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How does the degree of wrist osteoarthritis affect the outcomes of surgical treatment of scaphoid nonunion?

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Objective. To evaluate the effectiveness of surgical treatment of scaphoid nonunion using screw fixation with bone grafting in patients with different stages of wrist osteoarthritis. **Methods.** This single-center study included 81 adult patients with nonunion located in the middle third of the scaphoid. All patients underwent surgical treatment consisting of nonunion resection via a volar approach, iliac crest bone grafting, and fixation with a specialized compression screw. Exclusion criteria were nonunion of the proximal or distal third of the scaphoid, signs of avascular necrosis of bone fragments, and bilateral wrist involvement. Patients were divided into four subgroups: without osteoarthritis and with stage I, II, and III osteoarthritis according to the SNAC classification (SNAC 0, I, II, III), comprising 34, 21, 19, and 7 patients, respectively. Outcomes were assessed at 1 year or longer postoperatively, including union rate, cylindrical grip strength (as a percentage of the contralateral side), DASH score, and wrist flexion–extension range of motion. **Results.** Bone union was achieved in 88 % of cases overall. The rate of nonunion increased significantly with advancing osteoarthritis stage: 3, 10, 21 and 42 % for SNAC 0, I, II, and III, respectively ($p = 0.0021$). Most postoperative functional outcomes (range of motion, grip strength, and qDASH scores) demonstrated clinical and subjective improvement in patients with achieved union; however, the magnitude of improvement decreased with increasing osteoarthritis severity, particularly in SNAC III. Among patients who achieved scaphoid union, no statistically significant differences were found in the improvement of strength, range of motion, or disability scores depending on the stage of wrist osteoarthritis.

Мета. Визначити ефективність хірургічного лікування несправжнього суглоба човноподібної кістки шляхом її остеосинтезу гвинтом із кістковою пластикою на фоні деформівного артрозу кистьового суглоба різної стадії. **Методи.** Здійснено одноцентрове дослідження, відібрано 81 дорослого пацієнта з псевдоартрозом на рівні середньої третини човноподібної кістки. Усі прооперовані методикою резекції несправжнього суглоба човноподібної кістки з долонного доступу з кістковою пластикою з крила клубової кістки та остеосинтезом спеціалізованим компресійним гвинтом. Результати аналізували в 4-х підгрупах: перша — без деформівного артрозу та ще три — з деформівним артрозом першої, другої та третьої стадій (SNAC 0, I, II, III) — 34/21/19/7 пацієнтів відповідно. Ефективність лікування оцінювалась через рік і більше за частотою зрощення несправжнього суглоба, силою циліндричного захвату у відсотках від здорової сторони, балів qDASH та амплітудою згинання/розгинання в зап'ястку. Результати. Зрощення кістки у 88 % випадків за умов зростання стадії артрозу, відповідно SNAC 0, I, II, III, частота незрощення після хірургічного лікування склала 3, 10, 21, 42 % відповідно, і тенденція до збільшення частки незрощення достовірна ($p = 0,0021$). Більшість кінцевих післяопераційних амплітудно-силових та qDASH показників у пацієнтів із консолидацією псевдоартрозу човноподібної кістки були з клініко-суб'єктивним покращенням, проте його кількісні значення зменшувались згідно зі зміною стадії артрозу, особливо це стосувалося SNAC III. У пацієнтів, яким проведено втручання і досягнуто зрощення човноподібної кістки, приріст силових та амплітудних показників та динаміка змін неіездатності не відрізняється достовірно залежно від стадії артрозу зап'ястка. **Ключові слова.** Кистьовий суглоб, деформівний артроз, псевдоартроз, човноподібна кістка, незрощення, контрактури

Keywords. Wrist joint, deforming osteoarthritis, nonunion, scaphoid, nonunion rate, contractures

Introduction

The basic technique for treating scaphoid nonunion is resection of the pseudarthrosis zone, correction of its shape and length, followed by bone grafting and osteosynthesis with a compression screw [1]. In the treatment of such nonunions without degenerative changes in the joint, relatively high union rates (up to 88–90%) can be achieved [2]. In degenerative arthritis (DA) of the wrist joint, traditionally classified for this pathology as stages I, II, and III of wrist collapse or by the abbreviation SNAC — 0, I, II, III (Scaphoid Nonunion Advanced Collapse), respectively [3], the effectiveness of surgical treatment is known to decrease depending on the stage. The authors note that the patient series presented in studies, especially those involving stages II and III DA, are relatively small, and the results are inconsistent [4, 5]. Therefore, the effectiveness of this surgical approach for the treatment of scaphoid nonunion associated with DA of the wrist joint caused by the nonunion itself requires further scientific analysis and clarification.

