Management of Chronic Scapholunate Ligament Tears Before Arthritis Occurrence or to Prevent Arthritis

Ch. Mathoulin, E. Papadogeorgou, and A. Pagliei

1 Introduction

The scapholunate ligament injury is the most frequent lesion that results from supination and extension trauma of the wrist [1]. It engenders a chronic instability that may turn to arthritis.

This lesion can be associated with a fracture of the radial epiphysis [2]. Acute injuries (less than 2 months old) are difficult to diagnose. Wrist arthroscopy is useful to detect these injuries at an early stage and to treat them by stable fixing, without open surgery of the wrist. The management of chronic injuries of the scapholunate ligament before occurrence of arthritis remains a challenge for the surgeon who often manages to correctly stabilize the instability but may not prevent wrist stiffness. We report a new therapeutic scheme based on the classification proposed by Marc Garcia-Elias et al. [3], using two new methods: an arthroscopic technique and an open surgery with ligamentoplasty. Both techniques enabled us to obtain encouraging results, even if many series showed that the result of the early treatment was superior to any attempt of secondary stabilization [1, 2, 4–11].

2 Anatomic Basis

As a full part of a sophisticated multiarticular system, the scapholunate joint is a critical joint, which is very ductile for man and essential for a 'skilful hand'. The structural integrity of the bone and the stabilization means, static and dynamic, allow the scaphoid to play a key role in the dynamics of the carpal rows which are

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E. Camus, L. Van Overstraeten (eds.), *Carpal Ligament Surgery*,
DOI 10.1007/978-2-8178-0379-1_20, © Springer-Verlag France 2013

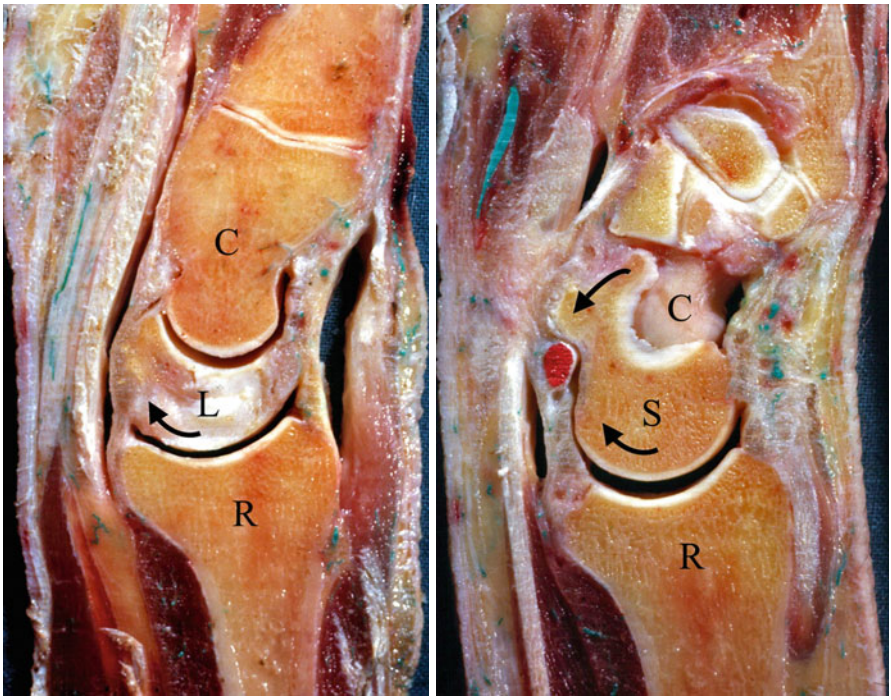

Fig. 1 Fresh cadaver, frozen wrist: lateral section showing the constraints applied on the scapholunate complex. We can notice the thickness of the palmar capsulo-ligamentous structures creating a sort of cushion positioned against the anterior translation of the carpus. *C* capitate, *L* semilunate, *S* scaphoid, *R* radius

in a precarious balance, considering the opposite constraints acting on the proximal and distal poles. The distal pole tends to flex in response to the strengths applied on the first ray, while the proximal pole extends due to its links with the semilunate. This condition, which is peculiar to the scaphoid, follows the acquisition of opposition of the thumb (anteposition of the first ray, scaphoid anteversion), a fundamental progressive event for the man's hand.

As it is related to the progressive flexion of the scaphoid, the trapezium comes on a much volar plane: the structure of the trapezio-metacarpal favours the opening of the first ray of the palm, which gives it the possibility to oppose the four digital other rays. This recent phylogenetic acquisition makes the scaphoid no longer parallel to the other elements of the carpus, with the application of important unbalanced strengths on the opposite poles (Fig. 1).

2.1 Means to Stabilize the Distal Pole of the Scaphoid

Devices meant to stabilize the distal pole of the scaphoid play a quite important part considering the constraints transmitted by the first ray due to its anteposition. The

