Percutaneous Fixation Without Graft vs Open Fixation with Graft in Delayed Stable Consolidation of the Scaphoid: Retrospective Analysis

Fijación percutánea sin injerto vs fijación abierta con injerto en retardo de consolidación estable de escafoides: Analisis retrospectivo

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Abstract

Introduction The most appropriate surgical management of delayed symptomatic scaphoid consolidation remains controversial. Few studies compare different treatment options. This study aimed to compare the outcomes from percutaneous osteosynthesis with no associated bone graft and open reduction and internal fixation with cancellous autograft for stable delayed scaphoid consolidation.

Material and Methods A retrospective study included 24 patients: 13 subjects underwent percutaneous osteosynthesis without graft, while 11 patients underwent open reduction and internal fixation with associated cancellous graft. The main study variable was the average consolidation time in weeks. We determined the following secondary variables before and after surgery. The secondary radiological included the scapholunate angle, scapholunate distance, capitolunate angle, radiolunate angle, scaphoid length, and lateral intrascaphoid angle. The secondary functional variables at 6, 12, and 24 weeks included range of motion in flexion and extension, radial and ulnar deviation, pain according to the visual analog scale (VAS), the Quick Disability of Arm Shoulder and Hand (DASH) questionnaire, and the Patient-Rated Wrist Evaluation (PRWE) score, average number of physical therapy sessions, and average time to return to work. The Mann-Whitney U test analyzed quantitative variables, while the chi-square test analyzed qualitative variables at a significance level set at $p < 0.05$.

Results The mean time until surgery was 10 weeks in the group without graft and 23 weeks in the group with graft. The mean consolidation time in the group without

Keywords
- scaphoid pseudoarthrosis
- percutaneous osteosynthesis
- internal fixation
- bone graft

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graft was 10 weeks (range, 8 to 12 weeks) and 12 weeks (range, 8 to 20 weeks) in the group with graft. The consolidation rate was 100% in all cases. Differences favored the group without graft for the following parameters: visual analog scale (VAS) for pain at 3 months (5 vs. 7, $p = 0.002$), 6 months (3 vs, 6, $p = 0.000$), and 1 year (1 vs. 2, $p = 0.001$); DASH at 1 year (9 vs. 24, $p = 0.000$); PRWE score at 1 year (6 vs. 10, $p = 0.011$), mean flexion at 6 months (65° vs. 45°, $p = 0.010$); mean extension at 6 months (70° vs. 46°, $p = 0.009$); and ulnar deviation at 6 months (25° vs. 15°, $p = 0.047$). Differences favored the group with graft for the radial deviation at 6 months (15° vs. 12°, $p = 0.038$). The average time to resume working was 8 weeks in both groups.

Conclusion For surgical treatment of delayed consolidation in scaphoid fractures with no instability, percutaneous osteosynthesis without a bone graft could be superior to open reduction and internal fixation with cancellous autograft regarding radiological consolidation time and functional recovery.

Resumen

Introduccion Actualmente hay controversia sobre el manejo quirúrgico más adecuado del retardo de consolidación de escafoides sintomático. Hay pocos estudios comparativos entre las diferentes alternativas de tratamiento. El objetivo del estudio es comparar los resultados obtenidos entre la osteosíntesis percutánea sin injerto óseo asociado, y la reducción abierta y fijación interna con autoinjerto esponjoso para el retardo de consolidación de escafoides estable.

Material y Metodos Se realizó un estudio retrospectivo con 24 pacientes: 13 pacientes intervenidos mediante osteosíntesis percutánea sin injerto y 11 pacientes intervenidos mediante reducción abierta y fijación interna asociando injerto esponjoso. La variable principal de estudio fue el tiempo medio de consolidación en semanas. Se midieron variables radiológicas secundarias en el pre y posoperatorio: ángulo escafolunar, distancia escafolunar, ángulo lunogrande, ángulo radiolunar, longitud escafoides, ángulo intraescafoideo lateral, y variables funcionales secundarias a las 6 , 12 y 24 semanas: rango de movilidad en flexión, extensión, desviación radial y cubital, dolor en escala VAS, valoración Quick Dash y PRWE, número medio de sesiones de fisioterapia y tiempo medio de reincorporación a actividad laboral. Se empleó el test de U de Mann-Whitney para variables cuantitativas y el test de Ji-Cuadrado para las cualitativas, estableciendo un nivel de significación en $p < 0,05$.

Resultados El tiempo medio en semanas hasta la cirugía fue de 10 semanas en el grupo sin injerto y 23 semanas en el grupo con injerto. El tiempo medio de consolidación en semanas en el grupo sin injerto fue de 10 sem (R 8-12 sem) y en el grupo con injerto de 12 sem (R 8-20 sem) ($p = 0,002$). Se obtuvo un 100% de consolidación en todos los casos. Se obtuvieron diferencias a favor del grupo sin injerto para los siguientes parámetros : EVA a los 3 meses (5 vs 7 , $p = 0,002$), 6 meses (3 vs 6 $p = 0,000$) y al año (1 vs 2 $p = 0,001$); DASH 1 año (9 vs 24 $p = 0,000$); PRWE 1 año (6 vs 10 $p = 0,011$), flexión media 6 meses (65° vs 45° $p = 0,010$); extensión media 6 meses (70° vs 46° $p = 0,009$); desviación cubital 6 meses (25° vs 15° $p = 0,047$). Se obtuvieron diferencias a favor del grupo con injerto en el parámetro desviación radial 6 meses (15° vs 12° $p = 0,038$). El tiempo medio de incorporación al trabajo fue de 8 semanas de media en los dos grupos.

Conclusion Para tratamiento quirúrgico del retardo de consolidación en fracturas de escafoides sin criterios de inestabilidad, la osteosíntesis percutánea sin injerto óseo asociado podría ser un tratamiento superior a la reducción abierta y fijación interna con autoinjerto esponjoso en cuanto a tiempo de consolidación radiológica y recuperación funcional.