Purpose: to determine the effectiveness of surgical treatment of scaphoid nonunion by screw osteosynthesis with bone grafting in the presence of wrist joint DA of different stages.

Materials and Methods

A single-center study was conducted. The analysis included 81 patients who were admitted to the Clinic of Reconstructive and Restorative Surgery of the Upper Extremity, SI “National Institute of Traumatology and Orthopedics of the NAMS of Ukraine” (Kyiv) with pseudarthrosis at the level of the middle third of the scaphoid.

Exclusion criteria included patients under 18 years of age; pseudarthrosis of the proximal or distal third of the bone; radiographic and MRI findings of evident aseptic necrosis of the bone fragments; involvement of both wrists; and previous procedures on the scaphoid.

The study was approved by the local Bioethics Committee (Protocol No. 2 dated 12.03.2026) of the respective institution in accordance with ICH GCP, the Declaration of Helsinki on Human Rights and Biomedicine, and current Ukrainian legislation. All enrolled patients were informed about the study plan and conditions and provided written informed consent.

All patients underwent surgical treatment using a palmar approach with resection of the scaphoid nonunion, separation of the pseudarthrosis zone, correction of the shape and length of the scaphoid, resection of the pseudarthrosis zone using a 7-mm outer-diameter cylindrical burr to reach cancellous bone

tissue, and replacement with an autologous structural cancellous bone graft harvested from the iliac crest using a second burr with a 7-mm inner diameter. Osteosynthesis was performed using a specialized compression screw (scheme). Thus, osteosynthesis was supplemented by a specific “press fit” fixation with the bone graft.

Treatment outcomes were assessed in four subgroups: without DA and with stage I, II, and III DA (SNAC 0, I, II, III) — 34/21/19/7 patients, respectively.

Treatment effectiveness was analyzed after one year or more based on the rate of scaphoid union (CT findings), cylindrical grip strength (hand dynamometer) expressed as a percentage of the healthy side, qDASH scores, and wrist flexion/extension range of motion (measured with an orthopedic goniometer).

Nonparametric statistical methods were used in the study (Kruskal–Wallis test, Mann–Whitney U test), as well as logistic regression with calculation of odds ratios (OR, 95% CI), and descriptive statistics (median, range, IQR).

The distribution of patients according to the degree of arthritis and their demographic characteristics is presented in Table 1. Parameters such as the mechanism of injury, time since injury, and side of involvement were not included in the analysis.

Baseline patient data before surgical treatment, including wrist extension, wrist flexion/extension range of motion, cylindrical grip strength, and qDASH values by patient groups according to the degree of arthritis, are presented in Table 2.

Results

Union of the scaphoid nonunion was achieved in 71 (88 %) patients, generally within 8–12 weeks. Age, sex, baseline range-of-motion and strength characteristics, and the degree of upper extremity disability according to qDASH did not have a statistically significant effect on union rates.

However, union rates for all stages of arthritis were 3 %, 10 %, 21 %, and 42 %, respectively, and the trend toward an increased proportion of nonunion in patients with more severe arthritis was statistically significant ($p = 0.0021$). According to the logistic model, a one-stage increase in SNAC was associated with a 2.83-fold increase in the odds of nonunion (OR 2.83; 95 % CI 1.36–5.92; $p = 0.0055$).

The presence of persistent nonunion significantly and adversely affected the outcomes of surgical treatment. Table 3 presents the baseline and final parameters in patients with scaphoid union and nonunion one year or more after surgery.

