



## Original article

# Randomized clinical trial between proximal row carpectomy and the four-corner fusion for patients with stage II SNAC<sup>☆</sup>

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### ABSTRACT

**Objective:** To compare the outcomes of patients with stage II SNAC submitted to surgical treatment by proximal row carpectomy (PRC) or four-corner fusion (FCF).

**Method:** Twenty-seven patients aged 18–59 years (mean 37.52 years) were included. Thirteen patients underwent PRC in Group A, and 14 underwent FCF of the wrist in Group B. Evaluations were made before and after surgery with follow-up between 45 and 73 months. Range of motion (ROM); pain assessment with a visual analog scale (VAS); grip strength; disability of the arm, shoulder, and hand (DASH); and return to work were evaluated.

**Results:** Group A patients had 68.5% and Group B patients, 58.01% of the ROM of the contralateral side. The VAS score was 2.3 in Group A and 2.9 in Group B. Grip strength was 78.67% and 65.42%, respectively, relative to the side not affected. The DASH score was 11 for PRC and 13 for FCF. In Group A, 9/13 (69.23%) and in Group B, 8/14 (57.14%) patients are currently working. Complications were symptomatic osteoarthritis in the mid-carpal joint in Group A and loosening of a screw in Group B.

**Conclusion:** The clinical and functional results do not present statistically significant differences for both analyzed methods.

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## Ensaio clínico randomizado entre ressecção da fileira proximal (carpectomia) e artrodese dos quatro cantos nos pacientes portadores de SNAC no estágio II

### RESUMO

**Objetivos:** Comparar os resultados clínicos e funcionais dos pacientes com diagnóstico de Scaphoid Non Union Advanced Collapse (SNAC), no estágio II, submetidos à ressecção da fileira proximal do carpo ou à artrodese dos quatro cantos.

**Método:** Foram incluídos no estudo 27 pacientes, com média de 37,52 anos (18-59). Treze foram submetidos à carpectomia proximal no Grupo A e 14 à artrodese dos quatro cantos

#### Palavras-chave:

Punho

Dor

Ossos escafoide

Artrodese

<sup>☆</sup> Study conducted at the Hand and Microsurgery Group, Department of Orthopedics and Traumatology, Faculdade de Medicina do ABC, Santo André, SP, Brazil.

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no Grupo B. O seguimento médio foi de 45 a 73 meses. Foram avaliados os arcos de movimento, a dor, a força de preensão palmar, o *Disability Arm Shoulder Hand* (DASH) escore e o retorno ao trabalho.

**Resultados:** No Grupo A os pacientes apresentaram 68,5% do arco de movimento no lado não afetado e no Grupo B, 58,01%. Na avaliação subjetiva da dor (VAS), obtivemos 2,3 no Grupo A e 2,9 no Grupo B. A força de preensão palmar foi de 78,67% no Grupo A do lado não acometido e de 65,42% no Grupo B. O DASH escore no Grupo A foi 11 e no Grupo B, 13. Quanto ao trabalho, 69,23% (9/13) dos pacientes no Grupo A e 57,14% (8/14) no Grupo B retornaram a alguma atividade laboral. A taxa de complicações no Grupo A foi de (1/13) e no Grupo B, de 7,1% (1/14).

**Conclusões:** Os resultados clínico-funcionais estudados não apresentam diferenças estatísticas para os dois métodos analisados.

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## Introduction

Scaphoid fracture is a complex injury, representing the most incident injury among carpal bones; sometimes, it is not diagnosed and evolves with high rates of complications, such as pseudarthrosis, necrosis of the proximal pole, and even osteoarthritis of the entire wrist. Pseudarthrosis, if untreated, causes a burden on the radial side of the carpus, promoting degeneration of the radioscaphoid joint, mainly in the radial styloid process, which leads to a local impact. With evolution, the outline of the scaphoid is worn down, which affects the scaphocapitate and capitulunate joints, causing proximal migration of the capitate and promotes carpal derangement,<sup>1-3</sup> described as scaphoid non-union advanced collapse (SNAC). To guide treatment of this disease, the classification according to the stages of Watson and Ryu<sup>1</sup> is used.

