Technical Note

Arthroscopic Scapholunate Synthetic Ligamentoplasty

Michael Bouyer, M.D., Thibault Lafosse, M.D., and Antonin Bentejac, M.D.

Abstract: The scapholunate ligament is made of 3 portions: proximal, volar, and dorsal. The latter is the major stabilizer of the scapholunar pair, and its lesion is bound to cause a destabilization of the carpus, as well as scapholunar diastasis, dorsal intercalated segment instability, then eventually SLAC (i.e., scapholunate advanced collapse) wrist. The healing process of this ligament, either spontaneous or after primary repair with direct suture, is rarely observed and a significant number of patients are diagnosed only at a late stage, thus making an illusion of a maintained stability of the carpus first range. Management then consists of ligamentoplasty. Several open techniques are described to restore stability, but at the cost of a frequent and significant tightening of the wrist. We will introduce here an arthroscopic ligamentoplasty technique completed by a posterior capsulodesis.

The scapholunar ligament (SLL) tear is the wrists' most frequent intrinsic ligament lesion. Its clinical presentation is rarely specific during the acute phase, and a lack of awareness of the pathology both by the wider public and the medical sphere often leads to a late diagnosis.[1] There is a general consensus that SLL tears after 3 months make primary healing[2] through degeneration of ligament stumps impossible and require one to perform a ligamentoplasty. Many open techniques have been described to restore the stability of the scapholunar pair, but they generate a constant[3] tightening of the wrist caused by the extrinsic capsular contraction caused by capsulotomy.[4,5] These open procedures impose an approach that may damage the secondary stabilizers of the scapholunar pair, especially the dorsal capsuloligamentous scapholunate septum (DCSS), which would play the role of a secondary stabilizer of the scapholunar pair.[6] They also disturb wrist proprioception,[7] as they cause trauma to the posterior interosseous nerve. There are arthroscopic techniques of direct suture with reconstruction of the DCSS that cannot be used in the event of chronic tears.[8] Some offer mixed arthroscopic techniques with a minimally invasive approach by placing the transplant in an extracapsular position, which does not reflect the anatomy. These procedures consist in building transosseous tunnels but at the risk of secondary osteonecrosis.[9] A ligamentoplasty technique partially uses arthroscopy but requires dorsal capsulotomy and uses transosseous tunnels and does not recreate the DCSS.[10] Another technique also uses transosseous tunnels and multiplies the approaches, dorsal, and palmar routes, still without reconstructing the DCSS.[11,12] A similar technique to ours also has been described on cadavers, but its authors reserve it for partial and recent ruptures as an aid in the healing of the native scapholunate ligament and not as a ligamentoplasty; again, the DCSS is not recreated.[13] Finally, current arthroscopic procedures of posterior capsulodesis only replicate posterior capsular joining if we consider the scapholunar interline (DCSS), which would play a role of accessory stabilizer of the scapholunar pair without offering proper repair of the SLL itself. Here, we introduce an arthroscopic technique of synthetic scapholunar ligamentoplasty completed by capsulodesis.

Indications

The patients targeted by this arthroscopic technique suffer from an acute or chronic lesion (>3 months) of

From the Hand, Upper Limb, Brachial Plexus, and Microsurgery Unit (PBMA), Clinique Générale d'Annecy, Annecy, France.

The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received March 9, 2021; accepted May 26, 2021.

Address correspondence to Antonin Bentejac, M.D., 33 chemin des Ratz, 38330, Saint Nazaire les Eymes, France. E-mail: antonin.bentejac7@orange.fr

2212-6287/21368

https://doi.org/10.1016/j.eats.2021.05.022

Table 1. Modified Classification of Garcia–Elias[14] and Indication of Arthroscopic Ligamentoplasty

Stage (Garcia–Elias)[14]	Degree of the Lesion	Radiography	Instability	Indication for Arthroscopic Ligamentoplasty
1	Partial SL lesion (Geissler 1, 2, 3,[8] EWAS I-IIIB[15])	Normal	Predynamic	Yes
2 / 3	Complete SL lesion (Geissler 4, EWAS III C-IV)	Abnormal dynamic radiography; diastasis of the SL/DISI	Dynamic	Yes
4	Complete SL lesion + lesions of secondary stabilizers (EWAS V)	Diastasis of the SL/DISI	Static reducible	No open ligamentoplasty
5	Complete SL lesion + lesions of secondary stabilizers + fibrosis (EWAS V)	Diastasis of the SL/DISI	Static	No
6	Secondary arthrosis	SLAC	Static	No

DISI, dorsal intercalated segment instability; EWAS, European Wrist Arthroscopy Society; SL, scapholunar ligament; SLAC, scapholunate advanced collapse.

Table 2. Tips and Tricks

Place the image intensifier perpendicular to the wrist
Perform "dry arthroscopy" as long as possible
Protect extensor tendons with a clamp during the insertion of the pins
Respect a gap of 2 mm between the pin's insertion point and scapholunar and midcarpal interlines
Use a bit with laser marking not to drill beyond 10 mm
Protect extensor tendons with a clamp during the drilling
Test the passive flexing of the fingers after dorsal capsulodesis to ensure not to bind an extensor tendon

