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Arthroscopic ligamentoplasty (bone–tendon–tenodesis). A new surgical technique for scapholunate instability: preliminary cadaver study

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Abstract
We present an anatomical study and description of a new surgical technique for arthroscopic treatment of scapholunate ligament injuries. Five cadaver specimens were used to perform the technique. After arthroscopic surgery, anatomic dissection was performed to measure the distances to critical wrist structures such as the posterior interosseous nerve and the radial artery, and the size and position of the plasty. This arthroscopic technique offers three advantages: soft tissue damage is reduced (avoiding an extensive approach and injury to the secondary stabilizers and reducing scar tissue); injury to the posterior interosseous nerve is avoided (maintaining wrist proprioception and the role of the dynamic stabilizers); and a biotenodesis is made that ensures proper placement, tension and functionality of the flexor carpi radialis ligament reconstruction.

Keywords
scapholunate instability, wrist arthroscopy, arthroscopic tenodesis, scapholunate ligament

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Introduction

The treatment of scapholunate ligament injuries is complex and unreliable. Various open techniques have been described for its treatment including capsulodesis, bone–ligament–bone transfers, tenodesis, partial fusions, proximal row carpectomies, etc. (Kuo and Wolfe, 2008; Manuel and Moran, 2007). The development of wrist arthroscopy offers a new range of minimally invasive techniques including debridement, electrocoagulation and percutaneous fixation without opening the wrist. Arthroscopic wrist ligament reconstruction is as yet very difficult.

We have developed an arthroscopic ligamentoplasty for the reconstruction of the scapholunate ligament. We present an anatomical study of its efficacy.

Materials and methods

We have planned and performed the new technique on five cadaver wrists.

Standard arthroscopy

With the cadaver forearm, wrist and hand suspended from the arc wrist tower (Acumed, Hillsboro, OR, USA), the 3/4 and 6R dorsal radiocarpal portals and radial and

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Figure 1. Cadaver forearm, wrist and hand suspended from the arc wrist tower (Acumed, Hillsboro, OR, USA).

ulnar midcarpal portals are developed and a wrist standard arthroscopy is performed (Figure 1).

Scaphoid tunnel

With the optic in the 6R portal and under fluoroscopic control, a Kirschner wire is introduced through the 3/4 portal. The insertion point of the wire is made 10 mm radial to the dorsal portion of the scapholunate ligament and the exit point is in the scaphoid tubercle (Figure 2A). A 3 mm drill bit is used to make the tunnel (Figure 2B).

Lunate tunnel

It must be performed centred on the lunate, at the level of the dorsal portion of the scapholunate ligament.

The insertion point usually corresponds to the most ulnar portion of the fourth compartment, therefore a 1.5–2 cm longitudinal cutaneous incision is performed (Figure 2C). Afterwards, the extensor retinaculum is opened longitudinally and the extensor tendons of the fourth compartment are retracted towards the ulnar side, gaining access to the dorsal capsule of the carpus (Figure 3).

The Kirschner wire is introduced parallel to the lunate articular surface, with care to avoid advancing the wire more than 2–3 mm further than the volar cortex in order to avoid damage to the volar structures.

The lunate tunnel is also made with the 3 mm drill bit (Figure 2D).

Recovery of the plasty

With the arthroscope in the 6R portal, a 1 cm capsulotomy is performed to connect the lunate tunnel with the radiocarpal joint. Either a curved suture lasso (Arthrex, Naples, FL, USA), or a thread loop is introduced and is taken out through the 3/4 portal (Figure 2E).

Another straight suture lasso is passed through the loop and taken to the volar side of the wrist through the scaphoid tunnel (Figures 2F and 4).

Flexor carpi radialis graft (FRC)

A 2 cm curved incision is made from the exit of the suture lasso to the FRC tendon. In this incision, the superficial branch of the radial artery is frequently found, which must be either dissected out or coagulated.

A strip of distally based FCR tendon 3–4 mm thick and 8–10 cm long is raised in a standard manner.

Plasty passage along the osseous tunnel

The passage through the scaphoid tunnel is carried out by capturing the tendon strip with the straight lasso suture and pulling until it is taken out through the 3/4 portal (Figure 2G,H).

The tendon strip remains inside the first loop, it is captured and it is taken out through the capsulotomy under the fourth compartment (Figures 2I,J).