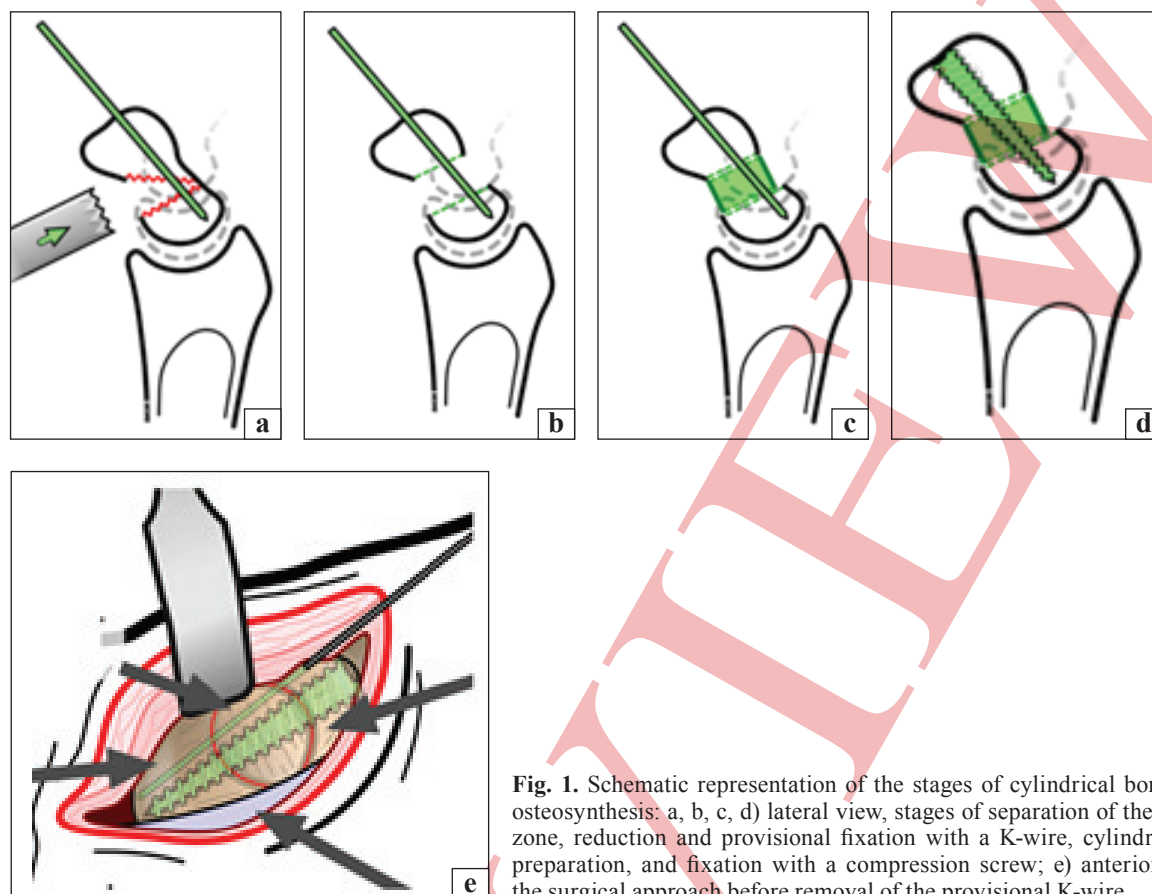


Fig. 1. Schematic representation of the stages of cylindrical bone grafting and osteosynthesis: a, b, c, d) lateral view, stages of separation of the pseudarthrosis zone, reduction and provisional fixation with a K-wire, cylindrical bone graft preparation, and fixation with a compression screw; e) anterior view through the surgical approach before removal of the provisional K-wire

Table 1

Quantitative distribution of patients according to arthritis stage, sex, and age*

Arthritis stage	Number, n	Men, n (%)	Women, n (%)	Age, years, median (range), IQR
SNAC 0	33	30 (90.9 %)	3 (9.9 %)	29 (19–45) 13
SNAC I	21	19 (90.9 %)	2 (9.1 %)	32 (20–61) 17
SNAC II	19	17 (90.5 %)	2 (9.5 %)	32 (19–62) 21
SNAC III	8	17 (89.5 %)	2 (10.5 %)	35 (22–68) 21
Total	8	73 (90.1 %)	1 (12.5 %)	32 (19–64) 16

Note. * — There were significantly more men than women; however, the distribution across the groups was uniform. The overall difference in age among the four groups was not statistically significant: Kruskal–Wallis $p=0.742$ (i.e., age did not differ between groups).