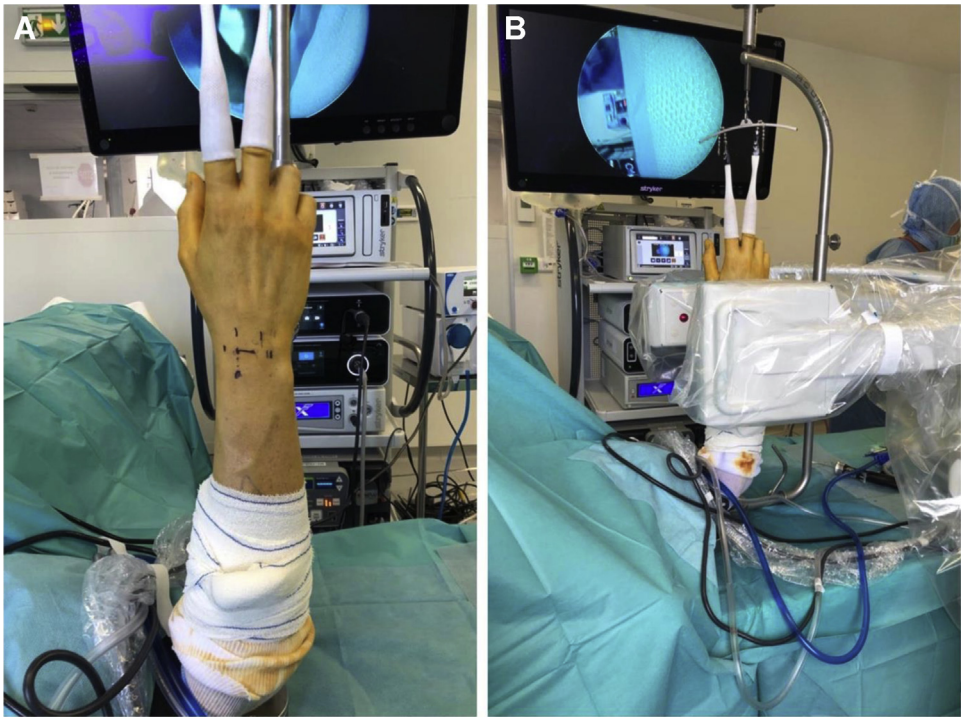

Fig 1. Patient and image sensor installation (right wrist, wrist on arthroscopic tower). (A) Patient installation: dorsal decubitus position, upper limb in pronation on an arm table held by an arthroscopic tower. (B) Imaging sensor installation: placed perpendicular to the wrist.

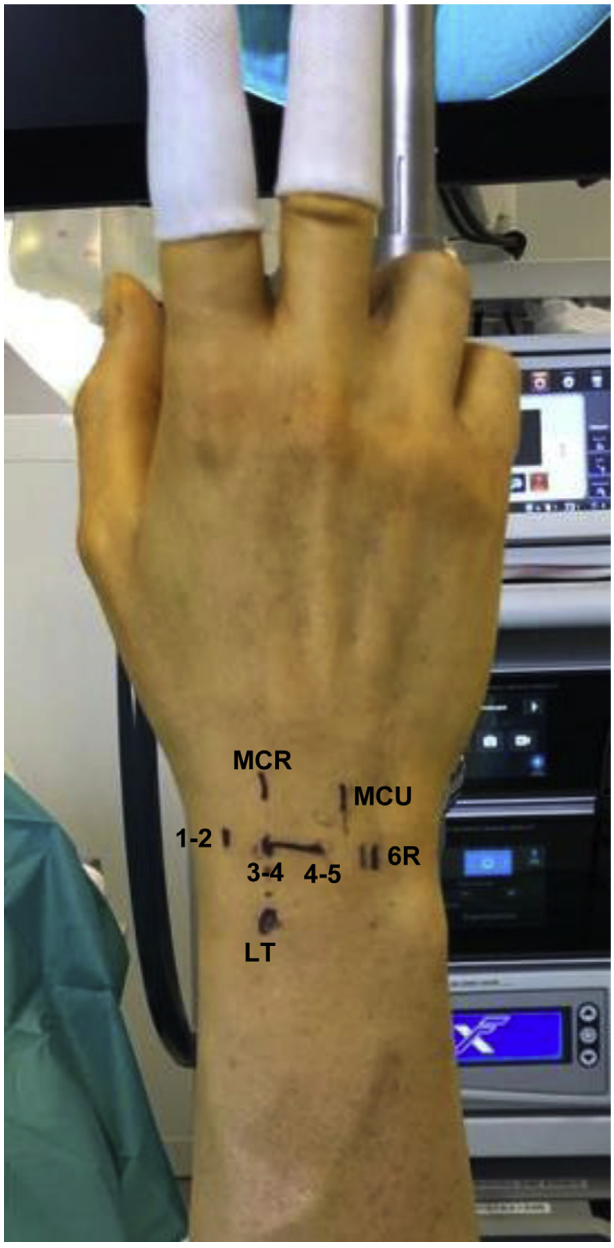

Fig 2. Arthroscopic approach pathways (right wrist, wrist on arthroscopic tower). (LT, lister tubercle; MCR, mediocarpal radial; MCU, mediocarpal ulnar.)

the SLL and a predynamic or dynamic instability or stage 1, 2 and 3 according to the Garcia–Elias classification.[14] Patients with SLAC 1 (scapholunate advanced collapse) little evolved arthrosis without DISI (dorsal intercalated segment instability) are also targeted for this procedure, and they can benefit from radial arthroscopic styloidectomy during the same surgery time as a ligamentoplasty. Reducible static scapholunar stage 4 instabilities according to the Garcia–Elias classification[14] remain indications for open ligamentoplasty, thus guaranteeing a better control of the reduction of the scapholunar interline and of DISI. In case of nonreducible static instability or SLAC 2, 3, and 4 spread arthrosis (stage 5 and 6 of Garcia–Elias classification[14]), arthroscopic or open ligamentoplasty is not indicated (Table 1).[8,14,15]

Surgical Technique (With Video Illustration)

The patient adopts a dorsal decubitus position, with the upper limb in pronation on an arm table and a pneumatic tourniquet at the basis of the limb. Placing it on an arthroscopic Arc Wrist Tower (Acumed, Hillsboro, OR) enables to obtain 10 kg of traction. We use a 2.5-mm arthroscope (Arthrex, Naples, FL), a shaver of 2.9 mm (CONMED, Largo, FL), an arthropump (CONMED), and an electrocoagulation probe MICROBLATOR 30 (Smith & Nephew, Tuttlingen, Germany). The image intensifier is positioned perpendicular to the wrist, enabling to obtain face and profile scans without affecting the position of the wrist (Table 2; Fig 1).

The ligamentoplasty is made with a synthetic band of ultra-high-molecular-weight polyethylene SutureTape 1.3 mm (Arthrex) with an intraosseous fixation with 2 SwiveLock DX 3.5 anchors (Arthrex). Arthroscopic pathways 1-2, 3-4, 4-5, 6R, midcarpal ulnar, and midcarpal radial are used (Fig 2).