After finding the suitable length of the tendon strip, a crossed suture is made and the excess tendon is excised (Figure 2K).

The volar exit of the lunate tunnel is located with fluoroscopic control and a small cutaneous incision of 1–1.5 cm is made. Using blunt dissection, the volar capsule and the lunate tunnel are reached. This approach is the same as the one used in the volar ulnar arthroscopy portal (Slutsky, 2004). The superficial flexor tendons are retracted, thus protecting the median nerve.

A suture passing wire (Arthrex, Naples, FL, USA), is introduced through the lunate tunnel from dorsal to volar and the crossed suture strings are taken out to the volar approach (Figure 2L). Pulling on them will introduce the tendon strip inside the lunate tunnel (Figure 2M).

Plasty fixation with biotenodesis screws

The arthroscope is placed in the radial midcarpal portal and the probe in the ulnar midcarpal portal.

(A) (B) (C) (D)

(E) (F) (G) (H)

(I) (J) (K) (L)

(M) (N) (O) (P)

Figure 2. Surgical technique.

Pulling the suture strings it can be seen how the scapholunate space is closed and the proper tension of the reconstruction is assessed.

Whilst maintaining the correct tension the first 3 × 8 mm biotenodesis screw is introduced in the scaphoid tunnel and the second one in the lunate tunnel (Figure 2N).

The ligamentoplasty BTT – Bone (base of second metacarpal bone) Tendon (flexor carpi radialis graft) Tenodesis (in the scaphoid and lunate) – is completed.

Anatomical study of the proposed technique

In order to check the efficacy of the proposed in vitro technique, the specimens were dissected and the following assessed: the sizes of the approaches (Table 1); the distances to the at risk structures (Table 2); and the sizes and positions of the ligament reconstruction (Table 3).

Results

The soft tissue injury was minimal, compared with open reconstructions: 1.7 cm dorsal approach, 1.4 cm extensor retinaculum opening and 0.6 cm capsulotomy (Figure 5).

The posterior interosseous nerve was not damaged in any of the specimens, with an average distance of 7.4 mm from the arthrotomy to the nerve (Figure 6).

Figure 3. Dorsal approach. A: Retinaculum opening. B: Dorsal capsule exposure.

Figure 4. The straight suture lasso is passed through the loop and taken to the wrist's volar zone through the scaphoid tunnel.

Table 1. The sizes of the approaches (mm)

Case number	Dorsal approach over the lunate	Volar approach over the scaphoid	Proximal approach over FRC sheath	Volar approach over the lunate	Retinaculum opening	Capsulotomy
Case I	17	20	25	14	14	7
Case II	15	15	15	10	12	6
Case III	14	25	30	13	13	6
Case IV	19	20	19	13	14	5
Case V	20	30	27	16	15	8
Mean	17	22	23.2	13.2	13.6	6.4

There were no injuries to the radial artery or the superficial radial artery which were at an average of 15.6 mm and 10.6 mm respectively from the exit of the tunnel in the scaphoid tubercle. But in all cases, the superficial radial artery crossed the volar approach.

The ligament reconstruction was always located at the dorsal portion of the scapholunate ligament, with a mean thickness of 4 mm and a mean length of 20 mm (Figure 7).

Finally, there were no carpal bone fractures whilst making the tunnels.

Table 2. The distances to the at risk structures (mm)

Case number	Posterior interosseous nerve – capsulotomy	Scaphoid tunnel – superficial radial artery	Scaphoid tunnel – radial artery	Lunate volar approach – median nerve	Lunate volar approach – median nerve superficial branch
Case I	8	9	14	16	20
Case II	8	11	16	10	15
Case III	4	4	15	16	20
Case IV	9	19	18	17	23
Case V	8	10	15	16	19
Mean	7.4	10.6	15.6	15	19.4

Table 3. The sizes and positions of the ligament reconstruction (mm)

Case number	Plasty thickness	Plasty length	Scaphoid tunnel – scapholunate ligament	Lunate tunnel – scapholunate ligament
Case I	4	16	8	8
Case II	4	16	6	10
Case III	4	18	7	11
Case IV	3	25	13	12
Case V	5	25	15	10
Mean	4	20	9,8	10.2

Discussion

This technique requires discussion under four key headings: (1) why current treatment requires a new technique; (2) what are the anatomical and pathophysiological justifications; (3) what are the advantages and potential risks or complications; and (4) when is this technique indicated.

