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Katerina Kasapinova & Viktor Kamiloski

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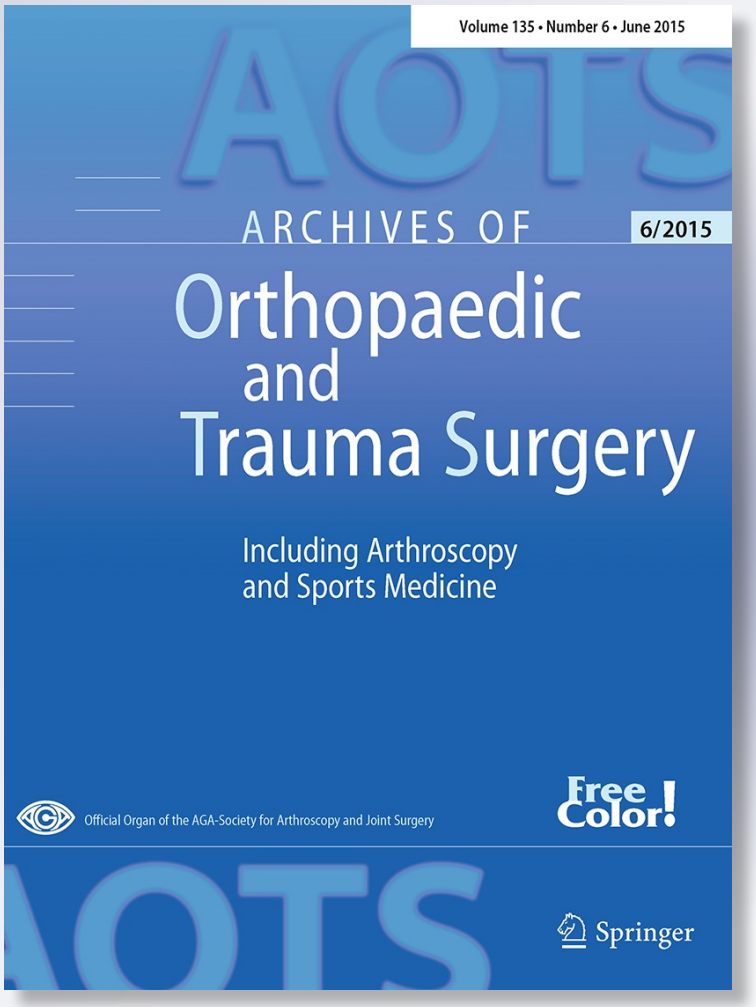

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ARTHROSCOPY AND SPORTS MEDICINE

Influence of associated lesions of the intrinsic ligaments on distal radius fractures outcome

Katerina Kasapinova[1,2] · **Viktor Kamiloski**[1,2]

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Abstract
Introduction We aimed to evaluate the influence of associated scapholunate (SL) and/or lunotriquetral ligament (LT) injury on the outcome of distal radius fractures.
Materials and methods This prospective study included 40 patients with surgically treated distal radius fracture. Wrist arthroscopy was used to identify associated lesions of the scapholunate and lunotriquetral ligaments and classify them according to Geissler. Patients were divided in two groups by presence (injured group) or absence (intact group) of associated injury of the SL and/or LT ligament. The patient-rated wrist evaluation (PRWE) and the disabilities of the arm, shoulder and hand (DASH) questionnaires were used to evaluate disability 3 and 6 months after injury. Grip strength was also evaluated.
Results Wrist arthroscopy identified SL and/or LT injury in 15 patients (37.5 %). Mean total PRWE score for the intact group was 26.64 at 3 months and 16.22 at 6 months, and 50.47 (at 3 months) and 20.7 (at 6 months) for the group with ligament injury. Mean DASH scores were 26.03 and 13 at 3 and 6 months for the intact group, and 49.5 and 24.11 for the injured group. Mann–Whitney test results showed significant difference for the PRWE and DASH scores and the grip strength for the two examined groups.
Conclusions Patients with distal radius fracture with associated intrinsic ligament injury had worse outcomes than did patients without associated ligamentous injury. Associated injuries of the SL and LT ligament should be considered when treating distal radius fractures, and wrist arthroscopy should be incorporated into the operative protocol.

