Acta Orthop. Belg., 2016, **82**, 210-215

ORIGINAL STUDY

Scaphoid nonunion with carpal ligament injury – radiological, arthroscopical assessment and clinical results

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The purpose of this study was to review the clinical results of carpal ligaments injuries with scaphoid nonunion. We hypothesized that scaphoid nonunion with carpal ligament injury is associated with clinical result. We retrospectively reviewed 60 cases of Herbert screw fixation with bone graft for scaphoid nonunions. Scapholunate (SL) and lunotriquetral (LT) ligaments lesions were confirmed by arthroscopy. Approximately half of the nonunion scaphoid cases had carpal ligaments injuries. At final follow-up evaluation, wrist function as evaluated by the Mayo wrist score was excellent in 34 patients, good in 16 patients, fair in 8 patients, and poor in 2 patients. Cases with both SL/LT ligaments injuries tended to have decreased wrist flexion-extension motion. Our results suggest that there is an indication for arthroscopy in scaphoid nonunion if surgical fixation is offered to avoid detrimental effects of an undiagnosed ligament tear.

Keywords : scaphoid nonunion ; arthroscopy ; carpal ligament injury.

INTRODUCTION

The scaphoid is the only carpal bone that bridges both the proximal and the distal rows (*8*). This carpal bone is subjected to continuous shearing and bending forces. Once fracture occurs, the scaphoid tends to have a "hump-back" deformity. Nonunion and avascular necrosis can occur from scaphoid fractures. Many excellent clinical results have been reported for Herbert screw fixation with bone graft for scaphoid nonunion (*2,8*). Functional improvement is expected if scaphoid nonunion is treated within five years of injury (*18*). The interval between injury and operation, the location of the fracture site, and the presence of sclerotic change in the proximal fragment all have a significant effect on the surgical result (*14,24*).

Johnson stated that any combination of carpal instabilities could be found, but scaphoid fracture and complete scapholunate (SL) disruption were unlikely to occur simultaneously (*10*). As for scaphoid fracture, some paper reported the incidence of ligaments lesions between 14% and 50% has been

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No benefits or funds were received in support of this study. The authors report no conflict of interests.

reported (*1,3,9,11,23,29*). On the other hands, Thomsen did not observe any SL lesions associated with non-displaced or minimally displaced isolated fractures of the scaphoid (*26*). Cheng emphasized the need for careful assessment of the intrinsic and extrinsic ligaments, particularly the scapholunate ligament, before deciding on treatment and also proposed that combined treatment of scaphoid fracture and SL dissociation was necessary to obtain a good result (*4*). Wong found lower Mayo wrist scores and poor functional outcomes in acute scaphoid fracture patients with concomitant carpal instability that were probably due to symptomatic ligaments injuries (*29*).

There are no reports about ligament lesions with scaphoid nonunion. Megerle reported that osseous union alone is not enough to ensure optimal clinical results after scaphoid reconstruction (*14*). Moreover, the influence of carpal ligaments injuries on the risk of nonunion is unclear. The purpose of this study was to review the clinical results of carpal ligaments injuries with scaphoid nonunion. We reviewed arthroscopic evaluation of scaphoid nonunions both clinically and radiologically. Our null hypotheses were as follows : clinical results of scaphoid nonunion are associated with SL ligaments injuries.

PATIENTS AND METHODS

This retrospective study was performed at a tertiary care centre for hand and wrist surgery. All study protocols were approved by the institutional review board. We retrospectively reviewed 70 cases of Herbert screw fixation from October 1996 to August 2011 with bone graft for scaphoid nonunions that involved both the radiocarpal joint and the midcarpal joint. We were able to access at least six months' postoperative follow-up data in 60 of the 70 cases and these cases were included in this study. The mean time delay from injury to surgery was 30 months (range, 3 to 250 months). Arthroscopic examinations were performed after obtaining informed consent from all patients. Injury characteristics were classified into three grades : mild trauma such as a fall from standing height as "low energy", moderate trauma such as sports-related injury as "medium energy" and severe trauma such as motor vehicle accidents or a fall from a height as "high energy".

We measured radiolunate angle, radioscaphoid angle and scapholunate angle by plain radiograph and confirmed the fracture pattern, the presence of sclerotic change and displacement of the nonunion fragment (fragment gap > 1 mm) with CT (*16*).

Arthroscopic assessment

SL and lunotriquetral (LT) ligaments injuries were evaluated with arthroscopy. Arthroscopic SL/LT ligaments injuries were classified using the Geissler classification system (*6*). We made the following definitions to combine the arthroscopy results : a Geissler score of I or II on arthroscopy was defined as "no SL/LT lesions". A Geissler score of III or IV was defined as "SL/LT lesions".