The development stages are described as follows:

1. Stylo-scaphoid osteoarthritis – SNAC stage I;
2. Stylo-scaphoid + radioscaphoid osteoarthritis – SNAC stage II;
3. Stylo-scaphoid + lunocapitate osteoarthritis – SNAC stage III;
4. Stylo-scaphoid + lunocapitate osteoarthritis + radiolunate osteoarthritis – SNAC stage IV.

No published study has concluded which is the best method for treating this disease; arthrodesis carpectomy and four-corner fusion (FCF) are the most studied methods. These surveys show no scientific evidence,<sup>4-8</sup> since they are retrospective studies, non-randomized, and include other degenerative diseases of the carpus, such as post-traumatic osteoarthritis of the wrist, Kienböck disease, and scapholunate advanced collapse (SLAC). Other randomized studies<sup>9</sup> that addressed the same conditions other than SNAC<sup>10</sup> were also non-conclusive.

Only patients with the disease in stage II may undergo salvage surgery,<sup>2,11-13</sup> which preserves some degree of movement, as do carpectomy<sup>14-18</sup> and FCF.<sup>1,19-21</sup> Patients in stage I should undergo reconstructive surgery, such as the correction of the scaphoid non-union<sup>3</sup> and/or radial styloidec-

joint (stage III) cannot undergo carpectomy, only partial wrist arthrodesis.<sup>11,19,22-24</sup> Patients in stage IV have the best treatment option in salvage surgeries, such as total fusion,<sup>2,11,25</sup> or total wrist arthroplasty, whose indication is still controversial.<sup>26</sup>

Both for carpectomy<sup>18,27,28</sup> and FCF, 29 studies presented satisfactory long-term clinical and functional results, with approximately ten years of follow-up. But there are still questions about what is the best method of treatment for patients with pain, loss of hand grip strength, and range of motion limitation to perform daily life or professional activities. For these reasons, the authors decided to perform this clinical trial.

This study aimed to compare the clinical and functional outcomes of patients with stage II<sup>1</sup> SNAC who underwent proximal row carpectomy (PRC) or FCF.

## Methods

From 2005 to December 2014, 78 patients treated in the outpatient clinics of the Hand and Microsurgery Department and diagnosed with SNAC were evaluated. Only 27 met inclusion criteria and were included in the study; they underwent physical examination, plain radiographs in posteroanterior (PA) and lateral (P), computed tomography, and magnetic resonance imaging (MRI) of the affected wrist.

Inclusion criteria were adult patients aged 18–60 years, of both genders, with clinical and imaging diagnosis of SNAC (Fig. 1), in stage II, who signed the informed consent form and the conflict of interest protocol, as per the Research Ethics Committee decision. Patients with associated wrist diseases, such as bone metabolic diseases, or who had undergone any prior surgical procedure, or those who had bilateral conditions on the wrists, were excluded.

Functional assessment was conducted by the professionals from the Hand Occupational Therapy Department of the institution, who did not have access to information regarding the group to which the patient belonged.

Functional assessment was performed by measurement (in degrees) of the wrist range of motion with a single, specific goniometer; the measurement of grip strength was in kilogram-force (kgf), performed with the Jamar<sup>®</sup> device (hydraulic dynamometer).



**Fig. 1 – Preoperative tests: (a) wrist X-ray in posteroanterior (PA); (b) X-ray in profile (P); (c) coronal tomographic slice of this wrist.**

Clinical analysis of pain was made with the visual analog scale (VAS) from 0 to 10, for subjective evaluation. The assessment of quality of life was made with the DASH questionnaire.<sup>13</sup>

Randomization was done by drawing lots with a coin: heads, the patient would undergo PRC (Fig. 2); tails, FCF (Fig. 3). Therefore, patients were divided into two groups, A and B. Group A (heads) underwent resection of the proximal row (Table 1), with interposition of the dorsal wrist capsule.<sup>14-18</sup>

### PRC surgical technique

Dorsal and oblique surgical approach, using the base of the second metacarpal bone and the distal radioulnar joint, was the same for both groups.

A single transverse opening of the dorsal capsule was made; a flap was created to contour the head of the capitate.<sup>15,16</sup>

At that moment, proximal carpectomy was made with the removal of the scaphoid, lunate, and triquetrum.