Keywords Distal radius fracture · Scapholunate ligament · Lunotriquetral ligament · Wrist arthroscopy · Disability

Introduction

Distal radius fractures can be associated with lesions of the soft-tissue structures of the wrist, including the triangular fibrocartilage complex (TFCC), intrinsic carpal ligaments [scapholunate ligament (SL) and lunotriquetral ligament (LT)], volar and dorsal extrinsic ligaments, and chondral surfaces. The scapholunate ligament has its most important component located dorsally, as opposed to the lunotriquetral ligament where the volar aspect is most important [3].

The incidence of SL and LT injury associated with distal radius fractures has been reported to range from 8 to 54 % and from 7 to 61 %, respectively [6, 12, 14, 19, 24, 26].

Various consequences of associated SL and LT injuries have been reported. Peicha et al. [25] found that unrepaired complete SL tear resulted in scapholunate dissociation and possible subsequent carpal instability, and suggested that this is the cause of unsatisfactory long-term outcomes of distal radius fractures. However, this assumption was not confirmed by studies that evaluated the correlation of these findings with functional and patient-rated outcomes. While Ruch et al. [27] published excellent results in 13 out of 14 patients with SL or LT tear,

✉ Katerina Kasapinova
kasapinovakaterina@yahoo.com

[1] Medical Faculty, University "St. Cyril and Metodius", Skopje, Republic of Macedonia

[2] Department of Traumatology, University Surgery Clinic "St. Naum Ohridski" Skopje, 11 Oktomvri 53, 1000 Skopje, Republic of Macedonia

Westkaemper et al. [32] had poor results in 4 out of 5 patients treated only with debridement after LT tear. Forward et al. [8] reported that patients had pain over the scapholunate joint 1 year after complete SL tear, but there were no significant differences in the objective outcomes presented with wrist range of motion and grip strength. In the study of Weiss et al. [31], who followed the patients for an average of 27 months, in 19 of 29 patients with complete SL tear and 31 of 36 with partial SL tear, symptoms were decreased or completely resolved; the same was reported for 26 of 33 patients with complete LT tear and for all 40 patients with a partial LT tear. However, none of these studies used patient-reported questionnaires to evaluate disability.

Management of the disruption of intercarpal ligaments associated with distal radius fracture depends on the time since injury and the severity of disruption. Clear guidelines for treatment of these injuries confirmed with prospective cohort studies are lacking. Grade I injuries can be treated with immobilization only. Immobilization is sufficient with most of grade II tears as most patients are asymptomatic at 1 year [8]. An option is to reduce and pin the SL joint [3, 10, 12]. It has been shown that SL and LT grades III and IV injuries are likely to lead to chronic symptoms of carpal instability [3, 8, 25]. Most experts now agree on immediate surgical intervention if such severe disruptions are noted acutely following distal radius fractures. In such instances, even a direct open repair of the scapholunate ligament could be considered and the repair protected with K-wires [3, 8, 17]. Concomitant dorsal capsulodesis has shown to be useful in reinforcing the repair [3].

Clinical studies that have evaluated outcomes of distal radius fractures from the perspectives of patient satisfaction, perception of disability, and quality of life after the injury did not find associations with radiographic outcome, suggesting that a well-treated bone lesion does not guarantee patient satisfaction [1, 7, 13, 16, 33]. This finding may be explained by the presence of associated soft-tissue lesions that were not recognized or treated. The natural course of healing and the clinical outcomes of associated lesions of the intrinsic intercarpal ligaments are not yet known. There are not enough clinical studies employing patient-rated disability that have evaluated the correlation between associated lesions of the intrinsic ligaments and outcome of distal radius fractures. The aim of this study therefore was to evaluate the influence of associated scapholunate and/or lunotriquetral ligament injury on the outcome of distal radius fracture. The working hypothesis was that distal radius fractures associated with intrinsic ligament injury have worse outcome.

Materials and methods

Patients

This clinical study was designed as prospective randomized study of patients with distal radius fracture. The study was approved by the Ethical Committee of the Ministry of Health of our country as well as by our medical faculty. All patients gave their informed consent prior to inclusion in the study. The two authors of the study performed all the operations.

