Combined Tenodesis–Capsulodesis for Scapholunate Instability: Minimum 2-Year Follow-Up

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Abstract

Background The aim of this study is to evaluate the clinical and radiological midterm results of a combined dorsal tenodesis–capsulodesis for static and reducible scapholunate dissociation (SLD).

Patients and Methods We evaluated 20 of 22 consecutive patients with static SLD minimum with follow-up of 2 years operated between 2003 and 2012. The mean age was 40 years (range: 23–65 years). Seventeen were men. Final evaluation included comparative wrist range of motion (ROM) and grip strength, pre- and postoperative pain and function by visual analog scale, and QuickDASH and Wrightington scores. Radiographs included preoperative, early postoperative, and final X-rays. Scapholunate space (SLS) and scapholunate and radioscaphoid angles (SLA and RSA) were measured. Statistical significance was evaluated with Student *t*-test, considered significant when $p < 0.05$.

Results Mean follow-up was 67 months (range: 24–126 months). Mean final ROM was: flexion 55 degrees (73%), extension 62 degrees (90%), radial deviation 19 degrees (82%), and ulnar deviation 44 degrees (90%). Mean grip strength was 44 kg (92%). Pain at rest improved from 3.4 to 0.5 ($p < 0.05$). Pain in activity improved from 7 to 1.7 ($p < 0.05$). Final function was 8.5 (preoperative, 5.2; $p < 0.05$). Mean QuickDASH score improved from 38 to 8 ($p < 0.05$). Functional Wrightington score was as follows: 13 excellent, 3 good, 1 regular, and 3 poor. There were three postoperative minor complications. Radiological results (preoperative/early postoperative/final follow-up) were as follows: SLS, 4.7/1.6/1.8 mm; and SLA, 60/50/62 degrees; RSA, 39/45/37 degrees. Four patients showed arthritic changes (two SLAC wrist).

Conclusion The clinical and radiological results with more than 2-year follow-up suggest that this technique may be effective, reproducible, and safe for symptomatic static and reducible SLD.

Level of Evidence Level IV, case series.

Keywords
- capsulodesis
- carpal instability
- scapholunate dissociation
- tenodesis

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Scapholunate dissociation (SLD) is the most common cause of wrist instability and severe dysfunction of the wrist in young patients.[1]

Numerous surgical strategies have been developed to address SLD. Many of these procedures may be grouped generically into bone and soft-tissue reconstructions. Unfortunately, so far no therapeutic alternatives have shown predictable long-term results in relieving the symptoms and preventing arthritic changes, especially in severe cases with a static instability.[2–9] Thus, there is still no consensus about what is the ideal management of this complex problem.

Previously, we described an alternative for scapholunate ligament reconstruction that combined a novel tenodesis using a strip of the extensor carpi radialis longus (ECRL)[10] with a Mayo-type capsulodesis[11] through a single dorsal approach without tunneling the scaphoid, with good preliminary results (►**Figs. 1** and **2**).

The aim of this study is to describe the midterm clinical and radiological results of this technique in cases with static reducible rotary subluxation of the scaphoid.

Materials and Methods

We performed a retrospective analysis of 28 consecutive patients operated in our institution for SLD between September 2003 and July 2015 with the combined ligament reconstruction technique. Only those cases with an isolated complete tear with static-reducible carpal instability and a nonrepairable ligament, without preconditions, and with a minimum follow-up of 2 years were included in this study. Patients presenting with other stages of scapholunate injury at the time of surgery, those with associated injuries, patients treated with another surgical technique, and those with less than 2 years' follow-up were excluded.

Of the original 22 cases who met the inclusion and exclusion criteria, 20 were available for follow-up examination at an average of 65 months postoperatively (range: 24–126 months). There were 17 men and 3 women, and the mean age was 40 years (range: 23–65 years) at the time of surgery. The dominant hand was involved in 13 cases. The mean time from injury to operation was 9 months (range: 2–30 months). ►**Table 1** presents the demographic data for the entire group.

All patients were interviewed and examined by a single examiner not involved in the surgery. Objective clinical evaluation included range of flexion/extension and radial/ulnar deviation measured with a goniometer and grip strength using a Jamar dynamometer. Unfortunately, we could not find full retrospective information of these parameters in all patients before surgery; this is why, they were not included in the final analysis. Pain and function were evaluated pre- and postoperatively using a visual analog scale (VAS). All patients completed the QuickDASH questionnaire. Furthermore, the specific function of the wrist was evaluated with the Wrightington Hospital wrist scoring system that includes both objective and subjective parameters: pain, function, motion, and grip strength.[12,13] Questions about working and sports activity status, and satisfaction with the operation were also included.