A radius styloidectomy, of at most 2 mm, was mandatory.

Then, the dorsal capsule was interposed and the flap was sutured in the palmar capsule, followed by sutures of the planes and skin.

Subsequently, postoperative fluoroscopy and radiographs of the wrist were made for post-operative control.

### FCF surgical technique

Patients in Group B (Table 2) were treated using the FCF technique: they underwent two dorsal arthrotomies, one for resection of the scaphoid bone and the other for fixation of the four corners.

After the removal of the scaphoid bone and the preparation of the graft of the same bone, the four corners were opened.

At this point, a thick cavity of similar thickness to carpal bones was created in the center of the four corners, where the scaphoid graft was placed. The four corners were prepared with a special mill provided by the manufacturer. The lunate and triquetrum were appropriately reduced with provisional Kirschner wires.

All four bones (lunate, capitate, hamate, and triquetrum) were stabilized with a special plate (conventional carpal button® by SBI®, or blocked carpal button by Biotech®) and screws.<sup>15-17</sup>

### Postoperative period of Groups A and B

For completion of the procedure, wrist fluoroscopy and radiography were performed to assess the position of the implant and screws.

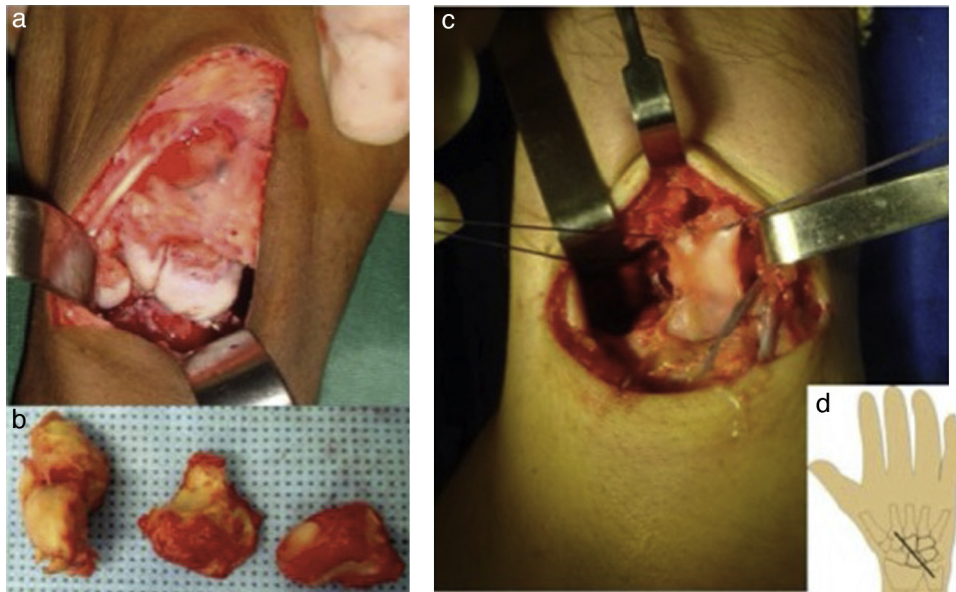
A plaster cast was made around the wrist, which was removed in the first week after surgery.

Patients were clinically and radiographically evaluated before surgery and then on a monthly basis. However, in the present study, only the preoperative and current values were used for statistical analysis. All patients underwent rehabilitation at the Hand Occupational Therapy Department of the institution, with the same protocol, from the first week after the surgery, when the immobilization was removed, until discharge from the department.