Inclusion criteria were acute distal radius fracture in a skeletally mature patient, age 16–65 years, and operative treatment indicated (regardless of the type of the fixation method used). Exclusion criteria were fracture in patient with unfused epiphyses; concomitant carpal or hand fracture on initial radiographs, neurovascular injury; and contraindications for wrist arthroscopy (local infection, compartment syndrome, and problems positioning in vertical traction). Forty patients met inclusion criteria and completed the follow-up. Each patient's age, sex, side and mechanism of injury were recorded.

Diagnostic wrist arthroscopy and fracture fixation

Arthroscopic examination followed a standardized protocol [3, 11]. The patient was positioned supine (general anesthesia); the hand was abducted, and a pneumatic tourniquet was applied. Wrist distraction was achieved using a standard mechanism for vertical wrist traction with finger traps. A 2.7 mm, 30°-angle arthroscope was used. Initially the arthroscope was introduced through the dorsal 3–4 portal and the joint was lavaged to clear it of hematoma and fracture debris. An additional radiocarpal portal, 6R, was than created. A small joint shaver was placed through this portal to help clear all the remaining hematoma and dorsal synovitis and provide a clear view of all joint structures and the fracture site, which were examined using a probe. Dorsal midcarpal radial (MCR) and midcarpal ulnar (MCU) portals were created and the midcarpal joint was inspected to evaluate the integrity of the intercarpal ligaments.

Intraoperatively, systematic inspection of the intercarpal ligaments was performed under arthroscopic vision. The SL and LT ligaments were assessed from both the radiocarpal and midcarpal joints and graded according to Geissler's arthroscopic classification of carpal interosseous ligaments [10, 12].

Following arthroscopic inspection of the radiocarpal and midcarpal joints, fixation of the distal radius fracture was performed. If arthroscopy identified grades III or IV SL and/or LT lesion, percutaneous scapholunate and/or

lunotriquetral joint transfixion with K-wires was performed with use of fluoroscopy. The injured ligament was not repaired, nor capsulodesis was performed.

To randomise the study, only patients that had postoperative satisfactory fracture reduction according Fernandez [5] were included in the study. Operated wrists were immobilized (those with internal fixation) for 4 weeks postoperatively, or for 6 weeks if associated intrinsic ligament injury had been diagnosed arthroscopically.

Group assignments

Patients were divided into two groups by arthroscopic findings: those with associated scapholunate and/or lunotriquetral ligament injury (injured group, $n = 15$) and a control group of patients with no associated lesion (intact scapholunate, lunotriquetral ligament and TFCC) (intact group, $n = 25$). Patients with arthroscopically diagnosed TFCC lesion or combined associated lesions of SL and/or LT ligament and TFCC were excluded from the study.

Outcome measures

Evaluation of the disability

Two patient-rated questionnaires were used to evaluate disability: the patient-rated wrist evaluation (PRWE) [22] and the disabilities of the arm, shoulder and hand questionnaire (DASH) [4, 21].

Examination of the physical characteristics of the wrist

Grip strength was measured bilaterally with a hydraulic hand dynamometer using a standardized procedure [15, 23]. It was expressed as a percentage and calculated as follows: (value of injured side)/(value of uninjured side) × 100, correcting by factor of 1.07 for the non-dominant hand strength [9, 15].

Patients were evaluated at 3- and 6-month follow-up visits, at which time the PRWE and DASH questionnaires were completed, and grip strength measured.

Statistical analysis

Data were analyzed using SPSS Statistics for Windows, version 17.0 (SPSS Inc., Chicago, IL, USA) and Minitab 15 statistical software (Minitab Inc., State College, PA, USA). Data are presented as means and percentages, standard deviations, and minimal and maximal values. Spearman's rank correlation was used to test correlations of non-parametric data. The Mann–Whitney *U* test was used to evaluate between-group differences in outcomes. A p value of <0.05 was considered statistically significant.

Results

Characteristics of the patients evaluated in this study divided in groups are shown in Table 1, presented as a number and percentage. Table 1 also shows the type of fracture fixation.

