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PŮVODNÍ PRÁCE

Scapholunate Ligament Partial Tears; Tear Localization, Extrinsic Ligament Injury Association and Conservative Treatment Responses Prior to Instability: Cross-Sectional Study

Parciální trhliny skafolunátního vazu; lokalizace, přidružená poranění vnějších vazů a odezva konzervativního léčení před instabilitou: průřezová studie

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ABSTRACT

PURPOSE OF THE STUDY

Scapholunate interosseous ligament (SLIOL) tears with accompanying extrinsic ligament rupture have been associated with scapholunate (SL) instability. SLIOL partial tears were examined in terms of tear localization, grade and accompanying extrinsic ligament injury. Conservative treatment responses were scrutinized according to injury types.

MATERIAL AND METHODS

Patients with SLIOL tear without dissociation were evaluated retrospectively. Magnetic resonance (MR) images were re-examined in terms of tear localization (volar, dorsal or combined volar and dorsal tears), grade of injury (partial or complete) and extrinsic ligament injury accompaniment (RSC, LRL, STT, DRC, DIC). Injury associations were examined with MR imaging. All patients treated conservatively were recalled at their first year for re-evaluation. Conservative treatment responses were analyzed according to pre- and post-treatment first year visual analog scale for pain (VAS), disabilities of the arm, shoulder and hand questionnaire (DASH) and Patient-Rated Wrist Evaluation (PRWE) scores.

RESULTS

In our cohort, 79% (n: 82/104) of patients had SLIOL tear and 44% (n: 36) of them had accompanying extrinsic ligament injury. The majority of SLIOL tears and all extrinsic ligament injuries were partial tears. In SLIOL injuries, volar SLIOL was most commonly damaged portion (45%, n: 37). DIC (n: 17) and LRL (n: 13) were most frequently torn ligaments, radiolunotriquetral (LRL) injury generally co-existed with volar tears and dorsal intercarpal ligament (DIC) with dorsal tears regardless of injury time. Extrinsic ligament injury accompaniment was associated with higher pre-treatment VAS, DASH and PRWE scores than isolated SLIOL tears. Injury grade, location and extrinsic ligament accompaniment had no significant effect on treatment responses. Test scores reversal was better in acute injuries.

CONCLUSIONS

On imaging SLIOL injuries, attention should be paid to the integrity of secondary stabilizers. In partial SLIOL injuries, pain reduction and functional recovery can be achieved with conservative treatment. Conservative approach can be the initial treatment option in partial injuries especially in acute cases regardless of tear localization and injury grade if secondary stabilizers are intact.

Key words: scapholunate interosseous ligament, extrinsic wrist ligaments, carpal instability, MRI of wrist, wrist ligamentous injury, volar and dorsal scapholunate interosseous ligament.

INTRODUCTION

Scapholunate (SL) joint ligamentous injuries are the frequent cause of wrist pain and disabling symptoms. Scapholunate complex formed by the primary (scapholunate interosseous ligament; SLIOL) and secondary stabilizers (extrinsic ligaments: RSC; radioscaphocapitate, LRL; radiolunotriquetral, DIC; dorsal intercarpal, DRC; dorsal radiocarpal, STT; scaphotriquetral) of scaphoid and lunate bone, plays a crucial role in carpal alignment and preservation of functional anatomy (4, 22, 28, 29). Injuries to these ligaments occasionally accompanies each other. Isolated SLL tears can result in gradual fraying of secondary stabilizers over time or SLIOL and extrinsic ligament injury can occur simultaneously following acute trauma (8, 16, 17). SLIOL tears with accompanying extrinsic ligament rupture had been associated with SL instability (9, 27). Progression to degenerative arthritis known as scapholunate advanced collapse (SLAC) constitutes the importance of investigating this relation. Although most of the researches about the injury biomechanics are cadaveric studies, a definite consensus regarding which and what degree of injury leads to instability has not been depicted. We think that further in vivo studies are needed. We retrospectively evaluated MRI images of the patients with SL complex tears without joint dissociation. The signal intensity and integrity of the SLIOL compartments and secondary stabilizers of the complex were examined. The aim of this study is to investigate SLIOL injury associations at the beginning of events by examining partial injuries in terms of tear location and their extrinsic ligament damage accompaniments previous to carpal instability. We also scrutinized conservative treatment responses of the subjects on the basis of these information.

