents

META-ANALYSIS

180 Meta-analysis of factors influencing anterior knee pain after total knee arthroplasty

Feng H, Feng ML, Cheng JB, Zhang X, Tao HC

LETTER TO THE EDITOR

192 Adenylate cyclase activates the cAMP signalling pathway to enhance platelet-rich plasma-treated Achilles tendon disease, a theoretical bioinformatics-based study

Sun JY, Li C, Du FY

Contents

ABOUT COVER

AIMS AND SCOPE

The primary aim of *World Journal of Orthopedics* (*WJO*, *World J Orthop*) is to provide scholars and readers from various fields of orthopedics with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJO mainly publishes articles reporting research results and findings obtained in the field of orthopedics and covering a wide range of topics including arthroscopy, bone trauma, bone tumors, hand and foot surgery, joint surgery, orthopedic trauma, osteoarthropathy, osteoporosis, pediatric orthopedics, spinal diseases, spine surgery, and sports medicine.

INDEXING/ABSTRACTING

WJO is now abstracted and indexed in PubMed, PubMed Central, Emerging Sources Citation Index (Web of Science), Scopus, Reference Citation Analysis, China Science and Technology Journal Database, and Superstar Journals Database. The 2023 Edition of Journal Citation Reports® cites the 2022 impact factor (IF) for *WJO* as 1.9. The *WJO*'s CiteScore for 2022 is 2.6.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: *Ying-Yi Yuan*; **Production Department Director:** *Xiang Li*; **Editorial Office Director:** *Jin-Lei Wang*.

NAME OF JOURNAL
World Journal of Orthopedics

ISSN
ISSN 2218-5836 (online)

LAUNCH DATE
November 18, 2010

FREQUENCY
Monthly

EDITORS-IN-CHIEF
Massimiliano Leigheb, Xiao-Jian Ye

EXECUTIVE ASSOCIATE EDITORS-IN-CHIEF
Xin Gu

EDITORIAL BOARD MEMBERS
http://www.wjgnet.com/2218-5836/editorialboard.htm

PUBLICATION DATE
February 18, 2024

PUBLISHING PARTNER
The Minimally Invasive Spine Surgery Research Center Of Shanghai Jiaotong University

INSTRUCTIONS TO AUTHORS
https://www.wjgnet.com/bpg/gerinfo/204

GUIDELINES FOR ETHICS DOCUMENTS
https://www.wjgnet.com/bpg/GerInfo/287

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH
https://www.wjgnet.com/bpg/gerinfo/240

PUBLICATION ETHICS
https://www.wjgnet.com/bpg/GerInfo/288

PUBLICATION MISCONDUCT
https://www.wjgnet.com/bpg/gerinfo/208

POLICY OF CO-AUTHORS
https://www.wjgnet.com/bpg/GerInfo/310

ARTICLE PROCESSING CHARGE
https://www.wjgnet.com/bpg/gerinfo/242

STEPS FOR SUBMITTING MANUSCRIPTS
https://www.wjgnet.com/bpg/GerInfo/239

ONLINE SUBMISSION
https://www.f6publishing.com

PUBLISHING PARTNER's OFFICIAL WEBSITE
https://www.shtrhospital.com/zkjs/info_29.aspx?itemid=647

World Journal of Orthopedics

Submit a Manuscript: https://www.f6publishing.com

World J Orthop 2024 February 18; 15(2): 110-117

DOI: 10.5312/wjo.v15.i2.110

ISSN 2218-5836 (online)

MINIREVIEWS

Review and update on the management of triangular fibrocartilage complex injuries in professional athletes

Valerio Pace, Francesco Bronzini, Giovanni Novello, Giuseppe Mosillo, Luca Braghiroli

Specialty type: Orthopedics

Provenance and peer review: Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification
Grade A (Excellent): A
Grade B (Very good): B, B
Grade C (Good): 0
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: Farì G, Italy; Widmer KH, Switzerland

Received: October 20, 2023
Peer-review started: October 20, 2023
First decision: October 24, 2023
Revised: October 30, 2023
Accepted: December 14, 2023
Article in press: December 14, 2023
Published online: February 18, 2024

Valerio Pace, Department of Trauma and Orthopaedics, AOSP Terni, Terni 05100, Italy

Francesco Bronzini, Giovanni Novello, Department of Trauma and Orthopaedics, University of Perugia, Perugia 06100, Italy

Giuseppe Mosillo, Luca Braghiroli, Department of Trauma and Orthopaedics, Hand Unit, AOSP Terni, Terni 05100, Italy

Corresponding author: Valerio Pace, MBBS, MSc, Researcher, Senior Research Fellow, Surgeon, Department of Trauma and Orthopaedics, AOSP Terni, London HA7 4LP, Terni 05100, Italy. valeriopace@doctors.org.uk

