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Review article

Wrist osteoarthritis

J. Laulan*, E. Marteau, G. Bacle

Département de chirurgie orthopédique, CHRU de Tours, route de Loches, 37044 Tours cedex, France

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ABSTRACT

Painful wrist osteoarthritis can result in major functional impairment. Most cases are related to post-traumatic sequel, metabolic arthropathies, or inflammatory joint disease, although wrist osteoarthritis occurs as an idiopathic condition in a small minority of cases. Surgery is indicated only when conservative treatment fails. The main objective is to ensure pain relief while restoring strength. Motion-preserving procedures are usually preferred, although residual wrist mobility is not crucial to good function. The vast array of available surgical techniques includes excisional arthroplasty, limited and total fusion, total wrist denervation, partial and total arthroplasty, and rib-cartilage graft implantation. Surgical decisions rest on the cause and extent of the degenerative wrist lesions, degree of residual mobility, and patient's wishes and functional demand. Proximal row carpectomy and four-corner fusion with scaphoid bone excision are the most widely used surgical procedures for stage II wrist osteoarthritis secondary to scapho-lunate advanced collapse (SLAC) or scaphoid non-union advanced collapse (SNAC) wrist. Proximal row carpectomy is not indicated in patients with stage III disease. Total wrist denervation is a satisfactory treatment option in patients of any age who have good range of motion and low functional demands; furthermore, the low morbidity associated with this procedure makes it a good option for elderly patients regardless of their range of motion. Total wrist fusion can be used not only as a revision procedure, but also as the primary surgical treatment in heavy manual labourers with wrist stiffness or generalised wrist-joint involvement. The role for pyrocarbon implants, rib-cartilage graft implantation, and total wrist arthroplasty remains to be determined, given the short follow-ups in available studies.

1. Introduction

Osteoarthritis is a chronic non-inflammatory joint disease characterised by degenerative lesions of the cartilage. At the wrist, osteoarthritis is usually secondary to posttraumatic sequel or metabolic disease and selectively arises in the joints that involve the scaphoid bone [1].

Although well tolerated for many years, wrist osteoarthritis can result in severe functional impairments. With the exception of a few patients seen at an early stage, surgery is not indicated unless conservative therapy has failed. Surgery is considered to be based on palliative procedures. The choice among the array of available techniques depends on the cause of the disease, joints involved, and patient-related factors [2].

Although the distal radioulnar joint is associated with the wrist, its involvement with osteoarthritis is related to specific causes and raises distinctive therapeutic challenges, which are not discussed here.

2. Biomechanics

The cohesion of the articular complex of the wrist is ensured by both the shape of the carpal bones and over 30 ligaments. The two-row model of the wrist is the most effective for understanding wrist biomechanics and the genesis of intra-carpal lesions.

The carpal bones receive no tendon attachments, and their movements are produced by compression forces. The second row of carpal bones (R2) behaves as a unit that is moved by off-center forces, similar to the beam of a scale moving around an instantaneous axis through the head of the capitate [3]. The first row (R1) is a deformable structure whose cohesion is provided in part by two intrinsic ligaments, the scapho-lunate (SL) and lunotriquetral (LT) ligaments. The strong forces applied to these ligaments can cause traumatic and degenerative lesions. In the three-link concept of the wrist, the intercalated segment is R1, which bridges the radial glenoid cavity and R2. Movements of R2 determine those of the three main bones of R1 and, in return, the cohesion of R1 ensures proper centring of the capitate head and R2 [3].

The shape and position of the scaphoid result in flexion of this bone in response to application of an axial compression force. Thus, the scaphoid converts compression forces to flexion forces. On the

* Corresponding author. Tel.: +33 247 475 946.
E-mail address: jacky.laulan@orange.fr (J. Laulan).

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Fig. 1. Radiographs of both wrists of a patient with SLAC wrist on the left and SNAC wrist on the right, both stage III. Note the radial translation of the row 2-scaphoid complex.

ulnar side, when axial compression is applied, the shape of the triquetro-hamatal joint surface moves the triquetrum in extension: compression forces are converted to extension forces. The balanced position of the lunate results from the combined effects of opposite forces applied to the two sides of the bone. If this balance is lost, the lunate can tilt into extension, an abnormality known as dorsal intercalated segment instability (DISI) or into flexion, which characterises volar intercalated segment instability (VISI).