Palabras Clave
- pseudoartrosis escafoides
- osteosíntesis percutánea
- fijación interna
- injerto óseo

Introduction

The scaphoid bone presents the highest rate of consolidation delay or lack due to mechanical and intrinsic factors, including an almost complete cartilage coverage, high fragment mobility during wrist movements, and poor bone vascularization. The incidence of scaphoid fracture delayed or no consolidation ranges from 5 to 25%.[1] Symptomatic delayed scaphoid consolidation treatment may use open reduction and internal fixation or percutaneous fixation with or without arthroscopy. It may also include autograft addition and associated alternative procedures, such as bone decompression or administration of growth factors or platelet-rich plasma.[2,3] These treatments attempt to obtain radiological fracture consolidation, scaphoid deformity correction, carpal anatomy and height restoration, pain relief, complete functional recovery, and degenerative change prevention.[4,5]

The current literature does not demonstrate the superiority of one treatment over the other for delayed scaphoid consolidation without instability criteria (displacement < 1 mm, no deformity or collapse, no dorsal intercalary segment instability (DISI), and a lateral intrascaphoid angle < 35), or established scaphoid nonunion.[6,7] Several studies demonstrated good outcomes with percutaneous osteosynthesis without associated cancellous graft.[5,8–10] However, few studies compare the effectiveness of osteosynthesis with and without cancellous bone graft according to radiological and functional criteria.

This study aimed to compare the outcomes from two types of treatment for delayed stable consolidation in scaphoid fractures: percutaneous osteosynthesis without associated bone graft and open reduction and internal fixation with cancellous autograft. We hypothesize that no treatment modality is superior to the other in terms of bone consolidation velocity and complete functional recovery and that percutaneous osteosynthesis would be sufficient to increase mechanical stability and promote the bone consolidation process.[11]

Material and Methods

This retrospective study included patients undergoing surgery from January 2019 to September 2021, comparing different variables in two groups with delayed stable scaphoid fracture: treatment by closed reduction and percutaneous osteosynthesis without biological contribution (without graft group) and treatment by open reduction and osteosynthesis with cancellous autograft (with graft group).

The study included all patients meeting the following criteria:

- Presence of intact cartilaginous envelope or delayed firm fibrous union assessed by advanced imaging tests or direct visualization.
- Delayed consolidation with minimal bone resorption ($<$ 5 mm), sclerosis ($<$ 1 mm), and absence of degenerative changes, hump deformity, carpal instability (DISI), ligamentous injury, or scaphoid nonunion advanced collapse (SNAC) wrist.
- Stable consolidation delay (absence of a mobility focus under image intensifier (II), lateral intrascaphoid angle $< 35°$, displacement < 1 mm).
- Slade classification types I to IV and Alnot classification type IIA.
- Consolidation delay for less than 1 year.
- The exclusion criteria for study patients were the following:
- Scaphoid delayed consolidation in smoking patients.
- Patients with microcirculation-altering conditions, such as diabetes.
- Delayed consolidation with evident signs of avascular necrosis in the proximal pole (sclerosis on radiography/-computed tomography (CT) or decreased signal on magnetic resonance imaging [MRI]).

For each patient, we recorded age, gender, dominant hand, manual worker (yes or no), time until surgery in weeks, delay type per the Slade, delayed consolidation site (waist, proximal pole, distal pole), and postoperative follow-up time in weeks.

For the surgical technique using a graft, the procedure employed a volar approach to the scaphoid with a golf club incision proximally extended for placing a radial graft and sparing the carpi radialis flexor tendon sheath and the radial artery. We performed a longitudinal volar capsulotomy, exposure, curettage, delayed consolidation focus perforation, placement of a cancellous bone autograft from the radius, olecranon, or iliac crest, and internal fixation with a Herbert-type compression screw (Worm, SAI; Acutrack Mini, Accumed).

The surgery with no graft employed a volar percutaneous technique with a distal and radial incision to the scaphoid tubercle with the wrist in extension. We checked fragment stability under II and placed a guide Kirschner wire following the longitudinal axis of the scaphoid and a Herbert-type screw before drilling the spinal canal under II control. In some cases, we also used a dorsal technique with a dorsoradial incision on the proximal pole of the scaphoid, determined the fragment stability under II, placed a guide Kirschner wire in a dorsovolar direction on the scaphoid axis, drilled, and placed a screw under II control with the wrist in flexion and pronation.

In the immediate postoperative period, patients from both treatment groups (with and without graft) received immobilization with a removable whalebone wrist splint for 4 weeks and began physical therapy at week 5.

The main study variable was the average time for radiological consolidation in weeks. In each patient, the radiological consolidation assessment used a posteroanterior (PA) and a lateral wrist radiograph at 4, 8, 12, 16, and 24 weeks and a high-resolution beam computed tomography at 12 and 24 weeks, checking the presence of bone bridges in two planes (coronal and sagittal). The secondary radiological variables in the pre- and postoperative study included scapholunate angle, scapholunate distance, capitolunate

angle, radiolunate angle, scaphoid length, and lateral intrascaphoid angle. The secondary functional variables were the range of mobility in flexion and extension, radial and ulnar deviation (at 24 weeks), pain on the VAS scale (at 12, 24, and 48 weeks), functional assessment based on the Quick Disability of Arm Shoulder and Hand (DASH) questionnaire and the Patient-Rated Wrist Evaluation (PRWE) score (at 12 and 24 weeks), the average number of physical therapy sessions, and the average time to return to work (in weeks).

