

TREATMENT OF SCAPHOID NONUNION WITH VOLAR LOCKED PLATE

TRATAMENTO DA PSEUDOARTROSE DO ESCAFOIDE COM PLACA BLOQUEADA VOLAR

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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.

RESUMO

Objetivos: Avaliar e comparar parâmetros radiográficos, tomográficos e funcionais pré e pós-operatórios de pacientes submetidos ao tratamento de pseudoartrose do colo do escafoide com placa bloqueada para escafoide. **Métodos:** Esta é uma série de casos de pseudoartrose do colo do escafoide, operados no período de março de 2017 a março de 2018 no Instituto de Ortopedia e Traumatologia do HCFMUSP, utilizando-se a técnica de Fisk-Fernandez e osteossíntese com placa bloqueada para escafoide APTUS®Hand da Medartis. Os pacientes foram submetidos a radiografias, tomografia computadorizada e avaliação funcional pela equipe de terapia ocupacional no pré e pós-operatório. **Resultados:** Houve consolidação da pseudoartrose do colo do escafoide em todos os casos e melhora nos parâmetros de alinhamento carpal nos exames de imagem, porém, funcionalmente, observamos redução da amplitude de movimento e força de preensão em relação ao membro contralateral. **Conclusão:** O tratamento da pseudoartrose do colo do escafoide com placa bloqueada se mostrou efetivo, com elevado índice de consolidação e melhora do alinhamento carpal nos exames de imagem, embora com redução da amplitude de movimento e força de preensão em relação ao membro contralateral, quando avaliados com 12 semanas de pós-operatório. **Nível de Evidência IV, Série de casos.**

Descritores: Pseudoartrose/cirurgia. Osso escafoide/lesões. Osso escafoide/cirurgia. Fixação interna de fraturas. Placas ósseas.

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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 form of scaphoid with autologous interpositional anterior wedge grafting and internal fixation by screw.³⁻⁷

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Study conducted at the Hand and Microsurgery Group, Orthopedics and Traumatology Institute, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

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Although osteosynthesis with compression screw is considered nowadays the standard method of fixation⁸⁻¹⁴, 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.¹⁵⁻¹⁷

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 accordingly to Alnot (Table 1) as: IIA (1 case), IIB (6 cases) and IIIA (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.

The preoperative planning included comparative radiographs of both wrists in the standard scaphoid views: Front (posteroanterior), front with wrist ulnar deviation, lateral and oblique views.

The radiological segment was performed accordingly with radiographic views of the scaphoid routine in 3, 6 and 12 weeks postoperatively, and patients used immobilization through short arm thumb spica cast or brace, in continuum, for eight weeks, with changes in the immobilization time (more than eight weeks) set by the CT scan imagery evaluation performed at the eighth week postoperatively. Scaphoid bone healing, intrascaphoid angle, and carpal alignment (radiolunate and scapholunate angles) related data were evaluated over the entire study, with the aid of the various imagery exams performed throughout the research development. The imagery exams (radiographs) taken from non-damaged counter lateral wrists were used as standard control for pre and postoperative measures. Ambulatory postoperative appointments were performed within range of 1, 3, 6, 8 and 12 weeks, even after the bone healing evidence, the patients had ambulatory segment attendance. Good results parameters of treatment were considered as follow: absence of pain, radiological bone healing proof (radiographic evidence of bridging bony trabeculae across the graft), absence of implant looseness signs, intrascaphoid angle correction, non-existence of carpal instability and carpal collapse, recovery of range of movement and strength.

Surgical Technique

The subjects with scaphoid nonunion were positioned in supine and had anesthesia procedures (general or local anesthesia). An air intake pneumatic tourniquet was used bearing a pressure of 250 mmHg throughout the entire wrist surgery procedure. An anterior exposure was performed for the scaphoid (Russe approach) (Figure 1). A lengthways incision was performed in the wrist joint capsule for exposure of scaphoid palmar surface. The surgery exposure was distally extended until the scaphotrapezium joint, preserving the region's ligaments. With the exposure of the scaphoid, pseudarthrosis irregular edges were resected using a delicate osteotome, rongeur and curette until viable and well vascularized tissue was observed (Figure 2).

The scaphoid was reduced through the application of a traction force, ulnar deviation and wrist extension. After that reduction, the size of the necessary autologous bone graft was calculated. The tricortical graft was taken away from the iliac bone. The graft, in the shape of a wedge, was inserted in the scaphoid volar defect and temporarily fixed with K wire. Deformity corrections of scaphoid and DISI pattern of instability were evaluated by radiograph analysis (Figure 3). The scaphoid internal fixation was performed with a low-profile locked plate for scaphoid APTUS®Hand from Medartis (Figure 4). After the definitive internal fixation (osteosynthesis), radioscapoid joint was inspected, and the joint movement tested to verify plate impact with the bone borders.

RESULTS

There was scaphoid nonunion consolidation in all cases and no complications like infection and implant material fatigue or

Table 1. Alnot Classification of Scaphoid Waist Nonunion.

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

Table 2. Epidemiological Profile.

Patient	Dominance	Operated Side	Profession	Time since trauma	Mechanism of Trauma
1	Right-handed	Right	Driver	8 months	Wrist sprain
2	Right-handed	Left	Bakery manager	6 months	Fall from own body length
3	Right-handed	Right	Civil construction	1 year and 6 months	Fall from high surface (roof)
4	Right-handed	Left	Sales manager	2 years	Fall during sports activity (soccer)
5	Right-handed	Left	Machine operator	1 year and 2 months	Fall from motorcycle
6	Right-handed	Right	Glazier	1 year	Fall from own body length
7	Right-handed	Right	Transport assistant	2 years	Fall from motorcycle
8	Right-handed	Right	Stockist	6 months	Fall during sports activity (basketball)



Figure 1. Russe's anterior approach.



