A Review on Scapholunate Interosseous Ligament Injuries, Disease Stages, and Treatment Techniques

Abstract
Scapholunate interosseous ligament injuries are common important conditions which include a wide range of pathologies in wrist joint. A lot of factors have significant role on clinical course or stage of disease. Treatment protocol depends on the stage of disease. Partial vs complete lesion, reparableability, radioscaphoid angle, radiolunate angle, reducibility and degenerative changes are modifiers of disease stage. Re-education and strengthening of supinator muscles, percutaneous pinning, arthroscopic debridement, open repair, capsulodesis, screw fixation and ligament reconstruction with local tendons are common treatment options used for scapholunate injuries. In this article we will review the stages of disease as well as the various treatment options. Some case series related to each treatment options will be discussed.

Keywords: scapholunate ligament, dissociation, articular degeneration, carpal alignment

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Introduction
The wrist is formed by a series of eight small carpal bones, twenty joint surfaces between these bones, metacarpus, and radial and ulnar bones. This joint is surrounded by volar and dorsal ligaments, which facilitate the complex wrist movements. Generally, ligaments are divided into two capsule and non-capsule categories. The capsule ligaments are either intrinsic and placed among the eight wrist bones or extrinsic and between the wrist and forearm bones. Wrist sprain can cause ligament damage, which includes a wide range of injuries based on the type and severity of trauma and angle of applied force and wrist position. Damage to each of these ligaments may lead to the strain or rupture of other ligaments after a while due to continued daily stress on the wrist, thereby causing dysfunction in other ligaments. One of the most common and important wrist injuries is scapholunate interosseous ligament injuries, consistently divisible into three anatomic dorsal, proximal, and palmar regions. Hyperextension and suspension can cause scapholunate interosseous ligament injuries, often starting from the palmar region and extending to the dorsal area. In this regard, the important factors are primarily partial or complete lesion. The second important factor is reparableability of the ligament, which, depending on time of injury, is divided into three categories of acute and reparable (less than a week), acute and relatively reparable (one-six weeks), and chronic and almost irreparable (more than six weeks). The next effective factors include radioscaphoid and radiolunate angles, ability of reduction, and joint cartilage condition in terms of degenerative changes. Garcia-Elias et al. proposed seven prognostic factors to consider when evaluating scapholunate ligament injuries depending on the presence of each injuries that gradually occur after each other (Table 1).
Table 1. Stages of scapholunate interosseous ligament injuries according to effective factors (Garcia-Elias)

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
<th>Stage 6</th>
<th>Stage 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-dynamic</td>
<td>Dynamic</td>
<td>Dynamic</td>
<td>Reducible</td>
<td>Reducible</td>
<td>Nonreducible</td>
<td>SLAC</td>
</tr>
<tr>
<td>Partial lesion</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Parable</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Normal</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>radioscaphoid angle</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Normal</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>radiolunate angle reducibility</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cartilage health (lack of degenerative changes)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The first stage is called hidden or pre-dynamic, where instability does not occur even by putting stress on the joint and the disease is only detected by arthroscopy. The second and third stages are dynamic, where radiography is normal but radiography under stress increases the scapholunate distance. The fourth and fifth stages are reducible static stages of the disease, where radiological criteria are not normal but deformity can be corrected. The sixth stage of the disease is irreducible static phase, where degenerative changes are observed in wrist in the final stage. Considering the diversity of injuries in various stages, the treatment approach must be definitely based on disease stage. The treatments include a range of arthroscopic or open treatments for scapholunate injuries, such as repair or reconstruction\(^2\),\(^3\). In this research, we reviewed and introduced different types of treatment techniques for scapholunate interosseous ligament injuries before the emergence of degenerative changes or irreducibility (including the stages of 1-5).

**Supinator Muscle Strengthening**

In scapholunate injuries, the scaphoid tends to assume a flexed position. Scaphoid flexion and extension of the rest of the proximal row cause pronated deformity of the distal fragment. By strengthening the supinator muscles of carpal tunnel (e.g., ECRL, APL, and FCR) and supinating the distal row, trapezium imposes an extension force on the distal scaphoid, preventing the collapse of the carpal tunnel and emergence of deformity flexion on scaphoid\(^4\). This treatment can be applied to prevent the progression of the disease from the first to the next stages.

**Pinning through Skin**

In incomplete scapholunate interosseous ligament injuries, including type 1 (pre-dynamic), we can repair scapholunate injury by pinning through the skin via radiographic control or arthroscopy. The 1-2-millimeter pins are maintained for 8-10 weeks, and patients will have plaster casts for another four weeks\(^5\).