MATERIAL AND METHODS

The study was approved by our hospital institutional review board (Approval no:18.02.2021-194). Written informed consents were obtained for all patients. The study has been reported in line with the STROCSS criteria (1).

311 patients admitted with radial sided wrist pain between 2018 and 2020 were retrospectively evaluated. Patients with radiological and clinical evident scapholunate dissociation; increased scapholunate gap and scapholunate angle in radiography or positive scaphoid shift maneuver (Watson test) were excluded from study. 119 of 311 patients had SLL and/or extrinsic ligament injury on MRI. 5 patients were excluded due to motion artefact and 10 patients due to missing pre-treatment questionnaires. 104 patients who had SLIOL and/or extrinsic ligament injury on MRI were included, 49% (n:51) were female, 51% (n: 53) were male with mean age 34 ± 10 (age range, 12–67 years). MR images of all patients were retrospectively re-interpreted by 9-year experienced musculoskeletal radiologist blinded to clinical information and patients' identities.

The information data about the trauma history and symptom duration was available in our hospital computer system. Symptom duration less than 6 weeks was accepted as acute injury. All patients had been treated with splint at least 6 weeks. Conservative treatment response was determined with visual analog scale for pain (VAS),

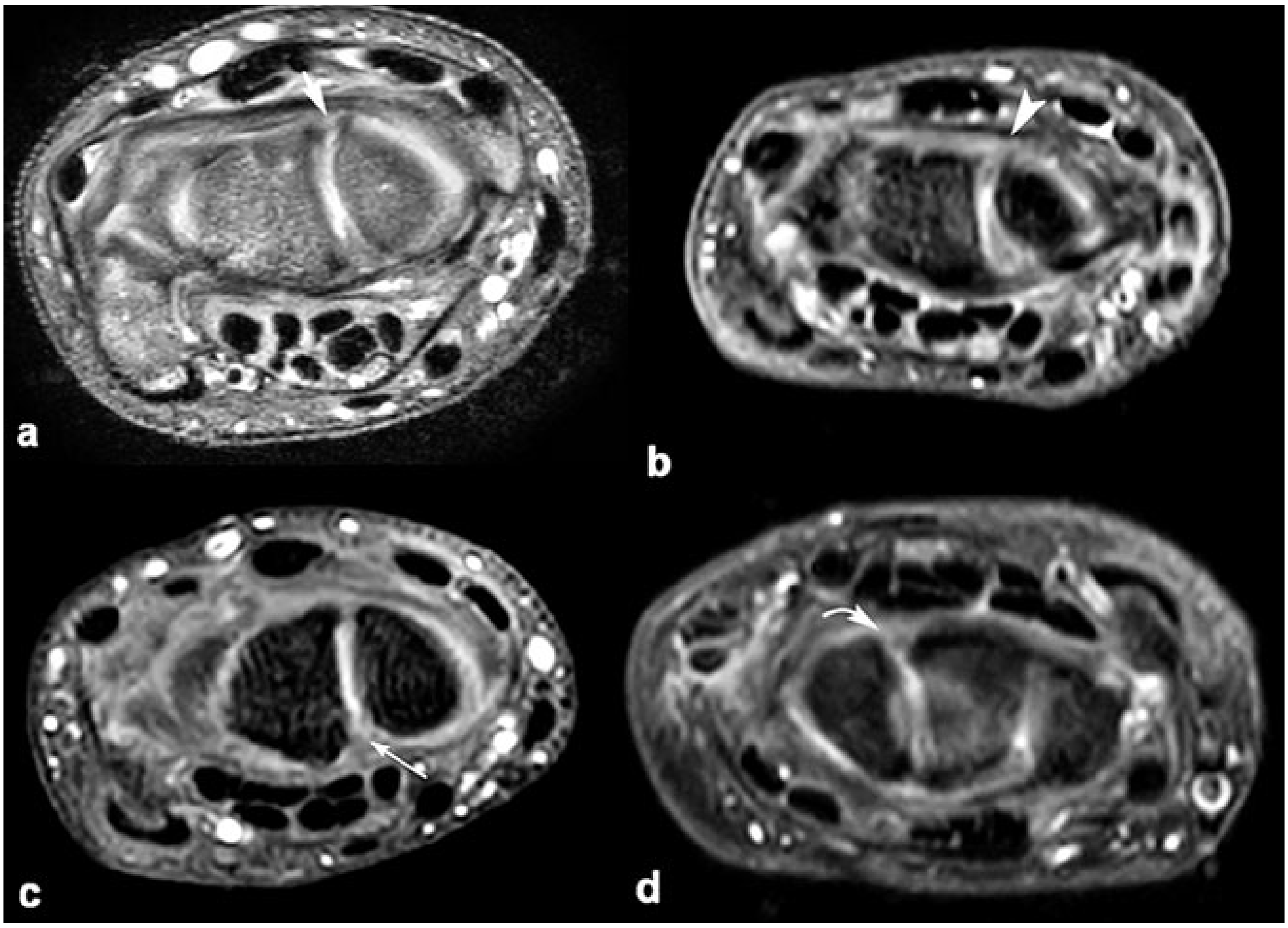


Fig. 1. Axial PD-weighted images:
a – SLIOL dorsal compartment partial tear (grade 2) is seen as focal thinning of transverse fibers and increased signal intensity (white arow);