Whereas flexion-extension movements are evenly distributed between the radiocarpal and midcarpal joints, movements in the frontal plane occur chiefly through the midcarpal joint. Functional motion arcs for activities of daily living are 5°–10° of flexion, 30°–35° of extension, 10° of radial inclination, and 15° of ulnar inclination. Wrist motions during everyday activities replicate the dart-thrower's arc of wrist motion, from radial inclination and wrist extension to ulnar inclination and wrist flexion. This complex wrist motion occurs chiefly through the midcarpal joint, with virtually no motion of the lunate [4]. The dart-thrower's arc is the most widely used wrist motion during everyday activities.

3. Aetiological diagnosis and pathophysiology of wrist osteoarthritis

Wrist osteoarthritis is usually secondary to a pathological condition, whose identification is important to ensure optimal management [2]. The main injuries responsible for wrist osteoarthritis are ligament lesions that impair the cohesion of R1 (scapholunate and lunotriquetral malalignment, scaphoid bone non-union, or malunion of a fracture involving the distal radial joint surface). Other causes include inflammatory joint diseases and metabolic diseases, chiefly articular chondrocalcinosis, or gout as a less common cause; primary avascular necrosis (Kienböck disease and Preiser disease); and deformities such as Madelung's disease [5–7].

There may be no detectable cause, for instance in some cases of scapho-trapezio-trapezoid osteoarthritis [7].

3.1. Osteoarthritis after disruption of the first carpal row (R1)

Scaphoid bone non-union and dissociative instabilities of R1 are responsible for carpal collapse with DISI or VISI and secondary osteoarthritis. In addition to this classical mechanism, any disruption of the intercalated segment can result in shear stress application to the midcarpal joint, which eventually causes midcarpal osteoarthritis [3].

Non-union of a scaphoid fracture is consistently followed by the development of osteoarthritis within 5–10 years. This pattern is known as scaphoid non-union advanced collapse (SNAC) wrist [5,8]. Progressive anterior wear with palmar flexion of the scaphoid results in loss of scaphoid height and in adaptive intra-carpal instability with DISI of the lunate, which follows the extension of the proximal pole of the scaphoid [9]. This malalignment is combined with radial translation and supination of the R2-distal scaphoid pole complex [8]. The result is osteoarthritis of the scaphostyloid joint (stage I) then of the scapho-capitate joint (stage II) and capitolunate joint (stage III) [5,8] (Fig. 1D).

Osteoarthritis complicating scapholunate instability (scapholunate advanced collapse or SLAC wrist) [1] occurs only in wrists characterised by the presence of static instability with DISI [3]. Disruption of the structures that normally stabilise the scapholunate joint puts the scaphoid in a horizontal and pronated position. With lunate DISI, the result is radial translation and supination of the R2-scaphoid complex responsible for dorso-radial subluxation of the proximal pole of the scaphoid [3] followed by osteoarthritis of the radioscaphoid joint, which is localised initially (stage I) then extensive (stage II). In parallel, loss of capitolunate centring produces shear stress with gradual development of midcarpal osteoarthritis (stage III) (Fig. 1G).

In most cases, the radiolunate joint space is spared [1], as it is not subjected to shear stress. However, osteoarthritis can develop in the radiolunate joint, producing the type IV SNAC or SLAC wrist pattern [5,9]. The cause may be sequel of perilunate lesions with partial lunate destabilisation (Fig. 2) or articular chondrocalcinosis.

Although midcarpal osteoarthritis may suggest articular chondrocalcinosis [6], another possible cause is lunotriquetral dissociation [10] in the absence of any metabolic disease (Fig. 3), accompanied with degenerative changes between the lunate and triquetral bone [5]. Also worthy of note is the existence of perilunate dislocation equivalents, either without dislocation or with spontaneous reduction, responsible for double instability [3,10]. The osteoarthritis may predominantly affect the radioscaphoid joint in the event of marked scapholunate dissociation or be confined to the midcarpal joint if lunotriquetral dissociation is the predominant abnormality [3] (Fig. 4).