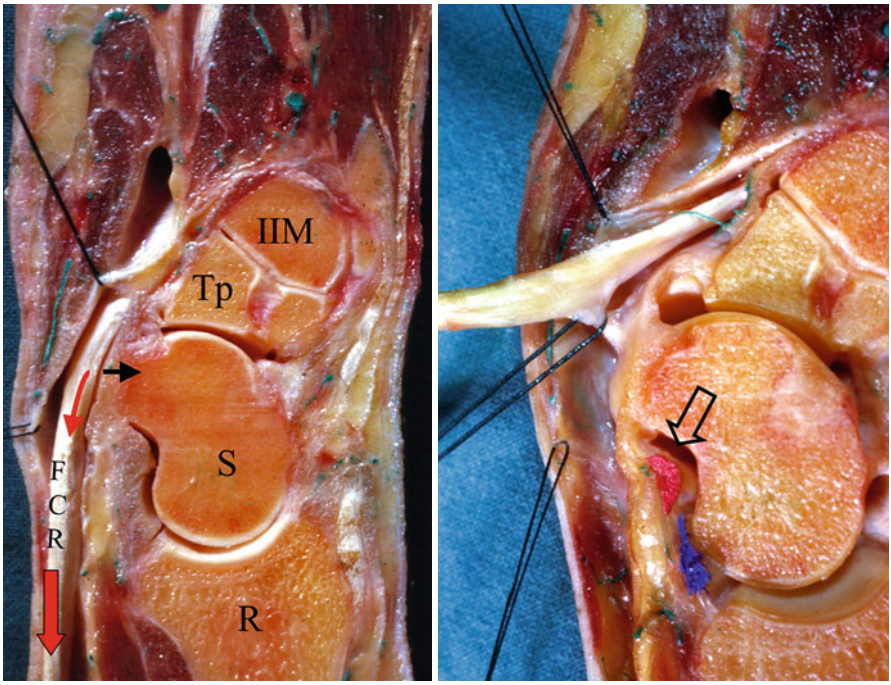

Fig. 2 Fresh cadaver, frozen wrist: lateral section showing the distal ligamentous complex of the scaphoid. The tendon of the flexor carpi radialis (*FCR*) can have accessory insertions on the scaphoid (*S*), on the trapezium (*Tp*) or on the scapho-trapezoid along its course towards the base of the 2nd metacarpal (*IIM*); through the trapezio-trapezoid complex, it exerts constraints in flexion on the scaphoid (*red arrows*). The *black arrow* represents the active stabilizing function of the *FCR*. In fact, this musculotendinous entity is opposed to an excessive volar dislocation of the tubercle of the scaphoid. The radio-scapho-capitate ligament can be clearly seen (*in red*, *empty arrow*) in its function of tense pivot between the radius and the capitate, around which the scaphoid makes movements of flexion and extension. *R* radius

flexor carpi radialis system (FCR) has both an active and a passive part: its osteofibrous canal is a real anterior abutment which is superimposed to the distal ligamentous complex of the scaphoid (scapho-trapezio-trapezoidal and scapho-capitate ligaments) (Fig. 2).

2.2 Interosseous Scapholunate Ligament

The scaphoid is linked to the semilunate by an interosseous ligament which acts like a twisting bar as it creates a system with viscoelastic dampers. It is a nonhomogeneous system composed of three parts: the anterior part is fitted into the long and short radio-lunate ligament and the radioscapholunate ligament. The intermediate proximal part is a real avascularized fibrocartilaginous membrane that corresponds to the depressed zone during arthroscopic palpation. The posterior part is strong and

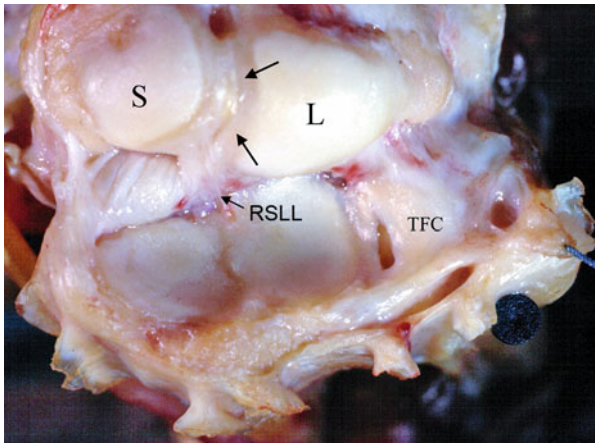

Fig. 3 Fresh cadaver, anatomic preparation of the radiocarpal: the carpus has been placed in exaggerated flexion to show the volar radiocarpal ligaments and the articular section only – intermediate section – of the scapholunate interosseous ligament (*black arrows*). The radioscapholunate ligament (*RSLL*) covers the anterior part of the interosseous ligament. *S* scaphoid, *L* semilunate, *TFC* triangular fibrocartilage

securely linked to the dorsal capsule as it is adjacent to the dorsal scapho-triquetral ligament and the dorsal intracarpal ligament (Fig. 3).

The carpus has also a capsulo-ligamentous system (extrinsic, intracapsular and extra-synovial ligament) organized in different ways at the volar and dorsal level, which enables the adaptability to the physiological constraints of the proximal row, especially that of the scapholunate complex (Fig. 4).

2.3 Assessment of the Anatomic Aspects

From a strictly anatomic point of view, the scapholunate joint is characterized by the superimposition of two smooth articular facets, creating an arthrodia in the presence of a syndesmotic element at the level of the proximal pole between two bones. The clinical experiment shows smooth joints, and especially syndesmoses show particular sensitivity to the passage of a metallic synthesis tool as it develops an important secondary fibrosis. Thus, if we want to make an 'arthrofibrosis' as close to the physiological condition as possible, it seems logical to treat an instability resulting from the injury of a syndesmosis by stabilization using trans-articular synthetic means.

Although we noticed an anatomic division of the interosseous scapholunate ligament into three parts, it would be an error to give a major role to particularly ligamentous parts. The mere notion of 'interosseous ligament' should be restricted to the intermediate section, that is to say, the sole fibrocartilaginous, avascularized and thus unrepairable section. On the contrary, the anterior and posterior parts of the scapholunate ligament are perfectly integrated into the volar and dorsal extra-synovial ligamentous system and consequently reminiscent of the system of all extra-articular ligaments with many cells and well-developed vascularization.