Radiological analysis included preoperative, immediate postoperative, and final studies. This involved posteroanterior and lateral views, "forced closing fist" stress views (in 16/20 cases), and radioulnar deviation of both wrists. All measurements were performed digitally by two investigators using the RAIM viewer software. On the lateral radiographs, the scapholunate and radioscaphoid angles (SLA and RSA, respectively) were measured using the tangential and axial methods, respectively.[14] The scapholunate space (SLS) was measured on posteroanterior and stress views (distance between midpoints of the edge of each bone).[15] The presence of osteoarthritic changes were also determined.

Statistical analysis of comparing clinical and radiologic parametric data was performed by the Student *t*-test. A p-value < 0.05 was considered as significant.

Results

►**Tables 2** and **3** described the objective and subjective results of the clinical evaluation. At the final follow-up examination,

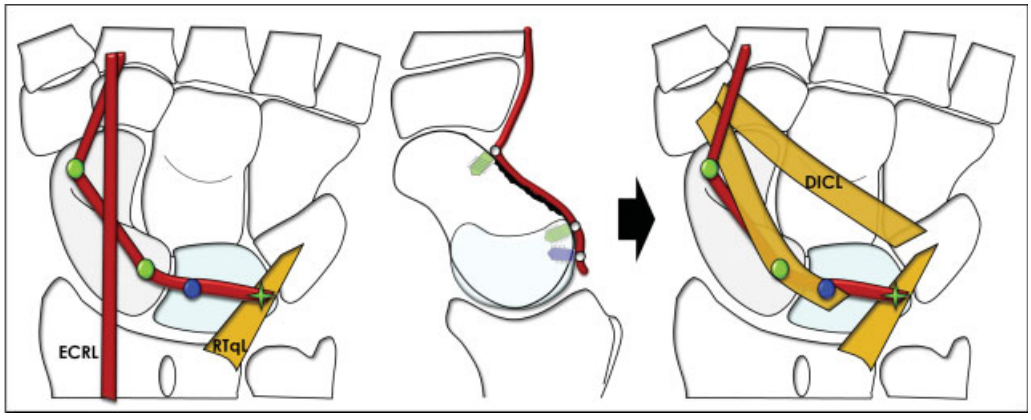

Fig. 1 Tenodesis using a distally based strip of the ECRL fixed with three suture anchors to the proximal and distal pole of the scaphoid and lunate. Reinforcement is made with a dorsal capsulodesis as described by Walsh et al.[11] DICL, dorsal intercarpal ligament; RTqL, radiotriquetral ligament.

the mean range of wrist motion relative to the contralateral side was: flexion = 73%; extension = 90%; radial deviation = 82%; and ulnar deviation = 90%. The final grip strength was 92%, compared with the other side. Pain relief was statistically significant. At final evaluation, only two cases presented increase of pain at rest compared with preoperative values, and five cases referred increased pain during activities. The improvement of function was also statistically