Table 2

Baseline hand function parameters before surgery

Parameter	Медіана (діапазон) IQR				
	SNAC 0	SNAC I	SNAC II	SNAC III	overall
Strength, as a percentage of the healthy side	35.7 (9.1–80.0) 23.2	25.7 (7.7–72.4) 23.5	20.0 (8.0–51.9) 18.8	15.4 (6.8–40.0) 8.7	29.2 (6.8–80.0) 24.6
Extension, degrees	30 (0–50) 30	30 (0–45) 25	20 (0–45) 30	15 (0–50) 20	30 (0–50) 30
Flexion/extension range of motion, degrees	130 (70–160) 40	120 (60–150) 35	120 (70–140) 40	110 (60–130) 35	120 (60–160) 40
qDASH, points	13.6 (4.5–63.6) 25.0	22.7 (6.8–61.4) 22.7	25.0 (4.5–63.6) 29.5	15.9 (6.8–45.5) 18.2	18.2 (4.5–63.6) 22.7

Thus, in both groups of patients (with union and without union), the baseline parameters did not differ significantly. However, the absence of pseudarthrosis consolidation significantly reduced wrist range of motion and grip strength, often resulting in a negative progression of upper extremity disability, which substantially affected treatment outcomes in these patients compared with those in whom bone union was achieved.

Nevertheless, even in cases of scaphoid union, the effectiveness of osteosynthesis with bone grafting differed considerably between groups with different stages of DA of the wrist joint (Table 4).

Therefore, the presence of DA of the wrist joint significantly worsens the results of surgical treatment, both in terms of union rates and range-of-motion and

strength parameters, including subjective assessment of upper extremity disability according to the qDASH questionnaire.

It is noteworthy that the effectiveness of surgical treatment, expressed as changes in these parameters between preoperative and postoperative values, did not differ significantly between patients with different stages of DA and those without arthritis.

Regarding the reduced range-of-motion characteristics of the joint in patients with DA, this should be considered a consequence of secondary changes in the scaphoid, manifested as a “humpback” deformity.

This is also associated with the formation of dorsal marginal osteophytes of both the scaphoid and the dorsoradial edge of the corresponding articular facet of the radius (Fig. 2).

Table 3

Results of surgical treatment in patients with scaphoid nonunion according to final nonunion/union status

Parameter	Nonunion (n = 10)	Union/other (n = 71)	p (MWU)
Age, years, median (range), IQR	26 (20–41) 16	32 (19–64) 15	0,498
Grip strength, as a percentage of the healthy hand: – before surgery; – after surgery	23 (10–50) 17 11 (4–22) 6	30 (7–80) 26 46.2 (8.8–86.7) 26	0.741 < 0.001
Flexion/extension range of motion, degrees: – before surgery; – after surgery	120 (70–160) 40 95 (70–140) 30	120 (60–160) 40 150 (70–180) 40	0.846 < 0.001
qDASH, points: – before surgery; – after surgery	22.7 (6.8–59.1) 29.5 22.7 (6.8–63.9) 13.6	18.2 (4.5–63.6) 22.7 2.3 (0.0–29.5) 6.8	0.721 < 0.001

Table 4

Range-of-motion, strength, and qDASH outcomes in patients with different stages of wrist joint arthritis and scaphoid nonunion consolidation after surgical treatment

Parameter	SNAC 0	SNAC I	SNAC II	SNAC III
Grip strength: – after treatment, kg; – as a percentage of the healthy hand	22.0 (5.0–40.0) 7.0* 52.7 (12.8–86.7) 20.7*	13.0 (3.0–28.0) 10.0 33.3 (8.8–72.4) 24.0*	13.0 (2.0–28.0) 10.0 27.1 (4.2–63.0) 31.5*	11.0 (2.0–24.0) 8.5* 24.0 (3.8–56.7) 25.0*
Change in grip strength, kg	11.8 (–7.7–68.2) 24.8	6.7 (–31.3–31.2) 18.2	10.8 (–36.4–43.5) 19.0	12.5 (–11.5–47.7) 20.5
Extension after surgery, degrees	45 (0–60) 30*	40 (0–60) 25*	45 (0–60) 30	30 (0–60) 35*
Flexion/extension range of motion after surgery, degrees	150 (90–180) 40*	140 (70–170) 40*	140 (90–180) 40*	130 (70–180) 60
Change in range of motion, %	15.4 (–10.0–50.0) 18.2	12.5 (–11.1–33.3) 17.9	16.7 (–7.7–33.3) 17.9	14.3 (–7.1–33.3) 17.9
qDASH after treatment, points	2.3 (0.0–29.5) 6.8	6.8 (0.0–40.9) 9.1	9.1 (0.0–34.1) 11.4	9.1 (0.0–22.7) 11.4
Change in qDASH score, points	11.4 (–6.8–63.6) 18.2	13.6 (–4.5–61.4) 18.2	13.6 (–4.5–63.6) 22.7	6.8 (–6.8–45.5) 15.9

Note. * — Statistically significant differences ($p < 0.05$) were observed between the following parameter pairs: postoperative grip strength in kilograms for SNAC 0 was higher than that for SNAC III. Postoperative grip strength expressed as a percentage of the healthy side for SNAC 0 was higher than that for SNAC I, II, and III. Wrist extension in degrees for SNAC 0 was greater than that for SNAC I and III. Postoperative flexion/extension range of motion for SNAC 0 was greater than that for SNAC I and II. According to treatment outcomes, upper extremity disability assessed by qDASH was significantly lower for SNAC 0 compared with SNAC I, II, and III.