b – in dorsal part of SLIOL, complete loss of transverse fiber integrity is shown in grade 3 tear (arrow head);
c – SLIOL volar compartment partial tear, partial discontinuity of fibers is seen (thin arrow);
d – volar portion complete tear is apparent at scaphoid attachment (shaped arrow).

disabilities of the arm, shoulder and hand questionnaire (DASH) and Patient-Rated Wrist Evaluation scores (PRWE). Test scores were calculated before treatment and at the first year-follow-up evaluation.

Wrist imaging has been performed with standardized wrist protocol on 3T MRI scanner without contrast agent. Intraligamentous edema or partial disruption with fluid signal accepted as partial injury; absence of the ligament or visible full thickness tear graded as complete tear on MRI. SLIOL injuries recorded as isolated volar, isolated dorsal, both volar and dorsal tears according to location (Fig. 1). RSC, LRL, STT, DRC, DIC signal and ligamentous integrity were examined in all patient. Preserved fiber integrity but peri-ligamentous edema was accepted as grade 1 injury, partial integrity loss or thickened/fibrotic appearance with reduced signal as grade 2 injury and complete tears accepted as grade 3 injury (Fig. 2).

Fisher exact test was used for comparison SLIOL tears in terms of injury localization, grade and extrinsic ligament damage accompaniment. For pre- and post-treatment test results analyzes One-Way ANOVA, Levene tests and Paired Sample-t- test were used.Statistical analyses were performed using the SPSS software version 15.A 5% type-1 error level was used to infer statistical significance.