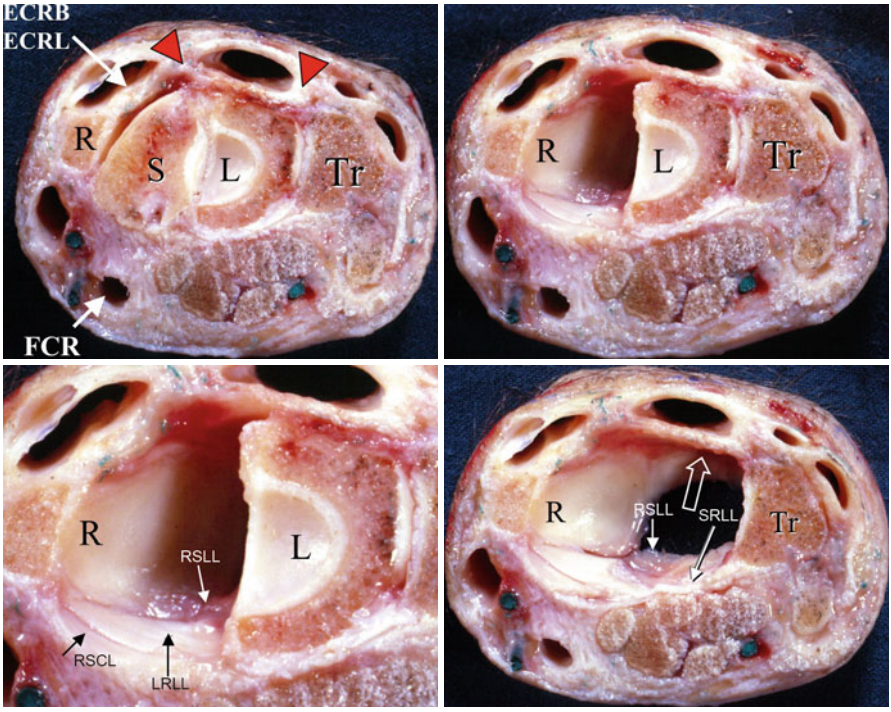

Fig. 4 Fresh cadaver, frozen wrist: coronal section at the level of the midcarpal, after the removal of the proximal pole of the scaphoid (*S*) and the semilunate (*L*). (*R*) radius, (*Tr*) Trapezium. We can notice: The correct osseous covering that the styloid section of the radial socket gives the proximal pole of the scaphoid. The structural differences between the volar and dorsal capsulo-ligamentous complex. We can underline the orientation of the volar radiocarpal ligaments (*RSCL* radio-scapho-capitate ligament, *LRLL* long radio-lunate ligament, *SRLL* short radio-lunate ligament) which have a reversed V-shape with converging arms on the capitate and lunate, making a less elastic and more stable system with 'a central symmetry' and with shorter and stronger ligaments: *RSLL* the radio-scapholunate ligament or the ligament of Testut and Kuentz. On the contrary, the dorsal capsule, which is thinner, seems to be reinforced by the dorsal intercarpal ligament which is tensed between the pyramidal and the *STT* complex (scapho-trapezio-trapedoidal) and linked to the posterior and more dorsal parts of the scapholunate and luno-triquetral interosseous ligaments (*tips of the red arrows*), where the posterior scapho-triquetral ligament originates. The dorsal intercarpal ligament and the dorsal radio-triquetral ligament (or dorsal radiocarpal, which belongs to the carpal ulnar sling of Kuhlmann – *empty white arrow*) form an oblique ligamentous 'V' with the apex centred on the pyramidal: a ligamentous system with an 'eccentric symmetry', longer and thinner but much more elastic oblique ligaments. The carpal tendinous cage created by the extra-articular slings (retinaculum of the flexors and retinaculum of the extensors; the latter is made more visible once the tendons are removed), insures a dynamic control system which elements are set in rays, forms a system with 'radial symmetry' which allows and adjusts wrist motion in all directions: *FCR* flexor carpi radialis, *ECRB* extensor carpi radialis brevis, *ECRL* extensor carpi radialis longus

The proximal row is a complex system that has to present both a twisting elasticity enabling the flexion-extension of the scaphoid and stability enough to resist without bending too much the constraints of compression transmitted by the distal

row and more particularly by the capitate. The far more elastic system of the volar carpal ligaments and the dorsal intercarpal ligaments enables the distal parts of the scaphoid, the semilunate and the pyramidal to execute limited movements on the sagittal plane and allows controlled twisting of the scaphoid-semilunate pyramidal chain. The correction of a rotary instability of the scaphoid at a chronicle level has to take into account the execution of a scapholunate 'arthrofibrosis' and the stabilization of the scaphoid distal pole. Surgical techniques aimed at reconstructing the capsulo-ligamentous system and preserving the anatomic characteristics of the physiological stabilization means must be given priority. The reconstruction of a dorsal capsulo-ligamentous system, especially that of the dorsal intercarpal complex, seems to guarantee limited stiffness and can be associated, if necessary, to scapho-trapezial stabilization at the volar level.

3 Garcia-Elias Classification

In January 2006, in an article published in the *Journal of Hand Surgery*, and which has become an important reference as far as injuries of the scapholunate ligament are concerned, Marc Garcia-Elias proposed a new scoring system based on answers to five questions dealing with the status of the wrist in chronic injuries [3]:

1. Is the scapholunate ligament, and more particularly its dorsal section, intact?
2. Is the injury of the scapholunate ligament partial or not?
3. Is the scapholunate ligament repairable?
4. Are osseous connections normal?
5. Is the scaphoid reducible?
6. Are cartilages normal?

