A New Arthroscopic Classification of Triangular Fibrocartilage Complex Disorders

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Abstract

Introduction The use of wrist arthroscopy has become a prerequisite for diagnosis and treatment of triangular fibrocartilage complex (TFCC) disorders. Since Palmer's landmark paper, many new arthroscopic descriptions of TFCC tears have been published but there is no currently available updated comprehensive arthroscopic classification of TFCC lesions.

Purpose We recently described the arthroscopic anatomy of the TFCC as viewed from a 3–4 portal. Our purpose was to propose a new TFCC disorders classification based on this new arthroscopic TFCC description.

Methods We included all currently described TFCC disorders to the best of our knowledge into our arthroscopic, functional, and vascular anatomical concept. We also included patient's specific ulnar variance and distal radial ulnar joint coronal inclination as baseline treatment-oriented parameters. The fresh or chronic, reparable or non-reparable nature of some types of TFCC tears were considered as separate parameters.

Results The proposed classification includes disc "D" (degenerative or traumatic), reins "R" (traumatic), and wall "W" (traumatic) lesions. Combined lesions of those three parts of the TFCC may be easily identified. This new classification should facilitate future analysis of isolated or combined TFCC disorders whether they are degenerative and/or traumatic.

Discussion The authors present a new three-dimensional-three-part arthroscopic updated description of TFCC disorders with relevance to etiology and treatment principles.

Keywords
- wrist
- TFCC tears
- TFCC disorders
- arthroscopy
- TFCC disorder classification

The use of wrist arthroscopy has become a prerequisite for the diagnosis and treatment of any triangular fibrocartilage complex (TFCC) disorders.[1–4] Palmer's landmark paper was the first attempt at producing a comprehensive three-dimensional (3-D) classification of TFCC lesions including wrist arthroscopy as one of its criteria.[5]

Since Palmer's description, there have been numerous arthroscopy-based contributions to the knowledge of TFCC

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lesions with many newly recognized lesions or subtypes.[2,6–13]

However, no comprehensive update of TFCC lesions classification based on arthroscopy has been proposed so far. A recently updated classification of TFCC disorders was based on classic 3-D anatomic drawings.[14] We recently proposed a new arthroscopic description of the TFCC from a 3–4 radiocarpal portal (disc, reins, and wall) including functional and vascular aspects along with a first attempt at stratifying TFCC tears.[3]

Here, we propose a new comprehensive arthroscopic classification of TFCC lesions and their variants based on our arthroscopic description of the TFCC as seen from a 3–4 radiocarpal wrist arthroscopy portal with the addition of distal radial ulnar joint (DRUJ) arthroscopy when necessary.

Arthroscopic Classification of Triangular Fibrocartilage Complex Disorders

This new arthroscopic classification of TFCC disorders includes in background patient's specific ulnar variance[15] and Tolat's type of sigmoid notch[16] because these parameters may significantly influence the treatment of TFCC disorders whatever their etiology may be (►**Fig. 1**). Correspondence between Palmer's classification and our new classification is shown in ►**Table 1** as well as the usefulness of DRUJ arthroscopy when appropriate.

Disc (D) Triangular Fibrocartilage Complex Tears

TFCC disc "D" tears may be called disc degenerative (DD) or disc traumatic (DT) as displayed in ►**Fig. 1**. "DD" and "DT" tears may be included in the same group because the avascularity and lack of healing potential of the disc make their treatment similar.