Abstract

Triangular fibrocartilage complex injuries are common in amateur and professional sports. These injuries are mainly caused by acute or chronic repetitive axial loads on the wrist, particularly on the ulnar side and in association with rotations or radial/ulnar deviations. In order to treat professional athletes, a detailed specific knowledge of the pathology is needed. Moreover, the clinician should fully understand the specific and unique environment and needs of the athletes, their priorities and goals, the type of sport, the time of the season, and the position played. An early diagnosis and appropriate management with the quickest possible recovery time are the uppermost goals for both the athlete and the surgeon. A compromise between conservative *vs* surgical indications, athletes' needs and expectations, and financial implications should be achieved. Arthroscopic procedures should be timely planned when indicated as they could allow early diagnosis and treatment at the same time. Conservative measures are often used as first line treatment when possible. Peripheral lesions are treated by arthroscopic repair, whilst central lesions are treated by arthroscopic debridement. Further procedures (such as the Wafer procedure, ulnar osteotomies, *etc.*) have specific indications and great implications with regard to rehabilitation.

Key Words: Triangular fibrocartilage complex injuries; Professional athletes; Ulnar sided wrist pain; Wrist arthroscopy; Wrist debridement

Core Tip: Triangular fibrocartilage complex injuries are common in amateur and professional sports. These injuries are mainly caused by acute or chronic repetitive axial loads on the wrist, particularly on the ulnar side and in association with rotations or radial/ulnar deviations. In order to treat professional athletes, a detailed specific knowledge of the pathology is needed. Moreover, the clinician should fully understand the specific and unique environment and needs of the athletes, their priorities and goals, the type of sport, the time of the season, and the position played. Conservative and surgical management are based on the latter aspects.

Citation: Pace V, Bronzini F, Novello G, Mosillo G, Braghiroli L. Review and update on the management of triangular fibrocartilage complex injuries in professional athletes. *World J Orthop* 2024; 15(2): 110-117
URL: https://www.wjgnet.com/2218-5836/full/v15/i2/110.htm
DOI: https://dx.doi.org/10.5312/wjo.v15.i2.110

INTRODUCTION

The triangular fibrocartilage is a small load-bearing disc-shaped anatomical structure located at the level of the distal part of the ulna and distal radio-ulnar joint, in close relation to the ulnar styloid and the ulnar margin of the distal radius. It is called the "triangular fibrocartilage complex" (TFCC) together with the dorsal and volar distal radio-ulnar ligaments, meniscal homolog, ulno-carpal ligaments and extensor carpi ulnaris tendon sheath. Vascularization is provided by dorsal and palmar branches of the ulnar artery, and palmar branches of the anterior interosseous artery[1-3]. The central portion has reduced regenerative capacities, whilst the peripheral portion is more prone to reparative processes, being provided with a better blood supply compared to the central portion.

The function of the TFCC is to act as a stabilizer for the ulnar aspect of the wrist. It can resist both loading and tensive forces. The TFCC is at risk for either acute traumatic or chronic degenerative injury[1-3]. One can intuitively understand that athletes are at greater risk of acute traumatic injuries to the TFCC rather than degenerative problems.

The diagnostic and therapeutic process can vary between the general population and professional athletes. Several factors must be taken into account in order to choose the most appropriate course of action[1,2].

LITERATURE SEARCH

A narrative review of published papers on the diagnosis and management of TFCC injuries in professional athletes was performed. PubMed, MEDLINE, Cochrane and EMBASE databases were searched. The search keywords were: TFCC injury; triangular fibrocartilage complex injury; TFCC athletes; triangular fibrocartilage complex athletes; TFCC sport; triangular fibrocartilage complex sport; TFCC professional athletes; triangular fibrocartilage complex professional athletes; TFCC treatments; triangular fibrocartilage complex treatments.

All Authors independently performed the review and all included articles were scrutinized. The included articles and results were merged after common agreement among the Authors. Only articles specifically based on the diagnosis and management of TFCC injuries in professional athletes published in the last 20 years were included. In addition, only articles with level of evidence I-II-III-IV were included. Informed consents and ethical approval were not necessary (narrative review).

EPIDEMIOLOGY

Whilst epidemiologic data in the general population have been reported, there is still uncertainty and a lack of high level scientific evidence with regard to the epidemiology of TFCC lesions related to sports. It is reported that these lesions represent between 3% and 9% of the hand-wrist injuries in athletes. It is also reported that the prevalence increases with age[1,2,4,5].

TFCC injuries are common in both amateur and professional sports. These injuries are mainly caused by acute or chronic repetitive axial loads on the wrist, particularly on the ulnar side and in association with rotations or radial/ulnar deviations[1,2,4-9].