This questionnaire results in a six-stage classification distributed as follows:

- *Stage 1*: There is a mere partial injury which is likely to be repaired thanks to a normal line, a reducible scaphoid and healthy cartilages.
- *Stage 2*: The injury is complete but intact repair seems possible.
- *Stage 3*: There is an important injury of the scapholunate ligament but the osseous connections are still normal.
- *Stage 4*: There is a complete tear of the scapholunate ligament with a dislocation of the scaphoid, but reduction appears possible.
- *Stage 5*: Reduction is not spontaneous as the horizontalization of the scaphoid is settled.
- *Stage 6*: Cartilages are affected (SLAC 1–4).

On this basis, Marc Garcia-Elias proposed the following therapeutic chart:

- *Stage 1*: It should be considered scapholunate broaching under arthroscopic control for acute cases and scapholunate broaching associated with dorsal capsulodesis for chronic cases.

- *Stage 2*: Suture of the scapholunate ligament by open surgery.
- *Stage 3:* Reconstruction either by bone-ligament-bone fixing or reconstruction by the three-ligament technique.
- *Stage 4*: Reconstruction by ligamentoplasty.
- *Stage 5*: Scapho-trapezio-trapezoidal arthrodesis is the most logical indication but in some cases after cleaning periosseous fibrosis and eventual reduction, stage 5 could be turn into stage 4 with reconstruction by ligamentoplasty.
- *Stage 6*: Potential surgery depending on the progression of arthrosis with palliative techniques such as resection of the first carpal row and arthrodesis of the 4 internal bones.

4 Arthroscopic Capsuloplasty (Stages 2–4)

In stages 2, 3 and 4 in particular, no matter if the ligament appears repairable or not, when the lines are strictly normal, we suggest a new technique of dorsal capsuloplasty associated with scapholunate and scapho-capitate pinning associated with arthroscopic control and support. The technique is based on a suture between the dorsal capsule and the scapholunate ligament. The arthroscope is introduced between the radiocarpal joint and the midcarpal. An internal knot is made between the scaphoid and the semilunate, and an external knot is made at the level of the capsule so as to create a link between the dorsal capsule and the dorsal part of the scapholunate ligament to reinforce the dorsal section of this ligament (Figs. 5, 6, 7, 8, and 9).

We used this technique to operate on 11 male patients, aged from 19 to 45 years (averaged age: 36 years). Most of them (nine cases) had sport accidents and three cases were high-level sportsmen.

Real effects of the procedure could not be assessed so early since the average period lasts 12 months (from 7 to 17 months). Pain disappeared in all cases except two who still suffer from moderate climatic pains. Mobility is normal in seven cases, as well as muscular strengths.

To date, no surgical failure occurred and these results are really favourable, but more time is necessary to analyse long-term results after the patients returned to sports activities (Figs. 10, 11, 12, 13, 14, and 15).

5 ECRB Ligamentoplasty and Scapholunate Stabilization

In stage 5, in particular when lines are disturbed and with a reducibility of the scaphoid which is easy or not, we systematically suggest by an open portal to perform reconstructive ligamentoplasty using a strip of the extensor carpi radialis brevis (ECRB). This technique aims at making an arthrofibrosis through the scapholunate joint and stabilizing the distal pole of the scaphoid thanks to this ligamentoplasty.

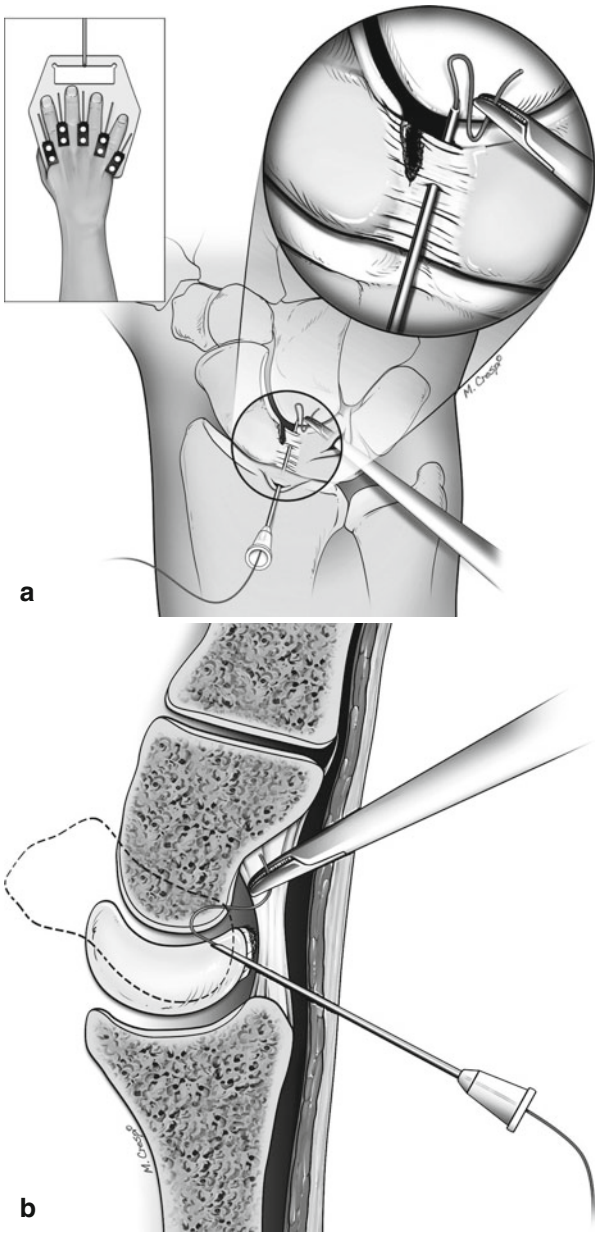

Fig. 5 (**a**, **b**) First introduction of a thread between the dorsal capsule and the scapholunate ligament. Under arthroscopic control, the thread is placed inside a needle and goes from the radiocarpal joint to the midcarpal joint where the thread is got back and removed by the radial midcarpal portal

The therapeutic principle was to fix the scapholunate joint in a reduced position for a long period (6 months). Following our anatomic studies, a new ligamentoplasty using a strip from the extensor carpi radialis brevis (ECRB) stabilized the complex of the carpal first row.

