Evaluation of the Painful Wrist

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Enrique Pereira

Introduction

The human wrist connects the forearm to the hand. Under healthy conditions, the wrist is capable of precise hand positioning in space due to a wide range of motion (flexion/extension, pronation/supination, and radio/ulnar deviation). Such freedom of wrist movement and position is necessary to perform highly complex and delicate movements of the thumb and fingers.

Following the notion that *function follows anatomy*, wrist's ample range of motion is the product of the complex interplay of a sophisticated arrangement of bony and ligamentous structures added to normal function of the five carpal joints (radioulnar, the radiocarpal, midcarpal, intercarpal, and carpometacarpal joints) [1, 2].

After evaluating 52 standardized tasks of activities of daily living, Palmer et al. [3] showed that the wrist *normal functional range of motion* allows 5° of flexion, 30° of extension, 10° of radial deviation, and 15° of ulnar deviation. On the other hand, according to the *ideal range of motion* for activities of daily living described by Ryu et al. [4] the wrist should reach 54° of flexion, 60° of extension, 17° of radial deviation and 40° of ulnar deviation.

The presence of wrist pain may lead to functional impairment of the entire upper extremity, and thus, greatly impacting the patient's quality of life. In view of the fact that there is a wide range of etiologies for wrist pain, the treating physician should keep a high index of suspicion during patient's history and physical examination. Collected findings during patient examination (along with auxiliary studies) are intended to generate the most likely diagnosis. As expected, further comprehension of the underlying anatomic abnormalities is pivotal for a precise diagnosis.

E. Pereira, M.D. (✉)
Department of Hand Surgery, Penta Institute of Traumatology and Rehabilitation, Ladislao Martinez 256 1° A, Martinez 1640, Buenos Aires, Argentina
e-mail: enriqueepereira@gmail.com

A brief discussion of some core anatomic concepts of the wrist is necessary though before addressing patient assessment. Considering that there are no muscles or tendons attached to the carpus, the stability of each carpal bone is only dependent on bone surface anatomy and ligament attachments.

There are two main ligament systems in the wrist:

1. Extrinsic system capsular (extraarticular) ligaments that extend from the radius or metacarpals to the carpal bones.
2. Intrinsic system: interosseous (intraarticular) ligaments that take origin from and insert on adjacent carpal bones.

The triangular fibrocartilage complex (TFCC) attaches the distal radius, the lunate, and the triquetrum to the distal ulna. This complex along with the bony architecture provides the stability for the distal radio ulnar joint (DRUJ). The vascular pattern and nerve distribution of the pain together with their pathophysiological correlation remain essential when facing a painful wrist. This complexity of the carpus and our incomplete understanding of carpal kinematics makes diagnosis of a painful wrist very difficult.

History

Obtaining a detailed history often helps narrow the differential diagnosis over a number of potential etiologies. Determining the diagnosis is usually a challenge in patients with wrist pain, to some extent due to the large number of structures found in the human wrist (bone, soft tissues, and extra-articular and intra-articular etiologies) as well as their complex biomechanical characteristics (Table 2.1). During the first step in history taking, the patient should be able to express any detail that judges related to the his/her symptomatoly. This step creates sympathy towards the patient and a suitable environment during the clinical encounter and enhances patient's compliance for future diagnostic and therapeutic steps. After that, the physician should direct the history in orderly sequence, collecting facts that have the greatest clinical relevance like pain characteristics, the presence of other symptoms and predisposing factors.

W.B. Geissler (ed.), *Wrist and Elbow Arthroscopy: A Practical Surgical Guide to Techniques*,
DOI 10.1007/978-1-4614-1596-1_2, © Springer Science+Business Media New York 2015