The descriptive analysis used position measurements (median and interquartile range) for quantitative variables and frequency distribution for qualitative variables. The independent evaluation of differences between groups employed the Mann-Whitney U test for quantitative variables and the Chi-Square test for qualitative variables. The paired difference assessment by groups used the Wilcoxon rank test. The generalized linear model for repeated measures evaluated differences between groups. The statistical significance level was $p < 0.05$ (►**Figure 1** and ►**Figure 2**)

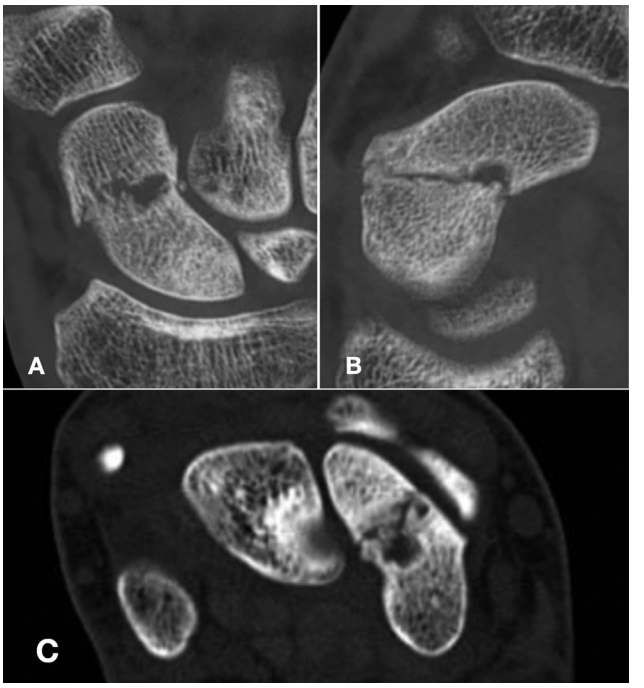


Fig. 1 Preoperative computed tomography delayed scaphoid consolidation in a 32-year-old patient with a history of right wrist trauma while playing hockey 12 weeks ago. Note the edge resorption, the cysts < 5 mm, and the focal displacement < 1 mm. A, Coronal image. B, Sagittal image. C, Axial image.

Results

The study included 24 patients (13 cases with delayed scaphoid consolidation treated with open reduction, internal fixation, and graft, and 11 subjects with delayed consolidation treated with closed reduction and percutaneous osteosynthesis without graft). We show the demographic, radiological, and functional outcomes.

Demographic Outcomes

►**Table 1** shows the descriptive analysis of the demographic variables studied. Most patients were males (10 and 12 subjects in each group). The mean age was 26 and 35 years in the group with and without graft, respectively. The involved limb was dominant in 16 cases, and most patients did not perform manual labor (17 subjects). According to the Slade classification, there were three cases with type I, nine with type II, seven with type III, and five with type IV injuries. The injury was on the scaphoid waist in 17 subjects, the proximal pole in six patients, and the distal pole in one case. Most patients[14] presented cysts < 5 mm. For all analyzed variables, there were no significant differences between

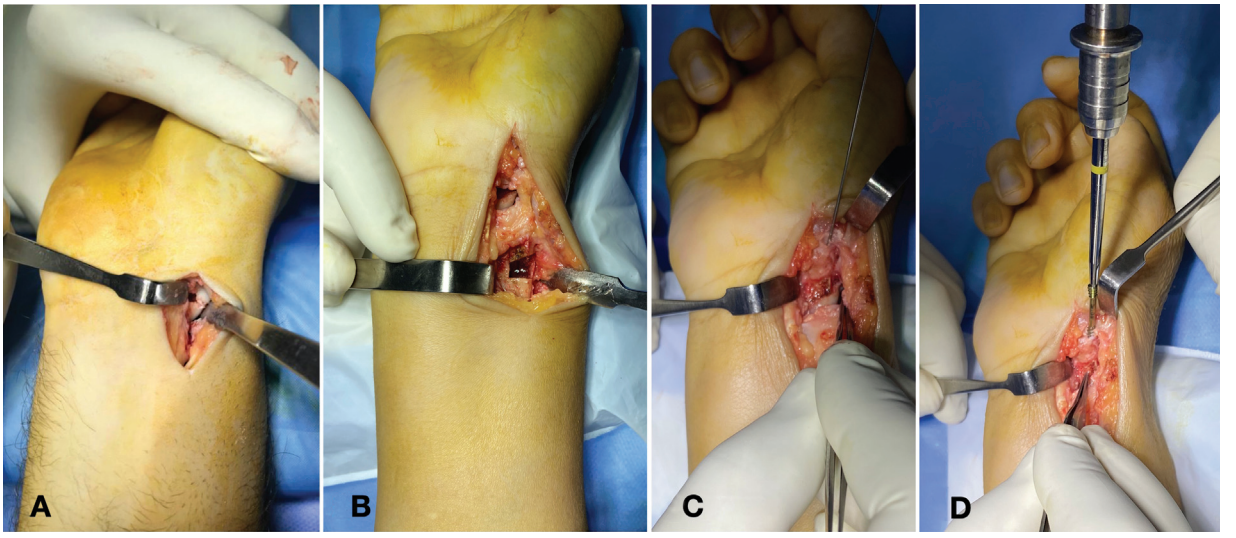


Fig. 2 Images from the volar surgical approach for open reduction and internal fixation of delayed scaphoid consolidation. 2A, Golf club approach on the scaphoid tubercle, volar capsulotomy, and focus exposure and curettage. 2B, Cancellous bone graft harvesting from the distal radius. 2C, Temporary fracture fixation with pin and defect filling with cancellous bone graft. 2D, Internal fixation with Herbert-type compression screw.

Table 1 Analysis of the demographic variables studied.