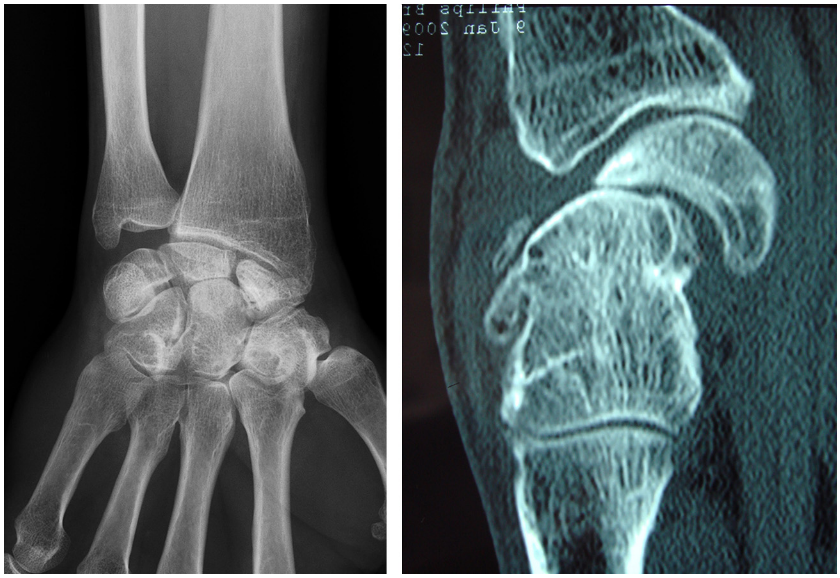

Fig. 2. Antero-posterior radiograph of an SNAC wrist, which seems to be stage III. Computed tomography showed degeneration of the radiolunate joint space indicating stage IV SNAC wrist.

3.2. Other patterns of wrist osteoarthritis

Radiocarpal osteoarthritis is a common complication of distal radius fractures, most notably in the event of malunion involving the joint surface. However, radiocarpal osteoarthritis can develop after anatomic reduction or even in the absence of a fracture line. Radiocarpal osteoarthritis is usually well tolerated, even in the long-term [11]. Concomitant abnormalities of the distal radio-ulnar joint are common and must be taken into account [12]. The lesions may be confined to the radiolunate joint and related to a die-punch fracture, Kienböck disease, or articular chondrocalcinosis [6].

Fig. 3. Midcarpal osteoarthritis complicating lunotriquetral malalignment. Note the combined flexion of the scaphoid and lunate and the extension of the triquetrum, in addition to the lunotriquetral step-off in the proximal carpal arch.

Scapho-trapezio-trapezoid osteoarthritis, although often combined with osteoarthritis of the trapezio-metacarpal joint, may be completely isolated. This pattern of osteoarthritis may be either idiopathic or secondary to articular chondrocalcinosis or to an injury. Absence of symptoms is common and radiographs may underestimate the lesions. The wear predominates at the palmar aspect, resulting in gradual displacement of the scaphoid towards an increasingly vertical position with adaptive DISI. However, scapho-trapezio-trapezoid osteoarthritis may also be combined with scapholunate malalignment [5].

Osteoarthritis of the pisotriquetral joint may be primary or secondary to trauma, micro-trauma, or pisotriquetral instability. Patients report pain at the anterior and ulnar aspect of the heel of the hand [13].

4. Clinical findings and investigations

Although wrist osteoarthritis is commonly encountered by hand surgeons, its prevalence is unknown. Absence of symptoms may be common, particularly after distal radius fractures, but also in patients with SLAC wrist [3,11]. A systematic review of 4000 wrist radiographs showed osteoarthritis in slightly over 5% of wrists, with involvement of the joints articulating with the scaphoid in over 95% of cases [1].

4.1. Clinical findings

Wrist osteoarthritis produces a fairly uniform clinical picture combining mechanical pain, motion range limitation, and decreased strength. These symptoms develop gradually in most patients but may be precipitated by an injury or unusual sustained activity. The occurrence of an acute flare of inflammation should suggest articular chondrocalcinosis.

In addition to motion range limitation, the physical findings may include a swelling, usually at the dorso-radial aspect of the wrist, related to a combination of osteophytes and focal synovitis (SLAC or SNAC wrist); or a doughy thickening of the radial side of the carpus (scapho-trapezio-trapezoid osteoarthritis). In wrists with severe SLAC or SNAC, radial translation and carpal supination may be clearly apparent (Fig. 5). All the sites of pain must be identified by careful palpation, and the distal radio-ulnar joint must be

Fig. 4. Midcarpal osteoarthritis complicating perilunate instability. Despite the obvious lunotriquetral instability and midcarpal osteoarthritis, the pain was ascribed to scapholunate instability (diagnosed arthroscopically!), which was treated with scapho-capitate fusion. As was to be expected, this procedure failed to relieve the pain.

palpated also, as its concomitant involvement may adversely affect treatment outcomes [2,12].

4.2. *Radiographs and other investigations*

Radiographs should be performed under strictly defined conditions, with the wrist in neutral pronosupination. The radiographic findings often establish the cause of wrist osteoarthritis. However, inter- and intra-observer agreement is moderate for classifying SLAC wrists and limited for classifying SNAC wrists. The distal radio-ulnar index should be evaluated, as a long ulna may result in ulnocarpal impingement after radio-scapho-lunate, four-corner, or total fusion. Given that the surgical procedure is chosen based on which joint spaces are involved and which are spared [5], a detailed radiographic analysis is crucial. Calcification of the triangular fibrocartilage should be sought, as well as osteoarthritis of the metacarpo-phalangeal joints, which supports a diagnosis of articular chondrocalcinosis. Specific views can be used, such as a lateral view with 20° or 30° of supination to detect pisotriquetral osteoarthritis [13].