Arthroscopy Diagnosis and Articular Debridement

The first phase of the surgery is the ligamentocartilaginous checkup with a dry arthroscopy. The arthroscope is inserted through 1-2 pathway and the sensor through 6R. Dynamic testing of the scapholunar ligament confirms the lesions. The lunotriquetral, palmar radio-carpal ligaments, DCSS, and TFCC also are assessed. The cartilaginous state also is checked and confirms there is no SLAC wrist. The exploration goes further with the mediocarpal one with the arthroscope used in midcarpal radial and the sensor in the mediocarpal ulnar. It thus confirms the instability and that there is no SLAC wrist (Fig 3). Lesions are thus classified,[6,7] and the indication of arthroscopic ligamentoplasty is confirmed. A debridement of inflammatory synovial tissues regarding SLL and DCSS is performed with the shaver without damaging the posterior capsule through the radiocarpal pathway. SLL stumps are unleashed (Fig 4). This debridement is performed as long as possible without irrigation to avoid an infiltration of the posterior tissues (articular capsule, extensor tendon) (Table 2) then completed with the electrocoagulation probe with irrigation.

Ligamentoplasty: Bone Tunnels, Anchors Setting, and Suture Tape

Two Kirschner pins are inserted under arthroscopic control, with the arthroscope through 1-2 or 6R pathway, in the proximal pole of the scaphoid

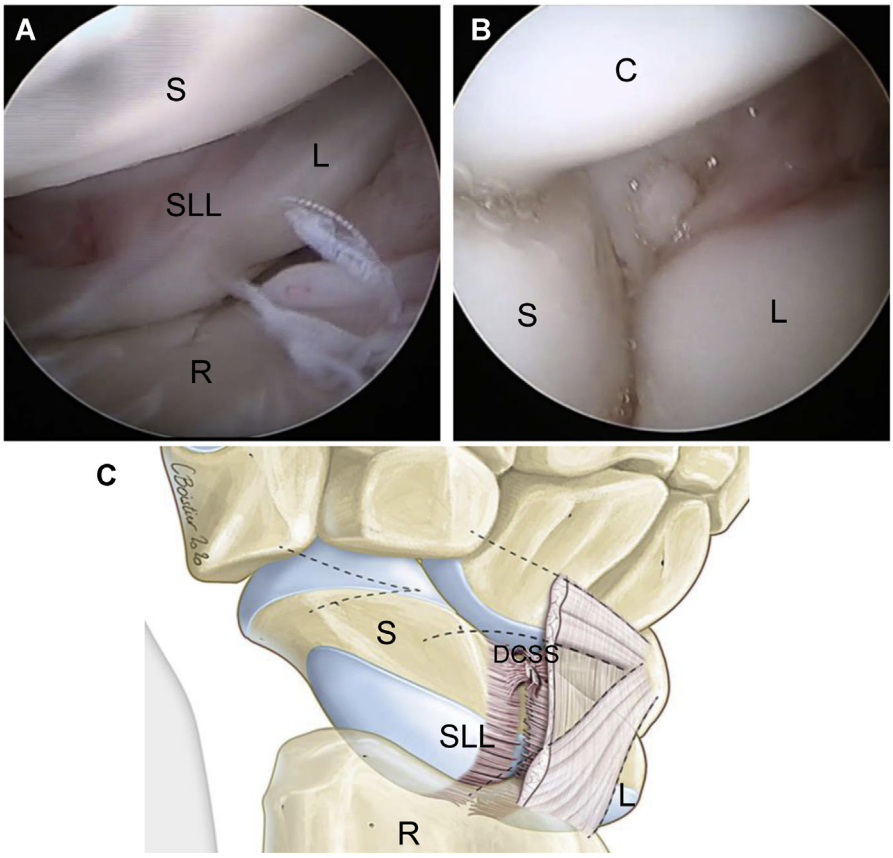

Fig 3. Ligament and articular checkup (right wrist, wrist on arthroscopic tower). (A) Assessment of the lesion of the SLL. Arthroscope in the radiocarpal interline through 1-2 pathway with a view on the scaphoid and lunate interline. (B) Arthroscope in the midcarpal interline through MCR pathway, LSL ligament, and cartilage of the head of the capitatum check-up. (C) Schema of the lesion of the scapholunar ligament and of DCSS. Right wrist. (C, capitate; DCSS, dorsal capsuloligamentous scapholunate septum; L, lunate; SLL, scapholunar ligament; MCR, mediocarpal radial; R, radius; S, scaphoid.)