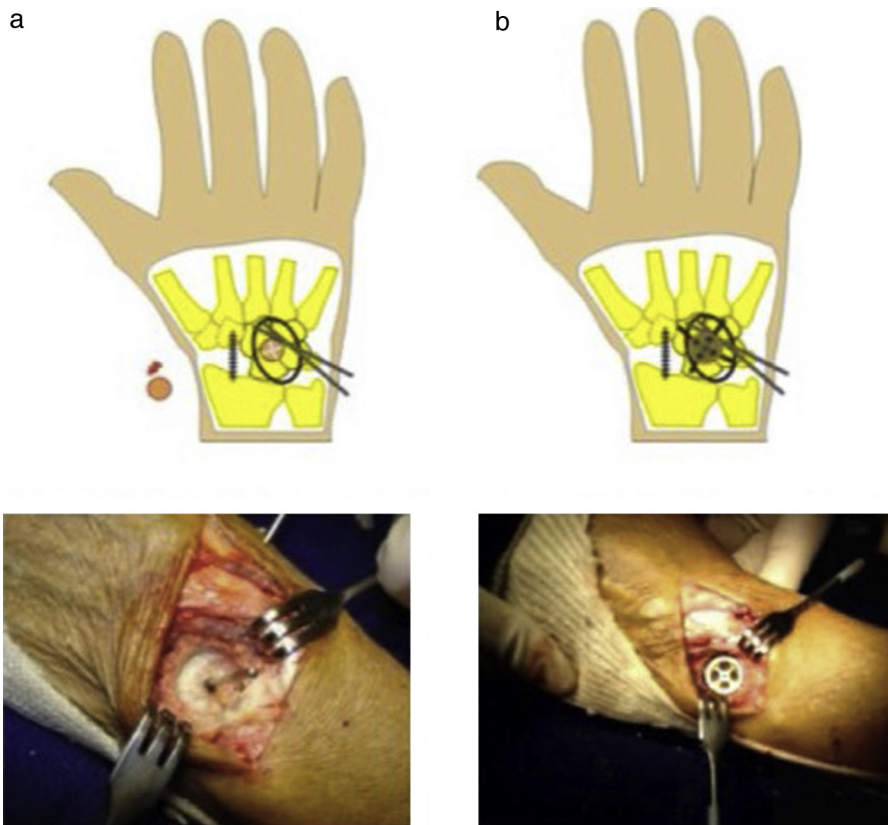
Group A comprised 13 patients with a mean of 32.38 years, who underwent PRC (Fig. 2).

Group B comprised 14 patients with a mean of 40.43 years, who underwent FCF (Fig. 3).

In the statistical analysis of the parametric variables, the Mann-Whitney test and the Wilcoxon signed-rank were used; the significance level (*p*) was set at 5% (0.05). When a statistically significant difference was observed, it was marked with an asterisk (\*); when the calculated significance



**Fig. 2 – Intraoperative aspect of resection of the proximal carpal row. (a) Dorsal access to the wrist; (b) scaphoid, lunate, and triquetrum removed; (c) making of the flap in the wrist dorsal capsule, which was used to coat the head of the capitate; (d) planning the wrist access route.**



**Fig. 3 – Intraoperative aspect of four-corner fusion. (a) Arthrodesis with opening of the four corners; (b) implant placement in the proper position.**

**Table 1 – Epidemiological distribution and postoperative follow-up of patients undergoing proximal carpectomy (Group A).**

Follow-up (months)	Sex	Age (years)	Identification	Return to work	Dominant side	Affected side
69	M	39	I	Yes	R	R
68	M	28	II	No	R	L
74	M	39	III	Yes	R	L
73	M	30	IV	Yes	R	R
75	M	18	V	Yes	R	L
76	M	52	VI	No	R	L
72	M	22	VII	Yes	R	R
70	F	41	VIII	Yes	R	R
74	M	30	IX	No	R	L
78	M	26	X	Yes	R	L
75	M	23	XI	Yes	R	L
77	M	38	XII	No	R	L
77	M	35	XIII	Yes	R	R

Source: Hospital's SAME.

**Table 2 – Epidemiological distribution and postoperative follow-up of patients undergoing four-corner arthrodesis (Group B).**

Follow-up (months)	Sex	Age (years)	Identification	Return to work	Dominant side	Affected side
77	M	56	I	Yes	R	R
77	M	25	II	Yes	R	L
81	M	40	III	Yes	R	L
71	F	39	IV	No	R	L
75	F	30	V	Yes	R	R
78	M	33	VI	Yes	R	R
74	M	45	VII	No	R	R
76	M	34	VIII	Yes	R	L
68	M	54	IX	No	R	L
69	M	48	X	Yes	R	L
68	M	37	XI	No	R	R
78	M	36	XII	Yes	R	R
70	M	48	XIII	Yes	R	R
67	M	41	XIV	No	R	L

Source: Hospital's SAME.

value ( $p$ ) was equal to or greater than 5% (0.050), a statistically non-significant difference was observed and it was not marked. For nonparametric variables, Fisher's exact test was used.

