TREATMENT OF SCHAPHOID NONUNION WITH VOLAR LOCKED PLATE

ABSTRACT

Objective: To assess and compare radiographic, tomographic and functional pre and postoperative parameters of patients submitted to treatment of nonunion of the scaphoid waist with locked plate for scaphoid. Methods: This is a case series of scaphoid waist nonunion, operated from March 2017 to March 2018 at the Institute of Orthopedics and Traumatology of HCFMUSP, using the technique of Fisk-Fernandez and osteosynthesis with locked plate for scaphoid APTUS®Hand from Medartis. The patients were submitted to radiographs, computed tomography and functional evaluation by the occupational therapy team in the pre and postoperative periods. Results: There was consolidation of the scaphoid waist nonunion in all cases, improvement in the parameters of carpal alignment in the imaging examinations, but functionally we observed reduction of the range of motion and grip strength in relation to the contralateral limb. Conclusions: The treatment of the scaphoid waist nonunion with locked plate was effective, with a high index of consolidation and improvement of the carpal alignment in the imaging tests, although with a reduction in the range of motion and grip strength in relation to the contralateral limb when evaluated with 12 weeks postoperatively. Level of Evidence IV, Case series.

Keywords: Pseudarthrosis/surgery. Scaphoid bone/injuries. Scaphoid bone/surgery. Fracture fixation, internal. Bone plates.

INTRODUCTION

Scaphoid fractures make altogether for 60 to 70% of all carpal bone fractures and they are second in frequency when it comes to wrist fractures, behind only distal radius fractures.\(^1\) Nonunion occurs in 10 to 15% of scaphoid fractures and the risk of nonunion development becomes higher with treatment delays, inadequate immobilization time, early fracture deviation and carpal instability association.\(^1\) When nonunion occurs at scaphoid waist level, the volar edges of proximal and distal fragments suffer from attrition, erosion and bone absorption, increasing the angular deformity due to distal fragment flexing (“humpback” deformity). This scaphoid angular deformity together with bone absorption, causes a carpal collapse into a DISI (Dorsal Intercalated Segment Instability) pattern that must be corrected.\(^2,4\)

There are consensus that the management of the scaphoid nonunion with angular deformity and carpal instability has three stages: open reduction with angular deformity correction (correction of intrascaphoid angle to about 20 degrees), restoration of length and intrascaphoid angle to about 20 degrees), restoration of length and form of scaphoid with autologous interpositional anterior wedge grafting and internal fixation by screw.\(^3,7\)
Although osteosynthesis with compression screw is considered nowadays the standard method of fixation, osteosynthesis with plate and screws has theoretical advantage of fixation with divergent multiple screws leading to stability in multiple vectors, including torsion stability, providing better and more reliable internal fixation, capable of maintaining angular scaphoid deformity correction, which is required to restore wrist anatomy, biomechanics and kinetics. In this context, the present study is a series of 8 cases of scaphoid waist nonunion treated with “Humpback” deformity correction by interpositional anterior wedge grafting and internal fixation with scaphoid volar locked plate.

MATERIALS AND METHODS

A series of 8 subjects of male gender is presented, with ranging ages from 22 to 46 years old (average of 30 years old), diagnosed with scaphoid waist nonunion classified according to Alnot (Table 1) as: IIA (1 case), IIB (6 cases) and IIA (1 case), with pseudarthrosis diagnostic superior to 6 months, without any previous surgery or other upper limb lesions. None of the patients display advanced degenerative wrist condition (SNAC III/IV).

Epidemiological data of aforementioned patients are found summarized in Table 2.

After the approval of the USP Hospital das Clinicas ethics committee (CAAE: 81038417.4.0000.0068) and the filling of the free consent term, the patients were taken under surgery by the hand surgery and reconstructive microsurgery group of HCFMUSP from march/2017 to march/2018.

All patients were subject to preoperative functional evaluation and 12 weeks postoperatively, performed by the Hand Therapy team of HCFMUSP’s orthopaedic and traumatology institute, including pain intensity analysis (analogic visual scale), range of movement (ROM), grip strength (Jamar), digital pinch strength (pinch test) and functional wrist score scales of DASH and MAYO.