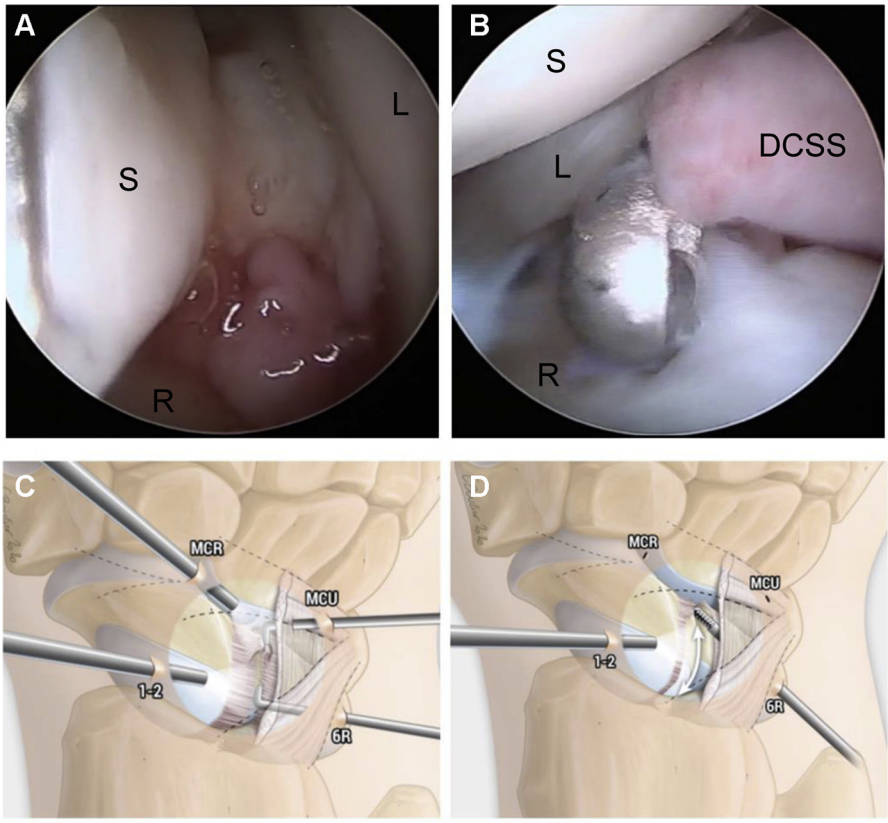

Fig 4. Ligament testing and debridement (right wrist, wrist on arthroscopic tower). (A) Ligament checkup: the arthroscope through MCR pathway moves from the midcarpal space to the radiocarpal one through the scapholunar interline: Geissler 4 stage. (B) Debridement of synovial inflammation and scar tissue in the radiocarpal interline, arthroscope through 1-2 pathway, shaver through 6R pathway. (C) Schema of ligament testing through radio-carpal (arthroscope through 1-2 pathway, sensor through 6R pathway), and midcarpal (arthroscope through MCR pathway, sensor through MCU pathway) interlines. (D) Schema of debridement of scapholunar residual ligament, arthroscope through 1-2 pathway, shaver through 6R pathway. Right wrist. (DCSS, dorsal capsuloligamentous scapholunate septum; L, lunate; MCR, mediocarpal radial; MCU, mediocarpal ulnar; R, radius; S, scaphoid.)

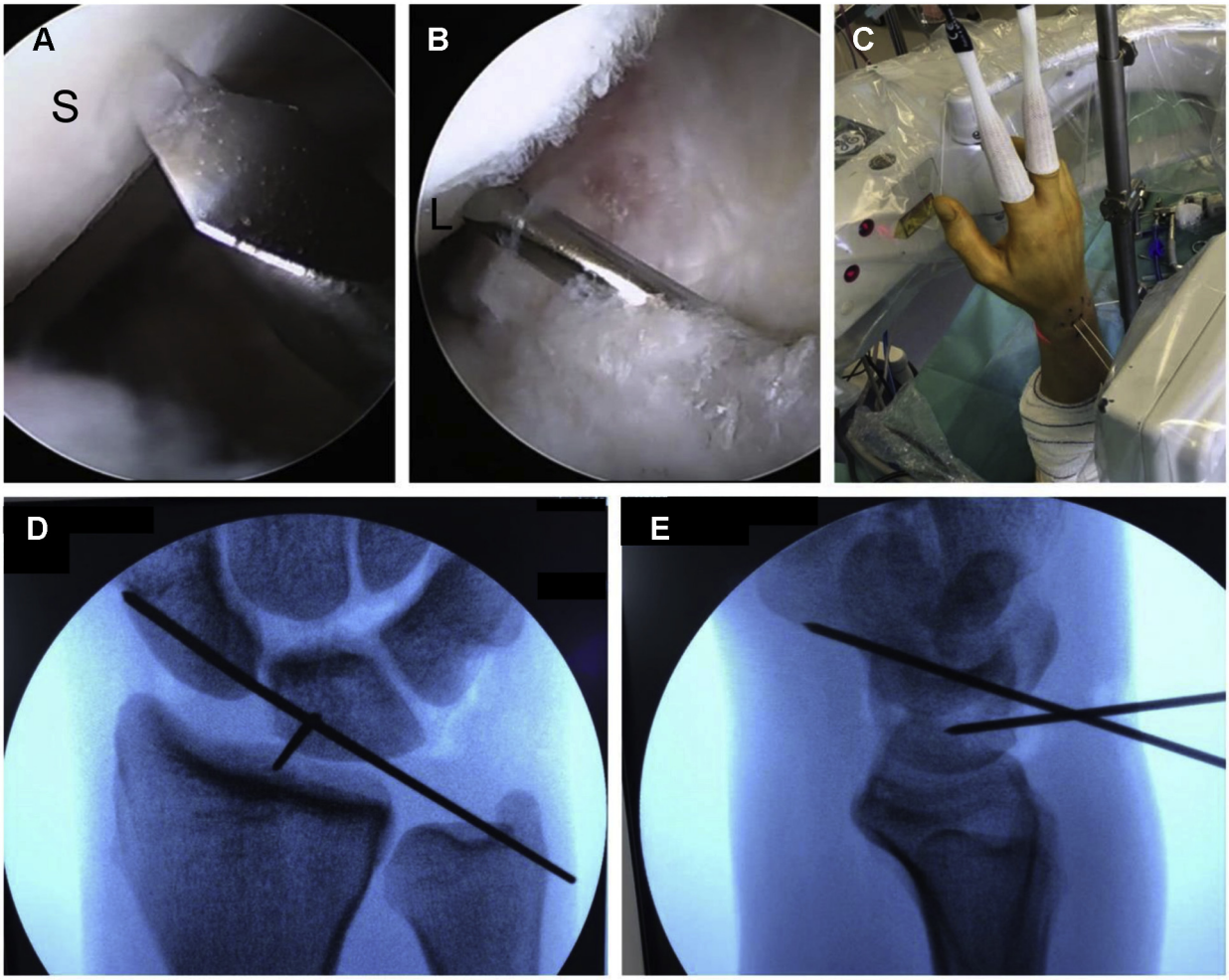

Fig 5. Setting the guide pins and fluoroscopic control (right wrist, wrist on arthroscopic tower). (A) Arthroscope in the radiocarpal interline through 1-2 pathway, a first pin is inserted through 3-4 pathway in the scaphoid proximal pole. (B) Arthroscope in the radiocarpal interligne through 1-2 pathway, a second pin is inserted through 3-4 pathway in the posterior cornea of the lunate. (C) Presurgery view of the installation for fluoroscopic control. (D) Frontal fluoroscopic control. (E) Profile fluoroscopic control. (L, lunate; S, scaphoid.)

through 3-4 pathway and in the posterior cornea of the lunate through 4-5 pathway respectively, while preserving articular surfaces responding to the scaphoid and lunar radial fossa in the most distal position. The pins are inserted between the spread claws of a clamp not to damage extensor tendons (Table 2). A fluoroscopic check-up confirms the good conditioning of the pins close to the midcarpal interline and their orientation. A gap of at least 2 mm between the position of the pins and the scapholunar and midcarpal interline has to be respected to avoid contact in these interlines during the drilling (Table 2; Fig 5). One-eyed bone tunnels of 10 mm of depth are performed under arthroscopic control through 3-4 pathway for the scaphoid then 4-5 for the lunate, arthroscope set in 6R or 1-2 depending on the best view angle, with a cannulated drill of 3mm of diameter and a thread limited to 10 mm of height. The drilling is done through the spread claws of a clamp not to damage extensor tendons (Table 2; Fig 6). The pins are then removed. The next step is to fix the SutureTape band to the tunnel of the proximal pole of the scaphoid through a 3-4 pathway, with the arthroscope set on 6R or 1-2, with a SwiveLock DX 3.5 anchor.