- "DD" central tears (previously Palmer's Class 2 A–E) are located within the flat central TFCC disc area. Palmer Class 2 stages provided a description of the natural history of "DD" tears[5] including the addition of regional degenerative changes to the lunate and lunotriquetral ligament tears in class 2D and 2E. We have chosen to mention "DD" TFCC tears first because they are related to patient's specific anatomical features producing a static or dynamic[15] positive ulnar variance and ulnocarpal impingement syndrome.[5] Central "DD" TFCC lesions as seen from the 3–4 portal may be simple central wears or central ovoid perforations of various sizes from localized to massive, allowing the tip of the ulnar head to protrude into the radiocarpal space. The degree of ulnar head perforation of the TFCC may be related to the amount of positive ulnar variance. One or several TFCC pedicled flaps can be observed in "DD" TFCC tears. Chondral erosive changes of the ulnar proximal lunate facet and/or ulnar head tip with or without secondary attritional lunotriquetral dissociation may be observed depending on the severity of the ulnocarpal impingement syndrome. The treatment of "DD" TFCC lesions whatever their stage and arthroscopic aspect consists of tears/flaps debridement and ulnar decompression (arthroscopic wafer procedure or ulnar shortening osteotomy).
- "DT" tears (previously Palmer class 1A) are most often sagittal slit tears located 2 to 3 mm medial to the radial insertion of the TFCC.[4] They are commonly encountered during arthroscopy following distal radius fractures.[3] They usually do not require any specific treatment. Two flap variants of "DT" tears have been recently described:

Distal horizontal flap "DT " tears were described by del Piñal[2] and mentioned by other authors.[4,17,18] They are well visualized and debrided through 3–4 and 6R radiocarpal portals.

Proximal horizontal flap "DT" tears[6] with potential interposition into the DRUJ joint space may be observed. They require a combination of radiocarpal and DRUJ arthroscopy for flap resection.

Reins (R) Triangular Fibrocartilage Complex Traumatic Tears

All "R" tears are potentially DRUJ destabilizing injuries. "R1" tears are located at the ulnar side of the TFCC, whereas "R2" tears are located at its radial side.

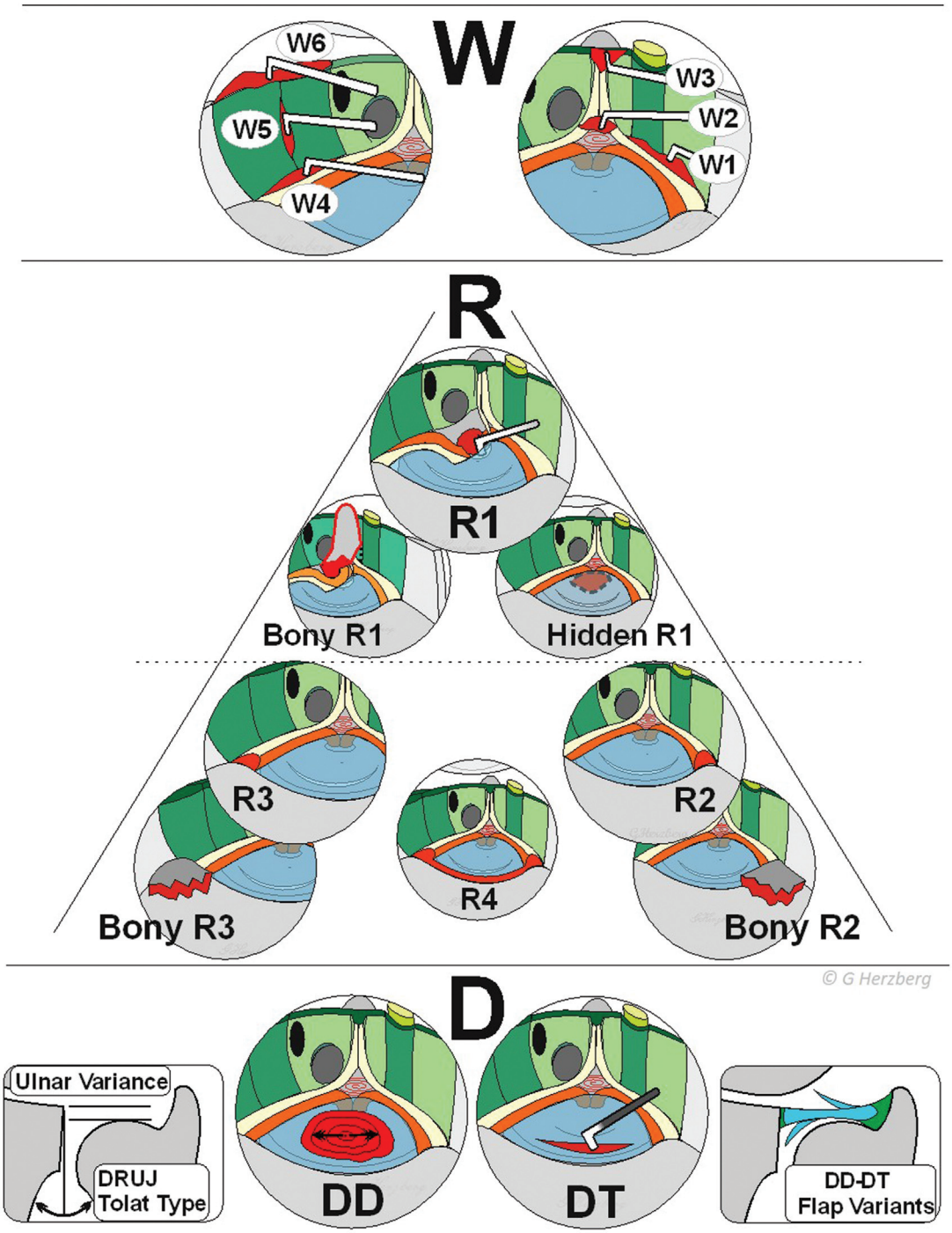
There is increasing evidence[3,19] that the deep (proximal) and superficial (distal) dorsal and palmar radioulnar ligaments are intimately merged so that they act simultaneously during forearm rotation to stabilize the DRUJ. The well-vascularized[20] deep and superficial dorsal radioulnar ligaments are taut in pronation.[3,19] By contrast, the deep and superficial volar radioulnar ligaments are taut in pronation.