In this study 15 patients (37.5 % of the total number of the patients included in the study) with arthroscopically diagnosed associated injury of the intrinsic carpal ligaments were included (scapholunate and/or lunotriquetral ligament). The scapholunate ligament (SL) was injured in 14 patients (35 %). In ten, there was also an associated injury of the lunotriquetral ligament (LT), and in four the SL injury was isolated (LT intact). The distribution of the types of the SL and LT lesions according to Geissler classification was as follows: scapholunate ligament, grade I, two patients (14.29 %); grade II, five patients (35.71 %); grade III, five patients (35.71 %); grade IV, two patients (14.29 %); lunotriquetral ligament, grade I, one patient

Table 1 Characteristics of the evaluated patients

	Total	Intact	SL/LT
Gender			
Female	25 (62.5 %)	15(60 %)	10 (66.67 %)
Male	15 (37.5 %)	10 (40 %)	5 (33.33 %)
Age (years)			
Mean	48.73	45.56	53.53
SD	13.94	15.36	10.20
Max	65	65	64
Min	16	16	27
Mechanism of injury			
Simple fall	24 (60 %)	15 (60 %)	9 (60 %)
Fall of height	11 (27.5 %)	8 (32 %)	3 (20 %)
Direct contusion	3 (7.5 %)	0	3 (20 %)
Overexertion	2 (5 %)	2 (8 %)	0
Injured side			
Left	55.29 %		
Right	44.71 %		
Dominant side			
Left	2.35 %		
Right	97.65 %		
Fracture fixation type			
AAIF K-wires	6 (15 %)	4 (16 %)	2 (13.33 %)
Ex.fix.	14 (35 %)	11 (44 %)	3 (20 %)
ORIF Vol.conv.plate	8 (20 %)	5 (20 %)	3 (20 %)
ORIF Vol.lock.plate	12 (30 %)	5 (20 %)	7 (46.67 %)

SL/LT scapholunate/lunotriquetral ligament, *SD* standard deviation, *Max* maximum value, *Min* minimum value, *AAIF K-wires* arthroscopy assisted percutaneous fixation with K-wires, *ORIF* open reduction and internal fixation, *Ex.fix* external fixation augmented with K-wires, *Vol.conv.plate* volar conventional plate, *Vol.lock.plate* volar locking plate

Table 2 Mean result with standard deviation and minimum and maximum values for the separate items, three scales and total PRWE score at 3 and 6 months for the control group of distal radius fractures without associated SL/LT lesions

Item	3 months				6 months			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Pain								
At rest	0.4	0.65	0	2	0.36	0.7	0	2
Repeated movement	3.52	2.97	0	10	1.6	0.91	0	3
Lifting heavy object	4.04	2.68	0	10	2.44	1.64	0	5
At its worst	3.8	2.97	0	10	2.88	2.05	0	6
Frequency	2.4	1.12	0	4	2.48	2.42	0	8
Specific activities								
Turn a door knob	1.8	1.91	0	7	1.04	1.17	0	3
Cut meat with knife	2.12	2.20	0	8	1.8	2.57	0	8
Fasten buttons	1.12	1.54	0	5	0.28	0.79	0	3
Push up from a chair	3.44	2.29	0	8	2.12	1.69	0	5
Carry a 5 kg object	4.92	3.26	0	10	2.84	2.76	0	9
Use bathroom tissue	1.8	2.33	0	8	0.8	1	0	3
Usual activities								
Personal care	1	1.12	0	4	0.4	0.76	0	3
Household work	2.56	2.26	0	7	1.04	1.14	0	3
Work	3.56	3.31	0	10	1.6	2.6	0	8
Recreation	2.64	1.87	0	6	1	1.38	0	4
Pain (50)	14.16	8.25	0	29	9.76	6.75	0	23
Specific activities (60)	15.2	10.84	1	42	8.88	7.64	0	24
Usual activities (40)	9.76	6.48	0	21	4.04	5.22	0	16
Total score (100)	26.64	14.18	1	54	16.22	12.7	0	43

Mean mean value, *SD* standard deviation, *Min* minimum value, *Max* maximum value, *SL/LT* scapholunate/lunotriquetral ligament

(10 %); grade II, three patients (30 %); grade III, five patients (50 %); grade IV, one patient (10 %).