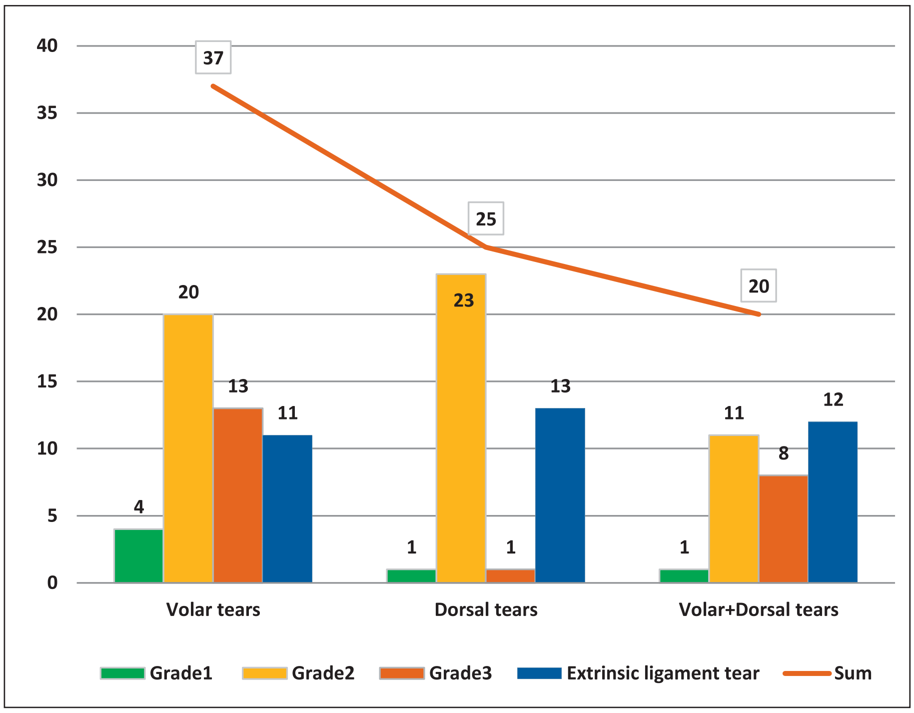
Imaging

All MRI examinations were performed on 3.0-T scanner (Philips-Achieva) in prone position with arm extended above the head and palm flat on the table, using a phased array dedicated wrist coil and wrist secured by adhesive taping. Following parameters were used for SL complex examination: axial fat-suppressed turbo-spin-echo proton-density (PD-weighted (TR/TE, 2736/30; NEX, 2; matrix, 280×234; slice thickness, 3 mm; FOV,10 cm), coronal fat-suppressed turbo-spin-echo PD-weighted (TR/TE, 2500/30; NEX, 2; matrix, 188×218; slice thickness, 3 mm; FOV,14 cm), sagittal fat-suppressed turbo-spin-echo PD-weighted (TR/TE, 2470/30; NEX, 2; matrix, 254×320; slice thickness, 3 mm; FOV, 10 cm) and coronal FFE gradient-echo 3-dimensional T2-weighted (TR/TE, 20/4; NEX, 1; matrix, 280×379; slice thickness, 1 mm; FOV, 14 cm), intravenous contrast-enhanced studies are not part of our protocol for wrist pain.

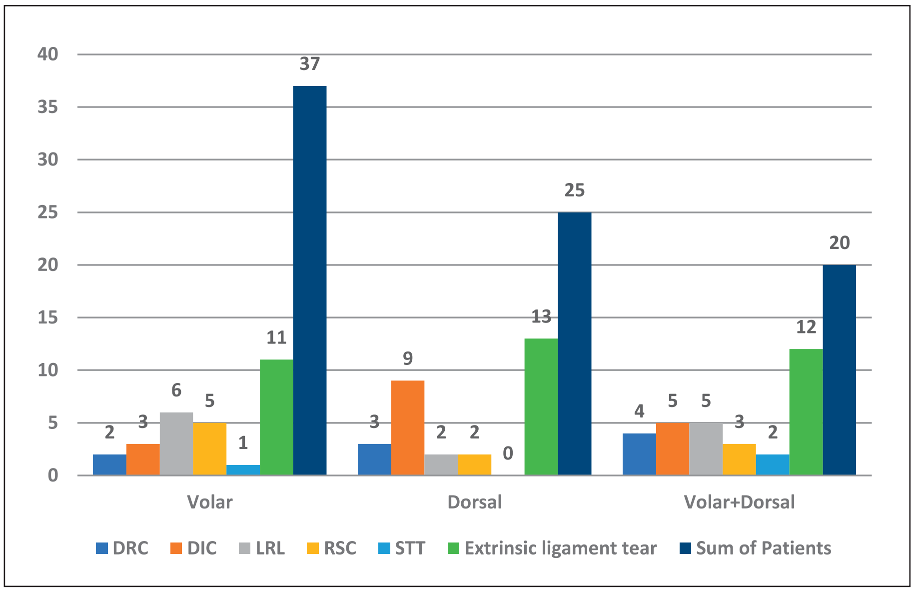
Fig. 2. Non-contrast PD-weighted images:
a, b – DIC ligament split tear, fluid signal in the ligament is shown on sagittal and coronal images (black arrow);
c – same patient with accompanying DRC ligament partial tear, intraligamentous fluid signal is seen (white arrow);
d – LRL and RSC ligament partial tears shown with apparent fluid signal in fibers (thin black arrow), ganglion cyst associating with extrinsic ligament tear is seen (black arrow head);
e, f – SLIOL volar compartment complete tear apparent in coronal and axial images with bone bruise (white arrow head), in this case concurrent partial tear of dorsal portion of SLIOL shown as increased signal in deep fibers on axial image (black thin arrow).