During wrist arthroscopy from the 3–4 portal, the deep proximal part of the "R" TFCC component (deep dorsal and palmar radioulnar ligaments) inserting into the foveal area cannot be readily seen. DRUJ wet or dry arthroscopy has recently been improved and can reliably show the foveal insertion of the deep radioulnar ligaments.[4,21–23]

At the ulnar side of the reins, although it has been recently challenged[24] most authors[21,25] rely on the combination of a clinical DRUJ instability and positive hook test[26] to indirectly assess the competence of the deep part of the TFCC reins.

At the radial side of the reins, probing is used to assess the radial insertions of the dorsal and volar radioulnar ligaments on each side of the disc.

- The classic foveal avulsion of the TFCC "reins" (i.e., the deep proximal dorsal and palmar radioulnar ligaments) or Atzei class 2 TFCC lesion is a well-recognized injury[5,21,25] typically resulting from forceful pronation or supination. It is called "R1" TFCC tear (►**Fig. 1**). "R1" TFCC tear requires an anchor or transosseous reinsertion. The use of DRUJ arthroscopy in addition to radiocarpal arthroscopy may be necessary.[21,24,25]
- Proximal ulnar styloid fractures occasionally include the deep foveal insertion of the TFCC. This is called "R1 bony" TFCC tears or "R1 ulnar styloid fracture with foveal avulsion." Ulnar styloid fixation may be required to fix both the fracture and the foveal avulsion. However, ulnar styloid fracture may also occur following an avulsion of