Sports that more commonly result in such injuries have been reported to be: Tennis, padel, table tennis, golf, and baseball. Sports that less commonly result in these injuries (but still with a significant number of reported cases) are: Volleyball, basketball, water board sports, and gymnastics[1,2,6-9].

CLASSIFICATIONS

Classifications of TFCC injuries are based on anatomy (central *vs* peripheral) or more commonly on the etiology. In fact

the classification most frequently used is Palmer's classification, which divides TFCC lesions into 2 groups: Type 1 (acute traumatic injuries) and type 2 (degenerative lesions)[10-12].

Type 1 lesions are further divided into subgroups on the basis of the anatomical location of the lesion: Type 1A (isolated central TFCC articular disc perforation); type 1B (peripheral ulnar sided TFCC tear (with or without ulnar styloid fracture); type 1C (distal TFCC disruption (from the distal ulno-carpal ligament); type 1D (radial TFCC disruption with or without sigmoid notch fracture)[10-12].

Type 2 lesions are also further divided into subgroups: Type 2A (TFCC wear); type 2B (TFCC wear with lunate and/or ulnar chondromalacia); type 2C (TFCC perforation with lunate and/or ulnar chondromalacia); type 2D (TFCC perforation with lunate and/or ulnar chondromalacia and with lunotriquetral ligament perforation); type 2E (TFCC perforation with lunate and/or ulnar chondromalacia, lunotriquetral ligament perforation and ulno-carpal arthritis)[10-12] (Table 1).

DIAGNOSIS

The most common symptoms of a TFCC injury are: Ulnar-sided wrist pain with tenderness mainly found at the level of the fovea; ulnar-sided minimal oedema; pain against resistance; reduced range of motion (ROM) of the wrist; joint sagging during rotations or load-bearing activities; audible and palpable "click" from the ulnar side of the wrist during forearm rotations (prono-supination) and sometimes radial and/or ulnar deviation. Pain and reduced function on radio-ulnar deviation can be characteristic of an ulnar impaction syndrome. Injuries can be asymptomatic or pauci-symptomatic [13-17].

Athletes often report sudden occurrence of pain during forearm rotations and axial-loading of the wrist. Different combinations of axial-loading, rotation and radial or ulnar deviations have been reported. Direct trauma on the ulnar side of the wrist is a rare but existing occurrence, especially with the wrist in radial deviation. Another possible finding is a chronic lesion caused by repetitive movements of the wrist and mechanical stress in general of the distal radio-ulnar joint [13,14,18].

These symptoms related to a TFCC injury are often reported by athletes playing sports involving significant axial-load and mechanical stress on the wrist, particularly if the axial-load is associated with rotations and radial/ulnar deviations (such as tennis, padel, golf, ping-pong, baseball, javelin *etc.*)[13-18].

An association between TFCC injuries and other major musculoskeletal lesions (such as Colles' fractures, Galeazzi's injury, Essex-Lopresti injury, *etc.*) in athletes competing in sports involving strong body contact such as football, rugby, *etc.* has rarely been reported [1,2,4,5].

If the TFCC injury is significant, the athlete is rarely able to continue to the end of the training sessions or games/competitions given the significant pain and wrist motion impairment.

Specific tests introduced in order to evaluate wrist stability are as follows: Ulnar fovea sign, piano key test, ulnar grinding test, compression test, and the ballottement test[1,2,19,20] (Table 2).

The next step is radiology. A plain radiograph is a must (at least the common antero-posterior (AP) and lateral view) and is the simplest and quickest radiological exam performed. It is of absolute relevance to identify any fractures (especially affecting the ulnar styloid), measure the standard radiological parameters of the wrist (ulnar variance in particular on the AP view), exclude a subluxation of the distal radio-ulnar joint (by examining the lateral view) and evaluate the potential presence of an ulnar impaction syndrome (especially in degenerative lesions)[1,2,16,19,20] (Table 2).

A computed tomography scan is rarely recommended, and is indicated only in cases of intra-articular fractures of the wrist. A wrist magnetic resonance imaging (MRI) scan is often indicated for TFCC injuries. Its sensitivity and specificity vary depending on the level of resolution of the scanning machine. High resolution MRI scans provide a level of accuracy up to 97%[1,2,16,19,20] (Table 2).

A wrist arthrogram is an option very commonly used in some units as this exam allows visualization of the lesion location and defines the characteristics of the TFCC lesion[1,2,16] (Table 2).

However, the literature indicates that wrist arthroscopy is the gold standard for TFCC injury diagnosis and to potentially allow appropriate treatment simultaneously. It is considered the test with the highest sensitivity and specificity, provides the opportunity to directly visualize the anatomical structures and make a specific diagnosis, and allows arthroscopic treatment at the same time (debridement or repair). Several arthroscopy portals and repair techniques have been reported in the literature, which are chosen specifically depending on the type of patient and lesion[1,2,21,22]. Specific aspects related to the choice and timing of radiological examinations will be discussed in the following sections.

