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Original article

Treatment of chronic scapholunate instability: Results with three-ligament tenodesis vs. scapholunate and intercarpal ligamentoplasty

Traitement de la dissociation scapho-lunaire chronique : comparaison des résultats de la triple ténodèse versus la ligamentoplastie scapho-lunaire et intercarpienne

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ABSTRACT

In this retrospective case control/comparison study, we compared the clinical and radiological outcomes in patients with chronic scapholunate dissociation treated with three-ligament tenodesis (3 LT) versus scapholunate and intercarpal ligamentoplasty (SLICL). Twenty patients with a mean age of 43 years were treated with the 3 LT procedure and 26 patients with a mean age of 44 years with the SLICL procedure. All patients had chronic reducible scapholunate dissociation without chondral lesions. The two groups of patients were operated on by senior surgeons, at the same facility, over two different time periods. All patients were evaluated (pain, motion, strength, function, X-rays) with a mean follow-up of 28 months (12–49) in the 3 LT group and 36 months (12–54) in the SLICL group. In the both groups, we found a significant improvement in pain levels, grip strength and functional scores (DASH and PRWE). The SLICL group had significantly less pain and greater grip strength than the 3 LT group. Patients in the SLICL group had a greater improvement in their DASH and PRWE Scores. The mean range of motion in flexion–extension was 82° (102° preoperative) in the 3 LT group and 113° (115° preoperative) in the SLICL group. In the 3 LT, there was no significant improvement in the mean static and dynamic scapholunate gaps (3.6 and 4.8 mm postoperatively versus 3.9 and 4.9 mm preoperatively), or the scapholunate angle (75° versus 72°). In the SLICL group, the mean static and dynamic gaps improved significantly (2.3 and 3.0 mm postoperatively versus 3.2 and 4.6 mm preoperatively), as did the scapholunate angle (62° versus 73°). In the 3 LT group, 4 patients developed osteoarthritis. In conclusion, the SLICL procedure for scapholunate ligament reconstruction led to better clinical and early radiological results than the 3 LT technique.

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R É S U M É

Dans cette étude rétrospective, nous avons comparé les résultats cliniques et radiologiques des patients présentant des dissociations scapho-lunaires chroniques traitées soit par une triple ténodèse selon Garcia-Elias (3 LT) soit par une ligamentoplastie scapho-lunaire et intercarpienne (SLICL). Vingt patients d'âge moyen de 43 ans ont été traités par une 3 LT et 26 patients d'âge moyen de 44 ans avec une SLICL. Tous les patients présentaient une dissociation chronique réductible sans lésions cartilagineuses. Les deux groupes de patients avaient été opérés par des chirurgiens seniors, dans le même établissement, sur deux périodes différentes. Tous les patients ont été évalués (douleur, mobilités, force, scores fonctionnels, radiographies) avec un recul moyen de 28 mois (12–49) dans le groupe 3 LT et de 36 mois (12–54) dans le groupe SLICL. Dans les deux groupes, nous avons constaté une amélioration significative de l'évaluation de la douleur, de la force de préhension et des scores fonctionnels (DASH et PRWE). Le groupe SLICL avait significativement moins de douleur et une plus grande force de préhension

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que le groupe 3 LT. Les patients du groupe SLICL avaient une meilleure amélioration de leurs scores DASH et PRWE par rapport au groupe 3 LT. L'arc de mobilité en flexion-extension était de 82° (102° en préopératoire) dans le groupe 3 LT et de 113° (préopératoire 115°) dans le groupe SLICL. Dans le groupe 3 LT, il n'y a pas eu d'amélioration significative des espaces scapho-lunaires statiques et dynamiques (3,6 et 4,8 mm en postopératoire contre 3,9 et 4,9 mm en préopératoire) ou de l'angle scapho-lunaire (75° versus 72°). Dans le groupe SLICL, les espaces scapho-lunaires statiques et dynamiques s'étaient significativement améliorés (2,3 et 3,0 mm en postopératoire contre 3,2 et 4,6 mm en préopératoire), de même que l'angle scapho-lunaire (62° versus 73°). Dans le groupe 3 LT, 4 patients avaient développé une arthrose. En conclusion, la procédure SLICL pour la reconstruction du complexe scapho-lunaire a conduit à de meilleurs résultats cliniques et radiologiques à court terme que la technique 3 LT.