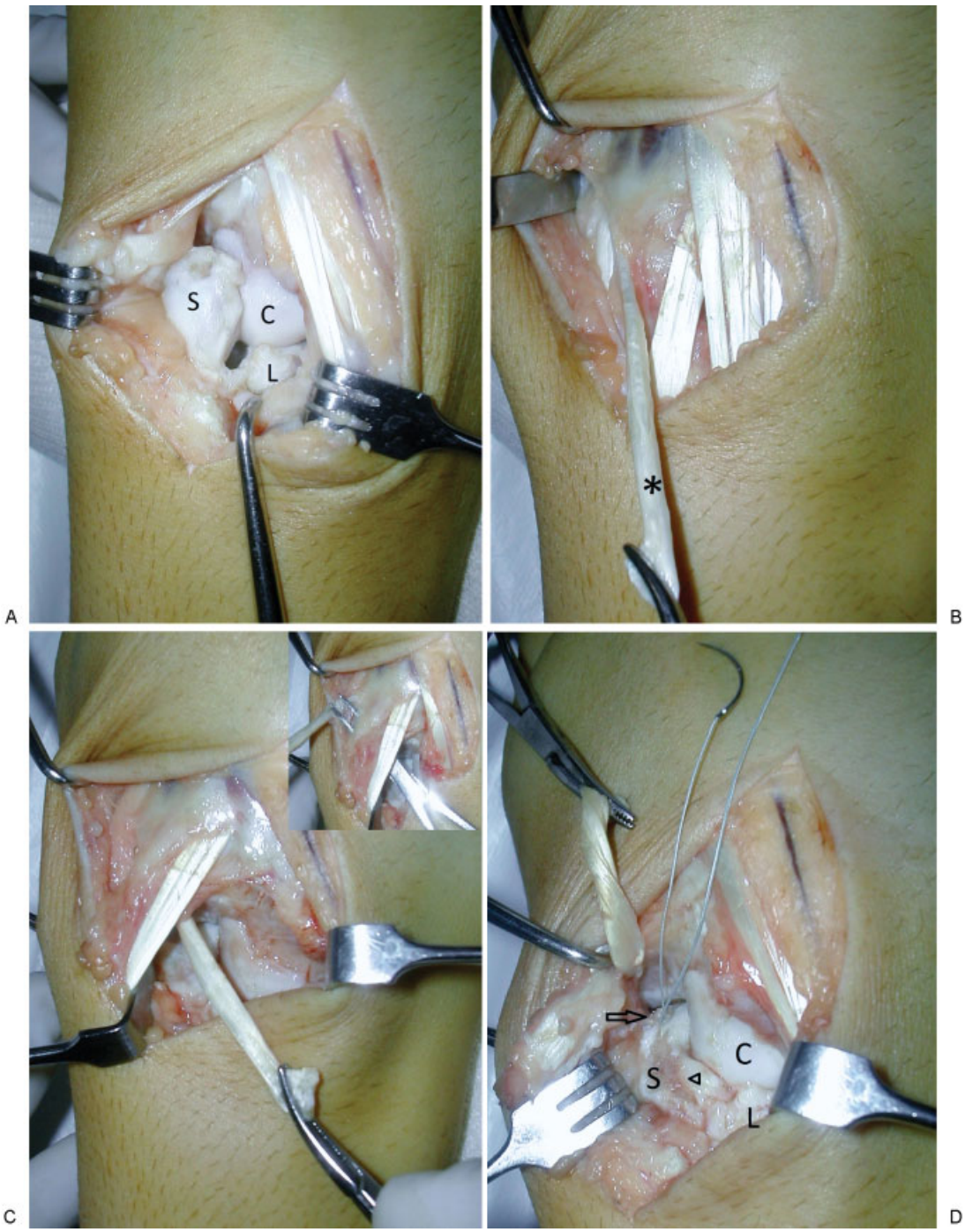

Fig. 2 A 30-year-old man with static SLD in his right dominant wrist (case 3). (**A**) Dorsal approach demonstrating a complete irreparable SL ligament tear with rotary subluxation of the scaphoid (S, scaphoid; C, capitate; L, lunate). (**B**) After carpal reduction, a distally based strip of the ECRL (*) is harvested through the same dorsal approach. (**C**) The ECRL strip is passed below the extensor carpi radialis brevis and extensor digitorum. (**D**) A channel is carved over the dorsal aspect of the scaphoid and lunate to uncover cancellous bone (arrowhead). At first, the tendon strip is fixed on the distal pole of the scaphoid with an anchor suture (arrow) to prevent rotary subluxation. (**E**) Subsequently, the strip is fixed on the proximal pole of the scaphoid and lunate with another two anchor sutures (arrows) to reconstruct the dorsal SL ligament. (**F**) Thereafter, the tendon is sutured onto the distal portion of the RTqL to preclude ulnar translation and extension of the lunate (arrow). Once the tendon reconstruction is finished, reinforcement is made with a Mayo dorsal capsulodesis using a proximal radially based slip of the dorsal intercarpal ligament (*). (**G**) Finally, the dorsal capsular flap (DC) is then brought back to its original position and sutured.