Table 2.1 Most common traumatic and atraumatic etiologies of wrist pain

Wrist pain: outline of most frequent etiologies
• *Bone* Fractures (distal radius, scaphoid, triquetral, hook of the hamate) Malunions (distal radius, scaphoid) Nonunions (scaphoid, hook of the hamate, ulnar styloid) Impingement (radiocarpal, ulnocarpal / stylocarpal impaction syndrome) Osteonecrosis (Kienböck disease, Preiser disease)
• *Joint* Synovitis Loose Bodies Chondral lesions Posttraumatic arthritis Degenerative arthritis (radiocarpal, radioulnar, midcarpal, intercarpal) Crystal arthritis (gout, pseudogout, lupus) Inflammatory arthritis (rheumatoid arthritis, psoriatic arthritis, Reiter's syndrome)
• *Ligament* Ligament tear/rupture (TFCC, SLIL, LTIL) Instability (scapholunate, lunotriquetral, DRUJ, midcarpal, capitolunate, pisotriquetral, STT)
• *Tendon* Tendonitis and tenosynovitis (De Quervain's) Tendon tear/subluxation (ECU) Tendon rupture
• *Nerve* Trauma/neuroma (superficial branch of radial or ulnar nerve) Compression (carpal tunnel syndrome, Wartenberg syndrome, Guyon's canal) Peripheral neuropathy (diabetes mellitus)
• *Vascular* Arterial occlusion Hypothenar hammer syndrome
• *Tumor* Soft Tissue (ganglion cyst, giant cell tumor, fibroma, synovial cell hemangioma) Bone tumors (primary, metastatic)
• *Infection* Bacterial arthritis (staphylococco, steptococco, Lyme disease, tuberculosis, gonorrhea) Viral arthritis
• *Other* Complex regional pain syndrome (CRPS)

TFCC Triangular Fibrocartilage Complex, *SLIL* Scapholunate Interosseous ligament, *LTIL* Lunotriquetral Interosseous ligament, *DRUJ* distal radio ulnar joint, *STT* Scaphotrapeziotrapezoid joint, *ECU* extensor carpi ulnaris

Pain

Several pain features are worth recording such as its quality (cramping, dull, aching, sharp, shooting, severe, or diffuse), frequency, duration, intensity, radiation, and movements in conjunction with the activities that may elicit pain. Nerve injury usually manifests as a sharp pain associated to a burning sensation. On the other hand, a deep, constant, boring pain mostly accompanies bone fractures. Pain from a ligamentous injury is often intermittent and elicited upon activity. In addition, location of symptoms can help guide diagnosis. The presence of localized pain may point towards ligamentous disruption, whereas nerve compression (due to carpal tunnel syndrome) is frequently associated with a more diffuse discomfort.

Predisposing Factors

Trauma

The patient should describe thoroughly any recent trauma, as its mechanism of injury may give up the diagnosis. For instance, a fall onto an outstretched hand during practice of contact sports is a common mechanism for fractures of the distal radius or scaphoid, whereas a direct palmar trauma from swinging a baseball bat or golf club could lead to a fracture of the hook of the hamate. Ligament tears may also occur, mainly at the TFCC, scapholunate and/or lunotriquetral ligaments. Depending on the kinetic energy of the trauma, these ligament injuries could either be partial or complete, isolated or associated with either distal radius fractures or scaphoid fractures. TFCC tears (with or without DRUJ instability) are often seen in gymnastic and racquet sports and may mimic extensor carpi ulnaris (ECU) pathology.

At times, trauma kinetics of a given wrist lesion remains elusive. In these situations, symptom duration may provide a temporal clue related to a vague history of trauma, while the patient refers spontaneous onset of the pain. Sometimes, the examiner faces such challenging scenario in patients with carpal bone nonunion or avascular necrosis, in whom symptoms may manifest several years after the index injury because of ongoing inflammation, leading to arthritis, swelling, pain, and loss of grip strength. The scaphoid is particularly prone to developing nonunions [5]. The latter is due to its vulnerable blood supply that can lead to complete vascular interruption of a bone fragment following wrist trauma. Idiopathic avascular necrosis generally occurs either at the lunate (Kienböck's disease) or at the scaphoid (Preiser's disease).

Patient Occupation or Recreational Activities

Several leisure or labor activities can affect wrist function. For example, long-standing history of typing that involves repetitive motion can trigger wrist pain, while knitting or sewing may lead to compressive neuropathy. Activities requiring forceful grasping with ulnar deviation or repetitive use of the thumb (e.g., caring for a newborn infant) can lead to De Quervain's tenosynovitis with pain and swelling along the first extensor compartment.

Specific details regarding sport activities can be very informative about the mechanism of injury: repetitive stress versus blunt trauma. Contact sports, such as American football or rugby, may lead to blunt trauma, while noncontact sports, such as golf, tennis, field hockey involve repetitive stress of the wrist.