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1. Introduction

Scapholunate (SL) dissociation is the most common cause of intracarpal instability and is often diagnosed at a late stage [1]. Without treatment, scaphoid rotary subluxation and lunate dorsiflexion (dorsal intercalated segment instability, DISI) contribute to the development of SL advanced collapse (SLAC) osteoarthritis [2,3]. Several ligament reconstruction techniques have been described for treating symptomatic chronic reducible SL dissociation when no chondral lesions are present [4]. They all aim to reduce the scaphoid's flexion deformity, SL gap and DISI deformity to prevent SLAC osteoarthritis [5]. Moreover, recent biomechanical studies have highlighted the important stabilizing role of the extrinsic palmar and dorsal ligaments, which are considered secondary stabilizers for the SL complex [6,7].

The three-ligament tenodesis (3 LT) procedure described by Garcia-Elias et al. [8] uses a distally pedicled flexor carpi radialis (FCR) slip to reconstruct the dorsal segment of the SL interosseous ligament and the ligament complex on the distal pole of the scaphoid. In our practice, we initially used the 3 LT procedure and then developed a new SL ligament reconstruction, the scapholunate intercarpal ligamentoplasty (SLICL) [9]. This procedure uses a free palmaris longus (PL) graft to reconstruct the dorsal segment of the SL interosseous ligament and the dorsal intercarpal ligament. Here, we compare the preliminary results of these two procedures with a minimum follow-up of 12 months.

2. Patients and methods

2.1. Patients

This is an institutional review board-approved study reflecting the experience of senior surgeons at the same facility, over two different time periods. From May 2008 to June 2011, twenty patients with chronic SL dissociation were treated with the 3 LT technique as described by Garcia-Elias et al. [8]. From March 2013 to September 2016, twenty-six patients with chronic SL dissociation were treated with the SLICL procedure as described by Athlani et al. [9] (Fig. 1). For the two procedures, stabilization was achieved by scapholunate and scaphocapitate pinning (1.2 mm K-wires) for 2 months.

Both groups were reviewed retrospectively at two different periods by the same independent examiner with the same methodology.

The two groups of patients had comparable characteristics and follow-up time. The mean age in the 3 LT group was 43 years (22–56), and 15 of the patients were men. Eleven were right-handed, and 9 (45%) had their dominant hand injured. Follow-up for the 3 LT group was 28 months (12–49). The SLICL group had an average follow-up time of 36 months (12–54). The mean age in the SLICL

group was 44 years (22–57 years), and 20 of the patients were men. Fourteen patients were right-handed, and 17 (65%) was involved of their dominant hand. The time to surgery was similar between the two groups with a mean wait of 13 months (2–79) for the 3 LT group and 14 months (3.5–72) for the SLICL group. Ten (50%) patients performed heavy manual labor in the 3 LT group and 15 patients (58%) in the SLICL group.

2.2. Review

All patients underwent a full imaging assessment consisting of standard radiographs with posterior-anterior (PA) and lateral views, dynamic clenched fist views, PA view in radial deviation and ulnar deviation; CT arthrography was also done. All patients were diagnosed with chronic SL instability [2] – either dynamic or static reducible [11] with no chondral damage – which corresponds to stage 3 or 4 in the Garcia-Elias classification [8] (Figs. 2 and 3). Beforehand, an arthroscopy of the injured wrist was performed in all cases first to confirm the SL instability, quantify its magnitude [12], confirm that no repairable ligament remnant was present, and confirm the scaphoid was easily reducible and that no chondritis was present.

All patients were reviewed in person with a minimum follow-up of 12 months. After having collected each patient's consent, an independent examiner performed a clinical evaluation and requested radiographs.

2.3. Surgical technique of the SLICL procedure

The surgical procedure (Fig. 1B) was performed by two senior surgeons (NP and GD). They made a dorsal incision along the axis of the third metacarpal, centered on the midline of the radiocarpal joint. The extensor retinaculum was opened between the third and fourth compartments, and a dorsal capsulotomy performed according to Berger et al. [13].

