Locking Dorsal Plate in Four-Bone Arthrodesis in SLAC and SNAC 3 Wrist

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Joints 2018;6:37–41.

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Abstract

Purpose The aim of this study was to evaluate the effectiveness and the safety of performing a four-bone arthrodesis (FBA) with dorsal locking plate in patients suffering from stage III scapholunate advanced collapse/scaphoid nonunion advance collapse (SLAC/SNAC) wrist.

Methods We evaluated retrospectively 20 patients surgically treated by a FBA with the use of locking dorsal plate. All the patients were clinically evaluated at follow-up for grip strength, range of motion, and pain (visual analog scale), and with the Disability of the Arm, Shoulder and Hand score and the Mayo wrist score. Imaging evaluation was performed on standard X-rays.

Results The mean follow-up was 6 years (range: 1–11 years). During follow-up, the patients showed good clinical outcomes in terms of pain relief and grip strength. Revision surgery was necessary only in one case because of screws loosening. In all cases, a solid bone fusion was achieved except in one patient, who presented a healing of lunocapitate joint. This condition did not affect the clinical outcomes.

Conclusion FBA performed using a dorsal locking plate is a salvage procedure effective in treating stage III SLAC/SNAC wrist. In our study, this technique provided good clinical outcomes at mid-term follow-up with a very low complication rate.

Level of Evidence Level IV, therapeutic case series.

Keywords

- four-bone arthrodesis
- SLAC
- SNAC
- wrist
- locking plate

Introduction

Scapholunate (SL) ligament integrity is crucial in maintaining the stability of the wrist. In fact, a lesion of this ligament could also lead to a degenerative change called scapholunate advanced collapse (SLAC) with a severe articular impairment.

The SLAC condition was first described in 1984 by Watson and Ballet,[1] who described an initial SL incompetence with an initial degenerative condition of the radioscaphoid joint (stage I), followed by a more important degeneration of it (stage II) with a progressive involvement to the midcarpal joint (stage III). After these three stages, a stage IV was introduced to indicate a condition with a pan-radiocarpal osteoarthritis (OA)[2] (►**Fig. 1**).

A similar progressive wrist degeneration is due to a scaphoid nonunion in undiagnosed fracture. The same progressive degenerative stages are described and the same surgical treatment is indicated in case of scaphoid nonunion advanced collapse (SNAC).

The treatment of all these conditions is surgical since no conservative treatment can restore both the competency of the SL ligament and the degenerated cartilage surfaces.

In advanced stages (stage III), the treatment is represented mostly by two salvage procedure: proximal row carpectomy (PRC) or scaphoid excision with fusion of the lunate, triquetrum, hamate and capitate, so-called four-bone arthrodesis (FBA).

The aim of this study is to evaluate the clinical and radiological outcomes in patients who underwent a FBA with dorsal locking plate because of a stage III SLAC/SNAC.

received
July 2, 2017
accepted after revision
January 2, 2018
published online
February 12, 2018

DOI https://doi.org/10.1055/s-0038-1626738.
ISSN 2282-4324.

Fig. 1 Stage III scapholunate advanced collapse wrist. Anteroposterior (**A**) and lateral views (**B**) show damage to the radioscaphoid and lunocapitate articular surfaces.

Methods

The inclusion criteria of this retrospective study were: stage III SLAC/SNAC wrist, surgical treatment performed between 2005 and 2010, and use of a locking dorsal plate (LDP) in performing the FBA. The diagnosis of SLAC/SNAC wrist was performed on the evaluation of standard X-rays.

Twenty patients (18 males and 2 females) were enrolled in this study. The mean age of the patients was 53.1 years. Fourteen patients were affected by a stage III SNAC and six by a stage III SLAC. No previous surgery to the affected wrist had been performed in 18 patients, one patient had open reduction and internal fixation with staple in scaphoid fracture, and one had proximal scaphoid pole excision and prosthesis substitution. In 14 cases, surgery was performed on the dominant upper arm, while in 6 cases the nondominant side was involved.

Surgery was performed through a dorsal approach to the carpus: a longitudinal midcarpal skin incision was performed, then the third extensor retinaculum was opened with retraction of the extensor pollicis longus. Triangular capsulotomy was achieved following the fiber of the radiotriquetral and dorsal intercarpal ligaments, then a scaphoidectomy was performed and the whole cartilage surfaces between capitate, hamate, triquetrum, and lunate were removed. All the four bones were temporarily fixed with K-wires, paying attention to place in neutral position the lunate, thus reducing the risk of dorsal intercalated segment instability and maintaining the carpal height, and then the locking plate was placed. When all the screws were positioned, the K-wires were removed. After removal of the cartilage surface, cancellous bone from the scaphoid was used to fill all the gaps to promote fusion. Attention was paid to mill the carpal bones, in particular the lunate that is more sclerotic than other carpal bones, to allow the plate to be placed under the dorsal margin of the bones, thus avoiding dorsal impingement with radial edge during wrist extension.