The presence of a painful clunking on the ulnar side of the wrist during activities that involve active ulnar deviation indicates midcarpal instability. In patients with symptoms at the ulnar side of the wrist, the examiner should to rule out DRUJ arthritis, ulnocarpal or stylocarpal impaction syndrome.

Medical History

While obtaining a thorough complete medical history, the physician should exclude the presence of systemic inflammatory disorders (lupus, rheumatoid arthritis, and degenerative arthritis), metabolic diseases (diabetes, gout, and hypothyroidism) in addition to previous surgeries. Pregnancy, hypothyroidism, and diabetes are predisposing risk factors for carpal tunnel syndrome. Rheumatoid arthritis has a tendency to involve the wrist while gouty arthritis and pseudo gout can involve the wrist joint, although more commonly they affect the lower extremities.

Patients with septic arthritis typically present with a history of constitutional symptoms or a recent infection and a poorly moveable wrist owing to severe, deep, and unrelenting pain.

Patient's age and sex should also be considered. As example, younger patients are prone to posttraumatic carpal injuries and occult ganglion cysts, whereas older patients are susceptible to systemic diseases and degenerative processes.

Physical Examination

The physician should perform a methodical physical examination, starting with a comprehensive visual inspection of the upper extremity.

Noticeable swelling, ecchymosis, or skin changes at the level wrist can provide major clues to comprehend the mechanism of injury. Gross deformity of the wrist generally indicates an obvious pathologic process that could be due to previous fracture, dislocation, or from soft tissue and/or joint swelling. A malunited distal radius fracture is often the cause of this deformity, presenting radial deviation of the wrist, and the carpus palmary displaced on the radius. Such misalignment of the distal radius may lead to extrinsic carpal instability and wrist pain. Disruption of the distal radioulnar joint can also produce wrist deformity.

Following inspection, the physician should proceed by palpating the nonpainful areas of the wrist first and then continue to areas of maximal tenderness. This sequence is crucial because once pain/discomfort is elicited, the patient may become apprehensive, preventing further palpation. Anatomical knowledge, especially surface anatomy, can be of great help during wrist exam.

All wrist structures should be palpated and compare with the contralateral side. A systematic circumferential palpation of the wrist is performed according to patient's history and degree of pain [6]. We routinely start on the dorso-radial corner and progress to the dorso-ulnar side and then to the palmar surface. The site of pain and tenderness suggests the presence of pathology of underlying structures; however, we should take into account the intricate three-dimensional features of the wrist structures (Table 2.2).

Subsequently, active and passive range of motion of the wrist along with grip strength should be tested and compared to the contralateral wrist. [7, 8] As a rule, we measure flexion, extension, radial deviation, ulnar deviation, pronation, and supination with a goniometer. Differences in the range of motion among wrists in addition to the presence of pain at extreme range of motion will carry significant information to narrow the differential diagnosis. Assessing neurovascular status is also important, with special focus on the integrity of the median, radial and ulnar nerves, and dual-hand circulation (Allen test).

Routine palpation may not suffice to reproduce patient's symptoms; therefore, it is often necessary to perform provocative tests to locate the specific anatomic structure(s) that is originating pain. These provocative tests apply an external force that is directed to stress specific anatomic structures, which in turn would provoke an expected clinical response. A positive test correlates closely with a specific wrist pathologic diagnosis. Although the specificity of these maneuvers is not always high, the combination of a positive finding during a provocative maneuver with the remainder of the patient's clinical data (history, rest of the exam, and noninvasive imaging) almost always reach a conclusive diagnosis.

Provocative Tests

- Scaphoid Shift Test [5]: provides a qualitative assessment of scapholunate stability and periscaphoid synovitits compare to the contralateral asymptomatic wrist.
- Basically, the test is intended to induce dorsal sublixation of the proximal pole of the scaphoid over the dorsal rim of the radius as the wrist is radially deviated.

