Partial Scapholunate Ligament Injuries Treated With Arthroscopic Debridement and Thermal Shrinkage

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Purpose: To present the early results of arthroscopic debridement and thermal shrinkage using radiofrequency probes for partial (Geissler grades I and II) scapholunate (SL) interosseous ligament injuries of the wrist.

Methods: Sixteen patients with a mean age of 34 years (range, 18–54 y) presenting with chronic dorsoradial wrist pain unresponsive to initial conservative treatment for a mean period of 12 weeks were included in this study. No patient showed radiologic signs of static dissociation (SL interval, $<$3.5 mm; mean SL angle, 49°) before surgery. Diagnostic arthroscopy showed a partial SL tear in 14 patients and redundancy of the ligament in 2. Partial SL tears involved the membranous (proximal) and volar part of the ligament. All lesions were debrided and treated with thermal shrinkage using a bipolar radiofrequency probe.

Results: The mean follow-up period was 19 months (range, 9–34 mo). Fourteen patients experienced substantial pain relief whereas in 2 the pain remained unchanged. Eight patients were completely pain free. The mean flexion-extension arc was 142° and the mean grip strength was 78% that of the unaffected side. No patient showed radiologic signs of arthritis or static or dynamic instability after surgery (SL interval remained $<$3.5 mm; mean SL angle, 53°). Based on the modified Mayo wrist score there were 8 excellent, 6 good, 1 fair, and 1 poor result.

Conclusions: Partial SL ligament tears can be a source of radial-sided wrist pain. Scapholunate ligament debridement and thermal shrinkage effectively provided pain relief for most of the patients treated. Stability was maintained radiographically. No complications were noted from the use of radiofrequency probes. These reasonably favorable short-term results should be viewed cautiously. A longer follow-up study is necessary to determine the ultimate efficacy of this procedure. (J Hand Surg 2005;30A:908–914. Copyright © 2005 by the American Society for Surgery of the Hand.)

Key words: Partial tear, radiofrequency probes, scapholunate ligament, thermal shrinkage, arthroscopic debridement.

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Chronic wrist pain in the presence of normal plain radiographs is a common problem in the practice of hand surgeons. Pain localization in the ulnar or radial aspect of the wrist is helpful in narrowing the possible differential diagnoses. When physical examination is inconclusive and an initial trial of conservative measures fails, wrist arthrography, magnetic resonance imaging, and often diagnostic arthroscopy are used in an attempt to determine the underlying cause of pain. Partial scapholunate (SL) interosseous ligament tears often are identified during diagnostic arthroscopy.[1–9]

Complete ruptures of the SL ligament are thought to lead to static dorsal intercalated segment instability and to result in arthritis in the wrist, which follows the scapholunate advance collapse pattern.[10] The significance of partial SL ligament tears is more obscure. Watson et al[11] identified this injury as one of the main causes of dorsal wrist pain in the absence of radiographic findings (what they called *dorsal wrist syndrome*). In the arthroscopic classification of wrist interosseous ligament instability by Geissler and Freeland[2] (Fig. 1) partial lesions are included. It should be noted that this classification quantifies the resultant instability and not the actual size of the tear, although grade III and IV instability is thought to be the result of complete SL tears. Attempts at arthroscopic debridement alone using synovial resectors for such lesions[3,4] have yielded satisfactory initial results. This was attributed to the stabilizing effect of scar tissue formation after the debridement and to the partial denervation of the wrist.[4] Concerns remain, however, about the possibility of long-term SL instability secondary to a partial SL ligament lesion treated with debridement alone.[3,4] In addition symptomatic redundant SL ligaments pose a dilemma for the surgeon because there is no frank tear to debride.

Recently the availability of radiofrequency (RF) probes for small-joint arthroscopy has permitted a more direct approach to the problem of partial SL ligament tears. Thermal shrinkage has been shown to be feasible in experimental settings for various collagenous tissues including the joint capsule (glenohumeral, patellofemoral), ligaments (medial collateral ligament of the knee), and tendons (patellar and extensor tendons, Achilles' tendon) although concerns over creep and reduced laxity of the treated tissues remain.[12–15] The main clinical application of RF probes for thermal shrinkage has been in the capsular and ligamentous tissues of the glenohumeral joint to treat shoulder instability.[13,14] Recently concerns have been raised about the long-term efficacy of thermal capsulorrhaphy, with a high failure rate (37%) reported at an average follow-up time of 38 months.[16] Other researchers have voiced similar concerns.[17,18] The ability of RF probes to both debride and shrink tissues make them an attractive alternative to mechanized resector debridement of partial SL ligament tears as a means of offering additional stability to the SL joint. We present the initial results of this procedure in 16 patients treated with arthroscopic debridement and thermal shrinkage of the SL ligament using a bipolar RF probe.