Clinical assessment

We obtained clinical data from the clinical charts. Therapists acted as independent observers to assess the range of motion and grip strength preoperatively and at final follow-up. We performed a wrist evaluation on the basis of the Mayo Wrist Scoring System (*5*), which included pain, functional status, range of motion, and grip strength assessment preoperatively and at final follow-up. Postoperative clinical results were compared with respect to the ligamentous lesions.

Surgical technique

Surgery was performed under axillary block or general anaesthesia with a tourniquet on the upper arm and the hand in a vertical traction tower. Five kg of traction was applied using fingertraps on the index and middle fingers. A 1.9 mm or 2.3 mm arthroscope was used in combination with a motorized shaver to clear the joint of blood, debris, and synovitis. The standard 3-4 and 4-5 intercompartmental portals were used in the radiocarpal joint. In the midcarpal joint, the standard radial and ulnar portals were used ; no volar portals were used. The scaphoid nonunion was visualised by a palmar approach for the dorsal and volar type of displacement. We used a dorsal approach for the proximal type of displacement. K-wires were temporarily placed into the lunate as joysticks to correct a dorsal lunate deformity if dorsal intercalated segment instability (DISI) pattern existed after nonunion debridement (*17*). A non-vascularised bone graft from the iliac crest was inserted into the defect. After reduction, the scaphoid was definitively stabilized with a Herbert screw. All patients were immobilised in a forearm cast or splint for at least six weeks postoperatively.

Table I. — Summary of clinical results (SD)

Number	60
Age	28.5 (8.7)
Sex	Male : 55 Female : 5
Pre-op flex-ext [degree]	117 (29)
Pre-op grip strength [%normal]	76 (20)
Pre-op Mayo wrist score	E : 0, G : 14, F : 25, P : 21
Pre-op RLA [degree]	-6.4 (15.2)
Pre-op RSA [degree]	58.0 (8.6)
Pre-op SLA [degree]	64.4 (12.9)
Follow-up periods [month]	20.1 (16.6) [range 6-65]
Post-op flex-ext [degree]	129 (30.0)
Post-op grip strength [%normal]	92.5 (14.4)
Post-op Mayo wrist score	E : 34, G : 16, F : 8, P : 2
Post-op RLA [degree]	5.8 (10.9)
Post-op RSA [degree]	58.8 (7.9)
Post-op SLA [degree]	53.0 (9.5)

Statistical analysis

Fracture pattern, sclerotic change, displacement, Mayo wrist score, injury characteristics and ligaments injuries grade were analysed using a chi-square test. Age, time period between injury and surgery and radiological parameters were analysed using using the Mann-Whitney U test (comparison of two groups : sclerotic change and displacement) and, where appropriate, a post hoc Bonferroni test (comparison of three or four groups : fracture pattern, ligaments injuries). Values of $P < 0.05$ were considered statistically significant.

RESULTS

Clinical results are summarized in Table I. There were other four cases that required additional treatment (93% of cases achieved bony union). Patient demographic and injury characteristics also had no association with any parameter. Lesions were categorized as follows : SL lesions only in 15 cases ; LT llesions only in 10 cases ; both SL and LT lesions in 5 cases (Table II). All LT cases were Geissler grade III, and four cases of SL cases were grade IV (three of these four also had LT ligaments injuries). The cases with SL and LT lesions had poor postoperative flexion-extension wrist motion when compared with patients who had only SL, only LT and no SL/LT lesions. No significant association was found between ligaments injuries and radiological carpal alignment.

Fracture patterns (Table III), sclerotic changes and fragment displacement show no significant differences between SL/LT lesions and clinical results. Fragment displacement and sclerotic changes had significant differences in time delay before surgery (Fragment displacement > 1 mm : 57 mo, < 1 mm : 18 mo, Sclerotic change yes : 51 mo, no : 20 mo). Fragment displacement had significant correlation with increased radiolunate/scapholunate angle

Table II. — Ligament injury and clinical results (SD)

Arthroscopic grade	SL lesion	LT lesion	SL+LT	No lesion
Number	15	10	5	30
Age [y.o.]	29.5 (11.3)	25.6 (6.0)	29.2 (7.5)	28.7 (8.4)
Pre-op interval [mo]	23.7 (54.4)	20.2 (15.7)	28.8 (22.8)	40.7 (64.5)
Pre-op flex-ext	117 (28)	105 (26)	111 (32)	113 (30)
Pre-op grip strength [%normal]	77 (22)	71 (29)	73 (22)	79 (12)
Pre-op RLA [degree]	-4.8 (15.6)	-10.0 (16.5)	-6.9 (11.1)	-6.4 (15.9
Pre-op RSA [degree]	58.7 (14.6)	57.9 (12.3)	54.9 (7.4)	58.5 (7.5)
Pre-op SLA [degree]	63.5 (14.6)	67.9 (9.5)	61.7 (14.1)	64.9 (13.6)
Post-op flex-ext [degree]	134 (24)	132 (22)	89 (44)*	130 (28)
Post-op grip strength [%normal]	95 (10)	94 (17)	90 (23)	91 (13)
Post-op Mayo wrist score	E :9, G :4, F :2, P :0	E :7, G :2, F :1, P :0	E :2, G :1, F :1, P :1	E :16, G :9, F :4, P :1

*$p < 0.05$.

