Grade I and II Dynamic Scapho-Lunate Instability Treated with Proprioception Via Dynamic Taping and Neuromuscular control

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Abstract

Study Design: Case report.

Introduction

One of the most common injuries to the wrist joint is often associated with "Scapholunate (S-L) dissociation" due to the disruption or weakening of the SL interosseous ligament (SLIL) complex.[1] S-L instability can be described as static or dynamic.[1] Static S-L injuries result in pain at rest causing dysfunction with everyday activities.[1] However, a large number of dynamic S-L injuries can have a delayed diagnosis due to absence of symptoms as the S-L joint receives stability from other surrounding structures.[1] Based on this research, Salv- Coll et al[1] proposed that after dynamic S-L injury, it is essential to attend to normal joint surfaces, supporting ligaments and muscles, and a complex network of neural pathways to attain the stability of the S-L joint. This case report analyzes conservative management treatment for Grade I and Grade II dynamic S-L injury using dynamic or leuko taping and neuromuscular strengthening to improve functional capabilities.

Purpose of the Study

The purpose of this case report is to incorporate proprioceptive input using dynamic taping, in combination with neuromuscular training to help with improving functional outcome in grade II dynamic S-L instability cases. The hypothesis is that taping helps reduce the misalignment by decreasing the gap between scaphoid and lunate. This decreases the pain which allows for neuromuscular strengthening exercises to ensue sooner, resume functional activities, and prevent further joint degeneration.

Methods

This article introduces a unique taping technique to treat grade I and II dynamic S-L injuries that provides stability of the wrist through pisotriquetral joint, enhances proprioception, and improves neuromuscular control. The taping method and functions are discussed in the paper (refer to the figures and video). Fluoroscopy was performed at the surgeon's office that provided us with objective data of the S-L gap measurement with taping and without taping along with extensor carpi radialis/longus (ECRB/L) isometric activation.

Results/Discussion

The patient subjectively reported decreased pain and increased function during daily activities. Objective data presented with increased grip strength, decreased pain level on visual analogue scale (VAS), and reduced S-L gap interval as measured on fluoroscopy. Please refer to table 1,2, and figures 8-13.

Conclusion
Wrist taping provides support by narrowing the gap between scaphoid and lunate. This reduces pain allowing early initiation of isometric neuromuscular strengthening which helps stabilize the wrist. Stabilization helps in faster return to ADLs and possibly prevents surgery in Grade I or Grade II dynamic SL cases.
Level of Evidence: Level IV

Keywords: instability, neuromuscular control, proprioception, wrist, scapho-lunate, dart throwing, splinting, dynamic taping, leuko taping

Introduction

Grade I and II S-L instability occurs far more often typically from a fall on an outstretched hand (with forearm supinated and wrist extended) or trauma to the wrist.[2] Watson et al[3] described grade I and II S-L instability as "pre-dynamic instability" that eventually may lead to static S-L instability in some patients. Salva-Coll G et al[1] described the difference between dynamic and static S-L instability: Dynamic S-L instability is determined based on space between S-L with functional motions for example hand grip, whereas static S-L instability is determined based on space between S-L in anterior-posterior and lateral views of the wrist during diagnostic studies.[1,4] According to Salva-Coll G et al[1], not all S-L instability patients are symptomatic. That neuromuscular stabilization of the S-L joint may play a role since S-L ligament disruption or attenuation alone does not contribute to wrist pain.[1,4]

Treatments of static instability of the wrist include, but are not limited to limited wrist fusion, proximal row carpectomy, and total fusion.[5,6] In comparison, treatments for dynamic instability is casting, debridement, thermal shrinkage surgically and splinting conservatively.[5,6] However, given the study by Salva-Coll G et al.[1], more could be done conservatively to treat grade I and grade II S-L instability to mobilize the wrist by using the neuromuscular component than to immobilize the wrist with splinting or casting. Mobilization/strengthening of the neuromuscular component can only be achieved when the pain has subsided. Casting and splinting can aid in subsidence of the pain; however, it also reduces the strength of neuromuscular components responsible for stability of the joint. [6] After immobilization, return to ADLs almost always results in flare up of symptoms due to weakness of muscular components. Casting may help