Three different type of dorsal locking plate were used: Arthrodesis Plate 2.0 (Medartis, Basel, Switzerland) in 5 patients, Hub-Cap TM (Acumed, Hillsboro, Oregon, United States) in 10 patients, and Flower plate (KLS Martin, Freiburg, Germany) in 5 patients.

After surgery, all patients wore an immobilization cast for 6 weeks. Rehabilitation was allowed only when healing was confirmed on X-rays and after positive clinical check.

All patients were clinically and radiographically re-evaluated at the final follow-up. The clinical outcomes were assessed by the evaluation of pain (visual analog scale, VAS score), range of motion (ROM) (flexion and extension of the wrist) and grip strength, and by collecting the Mayo wrist score and the Disability of the Arm, Shoulder and Hand (DASH) score, while the imaging evaluation was based on standard X-rays of the wrist (anteroposterior and lateral views).

Results

The mean follow-up was 6 years (range: 1–11 years). The mean DASH score was 16.6 $\pm$ 11 points; the Mayo wrist

score was good for 2 patients, fair for 16 patients, and bad for 2 patients. In the latter cases, surgery decreased the ROM of the wrist due to the dorsal prominence of the plate. VAS was two in case of heavy activity. The mean grip strength was 75% compared with the healthy side.

No differences were noticed using different kinds of locking dorsal plate. No ulnar translation of the carpal bone was detected in this series.

The mean ROM in flexion was 42° ± 18.5° (range: 20–70°) and in extension was 37° ± 12.7° (range: 20–60°) (►**Table 1**).

In one case, a revision surgery was needed to remove the device because of the loosening of the screws. In this case, a solid fusion between lunate and capitate was achieved and no further surgery was necessary (►**Fig. 2**).

Discussion

The SL ligament, as the scaphoid, has a key role in maintaining a normal kinematics of the wrist and in making possible a full ROM without pain. When this ligament is torn, it should be reconstructed to avoid degenerative changes to midcarpal articular surfaces. Similar degenerative changes can occur in case of unrecognized scaphoid nonunion.

Several techniques were presented to reconstruct this ligament[3–5] and to promote healing of scaphoid nonunion, and all of them could reach good clinical outcomes if both radiocarpal and midcarpal articular surfaces are preserved (stage I and II). If degenerative changes in articular surfaces take places in a wrist suffering from SL dissociation, SLAC, or from SNAC, wrist could develop radioscaphoid and midcarpal OA. These pathological conditions are classified in four stages (from I to IV), and in stage III (radioscaphoid and capitolunate OA, preserved radiolunate articular surface) the surgical salvage treatments are represented by PRC and FBA. Several studies compared the two techniques,[6–11] highlighting their advantages and disadvantages.

Table 1 Descriptive statistics and follow-up data

	M/F	Age	Involved wrist (R dominant)	Extension	Flexion
Patient 1	M	58	R/L	60	40
Patient 2	M	57	R/R	40	70
Patient 3	F	73	R/R	30	20
Patient 4	M	59	R/R	55	60
Patient 5	M	64	R/R	20	30
Patient 6	M	67	R/L	40	70
Patient 7	M	62	R/L	20	20
Patient 8	M	57	R/R	30	60
Patient 9	M	24	R/L	40	50
Patient 10	M	49	R/L	20	20
Patient 11	M	55	R/L	50	20
Patient 12	M	88	R/R	30	50
Patient 13	M	49	R/R	40	20
Patient 14	M	65	R/R	30	30
Patient 15	M	60	R/R	60	60
Patient 16	M	38	R/R	40	30
Patient 17	M	46	R/R	40	70
Patient 18	M	30	R/R	30	50
Patient 19	F	60	R/R	30	40
Patient 20	M	53	R/R	55	30
	18 M /2 F	Mean: 53.1	14 dominant	Mean: 37°	Mean: 42°

PRC restores a greater ROM and there is no need of implant or bone fusion, but it can preserve less grip strength compared with FBA.[7] However, FBA, which maintains a normal carpal height, can assure more preservation of grip strength, but guarantees less ROM and has higher rate of complications, such as implant failure or carpal nonunion.

