ORIGINAL ARTICLE

# Long-term outcomes following scaphoid nonunion surgery: the role of structural severity, avascular necrosis, and surgical timing

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## ABSTRACT

**BACKGROUND:** This study aimed to evaluate the long-term clinical and radiological outcomes of patients undergoing surgical treatment for scaphoid nonunion and to examine the independent effects of surgical timing and preoperative avascular necrosis (AVN) on postoperative recovery.

**METHODS:** This retrospective cohort study included 71 adult patients who underwent surgical treatment for scaphoid nonunion between 2011 and 2020 and had a minimum follow-up of five years. Variables included demographic characteristics, surgical timing, preoperative AVN, and radiographic severity. Clinical outcomes were assessed using the Visual Analog Scale (VAS), Patient-Rated Wrist Evaluation (PRWE), and Mayo Wrist Score (MWS). Radiological evaluation included scaphoid nonunion advanced collapse (SNAC) staging, scapholunate angle (SLA), radiolunate angle (RLA), and carpal height index. Multivariate linear and logistic regression analyses were performed to identify independent predictors of functional improvement, union, complications, and reoperation.

**RESULTS:** The mean patient age was 34.4±7.1 years, and the mean follow-up duration was 78.4±10.3 months. Preoperative AVN was present in 29.6% of patients. Union was achieved in 76.1% of patients, while complication and reoperation rates were 26.8% and 18.3%, respectively. In univariate analysis, surgery performed within 12 months of injury was associated with greater improvement in resting pain ($p=0.046$), and the absence of AVN was associated with greater improvement in pain scores and MWS ($p<0.05$). After adjustment for baseline pain and radiographic severity, surgical timing was no longer independently associated with pain improvement ($p=0.056$), whereas AVN remained an independent predictor of reduced symptomatic recovery ($p<0.001$). No variable independently predicted union. The preoperative SNAC stage was associated with complications ($p=0.007$), and Schernberg classification predicted reoperation ($p=0.011$). Radiographic parameters were not associated with functional outcomes. These findings suggest that biological and structural disease burden may have a greater influence on long-term recovery than surgical timing alone. Although vascular compromise appears to limit symptomatic improvement despite surgical intervention, structural severity influences the risk of adverse postoperative events. The absence of a correlation between radiographic healing and functional outcomes underscores the complex and multifactorial nature of recovery after scaphoid nonunion surgery.

**CONCLUSION:** Surgical timing and radiographic union were not independently associated with long-term functional recovery. In contrast, preoperative AVN predicted less symptomatic improvement, whereas structural severity, reflected by SNAC stage and Schernberg classification, was associated with postoperative complications and reoperation.

**Keywords:** Avascular necrosis; nonunion; scaphoid; scaphoid nonunion advanced collapse (SNAC); union rate.

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## INTRODUCTION

Scaphoid nonunion is defined as the absence of radiographic or advanced imaging evidence of bone healing six months after injury.[1] It develops in approximately 2%–15% of scaphoid fractures, with higher rates observed in proximal pole injuries.[2-4] Established risk factors include avascular necrosis (AVN), fracture displacement or instability, fracture location, and delayed treatment.[5,6]

Scaphoid nonunion is associated with persistent pain, functional impairment, and progressive carpal collapse. If left untreated, it may progress to scaphoid nonunion advanced collapse (SNAC) and secondary wrist arthritis.[3] The primary goals of treatment are restoration of carpal alignment, achievement of union, and durable functional recovery.

Surgical management is influenced by fracture location, deformity, vascular status, and patient-related factors.[4,7] Various techniques have been described, including deformity correction, bone grafting, rigid internal fixation, and the use of vascularized and nonvascularized grafts.[8-10] Despite these approaches, there is no clear consensus regarding the optimal surgical strategy or the prognostic significance of factors such as AVN.[7,10,11]

Although short-term outcomes are generally favorable, long-term clinical and radiographic outcomes remain insufficiently characterized, particularly regarding the independent effects of surgical timing and preoperative vascular status.[7,10,11] Therefore, the present study aimed to evaluate long-term outcomes following surgical treatment of scaphoid nonunion and to examine the effects of surgical timing and preoperative AVN on postoperative recovery.

## MATERIALS AND METHODS

This retrospective single-center cohort study included consecutive adult patients who underwent primary surgical treatment for scaphoid nonunion between 2011 and 2020, with a minimum postoperative follow-up of five years. Ondokuz Mayıs University Clinical Research Ethics Committee (Date: 12.09.2024, Decision no: 2024/360).

All preoperative, intraoperative, and postoperative data were obtained from institutional medical records.