One of the 2 strips of the band thus created is fixed to the proximal pole of the scaphoid then left to stand through the 3-4 pathway and the other is used in

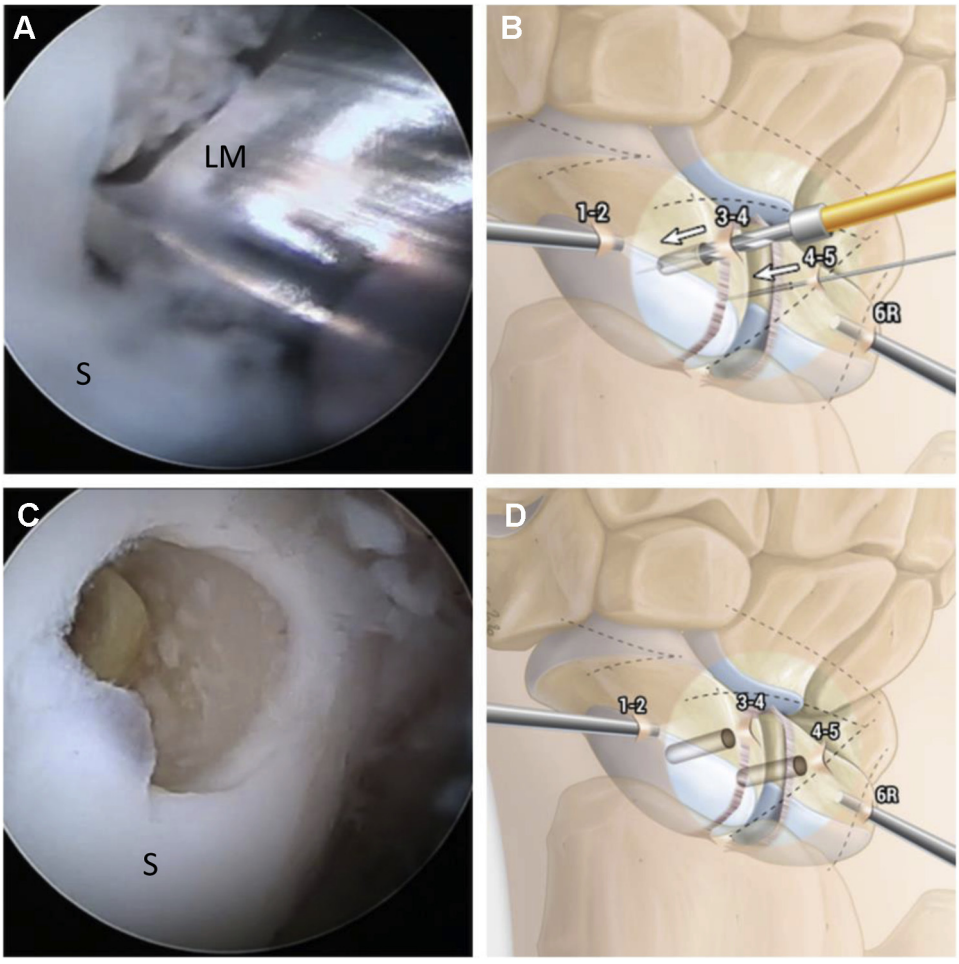

Fig 6. Drilling of one-eyed tunnels (right wrist, wrist on arthroscopic tower). (A) Drilling of the one-eyed bone tunnel in the proximal pole of the scaphoid up to laser marking (10 mm), arthroscope in the radiocarpal interline through 1-2 pathway, drill through 3-4 pathway. (B) Schema of the drilling in the proximal pole of the scaphoid, guide pin represented in the lunate. (C1) Arthroscopic view of the one-eyed tunnel in the proximal pole of the scaphoid, arthroscope in the radiocarpal interline through 1-2 pathway. (D) Schema of the 2 one-eyed tunnels: proximal pole of the scaphoid and posterior cornea of the lunate. (L, lunate; LM, laser marking; S, scaphoid.)

intra-articular mode and extracted through 4-5 pathway. The latter is fixed with a maximal tension in the tunnel of the posterior cornea of the lunate with a second SwiveLock DX 3.5 anchor through 4-5 pathway, with the arthroscope on 1-2 or 6R and its free strip is left aside through the 4-5 pathway (Fig 7). Scapholunar stability is then tested through radio-carpal then mid-carpal pathways.

A test with the sensor then ensures it is now impossible to open the scapholunar interline. A fluoroscopic check is performed with front and profile scans to make sure there is no diastasis and DISI (Fig 8).

Dorsal Capsulodesis

A centimetric skin incision to the dorsal side of the wrist is performed between the cutaneous orifices of the 3-4 and 4-5 pathways, through the extensor retinaculum. Tendons of extensors in the fourth chamber are reclined on the ulnar side of the incision. The free scaphoid strip of SutureTape is bound with the free lunar strip to apply the posterior capsule and the proximal portion of the scapho-triqueral extrinsic dorsal ligament on the ligamentoplasty in depth. This capsulodesis recreates the joining of DCSS (Fig 9). It is necessary to ensure that extensor tendons are not bound during this step (Table 2). The incisions are sealed with spate stitches of nonresorbable wire sutures, and a radiocarpal infiltration of cortisone is performed.