reduce inflammation, but also may weaken the neuromuscular components of the wrist stabilizers, provided there is no adequate development of a structured rehabilitation program in a clinical setting.[6] A bridge is needed to move the wrist from immobile reactive phase to functional use of the hand. The bridge must provide mobilization in a controlled movement pattern while aligning the S-L joint. This may prevent the wrist from becoming reactive due to the alignment provided by this bridge and allow for strengthening and promoting functional use of the hand. Mcneill and Pedersen[7] describe that the 4-way stretch elasticity of dynamic tape provides mechanical effects such as load absorption, force contribution, and modifying movement of targeted joints. For example, it can decrease lateral translation of the patella, support surrounding structure, and aide in knee extension.[7] Dynamic tape has been suggested to be used for both reducing load on the lateral ligament complex of the ankle, and on the painful structures involved with the upper limb in the subluxed hemiplegic shoulder.[7] Dynamic tape plays a role to provide "just enough" to unload injured tissues and allows for joint movement patterns that are needed for functional use.[7]

In S-L instability movement pattern of the carpal bones has been proven to play an important role.[4,7] Literature defines DTM occurs in the plane of radial extension and ulnar flexion (see ***Figure 1***).[4,8-9]

Figure 1 Dart Throwing Motion (DTM)[16]

Biomechanical study claims that DTM primarily occurs at the midcarpal joint with minimal motion of scaphoid and lunate when compared during normal wrist flexion-extension or radioulnar deviation motion.[10] Upal et al[11] *in vitro* study quantified elongation of normal S-L ligament demonstrated that there is minimal elongation of SLIL in DTM plane. In Contrast, a study conducted by Garcia-Elias M. et al[12] compared DTM kinematics in normal wrists and SL ligament injured wrists. This investigation demonstrated that in a normal wrist scaphoid and lunate movement is minimal towards radial styloid (average of 5.9 mm and average of 5.6 mm, respectively), whereas in S-L dysfunction, the scaphoid moved closer to the radial styloid (average of 12.8 mm compared to the lunate at average of 4.8 mm).[12] Thus implying that DTM increases the gap between the scaphoid and lunate with S-L tear.[12] This increases the risk of suture disruptions post-surgical repair[12], making the training of the neuromuscular component redundant. This emerging knowledge inspired us to develop S-L stabilization via taping through pisotriquetral joint for wrist stabilization. The focus of the taping application was to align the S-L

joint thus decreasing the gap via pressure through the carpal bones. The goal was to decrease pain, increase conscious and unconscious proprioceptive inputs during daily functional activities thus expediting neuromuscular strengthening. Other studies have attempted to provide stability through taping. Our aim was to take a step further to provide an objective data through imaging studies.[13]

S-L stability is maintained through a complex mechanism.[1,14,15] Correct alignment of carpal bones, normal articulating surfaces, ligaments, accurate sensory-motor feedback, the muscles crossing the wrist, and all nerves connecting to ligaments and muscles are contributing components to preserve wrist stability.[1] To prevent dissociation of the wrist, the wrist may be strengthened by aligning the bones with pisotriquetral joint splinting (*see* ***Figure 2, 3***), or DTM orthotic (*see* ***Figure 4***) by eliminating some gaping with range of motion, and thus reducing pain in the wrist. As stated by Holmes et al[6], DTM orthosis benefits are only effective as long as the

Figure 4 Pisotriquetral joint splinting

Figure 3 Pisotriquetral joint splinting

Figure 2 DTM orthosis

patient uses them. From a clinical perspective, follow through of the splint wear is not definitive. Specific mobility needs to be maintained with functional activities similar to the dart throwing motion to prevent the articular cartilage degeneration over time.[8]

Muscles activated in a dart throwing plane include extensor carpi radialis longus (ECRL), extensor carpi radialis brevis (ECRB), abductor pollicis longus (APL), and flexor carpi ulnaris (FCU). According to cadaver studies,[1,15,16] FCU, APL, ECRL, and ECRB are midcarpal supinator muscles. When isometrically activated, these muscles place the scaphoid into extension and supination as a result the proximal pole of the scaphoid goes back into its position reducing the S-L gap.[15]