**Arthroscopic Debridement and Electrothermal Shrinkage of Ligament Edge**

This debridement leads to removing of unstable flaps of ligaments and lack of development of synovitis and inflammation, reducing the disease symptoms at the dynamic stage (stage 2 and 3). It is worth noting that
arthroscopy plays a significant role in detection and treatment of scapholunate interosseous ligament injuries. In acute lesions, this damage is divided into four stages according to Gisler’s classification. In the first-grade Gisler injury, only the surface of scapholunate ligament is convexed in arthroplasty. At this stage of treatment, immobilization is recommended. In the second-grade injury, a slight step is observed only in the mid-carpal portal between the scaphoid and lunate and no such step is found in the radiocarpal portal. At this stage, while there is an increased distance between the scaphoid and lunate, it is shorter than the probe width. The treatment selected for this stage of injury is reduction and arthroscopic pinning. In the third stage of the injury, when there is the possibility of entering the probe into the space and even rotating it, the treatment of choice is reduction and arthroscopic or open pinning. In the fourth stage, the distance between the two bones is so much that the 2.7 arthroscopic lens can enter the space. Here, the treatment of choice is open repair and reduction. While this classification can be applied for chronic lesions, its treatment guidelines cannot be exploited for such injuries and it is better to use techniques based on Garcia-Elias classification\(^{(5)}\).

**Ligament Repair**

In cases of complete and reparable ligament ruptures (second stage), the most efficient treatment approach is open repair. For treatment, we use the approach of dorsal on the lister tubercle and wrist capsulotomy with proximally or radially-based flaps. In addition, repair is carried out with transosseous approach or applying anchor. With regard to excessive capitate force on the scapholunate and possibility of recurrent diastasis, the repair must be maintained by pinning of the scapholunate and/or scaphocapitate\(^{(6)}\).

**Capsulodesis**

Blatt introduced the dorsal capsulodesis technique in 1987 for the first time. Different types of changes in this technique have been expressed over time. In the original Blatt technique, a proximally and radially based capsule flap (width=1 cm) is connected to the rotation axis of a point on the scaphoid neck and distal after reduction and pinning of the scaphoid to lunate and capitate (Figure 1)\(^{(7)}\). Different capsulodesis techniques can be specifically applied in the third stage of the disease, which is still the non-stressed state of radiographic criteria of normal scapholunate. This method is used to prevent the extension of scaphoid under daily stress.

![Figure 1. Dorsal Capsulodesis by Capsule Flap](image)

In this regard, one of the modifications is the mergerle technique, where a radially based capsular flap extents from scaphoid to lunate and is fixed with anchor (Figure 2). In a research by Megerle et al., the long-term results of capsulodesis were evaluated in 59 patients with mean follow-up period of 8.25 years. In the final follow-up, no significant improvement was observed in the radiological criteria, compared to before the surgery, and even 78% of the patients manifested radiological evidence of degenerative arthritis. However, patients had acceptable function after the surgery\(^{(8)}\).

![Figure 2. Megerle Technique for Capsulodesis with Side Radial Base According to Berger Method](image)
In another research, Moran et al. evaluated the results of dorsal capsulodesis using Berger technique for dynamic scapholunate lesions (Figure 3). In this research, 11 patients were treated with this treatment technique, and the results were comparable to the Brownlee-Brownlee tenodesis method. Despite the improvement of pain in these patients, their range of motion significantly decreased after the surgery. In addition, radiological correction of carpal state was lost over time\(^9\).

In another method designed by Szabo, the capsulodesis was simultaneously used for strengthening the repair process in acute lesions in addition to repair of scapholunate and pinning. Results of this treatment were favorable in a patient treated with this technique (Figure 4)\(^{10}\).

In a study by Gajendran, medially based capsulodesis (triquetral) was carried out (Figure 5). The long-term (15 years) results of this method performed on 15 patients were indicative of satisfactory improvement and proper function in approximately 60% of patients. Nevertheless, this method failed to prevent the radiological destruction of joint condition and emergence of arthritis (Figure 5)\(^{11}\). One of the techniques of capsulodesis, which is specifically applied in the first stages of the disease, is the Matalon method, where the capsule is sewed to the ligament with late-absorbable suture materials entering the scapholunate ligament from the posterior capsule (Figure 6).

**Bone-Ligament-Bone Graft**

Another technique used for scapholunate reconstruction is the bone-ligament-bone (BLB) graft (Figure 7). Application of this graft is inspired from reconstruction surgeries of knee ligaments with the help of patellar ligament. In
this method, a wide range of ligaments is used on lister tubercle, including dorsal intercarpal, capitohamate, trapeziocapitate, and metacarpal–capitates\(^\text{12}\). These techniques have applications in the third stage of the disease.

In the Nakamura technique, where graft is removed from the capitohamate joint, pain score significantly decreased in 15 patients with mean age of 38 years and chronic scapholunate lesion. In addition, the scapholunate gap decreased from 4.8 to 2.1. According to the modified mayo wrist score, excellent scores were obtained by eight patients, whereas five and two patients received good and moderate scores, respectively. Moreover, the mean period of follow-up was 3.7 years\(^\text{14}\).

**Dynadesis**

This technique was introduced by Seradge and Seradge\(^\text{15}\). In this method, an ECRL strap is used instead of a capsule to pass the internal channel of scapholunate and its tenodesis to FCR. In this approach, 105 patients were evaluated and followed up for 63 months. In the end, grip power of the participants increased by 65%. According to green-abrin clinical criteria, excellent, good, and moderate results were observed in 49%, 24%, and 26% of the patients, respectively. It is notable that this technique can be used in the third stage of the disease.