They then harvested a 10 cm free PL graft through a short incision on the palmar side of the wrist. The graft was then pre-tensioned with 3 kg for 2 min on a dedicated workstation (Arthrex[®], Naples, Florida, United States). A first blind tunnel, 10 mm deep and 2.5 mm wide, was drilled at the site of the former scaphoid insertion of the dorsal segment of the SL interosseous ligament (proximal pole of the scaphoid). The posterior surface of the lunate was then drilled to create a shallow trench to serve as the interface for graft adhesion. A second blind tunnel of the same depth and width was drilled in the dorsal aspect of the triquetrum near the radial side of the dorsal radiocarpal ligaments (DRCL), following the axis of the lunate trench. One of the two ends of the graft was then whip stitched over a length of 10 mm with a non-absorbable Fiberloop[™] 4-0 (Arthrex[®], Naples, Florida, United States), wedged into the first proximal scaphoid tunnel, and

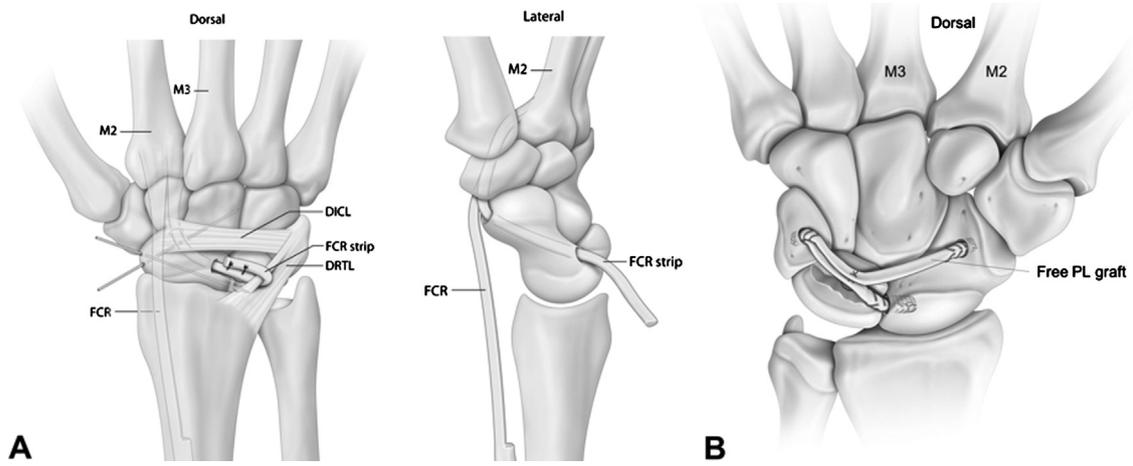


Fig. 1. Diagram illustrating the 3 LT technique as described by Garcia-Elias et al. A. The SLICL technique as described by Athlani et al. B. FCR: flexor carpi radialis; PL: palmaris longus; DICL: dorsal intercarpal ligament; DRTL: dorsal radiotriquetral ligament; M2: second metacarpal; M3: third metacarpal.



Fig. 2. Example of scapholunate dissociation detected on anteroposterior (A) and lateral (B) radiographs. Postoperative anteroposterior (C) and lateral (D) radiographs at 46 months' follow-up after the 3 LT procedure.