Fig. 5. Clinical appearance of severe form of SLAC or SNAC wrist. Note the radial translation and carpal supination.

Before performing limited wrist fusion, computed tomography (CT) or, preferably, a CT-arthrogram should be obtained routinely to confirm the good quality of the residual joint spaces. This investigation is also mandatory before proximal row carpectomy, to assess the cartilage covering the head of the capitate.

The only indication for magnetic resonance imaging is Kienböck disease, to look for synovitis and to assess the structure of the capitate before deciding whether proximal row carpectomy is appropriate.

5. Surgical techniques

Many techniques described as palliative have been reported, including excisional arthroplasty, limited or total fusion, partial or total joint replacement, interpositional arthroplasty, and rib-cartilage graft implantation. Finally, wrist denervation is a purely symptomatic treatment whose only effect is to alleviate the pain.

5.1. *Excisional arthroplasty with or without interposition*

5.1.1. *Excision of the radial styloid*

Excision of the radial styloid, which can be performed arthroscopically if appropriate, can eliminate symptomatic styloid-scaphoid impingement in patients with stage I SNAC wrist. When performed alone, this procedure does not prevent symptom recurrence. The excision should be limited to spare the attachments of the radiocarpal ligaments.

5.1.2. *Excision of the proximal pole of the scaphoid*

Excision of the proximal pole of the scaphoid, combined with interposition, has been suggested as a treatment for radioscaphoid osteoarthritis in SNAC wrists, as well as in SLAC wrists. Among the various interposition materials used, pyrocarbon is currently preferred [14]. An autologous osteochondral graft can be considered in the same indications [15].

Fig. 6. Example of long-term outcome after proximal row carpectomy. Note the major degenerative changes of the neo-articulation between the radius and capitate.

5.1.3. *Proximal row carpectomy*

Proximal row carpectomy is feasible only if the cartilage of the radial lunate fossa and capitate head are preserved [13,16]. The relative joint surface incongruity results in pressure elevation and in capitate head translation within the lunate fossa [17]. These abnormalities can cause early degenerative disease of the neo-articulation between the radius and capitate (Fig. 6), which does not, however, seem to correlate with the clinical manifestations [16,18,19]. Although early failure occurs in 5% to 12% of cases [13,19], good results are sustained in the long-term, with a 65% survival rate after more than 20 years [16]. About 50% of patients report complete freedom from pain. The outcomes are less satisfactory in manual labourers [19] and the improvements less durable in young individuals [16]. This procedure preserves two-thirds of mobility and three-fourths of strength on average, and patient satisfaction rates range from 80% to 90% [7,16,18,19].

5.1.4. *Excisional arthroplasty of the distal scaphoid*

Excisional arthroplasty of the scapho-trapezio-trapezoid joint can be considered in combination with interposition (of a tendon or pyrocarbon implant) in patients with osteoarthritis of this joint [20,21]. However, there is a risk of secondary instability in extension of R1, and care should be taken to rule out concomitant dorsal midcarpal instability, midcarpal osteoarthritis, and scapholunate damage [20]. Isolated excision of the distal scaphoid fragment has been suggested to treat selected cases of scaphoid non-union; the same restrictions apply, and the proximal fragment must be composed of at least 50% of the scaphoid.

5.2. *Limited carpal fusion*

Limited carpal fusion can be considered in patients with both localised osteoarthritis and a residual joint space of good quality capable of ensuring a long-lasting wrist motion arc consistent with the ability to accomplish everyday activities [22].

The joint surfaces must be removed down to the sub-chondral bone, and cancellous bone must be implanted in the amount needed to compensate for the loss in thickness [12]. K-wire fixation is the reference standard method of internal fixation. The wrist is then immobilised for 4 to 8 weeks depending on the operative site and surgical team.

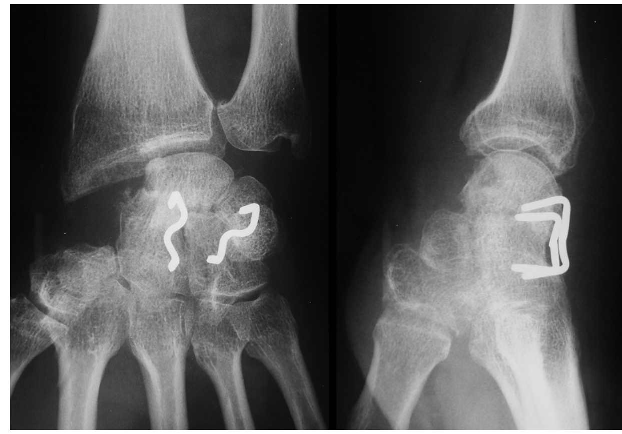

Fig. 7. Example of four-corner fusion with excision of the scaphoid. Note the good correction of the dorsal intercalated segmental instability. However, the presence of dorsal material may constitute a potential source of extension impingement.