Disability evaluation

Results from the analysis of the two examined groups presented as individual PRWE items, values of the subscales, as well as the total PRWE scores are shown in Tables 2 (intact group results) and 3 (injured group results), as well as Fig. 1 (presenting means of the both groups).

DASH questionnaire results, presented as total scores 3 and 6 months after injury are shown in Table 4 (mean values, standard deviation, minimal and maximal values for the two examined groups of patients) and Fig. 2 (mean DASH scores).

A nonparametric Mann–Whitney test was used, with confidence interval 95 % to compare the scores for the three PRWE subscales and the total PRWE score, as well as the DASH scores for the two examined groups. The results of the statistical analysis are shown in Table 5, wherein the asterisk indicates a significant difference. The PRWE results showed significant difference of pain, specific activities and usual activities at 3 months, significant difference of total pain and disability at 3 months, as well as significant difference of pain at 6 months. The statistical analysis of the disability evaluated with the DASH results showed significant difference of the disability at 3 months, as well as at 6 months.

Grip strength assessment

Results of grips strength evaluation for both groups, 3 and 6 months postoperatively, presented as percentages, are shown in Table 6.

The results from the Mann–Whitney test for the grip strength of the two examined groups showed a statistically significant difference for the results 3 months after operation ($W = 606.5$, $p = 0.0088$), but at 6 months the difference in the results of the two groups was not significant ($W = 516.0$, $p = 0.9331$).

Discussion

Key findings:

– PRWE results indicate that patients with a distal radius fracture associated with an intrinsic ligament lesion have significantly greater pain 3 and 6 months after

Table 3 Mean result with standard deviation and minimum and maximum values for the separate items, three scales and total PRWE score at 3 and 6 months for the examined group of distal radius fractures with associated intrinsic ligament lesion

Item	3 months				6 months			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Pain								
At rest	1.67	1.35	0	4	0.6	0.99	0	3
Repeated movement	4.33	1.76	1	8	2.07	1.33	0	6
Lifting heavy object	6.93	2.68	1	10	3.73	2.46	0	10
At its worst	6.93	2.40	1	10	3.13	1.68	0	5
Frequency	4.33	2.61	1	10	2.6	1.64	0	5
Specific activities								
Turn a door knob	4.67	2.13	2	9	1.73	1.62	0	6
Cut meat with knife	5.67	3.11	2	10	2.07	1.83	0	7
Fasten buttons	3.6	2.38	0	9	0.67	0.9	0	2
Push up from a chair	6.8	2.91	2	10	1.53	2.1	0	8
Carry a 5 kg object	7.73	2.69	4	10	2.87	2.39	0	10
Use bathroom tissue	5.07	3.06	1	10	1.13	2.1	0	8
Usual activities								
Personal care	4.4	2.47	0	9	1.07	1.39	0	4
Household work	4.93	2.05	1	8	1.53	1.06	0	4
Work	5.27	2.69	1	10	1.73	1.1	0	4
Recreation	4.4	2.90	0	10	1.53	1.77	0	7
Pain (50)	24.2	8.21	5	38	12.13	6.47	0	27
Specific activities (60)	33.53	10.49	17	52	10	7.72	4	35
Usual activities (40)	19	8.3	5	32	5.87	4.09	0	16
Total score (100)	50.47	15.97	17.5	80	20.7	10.41	2	43.5

Mean mean value, *SD* standard deviation, *Min* minimum value, *Max* maximum value