TREATMENTS

Conservative treatments

Athletes with a TFCC injury, after the appropriate diagnostic process, are very often prone to attempt conservative measures first, before more invasive options. However, this will be further developed in this article as many specific factors must be considered when making such decisions[1,2,20,21].

The following conservative measures are applied in different combinations: No sport activity for 3-6 wk (depending on the severity of the injury); immobilization with a splint for 2-4 wk; utilization of non-steroidal anti-inflammatory agents (oral and/or topical); one or more steroid injections and/or hyaluronic acid injections; physical therapy; occupational

Table 1 Palmer's classification

Type 1 acute traumatic injury	Type 2 degenerative injury
Isolated central TFCC articular disk perforation	TFCC wear
Peripheral ulnar-sided TFCC tear with or without ulnar styloid fracture	TFCC wear with lunate and/or ulnar chondromalacia
Distal TFCC disruption (disruption of the distal ulno-carpal ligaments)	TFCC perforation with lunate and/or ulnar chondromalacia
Radial TFCC disruption with or without sigmoid notch fracture	TFCC perforation with lunate and/or ulnar chondromalacia and with lunotriquetral ligament perforation
	TFCC perforation with lunate and/or ulnar chondromalacia, lunotriquetral ligament perforation and ulno-carpal arthritis

TFCC: Triangular fibrocartilage complex.

Table 2 Diagnosis of TFCC injuries

Clinical tests	Radiological tests
Areas of tenderness	X-ray (AP and lateral view)
Ulnar fovea sign	CT (rarely)
Piano key test	MRI
Ulnar grinding test	Wrist arthrogram
Compression test	Wrist arthroscopy (gold standard)
Ballottement test	
ROM evaluation	

AP: Antero-posterior; ROM: Range of motion; CT: computed tomography; MRI: Magnetic resonance imaging.

therapy[1,2,21-24].

If it is necessary for the athlete to carry on to the end of the competitive season or a specific game/competition (weeks or months), the clinician should postpone the surgical treatment until the annual break and carry out the above-mentioned conservative strategies, if the severity of the injury allows and bearing in mind that the athlete must perform at a certain high level. However, if the TFCC injury is very severe and strong surgical indications are defined, especially in the absence of imminent relevant competitions, the orthopaedic surgeon could recommend surgical repair straight away, with the aim of achieving the quickest possible recovery and return to sport activity avoiding long-term degenerative complications[1,2,22-24].

It is suggested that an experienced multidisciplinary team centered on an orthopaedic surgeon with strong experience in hand and wrist surgery should be involved in the treatment of elite athletes with TFCC injuries. In fact, injury management errors would be particularly evident when dealing with professional athletes and significant consequences could be caused by little mistakes. We stress again the importance of the initial decision on the timing of surgical repair: The athlete's entire career is at stake and this "crossroad" is the key management decision that could positively or negatively affect the outcome of treatment[1,2].

Surgical treatments

Type 1A lesions: Isolated central TFCC articular disk perforation. These lesions are avascularized and cannot be arthroscopically repaired. Therefore arthroscopic debridement is the surgical treatment of choice. It is reported in biomechanics studies that up to 80% of the disc could be debrided/removed without causing any significant wrist instability. A standard arthroscopic set up is usually required with the use of 2 portals (rarely 3 portals)[1,2,18-24].

Surgery is followed by 1 or 2 wk of wrist immobilization. This is followed by a rehabilitation program based on passive and active wrist movements. Athletes playing sports requiring strong wrist stress forces (tennis, golf, javelin, padel, *etc.*) are allowed light ball contact after 3 wk. Full return to sport is expected between 4 to 6 wk[1,2,18-24].

If a type 1A lesion is associated with neutral or positive ulnar variance, it may be necessary to perform a shortening ulnar osteotomy or a Wafer-procedure after debridement. The osteotomy could be postponed to the end of the season with the aim of allowing the injured athlete to return to high level performance in a few weeks and manage the remaining problem at the end of the season. The rehabilitation program after an osteotomy could last up to 3-4 mo (it requires immobilization for 6-8 wk) and the entire season could be at risk[1,2,18-24].

Type 1B lesions: Peripheral ulnar-sided TFCC tear with or without ulnar styloid fracture. These lesions are vascularized and can potentially be repaired. Using an inside-out, outside-in or all-inside technique, the lesion is arthroscopically repaired[1,2].

The rehabilitation program includes immobilization (splint or cast) for 4-6 wk, and then a further 6 wk of passive and active wrist exercises to regain an adequate ROM and muscle strength. The program may take up to 3 mo[2,18-24].