Materials and Methods

A retrospective review of the records of patients who had had arthroscopic debridement and thermal shrinkage of the SL ligament in the practice of the senior author (D.G.S.) identified 22 such procedures in 21 patients. In 3 patients the primary complaint was ulnar-sided wrist pain; a concomitant triangular fibrocartilage complex (TFCC) tear was debrided and 1 of these patients had bilateral ulnar-shortening osteotomies. These patients were excluded from this study because the TFCC injury was considered the primary source of their pain. Two more patients were lost to follow-up study.

Sixteen patients (10 men, 6 women) with a mean age of 34 years (range, 18–54 y) were included in this study. Sixteen wrists (9 dominant, 7 nondominant) were treated. All patients complained of wrist pain that was localized radially and dorsally. Thirteen patients could recall an injury to the wrist with a mean interval from injury to surgery of 5.4 months (range, 3–14 mo). Among them there were 4 patients with well-healed distal radius fractures. Three patients could not recall a traumatic event. All patients were unresponsive to initial conservative treatment (with immobilization and/or steroid injection and physiotherapy) for a mean period of 12 weeks (range, 6–18 wk). Five patients were involved in workers' compensation cases.

On physical examination before surgery all patients had pain to palpation dorsally over the SL interval. Additionally 5 patients had pain to palpation over the radial styloid, 2 had pain with radial deviation of the wrist, and 2 had pain to palpation over the flexor carpi radialis tendon palmarly. The Watson scaphoid shift test result was positive for pain in 13 patients and in 1 patient the clunk of scaphoid subluxation was felt bilaterally although it was painful only at the affected side. The preoperative range of motion (ROM) and grip strength values are presented in Table 1.

