

## CLINICAL SCIENCE

# Comparison between proximal row carpectomy and four-corner fusion for treating osteoarthritis following carpal trauma: a prospective randomized study

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**OBJECTIVE:** To compare the functional results of carpectomy and four-corner fusion surgical procedures for treating osteoarthritis following carpal trauma.

**METHODS:** In this prospective randomized study, 20 patients underwent proximal row carpectomy or four-corner fusion to treat wrist arthritis and their functional results were compared. The midcarpal joint was free of lesions in all patients.

**RESULTS:** Both proximal row carpectomy and four-corner fusion reduced the pain. All patients had a decreased range of motion after surgery. The differences between groups were not statistically significant.

**CONCLUSIONS:** Functional results of the two procedures were similar as both reduced pain in patients with scapholunate advanced collapse/scaphoid non-union advanced collapse (SLAC/SNAC) wrist without degenerative changes in the midcarpal joint.

**KEYWORDS:** Arthritis; Degenerative; Wrist injuries; Carpal bones; Arthrodesis; Wrist joint.

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## INTRODUCTION

Wrist osteoarthritis cases are part of the hand surgeons' daily practice. The etiology of osteoarthritis may be post-traumatic, degenerative, infectious or rheumatological. Symptoms are progressive pain and decreased wrist function.

When the etiology is non-traumatic, there is no pattern to the way in which the joints are impaired, since the consequences of this condition have various effects on radial and midcarpal joints. Post-traumatic osteoarthritis, however, shows a predictable standardized progression, and thus treatment depends on the stage of evolution of this condition. The etiology of post-traumatic wrist osteoarthritis is usually secondary to ligament injuries or carpal fractures.<sup>1-5</sup> In post-traumatic wrist arthritis cases, 95% are located around the scaphoid, and in 55% of the patients with arthritis the most common pattern is called scapholunate advanced collapse (SLAC) of the wrist, which results from ligament ruptures. The evolution of this type of arthritis is

divided into the following three stages:<sup>2,6</sup> (1) arthritis between the styloid process of the radius and the scaphoid; (2) arthritis in the radial scaphoid fossa, (3) arthritis between the capitate and the lunate.

The osteoarthritis can also result from pseudoarthrosis of the scaphoid (scaphoid non-union advanced collapse (SNAC)).<sup>7</sup> In this degenerative pattern, pseudoarthrosis of the scaphoid acts biomechanically in the same way as injuries to the scapholunate interosseous ligament; as observed in cases of SLAC wrist, but radial scaphoid fossa was preserved when pseudoarthrosis of the scaphoid occurred.<sup>8</sup> The SNAC stages are: (1) arthritis between the styloid process of the radius and the scaphoid; (2) arthritis between the scaphoid and the capitate and (3) arthritis between the capitate and the lunate.

Several surgical approaches for the treatment of post-traumatic osteoarthritis of the carpal bones have been reported—namely, proximal row carpectomy, four-corner fusion, selective denervation of the wrist, partial styloidectomy of the styloid process of the radius, fusion of the scaphoid–trapezium–trapezoid joint, fusion of the scaphoid–capitate joint, “atlas” fusion (lunate–capitate) and the complete fusion of the wrist.<sup>4,5,8-22</sup>

This study aimed to compare the functional results of proximal row carpectomy and four-corner fusion for the

treatment of post-traumatic wrist osteoarthritis with no effect on the midcarpal joint.

## PATIENTS AND METHOD

Twenty-three patients were selected based on the inclusion and non-inclusion criteria for this study (see below). All patients presented wrist osteoarthritis, with a diagnosis of SLAC or SNAC, but without involvement of the midcarpal joint. All patients were operated on by the same surgeon at the same hospital, between August 2004 and September 2007. All patients included in this study presented had a range of wrist motion. Three patients did not attend two postoperative assessments and were excluded. Of the 20 patients included, 16 had SNAC and 4 had SLAC.

The evolutionary stages of SNAC/SLAC were evaluated by radiography and computed tomography.