Type 1C lesions: Distal TFCC disruption (disruption of the distal ulno-carpal ligaments). These lesions are often diagnosed without arthroscopy and mainly require an open surgery repair. An incision on the ulnar side of the wrist just volar to the extensor carpi ulnaris should be made and the neurovascular structures carefully protected throughout the entire procedure. Following appropriate exposure, the lesion can be directly repaired; several techniques have been described[1,2,18-24].

Type 1D lesions: Radial TFCC disruption with or without sigmoid notch fracture. An arthroscopic repair is suggested for these lesions, together with thorough debridement of the sigmoid notch, particularly at the level of the triangular fibrocartilage insertion[1,2,18-24].

Type 2A lesions: TFCC wear. Symptoms related to these lesions may be insidious. Radiographs are necessary in order to rule out and diagnose degenerative changes in the distal radio-ulnar joint and evaluate the ulnar variance. Elite athletes are often offered surgical management including a shortening ulnar osteotomy for those with neutral or positive ulnar variance. However, the latter is contraindicated in the presence of radio-ulnar joint arthritis. In this case a distal ulnar resection is proposed[1,2,18-24].

Type 2B lesions: TFCC wear with lunate and/or ulnar chondromalacia. The treatment options do not differ from those related to type 2A lesions[1,2,18-24].

Type 2C lesions: TFCC perforation with lunate and/or ulnar chondromalacia. These lesions are treated by arthroscopic debridement and a Wafer resection procedure for those with neutral or positive ulnar variance. If the latter is bigger than 2 mm, a shortening ulnar osteotomy is recommended instead[1,2,18-24].

Type 2D lesions: TFCC perforation with lunate and/or ulnar chondromalacia and with lunotriquetral ligament perforation. This type of lesion rarely affects elite athletes as significant degenerative processes do not generally occur before 30-40 years of age. The treatment does not differ from that of 2C lesions, apart from the necessity to evaluate the stability of the lunotriquetrel ligament. Consequently a Wafer procedure is contraindicated in the case of instability, and accurate debridement of the ligament is also necessary. If instability persists even after the osteotomy procedure, a lunotriquetral arthrodesis should be considered as a second stage treatment option in those whose symptoms do not improve after osteotomy[1,2,18-24].

Type 2E lesions: TFCC perforation with lunate and/or ulnar chondromalacia, lunotriquetral ligament perforation and ulno-carpal arthritis. In the presence of degenerative changes, Wafer procedures and osteotomies are not indicated in these patients. The well studied salvage procedure called Sauve-Kapandji (or hemiresection arthroplasty) is a suitable option for these cases. A Sauve-Kapandji procedure is the treatment of choice for elite athletes as it offers the lowest risk of radio-ulnar impingement during sport activities[1,2,18-24]. The rehabilitation protocol of type 2 lesions does not differ from those described above.

Sport-specific treatments

The treatment of choice may depend and vary on several factors. The clinician should take into account the level of pain and movement limitations, the type of lesion, the severity of the injury, the level of competition, the timing of the injury in relation to the stage of the agonistic season, sport, and position played by the athlete[1,2,22-27].

Very early diagnosis is the key step for elite athletes as this allows early identification of the problem and subsequent early treatment planning. If temporary immobilization is advocated, professional athletes are often very reluctant to be compliant with this treatment strategy. Moreover, athletes participating in sports involving repetitive pronation/supination and radial/ulnar deviation do not significantly benefit from this type of conservative measure and very often immobilization is avoided[5,16,17].

On the other hand, steroid injections (with or without the use of hyaluronic acid) seem to be a quite common temporary or definitive option for professional athletes. These injections are indicated for injuries that do not have surgical indications or for injuries with surgical indications in athletes who are willing to end the season before undergoing surgery. However, there are exceptions: In the presence of radio-ulnar instability, central lesions (an early arthroscopic procedure for central lesions allows both an early and accurate diagnosis and appropriate surgical management at the same time, assuring the shortest rehabilitation time), and lesions associated with neutral or positive ulnar variance (debridement is initially needed, after which further surgical treatments are considered and evaluated in the following months), a prompt surgical plan is warranted[1,2,18-24].

Different to the surgical timing for central lesions, peripheral lesions with surgical indication do not need immediate surgical planning. Careful discussion (with pros and cons evaluation) between the athlete and the surgeon should take place with a shared final decision on whether to decide on a conservative or surgical option. As mentioned previously, several factors should be taken into account and the decision should be athlete-centred and specific. If the type of injury allows, many opt for temporary measures (steroid injections prevalently) in order to complete at least the season. In fact a surgical option implies the need for at least 3 mo rehabilitation. More invasive treatments such as Wafer procedures are very commonly delayed until the end of the season, whilst ulnar osteotomies are widely postponed at least until the end of the season, if not to the end of the professional career[1,2,18-24].