This conflict most likely prevents complete extension of the joint. Therefore, even bone union may not result in optimal clinical improvement, particularly regarding wrist extension range of motion (Fig. 3).

Considering the palmar approach used for osteosynthesis, performing dorsal cheilectomy through the same approach at the stage of osteosynthesis is technically impossible, while expanding the procedure to include two surgical approaches may affect blood supply to the bone fragments and is therefore highly undesirable.

In addition to bone deformity and marginal osteophyte formation, contracture may also be caused by degenerative-dystrophic changes in the synovial membrane and joint capsule, which is confirmed by quantitative morphological studies [8]. This represents an integral morphological component of DA, including that of the wrist joint [8]. This should be taken into account when performing repeated mobilizing procedures in cases of significant contractures following osteosynthesis procedures.

Discussion

The primary and fundamental outcome of surgical treatment remains achieving union of the scaphoid.

Failure to achieve union has a fundamentally negative impact on the results of osteosynthesis.

The data obtained in our patient cohort regarding the significant negative effect of DA stage on the rate of scaphoid nonunion consolidation quantitatively supplement and confirm previously published assumptions [1, 2].

In addition, the information reported by authoritative researchers regarding lower functional outcomes of osteosynthesis with bone grafting in the presence of wrist arthritis generally corresponds with the findings obtained in our patient series [3–5]. However, the number of cases involving patients with wrist DA, both in our study and in these previous studies, is relatively small; therefore, these studies complement and further refine each other's quantitative findings.

The data obtained in this study indicate that treatment effectiveness, namely the changes in strength and range-of-motion parameters and disability scores, does not differ significantly depending on the stage of wrist arthritis at which surgical treatment was performed and union was achieved. This requires further investigation, as no similar statements or contradictory findings were identified in the available

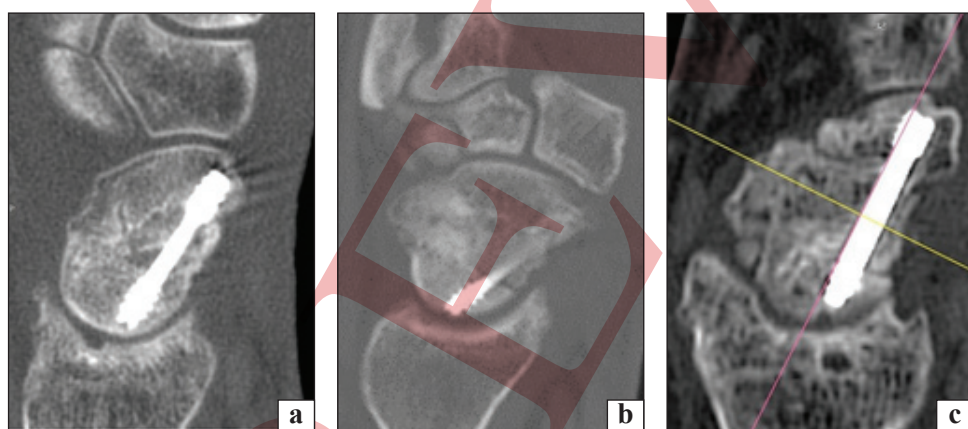


Fig. 2. Sagittal CT images through the consolidated scaphoid in patients with arthritis: a) SNAC I; b) SNAC II; c) SNAC III. Formation of dorsal osteophytes.