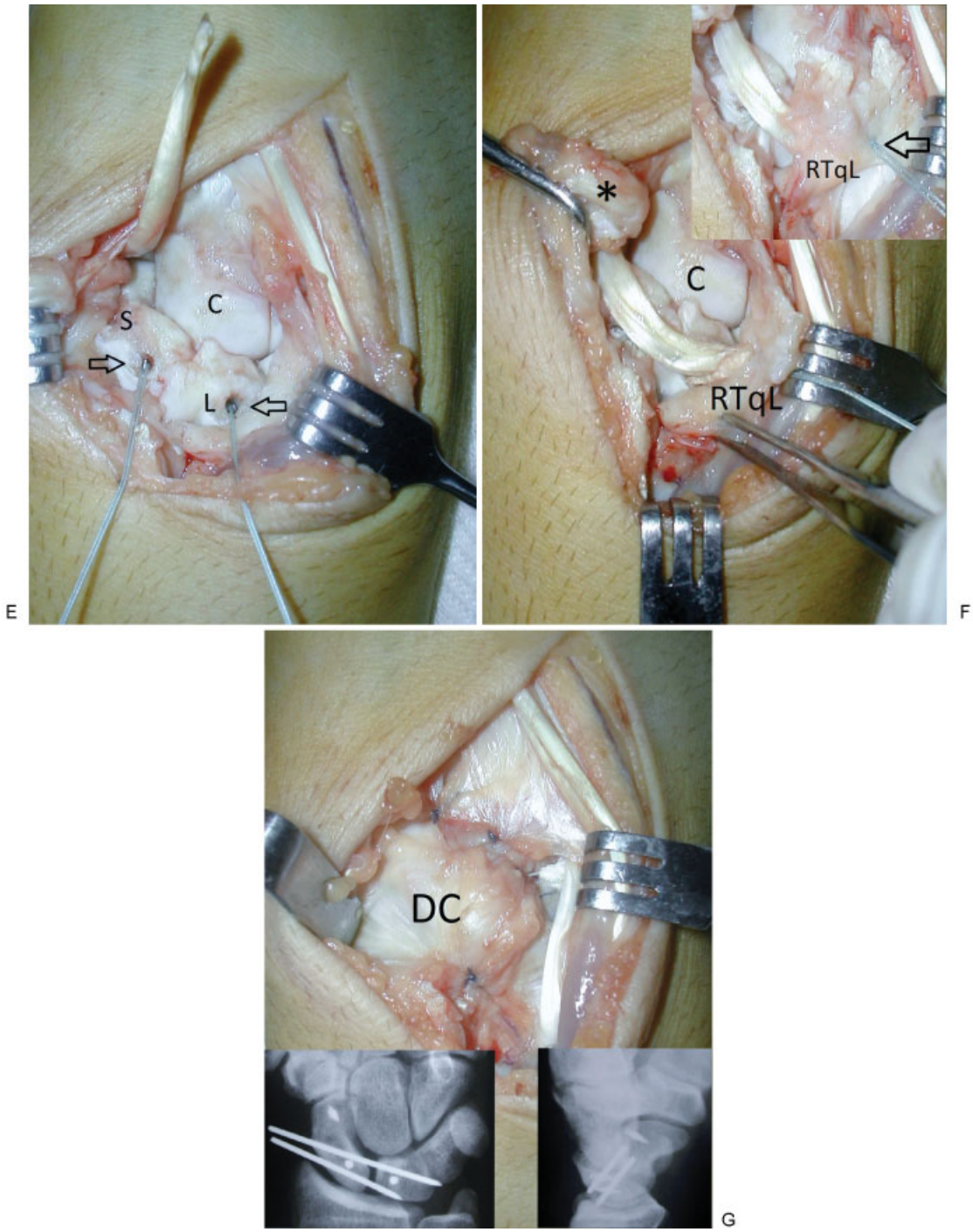

Fig. 2 (*Continued*)

significant. In 16 cases, the final postoperative function was superior to preoperative.

At final review, there was a significant decrease in the QuickDASH score, representing an improvement in the general function of the injured upper extremity. The functional results of the wrist according to the score of Wrightington were excellent in 13, good in 3, fair in 1, and poor in 3 cases. Before surgery, 11 patients reported a restricted work activity, while in the last assessment only 3 cases were restricted. Sports activity was restricted in 18 cases preoperatively and in 6 cases postoperatively. Fifteen patients (75%) returned to their labor or sports activities prior to the injury. Finally, 11 patients were very satisfied with the result, 5 patients satisfied, 3 patients mildly satisfied, and 1 patient dissatisfied.

Radiological outcomes are summarized in ►**Table 4**. ►**Fig. 3** shows the radiological results of an exemplifying case. When comparing the preoperative with the immediate postoperative findings, there were significant reductions in the three parameters evaluated. Both SLA and RSA increased significantly thereafter, while the SLS remained without significant changes.