		With graft	Without graft	Total	p-value
N		11	13	24	
Gender	Female	1	1	2	1.000
	Male	10	12	22	
Age		26	35		0.251
Dominant hand	Yes	9	7	16	0.211
	No	2	6	8	
Manual worker	No	8	9	17	1.000
	Yes	3	4	7	
Slade classification	I	3	0	3	
	II	2	7	9	
	III	1	6	7	
	IV	5	0	5	
Injury location	Medial third	8	9	17	
	Proximal third	2	4	6	
	Distal third	1	0	1	
Cysts	< 5 mm	4	10	14	0.613
	> 5 mm	3	3	6	
Time until surgery		10	23		0.001

groups except for the average time until surgery (10 weeks in the group with graft vs. 23 weeks in the group without graft, $p = 0.01$) (►**Table 1**)

Radiological Outcomes

►**Table 2** and ►**Graph 1** show the different radiological measurements in the subjects with delayed consolidation included in the study. All patients presented complete lesion consolidation. The mean average time for lesion consolidation was 10 weeks in the group without graft (range, 8 to 12 weeks) and 12 weeks in the group with graft (range, 8 to 20 weeks), with a significant difference ($p = 0.002$) (►**Diagram 1**). In contrast, there were significant differences from the preoperative to the postoperative period in the group with graft for the following parameters: scapholunate distance, radiolunate angle, and lateral intrascaphoid angle. Pre- and postoperative differences were also observed in the group without graft for the following parameters: scapholunate angle, scapholunate distance, capitolunate angle, radiolunate angle, coronal plane scaphoid length, and lateral intrascaphoid angle. The preoperative and postoperative comparison detected differences favoring the group without graft regarding scapholunate angle correction ($p = 0.012$) and capitolunate angle ($p = 0.004$). The remaining parameters had no differences between the two groups at the pre- to postoperative comparison (►**Table 2**, **Graph 1**, and **Diagram 1**)

Clinical and Functional Outcomes

►**Table 3**, ►**Diagram 2**, and ►**Diagram 3** show the functional variables studied. Significant differences favored the group without graft for the following parameters: VAS at 3 months (5 for the without group vs. 7 for the with group, $p = 0.002$), VAS at 6 months (3 for the without group vs. 6 for the with group, $p = 0.000$); VAS at 1 year (1 for the without group vs. 2 for the with group, $p = 0.001$); DASH at 1 year (9 for the without group vs. 24 for the with group, $p = 0.000$); PRWE at 1 year (6 for the without group vs. 10 for the with group, $p = 0.011$), mean flexion at 6 months (65° for the without group vs. 45° for the with group, $p = 0.010$); mean extension at 6 months (70° for the without group vs. 46° for the with group, $p = 0.009$); ulnar deviation at 6 months (25° for the without group vs. 14.5° for the with group, $p = 0.026$). Significant differences favored the group with graft for the radial deviation parameter at 6 months (12° for the without group vs. 15° for the with group, $p = 0.038$). Differences also favored the group without graft regarding the average follow-up time in months (26 for the without group vs. 13 months for the with group, $p = 0.003$) and the group with graft for the number of physical therapy sessions (40 for the without group vs. 10 for the with group, $p = 0.000$). The average time to return to work was about 8 weeks in both groups, with no differences between them (►**Table 3**, ►**Diagram 2**, ►**Diagram 3**, ►**Figure 3**).

Discussion

Scaphoid fractures constitute a complex condition with a high potential for consolidation delay or absence compared with other fractures despite the different conservative and surgical management options. Alnot considers the consolidation lack at 3 months enough to determine a nonunion, even though this is a controversial topic.[8] Based on the

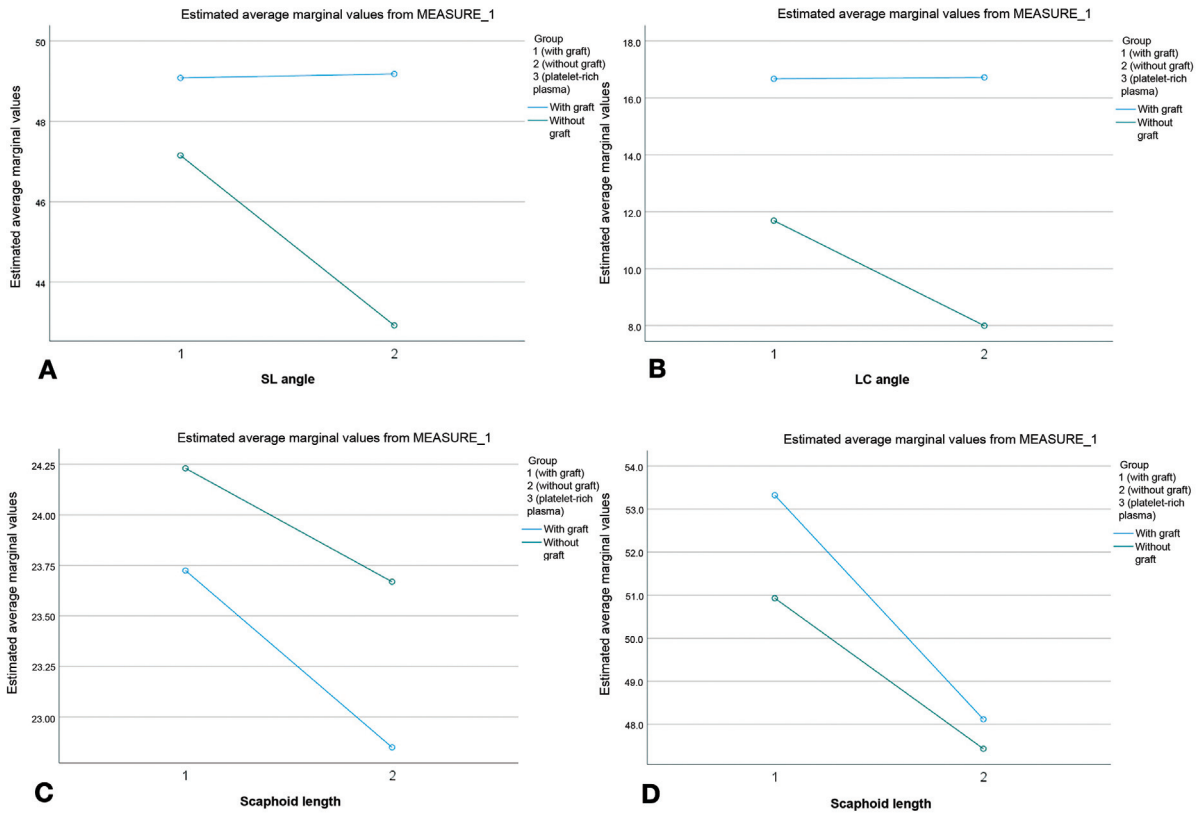
Table 2 Analysis of the radiological variables studied. Pre SL angle: preoperative scapholunate angle; post SL angle: postoperative scapholunate angle; pre/post SL angle: preoperative/postoperative scapholunate angle; pre SL distance: preoperative scapholunate distance; post SL distance: postoperative scapholunate distance; pre/post SL distance: preoperative/postoperative scapholunate distance; pre CL angle: preoperative capitolunate angle; post CL angle: postoperative capitolunate angle; pre/post CL angle: preoperative/postoperative capitolunate angle; pre RL angle: preoperative radiolunate angle; post RL angle: postoperative radiolunate angle; pre/post RL angle: preoperative/postoperative radiolunate angle; pre length: preoperative scaphoid length in the coronal plane; post length: postoperative scaphoid length in the coronal plane; pre/post length: preoperative/postoperative scaphoid length in the coronal plane; Pre IS angle: preoperative lateral intrascaphoid angle; post IS angle: postoperative lateral intrascaphoid angle; pre/post IS angle: preoperative/postoperative lateral intrascaphoid angle.