Overall, mean residual motion range is 50% to 67% after fusion of the radiocarpal joint with excision of the distal pole of the scaphoid or four-corner fusion [7]. Complete freedom from pain is achieved in only 50% to 60% of cases [12,23] and the mean pain score is 2 to 3 on a 10-point Visual Analogue Scale (VAS).

Importantly, limited carpal fusion is associated with a high complication rate of up to 40%. Non-union is the most common complication [22] and the outcome is often disappointing even after revision surgery [2].

5.2.1. *Four-corner fusion*

Four-corner fusion is usually combined with excision of the scaphoid and therefore involves all four medial bones [1,5]. The physiological radiolunate joint surface is preserved and the risk of degenerative lesions is lower than after proximal row carpectomy [17,18]. Indications for this procedure include midcarpal osteoarthritis complicating lunotriquetral dissociation and, above all, SLAC and SNAC wrists [5]. Correction of the DISI and midcarpal subluxation is important to minimise the risk of dorsal impingement and to obtain optimal extension [23] (Fig. 7).

About 50% to 60% of wrist mobility is preserved, with a motion arc of about 50%. However, mobility in the dart-thrower's motion arc is eliminated and the procedure is perceived as limiting (Wolfe in [24]). Pain severity decreases by 50% to 60% compared to the pre-operative level, and complete freedom from pain is achieved in half the patients. Strength ranges from 60% to 80%. The results remain satisfactory after more than 10 years of follow-up [25].

The risk of non-union after circular-plate fixation is lower with the last-generation material; the use of K-wires eliminates impingement in extension. Initial complications are not infrequent, the non-union rate is 3% to 9%, and conversion to total fusion is required in 2% to 36% of cases.

The fusion can be confined to the capitolunate joint, and the triquetrum may or may not be removed in addition to the scaphoid. This procedure may be associated with improved functional outcomes [26], although the risk of non-union may be increased [23,26]. As the radiolunate joint may be involved also [5,9], a CT-arthrogram must be obtained routinely before performing four-corner fusion.

5.2.2. *Radio-scapho-lunate fusion*

Conventional radio-scapho-lunate fusion limits the range of motion and is associated with a non-negligible frequency of complications, of which the most common are non-union and midcarpal

Fig. 8. Radio-scapho-lunate fusion for residual pain after a distal radial fracture. Note the concomitant excision of the distal pole of the scaphoid and head of the ulna.

osteoarthritis. However, concomitant excision of the distal pole of the scaphoid (Fig. 8) improves range of motion, most notably in flexion and radial inclination; increases the healing rate; and eliminates the risk of secondary scapho-trapezio-trapezoid osteoarthritis [12]. The main advantage of radio-scapho-lunate fusion is preservation of midcarpal motion range and, therefore, of the dart-thrower's motion arc [12].

The fusion can be confined to the radiolunate joint in patients with die-punch fracture sequelae or certain forms of Kienböck disease. Range of motion is better than after conventional radio-scapho-lunate fusion. Interposition of a graft is important to prevent upwards migration of the lunate and ulnolunate impingement [12].

5.2.3. Scapho-trapezio-trapezoid fusion

Scapho-trapezio-trapezoid fusion can be considered in patients with isolated scapho-trapezio-trapezoid osteoarthritis or advanced Kienböck disease.

Scapho-trapezio-trapezoid fusion, a technique promoted by Watson, preserves 70% to 80% of the flexion-extension arc and two-thirds of the range of inclination in the frontal plane. Strength improves but remains impaired.

The complication rate is 43%, with non-union in 14% and persistent pain in 49% of cases [22,23]. The risk of secondary osteoarthritis is limited when the scaphoid is fused in 40° to 60° of flexion. Watson advocates partial styloid excision to prevent impingement, which may occur in one-third of cases.

5.3. Total fusion

Total fusion seems best performed with the wrist in slight extension and slight ulnar inclination. When dedicated plates are used, healing rates of up to 98% to 100% have been achieved [2,27]. After excision of the various joint surfaces except that of the scapho-trapezio-trapezoid joint, followed by cancellous bone graft implantation, the distal part of the plate is secured to the third metacarpal. However, carpo-metacarpal joint fusion should not be performed, as it carries a risk of pain after plate removal.