As discussed early in this paper, evidently, in a wrist with S-L dysfunction, the scaphoid moved closer to the radial styloid (average of 12.8 mm compared to the lunate at average of 4.8 mm).[12] Thus implying that DTM increases the gap between the scaphoid and lunate with S-L tear. However, the muscles involved in dart throwing motion do assist to improve the gap between S-L in the normal wrist. Thus, we theorized that if the bones are mechanically brought together with splinting or taping, it would help reduce the pain by decreasing the stress on the ligaments mechanoreceptors and allow for pain free strengthening of the muscles if they pivoted around the pisiform. The pressure through the pisotriquetral joint may assist in bringing the proximal carpal row closer to each other. This theory was assessed by performing ECRL and ECRB isometric activation (wrist in radial deviation) under fluoroscopy study with and without taping.

Case Report

A 39-year old male, presented with a history of bilateral scapholunate instability, with no known cause. Functional limitation included, but not limited to inability to type for longer periods as required by his occupation as a computer engineer and unable to perform weight bearing activities on either wrist. MRI on the dominant right wrist revealed moderate-high grade levels of S-L, lunotriquetral (L-T), and TFCC tears. The non-dominant left wrist presented with mild symptoms compared to the right wrist. Patient was initially treated conservatively for bilateral wrists for 6 sessions. Then, the patient underwent surgery for the right S-L joint with debridement and thermal shrinkage, excision of ganglion cyst that had developed between the bones in order to decrease the pain, and TFCC debridement. While in cast, therapy was continued for the left wrist S-L instability for 8 more sessions. Refer to ***table 1*** for subjective and objective data collected while the patient was in therapy.

List of diagnosis associated with the case and ICD 10 codes	**S63.511A** Sprain of carpal joint of right wrist, initial encounter, **S63.512A** Sprain of carpal joint of left wrist, initial encounter, **S63.502A:** Unspecified sprain of left wrist, initial encounter, **S63.501A:** Unspecified sprain of right wrist, initial encounter, **M25.531** Pain in right wrist, **M25.532** Pain in left wrist					
	IE		**PR**		**D/C**	
Treatment Side	Right	Left	Right	Left	Right	Left
Watson Sign	Positive	Positive	Negative	Positive	Negative	Negative
DASH	49.1		38.3		35	
VAS	8/10 at worst; 5/10 at best	6/10 at worst; 3/10 at best	6/10 at worst; 3/10 at best	3/10 at worst; 1/1 at best	4/10 at worst; 0/10 at best	3/10 at worst; 0/10 at best
Grip Strength (lbs.)	NT	NT	55	75	60	80

Table 1*:* Objective and subjective data collected at initial evaluation (IE), follow-up progress report (PR) and discharge (D/C); VAS = visual analog pain score (0 = no pain and 10 = extreme pain); Grip strength = Jamar dynamometer measure with elbow at 90 degrees and forearm in neutral position; lbs. = pounds; DASH = Disabilities of the Arm, Shoulder, and Hand score

Conservative therapy treatment for this patient was provided for a total of 14 sessions. Treatment approach for the left wrist included myofascial release of the forearm extensors/flexors and S-L ligament, use of Graston technique to extensors and TFCC, ultrasound, cryotherapy, taping during daytime. In this case study, dynamic taping was applied to the left wrist at the end of each

therapy treatment session for twice a week for seven weeks. The goal was to use elastic potential energy to de-load the tissues involved and to use it to facilitate the normal proprioceptive, neurophysiological movements of the S-L joint. Patient was also given instructions on self-taping at home, if needed to replace the tape while not in therapy. Patient was instructed to use the booster splint only during sleep to prevent unconscious positioning of the wrist, with tape left in place as long as skin irritation was not a concern.

Treatment also consisted of pain-free isometric strengthening of ECRL, ECRB, FCU and PQ with supported pisotriquetral joint and in forearm pronation. Isometric strengthening of the wrist was done in forearm pronation for S-L deficiency as forearm supination increased scaphoid and lunate gap.[2] This was partly due to the action of ECU which is a strong midcarpal pronator and adds to the instability of the S-L joint.[14,15] Informed consent for treatment interventions, photographs, and video were obtained from the patient.

