Scapholunate Interosseous Ligament Disruption in Professional Basketball Players Treatment by Direct Repair and Dorsal Ligamentoplasty

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Functioning as the primary stabilizer of the scapholunate (SL) articulation,1–5 the intact SL interosseous ligament (SLIL) is vital to normal carpal mechanics. The integrity of the ligament is a requisite for unimpaired synchronous kinematics of the complex carpal articulations. In contrast, traumatic disruption, a not infrequent occurrence, of SLIL results in SL dissociation (SLD) (Fig. 1) and a highly dysfunctional wrist prone to debilitating degenerative joint disease. Moreover, disruption of the SLIL is the initial and constant lesion in the continuum of progressive perilunar instability that results in a wide spectrum of increasingly severe carpal derangement and culminates in perilunate dislocation.6,7 In a previous report of the operative pathology and management of advanced-stage perilunate injuries, the senior author (CPM) concluded that for the skilled athlete, precise repair and thorough healing of this lesion is essential for a successful return to competitive sports.8

Unanimity exists that for complete SLIL disruption with resultant SLD, especially in the high-demand athlete, operative treatment is necessary and that the acute injury affords the optimal conditions for direct ligament repair and an expectant favorable outcome.9–11 This article reports the

KEYWORDS/C15
Scapholunate interosseous ligament repair/C15
Scapholunate dissociation/C15
Carpal instability/C15
Sports injuries wrist/C15

KEY POINTS/C15
- Surgical repair with augmentation ligamentoplasty is indicated for disabling scapholunate interosseous ligament (SLIL) disruption before the occurrence of static, fixed scapholunate dissociation (SLD).
- Successful SLIL surgery depends on early diagnosis and operative intervention presenting with a reducible scaphoid, a reparable ligament, and an arthritis-free wrist.
- Intensive sport-specific rehabilitation is a prerequisite for optimal recovery with an unrestricted return to competition.
- Radiographic evidence of degenerative joint disease is apt to occur with increasing follow-up but seldom correlates with functional decline and rarely requires additional surgery.
authors’ experience with comprehensive surgical management of disabling SLD in a select group of professional basketball players and emphasizes the critical need for prompt detection and early repair of destabilizing SLIL disruption.

CLINICAL STUDY

Between 1995 and 2010, 25 professional basketball players, actively competing in national or international professional basketball leagues and in the prime of their careers, required surgery for disabling SLIL disruption incurred during competition. All injuries were categorized as Mayfield stage I perilunar injuries,6,7 as well as Mayo type I A carpal dislocations.12 Eighteen players of the group have been available for sequential postoperative evaluation over a period averaging 62 months (18–180 months). The average age of the players was 26 years (21–34 years). The dominant wrist was injured in 15 players and the nondominant side in 3. By their position in the game, 14 of the group were guards or small forwards (1, 2, and 3 positions) and 4 were power forwards or centers (4 and 5 positions, so called "bigs"). The time of surgery ranged from 1 week to 18 weeks after injury. Sixteen players of the group were treated between 4 and 8 weeks after injury, a time frame considered relatively brief when compared with intervals between injury and surgery reported in others series of direct SLIL repair.13–16

Common to all in this series were a static but flexible SLD (demonstrated clearly by standard radiography), a reducible scaphoid, a reparable ligament, and a wrist devoid of articular damage. For the group, comprehensive management comprised direct SLIL repair, dorsal intercarpal ligament (DICL) augmentation, and long-arm cast immobilization for 8 weeks followed immediately by intensive sport-specific rehabilitation.

DIAGNOSTIC FEATURES

Despite initial treatment with oral and topical anti-inflammatory modalities, analgesics, and short-term splinting, persistent wrist pain with any attempt at skilled or strenuous usage was the paramount symptom preoperatively. Repeated examination demonstrated classic signs of SLIL disruption: dorsal wrist swelling and tenderness; a prominent, tender proximal pole of the scaphoid, often associated with a palpable gap at the SL juncture; a painfully positive scaphoid shift test17; and severe limitations of both wrist motion and grip strength.