Figure 2. Scaphoid nonunion site after resection of devitalized bone edges.



Figure 3. Wedge shaped graft inserted in the scaphoid volar defect and temporarily fixed with K wire.

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 60° , which represents a carpal instability pattern of DISI type (preoperative scapholunate angle average of 74.87°). In all cases the scapholunate angle was reduced, with a postoperative average of 60.62° , however, two cases remained inside DISI indicative values.

An average preoperative value of 20.21° and postoperative value of 13.75° related to the radiolunate angle was observed, although two of the cases had an angle increase after surgery procedures. Intrascaphoid preoperative angle average was 43.12° , which represents a Humpback deformity (angle above 35°), but this value was corrected in the postoperative to an average of 17.37° .

Related to the patient's clinical evaluation, as summarized by Table 4, there was an average flexion/extension arc of the wrist of 53.12° preoperatively and 39.81° 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 15.25° and 16.87° and, postoperatively, 13.37° and 21° ; 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 35° , a scapholunate angle between 30° and 60° and a radiolunate angle ranging from 0° to $\pm 15^\circ$.

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 unstable fractures or scaphoid nonunion with humpback deformities, to neutralize compression forces and axis angles that occur when a compression screw cannot guarantee stability,^{15,19} 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



Figure 4. Osteosynthesis with volar locked plate APTUS® Hand.



Figure 5. Wrist CT showing the impact of the proximal region of the plate with the radius joint surface.

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 pinches were reduced after surgery. The average of the grip strength and key, tripod and tip pinches 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, Ghoneim¹⁶ 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

Table 3. Radiographic evaluation.

Patient	Alnot classification	Scapholunate angle			Radiolunate angle			Intrascaphoid Angle	
		Preop	Posop	Contralateral	Preop	Posop	Contralateral	Preop	Posop
1	IIB	74°	52°	49°	5°	5°	7°	19°	11°
2	IIB	70°	54°	59°	15°	15°	0°	68°	12°
3	IIB	92°	86°	59°	40°	15°	13°	50°	35°
4	IIB	76°	70°	80° (Nonunion)	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 4. Functional evaluation.

Patient	Dynamometry (Kgf)			Goniometry			Visual Analogue Scale		MayoWrist Score		Dash Score	
	(grip strength/key pinch/tripode pinch/tip pinch)			(Extension /Flexion/Ulnar Deviation/ Radial Deviation)			Preop	Posop	Preop	Posop	Preop	Posop
	Preop	Posop	Contralateral	Preop	Posop	Contralateral						
1	36/8/8/ 6.5	44,33/7,5/8,66/8	58/11/12/8	45°/65°/ 20°/20°	30°/80°/40°/22°	65°/85°/ 40°/35°	2	8	55	70	25	17.24
2	26/11 6/5.3	10/8 3.83/3.33	49/12.33 8.16/5.66	50°/60° 30°/15°	20°/20°/ 25°/10°	60°/75°/ 30°/25°	7	5	65	40	32.5	48.33
3	9.3/5.8 4/5.3	5.3/ 3.5 2.0/0.8	46.6/13 10.5/9.3	40°/50° 30°/15°	15°/15° 15°/10°	60°/65° 30°/20°	6	4	30	15	56.66	68.33
4	42/11 8/6	35/12 8/8	42/11 8/6	60°/80° 45°/15°	45°/45° 15°/10°	45°/60° 25°/15°	5	3	90	65	41.66	11.66
5	19.3/5.6 6/5.3	28/8 6/5	42/6.3 8/9.6	30°/40° 20°/12°	40°/50° 15°/10°	60°/75° 27°/15°	7	2	15	60	73.21	13.33
6	12/4/3/3	12/5.6 3.6/3	26/8/5/5	45°/35° 15°/10°	32°/50° 13°/10°	60°/50° 15°/10°	8	3	50	35	30.83	55
7	35/7.1 5.3/3.6	19.33/5.8 6.1/4.0	29/7.1 5.5/3.5	50°/60° 25°/20°	20°/35° 15°/20°	70°/80° 40°/25°	5	3	75	35	35	22.4
8	50/11 11/7.83	42/9.5 7.66/5.16	46.6/12.66 13.33/7.66	60°/80° 30°/15°	60°/80° 30°/15°	70°/90° 40°/30°	5	3	80	65	15.83	9.16

accordingly to the score as: excellent (90-100), good (80-90), satisfactory (60-80) and bad (<60); and a DASH (Disabilities of Arm, Shoulder and Hand) score, composed of 30 questions that evaluate patients accordingly to their physical function, symptoms and social function. In our casuistry, it was observed that the Mayo Wrist Score had an average of 57.5 preoperatively and 48.12 postoperatively, this worsening being justified by the reduction of ROM and grip strength. Possibly too because most of our patients execute occupational activities that request great wrist demand, being hard to return to their occupations with 12 weeks postoperatively. However, when we look to the DASH score, it is observed a clinical improvement of patients undergoing surgery procedures, with scores of 38.83 and 30.68, pre and postoperative respectively.

As complications of surgery procedures, it is observed the maintenance of pain even after consolidation of scaphoid nonunion in two of the patients, being that pain due to proximal plate portion impact with radius articular surface. As cited by Esteban-Feliu et al.,²⁰ maybe this is a problem that comes from the fact that there is only one design for scaphoid plate, in which no different shapes and sizes can be adapted.

However, 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.

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