	With graft	Without graft	p-value between groups
N	11	13	
Pre SL angle	50.00	45.00	
Post SL angle	50	42.000	
p-value, pre/post SL angle	0.683	0.003	0.012
Pre SL distance	1.9000	2.0000	
Post SL distance	1.6000	1.9000	
p-value, pre/post SL distance	0.009	0.012	0.076
Pre CL angle	16.000	12.000	
Post CL angle	17.000	8.000	
p-value, pre/post CL angle	0.232	0.001	0.004
Pre RL angle	5.400	6.000	
Post RL angle	5.120	4.000	
p-value, pre/post RL angle	0.033	0.006	0.216
Pre length	24.000	24.500	
Post length	23.500	23.500	
p-value, pre/post length	0.074	0.003	0.592
Pre IS angle	52.600	48.800	
Post IS angle	46.600	46.800	
p-value, pre/post IS angle	0.003	0.001	0.307
Consolidation time (weeks)	12.00	10.00	0.002
Complete consolidation	100.00	100.00	

literature and not determining exactly when a scaphoid injury is a delayed consolidation or nonunion, we decided to deem all our patients, whose evolution time was lower than or equal to 23 weeks (6 months), as delayed consolidation.

For the treatment of scaphoid nonunion or delayed consolidation, some authors have suggested that stable cases only require rigid fixation with no biological support. Slade proposed a classification for nonunion with different grades based on defect sizes, alignments, and associated features complicating healing, such as ligamentous lesions and proximal pole avascular necrosis. The indication for minimally invasive osteosynthesis with no graft includes cystic resorption < 5 mm, minimal sclerosis, intact external cartilage coverage, and no scaphoid collapse or deformity (Slade grade IV or lower).[1,12] Some authors expand the indication to Slade grade V (cystic resorption ranging from 5 to 10 mm).[13] Crowe established the following criteria for isolated fixation with no graft in scaphoid nonunion: evolution time < 1 year, displacement < 1 mm, no hump or collapse deformity, stable nonunion (no mobility at fluoroscopy, lateral intrascaphoid angle $< 35°$), no signs of avascular necrosis, resorption and/or sclerosis < 1 mm, no comorbidities such as diabetes or smoking, and no degenerative changes (SNAC wrist).[14]

Several studies obtained optimal outcomes for patients undergoing percutaneous osteosynthesis without graft contribution in pseudoarthrosis and stable delayed scaphoid consolidation with minimal bone resorption. Most of these studies were retrospective and analyzed a limited number of patients to allow populational extrapolation. Vanhees et al. used a transtrapezial retrograde approach in 16 patients, achieving a 94% consolidation rate in 16 weeks.[15] Taleb et al. studied 38 patients with Alnot type IIA nonunion (minimal resorption and no displacement) and IIB (unstable pseudoarthrosis with scaphoid flexion and DISI). These authors recommended percutaneous osteosynthesis in type IIA and arthroscopy and graft placement for type IIB injuries.[8] Tada



Graph 1 Changes in radiological parameters from the preoperative to the postoperative period in the osteosynthesis group with graft (blue color) and osteosynthesis without graft (green color). 1A, Changes in the scapholunate (SL) angle. 1B, Changes in the lunocapitate (LC) angle. Note that some of these parameters favor the group without graft. 1C, Changes in the scaphoid length in the coronal plane. 1D, Changes in the intrascaphoid angle in the sagittal plane.