### Table 1. Alnot Classification of Scaphoid Waist Nonunion

| Grade | Description                                                                                     |
|-------|-------------------------------------------------------------------------------------------------|
| I     | Linear nonunion without altered scaphoid form, instability or intracarpal malalignment          |
| II    | Stable nonunion with incipient bone resorption at fracture line, without instability or malalignment |
| II A  | More or less mobile nonunion with anterior deform and proximal pole flexion on distal tubercle inducing DISI |
| II B  | More or less mobile displacement nonunion with radial and/or intracarpal arthritis              |
| III   | More or less mobile displacement nonunion with instability or reducible malalignment with isolated stylo-scaphoid arthritis |
| III A | More or less mobile deformation nonunion with instability or reducible malalignment with isolated stylo-scaphoid arthritis |
| III B | More or less mobile displacement nonunion with radial and/or intracarpal arthritis              |
| IV    | Proximal fragment necrosis with malalignment                                                   |
| IV A  | Proximal fragment necrosis with malalignment                                                   |
| IV B  | Proximal fragment necrosis with radioscaphoid and/or intracarpal arthritis                     |

### Table 2. Epidemiological Profile

| Patient | Dominance | Operated Side | Profession                | Time since trauma | Mechanism of Trauma                  |
|---------|-----------|---------------|---------------------------|-------------------|--------------------------------------|
| 1       | Right     | Right         | Driver                    | 8 months          | Wrist sprain                          |
| 2       | Right     | Left          | Bakery manager            | 6 months          | Fall from own body length             |
| 3       | Right     | Right         | Civil construction        | 1 year and 6 months | Fall from high surface (roof)         |
| 4       | Right     | Left          | Sales manager             | 2 years           | Fall during sports activity (soccer)  |
| 5       | Right     | Left          | Machine operator          | 1 year and 2 months | Fall from motorcycle                  |
| 6       | Right     | Right         | Glazier                   | 1 year            | Fall from body length                 |
| 7       | Right     | Right         | Transport assistant       | 2 years           | Fall from motorcycle                  |
| 8       | Right     | Right         | Stockist                  | 6 months          | Fall during sports activity (basketball) |
looseness were observed. However, in two of the patients, there was persistence of moderate pain complaint that worsened with wrist flexion, that complaint was due to an impact of a proximal region of the plate with the radius joint surface (Figure 5). All other patients had a decrease of pain after the surgery procedure. As seen on Table 3, preoperative radiographs show that all patients had an increase of the scapholunate angle above 60º, which represents a carpal instability pattern of DISI type (preoperative scapholunate angle average of 74.87º). In all cases the scapholunate angle was reduced, with a postoperative average of 60.62º; however, two cases remained inside DISI indicative values. An average preoperative value of 20.21º and postoperative value of 13.75º related to the radiolunate angle was observed, although two of the cases had an angle increase after surgery procedures. Intrascaphoid preoperative angle average was 43.12º, which represents a Humpback deformity (angle above 35º), but this value was corrected in the postoperative to an average of 17.37º. Related to the patient’s clinical evaluation, as summarized by Table 4, there was an average flexion/extension arc of the wrist of 53.12º preoperatively and 39.81º postoperatively, this value making a total of 59% of counter lateral limb range of movement for this patient’s sample. The average radial and ulnar deviation of lesioned wrists is, preoperatively, respectively 15.25º and 16.87º and, postoperatively, 13.37º and 21º; values that have a 61.13% and 68.02%, respectively, of all radial and ulnar contralateral deviations. When data from the strength test with a dynamometer was analyzed, the average postoperative values for grip force, key pinch, three jaw chuck pinch and tip pinch was, respectively, 24.49 Kgf, 7.48 Kgf, 5.73 Kgf and 4.66 Kgf, with percentual correspondence related to non-affected contralateral side of 57.75%, 73.5%, 65.03% and 68.12% respectively. The average Mayo Wrist Score was, preoperatively, 57.5 and, postoperatively, 48.12, with a DASH Score of 38.83 and 30.68.