Different tapes can be used for treatment of S-L instability based on the patient reactivity. Leuko-tape (***Figure 5***) along with cover roll assists in providing more support to the wrist due to its ridge quality, thus limiting extreme ROM with functional activities, and decreasing stress to the joint with repetitive/impact activities. Leuko tape is more beneficial status post S-L repair, acute wrist injuries, and with hypermobile painful wrists. Dynamic tape (***Figure 6***) due to its biomechanical properties and less rigidity than leuko-tape provides 4-way stretch to support and offer elasticity to the wrist during everyday functional activities. During the initial therapy visits, with acute wrist injury leuko-tape/cover roll may be beneficial. As the pain reduces, therapists

Figure 6 Leuko Tape with Cover Roll

Figure 5 Dynamic Tape

can switch to dynamic tape.

Taping Application Technique

1st tape: The patient's forearm is placed in supination as in supination the ulna translates volar, tape applied from volar radial aspect to dorsal ulnar aspect, encompassing the ulnar head and ending at the dorsal radius, thus aligning forearm bones to the carpus. 2nd tape: with the forearm held in supination, the 2nd tape starts at the hook of hamate just above the pisotriquetral joint in a diagonal fashion on the volar ulnar carpus to the dorsal radius pronating the forearm. This is done while aligning the ulnar carpus to the forearm bones thus applying pressure on the pisiform

dorsally and radially and ulnar head volarly. For images refer to (***Figure 7***) and access to video link Click here

Figure 7 Dynamic Taping Technique

So, to summarize our goals with taping were to provide:

1. Inhibition of overactive movement synergists and antagonists.
2. Facilitation of underactive synergistic movements
3. Promotion of optimal inter joint coordination.
4. Direct optimization of joint alignment during static postures or movement.
5. Offloading irritable tissue.
6. Direct or indirect reduction of pain associated with functional movement

Results

The goal of this case report was to prevent surgery on the left wrist. Pain was assessed using visual analogue scale (VAS) with 6/10 at worst with activities and 3/10 at best at rest. At the end of fourteen visits, the patient reported pain of 0/10 after a couple hours of taping and 3/10 at its worst, intermittently. Patient's subjective report was "When I have the tape on my hand feels normal; and when I don't have the tape on, then I feel some popping in the wrist. I don't like going without the tape." Other objective data such as DASH score and grip strength are reported in ***table 1*** for reference that were collected on initial evaluation, follow-up progress report, and at discharge.

Fluoroscopy images as referenced in table 2 on the left wrist

Figure 8 Static image of wrist in neutral without support (See the arrow for area of Pain)

Figure 9 Static image of wrist in neutral without support

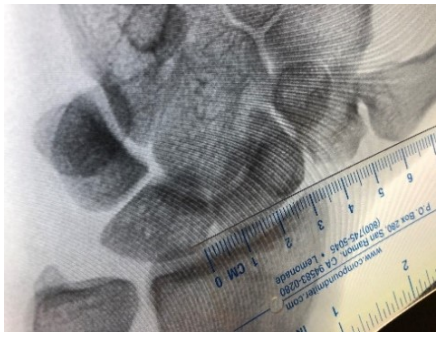

Figure 10 Static Image under fluoroscope wrist in radial deviation (RD) without support; S-L gap measured at 0.9 (mm)

Figure 11 Static Image under fluoroscope wrist in radial deviation (RD) with taping; S-L gap reduced to 0.6 (mm)

Figure 12 Static image under fluoroscope with wrist in isometric ECRL with taping; S-L gap further reduced to 0.4-0.5 (mm)

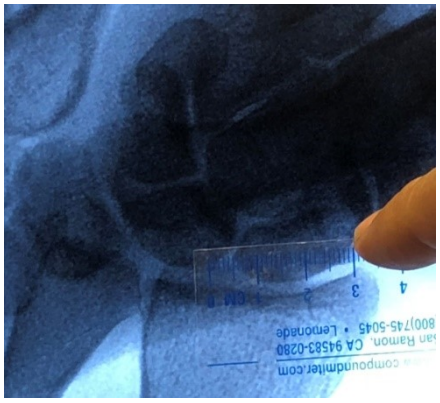

Figure 13 Static image under fluoroscope with wrist in isometric ECRL without taping; S-L gap also reduced to 0.4-0.5 (mm)