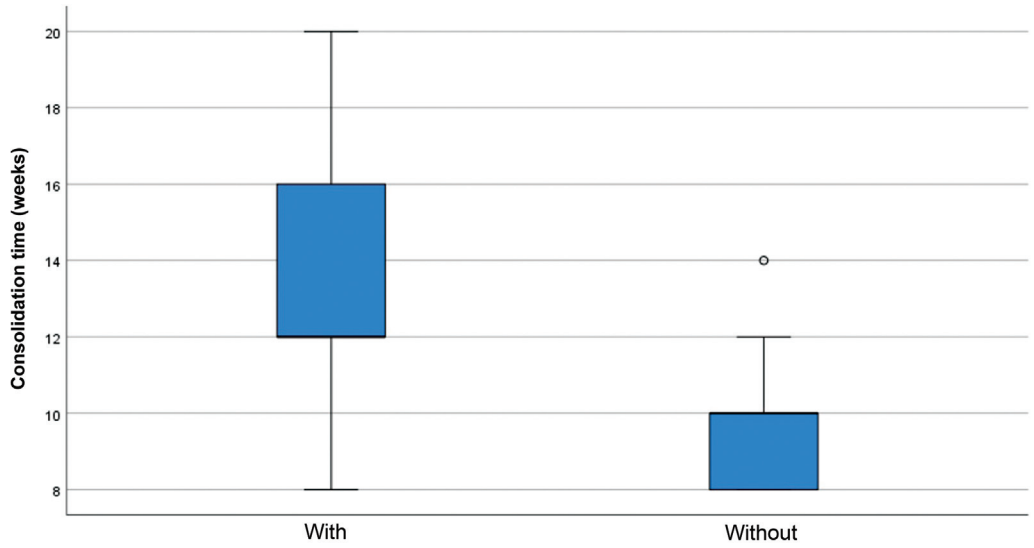


Diagram 1 Average consolidation time in weeks for both treatment groups. Differences favored the osteosynthesis group without graft (10 weeks vs. 12 weeks).

et al. divide nonunions into linear, cystic, and displaced types per evolution. They reported that percutaneous osteosynthesis can be successful in the first two types.[9] Hegazy et al. studied 21 patients with the above criteria (minimal cystic resorption, no DISI, no avascular necrosis of the proximal pole) and obtained 100% consolidation.[10]

Some surgical procedures have been proposed in association with percutaneous osteosynthesis to avoid the

Table 3 Analysis of the functional variables studied. VAS: Visual analog scale; DASH: Disability of Arm Shoulder and Hand; PRWE: Patient-Rated Wrist Evaluation;.

		With graft	Without graft	p-value between groups
N		11	13	
VAS	3 months	7.00	5.00	0.002
	6 months	6.00	3.00	0.000
	1 year	2.00	1.00	0.001
DASH	6 months	20.00	26.00	0.092
	1 year	24.00	9.00	0.000
PRWE	3 months	32.00	32.00	0.600
	6 months	19.000	23.000	0.449
	1 year	10.000	6.000	0.011
Flexion	6 months	45.00	65.00	0.010
Extension	6 months	46.00	70.00	0.009
Radial deviation	6 months	15.00	12.00	0.038
Ulnar deviation	6 months	15.00	25.00	0.047
Follow-up time (months)		13.00	26.00	0.003
Kinesiotherapy sessions		10.00	40.00	0.000
Return to work		8.00	8.00	0.537

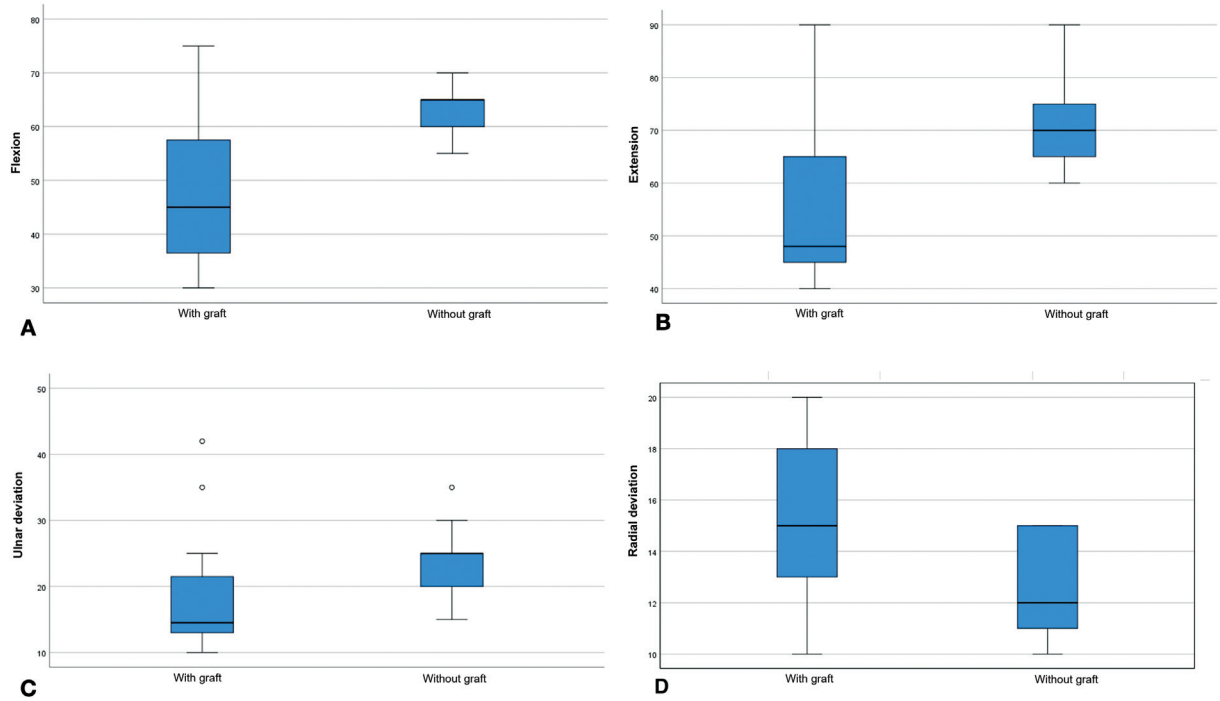


Diagram 2 Differences in some functional parameters in the osteosynthesis groups with graft and without graft. 2A, Average flexion at 6 weeks. 2B, Average extension at 6 weeks. 2C, Ulnar deviation at 6 weeks. 2D, Radial deviation at 6 weeks. Differences favored the osteosynthesis group with graft in the radial deviation parameter at 6 weeks and the group without graft in the remaining parameters.