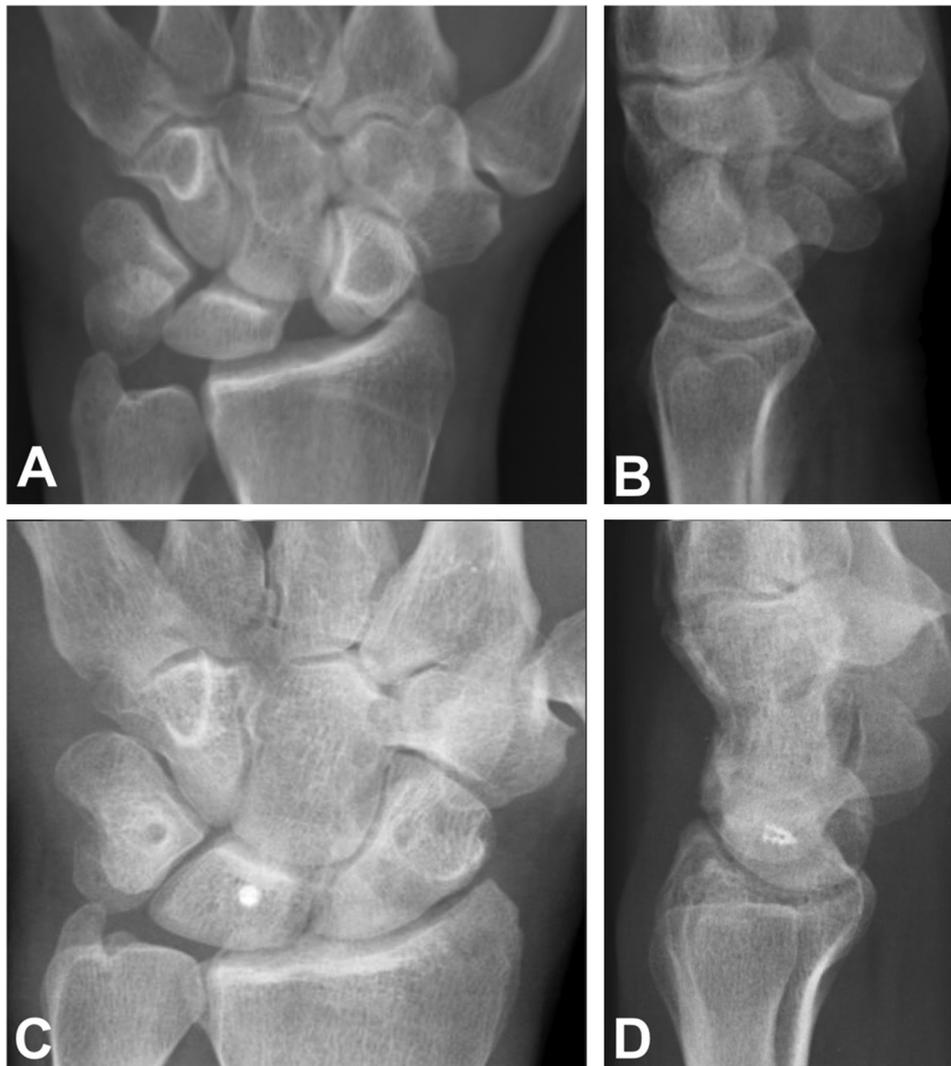


Fig. 3. Example of scapholunate dissociation detected on anteroposterior (A) and lateral (B) radiographs. Postoperative anteroposterior (C) and lateral (D) radiographs at 40 months' follow-up after the SLICL procedure.

secured in interference by means of an impacted 2.5 absorbable miniBioPushlock™ (Arthrex®, Naples, Florida, United States). A 2.2 mm non-absorbable titanium MicroCorkscrew™ anchor (Arthrex®, Naples, Florida, United States) was introduced into the lunate trench.

The dissociation was then reduced by manual maneuvers and pointed reduction forceps [9]. Stabilization was achieved by scapholunate and scaphocapitate pinning (1.2 mm K-wires). Fixing the graft in the second triquetral tunnel meant both tapering it and performing a longitudinal plication. The central half was resected over a distance of 12 mm starting from the entry point in the second tunnel. The two half strips thus obtained were folded back on themselves to create a new intermediary graft end as thick as the other two ends over a length of 6 mm. This new end was then whip stitched over 10 mm before being inserted and attached to the second blind tunnel by impacting a Pushlock. The graft located between the first two intraosseous fixation points was placed in the lunate trench, and then fixed by the anchor sutures to create the first segment. A third blind tunnel of the same depth and width was drilled at the level of the scaphoid isthmus near the scaphotrapeziotrapezoid (STT) joint surface.

To create the second segment the remainder of the graft was again passed through the lunate trench and fixed by the same anchor sutures, to allow for superposition of the two segments in

the tunnel. The remaining free end was resected beyond a distance of 8 mm from the entry point in the third blind tunnel and then inserted into the tunnel. To do so, this last end was whip stitched over 10 mm and fixed to the bottom of the third tunnel by impacting a Pushlock. At this point we could test the tension of both segments with a tendon hook. Capsular and retinacular stitching was performed.

2.4. Postoperative protocol

Immediately following surgery, the wrist was immobilized in a volar plaster cast for 48 to 72 hours. Immobilization was extended for 2 months with a short-arm fiberglass splint. K-wires were removed 2 months postoperatively, at which point the patients began 1 month of self-directed rehabilitation. Radiographs were taken at 3 months postoperative, after which physiotherapy sessions were initiated. No heavy loads could be placed on the wrist for the first 6 months postoperative.