Postoperative Instructions

The wrist is strictly immobilized 24/7 in a rigid splint in a neutral position for 4 weeks. The patient is prescribed postoperative physiotherapy straight away to move his or her fingers without strength or resistance and to drain the edema. The mobilization of the wrist is started 4 weeks after the surgery. The splint is kept in place overnight for an additional fortnight. The mobilization of the wrist in case of resistance and muscular reinforcement are worked out progressively

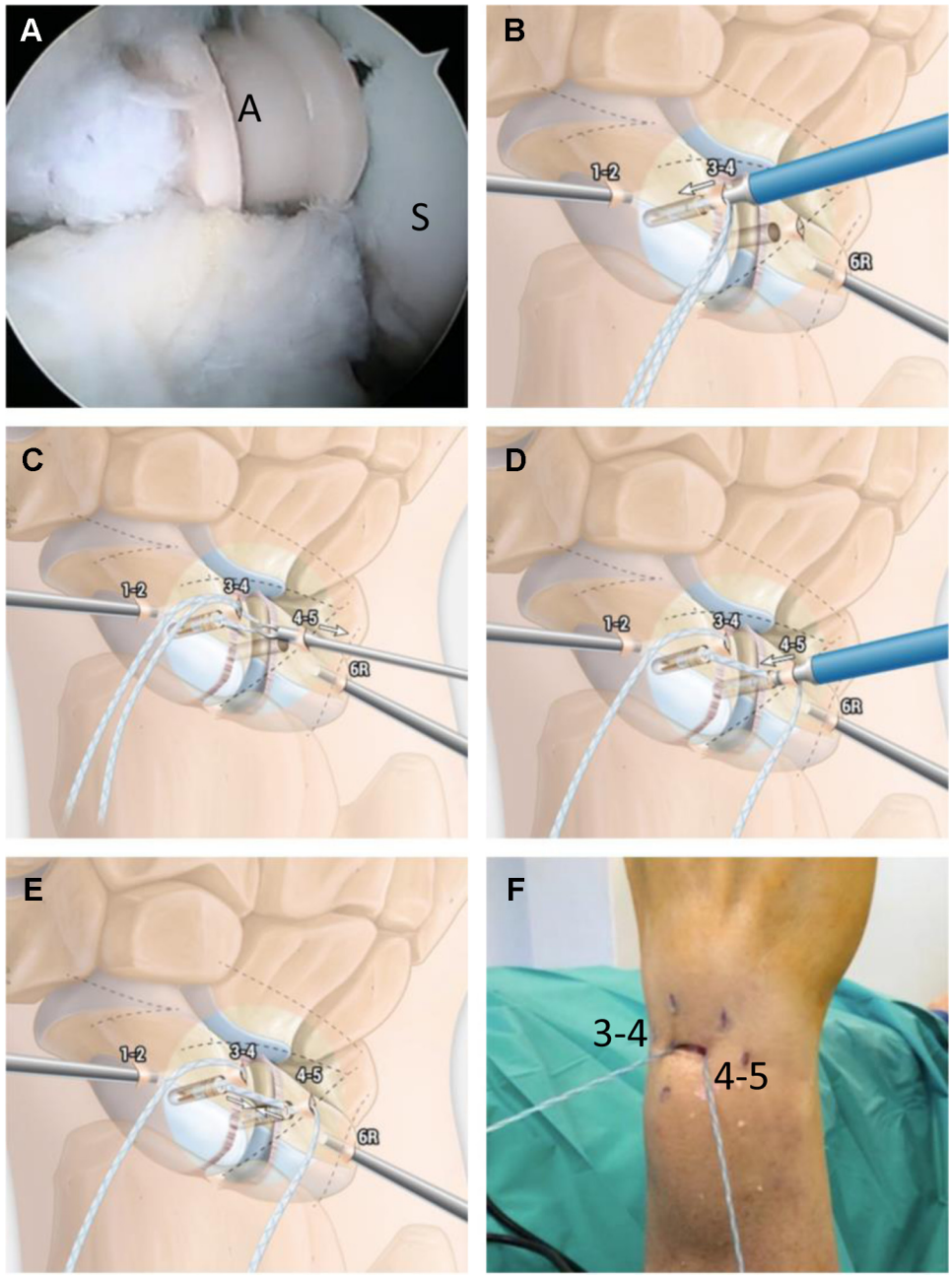

Fig 7. SutureTape fixation with anchors (right wrist, wrist on arthroscopic tower). (A) SutureTape fixation in the proximal pole of the scaphoid with a SwiveLock DX 3,5 anchor (Arthrex) through the 3-4 pathway, arthroscope in the radiocarpal interline through 6R pathway. (B) Schema of the SutureTape fixation in the proximal pole of the scaphoid through 3-4 pathway, arthroscope in the radiocarpal interline in 1-2 pathway or 6R pathway depending of the best view angle. (C) Schema of one strip pick up of the SutureTape from 3-4 pathway then exited through 4-5 pathway, arthroscope in the radiocarpal interline in 1-2 pathway or 6R pathway depending of the best view angle. (D) Schema of the fixation of the SutureTape second strip in the lunate through 4-5 pathway with a maximal tension, arthroscope in the radiocarpal interline in 1-2 pathway or 6R pathway depending of the best view angle. (E) Schema after the 2 strips' fixation: one strip fixed in the proximal pole of the scaphoid exited through the 3-4 pathway, one strip fixed in the posterior cornea of the lunate exited through the 4-5 pathway. (F) Peroperative view after the fixation of the 2 strips. (A, anchor; S, scaphoid.)

45 days postsurgery. Resuming sport activities involving the upper limb is considered between 3- and 6-months' postsurgery depending on wrist flexibility and pain.