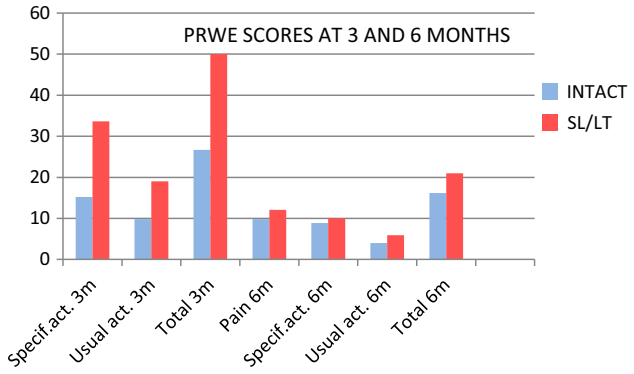

Fig. 1 Mean PRWE score for the two examined groups, 3 and 6 months after injury. *INTACT* patients with no associated injury, *SL/LT* group of patients with associated scapholunate and/or lunotriquetral ligament injury, *Specif.act* specific activities, *Usual act.* usual activities

Table 4 DASH questionnaire scores at 3 and 6 months

Group	DASH score			
	Mean	SD	Min	Max
DASH 3 months				
Intact	26.03	11.83	12.5	49.17
SL/LT	49.5	14.07	21.67	72.5
DASH 6 months				
Intact	13	11.98	0	35.83
SL/LT	24.11	14.06	6.67	53.33

Mean mean value, *SD* standard deviation, *Min* minimum value, *Max* maximum value, *DASH* disability of arm, shoulder and hand, *SL/LT* scapholunate/lunotriquetral ligament

injury, as well as significantly greater disability in performing specific and usual activities 3 months after injury.

– Patients with an associated injury of the scapholunate and/or lunotriquetral ligament have a significantly greater disability at 3 and 6 months than patients with a distal radius fracture not associated with intrinsic ligament injury, as evaluated with the DASH questionnaire.
– Patients with an associated intrinsic ligament injury have significantly lower grip strength at 3 months, but at 6 months the difference is not significant.

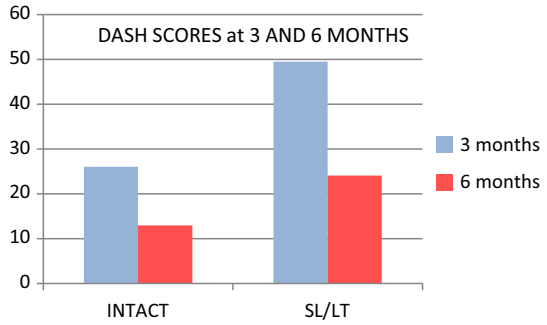

Fig. 2 Mean DASH scores, 3 and 6 months for the two examined groups. *INTACT* patients with no associated injury, *SL/LT* group of patients with associated scapholunate and/or lunotriquetral ligament injury

In the present study, results of the PRWE pain and disability evaluation showed that patients with a distal radius fracture associated with a lesion of the intrinsic ligaments compared with patients with intact intrinsic ligaments have significantly greater pain 3 and 6 months after injury, as well as significantly greater disability at 3 months. Total pain and disability was greater in the injured group at 3 months; at 6 months the injured group had greater pain but not greater disability.

DASH results showed that patients with associated intrinsic ligament injury had greater disability at 3 and 6 months after injury. It is also important, however, to analyze the so-called "clinical relevance" of the differences in DASH scores. It is considered that the minimum clinically important difference in DASH scores ranges between 10 and 15 points [2, 30]. Mean DASH scores of the two evaluated groups in this study differed by 23.47 points at 3 months and by 11.11 points at 6 months. This reinforces by clinical relevance the statistically significant difference between the intact and injured groups, and confirms that patients with distal radius fracture with associated ligamentous injury had worse outcomes than those with intact intrinsic ligaments.

We also found significantly lower grip strength in patients with associated intrinsic ligament injury than patients with distal radius fracture with intact intrinsic ligaments at 3 months, but not at 6 months.

Forward et al. [8] evaluated patients with carpal ligaments injury in distal radius fractures and published that patients with complete SL tear had significantly more pain on pressure over the scapholunate joint 1 year after injury, but the subjective patient-reported pain did not differ significantly between groups. They also observed no significant differences in objective outcomes of range of motion and grip strength, or the results of the Gartland and Werley score [8].

None of the studies that evaluated patients with associated carpal ligaments injury [25, 27, 31, 32] used the patient-rated questionnaires to evaluate the disability. This points to the importance of this study and its results showing the worse outcomes (subjective and objective) in patients with injured intrinsic ligaments.