Total wrist fusion is usually performed after one or more motion-preserving procedures have failed [27], although its outcomes are poorer in this situation [2]. Total fusion reliably relieves pain and improves strength. The loss of mobility is rarely perceived as problematic and patient satisfaction rates range from 80% to 100% [27].

After primary total fusion, a mean VAS pain score of 2/10 combined with 80% to 90% of normal strength can be expected, and most patients are able to return to their previous occupation [2].

Total fusion is indicated in manual workers who have stiffness of the wrist and generalised wrist-joint involvement or advanced Kienböck disease [2,27].

Fig. 9. Dislocation of an STPI® implant with midcarpal malalignment.

5.4. Total wrist denervation

Outcomes are better after total denervation than after partial denervation. Immediate failure and deterioration of the initial improvements may occur during the first few years, but the results are usually stable later on [28]. The revision rate varies from 0% to 16%.

Wrist denervation is associated with low morbidity rates and a prompt return to work. This procedure preserves or even improves mobility, at least in the medium term [28]. Effective pain relief can be expected in 70% to 75% of cases, with a patient satisfaction rate of 80% and a VAS pain score of 2 to 3/10. Similar good outcomes seem to be achieved in SLAC and SNAC wrists. The result is not influenced by age, but the degree of pain relief is inadequate in heavy manual labourers [28].

The best candidates for wrist denervation fall into two groups: patients who are physically inactive or perform light manual work and have good motion ranges; and elderly patients regardless of motion range, given the low morbidity rates associated with this procedure [2,13]. Wrist denervation can also be performed in patients with radiolunate joint osteoarthritis (stage IV SLAC and SNAC wrists).

5.5. Pyrocarbon implants

Pyrocarbon is a biocompatible material that is characterised by a low friction coefficient and a Young's modulus similar to that of bone and that does not undergo osteointegration [14,29]. Various interposition options have been suggested and seem well tolerated, although cases of dislocation have been reported [20] (Fig. 9).

The Adaptive Proximal Scaphoid Implant (APSI®) designed to replace the proximal pole of the scaphoid has an ovoid shape that allows adaptive mobility and ensures stability during wrist motions. This implant acts as a spacer that may preserve the height of the carpus, thereby limiting progression to carpal collapse [14]. It can be implanted arthroscopically, although this method does not eliminate the risk of dislocation.

The Scaphoid Trapezium Interposition Implant (STII®) is used to treat scapho-trapezio-trapezoid osteoarthritis, as an interposition implant, in combination with excision of the distal pole of the scaphoid. This implant may eliminate the risk of midcarpal destabilisation, while inducing little or no complications in the short term [21].

Amandys® is a free interposition implant for the radiocarpal and midcarpal joints. It replaces the lunate, proximal two-thirds of the scaphoid, and part of the head of the capitate. This implant is considered an alternative to total fusion and to joint replacement in patients with extensive symptomatic osteoarthritis and in revision procedures. It decreases pain intensity, although the mean VAS pain score remains at about 4/10 and the DASH score at 35 to 40 [29].

5.6. Partial joint replacements

Radial implants avoid the problems related to distal implant loosening that can occur after total arthroplasty.

The KinematX Midcarpal Hemiarthroplasty® implant is indicated for the treatment of osteoarthritis (Wolfe in [24]). It replaces R1 and "resurfaces" the distal radius to allow its articulation with R2, thereby preserving the dart-thrower's motion arc. This implant is indicated for the treatment of radiocarpal osteoarthritis and of type II SLAC and SNAC wrists.

The Resurfacing Capitate Pyrocarbon Implant (RCPI®) resurfaces the head of the capitate and broadens the indications of proximal row carpectomy to stage III SLAC and SNAC wrists. Two case-series studies with mean follow-ups of approximately 4 years showed about 50% mobility and 60% strength (Marcuzzi et al, Morchick in [24]). The poor outcomes may be chiefly ascribable to alterations in the lunate surface of the distal radius (Morchick in [24]).

5.7. Total wrist arthroplasty

Despite improved outcomes in the latest case-series studies, alterations in distal implant fixation continue to raise problems [24]. Among available implants, ReMotion® may provide promising outcomes in degenerative wrist disease, with 92% survival after a mean follow-up of 4 years and 95% of patients satisfied with the procedure [30]. However, loosening has already occurred in 18% of cases.

5.8. Rib-cartilage graft implantation

Implantation of autologous rib bone and cartilage can be performed either as a spacer or for resurfacing. Obert et al. used this technique in patients with osteoarthritis, SLAC and SNAC wrists, malunion confined to the lunate surface of the distal radius, and stage IV Kienböck disease [15]. Both pain and function improved, and the grafts remained viable.