Inclusion criteria were age ≥18 years, radiographically confirmed scaphoid nonunion, and availability of at least five years of follow-up. Patients with previous failed scaphoid surgery, advanced carpal collapse requiring salvage procedures, complex wrist trauma, systemic inflammatory disease, or incomplete clinical data were excluded. A total of 102 patients were initially identified; after application of the inclusion and exclusion criteria, 71 patients were eligible for final analysis.

All patients were treated using a modified Matti–Russe technique through a volar approach. A longitudinal incision was made along the radial border of the flexor carpi radialis tendon, followed by capsulotomy to expose the nonunion site. After thorough debridement of fibrous tissue and sclerotic bone, a corticocancellous iliac crest bone graft was inserted to restore scaphoid length and alignment. Internal fixation was performed using a headless compression screw, and stability was confirmed intraoperatively under fluoroscopic guidance.

Postoperatively, patients were immobilized in an arm cast for 4 weeks, followed by splint immobilization from weeks 4 to 6. Progressive active range-of-motion exercises were initiated after week 6. Clinical and radiographic evaluations were performed at 2, 4, 8, and 12 weeks and at 6 months postoperatively. Radiographic follow-up continued until bone healing was confirmed. Final assessment was performed at the most recent available follow-up visit, with a minimum postoperative follow-up of 5 years.

Standard posteroanterior (PA), lateral, ulnar-deviated PA, and semipronated radiographs were obtained during follow-up. Nonunion location was categorized as proximal pole, waist, or distal pole. Degenerative changes were classified according to the scaphoid nonunion advanced collapse staging system. Scapholunate (SL) angle, radiolunate (RL) angle, and carpal height index were measured on standard radiographs. Bone union was assessed using at least two postoperative radiographic views.

All patients had established scaphoid nonunion preoperatively. At final follow-up, bone healing status was categorized as union or non-union. Union was defined as cortical bridging with trabecular continuity across the fracture site and disappearance of the fracture line on at least two radiographic views. Nonunion was defined as the absence of cortical bridging with persistence of the fracture line at final follow-up. Computed tomography (CT) was obtained only when standard radiographs were inconclusive or when clinical–radiographic discordance was suspected. Because CT was not routinely performed, it was not incorporated into the primary outcome assessment. Preoperative avascular necrosis was diagnosed using magnetic resonance imaging (MRI) and defined as low signal intensity on T1-weighted images within the scaphoid, as assessed by an experienced musculoskeletal radiologist.

Clinical outcomes were assessed using the Visual Analog Scale (VAS) for pain at rest and during activity, the Patient-Rated Wrist Evaluation (PRWE), and the Mayo Wrist Score (MWS). Active wrist range of motion (ROM), including radial and ulnar deviation, was measured using a standard goniometer. Grip strength was assessed using a hydraulic hand dynamometer (Model SH5001, Masan, Korea) and expressed as a percentage of the contralateral side. Changes (Δ) in clinical scores were calculated as the difference between preoperative and final follow-up values. Postoperative complications and reoperation rates were recorded. Persistent pain was defined as pain at final follow-up requiring medical treatment,

activity modification, or additional clinical evaluation.

### Statistical Analysis

Statistical analyses were performed using SPSS version 22. Continuous variables are presented as mean ± standard deviation, and categorical variables as frequency and percentage. Comparisons between groups (<12 vs. ≥12 months and AVN vs. non-AVN) were performed using the Mann–Whitney U test or the chi-square/Fisher's exact test. Multivariate linear regression analysis was used to identify predictors of improvement in resting pain (ΔVAS), adjusting for baseline pain and radiographic severity. Logistic regression analysis was performed to identify predictors of union, complications, and reoperation. Variables with clinical relevance or a univariate p value <0.10 were included in the analysis. A p value <0.05 was considered statistically significant.

## RESULTS

A total of 71 patients were included, with a mean age of 34.4±7.1 years and a mean follow-up duration of 78.4±10.3 months. Baseline demographic and surgical characteristics (Fig. 1), including the prevalence of preoperative AVN and overall rates of union, complications, and reoperation (76.1%, 26.8%, and 18.3%, respectively), are summarized in Table 1. No significant associations were identified between demographic variables and complication rates or clinical outcomes (p>0.05).

A total of 26 complications occurred in 19 patients. Persistent pain was the most common complication (n=13), followed by persistent nonunion (n=8) and postoperative AVN (n=3). Less frequent complications included iliac crest donor-site pain (n=3), donor-site infection (n=1), hematoma (n=1), and lateral femoral cutaneous nerve deficit (n=1). Reopera-

**Figure 1.** A 26-year-old woman who underwent surgical treatment for scaphoid nonunion using the modified Matti–Russe technique. Five-year postoperative radiographs demonstrate complete osseous union, with trabecular continuity across the fracture site and no evidence of graft resorption, sclerosis at the fracture margins, or implant-related complications.