2.5. Clinical evaluation

Pain was evaluated using a Visual Analog Scale (VAS) (out of 10) at rest and during effort. Grip strength in the operated and contralateral side in kg/F was collected using a Jamar® hydraulic

hand dynamometer (Performance Health[®], Charleville-Mézières, France). The active joint range of motion (ROM) was measured in degrees during wrist flexion, extension, radial deviation and ulnar deviation (accuracy of 1°). The functional outcomes were evaluated using standardized questionnaires: DASH (/100) [14], PRWE (/100) [15]. Postoperative complications were also recorded.

2.6. Radiographic evaluation

At the follow-up visits, standard radiographic views, standard neutral PA and lateral views, and a clenched fist PA view were taken in all patients. The digital radiographs were viewed on OsiriX[®] (Pixmeo[®] 2016, Geneva, Switzerland). The static and dynamic SL gaps (SLG) in mm along with the SL angle (SLA) in degrees were calculated (0.1 mm accuracy for gaps and 1° for angles). Values greater than 3 mm were considered pathological, as was an SLA greater than 70° and a capitulunate angle (CLA) more than 15° [16]. At the in-person review, the patients were assessed for any signs of necrosis of the proximal pole of the scaphoid and/or posterior horn of the lunate along with the development of scaphotrapezotrapezoid (STT) or SLAC osteoarthritis.

2.7. Statistical analysis

The recorded data were summarised using mean values and ranges. The mean values obtained in the preoperative evaluation and at the last follow-up were compared using Student's *t*-test with any differences deemed significant with a type I error risk of 5% ($P < 0.05$).

3. Results

Results for both groups are given in Tables 1 and 2. The 3 LT group had 8 cases of dynamic instability and 12 of static. The SLICL group had 11 cases of dynamic instability and 15 of static. In every patient, the CT arthrography showed a tear of the SL interosseous ligament with contrast product leakage. During the arthroscopy evaluation, stage 2 instability was found in 4 cases and stage 3 in 16 cases in the 3 LT group. In the SLICL group, stage 2 instability was found in 6 cases and stage 3 in 20 cases. There was no chondral damage. All the 3 LT procedures were performed with an FCR and all the SLICL procedures using a free PL graft. The incision was healed within 2 weeks in all patients. The K-wires protecting the SL and scaphocapitate joints were removed at 2 months postoperative in all patients (range 56 – 65 days), and then the rehabilitation protocol initiated. The time away from work averaged 6 months

(4–12) in the 3 LT group and 5 months (0–12) in the SLICL group. In the 3 LT group, 90 percent of patients had returned to the original job and in the SLICL group, 88 percent.

3.1. Clinical evaluation

At final follow-up, in the 3 LT and SLICL groups, we found a significant ($P < 0.05$) reduction in pain levels at rest and during effort, a significant improvement in grip strength relative to the preoperative value and the contralateral side, and a significant improvement in the functional scores (DASH and PRWE). The SLICL group reported significantly less pain when compared with the 3 LT group ($P < 0.05$). The SLICL group had significantly higher grip strength at final follow-up. The improvement was greater in the SLICL group than in the 3 LT group (mean 14 kg/F versus 8 kg/F; $P < 0.05$). Also, the grip strength as a percentage of the contralateral side was higher in the SLICL group. Patients in the SLICL group had a larger improvement in their QuickDASH and PRWE scores, with a mean decrease of 40 points and 39 points, respectively, in this group versus a mean decrease of 18 points and 22 points, respectively, in the 3 LT group ($P < 0.05$). The mean ROM in flexion–extension was 82° (102° preoperative) in the 3 LT group and 113° (115° preoperative) in the SLICL group. Thus, the ROM in flexion–extension had significantly decreased ($P < 0.05$) in the 3 LT group (20° reduction) but not significantly ($p > 0.05$) in the SLICL group (2° reduction). Patients treated with the SLICL had better motion in flexion–extension than did the 3 LT group. The differences in radial and ulnar deviation were not statistically significant between groups.