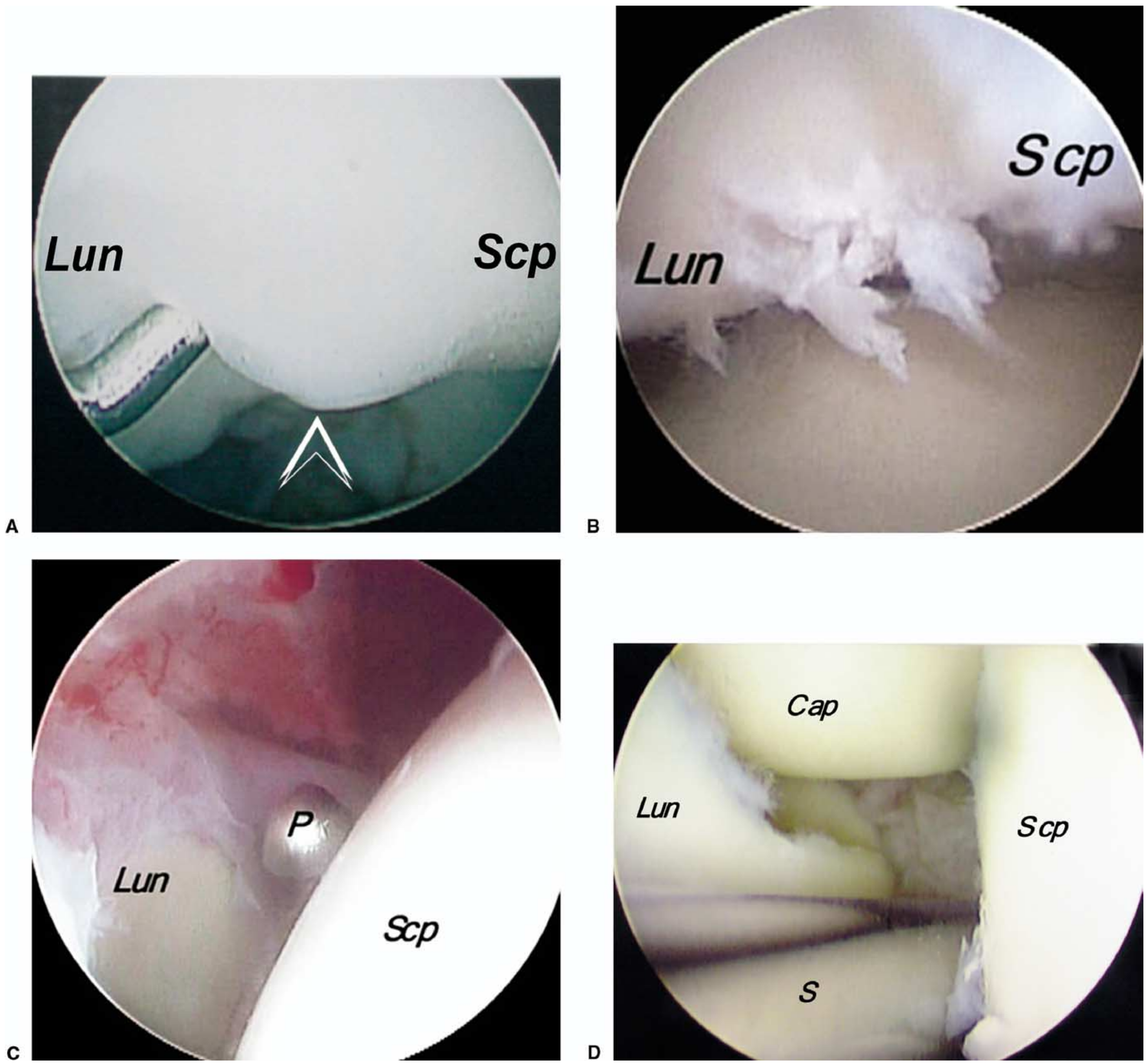

Figure 1. Geissler's arthroscopic classification of scapholunate ligament instability.[2] (A) Grade I, redundancy of the SL ligament. The ligament shows a V sign (arrow) on inspection from the radiocarpal joint. (B) Grade II, partial tear of the SL ligament with minimal gapping between the carpal bones. (C) Incongruence and gapping of the SL ligament. A probe can be passed between the scaphoid and the lunate (view from midcarpal portal). (D) Gross instability. A 2.7-mm arthroscope (or in this case a 3.5-mm shaver) can be passed through the gap in the SL interval. Only grade I and grade II injuries were treated with arthroscopic debridement and thermal shrinkage in this study. LUN, lunate; SCP: scaphoid; CAP, capitate; P, probe; S, shaver.

The preoperative radiographs of all patients were reviewed. No patient had signs of SL dissociation in the neutral and ulnar deviation posteroanterior views with an SL interval less than 3 mm. On the lateral views no signs of dorsal intercalated segment instability were found, with a mean SL angle of 49° (range, 35°–63°). Grip views were available for 11 patients. The SL interval was less than 3.5 mm in all patients. All measurements were performed using computer-aided design tools on digitized images (Medstrat; Medstrat Inc., Downers Grove, IL). Magnetic resonance imaging was performed in 12 patients and SL ligament abnormalities were noted by the radiologist in 9; however, a frank tear was diagnosed only in 6. Widening of the SL interval was not observed on magnetic resonance imaging in any of the patients. A wrist arthrogram was performed in 4 patients; it was interpreted as a possible SL ligament tear in 1.

Wrist arthroscopy was performed using a standard

Table 1. Summary of Results

Parameters	Preoperative Mean (range)	Follow-Up (N = 16) Mean (range)
Range of motion (deg)		
Flexion	62 (35–80)	73 (40–85)*
Extension	66 (30–70)	69 (35–90)†
Radial deviation	18 (5–25)	23 (10–30)†
Ulnar deviation	23 (15–35)	28 (15–45)†
Supination	68 (40–90)	76 (60–90)†
Pronation	72 (50–90)	80 (60–90)†
Grip strength (% vs contralateral)	55 (33–80)	78 (41–105)‡
Pain (visual analog scale)		
Rest	7.2§	2.2‡
Everyday activities	8.0§	4.0‡
Heavy manual work	8.4§	5.2‡

*$p = .02$.
†Not significant.
‡$p < .001$.
§Preoperative visual rating obtained retrospectively.