## Results

The values of Group A for range of motion were 68.50%, and for hand grip strength, 78.67%, both compared with the unaffected side; Group B, which underwent FCF, presented range of motion of 58.01%, and hand grip strength of 65.42%. The subjective assessment of pain was 2.3 in Group A and 2.9 in Group B. The DASH score was 11 for Group A and 13 for Group B. In relation to return to work, 64.3% (9/14) and 84.61% (11/13) of patients in Groups A and B, respectively, perform some work activity (Tables 3–5).

The complication rate observed in Group A was 7.69% (1/13), a patient diagnosed with symptomatic osteoarthritis in the radiocarpal joint (Fig. 4) who required total wrist arthrodesis; in Group B, this rate was 7.1% (1/14),

composed by a single patient with diagnosis of pseudarthrosis of the four corners and loosening of the screws. This patient was satisfied with his wrist functional outcome (Fig. 5).

**Table 3 – Clinical and functional results – comparative analysis between groups.**

Parameters	Carpectomy (Group A)	Arthrodesis (Group B)
Pain (VAS)	2.3	2.9
DASH	11	13
Force (kgf)	78.67%	65.42
ROM (°)	68.50%	58.01%
Return to work	84.61%	64.30%
Complications	7.69%	7.10%

VAS, Visual Analog Score; DASH, Disabilities of the Arm, Shoulder and Hand; ROM, range of motion.

% Compared to the normal side for strength/ROM % of the total for Return to work/complications.

**Table 4 – Statistical results of parametric variables.**

Variable	Group	n	Mean	Standard deviation	Significance (p)
Follow-up time	A	13	74	3.37	0.846
	B	14	74.21	2.79	
Age	A	13	32.38	9.39	0.039*
	B	14	40.43	8.94	
Preoperative pain	A	13	7.54	2.50	0.645
	B	14	8.21	1.81	
Postoperative pain	A	13	2.3	3.55	0.769
	B	14	2.9	3.45	
Preoperative DASH	A	13	99.62	24.46	0.331
	B	14	91.71	18.00	
Postoperative DASH	A	13	47.62	15.47	0.697
	B	14	45.00	10.93	
Preoperative strength	A	13	40.38	17.11	0.827
	B	14	40.64	19.88	
Postoperative strength	A	13	78.5	18.89	0.145
	B	14	56.0	11.69	
Preoperative ROM	A	13	80.54	54.75	0.132
	B	14	50.64	28.55	
Postoperative ROM	A	13	108.85	36.29	0.593
	B	14	118.36	39.76	

n, number of patients; DASH, Disabilities of the Arm, Shoulder and Hand; ROM, range of motion.

**Table 5 – Statistical results of nonparametric variables.**

Group	Return to work		Total
	Yes	No	
A	11	2	13
	84.61	15.38	100.00
B	9	5	14
	64.29	35.71	100.00
Total	20	7	27
	74.07	25.93	100.00
Group	Complications		Total
	Yes	No	
A	1	12	13
	7.69	92.31	100.00
B	1	13	14
	7.14	92.86	100.00
Total	2	25	27
	7.41	92.59	100.00

p = 0.695.  
p = 0.999.

## Discussion

The present authors agree with Mulford and Krimmer<sup>7,11</sup>; these are the two most commonly used methods in the treatment of SNAC. Thus, both have their advantages.