Correct restoration of the bony anatomy of the distal radius is essential to minimise complications [5, 18], but the effect of associated lesions of the soft tissues of the wrist on postoperative problems and outcomes should also be considered [20, 28, 29].

According the literature recommendations, treatment is indicated for traumatic grades III and IV lesions of the scapholunate and lunotriquetral ligament [3, 17]. In the present study, seven patients (17.5 %) presented with associated grades III or IV SL injury and six (15 %) presented with LT injury. So, the total number of patients were treatment of the intrinsic ligament injury was indicated was not negligible. Wrist arthroscopy included in the operative treatment of the distal radius fracture can prevent these

Table 5 Mann–Whitney test for the PRWE and DASH score results at 3 and 6 months for the two examined groups

	W	*p*
PRWE pain at 3 months, INTACT/SL	400.5	0.0018*
PRWE specific activities at 3 months, INTACT/SL	365.0	0.0000*
PRWE usual activities at 3 months, INTACT/SL	396.5	0.0012*
PRWE total at 3 months, INTACT/SL	368.6	0.0001*
PRWE pain at 6 months, INTACT/SL	464.0	0.0178*
PRWE specific activities at 6 months, INTACT/SL	487.0	0.4832
PRWE usual activities at 6 months, INTACT/SL	431.0	0.1043
PRWE total at 6 months, INTACT/SL	457.0	0.1234
DASH 3 months, INTACT/SL	362.0	0.0000*
DASH 6 months, INTACT/SL	414.0	0.0061*

*$p < 0.05$

SL/LT scapholunate/lunotriquetral ligament, *PRWE* patient-rated wrist evaluation, *DASH* disabilities of arm, shoulder and hand, *INTACT* group of patients with no associated injury, *SL* group of patients with associated scapholunate and/or lunotriquetral ligament injury

Table 6 Grip strength (percentage of the uninjured side) at 3 and 6 months for the two examined groups

Group	Grip strength (%)			
	Mean	SD	Min	Max
3 months				
Intact	61.46	25.82	0	87.62
SL/LT	41.06	26.25	0	92.73
6 months				
Intact	78.86	18.06	40.88	128.4
SL/LT	75.05	22.31	31.15	102.54

Mean mean value, *SD* standard deviation, *Min* minimum value, *Max* maximum value, *SL/LT* scapholunate/lunotriquetral ligament

associated injuries, with potentially poorer outcomes, from being overlooked.

The patients included in this study were a part of larger series of patients with arthroscopically treated distal radius fracture in which the influence of all associated soft-tissue lesions was analyzed. A limitation of this study is its relatively small number of patients and the follow-up period of only 6 months. Fracture healing of a distal radius fractures and rehabilitation process may not be complete 6 months after injury, so studies with a longer follow up periods are needed.

The recognition and treatment of soft-tissue injuries associated with distal radius fracture deserve greater attention because of the frequency of these injuries as well as their influence on the outcome of these fractures expressed as greater pain and disability. Modern trends of early and aggressive mobilization in distal radius fracture rehabilitation, and the greater expectations of the patients to return to "normal" pre-injury wrist function, put pressure on treating surgeons to find and use treatments that can facilitate this. Arthroscopy of the injured wrist plays an important role in the identification and treatment of soft-tissue lesions. Surgeons can affect the outcome of distal radius fracture not only through correct bony restoration, but with soft-tissue repair as well.

Conclusion

The present study provides evidence, both subjective (via patient-reported questionnaires) and objective (via evaluation of grip strength), that patients with distal radius fracture with associated intrinsic ligament injury have worse outcomes than those without associated injury.

Intrinsic ligament injuries are important cofactors affecting the outcome of distal radius fracture. Wrist arthroscopy can be used as a diagnostic as well as therapeutic tool for these associated injuries.

Associated injuries of the scapholunate and the lunotriquetral ligaments should be considered when treating distal radius fractures, and wrist arthroscopy should be incorporated in the operative treatment protocol of these fractures.

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Conflict of interest The authors declare that they have no conflict of interest.

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