**Ligamentoplasty**

At higher stages, where the scapholunate lesions establish static state deformity, first the scaphoid flexes and then the lunate extents and undergoes DISI changes. While the treatments mentioned in the previous stages can be applied in this phase as well, their success level is low. Therefore, we are obligated to close the scapholunate gap and treat the disease with reconstruction of extrinsic and intrinsic ligaments. The first attempts at reconstruction of volar and dorsal ligaments were made by Brownlee and Brownlee and then modified by Van Den Abbeele\(^\text{16}\). This is one of the first and most profitable techniques to treat the fourth stage of the disease. In the modified version of the technique by Brownlee and Brownlee, a FCR strap with a distal base of eight cm is released.
and passes the internal channel of the scaphoid and connects to lunate in dorsal. Following that, the strap is passed from an anchor inside the dorsal radiocarpal ligament. This technique is known as three ligament tenodesis. García-Elias applied the technique on 38 patients in a 46-month follow-up, reporting complete elimination of pain in 28 subjects. In addition, the total wrist range of motion was healthy in 76% of the participants, and gripping power was at a favorable level in 65% of the subjects. However, there was a prevalent emergence of carpal collapse (with no signs) in the participants in long term (Figure 9).

Changes were made in this method considering its aspects. Instead of passing the rest of FCR from inside the dorsal radiocarpal ligament, Ross (2014) created a tunnel inside the lunotriquetral and carried out the tension operation on the scapholunate ligament (Figure 10). The ligamentoplasty techniques are the treatment of choice for the fourth stage of the disease.

**Transarticular Graft or Screw**

One of the major problems of reconstruction and ligamentoplasty approaches is disruption of radiological reduction over time. In a research by Fernandez et al., Herbert screw was temporarily used for augment repair or reconstruction (Figure 11). In total, 36 patients (11 with dynamic and 25 with static lesions) with mean age of 43 years were enrolled in the mentioned research. Mean period of follow-up was 7.9 years. After the surgery and during the follow-up, the screws were removed in case of loosening. In the mentioned study, mean scapholunate angle and gap reached 56 and 2.5 millimeters, respectively, remaining constant during the follow-up period. Moreover, range of motion in extension, flexion and ulnar and radial was at a favorable degree of 55, 51, 26, and 15, respectively.
Another new technique performed as ligament reconstruction with palmaris longus tendon graft on the axis of rotation of the scapholunate is called the scapholunate axis method\(^{(19)}\). In this technique, which was introduced in 2016, 13 patients were followed up for a mean of 11 months. The palmaris longus tendon graft was fixed inside the lunate with an anchor graft and inside the scapholunate with a bio-interference screw. In the final assessment, grip power was about 62% of the other side (Figure 12). These two transarticular screw or graft methods can be used in the fourth stage of the disease as well.

Antipronation Spiral Tenodesis

If instability of radiolunate is detected in patients over the course of scapholunate injury, lunate is translocated toward the side ulnar due to the incompetence of radiolunate ligament. Therefore, the whole carpal extends to ulnar side. In this case, independent reconstruction of scapholunate ligament in the volar and dorsal, similar to the previously explained ligamentoplasty, is insufficient and a method is required to close the scapholunate gap and repair the correction of the scapholunate angle of radiolunate ligament. This technique provides help in the fifth stage of instability. In this regard, a method called antipronation spiral tenodesis was introduced by Chee, which returns the FCR strap from the surface of volar triquetral form the bottom of the carpal channel to the radial styloid and fixes it on the styloid, which leads to the extension of lunate and proximal row to the side radial and correction of the translocation ulnar (Figure 13). In a research, Chee et al. treated five patients with this approach, which is specifically recommended to be used in cases of prelunate dislocation, where there is lunotriquetral rupture as well\(^{(20)}\).

Discussion and Conclusion

The chronic scapholunate injury is one of the most prevalent wrist injuries and can cause pain and limited range of motion. With regard to the coordination of the intrinsic and extrinsic ligaments of wrist, the scapholunate injury can turn into a complete rupture from a partial rupture over time and involve other extrinsic ligaments as well, eventually causing instability and collapse of the wrist. There are
various types of repair and reconstruction methods depending on the severity and stage of the disease. Therefore, the disease stage must be identified at first by correct pathological diagnosis and performing of diagnostic and radiographic stress tests and calculating the angles and distances. As stated before, physiotherapy is performed at the first stage of the disease (partial rupture), and if not successful, the treatment of choice is arthroscopic debridement along with pinning. In the second stage, where ligament injury is complete but reparable, the proper method is open repair along with capsulodesis, which are significantly successful if used in the third stage of the disease as well. In the fourth stage, the treatment of choice is three ligament tenodesis. However, this method is insufficient for the fifth stage, and antipronation spiral tenodesis is the best technique to correct all pathologies and factors involved in the emergence of the injury in the best way possible. It should be noted that the majority of these methods significantly improve pain in patients if performed accurately. While they can increase grip power as well, the radiological improvement, that is immediately achieved after surgery, might be lost over time. However, radiological deterioration mostly occurs with no signs.

References