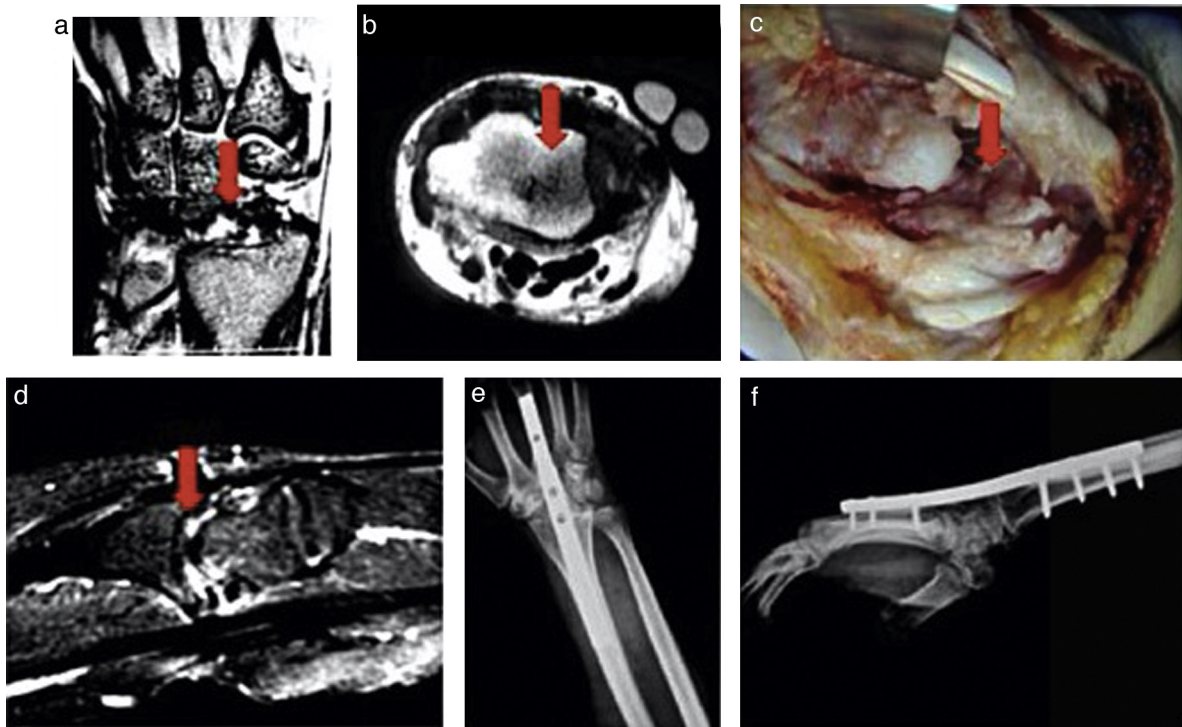
According to the literature,<sup>4-7,18,19,29</sup> FCF has as advantages in relationship to PRC the maintenance of carpal height and preservation of the radiolunate joint and, as disadvantages, the steeper learning curve, greater incidence of complications with the use of circular plates,<sup>19-21</sup> and higher cost.

According to Imbriglia,<sup>18</sup> PRC does not preserve the mid-carpal joint, and can lead to degeneration of the radius or the head of the capitate.

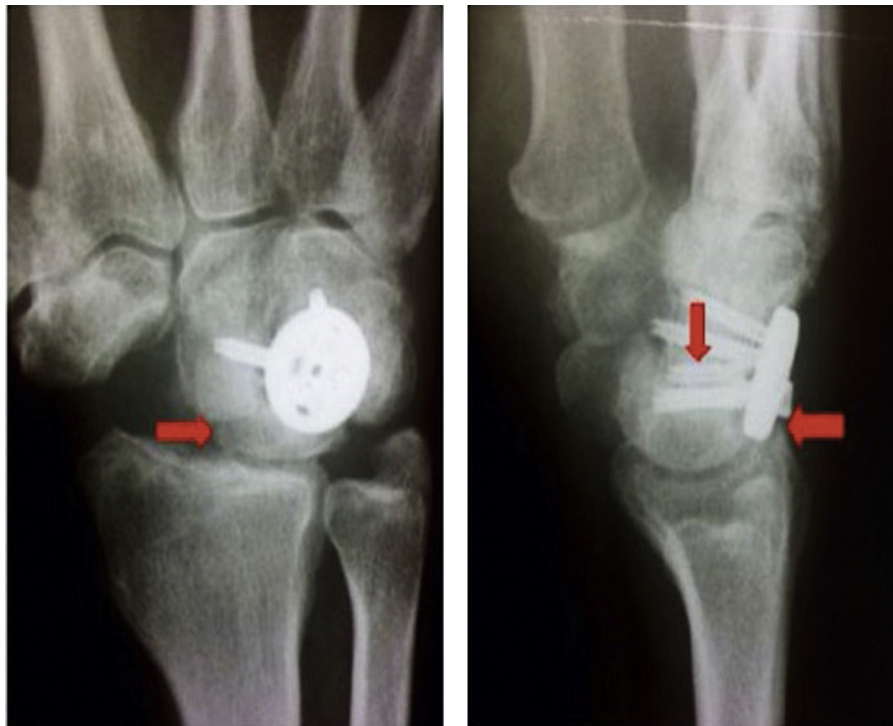
In order to protect the radio-capitate joint space, the authors chose to perform an interposition of the dorsal wrist capsule<sup>15,16</sup> and earlier joint mobility, with the removal of immobilization after a period not longer than one week.<sup>17</sup> However, other authors<sup>27,28</sup> have observed long-term results of degenerative radiographic alteration on the radius or even on the head of the capitate, without clinical consequences. In the present study, one patient from Group A presented radiographic alterations of the radial lunate fossa, with clinical repercussions one year after surgery.