3.2. Radiographic evaluation

At final follow-up, in the 3 LT group, there was no significant ($P < 0.05$) improvement of the mean static and dynamic SLG (3.6 and 4.8 mm postoperatively versus 3.9 and 4.9 mm preoperatively), or the SLA (75° versus 72°) (Fig. 2). In the SLICL group, there was a significant ($P < 0.05$) improvement of the mean static and dynamic SLG (2.3 and 3.0 mm postoperatively versus 3.2 and 4.6 mm preoperatively), as well as the SLA (62° versus 73°) (Fig. 3). The SLICL procedure led significantly greater improvement of the SLG and the SLA when compared with the 3 LT technique ($P < 0.05$).

3.3. Complications

There were no intraoperative complications or local postoperative infections in either group.

Table 1

Clinical and radiographic outcomes (mean) for patients treated with the three-ligament tenodesis (3 LT) and scapholunate intercarpal ligamentoplasty (SLICL) procedures.

Average value	3 LT (n = 20)			SLICL (n = 26)		
	Preoperative	Last follow-up	P	Preoperative	Last follow-up	P
Pain at rest (VAS) (/10)	3.2	1.6	0.01	4.5	0.4	0.01
Pain during effort (/10)	6.4	4.9	0.01	6.7	1.9	0.01
Grip strength (Kg/F)	24	32	0.01	26	40	0.01
	57% CL	76% CL		59% CL	89% CL	
Flexion (°)	52	39	0.01	59	57	0.663
Extension (°)	50.5	43	0.01	56	56	0.885
Ulnar deviation (°)	30	24	0.01	32	32	0.876
Radial deviation (°)	17	14	0.05	16	16	0.731
DASH (/100)	48.9	31.3	0.01	57.5	17.5	0.01
PRWE (/100)	55.5	33.6	0.01	52.6	13.6	0.01
Static scapholunate gap (mm)	3.9	3.6	0.477	3.2	2.3	0.01
Dynamic scapholunate gap (mm)	4.9	4.8	0.793	4.6	3.0	0.01
Scapholunate angle (°)	72	75	0.356	73	62	0.01
SLAC arthritis	0	2	–	0	0	–

Table 2

Comparison of differences in the clinical and radiographic outcomes between three-ligament tenodesis (3LT) and scapholunate intercarpal ligamentoplasty (SLICL).

Average change	3 LT (n = 20)	SLICL (n = 26)	P
Pain at rest (VAS) (/10)	-1.6	-4.1	0.01
Pain during effort (/10)	-1.5	-4.8	0.01
Grip strength (Kg.F)	+8	+14	0.01
Flexion (°)	-13	-2	0.01
Extension (°)	-7.5	0	0.01
Ulnar deviation (°)	-6	0	0.746
Radial deviation (°)	-3	0	0.896
DASH (/100)	-18	-40	0.01
PRWE (/100)	-22	-39	0.01
Static scapholunate gap (mm)	-0.3	-0.9	0.01

In the SLICL group, 3 patients (11.5%) developed De Quervain's tenosynovitis that resolved with conservative treatment (brace and corticosteroid injection). There were no radiographic signs of bone lysis at the proximal pole of the scaphoid and/or the posterior horn of the lunate. However, we noted 2 cases (7.5%) of asymptomatic loosening around miniBioPushlock™ implants (Fig. 4). The patients no required a new surgery but only radiological monitoring. At final follow-up, none of the patients had signs of SLAC osteoarthritis.

In the 3 LT group, 2 patients (10%) developed type 1 complex regional pain syndrome (CRPS) that resolved with medical treatment. Seven patients (35%) had palmar pain at entry point of the transscaphoid tunnel. Four patients (20%) developed osteoarthritis (10% STT osteoarthritis and 10% SLAC). Two patients required a new surgical procedure: one case of early STT osteoarthritis requiring STT arthrodesis at 10 months, and one case of type 2 SLAC osteoarthritis reoperated at 32 months with a four-corner fusion (Fig. 5). Two other patients developed postoperative osteoarthritis (one STT osteoarthritis, one SLAC), but did not require further surgical intervention as of the last follow-up. There was one case (5%) of scaphoid proximal pole radiolucency in the 3 LT group.



Fig. 4. Radiograph showing asymptomatic loosening around absorbable miniBioPushlock™ implants (Arthrex®, Naples, Florida, United States).