Disc Tears	Reins Traumatic Tears	Wall Traumatic Tears
DD: Disc Degenerative Central Tear	R1: Complete Foveal Avulsion (Atzei 2)	W1: Dorsal Peripheral Tear
DT: Disc Traumatic Sagittal Slit Tear	R1 Bony: Ulnar Styloid Fracture with Foveal Avulsion	W2: Ulnar Peripheral Tear (Atzei 1)
	R1 Deep: Hidden Foveal Avulsion (Atzei 3)	W3: Ulnocarpal Detachment
	R2 / R2 Bony: Dorsal Rim / Bony Dorsal Rim Avulsion	W4: Volar Peripheral Tear
	R3 / R3 Bony: Volar Rim / Bony Volar Rim Avulsion	W5: Ulnotriquetral Split Tear
	R4: Complete Radial Rim Avulsion	W6: Ulnocarpal Volar Avulsion

Fig. 1 Arthroscopically based classification of TFCC Disorders: the fresh or chronic, reparable or nonreparable nature of TFCC tears are considered as separate parameters (see text).

Table 1 Correspondence between our arthroscopically based classification of TFCC disorders and Palmer's classification of TFCC disorders

Palmer's TFCC disorders classification	New arthroscopic TFCC disorders classification
	First, consider ulnar variance and Tolat's type of DRUJ sigmoid notch
	D: Disc tears
2A-B-C-D-E	DD: Disc degenerative central tear (wear / perforation / massive with/without flap)
1A	DT: Disc traumatic sagittal slit tear
	DT proximal horizontal flap variant[a] (Arimitsu 2021)
	DT distal horizontal flap variant (del Piñal 2012)
	R: Reins traumatic tears
1B foveal avulsion	R1: Complete foveal avulsion[a] (Nakamura 2011- Atzei Class 2 - 2009)
1B with ulnar styloid fracture	R1 Bony: Ulnar styloid fracture with foveal avulsion
	R1 Deep: Hidden foveal avulsion[a] (Atzei Class 3 - 2009)
	R2/R2 Bony: Dorsal rim/bony dorsal rim avulsion (Nakamura - 2012)
	R3/R3 Bony: Volar rim[a]/bony volar rim avulsion (Nakamura - 2012)
1D	R4: Complete radial rim avulsion (including pre-1D injury variant [Luchetti - 2022])
	W: Wall traumatic tears
	W1: Dorsal peripheral tear (Fukuoka Nakamura - 2020)
	W2: Ulnar peripheral tear (Atzei Class 1 - Abe 2016 - Fukuoka Nakamura - 2020)
	W3: Ulnocarpal detachment syndrome (Nishikawa - 2012)
	W4: Volar peripheral tear (del Piñal - 2012)
	W5: Ulnotriquetral split tear (Tay Kakar Berger - 1997)
1C	W6: Ulnocarpal volar avulsion
	Combined tears
	Example DD + R1 (del Piñal - Nakamura - 2012)

Abbreviations: DRUJ, distal radial ulnar joint; TFCC, triangular fibrocartilage complex.
[a]Usefulness of DRUJ Arthroscopy.

the foveal insertion of the reins, producing a "floating styloid."[7] This condition does not benefit from ulnar styloid fixation to restore DRUJ stability.

- Isolated hidden avulsion of the foveal insertion of the proximal radioulnar ligament while its superficial counterpart has remained intact (Atzei class 3) is called "R1 deep" TFCC tear. The treatment may be the same as for "R1" lesions. The use of DRUJ arthroscopy in addition to radiocarpal arthroscopy is necessary.[1,4,21]
- Avulsion of the radial dorsal insertion of the reins[11] is called "R2" or "R2 dorsal rim avulsion" TFCC lesion. Fixation with anchors is recommended[11] to avoid DRUJ dorsal subluxation. When there is a displaced bony avulsion as in some intra-articular distal radius fractures, the injury is called "R2 bony." It requires specific osteosynthesis to avoid DRUJ dorsal subluxation.
- Avulsion of the radial volar insertion of the reins[11] is called "R3" or "R3 volar rim avulsion" TFCC lesion. Fixation with anchors is recommended[11] to avoid DRUJ volar subluxation. When there is a displaced bony avulsion as in some intra-articular distal radius fractures, the injury is called "R3 bony." It requires specific osteosynthesis to avoid DRUJ volar subluxation.
- "R4" TFCC tear is a complete traumatic avulsion of the TFCC from its radial attachment (Palmer's class 1D). This severe high-energy injury is exceedingly rare.[11] It may be observed in conjunction with radiocarpal dislocation. A less severe "pre-1D" variant of Palmer's classification has recently been described by Luchetti.[10]