Table 1 Demographic data

Patient	Gender	Age at surgery (y)	Injured limb/dominant limb	Delay for surgery (mo)	Follow-up (mo)
1	F	43	L/R	15	126
2	M	43	R/R	6	108
3	M	30	R/R	6	105
4	M	31	R/R	30	106
5	M	40	R/L	12	93
6	M	45	L/R	6	72
7	M	32	L/L	8	87
8	M	35	R/R	10	29
9	M	49	R/R	12	91
10	F	36	R/R	8	72
11	M	48	R/R	29	60
12	M	30	R/R	4	60
13	M	39	R/R	6	56
14	M	48	L/R	3	50
15	M	65	L/R	2	41
16	M	48	R/R	10	34
17	M	34	R/L	2	34
18	M	23	R/L	2	33
19	F	41	R/R	6	24
20	M	34	L/L	3	24
Mean	17 M/3 F	40		9	65

Analyzing the data individually, all but one patient had a loss of the initial reduction in any of the three parameters evaluated: SLS in 6 cases (11 cases on stress views); SLA in 16 cases; and RSA in 14 cases. However, only three patients had a carpal collapse (loss of all three parameters simultaneously). Finally, four cases showed arthritic changes. One of these cases evolved into an scapholunate advanced collapse (SLAC) II wrist and another into an SLAC III (►**Fig. 4**). Another case presented isolated advance midradiocarpal degenerative osteoarthritis but similar to the contralateral uninjured wrist (case 15, a man of 68 years at final evaluation). The last case showed osteoarthritis only in the midcarpal joint without significant widening of scapholunate gap, subluxation of the scaphoid, or carpal collapse (►**Fig. 5**).

There were three postoperative complications. One patient presented early migration of K-wires that did not seem to have affected the final outcome. Another two patients presented temporary radial sensory nerve dysesthesias that resolved spontaneously.

Discussion

The primary goals in the treatment of scapholunate instability are to relieve the patient's symptoms, thus preserving a functional wrist mobility, and to prevent carpal collapse, thereby avoiding osteoarthritic changes.[7,16,17] A variety of surgical techniques have been proposed to treat this complex problem, yet disagreement remains with respect to the best management.[16–32]

As mentioned by Kitay and Wolfe,[16] in the presence of a flexible deformity (dynamic instability) without osteoarthritis

Table 2 Final postoperative clinical results: objective parameters

	Injured wrist	Uninjured wrist	Percentage relative to the contralateral side (%)	*p*
Flexion (degree)	55 (44–62)	75 (55–90)	73	0.00001
Extension (degree)	62 (38–75)	68 (41–80)	90	0.0005
Radial deviation (degree)	19 (14–32)	24 (12–45)	82	0.006
Ulnar deviation (degree)	44 (30–58)	49 (30–66)	90	0.002
Grip strength (kg)	44 (11–61)	48 (29–69)	92	0.003

Table 3 Clinical results: subjective parameters

Case	Pain-rest (VAS)		Pain-activity (VAS)		Function (VAS)		QuickDASH	
	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op
1	4	0	6	0	5	8	28	2
2	3	0	8	0	4	10	40	13
3	1	0	6	3	3	8	64	9
4	1	0	6	0	5	9	25	2
5	0	0	7	0	5	10	20	0
6	3	1	8	4	3	5	66	46
7	2	3	6	3	8	6	2	0
8	5	1	7	1	6	9	52	2
9	6	1	9	1	4	9	66	18
10	2	3	5	7	7	6	36	38
11	4	1	8	1	4	9	46	2
12	5	0	9	0	4	10	42	0
13	3	0	7	5	5	8	20	2
14	7	0	10	0	2	9	60	0
15	8	0	8	2	4	8	84	14
16	2	0	2	0	10	10	6	2
17	2	0	6	1	7	8	30	7
18	3	0	8	1	5	9	28	2
19	5	0	5	0	5	10	34	0
20	1	0	8	5	8	8	10	0
Mean	3.4	0.5	7	1.7	5.2	8.5	38	8
Range	0–8	0–3	5–10	0–7	3–10	5–10	0–84	0–46
p-Value	<0.001		<0.001		<0.001		<0.001	

Abbreviation: VAS, visual analog scale.

some type of soft-tissue reconstruction may be indicated. The majority of the capsulodesis bring good results in these cases.[13,22,33–36] However, long-term studies described severe deterioration of these results in cases with static instability.[2,3,8]

In an attempt to achieve a stronger reconstruction, numerous authors propose the utilization of some type of tenodesis. The short-term results using the different modern techniques show good clinical and radiological results.[4–7,9] However, so far we have not found evidence in the literature that describes the evolution of these results in the medium- to long-term follow-up.

