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
reported \(1,3,9,11,23,29\). On the other hands, Thom-
son did not observe any SL lesions associated with 
non-displaced or minimally displaced isolated frac-
tures of the scaphoid \(26\). Cheng emphasized the 
need for careful assessment of the intrinsic and ex-
trinsic ligaments, particularly the scapholunate liga-
ment, before deciding on treatment and also pro-
posed 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 inju-
ries \(29\).

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 ar-
throscopic evaluation of scaphoid nonunions both 
clinically and radiologically. Our null hypotheses 
were as follows : clinical results of scaphoid non-
union 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 proto-
cols were approved by the institutional review board. We 
retrospectively reviewed 70 cases of Herbert screw fixa-
tion from October 1996 to August 2011 with bone graft 
for scaphoid nonunions that involved both the radiocar-
pal 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 ex-
aminations 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 con-
firmed the fracture pattern, the presence of sclerotic 
change and displacement of the nonunion fragment (frag-
ment gap > 1 mm) with CT \(16\).

**Arthroscopic assessment**

SL and lunotriquetral (LT) ligaments injuries were 
evaluated with arthroscopy. Arthroscopic SL/LT liga-
ments injuries were classified using the Geissler classifi-
cation 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 le-
sions”.

**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 in-
cluded 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 gen-
eral 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. We used 
K-wires were temporarily placed into the lunate as joy-
sticks to correct a dorsal lunate deformity if dorsal inter-
calated segment instability (DISI) pattern existed after 
nonunion debridement \(17\). A non-vascularised bone 
graft from the iliac crest was inserted into the defect. Af-
fer 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 postopera-
tively.
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 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 lesions 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 I. — Summary of clinical results (SD)

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

*Statistical analysis:

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

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

*P < 0.05.
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 ligament 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 sclerotic changes. Radiographic analysis of SL/LT ligament injuries is difficult, but these injuries can be detected by arthroscopy and 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

<table>
<thead>
<tr>
<th>Table III. — Fracture pattern and clinical results (SD)</th>
</tr>
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<tbody>
<tr>
<td>Fracture pattern</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Number</td>
</tr>
<tr>
<td>Age [y.o.]</td>
</tr>
<tr>
<td>Pre-op interval [mo]</td>
</tr>
<tr>
<td>Pre-op RLA [degree]</td>
</tr>
<tr>
<td>Pre-op RSA [degree]</td>
</tr>
<tr>
<td>Pre-op SLA [degree]</td>
</tr>
<tr>
<td>Post-op flex-ext [degree]</td>
</tr>
<tr>
<td>Post-op grip strength [%normal]</td>
</tr>
<tr>
<td>Post-op Mayo wrist score</td>
</tr>
</tbody>
</table>

(> 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. Ninety-three percent of our cases achieved 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 ligament 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.

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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.

REFERENCES