technique with the arm supported on a tower distraction device and 4.5 to 6.5 kg of distraction applied to the wrist. The 3-4 portal was used for viewing, the 6U portal was used for outflow, and the 4-5 and 6R portals were used for instrumentation. The wrist was examined from radial to ulnar and the SL interval stability was examined by probing the joint. In cases in which SL stability was doubtful midcarpal arthroscopy was performed (in 7 patients in the series) and stability was assessed from the midcarpal portal as well. The SL ligament was considered stable in all patients—that is, the probe could not be passed through the SL interval either from the radiocarpal or from the midcarpal side of the joint. Once the SL joint was deemed stable the SL ligament partial tear first was debrided with a synovial resector, and then a 2.3 mm bipolar RF probe (Vapr; Mitek, Westwood, MA) was introduced and thermal shrinkage of the SL ligament rim was performed (Fig. 2). The 4-5 portal provides easier access to the SL ligament for this procedure. Redundant SL ligaments were treated with thermal shrinkage alone. All the partial tears were located in the membranous (proximal) and volar portions of the SL interosseous ligament. Thermal shrinkage included the torn rim of the volar and proximal SL ligament and also extended to part of the dorsal portion (which was intact in all patients in this study). Thermal shrinkage was performed by applying the probe to the intact part of the ligament in a paintbrush fashion and confirming visually the changes in color and consistency of the tissue without causing ablation. Concomitant central TFCC tears were treated with debridement using the same RF probe. The RF probe was applied intermittently for a few seconds at a time and adequate outflow was ensured throughout the procedure to avoid overheating of the joint. At the end of the procedure the wrist was immobilized in a short arm splint.

After surgery a splint was used full time for 2 weeks and a removable cock-up splint was used intermittently between physiotherapy sessions for another 4 weeks. Range-of-motion exercises were initiated in the second postoperative week and strengthening exercises were introduced after the fourth week. Patients were allowed to return to light-duty work at the end of the sixth week.

Diagnostic arthroscopy showed a Geissler grade II

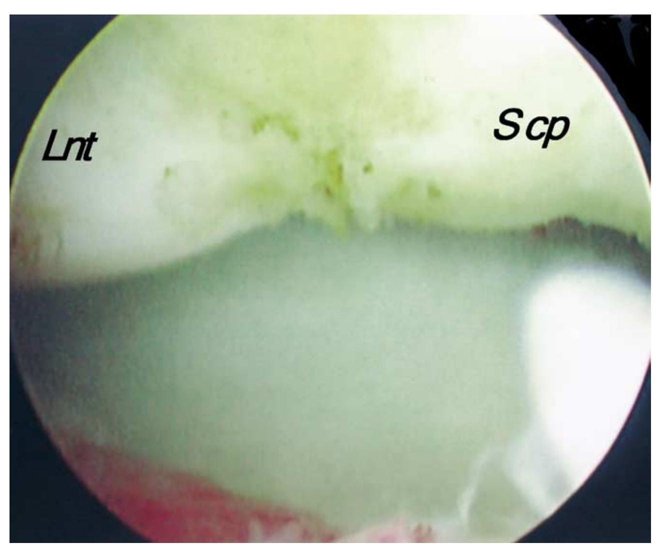

Figure 2. The Geissler grade II partial SL ligament tear shown in Figure 1B after it was treated with thermal shrinkage using an RF probe. SCP, scaphoid; LNT, lunate.

partial SL tear (Fig. 1B) in 14 patients whereas in 2 the ligament was attenuated (Geissler grade I) (Fig. 1A). All lesions were types I or II in the Geissler classification. Three patients had a concomitant small central TFCC tear. All SL lesions were treated with thermal shrinkage using a bipolar RF probe and all TFCC lesions were debrided using the same probe. None of the patients with concomitant TFCC lesion in this series complained of ulnar-sided wrist pain; patients with TFCC lesions and ulnar-sided wrist pain were excluded from this study. Chondral lesions of the scaphoid were detected in 3 patients and synovitis was detected in 12.

At follow-up examination patients were asked to record their pain level at rest, during everyday activities, and during heavy manual work on a 10-point visual analog scale in which 0 indicated no symptoms and 10 indicated pain as bad as it possibly could be. The patients also were asked to record their preoperative pain levels. The wrist ROM was measured and grip strength was measured both in the affected and the contralateral extremity with a hydraulic dynamometer (Jamar; Sammons Preston, Bolingbrook, IL). Standard posteroanterior, lateral, and grip view radiographs of the affected wrist were obtained. The SL interval on the posteroanterior views and the SL angle on the lateral views were measured and both views were assessed for joint space narrowing and sclerosis indicative of arthritis. The modified Mayo wrist score[19] was used to assess results. Statistical analysis was performed using the Student *t* test to compare preoperative and postoperative values; p values less than .05 were considered statistically significant.