High-quality radiography18–20 with standard posteroanterior, lateral, and oblique projections, supplemented with anteroposterior views of radioulnar deviation and clenched fist, and always with contralateral comparison studies, consistently confirmed the diagnosis. An SL gap exceeding 3 mm, accentuated by the clenched fist compression and ulnar deviation views, compared with that of the contralateral wrist, and an SL angle in excess of 70° as visualized on the true lateral projection have been defined as the radiographic hallmarks of SLD19–22 and have been demonstrated in all patients. In this series of patients, preoperatively, the SL gap averaged 6.5 mm (4–12 mm) and the SL angle averaged 81° (71°–93°), clearly indicating substantial ligament damage with carpal instability. Although these measures usually suffice for an accurate diagnosis, the professional athlete often requires additional objective corroboration before authorization for surgery. In such patients, precision magnetic resonance imaging techniques, such as those described by Moser and colleagues,23 have provided confirmation of the complete ligament disruption.

SURGICAL TECHNIQUES

The operative techniques used for the treatment of these patients are similar to those described previously for direct ligament repair.13–15,22,24,25 The operation incorporates a ligament sparing capsulotomy (Fig. 2), accurate carpal reduction, direct SLIL repair through small scaphoid drill holes, percutaneous Kirschner wire internal fixation, DICL advancement —ligamentoplasty, and partial radial styloidectomy, as preoperative radioscaphoid impingement invariably has been present.

A pneumatic tourniquet is used in all patients, and balanced regional anesthesia in most patients. A 3-cm dorsal incision (Fig. 3A) with its apex at the SL interval provides access to the partially disrupted radiocarpal capsule in the interval between the third and fourth extensor compartments. The
capsulotomy is incised along the radial margin of the dorsal radiocarpal ligament (DRCL) and the proximal edge of the dorsal intercarpal ligament (DICL). A radial-based capsular flap is created and reflected to the radial styloid, clearly exposing the SLIL disruption, and the adjacent carpal malalignment, while preserving the major substance of both the DRCL and DICL (see Fig. 3B).

Invariably the SLIL is ruptured or avulsed with small bony fragments (6 patients) from the scaphoid and demonstrates a characteristically substantive ligamentous cuff attached to the lunate, which after carpal reduction is readily advanced to the site of scaphoid detachment (see Fig. 3C). The SLIL is debrided to healthy tissue, and the adjacent surfaces of the scaphoid and lunate are abraded with fine Kirshner wires to promote local vascularity, fibrous healing, and SL ligament reattachment. In the majority of patients, radioscaphoid impingement is evident and judicious excision of the styloid, sparing the origin of the volar radiocarpal ligaments, is performed with a rongeur and fashioned to a smooth surface with a rasp. The direct ligament repair is then accomplished with absorbable mattress sutures passed through small drill holes at the proximal edge of the scaphoid (see Fig. 3D). Before securing the sutures, an atraumatic carpal reduction is achieved by dorsal to volar compression of the capitate, volar to dorsal compression of the scaphoid tubercle, and lateral compression of the SC juncture, thereby restoring SL coaptation and realigning the carpus in both the coronal and sagittal planes. The reduction is secured with two 0.045-in percutaneous Kirshner wires passed from the proximal scaphoid into the coapted lunate, and 1 wire passed from the distal scaphoid into the reduced capitate. The accuracy of reduction is affirmed with intraoperative radiography (see Fig. 3E), and the repair is completed by advancing the ligament and knotting the sutures.