DISCUSSION

Scaphoid is the carpal bone most commonly fractured, 60 to 70% of all the carpal bone fractures, of which, 10 to 15% will evolve to nonunion due to the fact that the scaphoid is a bone with scarce blood supply and predominantly retrograde from branches of the radial artery.1 The more proximal the fracture, greater the probability of the bone to become avascular and greater the risk of nonunion, which also increases when associated to delay in the beginning of the treatment, use of immobilization for unsuitable amount of time, when there is initial deviation of the fracture of more than 1mm and association with carpal instability. Scaphoid nonunion tends to evolve with a distal fragment flexion of the scaphoid and a DISI pattern of carpal instability that can develop into a predictable wrist arthritis pattern know as SNAC (Scaphoid Nonunion Advanced Collapse). To prevent this adverse evolution of scaphoid nonunion is fundamental to achieve bone consolidation of an anatomically aligned scaphoid, with a lateral intrascaphoid angle lower than 35º, a scapholunate angle between 30º and 60º and a radiolunate angle ranging from 0º to +/- 15º. Use of plates for scaphoid nonunion treatment was described by Ender in 1977, using a hook plate after an iliac graft, which was fixed to the proximal fragment by a hook and to the distal fragment by screw, in a way of exerting compression to the graft placed in the pseudarthrosis site.18 Recently, buttress plates were developed for instable fractures or scaphoid nonunion with humpback deformities, to neutralize compression forces and axis angles that occur when a compression screw cannot guarantee stability.18,19 besides insuring greater rotational stability and having the additional advantage of the plate medium segment holding the wedge-shaped graft in an anterior position, preventing extrusion. Accordingly, to other literature related
case studies, a great consolidation rate was obtained (100% of cases) of scaphoid nonunion treated with volar plates, besides great improvement of carpal alignment, as seen through comparison of average preoperative scapholunate angles (74.87°) and postoperative (60.62°), and the average of radiolunate angles from 20.12° to 13.75°, postoperatively, with an improvement of scaphoid humpback deformity, clearly visible through comparison of pre (43.12°) and postoperative (17.37°) intrascaphoid angle.

Concerning the clinical evaluation of patients was observed an improvement of pain after surgery, however, when compared to objective clinical parameters like wrist range of movement, grip strength and pinch (key, tripod and tip), we confront a worsening, postoperatively. The average flexion/extension arc of the operated wrists corresponded to 59% of the average flexion/extension arc of the unaffected wrists, and, the average of radial and ulnar deviations postoperatively were of 61.13% and 68.02%, respectively, related to the contralateral wrists.

Grip strength and key, tripod and tip pinchs were reduced after surgery. The average of the grip strength and key, tripod and tip pinchs after surgery were of 57.75%, 73.5%, 65.03% and 68.12%, respectively, when compared to contralateral wrists.

This data is concurrent with the data observed by Esteban-Feliu et al., 20 that in a retrospective series of 15 cases for the duration of 3 years, had observed a significant reduction of the affected wrist range of motion in relation to the contralateral (the mean ROM after surgery corresponded to 61% that of the opposite side), and a average grip strength which was 55% that of the unaffected side. However, Leixnering et al.18 published a series of 11 patients with scaphoid nonunion treated with volar plate in an average time segment of 13 months, where they had little and limited sequels to minor symptoms with a good ROM gain, also, Ghoneim 16 published a series of 14 patients with a mean follow-up time of 11 months in which they achieved more than 70% ROM gain and grip strength relative to the unaffected contralateral limb.

We believe that part of the ROM and force limitations observed in our study, may be justified by the fact that postoperative physical evaluation was only performed 12 weeks after surgery, considering that in the long term segment there was a progressive improvement of ROM, grip strength and pinch of the operated wrist, although they still have limitations when compared to the contralateral side. As part of the functional evaluation of our patients, we also used the Mayo Wrist Score that divides the function degree of patient

| Patient | Alnot classification | Scapholunate angle | Radiolunate angle | Intrascaphoid Angle |
|---------|----------------------|--------------------|-------------------|---------------------|
|         | Preop | Posop | Contralateral | Preop | Posop | Contralateral | Preop | Posop |
| 1       | IIB    | 74°   | 52°           | 49°  | 5°     | 7°            | 19°  | 11°   |
| 2       | IIB    | 70°   | 54°           | 59°  | 15°    | 15°           | 0°   | 66°   | 12°   |
| 3       | IIB    | 92°   | 86°           | 9°   | 15°    | 15°           | 13°  | 50°   | 35°   |
| 4       | IIB    | 76°   | 70°           | 80°  | 18°    | 30°           | 21°  | 40°   | 6°    |
| 5       | IIIA   | 69°   | 54°           | 55°  | 29°    | 34°           | 0°   | 61°   | 29°   |
| 6       | IIA    | 78°   | 51°           | 55°  | 31°    | 7°            | 4°   | 5°    | 5°    |
| 7       | IIB    | 76°   | 63°           | 43°  | 7°     | 4°            | 9°   | 76°   | 31°   |
| 8       | IIB    | 64°   | 55°           | 44°  | 16°    | 0°            | 0°   | 26°   | 10°   |

Table 3. Radiographic evaluation.
Accordingly, in the great majority of our casuistry (75%) the patients had an improvement in pain after surgery and choose to not perform remotion of scaphoid plate.