Wall (W) Triangular Fibrocartilage Complex Traumatic Tears

During wrist arthroscopy from the 3–4 portal, what we have described as the TFCC wall "W"[3] is the radially concave vertical well-vascularized[20] fibrous layer raising from the reins at the periphery of the disc and inserting on the medial aspect of the proximal carpal row (i.e., on the ulnar part of the lunate and triquetrum).

- Dorsal peripheral TFCC tears[27,28] which are typically painful but not (or little) DRUJ destabilizing are called "W1." These TFCC tears represent a laceration of the junction of the dorsal part of the reins to the dorsal wall. The suction test may be a useful arthroscopic maneuver to arthroscopically confirm "W1" TFCC tears.[29] "W1" TFCC tears are amenable to capsular repair.[28]

- Ulnar peripheral TFCC tears[30] which are tears of the ulnar part of the capsule merging with the ulnar termination of the converging superficial part of the reins are called "W2." These TFCC tears are amenable to capsular repair.
- Ulnocarpal detachment syndrome[12,31,32] is a lesion of the dorsal carpal attachment of the wall to the triquetrum merging with the radiotriquetral ligament which is called "W3."
- Volar Peripheral TFCC tears[2,33] are called "W4" TFCC tears. These TFCC tears represent a laceration of the junction of the volar part of the reins to the volar wall. They are amenable to capsular fixation.
- Longitudinal split tears of the ulno-triquetral ligament[9,34] are called "W5." It may be an isolated TFCC lesion but combined regional pathology (other TFCC tear, ECU pathology, and ulnocarpal impingement) was associated in 17% in a recent series.[35] "W5" TFCC tears are amenable to capsular repair.[9]
- Ulnocarpal volar TFCC avulsion (former Palmer's Class 1C) is an exceedingly rare and severe lesion called "W6." They may be amenable to reattachment to the carpal bones.

Combined Triangular Fibrocartilage Complex Lesions

In the past 10 years, many authors highlighted the fact that a combination of different types of TFCC tears was sometimes observed. Del Piñal was the first author to formally describe several cases of combined degenerative and traumatic TFCC tears,[2] that is, for example, combined "DD" and "R1" (if DRUJ destabilizing; ►**Figs. 2**–**3**) or "DD" and "W2." Other combined TFCC disorders may be identified in the future and easily added to our arthroscopic TFCC classification.

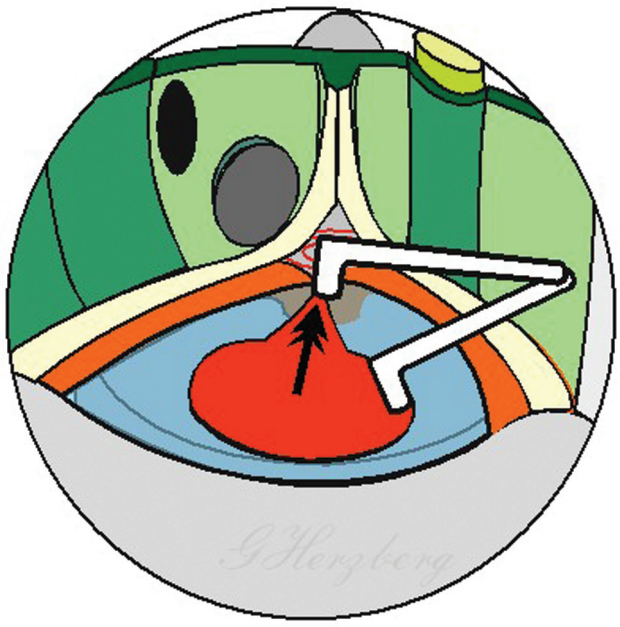


Fig. 2 Example of combined "« DD » and « R1" destabilizing lesion as described by del Piñal and Nakamura in reference.[8]