Results of fluoroscopy study on the left wrist:

Wrist Images	S-L interval (mm)
Static images wrist in neutral without support (*Figure 8 and 9*)	
Static images wrist in radial deviation without support (*Figure 10*)	0.9
Static images with taping in radial deviation (*Figure 11*)	0.6
Static images with taping and isometric ECRL (*Figure 12*)	0.4-0.5
Static Images without taping and Isometric ECRL (*Figure 13*)	0.4-0.5

Table 2**:** Results of fluoroscopy Study with images for the left wrist**.** Decrease in Scaphoid and Lunate gap with taping combined with isometric ECRL/ECRB activation. **(*See Figures 8- 13*);** mm = millimeter

Grip strength comparison:

Grip strength (Pounds)	**Left**	**Right**
Without Taping	65 lbs.	20 lbs.
With Taping	80 lbs.	20 lbs.

Table 3**:** Grip strength of the left wrist using dynamometer with forearm in neutral position elbow at 90 degrees. Increased in grip strength by 15 lbs. with application of dynamic taping; lbs. = pounds

Discussion / Conclusion

The goals with this case report with taping was to correct alignment of carpal bones via support through pisiform, as a result providing normal articulating surfaces by reducing the crepitus, decreasing the stress on the ligaments, which then would provide accurate sensory-motor feedback to the muscles crossing the wrist, and all nerves connecting to ligaments and muscles contributing to preserving pain free wrist stability.

Taping aides with pain management by assisting in the reduction of the scapho-lunate gap, thus decreasing the stress on the mechanoreceptors that cause pain. It is an intervention tool that can be applied at all times or as tolerated to provide the necessary support to calm the symptoms and allow for neuromuscular strengthening and functional activities.

As discussed before in this article, with Grade I and II S-L dynamic instability, wrist splints and casting the wrist provide passive support[6]; however, those interventions inhibit neuromuscular

training. By immobilizing the affected wrist, it decreases the strength and endurance of the secondary wrist stabilizers which are ultimately responsible for the carpal stability when primary stabilizers are redundant, resulting in weakening of the muscles, thus prolonging the recovery.

The goal with taping is to allow early strengthening of the secondary stabilizers which have proven to maintain the reduction of the S-L ligament interval. [1,12-15] Consequently, taping works as the bridge between reactive immobile phase to functional solution for the wrist. This also allows the wrist to regain early smooth and balanced motion after injury. Taping increased participants' perceptions of stability, confidence and reassurance in dynamic tasks. The subjective data provided by the patient correlated with the objective grip strength findings and improvement in functional activities. Therefore, improved functional activities resulted in the patient being able to type for longer periods without pain. There is less hindrance with tape application while performing daily activities.

Additionally, it helps with dynamic muscle stabilization to compensate for poor ligament support and promote the use of muscles that are protecting the joints. Taping when used combines the conscious and unconscious, providing stability while performing ADLs or co-activation drills, along with sensorimotor activation, perturbation training, reactive muscle activation. Due to decrease in pain and increased strength achieved via taping with functional activities/exercises, the patient was confident enough to perform functional tasks without the need for taping at the end of therapy.

Status of patient: two years since treatment provided the patient has not needed surgery and has continued to maintain the achievements gained in therapy.

Limitations

Our findings are based only on one case study. Further studies with an adequate number of participants would be necessary to assess the long-term benefits of taping and neuromuscular re-education and if these techniques prevent surgeries and arthritis in the future. Randomized control trials including a controlled group is needed to replicate the results in this study.

We recommend modifying future studies to acquire more objective data with likert scale criteria as follows: skin irritation on a 3-point Likert scale, pain with or without taping, orthotic wear hassle on a 5-point Likert scale and taping wear hassle on a 5-point Likert scale, along with DASH and grip strength.[17] We also recommend using a proprioceptive assessment tool to determine the benefits of taping at different stages of recovery.[18]

Allergic reaction may occur to patients with sensitive skin or if taping is done for long periods. It is recommended to use Benadryl® spray if sensitivity exists. It is also recommended to tape only during the day with functional activities for patients with sensitivity and use ulnar booster splints at night without the tape to prevent skin breakdown.

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