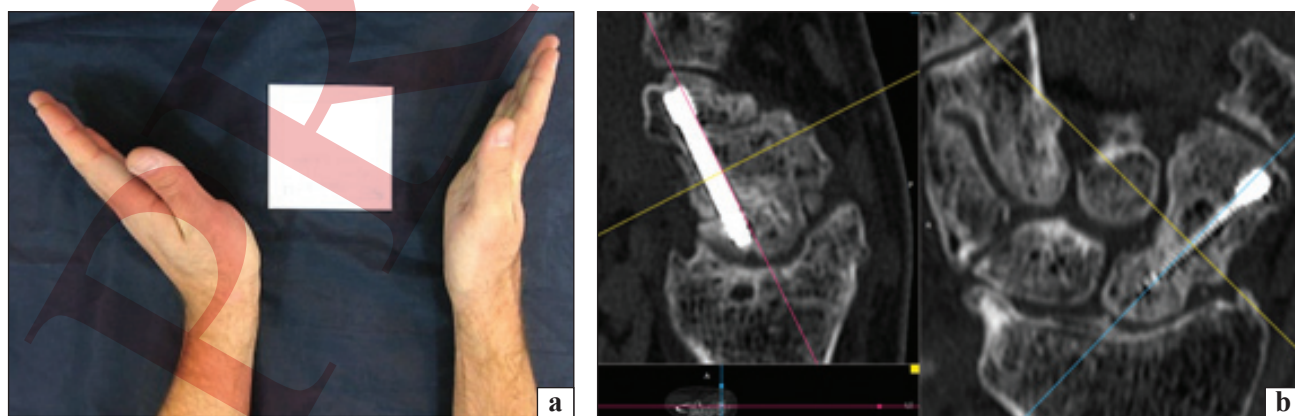


Fig. 3. Treatment outcomes in patient K., 33 years old: a) limited extension of the right wrist after consolidation of scaphoid nonunion in SNAC III; b) CT images.

literature. It is likely that, in cases of pseudarthrosis union, regardless of arthritis stage, a clinically meaningful improvement in joint functional parameters can be achieved. However, due to the low baseline parameters, even a positive change may not lead to an outcome considered acceptable by the patient. This is particularly relevant to wrist extension range of motion, which is often unsatisfactory for patients with SNAC II and III.

It should be noted separately that the 42 % non-union rate in SNAC III is unacceptable, and recommending osteosynthesis using the described technique for these patients is not appropriate.

In cases of contracture, mobilizing surgical procedures (both open and endoscopic), styloidectomy, joint capsular releases, and denervation procedures may be considered; these are generally advisable no earlier than one year after osteosynthesis. However, according to published data, the effectiveness of these procedures is relatively limited, with range of motion improving by only 10–15 % [6].

When planning surgical treatment for SNAC II and III, arthroplastic procedures that preserve motion, such as proximal row carpectomy or scaphoid excision, should be considered. This is especially relevant for patients with markedly reduced baseline range-of-motion parameters, as these resection arthroplasties are known to demonstrate high effectiveness despite acceptable rates of complications and revision procedures [7]. On the other hand, in cases of multiple previous unsuccessful procedures or high patient demands regarding hand strength in the setting of advanced joint damage, wrist arthrodesis should be considered as an alternative to reconstructive procedures [8].

Conclusions

Surgical treatment of scaphoid nonunion by resection of the pseudarthrosis zone, bone grafting from the iliac crest, and internal fixation with a specialized screw is a highly effective treatment method, achieving bone union in 88 % of cases; however, outcomes of this procedure in patients with different stages of DA of the wrist joint are heterogeneous.

With increasing arthritis stage, SNAC 0, I, II, and III, the nonunion rates after surgery were 3 %, 10 %, 21 %, and 42 %, respectively, with a statistically significant trend toward an increase ($p = 0.0021$).

According to the logistic model, a one-stage increase in SNAC was associated with an almost three-fold increase in the odds of nonunion (OR 2.83; 95 % CI 1.36–5.92; $p = 0.0055$).

Most final postoperative range-of-motion, strength, and qDASH outcomes in patients with scaphoid pseudarthrosis union demonstrated clinical and subjective improvement; however, the magnitude of improvement decreased with increasing arthritis stage, particularly in SNAC III.

In patients who underwent surgical treatment and achieved scaphoid union, the changes in both strength and range-of-motion parameters, as well as disability scores, did not differ significantly depending on the stage of wrist arthritis.

Study limitations: The dominant or non-dominant hand was not taken into account when assessing strength and qDASH parameters, which may have influenced the results. Range-of-motion and strength outcomes were calculated for all patients, including those who did not achieve union, which may have affected the accuracy of the analysis; however, this approach demonstrated the full range of obtained results.

Conflict of interest. The author declares no conflict of interest.

Prospects for further research. Comparison of outcomes from multiple hand surgery centers; separate analysis of treatment outcomes in union and nonunion groups; analysis of long-term outcomes in a group of patients undergoing wrist release for contractures. Further patient recruitment and data analysis to clarify the relationships between the studied factors.

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