Preliminary results of our technique of combined dorsal tenodesis and capsulodesis with 2 years of mean follow-up were similar to the other alternatives.[10] In this study, the results in the medium to long term were presented to determine whether they are maintained over time. According to the results obtained after an average 6-year follow-up, 16/20 patients were satisfied with the result, returning 15 of them to all their previous work and sports activities. No patient referred moderate or severe pain at rest (VAS [visual analog scale] > 4), and only four patients presented moderate or severe pain during activity. Two of them were those with an SLAC wrist. In the other two cases, the pain was probably related to his activities (golf and graphic design), as radiologically they did not have evidence of a severe carpal collapse.

This new tenodesis using an ECRL tendon slip gives some advantages over other techniques described previously: (1) only one dorsal approach is required; (2) scaphoid tunneling is not necessary, and thus it is technically less demanding and avoids the potential risk of fracture or necrosis of the bone; and (3) it is possible to combine the tenodesis with a dorsal capsulodesis to achieve a more consistent reconstruction through a single dorsal approach without increasing morbidity and complexity of the procedure.

In relation to the radiological findings, there are no reports of any surgical interventions for this problem that demonstrate consistent results to prevent or delay the progression to an SLAC wrist.[8,16] The correction and maintenance of alignment (kinetic) and mobility (kinematic) of the carpus are particularly relevant considering that many of these patients are young active people. As with all techniques of ligament

Table 4 Radiological results

Case	SLS (mm)				SLA (degree)			RSA (degree)		
	Pre-op	Immediate post-op	Final post-op	"Forced closing fist"	Pre-op	Immediate post-op	Final post-op	Pre-op	Immediate post-op	Final post-op
1	4	2	2	–	52	28	29	40	46	42
2	5.4	1.5	1.6	–	58	52	53	44	44	42
3	6.3	1.8	1.9	2	70	65	72	41	48	24
4	8.1	1.3	1.4	–	55	50	50	35	40	38
5	6.3	1.8	1.9	2	70	23	54	31	62	39
6	6.8	1.4	1.8	2.2	60	56	57	38	44	41
7	7.6	1.4	1.6	2.9	86	86	92	36	36	30
8	7.2	1.8	1.8	2.7	54	55	65	48	50	38
9	1.8	1.7	1.7	2.9	45	45	54	46	48	40
10	6.3	1.8	2.2	2.3	82	22	70	34	76	27
11	3.6	2.7	2.7	–	60	55	67	35	40	37
12	6.3	1	1	1.1	50	47	53	42	44	28
13	6.2	0.9	0.9	0.9	58	54	70	34	38	30
14	1.8	1.8	2.2	2.8	60	48	72	32	39	36
15	3.6	1.8	2	3.6	87	60	63	28	30	29
16	2.7	1.6	1.6	2	62	56	89	30	34	31
17	4.6	1.1	1.1	1.2	45	45	54	40	42	40
18	0.9	1	1.2	1.9	54	53	70	38	40	38
19	2.7	2	4.5	4.5	52	46	49	50	55	55
20	1.8	1.3	1.4	1.8	48	45	66	48	53	48
Mean	4.7	1.6	1.8	2.3	60	50	62	39	45	37
Range	0.9–8.1	0.9–2.7	0.9–4.5	0.9–4.5	45–87	22–86	29–92	28–50	30–76	27–55
p-Value		<0.001	0.12		0.007	0.003		0.008	0.002	

Abbreviations: RSA, radioscaphoid angle; SLA, scapholunate angle; SLS, scapholunate space.

reconstruction, it is expected that some radiological deterioration occurs over time. In our series, the SLS remained without significant changes over time. Technically, to avoid rotatory subluxation of the scaphoid, we believe it is critical to set the first anchor radially to the distal pole of the scaphoid to control not only flexion but also pronation of the carpal bone. On the contrary, the loss of the initial reduction was significant in the SLA and RSA, demonstrating a major difficulty of the procedure to support the alignment of the scaphoid and lunate in the sagittal plane. Nevertheless, at the time of the final evaluation, only four patients (20%) presented carpal osteoarthritis. This percentage is similar to that presented by Garcia-Elias et al using the three-ligament reconstruction with a shorter follow-up,[7] and lower than in previous studies using several capsulodesis with a long-term follow-up (27–50%).[2,3,8] Further evaluation of our patients will reveal whether these osteoarthritic changes will be maintained over time.