Table 2.2 Topographic palpation of the wrist

Region	Anatomic structure	Pathology
Dorso radial		
Snuffbox (distal)	STT	Carpometacarpal arthritis/ instability
		STT arthritis
Snuffbox (middle)	Floor of the snuffbox	Scaphoid fracture/nonunion
		Scaphoid Necrosis (Preiser's disease)
Snuffbox (proximal)	Radial styloid	Radial styloid fracture
		Radioscaphoid arthritis
First extensor compartment	APL/EPB	De Quervain tenosynovitis
		Intersection syndrome (proximal)
Dorso central		
3-4 dorsal recess	Lister tubercule	Dorsal synovitis
		SLIL instability
		Dorsal wrist ganglion
		Kiënbock disease
Dorso ulnar		
5-6 dorsal recess	LTIL	LTIL instability/arthritis
DRUJ space	DRUJ	DRUJ instability/arthritis
Ulnar head	ECU	ECU tendinosis/instability
Distal ulna	Ulnar styloid	Ulnocarpal/stylocarpal disorders
Midcarpal		Halt syndrome
Palmar ulnar		
FCU	FCU	FCU tendonitis
Distal ulna	Ulnar styloid	TFCC tears
Pisiform	Pisotriquetral joint	Pisotriquetral arthritis/instability
Hypotehnar eminence	Hook of the hamate	Fracture of the hook hamate
	Guyon's canal	Ulnar tunnel syndrome
Palmar central	Median nerve	Median nerve inflammation/ entrapment
Palmar radial	Palmaris longus	Palmaris longus tendonitis
	Scaphoid tubercule	Scaphoid fracture (distal pole)

APL abductor pollicis longus, *APB* abductor pollicis brevis, *EPB* extensor pollicis brevis, *FCU* flexor carpi ulnaris

- This maneuver is done by grabbing the patient's hand from its ulnar aspect and placing the physician's thumb on the palmar surface of the distal pole of the scaphoid.
- By moving the wrist from ulnar to radial deviation, the examiner exerts pressure to the distal pole of the scaphoid, which prevents the scaphoid from flexing normally.
- In patients with ligamentous laxity or instability, the combined stress of thumb pressure and normal motion of the adjacent carpus may induce the scaphoid to pop out of its fossa and up onto the dorsal rim of the radius. By diminishing the pressure exerted in the thumb, the scaphoid usually returns to its normal position. The presence of pain associated with unilateral hypermobility of the scaphoid is virtually diagnostic of scapholunate instability.
- Pisotriquetral Shear Test: offers a qualitative evaluation of the pisotriquetral joint. The examiner's thumb is placed over the pisiform and a dorsal directed pressure is applied along with a circular grinding motion over the triquetrum. Pain elicited by the maneuver is consistent with joint instability and/or degenerative. It is central to perform this test before assessing the lunotriquetral joint, to avoid pain overlapping.
- Lunotriquetral Compression Test [7]: evaluates the integrity of the lunotriquetral ligament. As its overall diagnostic accuracy is considered superior to other lunotriquetral tests, the compression test represents our current first choice. By supporting the wrist and pushing the triquetrum from an ulnar to a radial direction against the lunate, the test is considered positive if elicits pain. A positive test may indicate lunotriquetral ligament tear or instability.
- Lunotriquetral Ballottement Test [9]: detects lunotriquetral ligament injuries. While holding the lunate with the thumb and the index of one hand the triquetrum and pisiform are simultaneously displaced dorsally and palmary with the thumb and index of the other hand. Pain and excessive displaceability of the joint will suggest lunotriquetral ligament tear.
- Ulnocarpal Stress Test [10]: is considered as a screening test for intra-articular ulnocarpal disorders. The test is performed by applying axial stress to the wrist during passive supination-pronation with the wrist in maximum ulnar deviation.
- Piano-key Test [11]: examines the stability of the distal radioulnar joint and often reveals instability that cannot be detected even by imaging studies. The piano-key sign is demonstrated by depressing the ulnar head over and under the distal sigmoid notch while supporting the wrist in pronation. The result of this maneuver will be positive whenever the ulnar head returns to its normal position after the applying force is removed from the distal ulna, simulating as a piano key springing up.
- TFCC Compression Test: helps identify TFCC lesions. Under axial loading and ulnar deviation of the wrist, the test is positive when elicit a painful response and reproduce patient symptoms.
- Ulnar Fovea Test: identifies foveal disruptions of the TFCC (also ulno triquetral ligament tears). The examiner pressed his/her thumb into the ulnar fovea, between the flexor carpi ulnaris tendon and ulnar styloid between the volar surface of the ulnar head and pisiform with the forearm in neutral rotation. The test is considered positive when reproduces the patient's symptoms. Clinically, TFCC disruptions can be differentiated from ulno triquetral ligament tears by assessing DRUJ stability, since in TFCC disruptions the DRUJ is unstable whereas ulno triquetral ligament tears have stable DRUJ.