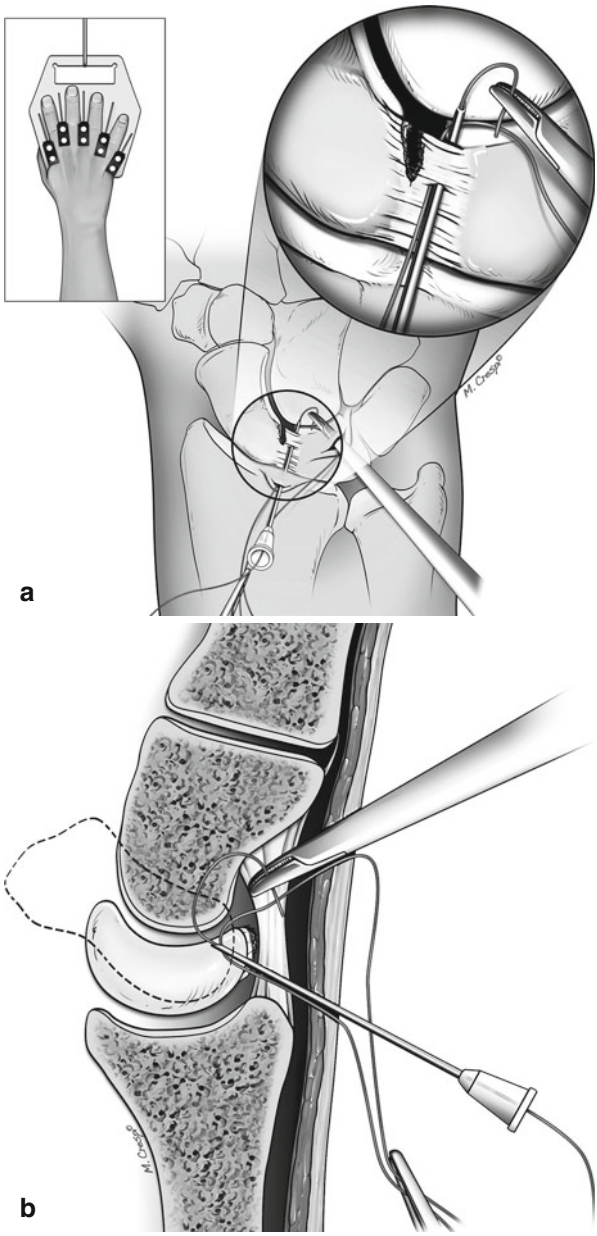

Fig. 6 (**a**, **b**) A second thread, parallel to the first one, is introduced using the same technique

Arthroscopic assessment was always made after surgery, following the same techniques, to check the presence of potential arthrosis and the importance of the dislocation.

The technique is based on an arciform approach. After the strip had been removed from the ECRB and fixed on the distal 2nd metacarpal, we performed dorsal arthrotomy and explored the scapholunate joint (Fig. 16). Reducing the radio-lunate joint

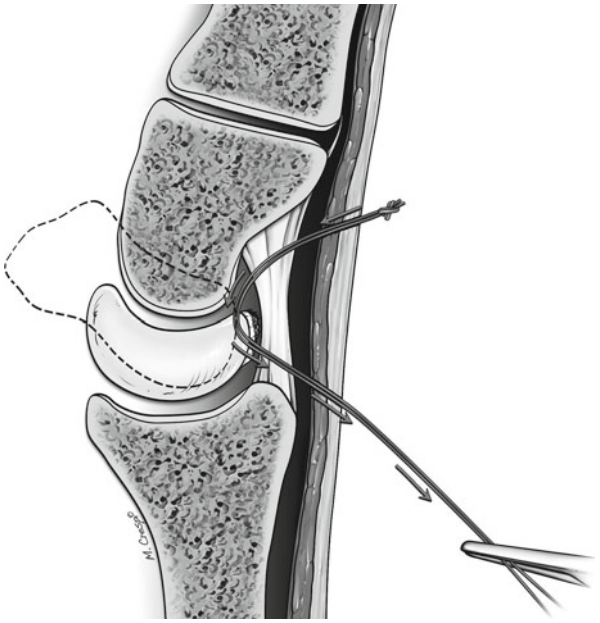

Fig. 7 A knot is done between the two sutures at the external side, at the level of the radial midcarpal portal. Then the thread is removed proximally so that the first knot is placed between the scaphoid and the lunate in intra midcarpal