6. Therapeutic indications

6.1. Treatment objectives

When medical treatment fails [7], the best surgical option is selected based primarily on the cause and extent of the osteoarthritis, although residual mobility, age, and the patient's level of demand are taken into account also, as well as job retraining possibilities. Each procedure is associated with specific complications and limitations that should be explained to the patient, whose ability to adapt to them is influenced by psychological and social factors. The risk of requiring a second operation should also be considered: in the event of early failure, the need for re-operation delays the patients' return to normal social and occupational activities and increases the risk that even total fusion will fail.

Joint motion preservation is among the treatment objectives. However, preserving mobility at any cost is ill-advised, as studies show comparable functional impairments in patients with partial versus full restriction of mobility and establish that nearly all

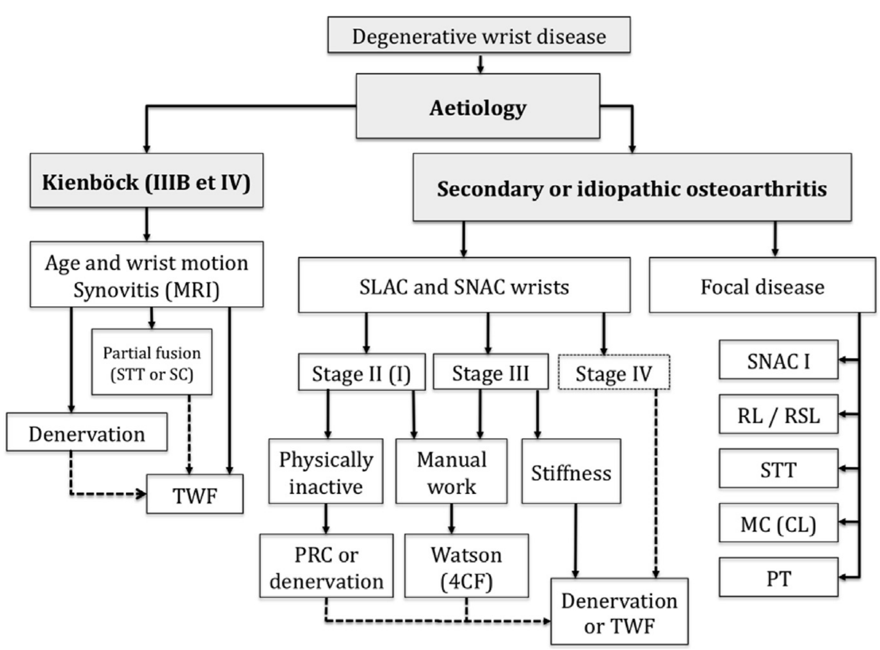

Fig. 10. Decision-tree for managing wrist osteoarthritis. STT: scapho-trapezio-trapezoid; SC: scapho-capitate; RL: radiolunate; RSL: radio-scapho-lunate; MC: midcarpal joint; CL: capitate-lunate; PT: pisotriquetral; PRC: proximal row carpectomy; 4CF: four-corner fusion; TF: total fusion ; TWF : total wrist fusion.
from Laulan et al., 2011.

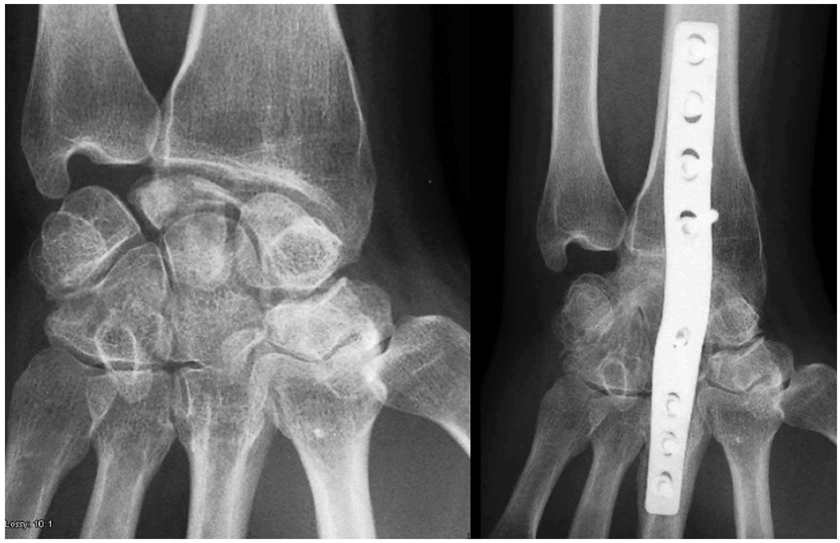

Fig. 11. Stage IV Kienböck disease treated with primary total fusion in a heavy manual labourer who returned to his previous job after 16 weeks.

everyday activities can be performed regardless of the degree of motion range limitation [13,27]. Although patients feel that preserving mobility is important, 59% are prepared to sacrifice mobility in order to achieve a greater level of pain relief; and after surgery, although loss of mobility is the main regret, persistent pain is the main source of dissatisfaction [2]. Therefore, among treatment objectives, pain relief should be given priority over motion preservation.