The inclusion criteria were the presence of wrist osteoarthritis grade I or II SLAC/SNAC and acceptance of the statement of free and informed consent. The exclusion criteria were presence of gross deformities in other limbs; rheumatological conditions; infections; involvement of the midcarpal joints, diseased condition in the contralateral wrist and previous fractures of the distal extremity of the radius or the carpal bones. The only other exclusion criterion was patients' non-attendance at two postoperative functional assessments.

The subjective analysis was based on the disabilities of the arm, shoulder or the hand (DASH) questionnaire and an analog pain scale.<sup>23,24</sup>

In the objective evaluation, the following were observed: wrist goniometry, grip force (Jamar), grip force of pulp-pulp, lateral (key) and three-finger (tripod) pinches, discrimination between two points on the pulp of the second and fifth fingers, and on the dorsum of the first web, measurements of the hand and wrist volumes and the Jebsen-Taylor functional test.<sup>25</sup>

Patients underwent preoperative and postoperative assessments and the latter were done 3, 6 and 12 months after the surgical procedure. All assessments were made by the same occupational therapist. Randomization was carried

out by a draw on the day of the surgery. All operations were done by the same surgeon at the same institution. Patients who underwent proximal row carpectomy and those who had four-corner fusion started their rehabilitation with kinesiotherapy and physical means 3 weeks and 2 months after the operation, respectively.

## Statistical Analysis

Comparison of the evolutionary results within the same surgical group, between the preoperative and postoperative assessment were performed by the Wilcoxon test. Data on the operated and contralateral wrist were also compared using the Wilcoxon test. A non-parametric Mann-Whitney test was used to analyze the results between the two surgical groups. The significance level of 5% ( $p \leq 0.05$ ) was adopted for this study.

## RESULTS

The mean ages of the fusion and the carpectomy groups were  $42 \pm 10.6$  and  $43.4 \pm 10.1$  years, respectively. There was no difference in the handedness of the affected limbs between the two groups.

The data were divided into a direct evolutionary analysis and comparative analysis within the same group and between the groups.

## Direct Evolutional Analysis

Data on direct evolutionary analysis—direct comparison of evolution of the parameters over time—within each group are shown in Table 1. After 12 months despite the radial deviation values, all the wrist parameters decreased in both procedures. Values related to pronation and supination were almost the same as before surgery.

Grip force was evaluated and the fusion group achieved the same values at 12 months as before surgery, this did not occur in the carpectomy group (Table 2).

For pinch force evaluation, all the patients, in both groups, recovered or improved their preoperative values. Discrimination between two point values showed no differences in this study.

**Table 1 - Goniometry evaluation.**

Side	Time of the measurements							
	Preoperative		3 Months		6 Months		12 Months	
	Operated wrist	Contralateral wrist	Operated wrist	Contralateral wrist	Operated wrist	Contralateral wrist	Operated wrist	Contralateral wrist
Flexion F	40*	56	20	54	19*	53	27*	54
Extension F	47*	64	38*	65	38*	61	38*	65
RD F	9	11	8	14	9	11	11	13
UD F	21	23	11*	22	13*	23	18*	24
Pronation F	83	86	86	84	87	84	87	86
Supination F	80	89	86	89	86	89	87	89
Flexion C	45*	60	26*	60	33*	62	32*	58
Extension C	42*	63	35*	66	37*	65	40*	64
RD C	7*	15	7*	14	9*	15	8*	14
UD C	22	27	18*	27	16*	26	18*	23
Pronation C	79	89	85	90	82*	89	80*	90
Supination C	85	91	85	90	87	90	89	90

Values are shown in degrees.

\* $p \leq 0.05$  in the Wilcoxon test.

C = carpectomy; F = fusion; RD = radial deviation; UD = ulnar deviation.

**Table 2 - Grip force evaluation.**

Side	Time of the measurements							
	Preoperative		3 Months		6 Months		12 Months	
	Operated wrist	Contralateral wrist	Operated wrist	Contralateral wrist	Operated wrist	Contralateral wrist	Operated wrist	Contralateral wrist
<b>Fusion</b>	25.7*	35.6	15.4*	35.9	17.7*	30.7	25.7*	35.4
<b>Carpectomy</b>	18.6*	38.3	12.8*	35.9	13.9*	37.6	17.6*	37.6

Values are shown in kgf.

\*p≤0.05 in the Wilcoxon test.