4. Discussion

Based on this study's findings, the 3 LT and the SLICL procedures can significantly reduce pain and increase grip strength. The clinical and radiological outcomes were better with the SLICL technique than the 3 LT. The SLICL group reported significantly less pain at rest and during effort than the 3 LT group. Grip strength in the SLICL group had recovered to a mean of 89% when compared with the contralateral side. For the 3 LT group, grip strength was 76%. This difference was also statistically significant. When compared with preoperative values, there was significantly decreased flexion and extension in the 3 LT group only. The preoperative values were similar in the two groups. The mean ROM had decreased by 20° in the 3 LT group while the decrease was 2° in the SLICL group. At final follow-up, the SLICL group had better motion in flexion and extension. Differences between the two procedures in radial and ulnar deviation were not significant.

The 3 LT procedure [8] uses a distally pedicled slip of FCR to reconstruct the dorsal segment of the SL interosseous ligament and vertically reposition the scaphoid. This technique is considered the benchmark and has served as the basis for numerous clinical studies [8,17,18]. Authors of these study described a loss of ROM and grip strength after ligament reconstruction. At 46 months' follow-up, Garcia-Elias et al. [8] reported an average postoperative ROM in flexion-extension of 103° and the grip strength was 65% of the contralateral side. At 10.5 months' follow-up, Kalb et al. [18] reported better recovery of grip strength with an average 80% of the noninvolved side. Average postoperative ROM in flexion-extension was 88°. In the 3 LT group, the average postoperative ROM in flexion was 39° in our study while Garcia-Elias et al. [8] reported 51° and Kalb et al. [18] reported 35°. In the SLICL group, this amplitude was better with a mean 57°. This relative preservation of wrist flexion with the SLICL procedure can be attributed to not using a volar approach or the FCR.

In the SLICL group, we found a significant improvement in SLG and SLA, with a return to normal values [16]. This procedure has corrected the radiologic features of SL dissociation. In the 3 LT group, the SLG and SLA did not decrease significantly. De Smet et al. [17] noted a significant reduction of the SLG (4.25 mm vs. 3.29 mm preoperative) and the SLA (77° vs. 68° preoperative) at 39 months' follow-up. However, the SLG and SLA were considered normal in only 33% and 25% of patients, respectively.

In the 3 LT group, we found seven cases of persistent palmar pain. Talwalker et al. [19] noted four cases, three of which were treated surgically by excising a neuroma of the palmar branch of the median nerve.

We also found two cases (10%) of postoperative STT osteoarthritis. Poor positioning at the entry point of the scaphoid tunnel may have caused joint penetration, or even a modification of articular congruence, owing to pressure exerted by the tenodesis.

In the SLICL group, the rate of SLAC-type osteoarthritis was 0% while it was 10% (2 cases) in the 3 LT group. This rate was similar to that found in the literature: 5% for Chabas et al. [20], 12.5% for Nienstedt et al. [21], 13% for Moran et al. [22], 23% for Garcia Elias et al. [8]. Finally, we also observed a case of scaphoid proximal pole radiolucency six months postoperatively. One case of avascular necrosis of the scaphoid was reported by De Smet and Van Hoonacker [23]. In the SLICL group, no bone-related complications were found. Since no anteroposterior scaphoid transosseous tunnel was made, there were no radiological signs of necrosis in the proximal pole of the scaphoid or signs of osteoarthritis in the STT joint.

Limitations of this comparative study include the relatively short follow-up period and small patient populations in each group. However, the mean sample size and mean follow-up are similar to that found in the literature. Comparisons may be affected



Fig. 5. Radiograph (A) and computed tomography scan (B) showing STT osteoarthritis 10 months after 3 LT. Radiograph (C) and computed tomography scan (D, E) showing SLAC osteoarthritis 30 months after 3 LT.

by the different time periods, as the authors replaced one technique (3 LT) with a new technique (SLICL). Long-term follow-up as well as the inclusion of other chronic SL instability cases will provide greater insight into the optimal management of this difficult problem.

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Informed consent

All patients gave their informed consent for this study

Disclosure of interest

Gilles Dautel and Nicolas Pauchard declare a conflict of interest with Arthrex[®]. The authors declare that they have no competing interest.

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