An alternative to soft-tissue reconstruction techniques is to conduct some type of limited carpal arthrodesis. The results reported are very similar to the ligament reconstructions but with higher incidence of complications, including nonunion and radiocarpal arthrosis (4–51% and 15–35%, respectively).[21,37–40] The major advantage of dorsal capsulodesis and tenodesis when compared with partial arthrodesis is the preservation of some intercarpal motion. To achieve this, the reconstruction should be strong enough to stabilize the carpus, and simultaneously flexible enough to preserve its dynamics. To evaluate both features, we considered not only static radiographs, but also dynamic radiographs in maximum radioulnar deviation. Two-thirds of the cases examined showed some kind of mobility for flexion and extension of the scaphoid, suggesting the possibility of preserving at least part of the carpal biomechanics with this type of soft-tissue reconstruction (►**Fig. 6**).

Regarding the level of evidence, this study presents all limitations associated with a case series retrospectively evaluated with no comparison group. In addition, the relatively small sample size determines some statistical limitations. However, some aspect must be considered to provide relevance to our results. While the technique presented would be also indicated in cases of SLD with dynamic instability (grade III of Garcia-Elias et al classification), in this study we decided to include only those with static reducible instability (grade IV), in which the prognosis is less predictable and therapeutic alternatives are more limited.

In conclusion, we believe that the results obtained justify the indication of this procedure in symptomatic patients, preserving in most cases pain relief and functional mobility of the wrist with acceptable radiographic changes for at least 5 years after average follow-up. However, re-evaluation of this result with a longer follow-up would be necessary in an attempt to determine its effectiveness in preventing or at least delaying the carpal collapse and osteoarthritic changes of the injured wrist, and also to define the surgical indication for asymptomatic patients.