Discussion

Wrist arthroscopy has proven to be a prerequisite for the contemporary diagnosis and treatment of TFCC disorders. However, since the landmark Palmer's classification of TFCC disorders and despite many recent papers about newly recognized TFCC injuries, no comprehensive arthroscopic classification of TFCC lesions has been published.

We recently proposed an arthroscopic description of the box-like TFCC structure as seen from the 3–4 radiocarpal portal including functional, vascular, and thus therapeutic aspects along with a preliminary attempt at stratifying TFCC tears.[3] We now propose a final version of the classification including all the known disorders of the TFCC to the best of our knowledge and considering the need for combining radiocarpal and DRUJ arthroscopy.

The format of the comprehensive above-described arthroscopic classification is simple, user-friendly, and updatable with future new descriptions. Patient's specific acute or chronic pattern of the traumatic lesions must be mentioned as well as the reparability or need for reconstruction of the injury.

Palmer's landmark paper was the first attempt at producing a comprehensive 3-D classification of TFCC lesions including wrist arthroscopy as one of its criteria.[5] Although it is still widely used, many authors have shown that it does not include some newly described injuries[2,18,36] or allow identifying combined TFCC lesions[8] as the combination of a degenerative and traumatic injury for example. Moreover, Palmer's Class 1 lesions described different locations of traumatic TFCC injuries, whereas the Class 2 lesions described the natural history of a degenerative central tear due to ulnocarpal impingement.[5]

Numerous papers focusing on the analysis of subtypes of Palmer's Class 1B lesions have been published.[1,2,4] Some TFCC lesions could not be found in Palmer's landmark paper.[36]

Using 3-T MRI, Zhan et al[17,18] reviewed 86 wrists with TFCC injuries. A total of 17 (20%) could not be classified according to Palmer's classification.

Using arthroscopic diagnosis and treatment, Estrella et al[36] analyzed 35 wrists with traumatic dorsal tears of the TFCC. They found that 18 (51%) could not be classified according to Palmer's classification.

Atzei and Luchetti[1,7] included reparability as a key criterion in their classification of foveal TFCC tears to advise repair versus reconstruction. It is the author's opinion that this key criterion should be used as an additional parameter for some specific types of "R" and "W" TFCC disorders. The acute or chronic nature of the TFCC tears should be included as an additional parameter. Usually, the 45th day is accepted as the landmark delay after which ligamentous injury is considered to be chronic.

The limitations of existing classifications of TFCC disorders have led Schmitt et al[14] to recently propose a new classification system, the "CUP" classification ("C" for central, "U" for ulnar, and "P" for peripheral). This classification is based on a classic 3-D anatomical description of the TFCC and includes a "combined lesions" category as recommended by previous authors.[3,8] However, this new classification is not