Discussion

SLL stabilizes the scapholunar pair through its dorsal portion, prevents intra-carpal instabilities and maintains good kinetics in the first range of carpus bones.[16] Scapholunar instability is characterized by pain and a loss of grip strength but is often paucisymptomatic before the occurrence of middle term arthrosis. Therapeutic solutions for SLAC for these patients who are often young, active or sporty are only palliative and are often a compromise on grip strength and wrist mobility. It is thus essential to diagnose scapholunar lesions at an early stage to catch up with potential diagnosis wandering to restore the stability of the first range of the carpus as soon

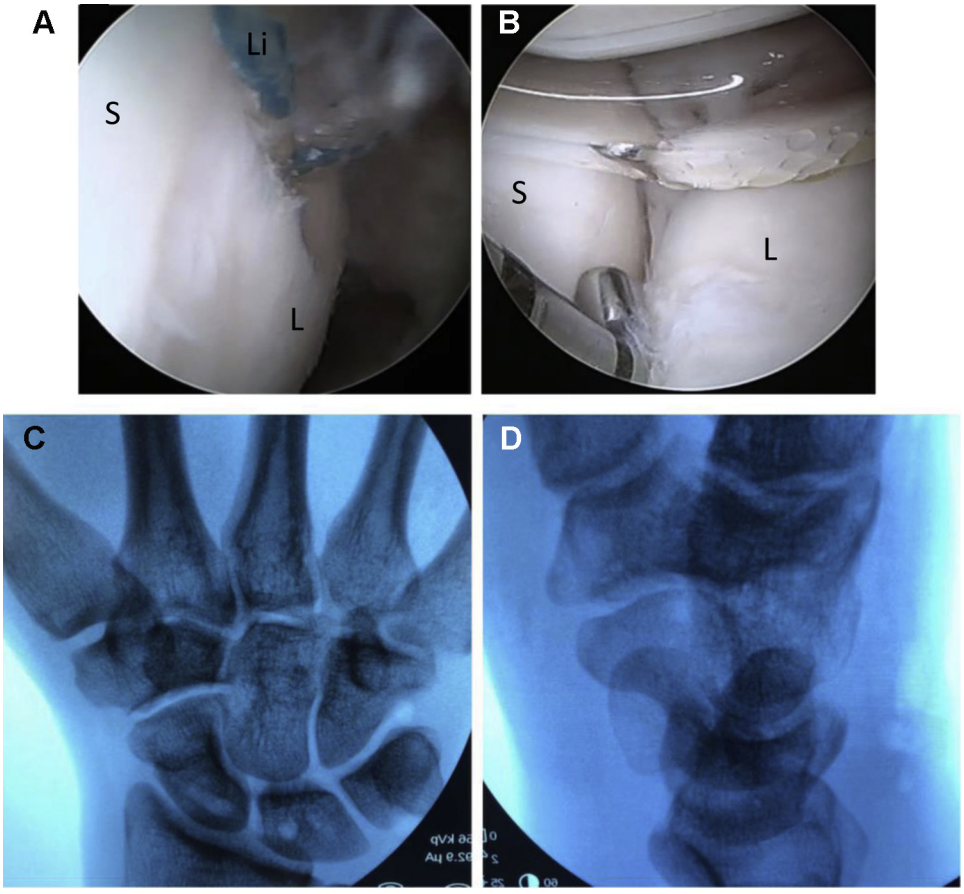

Fig 8. Ligamentoplasty testing and fluoroscopic checkup (right wrist, wrist on arthroscopic tower). (A) Visual checkup and ligamentoplasty testing, fixed in maximal tension between the scaphoid and the lunate, arthroscope in the radiocarpal interline through 1-2 pathway, sensor through 6R pathway. (B) Peroperative testing of the ligamentoplasty in the midcarpal interline: sensor can no longer be passed in the scapholunate space, arthroscope through MCU pathway, sensor through MCR pathway. (C) Frontal fluoroscopic control. (D) Profile fluoroscopic control. (MCR, mediocarpal radial; MCU, mediocarpal ulnar; L, lunate; Li, ligamentoplasty; S, scaphoid.)

as possible and to avoid the occurrence of arthrosis. Arthroscopic scapholunar ligamentoplasty is an effective solution and it is not highly invasive. This technique is free from the consequences of capsulotomy, i.e., a certain tightening and a modification of the intra-carpal proprioceptive sensitivity by trauma of the posterior interosseous nerve, which can explain a long and hazardous rehabilitation. The morbidity caused by an arthroscopic gesture on the ligament is also supposed to be inferior and to save articular ranges (Table 3). This procedure enables us to expect little postoperative pain, a faster rehabilitation, and an earlier possibility to resume professional, sporty and daily activities as well as better treatment compliance from the patient. A clinical trial is currently underway to confirm these hypotheses.

However, arthroscopic ligamentoplasty is a demanding and more difficult technique than "open" surgeries with more peroperative traps (Table 4). This results in an elongation of the operative time and time of ischemia due to the tourniquet (Table 3).

Resorting to arthroscopy also enables one to limit bone devascularization and could limit the risk of osteonecrosis. We choose to use a synthetic strip to avoid ligament loosening in case of autograft, but this has for counterpart the absence of "ligamentization" of the synthetic ligament whose lifespan remains in question (Table 3). The combination with posterior capsulodesis reinforces the repair and contributes to the reconstruction of DCSS, potentially improving the obtained stability.[17] In contrast, we have observed that the knot made with the 2 strips of SutureTape is bulky and creates relief under the skin, which can cause discomfort in forced extension of the wrist. To overcome this, we have planned to add a PDS suture to the SutureTape during the SL ligamentoplasty, then to cut the 2 strips of SutureTape intra-articularly and to perform the capsulodesis by binding the 2 strands of PDS taken out through 3-4 and 4-5 pathways as we described previously (Table 3).

If we consider the very strong bone fixation of the strip, we would also consider using this procedure for reducible static scapholunar instabilities with reductions of scapholunar diastasis and of DISI with arthroscopy. A technical modification is currently studied and would