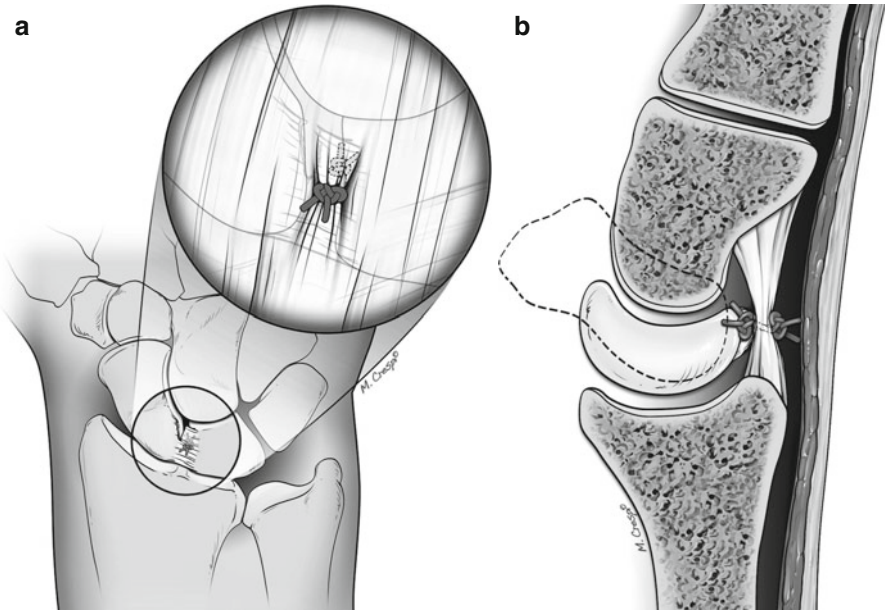

Fig. 8 (**a**, **b**) A suture is done at the radiocarpal so as to create a capsuloplasty between the dorsal capsule and the dorsal section of the scapholunate ligament

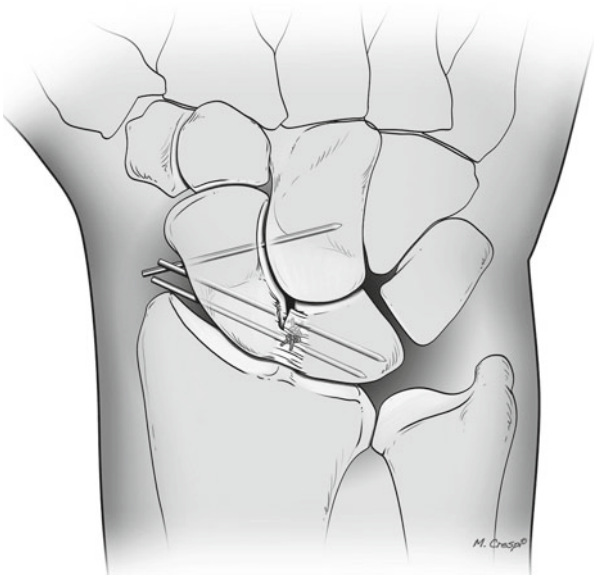

Fig. 9 The reduction of the scapholunate interval is maintained by a crossed scapholunate double pining and sometimes a scapho-capitate K-wire

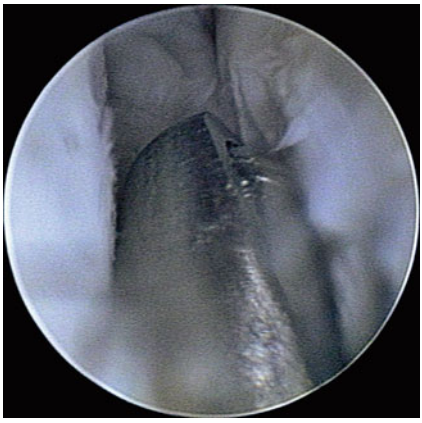

Fig. 10 Case 1: Midcarpal arthroscopic view of a stage four injury showing quite an important gap between the scaphoid and the semilunate with space enough to let a 3-mm shaver being introduced from the radiocarpal to the midcarpal joint

was sometimes difficult (Fig. 17) and scapholunate pinning maintained temporarily this reduction (Fig. 18).

The scapholunate space is then fixed either with staple and K-wires or with a cannulated screw.

The strip from the ECRB was placed from the midcarpal joint to the radiocarpal joint inside the dorsal radio-luno-triquetral ligament (Fig. 19) and then fixed in the neutral position of the wrist in the distal dorsal part of the scaphoid using an intraosseous anchor (Fig. 20). Associated capsulodesis was performed by the introduction of two anchors into the posterior horn of the lunate and the dorsal section of

Fig. 11 Case 1: A 36-year-old man who had a scapholunate dislocation after a sport injury having occurred 5 months earlier. Normal front X-ray view showing an important gap between the scaphoid and the semilunate

Fig. 12 Case 1: Profile view showing a dorsal drift of the semilunate (*DISI*) and a 80° scapholunate angle

the proximal pole of the scaphoid. The aim of this ligamentoplasty is double: first, the ligamentoplasty, by tenodesis, is expected to fight naturally against the horizontalization of the scaphoid and when the wrist flexes (Fig. 21). Moreover, it should establish a narrowing between the luno-triquetral complex and the scaphoid. Its distal fixing on the dorsal side of the scaphoid distal tubercle achieves easier stabilization of the distal pole of the scaphoid (Fig. 22).

Fig. 13 Case 1: X-ray after capsuloplasty with two pins placed with arthroscopic assistance

Fig. 14 Case 1: Profile view showing the good position of the K-wires and the correct reduction of the lunate, with disappearance of the DISI and a normal 45° scapholunate angle

Fig. 15 Case 1: Radial frontal X-ray and ulnar deviation 2 years after the repair, with the recovery of normal anatomy and mobility of the scaphoid