For augmentation of these typically delayed repairs, the readily accessible DICL is split transversely (see Fig. 3F), and the more substantive proximal half is advanced in a V-configuration and sutured, with or without drill holes, to the dorsal component of the SLIL and the adjacent scaphoid and lunate. Reinforcement is thus achieved by direct suturing to the conjoined components of the SL articulation. A key focus throughout the operation is the avoidance of excessive soft tissue and skeletal surgical trauma apt to compromise vascularity and structural integrity of the inherently ischemic carpus.26

The capsular flap, as well as the overlying retinaculum, is repaired, the tourniquet deflated, hemostasis achieved, and the skin incision is closed. The surgical repairs are protected with a long-arm thumb spica cast for 8 weeks, at which time the wires are removed in the office and rehabilitation is begun.

**SPORT-SPECIFIC REHABILITATION**

A favorable surgical outcome depends on a carefully planned, intensive, and skillfully executed therapy program. A creative therapist experienced in the management of hand and wrist sports injuries and an athlete dedicated to participating in rigorous rehabilitation on a near-daily basis for an uninterrupted period of at least 2 months are essential.
for the success of the program. In the authors’ experience, a strongly favorable factor in the rehabilitation process is the positive enthusiastic attitude, especially as progress becomes apparent, and an exceptional level of motivation with an intense desire for a rapid return to competition displayed by the professional basketball player.

The knowledgeable therapist has a keen awareness of normal wrist anatomy and kinematics, the specific alterations in function that occur with SLD, and the methodology to achieve an expeditious but thorough recovery. Realistic goals with a rational time frame for recovery are established at the outset of therapy, and progress is continually conveyed from the surgeon and therapist, in concert, to the athlete, team management, medical staff, and usually to personal agents or advisors. This constant communication is an essential aspect of patient management for the professional athlete, which avoids confusion and facilitates uninterrupted and successful rehabilitation. Although the basic goal is restoration of a pain free, stable and functional wrist with a minimal risk of reinjury, recovery of mobility, strength, and dexterity specific to individual needs must also be acknowledged. The requirements of a player playing in a point or

Fig. 3. Surgical techniques for scapholunate dissociation. (A) Dorsal incision centered over the scapholunate interval provides access for (B) the ligament sparing capsulotomy and exposure of the disrupted scapholunate interosseous ligament with resultant scapholunate dissociation (arrow). (DICL, dorsal intercarpal ligament; DRCL, dorsal radiocarpal ligament; L, lunate; S, scaphoid). (C) A substantive scapholunate interosseous ligament (SL), attached to the lunate (L), is advanced and (D) secured with sutures passed thorough drill holes at the proximal edge of the scaphoid. (E) After restoration of carpal alignment and stabilization with Kirschner wires, the sutures are knotted, completing the ligament repair. (F) For augmentation ligamentoplasty, the dorsal intercarpal ligament (DICL) is split transversely (at tip of forceps) and the substantive proximal half is secured to the dorsal component of the scapholunate interosseous ligament, the scaphoid (S), and the lunate (L).
shooting guard position are different from those of a player playing in a power forward or center position. For all players, irrespective of their position, attainment of wrist and hand speed, agility, and durability is essential.

Investigative studies have demonstrated that the dart throwers’ motion\(^{27,28}\) (the arc of wrist motion progressing from extension and radial deviation to flexion and ulnar deviation) transmits minimal stress to the SLIL while restoring the important functional needs. This maneuver is used in the initial stages of therapy as a rational method of mobilizing the stiffened postoperative wrist and simultaneously permitting additional healing of the repaired ligament. As patient tolerance increases, the program advances to aggressive multiplanar active and passive mobilization, followed by progressive strengthening. The final phase of therapy focuses on the restoration of dexterous sport- and position-specific maneuvers essential for a skillful return to competition.

The reactivated player requires careful monitoring and is encouraged to continue a wrist strengthening program as further improvement invariably occurs with time, usage, and increased confidence in the repaired wrist. The player is also urged to use protective but flexible wrist supports whenever possible.