Table 2.3 Radiographic examination of the wrist: complementary views

View	Area of interest/pathologic finding
PA with radial deviation	Lunotriquetral interval/lunotriquetral instability
PA with ulnar deviation	Scapholunate interval/scapholunate instability
PA clenched fist view	Scapholunate interval/scapholunate instability
Oblique view pronated 20°	Dorsal triquetrum avulsion
	Distal pole waist scaphoid fractures
	Fourth and fifth CMC joint fracture dislocation
Oblique view pronated 60°	Scaphoid fractures
Oblique view supinated 30°	Pisotriquetral joint status
	Hook of the hamate fractures
	Second and third CMC joint fracture dislocation
Carpal tunnel view	Trapezium, scaphoid tuberosity, capitate, hook of the hamate, triquetrum, and the entire pisiform

- Midcarpal shift test [12]: confirms midcarpal instability. In this maneuver, the examiner applies an axial load to the wrist while on pronation and mild flexion. In this setting, axial load generates radial to ulnar deviation. This maneuver normally reproduces a characteristic painful "clunk". This finding is based on the loss of the smooth transition from proximal row flexion to extension as the unit moves from radial to ulnar deviation. Based on how much resistance is necessary to maintain the wrist palmary subluxed while in ulnar deviation, wrists are classified into five grades of instability.
- Ice Cream Scoop test [13]: exacerbates extensor carpi ulnaris subluxation. The wrist is first positioned in full pronation, ulnar deviation, and extension, and then is slowly moved into supination while maintaining ulnar deviation against resistance with the other hand of the examiner ("as the ice cream is scooped"). The test is considered positive if symptoms are reproduced and snapping of the extensor carpi ulnaris tendon over the distal ulna is visualized, heard, or palpated.

Radiographic Evaluation

Initially, routine x-ray examination (posteroanterior, oblique, and lateral views) may suffice for the detection of gross wrist abnormalities. However, specialized x-rays views such as a scaphoid view (posteroanterior view in ulnar deviation), 45-degree semipronated oblique and a true lateral may result instrumental for the identification of more subtle problems. We should probably include these specialized x-rays views in the initial imaging assessment [14]. X-ray imaging provides significant information regarding bone integrity, structure, and alignment along with the joint space dimension and symmetry.

A specialized posteroanterior view with the elbow on 90° of flexion (at shoulder height) and the forearm in neutral position is convenient to define ulnar variance (plus, neutral, negative) and constitutes a suitable view to analyze breaks in Gilula's lines. The Gilula's lines represent the arcs formed by the proximal and distal articular surfaces of the proximal row of carpal bones and the proximal articular surfaces of the distal row of carpal bones. A wide carpal joint space or a break in Gilula's lines suggests carpal instability.

In the neutral posteroanterior view, the lunate remains in a trapezoidal shape. A true lateral must be done though (elbow adducted to the patient's side and the wrist in neutral rotation) to allow the pisiform locate between the palmar surface of the distal scaphoid tuberosity and the capitate head. This view is particularly helpful for assessing carpal alignment. Carpal alignment has historically been determined using specific distances and measuring various angles on PA and lateral x-ray views. Several angles (capitolunate, scapholunate, and radiolunate) and indexes (carpal height, capitate-radius, and ulnar translocation) have been used showing modest (at best) diagnostic accuracy. Nonetheless, a scapholunate angle greater than 60° suggests scapholunate instability, whereas a small angle (less than 30°) points towards ulnar-sided wrist instability. Other measures can confirm this diagnosis: a radioscaphoid angle greater than 60° and a radiolunate angle greater than 15°. In case of suspecting carpal collapse secondary to Kienböck's disease, carpal height can be compared with the length of the third metacarpal. Several specialized views are sometimes required to narrow the diagnosis. The most frequently used are listed in Table 2.3.

Computed Tomography

Computed tomography (CT) constitutes an excellent imaging modality to assess bone and articular lesions and well as bone healing pattern after fracture or surgery. This technique can also detect with great precision cysts and tumors. The ability to perform multiple plane images and three-dimensional reconstruction proves particularly useful for the evaluation of bone with oblique axis like the scaphoid.

Furthermore, CT may represent the imaging method of choice for detecting DRUJ instability. This technique is also valuable in certain situations in which performing a magnetic resonance imaging (MRI) is impractical (example: evaluation of the hook of the hamate).