Why current treatment requires a new technique

Scapholunate instability is divided into three types: predynamic (ligament partial injury), dynamic (ligament complete injury with secondary stabilizer integrity) and static (ligament and secondary stabilizer complete injuries) (Garcia-Elias et al., 2006).

Current treatments are based on two different approaches: arthroscopic treatment relies on debridement, vaporization and percutaneous Kirschner wires; and open treatment uses multiple techniques such as capsulodesis, bone–tendon–bone, tenodesis, etc. Arthroscopic treatment has yielded good results when applied to predynamic instabilities (Darlis et al., 2005; Hirsh et al., 2005), but when applied to complete scapholunate ligament injuries the success rate decreases markedly (Darlis et al., 2006). This is presumably because there is no real anatomical reconstruction of the ligament which, in chronic injuries, has little healing capacity. Open treatment enables a ligament reconstruction, but implies a wide approach and longer immobilization (Kuo and Wolfe, 2008; Manuel and Moran, 2007). The triple tenodesis proposed by Garcia-Elias et al. (2006) is one of the most used open treatments giving success rates of around 80% but with a marked loss of mobility. Our technique aims to reproduce the triple tenodesis technique but with an arthroscopic approach reducing soft tissue trauma.

Anatomical and pathophysiological advantages

Anatomically, the scapholunate ligament has a 'C' shape, with volar, dorsal and proximal membranous portions. Our technique, as in other tenodesis procedures (Brunelli and Brunelli, 1995; Garcia-Elias et al.,

Figure 5. A: Dorsal portals and extensor retinaculum opening. B: Dorsal capsulotomy.

Figure 6. Posterior interosseous nerve with an average distance of 7.4 mm from the arthrotomy to the nerve.

2006), reconstructs only the dorsal portion of the scapholunate ligament because it is the strongest portion and the most significant for the mechanical function of the scapholunate ligament.

Figure 7. The plasty is located at the dorsal portion of the scapholunate ligament.

Physiologically the different parts of the ligament have different functions as shown in recent anatomical, histological and immunohistochemical studies of the wrist ligaments (Hagert et al., 2005; 2007; Viegas, 2001). There are two major groups of ligaments, those with a high density of collagen and low density of mechanoreceptors and those that have less dense connective tissue but are richly innervated. The first includes the ligaments with predominantly mechanical functions (involved in motion resistance and carpal stability); the second comprises the ligaments with a predominantly proprioceptive function. This division between 'mechanical and proprioceptive' types has been studied in the scapholunate ligament (Mataliotakis et al., 2009). The volar portion appears to be predominantly proprioceptive while the dorsal portion is predominantly mechanical. The ligamentoplasty we describe reconstructs only the dorsal area of the scapholunate ligament (the mechanical portion), without affecting the 'proprioceptive' volar ligament.

In scapholunate instabilities the scaphoid tends to flexion and pronation, rotating around the radioscaphoid–capitate ligament. This has been verified in cadaver studies (Short et al., 2005).

Flexion is corrected with the first tenodesis over the scaphoid tunnel since a secondary stabilizer is reconstructed and scaphoid extension is assisted by keeping it linked to base of the second metacarpal. Pronation is corrected with the second tenodesis,

Figure 8. By pulling the plasty from the lunate volar zone, the dorsal portion of the scapholunate articulation is closed, so the scaphoid is supinated and thus the dorsal conflict of the scapholunate instability is avoided.

linking the dorsum of the proximal scaphoid and the lunate (Figure 8).

Theoretical advantages and risks

This technique provides two theoretical advantages. First, it minimizes the surgical approach decreasing the scar tissue and, theoretically, preserving the ranges of movement better than the open techniques.

The second advantage is based on maintaining the proprioception integrity by avoiding damage to both the posterior interosseous nerve and the volar part of the ligament.

There are potential risks. The most relevant and worrying relate to carpal bone tunnelling because fractures can occur during tunnel creation or in the postoperative period. To avoid fractures, the positioning of the guide wires is critical. Another potential risk arises from devascularization and lunate necrosis. The capsulotomy is dorsal whilst the blood supply is greater in the volar side of the lunate. The palmar nutrient vessels enter the lunate through the RSL ligament, RLT ligament and ULT ligament, so the tunnel centred in the lunate should not damage these peripheral vessels (Lamas et al., 2007). With a limited surgical approach, vascularization should not be significantly damaged and necrosis will probably not occur. Even in open tenodeses as described by Almquist et al., (1991) or the triple tenodesis (Garcia-Elias et al., 2006) it does not happen frequently.