The operated wrists showed volumetry values that were smaller than those of contralateral wrists by the end of the evaluations, after 12 months of surgery, in both groups.

Both groups showed reduced pain on an analog pain scale. The preoperative values in the fusion and carpectomy groups were 7.6 and 8.2, respectively. After 12 months of surgery the values were 5.1 and 4.8.

DASH values corresponded to the analog pain scale values, which meant that all patients showed an improvement in their daily living and work activities. Preoperative DASH values in the fusion and carpectomy groups were 42.7 and 52.4, respectively, and postoperative values were 29.9 and 37.7, respectively.

Jebsen-Taylor test values showed that hand abilities had improved in both groups, from 57 to 40.9 seconds in the fusion group and from 74.1 to 65.2 seconds in the carpectomy group.

### Comparative Analysis

Comparative analysis is a proportional comparison of the data between the groups as follows:

*Horizontal analysis:* evaluation of the data between the operated and the contralateral wrist 12 months after the operation (Table 3).

*Vertical analysis:* evaluation of the data on the operated wrist 12 months after the operation in relation to the preoperative ipsilateral data (Table 4).

In the horizontal analysis, the data were compared proportionally and values for the contralateral limb were

**Table 3 - Horizontal analysis. Proportional evaluation between the operated and the contralateral wrist, 12 months after surgery.**

	Percentage in relation to the contralateral wrist	
	Fusion	Carpectomy
<b>Flexion</b>	50	55
<b>Extension</b>	58	63
<b>RD</b>	85	57
<b>UD</b>	75	78
<b>Pronation</b>	101	89
<b>Supination</b>	98	99
<b>Key pinch</b>	91	67
<b>Pulp-pulp pinch</b>	69	59
<b>Tripod pinch</b>	73	65
<b>Jamar</b>	73	47
<b>Jebsen-Taylor</b>	98	99

RD = radial deviation; UD = ulnar deviation.

used as the baseline. In the vertical analysis, the preoperative measurements were used as the baseline values

### Complications

In the four-corner fusion group, 1 case of reflex sympathetic dystrophy was seen.

In the proximal row carpectomy group, 3 cases of synovitis with significant wrist edema and 2 cases of reflex sympathetic dystrophy were seen.

All observed complications occurred no later than the second month after the operation and were treated clinically. None of the patients presented any breakage of the synthesis material or deep infection, or any other condition that might have required further surgical intervention.

### DISCUSSION

The mean age (40–52 years) of patients in this study is similar to that in other studies.<sup>8,16-22</sup> A period of 5–10 years between the trauma and the start of signs and symptoms of arthrosis

**Table 4 - Vertical analysis. Proportional evaluation on the operated wrist between the preoperative assessment and the assessment 12 months after the operation.**

	Percentage in relation to the preoperative values	
	Fusion	Carpectomy
<b>Flexion</b>	68	71
<b>Extension</b>	81	95
<b>RD</b>	122	114
<b>UD</b>	86	82
<b>Pronation</b>	105	101
<b>Supination</b>	109	105
<b>Key pinch</b>	124	103
<b>Pulp-pulp pinch</b>	109	95
<b>Tripod pinch</b>	100	108
<b>Jamar</b>	100	95
<b>Edema assessment</b>	97	100

  

	Percentage evolution in relation to the preoperative values	
	Fusion	Carpectomy
<b>Jebsen-Taylor*</b>	28	12
<b>DASH*</b>	30	28
<b>Pain scale*</b>	33	41

\*These parameters are represented by inversely proportional values that were obtained by means of the 100–x function, in which x was the directly proportional value).

All the data in this table had a p-value ≥0.05 according to the Mann-Whitney test.

DASH = disabilities of the arm, shoulder or the hand; RD = radial deviation; UD = ulnar deviation.

implies a condition that occurs in patients who are around 35 year old.<sup>7</sup>

Rigor in applying the non-inclusion criteria was fundamental for obtaining a homogeneous group of patients. The use of computed tomography to evaluate the joints, particularly the midcarpal joint, contributed greatly towards homogenizing the study groups.