In FBA, several technique were presented in the literature using different implant such as using K-wire, Herbert's screws, staples, or specific plates. Multiple pinning was initially used, then staples were introduced in 1990s and different designs were studied in 2000s. Dorsal circular plates with locking design were recently presented. The goal was to provide stable fixation and early mobilization, thus improving final ROM.

The use of specific plate, as shown in studies by Kendall et al[12] and Merrell et al,[13] showed good results in the short- and mid-term follow-up, with a low rate of complications, particularly nonunion of the carpal bones.

Several studies compared different hardware designs to understand if there is a real advantage in using LDP. Literature referred about a low nonunion rate in case of K-wire technique, ranging from 3% to 16%;[1–7] in contrast, migration, entry-point infection, and new surgery to remove K-wire were more or less systematically reported, with discomfort for the patients.[14] Even with staples or compression screws the nonunion rate was similar, and time of immobilization after surgery was 6 to 10 weeks. In case of staples, removal was required because of dorsal impingement.[15]

Nonlocking dorsal plates (NLDPs) were introduced to obtain greater stability and to allow early mobilization and to gain greater ROM, but results were less satisfactory than expected. De Smet et al[6] reported approximately 62.5% of nonunion and no improvement in ROM. Merrell et al[13] observed that this high rate of nonunion is partly due to the use of plate to compensate for imprecision in performing surgical technique. It is necessary a high precision in reaming into cancellous bone, grafting from ipsilateral radius or excised scaphoid, elimination of riming debris, correct position of the plate to avoid dorsal impingement and fixation of each carpal bone by two screws. They also recommended 6 weeks of immobilization.

Kraisarin et al[16] in a cadaveric study compared NLDPs, K-wires, and LDPs. They demonstrated the biomechanical superiority of LDP. Rhee and Shyn[17] reported approximately 4% of nonunion rate after 6 weeks of immobilization. On the contrary, Luegmair and Houvet[18] reported 8% and 9% nonunion with 1 to 2 weeks of strict immobilization followed by

Fig. 2 Stage III scaphoid nonunion advance collapse wrist. (**A**) Anteroposterior and lateral view. (**B**) Surgical treatment with dorsal locking plate. (**C**) Screws loosening 9 years after surgery. (**D**) Plate and screws removal: lunocapitate joint fusion is evident. (**E**) Clinical outcome 2 months after hardware removal.

a removable cast or 2 more weeks and rehabilitation after 4 weeks.

In opposite of what expected, using DLP does not give advantages in term of ROM, strength, or pain after surgery if compared with staples. The real improvement is in time to return to work. Pauchard et al[14] showed that return to work was 3 to 4 months before with DLP than with staples or NLDP;[14] even the rate to return to work was higher in LDP.

Ritt et al and Cayci and Carlsen showed that the block effect of the four-corner procedure and the biomechanical effectiveness of this surgery were achieved even if the lunotriquetral joint did not fuse.[19,20] Nevertheless, the goal

of four-corner procedure is to fuse the four joint lines and it is necessary for a meticulous cartilage resection to obtain a complete arthrodesis.

The main reason for revision surgery is dorsal impingement between the fixation device and the posterior edge of radius. However, Le Corre et al[21] observed no correlation between hardware failure and surgical revision in the plate group, as 44% of failed implant were asymptomatic.

The duration of postoperative immobilization is still controversial in the literature. Some authors suggest that stable fixation allows early rehabilitation;[22] however, others recommended 6 to 8 weeks of cast after surgery to obtain a complete healing.[23] Tielemans et al[24] established that a shorter postoperative immobilization results in better recovery of function.

In our series, the use of these plates showed good clinical results, with a DASH score that could be compared with the score of the healthy population,[25] with a very low rate of surgical revision and complications.

As stated in several clinical studies and confirmed also in biomechanical studies, the FBA needs a good reduction in the lunate before the arthrodesis[14,15,26] to improve ROM. Indeed, in all of our cases, the first surgical step was to get a good reduction in the lunate before performing the fusion. The use of bone chips from the excised scaphoid was preferred to avoid harvest site morbidity and to shorten the operative time. Furthermore, we played great attention in reaming cartilage, sinking the plate, and maintaining the height of carpal bones.

In conclusion, the use of dorsal plate in performing FBA seems to be a safe and effective procedure with a low rate of complications and good clinical and imaging outcome at mid-term follow-up in treating stage III SLAC/SNAC wrist.

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