6.2. Indications according to the cause and location of osteoarthritis

6.2.1. Kienböck disease

In advanced Kienböck disease, palliative treatment is usually required. Scapho-trapezio-trapezoid or scapho-capitate fusion is sometimes considered at this stage to unload the lunate, although the failure rate is higher than with total fusion [22] (Fig. 10). The long-term validity of using rib-cartilage as a spacer remains to be established [15].

In young patients and heavy manual labourers, total fusion is the only method associated with reliable outcomes [2] (Fig. 11). In physically inactive patients with preserved wrist mobility and in elderly patients, wrist denervation can avoid immobilisation and the potential complications of fusion procedures [13,28].

6.2.2. SLAC and SNAC wrists

In some cases of scaphoid non-union with isolated styloscaphoid osteoarthritis (type 1 SNAC wrist), bone grafting combined with styloid excision may be feasible. Otherwise, a palliative procedure must be performed [8].

A meta-analysis comparing case-series of proximal row carpectomy versus four-corner fusion showed no significant differences for pain relief, strength, or subjective outcomes [18]. According to decision analysis, proximal row carpectomy was slightly better than four-corner fusion in patients with early osteoarthritis (Graham and Detsky, in [2]). Proximal row carpectomy is technically easier to perform. This technique is associated with a low morbidity rate that offsets the risk of early failure inherent in this procedure and may provide a mobility gain of about 10° [17,18].

The choice of the treatment method depends on the extent of the lesions and on patient-related factors. In heavy manual labourers with stage II disease, four-corner fusion may be the best choice given the apparently longer time to joint space degradation associated with this procedure; also, proximal row carpectomy is best avoided in young patients [16,18,19]. In patients who are physically inactive or perform light manual work, proximal row carpectomy or denervation may be considered, depending on age, mobility, and the patient's wishes. Proximal row carpectomy is not indicated in stage III disease, which can be treated with four-corner fusion or denervation, depending on age and activity level.

In diffuse disease responsible for wrist stiffness and pain, total wrist fusion is indicated in young manual workers and denervation in physically inactive patients. Denervation is the best primary procedure in elderly patients. Only when this procedure fails can interposition arthroplasty (Amandys®) or total wrist arthroplasty be considered.

Fig. 12. Scapho-trapezio-trapezoid fusion with an excellent functional outcome after 15 years.

6.2.3. Focal osteoarthritis

In radiocarpal osteoarthritis due to a distal radius fracture, the reference standard procedure is radio-scapho-lunate fusion combined with excision of the distal pole of the scaphoid [12]. When the osteoarthritis is confined to the radiolunate joint, either radiolunate fusion or an osteochondral graft can be considered [15]. The reference standard for isolated scapho-trapezio-trapezoid osteoarthritis is fusion of the joint (Fig. 12). Other possibilities include excision of the distal pole of the scaphoid with interposition, with the above-described precautions to avoid midcarpal instability in extension [20]. Finally, in symptomatic pisotriquetral osteoarthritis, sub-periosteal excision of the pisiform is the treatment of choice [7,13].

6.2.4. Diffuse osteoarthritis, failed palliative procedure

Possible treatments are total fusion, total arthroplasty, and interposition arthroplasty, depending on age and functional demand.

7. Conclusion

Denervation is a valuable procedure in elderly patients, given the low morbidity rate and absence of major constraints. Denervation provides effective pain relief in three-fourths of patients and preserves residual mobility.

Otherwise, the two reference standard procedures for stage II SLAC and SNAC wrists are proximal row carpectomy and four-corner fusion. Apart from the early specific disadvantages of each of these procedures, the functional outcomes are satisfactory and sustained in the long-term.

Total fusion should not be reserved as a salvage method for failed procedures. In some situations, total fusion maximises the likelihood of returning to heavy manual labour and avoiding social isolation.

Finally, partial arthroplasty rib-cartilage autografts and total arthroplasty probably have a role within the therapeutic armamentarium, although longer follow-ups are needed to determine their exact indications.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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