Results

The mean follow-up period was 19 months (range, 9–34 mo) (Table 1). Fourteen patients experienced substantial pain relief whereas in 2 the pain remained unchanged. Eight patients were completely pain free. Six patients reported pain only with strenuous activities; among them 2 recalled a new injury to the wrist. Overall pain visual analog scale scores improved significantly ($p < .001$) both during rest and during activities. The mean flexion-extension arc was 142° and the mean grip strength was 78% that of the unaffected side. No statistically significant changes over preoperative values were observed for ROM measurements other than wrist flexion, which improved marginally ($p = .02$). Grip strength improved significantly over preoperative values ($p < .001$).

No perioperative complications occurred. During the follow-up period 1 patient developed carpal tunnel syndrome of the affected extremity that was treated with splinting until the last follow–up evaluation. Another patient developed de Quervain's tenosynovitis, which was treated with local steroid injection

No patient had radiographic deterioration (exhibited as arthritis or static or dynamic instability). In all patients the SL interval remained less than 3.5 mm at the latest follow-up evaluation, including the 2 patients who had sustained a new injury to the wrist. The mean SL angle on the lateral view remained within normal limits (mean, 53°, range, 45°–68°).

In the modified Mayo wrist score[19] there were 8 excellent, 6 good, 1 fair, and 1 poor result. Of the 11 patients who were employed at the time of the procedure, 6 returned to the same or similar work duties and 3 to a lighter duty. One patient is unemployed for reasons unrelated to the surgery and another patient is currently on disability. A young professional tennis player was unable to return to competitive sporting activity although he had excellent ROM, pain only when playing tennis, and a good overall result. The 1 fair result was that of a 33-year-old female patient with mild pain and stiffness but severe limitation of grip strength. A 54-year-old truck driver continued to complain of severe pain during activities after the procedure and was unable to return to work, constituting a poor result. That patient was involved in workers' compensation litigation. His radiographs remained unremarkable at the final follow-up evaluation and he declined further investigation or treatment.

Discussion

The most consistent finding of this study is symptomatic relief. Although there are limitations to retrospective visual analog scale pain assessment, 14 of 16 patients reported substantial pain relief after arthroscopic debridement and thermal shrinkage of the partially torn SL ligament. Patients with a concomitant TFCC tear and ulnar-sided wrist pain were excluded from this study to avoid overlap of the 2 procedures. This study verifies the view that a partially torn SL ligament can be a source of pain to the wrist.[3,4,11] Although partial degenerative tears have been found in 19% of cadaveric wrist dissections[20] the average age of the specimens in that study was 78 years, which is much older than the mean age of our patients (34 y). Partial SL ligament tears are found in the proximal and volar portion of the SL ligament. Compared with the dorsal portion the proximal and volar portions are considerably thinner (<1 mm compared with 2–3 mm) and can withstand less than half of the tensile stress (25–150 N compared with 300 N).[21] To facilitate the inspection of the volar portion of the SL ligament, an additional volar viewing portal (through the flexor carpi radialis tendon sheath) has been proposed.[22] This seldom has been a significant problem in our experience.

Two previous studies have described debridement alone for partial SL tears. Ruch and Poehling[3] reported 7 partial SL ligament tears treated with arthroscopic debridement. Included in that study were only patients with tears of the membranous portion of the SL ligament (volar and dorsal portions intact) and a flap that resulted in mechanical impingement (causing catching or clicking). All 7 patients were reported to be satisfied by the procedure and none had radiologic evidence of instability at a mean follow-up time of 34 months. Weiss et al[4] in a study that presented results of arthroscopic debridement for partial and complete tears of the SL and lunotriquetral ligaments included 13 patients with partial SL tears. Of these patients 85% reported symptomatic relief at a mean follow-up time of 27 months compared with 67% of patients with complete SL tears. No statistically significant deterioration in radiographs was found in that study.