The major issue for all athletes whose injuries have a surgical indication but are treated temporarily with conservative measures until the end of the season, is the possibility of compromising the final surgical results and increasing the risk of medium- and long-term consequences (such as degenerative changes)[1,2,18-24].

SPORT-SPECIFIC REHABILITATION INSIGHT

It is known that central lesions can be treated arthroscopically. Patients are required to use a splint for 1 to 2 wk after the surgical procedure and then start passive and active ROM exercises. Athletes playing sports such as golf are usually able to start their routine training (including ball-contact) after about 3 wk. Full return to competitive sport activities can be achieved in 4-6 wk in these patients. On the contrary, for sports involving significant axial loading forces onto the wrist (such as boxing and gymnastics) full return to competition level may take up to 8-12 wk. Athletes playing sports involving frequent and intense radial-ulnar deviation and rotations of the wrist (such as tennis and padel) may return to competitions in approximately 6-8 wk[1,2,22-27].

The rehabilitation protocol after arthroscopic debridement for peripheral lesions is longer than that described above. In fact, patients require a period of immobilization with a splint or cast for 2-6 wk. This should be followed by a further 6-8 wk of passive and active wrist ROM exercises and strengthening exercises. The return to competitive sport activity may be achieved after 2-3 mo, independent of the type of sport[1,2,22-27].

The return to sport might take longer following surgical treatment of type 2 lesions. A Wafer procedure requires 1-2 wk of immobilization in a splint or cast which should be followed by early active exercises first and strengthening exercises in the second stage. Full return to competition is authorized after 6-8 wk minimum depending on symptoms: The athlete can compete at the end of the rehabilitation protocol when pain free. No differences among the types of sport have been reported[1,2,18-27].

A shortening osteotomy requires 5-6 wk of immobilization, preferably with a cast. This is followed initially by passive and active ROM exercises of the wrist and then by strengthening exercises. Full return to competitive sport may be achieved after 10-12 wk at the earliest. Full bone healing (with radiological evidence from plain radiographs) is necessary in order to allow the athlete to compete again[1,2,18-27].

Elite athletes playing certain sports can be aided by the use of taping, splinting or padded casts, especially after Wafer or osteotomy procedures in order to reduce stress. However, not all sports allow the use of these aids. In fact, athletes playing ball contact sports (such as rugby, football, baseball and tennis) cannot fully compete if they require these aids and their rehabilitation protocol might take longer than expected as a consequence. Therefore, protective equipment varies between non-contact and contact sports, and its use may vary even among different roles played by the athletes within the same sport activity[1,2,18-27].

In general, a professional athlete with key roles within the team or with very high potential and expectations can wait until the end of the season to undergo a surgical procedure after sustaining a TFCC injury (and utilize temporary measures such as steroid injections); moreover, the rehabilitation protocols tend to be more intense as the quickest possible return to sport is attempted. On the other hand, professional athletes with lower expectations decide on surgical treatment at an earlier stage and a slightly more prudent rehabilitation protocol is adopted[1,2,18-27].

With regard to throwing sports, if the lesion affects the non-throwing arm, the return to competitive sport may be achieved quicker at 2 to 4 wk compared to standard rehabilitation protocols for all types of TFCC injuries and surgical treatments[1,2,18-27].

Patient education is absolutely essential in order to allow the best possible rehabilitation, avoid further injuries and disease progression in those conservatively treated (or whilst waiting until the end of the season for definitive surgical management). Activities reproducing the mechanism of injury and pain should be avoided[1,2,18-29].

CONCLUSION

TFCC injuries are common in amateur and professional sports. These are mainly caused by acute or chronic repetitive loads on the wrist, particularly on the ulnar side. This is even worse if axial loads are associated with rotations or radial/ulnar deviations.

In order to treat professional athletes who sustain TFCC injuries, a detailed specific knowledge of the pathology is needed. Moreover, the clinician should fully understand the specific and unique environment and the needs of the athletes, their priorities and goals, the type of sport, the time of the season, and the position played.

An early diagnosis and appropriate management with the quickest possible recovery time are the uppermost goals for both the athlete and the surgeon. A compromise between conservative *vs* surgical indications, athletes' needs and expectations, and financial implications should be achieved. Arthroscopic procedures should be timely planned when indicated as they may allow early diagnosis and treatment at the same time.

Conservative measures are often used as first line treatment when possible. Peripheral lesions are treated by arthroscopic repair, whilst central lesions are treated by arthroscopic debridement. Further procedures (such as the Wafer procedure, ulnar osteotomies, *etc.*) have specific indications and great implications with regard to the rehabilitation time and long-term consequences for the athletes.

Competitive levels are very often achieved by athletes with TFCC injuries surgically. Only a small percentage do not reach satisfactory levels, and this is more common in those undergoing repair procedures or procedures related to radial/ulnar instability and neutral or positive ulnar variance.