**OUTCOME ASSESSMENT**

Follow-up evaluation averaged 62 months (18–180 months) and demonstrated considerable improvement in symptoms, function, and carpal alignment. Based on the Mayo clinical scoring system,\(^{12}\) which incorporates the alleviation of pain, return to regular activity, recovery of wrist mobility, and restoration of grip strength, all of the patients rated highly satisfactory (good or excellent) with an average score of 85 points. In this comprehensive system, the patient scoring ranged from 80 to 95 points, with 100 points considered a normally functioning wrist.

Radiographic analysis revealed substantial improvement in the previously distorted parameters of carpal alignment. SL angles averaged 62° compared with 81° measured preoperatively, and the SL gap averaged 2.5 mm compared with the wide, 6.5 mm average diastasis noted before surgery (Fig. 4). Furthermore, with the exception of 3 patients, the radiographs demonstrated preservation of radiocarpal and midcarpal articular congruity. The 3 exceptions, all evaluated 7 years or more after surgery, displayed variable, but minimally symptomatic, degrees of wrist arthrosis (Fig. 5).

Patient satisfaction was consistently high because all the players returned to full competition and were able to pursue their careers without wrist impairment for periods of at least 5 years after surgery. Reinjury was not reported, and no additional surgery has been necessary.

**OVERVIEW OF SLD IN PROFESSIONAL BASKETBALL PLAYERS**

Restoration with the preservation of SL anatomy and function after traumatic SLD is a formidable challenge to the hand surgeon. Supporting this concept, the literature is replete with a myriad of surgical procedures attempting to restore the disrupted carpal architecture. However, reported results of these varied techniques have been conflicting and confusing, and a consensus regarding optimal management is nonexistent. Differences in patient selection, timing of surgical intervention, diverse operative techniques, and methods and length of outcome assessment are among the factors contributing to the dilemma. Most reports, however, do concur that despite early and substantial functional improvement, a process of radiographic deterioration with the development of intercarpal and radiocarpal arthrosis tends to

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**Fig. 4. Clinical outcome Case 1. Thirty-two–year old active player reports occasional pain but unrestricted wrist function 6 years after surgery. (A) Preoperative radiograph displays scapholunate dissociation with a 4- to 5-cm scapholunate gap and the classical cortical ring sign of scaphoid rotatory subluxation. (B) 6 years postoperatively, the radiograph demonstrates preservation of carpal alignment with no evidence of arthrosis.**
occur with increasing intervals between surgery and outcome assessment. To date, an arthritis-free wrist has not been consistently documented for any surgical procedure with long-term assessment exceeding 5 years. However, neither the extent and effect of associated disability nor the incidence of secondary surgery are well defined, and require further documentation and clarification.

Although the literature, as well as personal experience, does not support a strict correlation between functional outcome and radiographic arthrosis, the potential for disabling traumatic arthritis nonetheless remains a major concern. This disturbing fact is especially relevant to the professional basketball player whose wrist is continually subject to the inherent trauma of competitive sports and prone to repeated injury and ultimately the development of degenerative joint disease. SLD should be recognized as a precursor to arthrosis for which timely accurate restoration with preservation of carpal anatomy is an essential measure of prevention.

In a previous study of surgical treatment of more extensive perilunate injuries, the senior author (CPM) reported delayed treatment and residual carpal malalignment as the major factors compromising recovery and emphasized the efficacy of early comprehensive repair of all soft tissue and skeletal components of injury for preservation of carpal anatomy and recovery of maximum function. The same concepts of management have been applied to this series of stage I perilunate injuries with consistently favorable results. Regardless of the stage, the spectrum of perilunar injury causes SLD with severe carpal derangement, which is optimally treated by prompt anatomic repair, restoration of carpal alignment, and secure internal fixation. The previous study also emphasized the importance of accurate restoration of the SL articulation as the key method of lessening the occurrence and severity of radiographic carpal and radiocarpal arthrosis.