RESULTS

Patients mean scapholunate gap was 2.1 ± 0,6 and the mean scapholunate angle was 46° ± 4.0° in neutral anteroposterior (AP) and lateral radiography. 79% (n: 82) of 104 patients were SLIOL tear and 21% (n: 22) were isolated extrinsic ligament injury. Among the SLIOL tears, 44% (n: 36/82) had accompanying extrinsic ligament injury and 56% (n:46/82) were isolated tears. 45% (n: 37) of SLIOL tears were volar, 31% (n: 25) dorsal and 24% (n: 20) were combined volar and dorsal tears. 65% (n: 24/37) of isolated volar tears were partial and 35% (n: 13/37) were complete. 88% (n: 22/25) of isolated dorsal tears were partial, 12% (n: 3/25) were complete tear. Among both volar and dorsal tears, partial injuries of each compartment were most frequently observed (60%, n: 12/20) (Graph 1). 5 cases had volar complete and dorsal partial tear, 1 case had dorsal complete and volar partial tear. Complete tears of both ligaments were seen in 2 cases.



Graph 1. Scapholunate interosseous ligament tears.



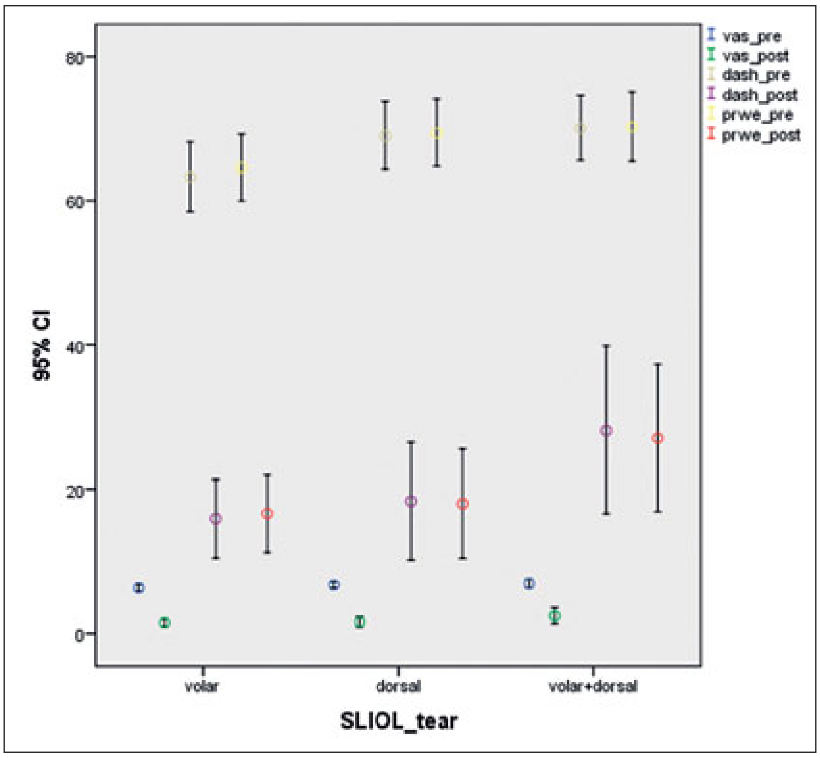
Graph 2. Extrinsic ligament injury rates accompanying SLIOL tears.