contribution of the cancellous graft to the nonunion focus. In a series of 29 patients, Dedeoglu et al. combined percutaneous osteosynthesis with bone decompression in the distal radius, achieving 90% consolidation in 11 weeks. However, the lack of comparison with a control group makes it difficult to measure the effectiveness of the consolidation process of bone decompression.[5] Slade proposed a few techniques to increase stability and reduce the axial and shear load on the nonunion focus, including a second scaphoid screw, a scaphocapitate screw, or a provisional scapholunate screw.[12]

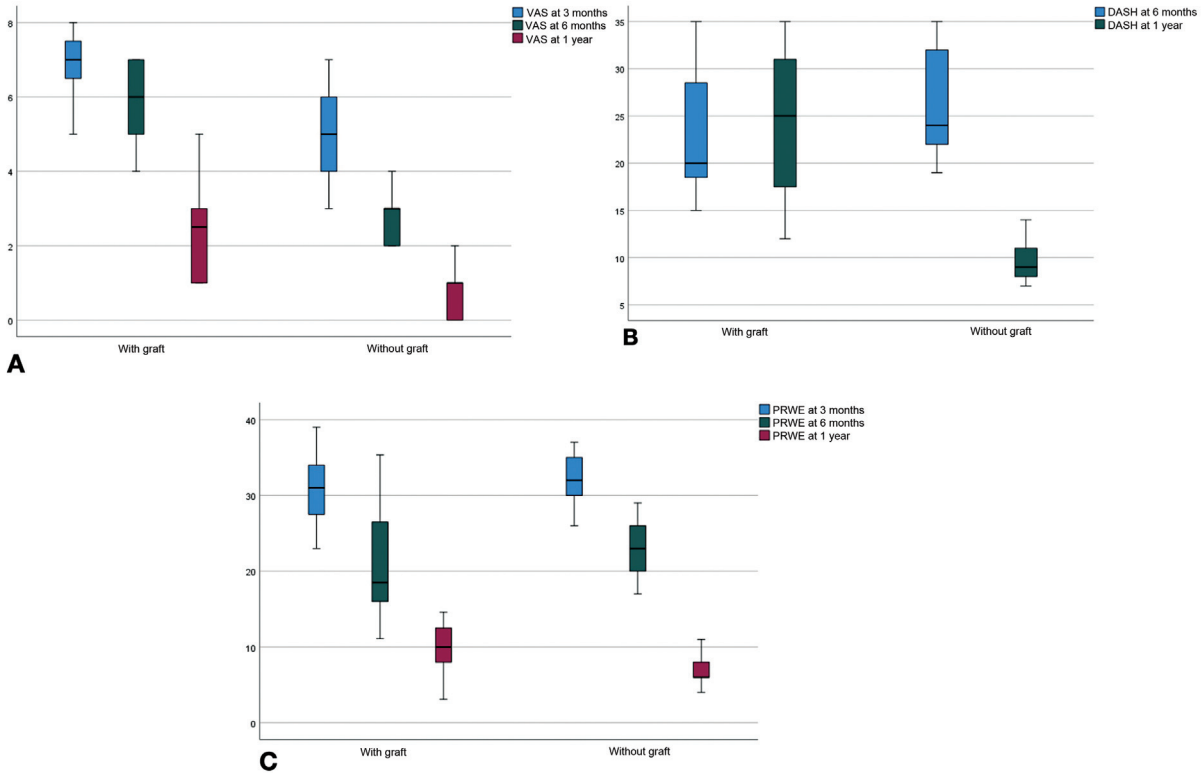


Diagram 3 Functional assessment scores in the osteosynthesis groups with graft and without graft. 3A, Average pain on the visual analog scale (VAS). Differences favored the group without graft at 3 weeks, 6 weeks, and 1 year. 3B, Quick Disability of Arm Shoulder and Hand (DASH) questionnaire. Significant differences favored the group without graft at 1 year. 3C, Patient-Rated Wrist Evaluation (PRWE) score. Differences favored the group without graft at 1 year.

Among the factors to consider when deciding the treatment method for delayed scaphoid consolidation, some authors highlight the time since the injury. Mahmoud et al. studied 27 patients and considered that the distance at the focus or resorption in mm is not as significant as a prognostic factor for consolidation as the time until surgery. These authors included cases with a resorption distance of 7 mm with good outcomes.[13] Slade et al. considered that the consolidation time is shorter in cases treated within 6 months from the injury.[16,17] A systematic study with six case series concluded that the main determining factor in healing time is the delay between the injury and the intervention and that there are no clear data on the effect of fracture location on functional and radiological outcomes.[18] Our study included six patients with delayed consolidation of the scaphoid proximal pole of the scaphoid with good outcomes.

Few studies compared clinical and radiological outcomes of nonunion treated with and without graft using arthroscopy or not. Gvozdenovic et al. studied 16 patients comparing treatment with arthroscopic graft versus percutaneous procedure without graft, obtaining favorable consolidation times in the graft group.[19] Liu et al. used arthroscopy in a study of 25 patients to evaluate the stability of the pseudoarthrosis and the need to associate or not a cancellous graft. They concluded that stable nonunions had good outcomes without a graft.[20]

The results obtained in our study demonstrated that the consolidation time and the correction of some radiological parameters and most of the functional parameters are superior for the percutaneous osteosynthesis group without graft compared with the open reduction and internal fixation group with graft for delayed stable scaphoid consolidation with less 6 months of evolution. The percutaneous technique has advantages, including not compromising scaphoid stability or vascularization, avoiding carpal ligament injuries, leaving a more aesthetic scar, causing lower morbidity as it does not require another surgical approach for graft harvesting, and accelerating functional recovery.[11]

The study had some limitations: first, it was a retrospective study, which hindered data collection from some patients. Secondly, the patient sample was small, and the average age was 26 to 35, limiting external validity and the power to extrapolate the results to all population groups. Thirdly, the good functional and recovery outcomes in the percutaneous osteosynthesis group without graft could be due to the considerably less soft tissue damage attributable to minimally invasive surgery and the presence of cases with lower Alnot classification grades (this group had no Alnot type IV case). A comparison with a group undergoing an arthroscopy-assisted graft placement would be relevant.