FOOTNOTES

Author contributions: Pace V designed the article; Pace V, Bronzini F, Novello G, Mosillo G and Braghiroli L performed research and literature review, analyzed data, wrote and finalized the review.

Conflict-of-interest statement: No conflicts of interest.

Country/Territory of origin: Italy

ORCID number: Valerio Pace 0000-0002-4499-9157.

Corresponding Author's Membership in Professional Societies: General Medical Council (United Kingdom), No. 7192447.

S-Editor: Fan JR
L-Editor: Webster JR
P-Editor: Zhao S

REFERENCES

1 **Ko JH**, Wiedrich TA. Triangular fibrocartilage complex injuries in the elite athlete. *Hand Clin* 2012; **28**: 307-321, viii [PMID: 22883871 DOI: 10.1016/j.hcl.2012.05.014]
2 **Robertson G**, Ang KK, Maffulli N, Simpson CK, Rust PA. Return to sport following surgical management of triangular fibrocartilage tears: a systematic review. *Br Med Bull* 2019; **130**: 89-103 [PMID: 30943287 DOI: 10.1093/bmb/ldz013]
3 **Jarrett CD**, Baratz ME. The management of ulnocarpal abutment and degenerative triangular fibrocartilage complex tears in the competitive athlete. *Hand Clin* 2012; **28**: 329-337, ix [PMID: 22883875 DOI: 10.1016/j.hcl.2012.05.018]
4 **Rettig AC**. Epidemiology of hand and wrist injuries in sports. *Clin Sports Med* 1998; **17**: 401-406 [PMID: 9700410 DOI: 10.1016/s0278-5919(05)70092-2]
5 **Dailey SW**, Palmer AK. The role of arthroscopy in the evaluation and treatment of triangular fibrocartilage complex injuries in athletes. *Hand Clin* 2000; **16**: 461-476 [PMID: 10955219]
6 **Farì G**, Notarnicola A, DI Paolo S, Covelli I, Moretti B. Epidemiology of injuries in water board sports: trauma versus overuse injury. *J Sports Med Phys Fitness* 2021; **61**: 707-711 [PMID: 33975428 DOI: 10.23736/S0022-4707.20.11379-3]
7 **Farì G**, Fischetti F, Zonno A, Marra F, Maglie A, Bianchi FP, Messina G, Ranieri M, Megna M. Musculoskeletal Pain in Gymnasts: A Retrospective Analysis on a Cohort of Professional Athletes. *Int J Environ Res Public Health* 2021; **18** [PMID: 34065250 DOI: 10.3390/ijerph18105460]
8 **Farì G**, Santagati D, Macchiarola D, Ricci V, Di Paolo S, Caforio L, Invernizzi M, Notarnicola A, Megna M, Ranieri M. Musculoskeletal pain related to surfing practice: Which role for sports rehabilitation strategies? A cross-sectional study. *J Back Musculoskelet Rehabil* 2022; **35**: 911-917 [PMID: 35068441 DOI: 10.3233/BMR-210191]
9 **Farì G**, Macchiarola D, Quarta F, Bianchi FP, Caforio L, Cutti AG, Ranieri M. Epidemiology of injuries in wheelchair basketball: Trauma versus overuse mechanism and prevention rehabilitative strategies. *J Prosthet Orthot***35**: 32-37 [DOI: 10.1097/JPO.0000000000000458]
10 **Palmer AK**, Werner FW. The triangular fibrocartilage complex of the wrist--anatomy and function. *J Hand Surg Am* 1981; **6**: 153-162 [PMID: 7229292 DOI: 10.1016/s0363-5023(81)80170-0]
11 **Kovachevich R**, Elhassan BT. Arthroscopic and open repair of the TFCC. *Hand Clin* 2010; **26**: 485-494 [PMID: 20951898 DOI: 10.1016/j.hcl.2010.07.003]
12 **Palmer AK**. Triangular fibrocartilage complex lesions: a classification. *J Hand Surg Am* 1989; **14**: 594-606 [PMID: 2666492 DOI: 10.1016/0363-5023(89)90174-3]
13 **Palmer AK**, Glisson RR, Werner FW. Relationship between ulnar variance and triangular fibrocartilage complex thickness. *J Hand Surg Am* 1984; **9**: 681-682 [PMID: 6491211 DOI: 10.1016/s0363-5023(84)80013-1]
14 **Hagert CG**. Distal radius fracture and the distal radioulnar joint--anatomical considerations. *Handchir Mikrochir Plast Chir* 1994; **26**: 22-26 [PMID: 8150382]
15 **Palmer AK**, Werner FW. Biomechanics of the distal radioulnar joint. *Clin Orthop Relat Res* 1984; 26-35 [PMID: 6744728]
16 **Blazar PE**, Chan PS, Kneeland JB, Leatherwood D, Bozentka DJ, Kowalchick R. The effect of observer experience on magnetic resonance imaging interpretation and localization of triangular fibrocartilage complex lesions. *J Hand Surg Am* 2001; **26**: 742-748 [PMID: 11466652 DOI: 10.1053/jhsu.2001.24966]
17 **Kleinman WB**. Stability of the distal radioulna joint: biomechanics, pathophysiology, physical diagnosis, and restoration of function what we have learned in 25 years. *J Hand Surg Am* 2007; **32**: 1086-1106 [PMID: 17826566 DOI: 10.1016/j.jhsa.2007.06.014]
18 **Farr S**. Editorial Commentary: The Hook Test Is More Accurate for Detecting Foveal Triangular Fibrocartilage Complex Tears but Not More Important Than the Trampoline Test. *Arthroscopy* 2021; **37**: 1808-1810 [PMID: 34090566 DOI: 10.1016/j.arthro.2021.04.011]
19 **Kuru CA**, Uysal O, Karaca NB, Akar Z, Ayhan E, Kuru I. Responsiveness and Validity of Weight-Bearing Test for Measuring Loading Capacity in Patients With Triangular Fibrocartilage Complex Injury. *J Sport Rehabil* 2022; **31**: 876-884 [PMID: 35461186 DOI: 10.1123/jsr.2021-0386]
20 **McAdams TR**, Swan J, Yao J. Arthroscopic treatment of triangular fibrocartilage wrist injuries in the athlete. *Am J Sports Med* 2009; **37**: 291-297 [PMID: 19059892 DOI: 10.1177/0363546508325921]