Table III. — Fracture pattern and clinical results (SD)

Fracture pattern	Volar	Dorsal	Proximal
Number	38	18	4
Age [y.o.]	29.5 (10.1)	27.7 (5.5)	23.8 (3.3)
Pre-op interval [mo]	39.4 (65.5)	20.6 (19.5)	19.5 (13.7)
Pre-op RLA [degree]	-7.4 (15.5)	-5.6 (18.6)	-0.4 (11.7)
Pre-op RSA [degree	57.7 (7.6)	59.4 (10.9)	54.6 (4.9)
Pre-op SLA [degree]	65.0 (13.4)	65.0 (11.9)	55.0 (10.7)
Ligaments lesions [SL:LT:SL+LT:No lesion)	11:5:1:21	4:4:3:7	0:1:1:2
Post-op flex-ext [degree]	134 (25)	122 (29)	112 (62)
Post-op grip strength [%normal]	93 (14)	93 (13)	84 (25)
Post-op Mayo wrist score	E : 22, G : 12, F : 4, P : 0	E : 10, G : 4, F : 3, P : 1	E : 2, G : 0, F : 1, P : 1

(> 1 mm : -12.6/69.6 degree, < 1 mm : -3.6/62.3 degree). Fracture patterns, sclerotic change, time delay before surgery, and radiological parameters demonstrated no significant difference in clinical results.

DISCUSSION

This study showed that approximately half of the scaphoid nonunion cases had SL/LT ligaments injuries. Ninty-three percent of our cases achived bony union ; however, the patients with SL/LT lesions had decreased wrist flexion-extension range of motion. The goal of the surgical management of scaphoid nonunion is improving wrist function ; therefore the SL/LT lesions must be treated. This includes not only bony union but also restoring scaphoid alignment for functional improvement, because scaphoid length re-establishment relieves pain, improves grip strength and prevents degenerative changes (*20*).

The incidence of SL/LT ligaments injuries is similar to previous reports of acute scaphoid fracture. We had four cases of Geissler grade IV SL ligament injury and no cases of grade IV LT ligament injury. We could not find any correlation between SL/LT ligaments injuries and radiological carpal alignment. One possible reason is that SL ligament injury exists on a spectrum rather than all-or-none (*12*). Some cadaveric studies showed that intrinsic and extrinsic ligaments function to maintain carpal stability and that the dorsal radial carpal and dorsal intercarpal ligaments play an important role in scapholunate and lunotriquetral stability (*15,19,21,22,28*). We found no prior study that assessed the kinematics of scaphoid fracture with carpal ligaments injuries, however, the extrinsic ligaments could maintain carpal alignment even in the scaphoid fracture with SL/LT ligamnets injuries. Most of our cases had mild carpal ligament injuries, so that extrinsic ligaments could work as secondary stabilizers, thus carpal alignment was maintained with no radiologic differences detectable.

Cheng reported that managing these difficult problems requires both critical recognition and repair of bony and ligamentous damage (*4*). The clinical significance of carpal ligamentous injuries depends on their severity (*13*). We found DISI deformity pattern correlated fracture displacement, however, no correlation with SL/LT lesions, fracture pattern and screlotic changes. Radiographic analysis of SL/LT ligaments injuries is difficult, but these injuries can be detected by arthroscopy and be cause of decreasing wrist motion. Healing can occur when the ligament is mild (*29*) then our cases treated with temporary SL pinning showed good wrist motion. Our results suggest that there is an indication for arthroscopy in scaphoid nonunion if surgical fixation is offered to avoid detrimental effects of an undiagnosed ligament tear. The advantage is that arthroscopy allows for evaluation of associated ligaments injuries that cannot be seen in standard imaging. Bohringer also concluded that arthroscopy should be completed to detect and treat any

associated soft tissue injuries (*1*), while others support the technique of arthroscopically assisted scaphoid fracture fixation (*7,25,27*). Nevertheless, preoperative radiographs cannot detect the SL/LT ligaments injuries with scaphoid nonunion and we recommend using arthroscopy, although it is an invasive method.

This study had some limitations. First, the investigation was retrospective and was also a heterogeneous case study. We only had access to the clinical records of 60 of 70 total patients and only short-term follow up. Second, the number of each type of case was small. Differences in each parameter were also relatively small, and the small sample size could have limited the statistical power of the analyses. Further prospective research is thus warranted.

In conclusion, we found that about 50% of scaphoid nonunion cases had SL and/or LT ligaments injuries and both SL and LT had to be present for decreased wrist flexion-extension range of motion. Arthroscopy can detect SL/LT lesions and we believe that arthroscopy is useful before performing surgery for scaphoid nonunion.

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