In the present study, carpal button<sup>®</sup> and bone graft in block were used for FCF. Mantovanni et al.,<sup>19</sup> and Merrell et al.,<sup>20</sup> who also used circular plates in their research, and suggested modifications to the technique, such as using block graft harvest from the scaphoid or metaphysis of the distal radius, showed superior results with lower rate of complication than that observed by Kendall et al.<sup>21</sup> There were no statistically significant differences in functional parameters after one or ten years postoperative in patients who underwent FCF.<sup>29</sup> In the present study, there was only one case of pseudarthrosis of the four corners, with release of a screw in the carpal button.

The range of motion in Group A (PRC) was 68.50% in relation to the contralateral side in the present study; Tomaino et al.<sup>4</sup> observed 64%; Wryick et al.,<sup>5</sup> 7%; Cohen and Kozin,<sup>6</sup> 57%; DiDonna et al.,<sup>27</sup> 61%; and Jebson et al.,<sup>28</sup> 63%. In Group B, 58.01% of wrist range of motion compared to the non-affected side was observed; Tomaino et al.<sup>4</sup> observed 41%; Wryick et al.,<sup>5</sup> 47%; Cohen and Kozin,<sup>6</sup> 64%; and Kendall et al.,<sup>21</sup> 46%. The data for pronation and supination were not used because the present authors believe that the distal radioulnar joint is not affected in this pathology, which is also corroborated by other authors.<sup>1-3</sup> When the results of hand grip strength in



**Fig. 4** – Additional preoperative exams and intraoperative aspects (complication) of the second procedure to correct radio-capitate osteoarthritis. (a) coronal MRI of the wrist; (b) axial MRI of the wrist; (c) intraoperative image of radial osteoarthritis and the integrity of the cartilage of the head of the capitate bone; (d) sagittal MRI of the wrist; (e) X-ray of the wrist, in posteroanterior (PA); (f) X-ray of the wrist in profile (P) – total arthrodesis procedure.



**Fig. 5** – Additional postoperative exams: X-ray of the wrist in PA and P showing screw loosening and pseudarthrosis of the four corners.

Group A in the present study (78.67% of the normal side) are compared with the literature, Tomaino et al.<sup>4</sup> observed 96%; Wryick et al.,<sup>5</sup> 94%; Cohen and Kozin,<sup>6</sup> 71%; Bisneto et al.,<sup>9</sup> 47%; Imbriglia,<sup>18</sup> 80%; Didonna et al.,<sup>27</sup> 91%; and Jebson et al.,<sup>28</sup> 83%. In Group B, the hand grip strength was 65.42% of the unaffected side; Tomaino et al.,<sup>4</sup> observed 81%; Wryick et al.,<sup>5</sup> 74%; Cohen e Kozin,<sup>6</sup> 79%; Bisneto et al.,<sup>9</sup> 73%; and Kendall et al.,<sup>21</sup> 56%. There were no significant differences in clinical and functional results.