21 **Papapetropoulos PA**, Ruch DS. Repair of arthroscopic triangular fibrocartilage complex tears in athletes. *Hand Clin* 2009; **25**: 389-394 [PMID: 19643338 DOI: 10.1016/j.hcl.2009.05.011]

22 **Rios-Russo JL**, Lozada-Bado LS, de Mel S, Frontera W, Micheo W. Ulnar-Sided Wrist Pain in the Athlete: Sport-Specific Demands, Clinical Presentation, and Management Options. *Curr Sports Med Rep* 2021; **20**: 312-318 [PMID: 34099609 DOI: 10.1249/JSR.0000000000000853]

23 **Tosti R**, Shin E. Wrist Arthroscopy for Athletic Injuries. *Hand Clin* 2017; **33**: 107-117 [PMID: 27886828 DOI: 10.1016/j.hcl.2016.08.005]

24 **Robba VI**, Karantana A, Fowler APG, Diver C. Perceptions and experiences of wrist surgeons on the management of triangular fibrocartilage complex tears: a qualitative study. *J Hand Surg Eur Vol* 2019; **44**: 572-581 [PMID: 30741080 DOI: 10.1177/1753193419826459]

25 **Henderson CJ**, Kobayashi KM. Ulnar-Sided Wrist Pain in the Athlete. *Orthop Clin North Am* 2016; **47**: 789-798 [PMID: 27637665 DOI: 10.1016/j.ocl.2016.05.017]

26 **Pang EQ**, Yao J. Ulnar-sided wrist pain in the athlete (TFCC/DRUJ/ECU). *Curr Rev Musculoskelet Med* 2017; **10**: 53-61 [PMID: 28185125 DOI: 10.1007/s12178-017-9384-9]

27 **Yamabe E**, Nakamura T, Pham P, Yoshioka H. The athlete's wrist: ulnar-sided pain. *Semin Musculoskelet Radiol* 2012; **16**: 331-337 [PMID: 23047280 DOI: 10.1055/s-0032-1327006]

28 **Rollo G**, Bisaccia M, Irimia JC, Rinonapoli G, Pasquino A, Tomarchio A, Roca L, Pace V, Pichierri P, Giaracuni M, Meccariello L. The Advantages of Type III Scaphoid Nonunion Advanced Collapse (SNAC) Treatment With Partial Carpal Arthrodesis in the Dominant Hand: Results of 5-year Follow-up. *Med Arch* 2018; **72**: 253-256 [PMID: 30514989 DOI: 10.5455/medarh.2018.72.253-256]

29 **Pace V**, Sessa P, Guzzini M, Spoliti M, Carcangiu A, Criseo N, Giai Via A, Meccariello L, Caraffa A, Lanzetti RM. Clinical, functional and radiological outcomes of the use of fixed angle volar locking plates in corrective distal radius osteotomy for fracture malunion. *Acta Biomed* 2021; **92**: e2021180 [PMID: 34212911 DOI: 10.23750/abm.v92i3.11265]

Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: office@baishideng.com
Help Desk: https://www.f6publishing.com/helpdesk
https://www.wjgnet.com