In this series of professional basketball players with SLD, a consistent surgical protocol has been used for a uniform group of young, healthy patients with similar functional requirements and goals. In all patients, direct repair of a substantive SLIL has been possible and reinforcement of the repair has been achieved with the DICL. Although direct SIL repair does not address all components of SL instability, it does restore the primary carpal stabilizer. A successful repair of the SLIL has provided the keystone for a favorable outcome.

With recognition that the SLIL is not the only stabilizer of the SL articulation and awareness that all ligaments, regardless of the site of injury, are prone to a variable process of devitalization with delayed treatment, augmentation of the direct

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Fig. 5. Clinical outcome Case 2. Forty-three–year old player has completed an illustrious career and, 11 years after surgery, functions as a full-time coach without wrist impairment. (A) Follow-up radiograph demonstrates residual carpal malignment with periscaphoid arthrosis. (Note the previous radial styloidectomy has eliminated radioscapoid impingement) Despite radiographic evidence of arthrosis, examination (B–D) of the repaired dominant right wrist (to the left) illustrates near-normal grip strength and wrist mobility.
repair with the DICL has been a constant component of the operative procedure. Anatomic, biomechanical, and clinical studies\textsuperscript{25,29–31} have demonstrated that the DICL is an important secondary stabilizer of the SL articulation and that the DICL is also prone to detachment from its scaphoid and lunate insertions with the occurrence of SLD. Furthermore, its ease of access lessens surgical trauma and renders it highly suitable for augmentation. In this series, the DICL has provided a sturdy method of reinforcement for the SLIL and SL articulation.

Similar to all surgical techniques for SLD, the long-term efficacy of direct SLIL repair with DICL augmentation remains uncertain and requires further evaluation. Nonetheless, this surgical protocol has provided a highly satisfactory method of achieving the essential requirements and goals for professional basketball players at a vital time of their life. Moreover, for most, it has proved durable not only throughout their professional careers but also for extended periods thereafter.

For professional athletes with SLD, the authors have not used reconstructive operative procedures, such as capsulodesis,\textsuperscript{29,32,33} tenodesis,\textsuperscript{33,34} 3-ligament repair,\textsuperscript{35,36} or intercarpal arthrodesis.\textsuperscript{37,38} These procedures are most suitable for chronic SLD with irreparable SLIL damage and provide alternative methods of restoring carpal stability. Although reconstructive surgery can favorably alter the deteriorating pattern of carpal instability, it is limited in its capacity to restore sufficient function for the skilled athlete because stability can only be achieved at the expense of mobility. For the professional athlete, seldom is a satisfactory solution available when treatment is considerably delayed. In contrast, and in accordance with the basic principle of all ligament disruptions, the acute injury with direct SLIL repair offers the optimal conditions for a favorable outcome. The significance of early surgery, preferably within 3 weeks from the time of injury, cannot be over emphasized as critical to successful recovery.

**SUMMARY**

The fundamental principle of successful surgery is restoration of superior function with consistent patient satisfaction. At present, this study of professional basketball players with static SLD indicates that direct SLIL repair with DICL augmentation is a highly satisfactory method of restoring wrist stability and function commensurate with the needs of these skilled and physically challenged athletes. The techniques of treatment used for this select group have consistently facilitated their goals at a critical period of their professional life as all have returned to unrestricted competition. Factors undoubtedly contributing to the successful recovery of the group are the homogenous patient population, the presence of substantive soft tissue and skeletal structures with an enhanced potential for healing, relatively early surgical intervention, and a consistent surgical protocol. The favorable outcome reported in this article supports the contentions that prompt surgical intervention affords the optimal prospect for preservation of carpal stability and that early direct SLIL repair for carefully selected patients is apt to result in a superior recovery.

**ACKNOWLEDGMENTS**

The authors express sincere gratitude to Jill K. Gregory, MFA, Certified Medical Illustrator, for her original artwork in Fig. 2. Special appreciation also is extended to Jacqueline Lopez of the Beth Israel Hand Surgery Center for her invaluable assistance in the preparation of this manuscript.

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