**CONCLUSION**

From analysis of our cases series, we considered osteosynthesis with volar plate an effective alternative for scaphoid nonunion treatment, since there was a high rate of consolidation, with improvements in carpal alignment and in consequence a prevention against SNAC, in addition to a low rate of complications and clinical enhancement of DASH score, although there was a reduction of postoperative ROM and grip strength. It is worth to emphasize that because our sample had a limited size and also the absence of a control group that had been treated with Herbert’s screw for osteosynthesis, method still considered the gold standard procedure for scaphoid nonunion, the analysis of our work must be performed in a critical manner with more studies comparing the two osteosynthesis methods.

**REFERENCES**

1. Wolfe SW, HotchkissRRN, Pederson WC, KozinSH, Cohen MS. Green’s operative hand surgery. 7th ed. Philadelphia: Elsevier; 2017.

2. Fernandez DL. Anterior bone grafting and conventional lag screw fixation to treat scaphoid nonunions. J Hand Surg Am. 1990;15(1):140-7.

3. Nakamura R, Horii E, Watanabe K, Tsuonoda K, Miura T. Scaphoid nonunion—unification: factors affecting the functional outcome of open reduction and wedge grafting with Herbert screw fixation. J Hand Surg Br. 1993;18(2):219-24.

4. Tomaino MM, King J, Phlilo M. Correction of lunate malalignment when bone grafting scaphoid nonunion with humpback deformity: rationale and results of a technique revisited. J Hand Surg Am. 2000;25(2):322-29.

5. Daly K, Gill P, Magnusson PA, Simonis RB. Established nonunion of the scaphoid treated by volar wedge grafting and Herbert screw fixation. J Bone Joint Surg Am. 1996;78(4):530-4.

6. Radford PJ, Mathewson MH, Meggitt BF. The Herbert screw for delayed and non-union of scaphoid fractures: a review of fifty cases. J Hand Surg Br. 1990;15(4):455-9.

7. Bunker TD, McNamee PB, Scott TD. The Herbert screw for scaphoid fractures. A multicentre study. J Bone Joint Surg Br. 1987;69(4):631-4.

8. Ford DJ, Khudri G, El-Hadjidji S, Lynn PG, Burke FD. The Herbert screw for fractures of the scaphoid. A review of results and technical difficulties. J Bone Joint Surg Br. 1987;69(1):124-7.

9. Herbert TJ, Fisher WE. Management of the fractured scaphoid using a new bone screw. J Bone Joint Surg Br. 1984;66(1):114-23.

10. Leyshon A, Ireland J, Trickey EL. The treatment of delayed union and non-union of the carpal scaphoid by screw fixation. J Bone Joint Surg Br. 1984;66(1):124-7.

11. Manske PR, McCarthy JA, Strecker WB. Use of the Herbert bone screw for scaphoid nonunions. Orthopedics. 1988;11(12):1653-61.

12. Pring DJ, Hartley EB, Williams DJ. Scaphoid osteosynthesis: early experience with the Herbert bone screw. J Hand Surg Br. 1987;12(1):46-9.

13. Tu YK, Chen AC, Chou YC, Ueng SW, Ma CH, Yen CY. Treatment for scaphoid fracture and nonunion—the application of 3.0 mm cannulated screws and pedicle vascularized bone grafts. Injury. 2005;36 Suppl 4:486-106.

14. Schatzker J. Screws and plates and their application. In: Muller ME, Allgower M, Schneider R, Willenegger H. editors. Manual of internal fixation. Techniques recommended by the AO-ASIF. 3rd ed. Berlin: Springer-Verlag; 1991. p. 200; 206-10.

15. Ghoneim A. The unstable nonunited scaphoid waist fracture: results of treatment by open reduction, anterior wedge grafting, and internal fixation by volar buttress plate. J Hand Surg Am. 2011;36(1):17-24.

16. Dodos SD, Halim A. Scaphoid Plate Fixation and Volar Carpal Artery Vascularized Bone Graft for Recalcitrant Scaphoid Nonunions. J Hand Surg Am. 2016;41(7):e191-8.

17. Leixnering M, Pezzii C, Widinger P, Mayer M, Bogner R, Lederer S, et al. First experiences with a new adjustable plate for osteosynthesis of scaphoid nonunions. J Trauma. 2011;71(4):933-8.

18. Jurkowitsch J, Dall’Ara E, Quadrabauer S, Pezzii C, Jung I, Pahr D, et al. Rotational stability in screw-fixed scaphoid fractures compared to plate-fixed scaphoid fractures. Arch Orthop Trauma Surg. 2016;136(11):1623-8.

19.Esteban-Feliu I, Barrera-Ochoa S, Vidal-Tarrason N, Mir-Simon B, Lluch A, Mir-Bullo X. Volar plate fixation to treat scaphoid nonunion: a case series with minimum 3 years of follow-up. J Hand Surg Am. 2018;43(6):569.e1-8.