In our cohort, 75% (n: 27/36) of extrinsic ligament injuries accompanying SLIOL tear were grade 2 and 25% (n: 9) were grade 1 injury. Among isolated extrinsic ligament tears 63% (n: 14/22) were grade 2 tear and 37% (n: 8/22) were grade 1 injury. Extrinsic ligament complete tear was not present in our study group.

Regardless of SLIOL tear localization, DIC(n:17) and LRL(n: 13) were the most commonly torn ligaments in SLIOL injuries, followed by RSC(n:10), DRC(n: 9), STT(n: 3). The ratio of coexistence at least one extrinsic ligament injury was (60%, n:12/20) in combined volar and dorsal tears, (52%, n: 13/25) in dorsal tears and (29%, n: 11/37) in volar tears. (p: 0.02) The frequency of accompanying extrinsic ligament injuries increased from volar tears to dorsal, but was the highest in combined tears. The incidence of extrinsic ligament tears in SLIOL injuries as follows; 55% (n: 6/11) of volar SLIOL tears had one, 45% (n: 5/11) had 2 extrinsic ligament injuries. 62% (n: 8/13) of dorsal SLIOL tears had 1, 38% (n: 5/13) had 2 extrinsic ligament injuries. In combined volar and dorsal tears, 58% (n: 7/12) had 1, 33% (n: 4/12) 2 and 1 had 3 extrinsic ligament injuries. In Individual evaluations of extrinsic ligaments according to tear localization; DIC (36%) was the most commonly injured ligament in dorsal tears, LRL (16%) and RSC (13%) in volar tears and LRL (25%), DIC (25%) in combined volar and dorsal tears (Graph 2).

Half of the patients (n: 52) admitted with symptom duration less than 6 weeks. 65% of these patients had trauma history and 50% had soft tissue edema consisted with acute injury. Among patients admitted with chronic pain (symptom duration ≥ 6 weeks), 70% had no trauma history and edema. (p: 0.01). Concomitant extrinsic ligament tears existed in 41% (n:16) of acute SLL injuries and 46% (n: 20) of chronic group (p: 0.61). Patients presenting with acute symptoms 49% (n: 19) had volar, 28% (n: 11) had dorsal and 23% (n: 9) had combined volar and dorsal tears; in chronic injury group 42% (n: 18) had volar, 32% (n: 14) had dorsal and 25% (n: 11) had both volar and dorsal tears. No statistically significant difference was found between acute and chronic SLL injuries in terms of the SLIOL injury localization and frequency of association extrinsic ligament tears (p: 0.8).

The average pre-treatment VAS score was 6.6 (SD, 1.8), post-treatment 1.7 (SD, 1.1), pre-treatment DASH score was 67.3 (SD, 12.7), post-treatment 18.7 (SD, 13.4), pre-treatment PRWE score was 68.6 (SD, 12.3), post-treatment 18.7 (SD, 15.6). Patients DASH, VAS and PRWE score's significant decrease demonstrate positive response to conservative treatment (p: < 0.001) (Graph 3). Accompanying extrinsic ligament injuries to SLIOL tear had higher pre-treatment VAS, DASH and PRWE scores than isolated SLL tears. In comparison of treatment responses, significant difference was not observed between isolated SLIOL tears and SLIOL with concurrent extrinsic ligament injuries (p: 0.9). Additionally, no significant difference was established in treatment responses regarding grade and location of the SLL tears. Improvement of test scores is more evident in acute injuries and VAS scores in these patients had also statistically significant decrease comparing to chronic injury group (p: 0,01). DASH (p: 0.07) and PRWE (p:0,06) score reversal was also greater than chronic injuries.