The patient population in the study by Ruch and Poehling[3] was somewhat different than ours. Most of the patients in our study had a tear extending to the volar portion of the ligament and mechanical impingement was an infrequent complaint. The study by Weiss et al[4] presented limited data on pain assessment (symptomatic improvement was referred to cumulatively as "symptoms resolved or improved"). Given these differences no meaningful direct comparison can be made with this series. Our approach with debridement and thermal shrinkage yielded satisfactory results regarding pain relief. It is unclear how much thermal shrinkage alone contributed to pain relief. The fact that the 2 patients with partial SL ligament tears treated with thermal shrinkage alone had complete pain relief is indicative of such a contribution. The main purpose of thermal shrinkage, however, is to prevent instability.

The limitation of all available studies (including ours) is the short follow-up time. Scapholunate interval stability should be interpreted with caution because a recent study on the natural history of untreated Geissler types 1 and 2 SL ligament tears found no radiologic signs of instability at an average follow-up time of 7 years.[9] Nevertheless the patients in that study continued to experience considerable pain, restriction in the flexion-extension arc (mean, 80°) and functional limitation. It is clear that the natural history of these lesions is not favorable. The patients in our study achieved a mean flexion-extension arc of 142° and significantly improved grip strength. After surgery improvement in ROM reached statistical significance only for flexion but good preoperative ROM was maintained in all other planes. Range of motion was found to be almost full in both of the 2 aforementioned studies[3,4] and in this study.

Diagnosis of partial SL ligament tears can be difficult. Plain radiographs can be unremarkable; arthrography has only 60% sensitivity on SL ligament tears and cannot differentiate complete from partial tears.[23] Magnetic resonance imaging can be helpful in differentiating other sources of chronic wrist pain but its role in diagnosing SL ligament tears has been questioned, with its sensitivity reported to be between 37% and 63% compared with arthroscopy.[5,24] This also has been our experience in this study. In our practice pain to palpation dorsally over the SL interval and pain with Watson's scaphoid shift test in a patient with chronic wrist pain may be diagnostic of a partial SL ligament tear. Wrist arthroscopy should be considered with these findings.

Radiofrequency probes work by creating a high-frequency alternating current between their tips. Heat is generated by friction of ions in the tissue treated as they try to follow this alternating current. The only limitation to their use is in patients with pacemakers or other implantable electronic devices. In the tissue treated a very narrow rim of heating typically occurs (<1 mm). When the temperature in that tissue rim reaches approximately 60°C the collagen triple helix unwinds, leading to reduction of the length of the molecule and tissue shrinkage.[12–14] When the temperature exceeds 100°C water in the tissue treated is vaporized and ablation of the tissue occurs. In contrast to the electrocautery devices the RF probe itself is not heated but heat is generated in the tissue. The amount of heating that occurs is determined by the distance from the probe, the size of the probe, the temperature and flow rate of the arthroscopic irrigation, and the duration of application.[25] Current systems rely on visual inspection of the tissues to determine adequate probe application. Overzealous RF probe application should be avoided when tissue shrinkage is required because the same probes are used for tissue ablation and thermal shrinkage. Recently dedicated RF probes for thermal shrinkage in small joints became available and offer additional safety for the procedure because they do not exceed ablation temperatures.

The healing response of the tissues treated with thermal modification is considered important in maintaining its strength. Concerns over the biomechanical properties of the treated tissues have been expressed, especially concerning creep and reduced elasticity, in experimental studies.[12,13,15] It seems that the extent to which these phenomena occur is influenced by multiple factors such as the type of tissue treated, the amount and duration of thermal energy delivery, and the extent of tissue shrinkage. The change in biomechanical properties is reversible and the recovery period is reported to be between 2 and 12 weeks.[12,14] Thus it is important to protect the treated tissues (the SL ligament in this case) from overloading during the first postoperative weeks. From the results of this study it appears that these phenomena do not play a clinically significant role in SL ligament thermal shrinkage because stability of the SL interval was maintained in all cases.

The initial results of debridement and thermal shrinkage for partial SL ligament injuries indicate that this approach is efficient in providing pain relief for the majority of patients treated. Radiofrequency probe application for thermal shrinkage was found to be safe with no complications noted. Although the short-term results presented in this study are favorable longer follow-up study is necessary to determine the ultimate efficacy of thermal shrinkage in maintaining stability of the SL interval.