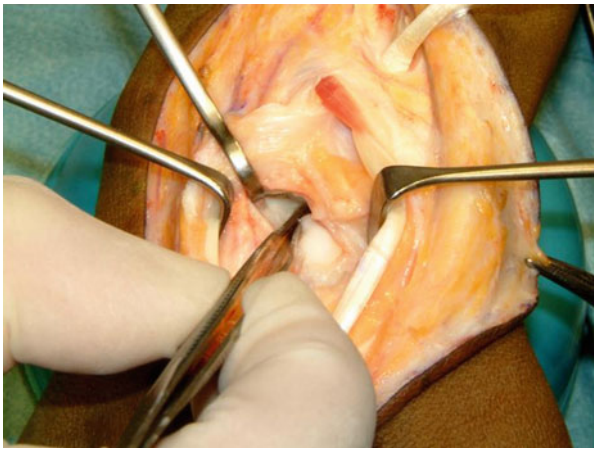

Fig. 16 After arthrotomy, the investigation of the joint shows a rupture of the scapholunate ligament (it is a stage III after arthroscopy)

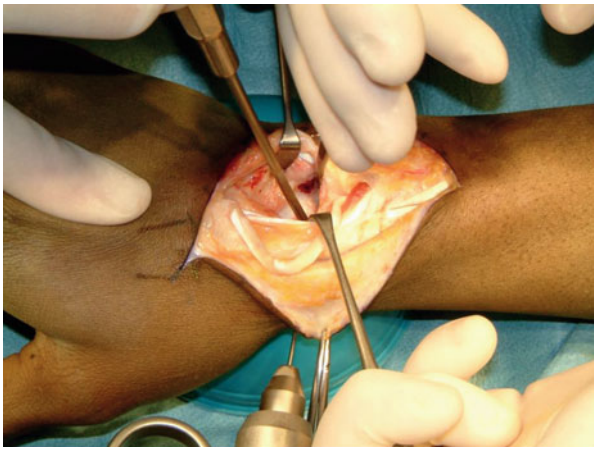

Fig. 17 The reduction of the scaphoid when it is well positioned can be made with a peak bone, the wrist in slight traction, in extension and in ulnar drift. A temporary K-wire maintains the reduction

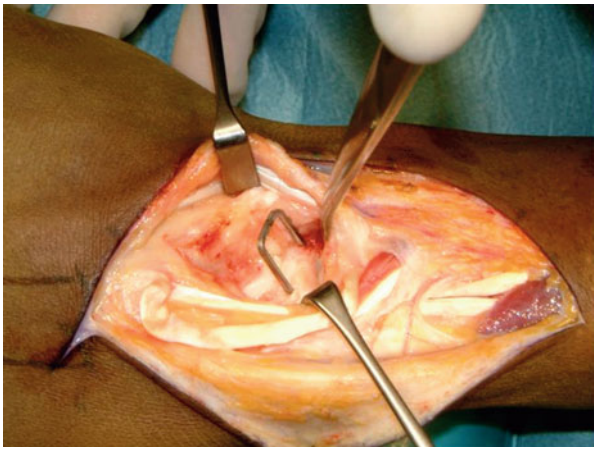

Fig. 18 Dorsal staple is placed over the scapholunate joint and fix the reduction. The oblique position of the staple allows normal mobility in extension

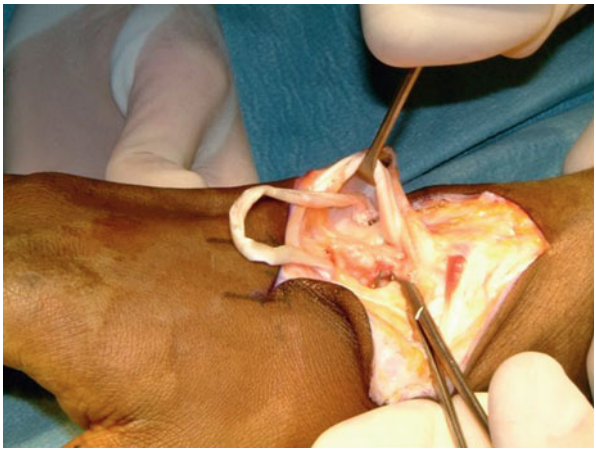

Fig. 19 A strip from the ECRB is distally placed on the 2nd metacarpal and goes from the midcarpal joint to the radiocarpal joint inside the dorsal radio-luno-triquetral ligament

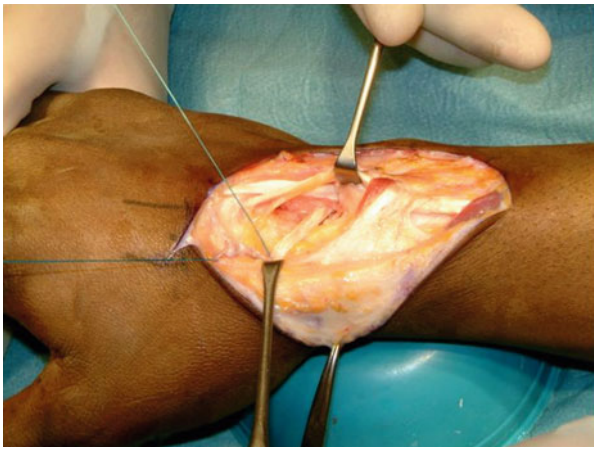

Fig. 20 The ligamentoplasty is fixed in the dorsal section of the distal tubercle by an intraosseous anchor, the wrist in a neutral position

Fig. 21 By tenodesis effect, the ligamentoplasty is going to naturally resist the horizontalization of the scaphoid and when the wrist flexes