Indications for this technique

We believe the indications for our arthroscopic ligamentoplasty are very clear: Geissler lesions type III and IV in which there is a dynamic or static instability that is easily reducible percutaneously.

With this technique, two of the three objectives of the three-ligament tenodesis are achieved: the reconstruction of the dorsal portion of the scapholunate ligament; and the reinforcement of the volar and distal capsules (the secondary stabilizers). However, this technique does not tighten the dorsal radiotriquetral ligament. If this is injured that is a contraindication for this technique.

Conclusion

With this new arthroscopic technique we have three main objectives aimed at improving the current open techniques:

- Reduce soft tissue injury by minimizing dissection and thus greater postoperative mobility should be achieved.
- Avoid posterior interosseous nerve injury, thus maximizing the proprioception of the wrist and the role of the dynamic stabilizers.
- Make a biotenodesis that ensures optimal placement, tension and functionality of the ligament reconstruction.

We are confident that the technique is technically feasible in a systematic and reproducible manner, with a wide margin of safety.

This anatomical study has enabled us to develop the skills to perform the technique in clinical application. The theoretical advantages are clear, but the technique needs to be proven in vivo.

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Conflict of interests

None declared.

References

Almquist EE, Bach AW, Sack JT, Fuhs SE, Newman DM. Four-bone ligament reconstruction for treatment of chronic complete scapholunate separation. J Hand Surg Am. 1991, 16: 322–7.

Brunelli GA, Brunelli GR. A new technique to correct carpal instability with scaphoid rotary subluxation: A preliminary report. J Hand Surg Am. 1995, 20: S82–5.

Darlis NA, Kaufmann RA, Giannoulis F, Sotereanos DG. Arthroscopic debridement and closed pinning for chronic dynamic scapholunate instability. J Hand Surg Am. 2006, 31: 418–24.

Darlis NA, Weiser RW, Sotereanos DG. Partial scapholunate ligament injuries treated with arthroscopic debridement and thermal shrinkage. J Hand Surg Am. 2005, 30: 908–14.

Garcia-Elias M, Lluch AL, Stanley JK. Three-ligament tenodesis for the treatment of scapholunate dissociation: Indications and surgical technique. J Hand Surg Am. 2006, 31: 125–34.

Hagert E, Forsgren S, Ljung BO. Differences in the presence of mechanoreceptors and nerve structures between wrist ligaments may imply differential roles in wrist stabilization. J Orthop Res. 2005, 23: 757–63.

Hagert E, Garcia-Elias M, Forsgren S, Ljung BO. Immunohistochemical analysis of wrist ligament innervation in relation to their structural composition. J Hand Surg Am. 2007, 32: 30–6.

Hirsh L, Sodha S, Bozentka D, Monaghan B, Steinberg D, Beredjiklian PK. Arthroscopic electrothermal collagen shrinkage for symptomatic laxity of the scapholunate interosseous ligament. J Hand Surg Br. 2005, 30: 643–7.

Kuo CE, Wolfe SW. Scapholunate instability: Current concepts in diagnosis and management. J Hand Surg Am. 2008, 33: 998–1013.

Lamas C, Carrera A, Proubasta I, Llusa M, Majó J, Mir X. The anatomy and vascularity of the lunate: Considerations applied to Kienböck's disease. Chir Main. 2007, 26: 13–20.

Manuel J, Moran SL. The diagnosis and treatment of scapholunate instability. Orthop Clin North Am. 2007, 38: 261–77. (vii).

Mataliotakis G, Doukas M, Kostas I, Lykissas M, Batistatou A, Beris A. Sensory innervation of the subregions of the scapholunate interosseous ligament in relation to their structural composition. J Hand Surg Am. 2009, 34: 1413–21.

Short WH, Werner FW, Green JK, Masaoka S. Biomechanical evaluation of the ligamentous stabilizers of the scaphoid and lunate: Part II. J Hand Surg Am. 2005, 30: 24–34.

Slutsky DJ. The use of a volar ulnar portal in wrist arthroscopy. Arthroscopy. 2004, 20: 158–63.

Viegas SF. The dorsal ligaments of the wrist. Hand Clin. 2001, 17: 65–75. (vi).