Twelve months after the operation, the overall range of wrist motion was smaller in relation to the preoperative values in both procedures ( $p \leq 0.05$ ). The arc of flexion-extension was, on average, 25% and 17% less in the cases of four-corner fusion and in proximal row carpectomy, respectively. The radial-ulnar deviation, on average, was, 0.3% and 10% less in fusion patients and carpectomy patients, respectively.

The radial deviation in cases of four-corner fusion was the only goniometry parameter that had improved 12 months after the operation. The postoperative pronation-supination movements were not statistically different in either group. Decreases in the overall range of motion in relation to preoperative values in proximal row carpectomy<sup>5,26-28</sup> and four-corner fusion<sup>5,29</sup> has been reported. In our study, horizontal analysis within each group showed proportional range-of-motion results favoring proximal row carpectomy, except for radial deviation, for which fusion was favored ( $p \leq 0.05$ ). The results presented here are consistent with other published results.<sup>8,16-19,22</sup> However, others found that the arc of flexion-extension in cases of four-corner fusion was greater than the arc in cases of proximal row carpectomy.<sup>20</sup>

Vertical analysis of the four-corner fusion group showed that the grip force recovered to preoperative values ( $p \leq 0.05$ ). In the carpectomy group, 95% of the preoperative grip force was recovered ( $p \leq 0.05$ ).

A loss of carpal height in the proximal row carpectomy procedure owing to relative stretching of the flexor and extensor tendons has been reported.<sup>2</sup> The improvement in grip force after the operation can be credited to pain relief.<sup>27,28</sup>

Horizontal data from a series of proximal row carpectomy cases with longer follow-up duration have shown that between 60% and 80% of the grip force in the contralateral wrist is achieved.<sup>4,26-28</sup> In contrast, only 47% of the grip force was achieved in this study. Patients undergoing proximal row carpectomy may take up to 1 year to achieve complete rehabilitation.<sup>28</sup> Horizontal analysis of the grip force in patients undergoing four-corner fusion provided the best defense of this technique, to the detriment of proximal row carpectomy, because of the preservation of grip force in relation to the non-operated side.<sup>2,16</sup>

A 10% increase in relative grip force may occur over a 3-year period between postoperative evaluations in cases of four-corner fusion.<sup>30</sup> Grip force values of between 70% and 87%, in relation to the contralateral wrist have been reported.<sup>8,17-20,30</sup> In this study, the grip force was 73% of the contralateral wrist in patients who underwent four-corner fusion and 47% in patients undergoing proximal row carpectomy compared with the non-operated side ( $p \leq 0.05$ ). These comparative values between groups were not statistically significant.

Evaluation of the grip force was done by finger pinches (key pinch, pulp-pulp pinch and tripod pinch), together with a test to discriminate between two points. This was done to determine whether surgical procedures might have caused lesions in the peripheral nerves.<sup>23</sup> The results obtained proved that both surgical procedures were safe.

The universal analog pain scale was applied to the study patients. In the four-corner fusion group, there was a 33% reduction in pain, compared with preoperative values ( $p \geq 0.05$ ). In the proximal row carpectomy group, there was a 41% reduction in pain ( $p \leq 0.05$ ). The comparative values between groups were not statistically significant.

In the vertical DASH analysis, the patients who underwent four-corner fusion or proximal row carpectomy achieved 30% and 28% evolution, respectively, compared with preoperative values ( $p \geq 0.05$ ). In the vertical analysis of the Jebsen-Taylor test,<sup>25</sup> the patients who underwent four-corner fusion achieved, on average, 28% evolution over the task duration, whereas the value was 12% in patients who underwent proximal row carpectomy ( $p \geq 0.05$ ). In the horizontal analysis, almost all patients recovered their function compared with the contralateral side; 98% in four-corner fusion group and 99% in proximal row carpectomy group. Comparison of the results between groups was not statistically significant.

## CONCLUSION

Both proximal row carpectomy and four-corner fusion surgical procedures provided similar functional results for treating degenerative conditions of SLAC/SNAC without the impairment of the midcarpal joint. Indication for the surgical technique should be based on several parameters, such as patient's age, duration of immobilization, risk of pseudoarthrosis, possibility of breakage of the synthetic material, infection, duration of rehabilitation and the experience of the surgical team.

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