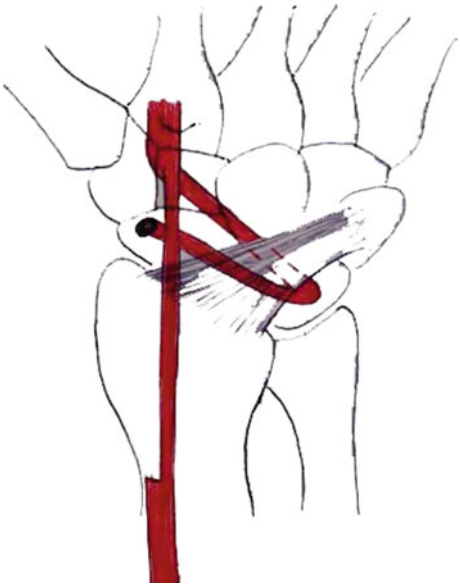

Fig. 22 The ligamentoplasty establishes a narrowing between the luno-triquetral complex and the scaphoid. Its distal fixing on the scaphoid dorsal side of the distal tubercle makes easier the stabilization of the scaphoid distal pole

Fig. 23 Case 2: A 25-year-old tennis player (high level). Eight months after a tennis accident (smash), he had wrist pains and cracks at ulnar deviation. X-ray view shows a horizontalization of the scaphoid and a scapholunate gap

Then, a plastered splint was placed for a 2-month period after which patients could use their wrist normally. The fixing equipment was removed 6 months later.

We operated on 32 patients (23 men and 9 women). The average age was 39 (20–55 years of age).

The average follow-up was 50 months (27–67 months). Twelve patients had no pain, 12 patients had climatic pains only. Four patients had moderate pains and four others had permanent moderate pains. No patient experienced invalidating pain. Mobility in extension was about 70° and 42° in flexion, the moderate but real loss of flexion was the price to pay for this type of stabilization. Strength was about 86 % compared to the opposite side (Figs. 23, 24, 25, 26, 27, 28, and 29).

The complications that occurred were four complete losses of flexion, two Südeck's dystrophy which were treated and healed, and a staple which was expelled and necessitated the modification of our system of scapholunate fixing to systematically choose a cannulated screw.

6 Discussion

The analysis of the state of the scapholunate ligament with the help of wrist arthroscopy and the analysis of the peripheral structures allow, as Marc Garcia-Elias pointed out, to refine the classifications of chronic scapholunate injuries.

The use of mere immobilization by pinning in acute injuries of the scapholunate ligament resulted in satisfactory outcome.

Fig. 24 Case 2: The arthro CT-scan confirms a rupture of the scapholunate ligament. The associated arthroscopy showed a stage IV

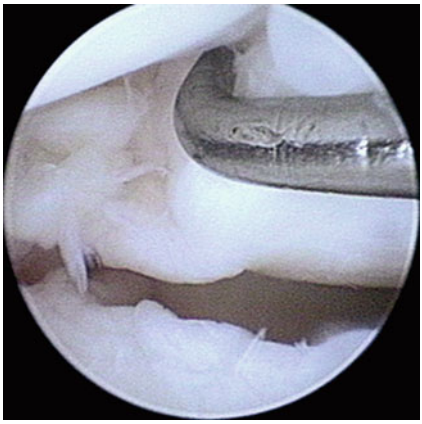

Fig. 25 Case 2: Radiocarpal arthroscopic view of a stage IV injury showing a more important gap with space enough to let a hook being introduced between the scaphoid and the lunate from the radiocarpal to the midcarpal joint

The repair of the intermediate part of the scapholunate ligament is illusory as it is a fibrocartilaginous tissue which structure is close to that of the free section of a meniscus or the central section of the triangular ligament. The correction of the rotary instability of the scaphoid must then be associated with a scapholunate arthrofibrosis and the stabilization of the distal pole of the scaphoid. Therefore, surgical techniques aimed at reconstructing the capsulo-ligamentous system should be preferred as they respect the anatomic characteristics of the physiological stabilization means. The

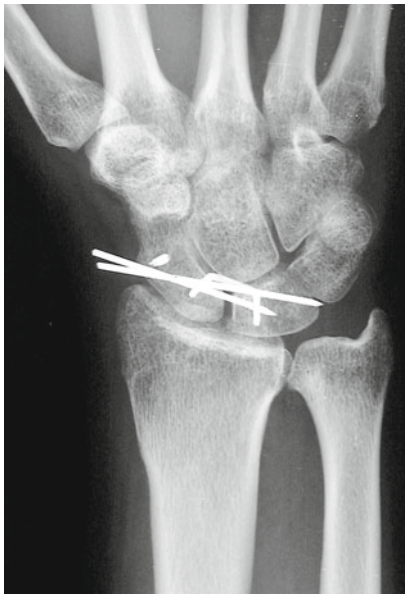

Fig. 26 Case 2: Radiography 6 months after the surgery and before the removal of the staple. We can notice a correct reduction of the scapholunate interval

Fig. 27 Case 2: Profile radiography 6 months after the surgery showing a normal scapholunate angle

repair of the dorsal and volar systems of the scapholunate ligament but also the distal volar scapho-trapezial section looks logical. Brunelli suggested a technique with similar ambition, but it was often responsible for a post-operative stiffness that jeopardized the functional result [12]. The three-ligament tenodesis suggested by Garcia-Elias

Fig. 28 Case 2: Full front radiography in radial drift 3 years after the surgery. It shows normal mobility with normal osseous connections

Fig. 29 Case 2: Same observation in ulnar deviation. The patient returned to all his sports activities without discomfort and at the same level

improves this problem, but it remains quite stiffening in extension [3]. Moreover, capsuloplasties fixed on the radius, as mentioned by Blatt, are also stiffening [13].

Posterior arthroscopic capsulodesis prevents these complications at stages which keep normal carpal architecture. At more advanced stages, reconstruction of a capsulo-ligamentous system of the mere dorsal intercarpal complex seems to limit the effects of stiffening. The results of the ligamentoplasty using ECRB associated with temporary fixing of the scapholunate interval result in good long-term stabilization as they maintain correct mobility despite a moderate loss of flexion.

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