Graph 3. Conservative treatment response according with respect to SLIOL tear localization.

DISCUSSION

SLIOL ligament tears are not always presented with clinical and radiological evident instability in symptomatic patients. MRI imaging has important contribution in both exclusion of other causes of radial sided wrist pain (occult ganglion, scaphoid fracture, kickenbörg disease) and evaluation of SL joint ligamentous integrity upon the diagnosis is not obvious and invasive diagnostic methods are not applied initially. Albeit 38%–88% sensitivity and 34%–100% specificity ratios in literature had broad range, current studies reported 89% MRI sensitivity, 100% specificity was a considerably high ratio (5, 8, 11, 15, 23, 24, 25, 30). Imaging on high resolution MRI sequences with 3D reformation provides opportunity to visualize extrinsic ligaments entirely, which cannot be done even with the use of multiportal wrist arthroscopy (19, 20, 27). Nonetheless, MRI analysis of scapholunate complex is beneficial and injuries can be depicted accurately (30).

Physiological uncoupling of scapholunate joint is cascade of events that emerge from scapholunate interosseous ligament disruption with accompanying at least one or more extrinsic ligament tear. Although many studies aimed to reveal the contribution of these ligaments in stability, a definitive consensus regarding pathomechanical function of each has not been revealed yet.

Short et al. cadaveric studies showed that SLIOL provides scaphoid and lunate bone to act together especially during flexion-extension movement. Their experimental study showed the virtual role of extrinsic ligaments is keeping them to their corresponding radial fossa during flexion-extension and radial-ulnar deviation. Whilst STT and RSC ligament cutting after SLIOL resulted in further scaphoid flexion and ulnar deviation, DIC, DRC sectioning produced further lunate extension, radial deviation (21, 22). It is quite apparent that the results were compatible with anatomical extensions of these ligaments.

Current studies have showed that intrinsic ligament injuries even complete ones do not cause carpal instability in the absence of concomitant extrinsic ligaments tears (12, 18, 20). Regarding the topic, Theumann et al. demonstrated increased SL gap, scaphoid ulnar deviation and intercalated segment instability in SLIOL tears coexisting with RSC-LRL ligament rupture (27). Van Overstraeten et al. correlated SL instability with accompanying LRL complete tears to SLIOL tears (28). Elsaidi et al. revealed DIC preventing role in scaphoid rotatory subluxation and DRC in keeping lunate position and inferred that isolated scapholunate ligament injury may not result in immediate instability if the secondary stabilizers are intact (4). Lee et al. emphasize pivotal role of dorsal extrinsic ligament in SL stability by showing the disruption progressed to Geissler grade 4 injury after SLIOL and palmar extrinsic ligaments cutting (9). Messina et al. demonstrated significantly increased arthroscopic grade of injury with additional sectioning of at least two secondary stabilizers (13). Mitsuyashu et al. signified similar conclusion by associating dorsal extrinsic ligament insufficiencies with dynamic and static instability (14).

Our study is unique in terms of studying SL ligament complex partial injuries with MRI and providing an advantage of in vivo assessment SLIOL's isolated volar, dorsal or combined injuries with their coexisting extrinsic ligament damage to comprehend the biomechanical relation of this association prior to instability developed. In our study group, admitted with radial side wrist pain, MRI showed that 26% (n: 82/311) of patients had at minimum one compartmental SLIOL partial tear and 44% of them had at least 1 accompanying extrinsic ligament injury. Volar compartment of SLIOL was the most frequently damaged part in acute or chronic injuries, followed by dorsal and complete tears. Dorsal compartment is the thickest and biomechanically strongest part of the ligament and considered to be the most important portion for stability (3, 17). Consequently, higher rates of isolated volar injuries is predictable owing to its structural feature, making it more prone to trauma and/or degeneration.