Magnetic Resonance Imaging

MRI is very useful for the assessment of the integrity of soft tissues of the wrist and the vascular status of the carpal bones [15]. Nonetheless, accurate reading of MRI requires considerable anatomical knowledge and radiologist`s experience. T1-weighted images provide optimal resolution for the assessment of anatomy while T2-weighted images are more suitable for the detection fluid, cysts, and tumors. This modality can evaluate the quality of carpal bone blood perfusion, including the lunate, the scaphoid, and the capitate [16]. MRI is particularly accurate to gage lunate perfusion, and is superior to bone scanning when assessing Kienböck's disease [17]. Even minimal changes in bone perfusion (example: ulnar abutment syndrome) can be identified by MRI.

MRI enables optimal visualization of occult ganglions, soft tissue tumors, tendinitis, and joint fluid collection [18]. In addition, this imaging technique may detect subtle bone abnormalities such as bone bruises and micro fractures [19]. Consequently, this imaging modality is very reliable for diagnosing occult scaphoid fractures [20].

MRI constitutes an excellent study for the evaluation of intrinsic carpal ligaments and TFCC. State-of-the-art MRI technology (with 3.0 Tesla) have an improved ability for the detection of TFCC tears compared to MRIs with 1.5 Tesla. These lesions appear as linear hyperintense defects on coronal gradient-echo or T2-weighted pulse sequences. The assessment of the scapholunate and lunatotriquetral ligaments is somewhat more challenging but it is also feasible with reasonable accuracy (71 % sensitivity and 88 % specificity), especially with addition of arthrographic contrast. Although 1.5 Tesla MRIs are capable of diagnosing scapholunate tear, 3.0 Tesla MRIs are more precise (89 % sensitivity and 100 % specificity) and thus, represents the imaging modality of choice for evaluating the status of the scapholunate ligament.

MRI identifies lesion of the extrinsic carpal ligaments; however, their role in these lesions is still unclear since the information acquired by MRI rarely changes their management.

In patients with carpal tunnel syndrome, axial imaging with T2 weighting can clearly display masses within the confines of the carpal tunnel, as well as edema and swelling of the median nerve. However, this advanced imaging modality is often unnecessary when suspecting carpal tunnel syndrome, since this syndrome is usually diagnosed with after a good history and physical exam.

Radionuclide Imaging

Bone scans have high sensitivity for detection of wrist lesions (particularly in patients with chronic wrist pain) but low specificity. Thus, bone scans are quite useful as a screening imaging modality chiefly for bone integrity. Osteonecrosis of the scaphoid, lunate, and capitate can be picked with scintigraphy. Bone scanning can also detect occult fractures or the presence of osteoblastic activity (bone turnover). In order to confirm a positive bone scan, CT imaging should then be performed to precise the location and the amount of fracture material. CT imaging can identify fractures subluxations that were overlooked by routine x-rays imaging. Scintigraphy can also be useful for the early detection of complex regional pain syndrome, and evaluating soft tissue lesions. Bone scans are usually abnormal (93 %) in cases of complete intrinsic ligament ruptures, however, detection rates diminished substantially in partial lesions. Compared to bone scans, MRIs have equal sensitivity and higher specificity for the detection soft tissue injuries.

Arthroscopy

Arthroscopic examination of the wrist enables direct visualization and palpation of intra-articular structures such as intrinsic ligaments, TFCC, and the articular cartilage. Its diagnostic accuracy is high for the detection of soft tissue injuries or small fractures, and for that reason, at the end of the day arthroscopy has gradually replaced other diagnostic studies as the gold standard [21–23]. Undoubtedly, the role of wrist arthroscopy has evolved, especially for the detection of associated soft tissue lesions associated to distal radius or scaphoid fractures in active, high demanding patients. This procedure currently has a well-established role in the evaluation of wrist pain, providing a conclusive diagnosis in most cases. However, a potential pitfall of this procedure is the identification of asymptomatic (incidental) lesions, which in turn could lead to unnecessary treatment.

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http://www.springer.com/978-1-4614-1595-4

Wrist and Elbow Arthroscopy
A Practical Surgical Guide to Techniques
Geissler, W. (Ed.)
2015, XI, 430 p. 485 illus., 394 illus. in color. With online files/update., Hardcover
ISBN: 978-1-4614-1595-4