The complication rate was 7.69% in Group A and 7.1% in Group B; Tomaino et al.<sup>4</sup> observed 0%; Jebson et al.,<sup>28</sup> 10%; Didonna et al.,<sup>27</sup> 18%; Cohen and Kozin,<sup>6</sup> 0%; Wryick et al.,<sup>5</sup> 11%; Kendall et al.,<sup>21</sup> 62.5%; and Imbriglia,<sup>18</sup> 3.7%. Radio-capitate joint degeneration is frequent<sup>7,27,28</sup> (12/26 patients after ten years of follow-up) and asymptomatic in most patients,<sup>18</sup> but one patient, an active adult who returned to work, evolved poorly with radio-capitate joint degeneration,<sup>7,12,18</sup> and underwent total wrist arthrodesis.<sup>18,25</sup> Although not statistically significant, the indication of carpectomy in young adult patients should be avoided. Group B presented inferior results when compared with studies that used circular plates, and similar results when compared with studies that used Kirschner wires and screws, perhaps due the improvement of the method and safety of the technique.<sup>7,12,19,20</sup> The complication observed in the present trial was pseudarthrosis of the four corners; this patient declined revision surgery, as he was satisfied with his clinical and functional outcome.

As for the return to work, results were very similar to those from the literature. Return to work activities was observed in 69.23% of patients who underwent PRC in the present study; 86% in the study by Cohen and Kozin<sup>6</sup> and 80%, in the study by Tomaino et al.<sup>4</sup> Of the patients who underwent FCF in the present study, 57.14% returned to work; 100% in the study by Tomaino et al.<sup>4</sup> and 86% in the study by Cohen and Kozin.<sup>6</sup>

There was no statistical difference between the groups for this variable. However, the authors believe that the above-mentioned data presented objective and subjective values; therefore, they do not consider the result of the variable of return to work to be reliable.

When comparing both methods, the literature<sup>4-8,12</sup> presents a slight superiority in all analyzed functional parameters of patients undergoing PRC, except for the studies by Cohen and Kozin<sup>6</sup> and by Bisneto et al.,<sup>9</sup> who observed better hand grip strength results for patients undergoing FCF.

To date, no article features only patients with the same initial condition of SNAC, which leads to wrist osteoarthritis. Most studies using FCF for the treatment of osteoarthritis did not standardize the wrist osteosynthesis technique for fixation of the four corners (which combines the use of Kirschner wires, compression bolts, or circular plates). Of the aforementioned studies, only one was randomized<sup>9</sup>; nevertheless, it did not standardize the initial pathology that progressed to carpal collapse. One study<sup>10</sup> included only patients with SLAC and had shorter hospital stay and lower complication rate in favor of PRC; those authors suggested the use of this procedure for stages I and II. The study by Mulford et al.,<sup>7</sup> a systematic review of 52 articles, also suggested PRC as the procedure with the lowest complication rate; the authors highlighted

radio-capitate osteoarthritis, which in most patients is asymptomatic.

For these reasons, some differences in the variables studied may be observed when compared with those of the present study.

Both are salvage surgeries that present functional and social limitations, with decreasing values in all criteria analyzed when comparing these wrists with the uninvolved side.

In the comparison with other methods of surgical salvage treatment, such as arthroplasty and total wrist arthrodesis, the present study presented superior DASH scores when compared with the study by Anderson and Adams<sup>26</sup> and superior return when compared with that by Weiss and Hastings.<sup>25</sup>

When compared to other procedures of partial wrists arthrodesis, such as radioscapholunate fusion, which allows for wrist mobility in the midcarpal joint, the results of the present study are also superior to that observed by Saffar,<sup>22</sup> who observed 57% hand grip strength. Beyermann et al.<sup>23</sup> observed a DASH score<sup>24</sup> of 25.7. Dimitrios et al.<sup>24</sup> showed good results in a retrospective study of modified midcarpal arthrodesis, wherein an iliac graft was used to maintain the carpal height, observing consolidation in all cases, without complications.

## Conclusion

Patients had clinical and functional improvement of the wrist, increased hand grip strength, reduced pain, and improved quality of life after treatment of this disease with both methods used in this trial.

Clinical and functional results showed no statistical differences between the two methods.

## Conflicts of interest

The authors declare no conflicts of interest.

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