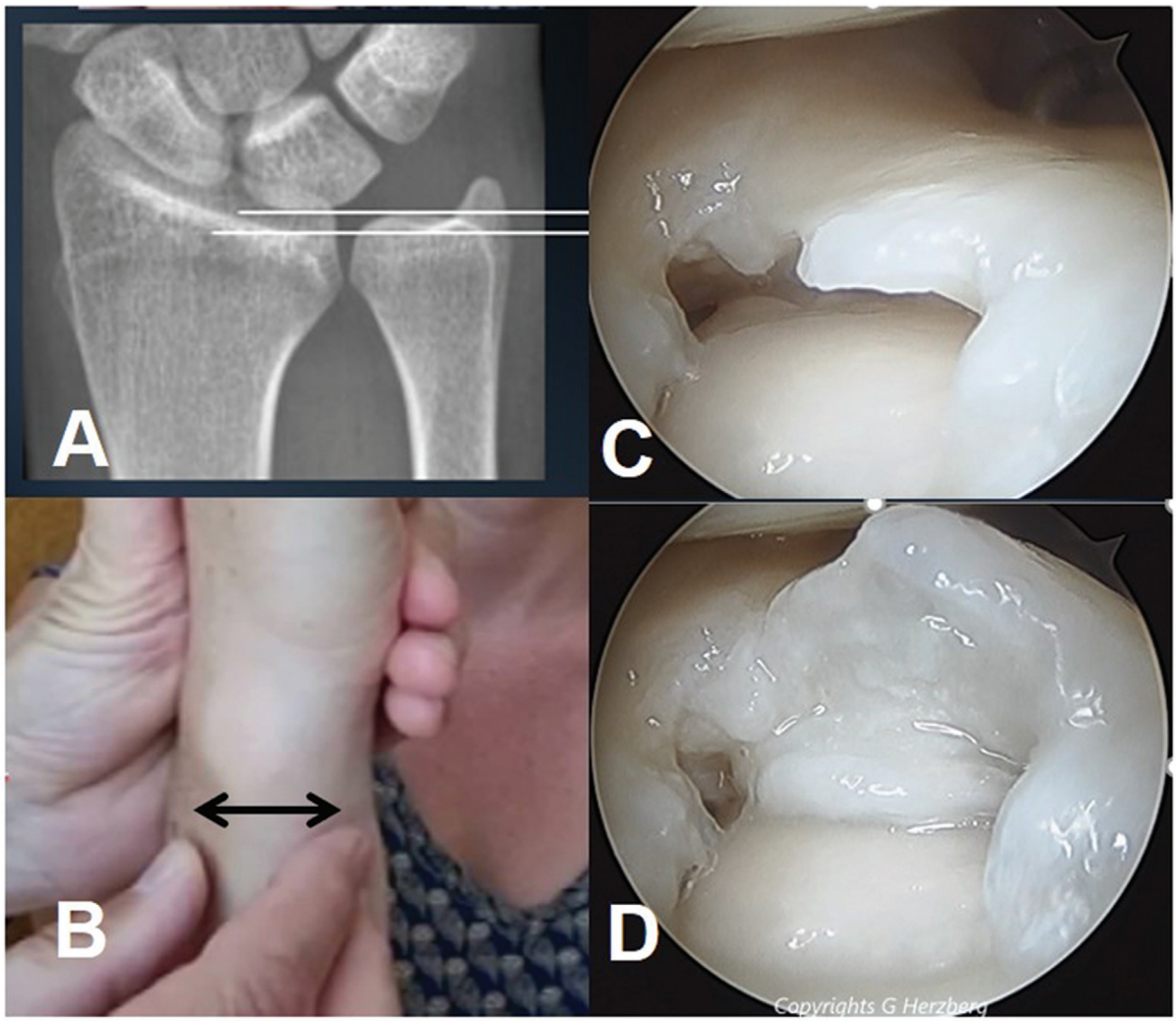


Fig. 3 Clinical example of combined « DD » and « R1 » TFCC tears. (**A**) Ulna + 2 mm variance in a 39 year-old lady (high-level volleyball player during 10 years). (**B**) She presented with both positive ulnocarpal stress test and positive painful DRUJ drawer test 1 year after a twisting and hyperflexion wrist trauma. (**C**) Obvious disc degenerative "DD" central tear as seen from 3–4 portal. (**D**) Positive arthroscopic hook test showing an additional "R1" tear.

easy to memorize and includes measurements in millimeters which may be difficult to reproduce.

We believe that our new arthroscopic TFCC classification is the simplest and most comprehensive current update about TFCC disorders.

Ethical Review Committee Statement
Not Applicable.

Conflicts of Interest
None declared.

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