Conclusion

For the surgical treatment of delayed scaphoid fracture consolidation with no instability criteria, percutaneous

Fig. 3 Postoperative radiographs and computed tomography scans at 10 weeks of the previously mentioned case of delayed scaphoid consolidation in a 32-year-old patient who underwent percutaneous osteosynthesis without graft contribution. Note the bone consolidation bridges in all images and the correct scaphoid alignment. 3A, Anteroposterior radiography. 3B, Strict lateral radiography. 3C, Coronal computed tomography scan. 4C, Sagittal computed tomography scan. 5C, Axial computed tomography scan.

osteosynthesis without bone graft could be a superior treatment to open reduction and internal fixation with cancellous autograft regarding radiological consolidation time and functional recovery. Prospective studies with a higher patient number and follow-up time are required to draw conclusions for populational extrapolation.

Conflict of Interest
None.

Bibliography

1 Capo JT, Orillaza NS Jr, Slade JF III. Percutaneous management of scaphoid nonunions. Tech Hand Up Extrem Surg 2009;13(01): 23–29
2 Bilic R, Simic P, Jelic M, et al. Osteogenic protein-1 (BMP-7) accelerates healing of scaphoid non-union with proximal pole sclerosis. Int Orthop 2006;30(02):128–134
3 De Vitis R, Passiatore M, Perna A, Fioravanti Cinci G, Taccardo G. Comparison of Shape Memory Staple and Gelled Platelet-Rich Plasma versus Shape Memory Staple alone for the Treatment of Waist Scaphoid Nonunion: A Single-Center Experience. Joints 2020;7(03):84–90
4 Dedeoğlu SS, İmren Y, Çabuk H, Tekin AC, Türe YC, Gürbüz H. Results of percutaneous fixation and distal radius core decompression in scaphoid waist non-unions treated without grafting. Hand Surg Rehabil 2018;37(01):43–47
5 Cifras JL, Azócar C, Sanhueza M, Cavalla P, Liendo R. Manejo Artroscópico de Pseudoartrosis de Escafoides con Deformidad en Joroba: Técnica Quirúrgica y Serie de Casos. Rev Chil Ortop Traumatol 2019;60:47–57
6 Pinder RM, Brkljac M, Rix L, Muir L, Brewster M. Treatment of Scaphoid Nonunion: A Systematic Review of the Existing Evidence. J Hand Surg Am 2015;40(09):1797–1805.e3
7 Kim JK, Yoon JO, Baek H. Corticocancellous bone graft vs cancellous bone graft for the management of unstable scaphoid nonunion. Orthop Traumatol Surg Res 2018;104(01):115–120
8 Taleb C, Bodin F, Collon S, Gay A, Facca S, Liverneaux P. Retrograde percutaneous screw fixation for scaphoid type II non-union in Schernberg zones 2 to 4: a series of 38 cases. Chir Main 2015;34 (01):32–38
9 Tada K, Ikeda K, Nakada M, Matsuta M, Murai A, Tsuchiya H. Screw fixation without bone grafting for scaphoid fracture nonunion. J Clin Orthop Trauma 2020;13:19–23
10 Hegazy G. Percutaneous Screw Fixation of Scaphoid Waist Fracture Non-Union Without Bone Grafting. J Hand Microsurg 2015;7 (02):250–255
11 Belloti JC, Vasconcelos KBL, Raduan Neto J, Okamura A, Fernandes M, de Moraes VY. Percutaneous Fixation without Bone Graft for Scaphoid Nonunion. Rev Bras Ortop 2020;55(06):759–763
12 Slade JF III, Dodds SD. Minimally invasive management of scaphoid nonunions. Clin Orthop Relat Res 2006;445(445):108–119

13 Mahmoud M, Koptan W. Percutaneous screw fixation without bone grafting for established scaphoid nonunion with substantial bone loss. J Bone Joint Surg Br 2011;93(07):932–936
14 Ernst SMC, Green DP, Saucedo JM. Screw Fixation Alone for Scaphoid Fracture Nonunion. J Hand Surg Am 2018;43(09):837–843
15 Vanhees M, van Riet RRP, van Haver A, Kebrle R, Meermans G, Verstreken F. Percutaneous, Transtrapezial Fixation without Bone Graft Leads to Consolidation in Selected Cases of Delayed Union of the Scaphoid Waist. J Wrist Surg 2017;6(03):183–187
16 Capo JT, Shamian B, Rizzo M. Percutaneous screw fixation without bone grafting of scaphoid non-union. Isr Med Assoc J 2012;14 (12):729–732
17 Slade JF III, Geissler WB, Gutow AP, Merrell GA. Percutaneous internal fixation of selected scaphoid nonunions with an arthroscopically assisted dorsal approach. J Bone Joint Surg Am 2003; 85-A(Suppl 4):20–32
18 Elgayar L, Elmajee M, Aljawadi A, Abdelaal A, Khan S, Pillai A. A systematic review of mechanical stabilization by screw fixation without bone grafting in the management of stable scaphoid nonunion. J Clin Orthop Trauma 2021;17:112–117
19 Gvozdenovic R, Joergensen RW, Joerring S, Jensen CH. Arthroscopically Assisted Bone Grafting Reduces Union Time of Scaphoid Nonunions Compared to Percutaneous Screw Fixation Alone. J Wrist Surg 2020;9(01):13–18
20 Liu B, Wu F, Ng CY. Wrist arthroscopy for the treatment of scaphoid delayed or nonunions and judging the need for bone grafting. J Hand Surg Eur Vol 2019;44(06):594–599