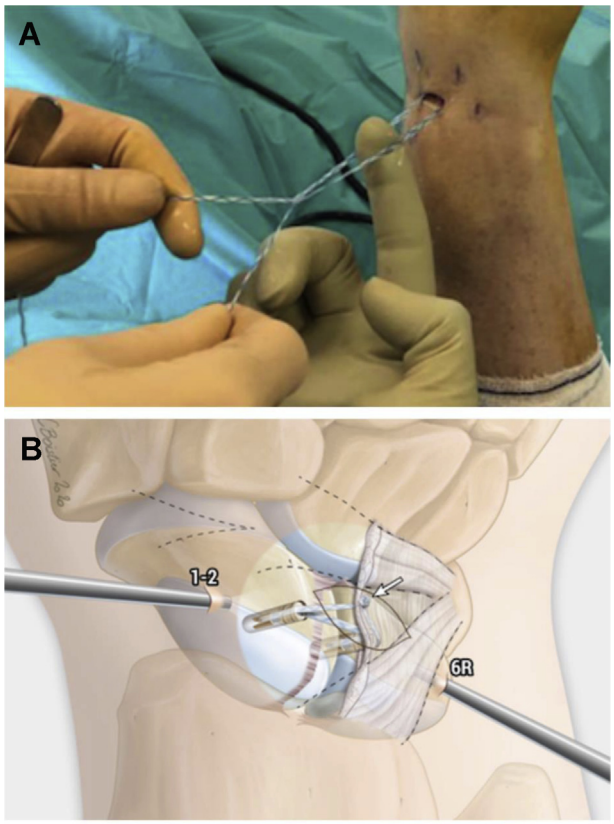

Fig 9. Dorsal capsulodesis (right wrist, wrist on arthroscopic tower). (A) Peroperative view of the dorsal capsulodesis: the 3-4 and 4-5 cutaneous paths are united, the 2 strips of the SutureTape are tied over the dorsal capsule, under the extensor retinaculum and extensor tendons. (B) Schema of the dorsal capsulodesis: the arrow indicates the knot between the 2 strips of the SutureTape, placed extra capsularly, subcutaneously, under the extensor retinaculum and extensor tendons, adjoining the dorsal capsule on the in-depth ligamentoplasty.

consist in using 2 strips to create tenodesis of the lunate posterior cornea with the base of the scaphoid which would protect from the shift to DISI in a way similar to the one of open techniques.

Table 3. Advantages and Disadvantages

Advantages	Disadvantages
Minimally invasive	Lengthening of operative time
Limitation of stiffness	Technically difficult (learning curve)
Preservation of proprioceptive sensitivity	No "ligamentization" of the synthetic ligament
Limitation of bone devascularization	Bulky and nonabsorbable capsulodesis node
Faster recovery	
Faster return to professional and sports activities	
No loosening of the ligamentoplasty	

Table 4. Peroperative Traps and Consequences

Traps	Consequences
Prolonged and forced use of irrigation	Edema of the soft tissues: poor visibility
Too aggressive debridement of the posterior capsule	Lesion of the posterior capsule then failure of the capsulodesis
Implementation of the pin/wick through the arthroscopic pathways with insufficient exposure between the claws of the clamp	Winding of soft tissues around the pin or wick: poor visibility
Positioning of the pins too close to the corticals of the scaphoid or lunate	Cortical collapse during drilling: ligamentoplasty failed
Drilling above 10 mm	Transosseous tunnels: secondary osteonecrosis
	No holding of the anchors: ligamentoplasty failed
Insufficient tension of the SutureTape when fixing it in the lunate	Persistence of instability: ligamentoplasty failed
Bad reclining of the extensor tendons during the posterior capsulodesis	Bounding of an extensor tendon in the knot: loss of finger mobility

References

1. O'Brien L, Robinson L, Lim E, O'Sullivan H, Kavnoudias H. Cumulative incidence of carpal instability 12-24 months after fall onto outstretched hand. *J Hand Ther* 2018;31:282-286.
2. Manuel J, Moran SL. The diagnosis and treatment of scapholunate instability. *Orthop Clin North Am* 2007;38:261-277.
3. Daly LT, Daly MC, Mohamadi A, Chen N. Chronic scapholunate interosseous ligament disruption: a systematic review and meta-analysis of surgical treatments. *Hand* 2020;15:27-34.
4. Athlani L, Pauchard N, Detammaecker R, et al. Treatment of chronic scapholunate dissociation with tenodesis: A systematic review. *Hand Surg Rehabil* 2018;37:65-76.
5. Michelotti BF, Adkinson JM, Chung KC. Chronic scapholunate ligament injury. *Hand Clin* 2015;31:437-449.
6. Tommasini Carrara de Sambuy M, Burgess T, Cambon-Binder A, Mathoulin C. The anatomy of the dorsal capsulo-scapholunate septum: A cadaveric study. *J Wrist Surg* 2017;6:244-247.
7. Hagert E, Lluch A, Rein S. The role of proprioception and neuromuscular stability in carpal instabilities. *J Hand Surg Eur* 2016;41:94-101.
8. Carratalá V, Lucas FJ, Miranda I, Sánchez Alepuz E, González Jofré C. Arthroscopic scapholunate capsuloligamentous repair: suture with dorsal capsular reinforcement for scapholunate ligament lesion. *Arthrosc Tech* 2017;6:e113-e120.
9. Ho P, Wong C, Tse W. Arthroscopic-assisted combined dorsal and volar scapholunate ligament reconstruction with tendon graft for chronic SL instability. *J Wrist Surg* 2015;4:252-263.

10. Carratalá V, Lucas FJ, Alepuz ES, Guisasola E, Calero R. Arthroscopically assisted ligamentoplasty for axial and dorsal reconstruction of the scapholunate ligament. *Arthrosc Tech* 2016;5:e353-e359.
11. Corella F, Del Cerro M, Ocampos M, Larrainzar-Garijo R. Arthroscopic ligamentoplasty of the dorsal and volar portions of the scapholunate ligament. *J Hand Surg* 2013;38:2466-2477.
12. Corella F, Del Cerro M, Ocampos M, Simon de Blas C, Larrainzar-Garijo R. Arthroscopic scapholunate ligament reconstruction, volar and dorsal reconstruction. *Hand Clin* 2017;33:687-707.
13. Bustamante Suárez de Puga D, Cebrián Gómez R, Sanz-Reig J, et al. Indirect scapholunate ligament repair: All arthroscopic. *Arthrosc Tech* 2018;7:e423-e428.
14. Garcia-Elias M, Lluch AL, Stanley JK. Three-ligament tenodesis for the treatment of scapholunate dissociation: Indications and surgical technique. *J Hand Surg* 2006;31:125-134.
15. Messina J, Van Overstraeten L, Luchetti R, Fairplay T, Mathoulin C. The EWAS classification of scapholunate tears: An anatomical arthroscopic study. *J Wrist Surg* 2013;2:105-109.
16. Rajan PV, Day CS. Scapholunate interosseous ligament anatomy and biomechanics. *J Hand Surg* 2015;40:1692-1702.
17. Overstraeten L, Camus E, Wahegaonkar A, et al. Anatomical description of the dorsal capsulo-scapholunate septum (DCSS)—arthroscopic staging of scapholunate instability after DCSS sectioning. *J Wrist Surg* 2013;2:149-154.