LRL and DIC were most frequently damaged ligaments in SLIOL tears. Similar to of A.Taneja et al. study, reporting LRL as most commonly affected ligament and DIC as most frequently full thickness torn ligament in trauma patients (26). In our study, LRL was the most common injured extrinsic ligament in volar SLIOL tears and DIC in dorsal tears (p: 0.02). Mayfield et al. study regarding the volar extrinsic ligaments were torn before dorsal extrinsic ligaments may be implicitly related with higher frequency of volar SLIOL injuries and mentioned palmar secondary stabilizers associations (7). Messina et al. study had similar findings regarding extrinsic ligament accompaniment according to SLIOL tear localizations. They depicted anterior laxity (EWAS stage IIIA) in volar SLIOL tears with accompanying LRL-RSC cutting, posterior laxity (EWAS stage IIIB injury) in dorsal SLIL tears with DIC cutting (13). We think that this association can be important for comprehending etiopathogenesis. Remarkably we observed similar extrinsic and intrinsic ligament injury co-existence in both acute and chronic injuries. In acute injuries, concomitant ipsilateral secondary stabilizer tears in SLIOL disruptions may have been attributed to the injury mechanism impairing both. However, ipsilateral attenuation of LRL ligament with volar tears and DIC with dorsal tears in chronic cases must have reflected wearing process of secondary stabilizers, which takes on primary role to compensate alignment throughout wrist motions. Because our SLIOL tears were not complete tears and complete extrinsic ligament rupture not accompanied, the same grade of injury, corresponding dynamic instability in Messina's study was not observed. In addition supporting the literature, we think that this association created different perspective in comprehending the causative relation of injury cascade.

Our study showed that partial injuries of SLIOL even dorsal compartment tears did not result in carpal instability in the absence of complete extrinsic ligament rupture. Studies regarding conservative treatment response in SLIOL partial injuries were limited. At the beginning of our study, we hypothesized that dorsal SLIOL tears may have diminished conservative treatment responses compared to volar tears as the strongest and biomechanically greatest functional part. Linkous et al. study that reported higher rates of dorsal communication defects in symptomatic patients and Patterson et al. recommendation about the effectiveness of dorsal component repairing in predynamic instability had supported our hypothesis (10, 17). However, conservative treatment responses of dorsal tears did not significantly differ from volar tears. Regression of test results with conservative treatment in both groups showed satisfactory improvement in pain levels, grip strength and functional regain ($p<0.001$) and supported the studies in literature (2, 6). We think that conservative approach could be the initial treatment option even in complete one compartmental tear of SLIOL regardless of localization if the integrity of contralateral portion is preserved and extrinsic ligament rupture is not accompanied. O'Meeghan et al. study demonstrating that untreated SLIOL tears do not progress to radiographic scapholunate dissociation or DISI deformity supports to present our proposal with more confidence.

Retrospective nature is one of the limitations of our study. Verifying the MRI results with arthroscopy would be better for more confidential results. Although blinded to clinical information and patients' identities, interpretation of images by a single radiologist's decreases the reliability of the study. Studying only partial tears of SLIOL and extrinsic ligament was another limitation. Comparison the results with corresponding complete tears of these structures would be better for a more precise conclusion. We also know that 1-year follow-up is not a sufficient time period for evaluation effectiveness of the treatment and to make decisive conclusion regarding injury progression.

CONCLUSIONS

Extrinsic ligament injuries frequently accompany SLIOL ligament tears. LRL and DIC ligaments are the most commonly damaged ligaments. LRL damage accompaniment to volar SLIOL tears and the DIC to dorsal tears in both acute and chronic injuries may provide an important contribution to comprehend etiopathogenesis of SL instability. In imaging SLIOL injuries, additional attention should be paid to the integrity of these structures. In partial SLIOL injuries, if extrinsic ligament integrity was preserved, noteworthy improvement in pain levels, grip strength, functional capability was achieved with conservative treatment regardless of tear localization and symptom duration. However, retrieval of test results was more pronounced in acute injuries. Consequently, conservative approach could be the initial treatment option in these subjects.

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