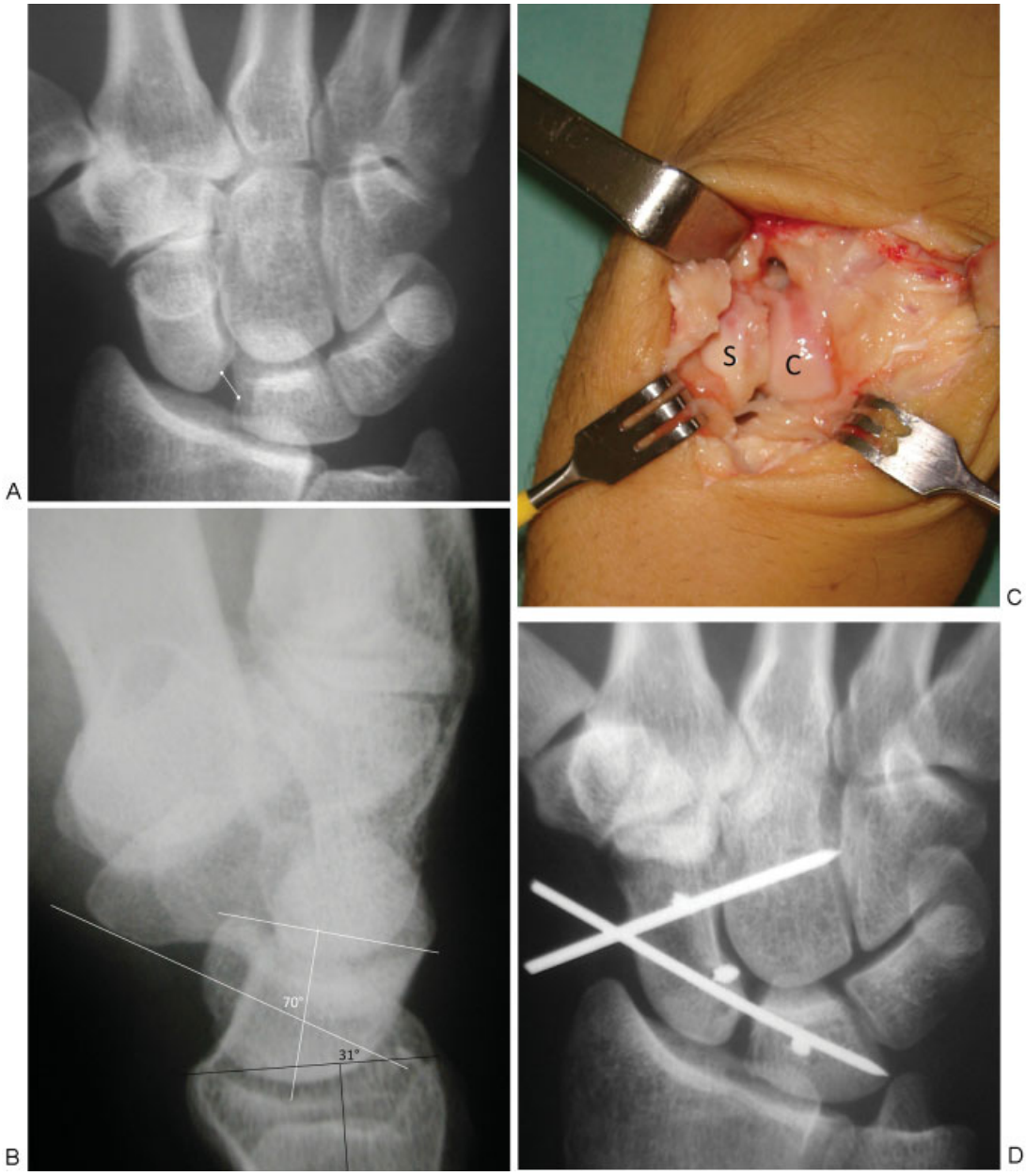

Fig. 3 A 40-year-old man with static SLD in his right nondominant wrist (case 5). (**A, B**) Preoperative X-rays: SLS, 6.3 mm; SLA, 70 degrees; RSA, 31 degrees. (**C**) Intraoperative findings: total and irreparable ligament rupture with rotary subluxation of the scaphoid. (**D, E**) Immediate postoperative radiographs. Note some initial overcorrection. SLS, 1.8 mm; SLA, 23 degrees; RSA, 62 degrees. (**F, G**) Comparative X-rays at final assessment (93 months) appreciating an acceptable carpal alignment. SLS, 1.9 mm; SLA, 54 degrees; RSA, 39 degrees. (**H, I**) Comparative "forced closing fist" stress views. The scapholunate space is maintained.

Fig. 3 (*Continued*)

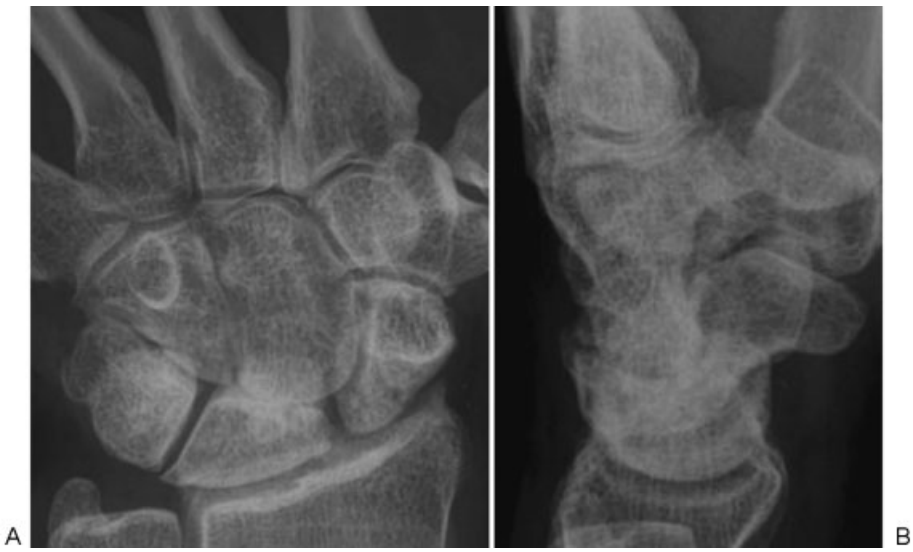

Fig. 4 Case 10. A 36-year-old woman presenting an SLAC III right wrist at final evaluation (72 months). (**A, B**) SLS, 2.3 mm; SLA, 70 degrees; RSA, 27 degrees.

Fig. 5 Case 3. Patient with isolated midcarpal arthritis at final follow-up (105 months). (**A, B**) Nevertheless, X-rays demonstrate acceptable carpal alignment. SLS, 1,9 mm; SLA, 72 degrees; RSA, 24 degrees.

Fig. 6 Case 3. (**A–D**) Comparative radiographs in maximum radioulnar deviation of both wrists, showing certain mobility of the proximal carpal row (flexion-extension).

Note

All authors adhere to the ethical standards described by the Committee on Publication Ethics and the International Committee of Medical Journal Editors.

Conflict of Interest

None.

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