References

1. Dautel G, Goudot B, Merle M. Arthroscopic diagnosis of scapho-lunate instability in the absence of x-ray abnormalities. J Hand Surg 1993;18B:213–218.
2. Geissler WB, Freeland AE. Arthroscopically assisted reduction of intraarticular distal radial fractures. Clin Orthop 1996;327:125–134.
3. Ruch DS, Poehling GG. Arthroscopic management of partial scapholunate and lunotriquetral injuries of the wrist. J Hand Surg 1996;21A:412–417.
4. Weiss APC, Sachar K, Glowacki KA. Arthroscopic debridement alone for intercarpal ligament tears. J Hand Surg 1997; 22A:344–349.
5. Johnstone DJ, Thorogood S, Smith WH, Scott TD. A comparison of magnetic resonance imaging and arthroscopy in the investigation of chronic wrist pain. J Hand Surg 1997; 22B:714–718.
6. Kozin SH. The role of arthroscopy in scapholunate instability. Hand Clin 1999;15:435–444.
7. Ruch DS, Smith BP. Arthroscopic and open management of dynamic scaphoid instability. Orthop Clin North Am 2001;32:233–240.
8. Walsh JJ, Berger RA, Cooney WP. Current status of scapholunate interosseous ligament injuries. J Am Acad Orthop Surg 2002;10:32–42.
9. O'Meeghan CJ, Stuart W, Mamo V, Stanley JK, Trail IA. The natural history of an untreated isolated scapholunate interosseus ligament injury. J Hand Surg 2003;28B:307–310.
10. Watson HK, Ballet FL. The SLAC wrist: scapholunate advanced collapse pattern of degenerative arthritis. J Hand Surg 1984;9A:358–365.
11. Watson HK, Weinzweig J, Zeppieri J. The natural progression of scaphoid instability. Hand Clin 1997;13:39–49.
12. Wallace AL, Hollinshead RM, Frank CB. The scientific basis of thermal capsular shrinkage. J Shoulder Elbow Surg 2000;9:354–360.
13. Hayashi K, Markel MD. Thermal capsulorrhaphy treatment of shoulder instability: basic science. Clin Orthop 2001;390: 59–72.
14. Medvecky MJ, Ong BC, Rokito AS, Sherman OH. Thermal capsular shrinkage: basic science and clinical applications. Arthroscopy 2001;17:624–635.
15. Wallace AL, Hollinshead RM, Frank CB. Creep behavior of a rabbit model of ligament laxity after electrothermal shrinkage in vivo. Am J Sports Med 2002;30:98–102.
16. D'Alessandro DF, Bradley JP, Fleischli JE, Connor PM. Prospective evaluation of thermal capsulorrhaphy for shoulder instability: indications and results, two- to five-year follow-up. Am J Sports Med 2004;32:21–33.
17. Levine WN, Bigliani LU, Ahmad CS. Thermal capsulorrhaphy. Orthopedics 2004;27:823–826.
18. Chen S, Haen PS, Walton J, Murrell GAC. The effects of thermal capsular shrinkage on the outcomes of arthroscopic stabilization for primary anterior shoulder instability. Am J Sports Med 2005;33:705–711.
19. Cooney WP, Bussey R, Dobyns JH, Linscheid RL. Difficult wrist fractures. Perilunate fracture-dislocations of the wrist. Clin Orthop 1987;214:136–147.
20. Wright TW, Del Charco M, Wheeler D. Incidence of ligament lesions and associated degenerative changes in the elderly wrist. J Hand Surg 1994;19A:313–318.
21. Sokolow C, Saffar P. Anatomy and histology of the scapholunate ligament. Hand Clin 2001;17:77–81.
22. Abe Y, Doi K, Hattori Y, Ikeda K, Dhawan V. Arthroscopic assessment of the volar region of the scapholunate interosseous ligament through a volar portal. J Hand Surg 2003;28A: 69–73.
23. Weiss APC, Akelman E, Lambiase R. Comparison of the findings of triple-injection cinearthrography of the wrist with those of arthroscopy. J Bone Joint Surg 1996;78A:348–356.
24. Schädel-Höpfner M, Iwinska-Zelder J, Braus T, Böhringer G, Klose KJ, Gotzen L. MRI versus arthroscopy in the diagnosis of scapholunate ligament injury. J Hand Surg 2001;26B:17–21.
25. Owens BD, Stickles BJ, Busconi BD. Radiofrequency energy: applications and basic science. Am J Orthop 2003; 32:117–120.