**Table 1.** Demographic and baseline characteristics of the study population

| Characteristic | Value |
|---|---|
| Age, mean (SD) | 34.4±7.1 |
| Follow-up duration, mean (SD), months | 78.4±10.3 |
| Sex (male/female) | 61 (85.9%)/10 (14.1%) |
| Injured hand (dominant/non-dominant) | 56 (78.9%)/15 (21.1%) |
| Smoking status (current smoker/non-smoker) | 24 (33.8%)/47 (66.2%) |
| Occupation (manual labor/non-manual labor/not working) | 34 (47.9%)/30 (42.3%)/7 (9.3%) |
| Preoperative SNAC stage (no arthritis/stage 1/stage 2) | 29 (40.8%)/30 (42.3%)/12 (16.9%) |
| Schernberg classification (type 1/type 2/type 3) | 9 (12.7%)/36 (50.7%)/26 (36.6%) |
| Time from injury to surgery (months) | 11.2±4.3 |
| Time to surgery (<12months/≥12 months) | 42 (59.2%)/29 (40.8%) |
| Preoperative AVN (present/absent) | 21 (29.6%)/50 (70.4%) |
| Union status at final follow-up (union/nonunion) | 54 (76.1%)/17 (23.9%) |
| Postoperative SNAC stage (no arthritis/stage 1/stage 2) | 20 (28.1%)/32 (45.1%)/19 (26.8%) |
| Postoperative complications (present/absent) | 19 (26.8%)/52 (73.2%) |
| Reoperation (yes/no) | 13 (18.3%)/58 (81.7%) |

SNAC: Scaphoid nonunion advanced collapse; AVN: Avascular necrosis.

**Table 2.** Univariate analysis of factors associated with postoperative complications

| Variable | Complication (n=19) | No complication (n=52) | p |
|---|---|---|---|
| Occupation (manual labor/non-manual labor/not working, %) | 52.6%/42.1%/5.3% | 46.2%/42.3%/11.5% | 0.710 |
| Injured hand (dominant/non-dominant, %) | 78.9%/21.1% | 78.8%/21.2% | 0.192 |
| Schernberg classification (type 1/type 2/type 3, %) | 10.5%/31.6%/57.9% | 13.5%/57.7%/28.8% | 0.039 |
| Preoperative SNAC stage (no arthritis/stage 1/stage 2, %) | 21.1%/42.1%/36.8% | 48.1%/42.3%/9.6% | 0.014 |
| Time to surgery (<12 months/≥12 months, %) | 47.4%/52.6% | 63.5%/36.5% | 0.222 |
| Preoperative AVN (present/absent, %) | 42.1%/57.9% | 25.0%/75.0% | 0.162 |

SNAC: Scaphoid nonunion advanced collapse; AVN: Avascular necrosis.

tion was required in 13 patients, most commonly revision surgery with bone grafting (n=8).

### Univariate Analysis

Proximal nonunion localization and preoperative SNAC stage 2 were associated with higher complication rates (p=0.039 and p=0.014, respectively) (Table 2). Surgical treatment within 12 months of injury was associated with a greater reduction in resting pain (ΔVAS −6.6±1.1 vs. −5.7±1.3; p=0.046) (Table 3), whereas no significant differences were observed in other clinical or event-related outcomes.

Patients without preoperative AVN demonstrated greater improvements in resting pain, activity-related pain, MWS, and grip strength (p<0.05) (Table 4). Union status was not associated with long-term clinical or radiographic outcomes (Table 5).

### Multivariate Analysis

In multivariate linear regression adjusted for baseline resting pain and radiographic severity, surgical timing was not independently associated with improvement in resting pain (β=−0.372, 95% confidence interval [CI]: −0.754 to 0.010; p=0.056). In contrast, preoperative AVN independently predicted reduced pain improvement (β=0.731, 95% CI: 0.336 to 1.126; p<0.001). Baseline resting pain was independently associated with greater postoperative pain reduction (β=−0.767, 95% CI: −1.019 to −0.516; p<0.001). The preoperative SNAC stage was not independently associated with pain improvement.

In logistic regression analysis, no independent predictors of radiographic union were identified. Surgical timing (odds ratio [OR]: 1.16, 95% CI: 0.36–3.68; p=0.805), preoperative AVN

**Table 3.** Clinical outcomes according to surgical timing

| Outcome | <12 months (n=42) | ≥12 months (n=29) | p |
|---|---|---|---|
| Δ Resting VAS | −6.6±1.1 | −5.7±1.3 | 0.046 |
| Δ Activity VAS | −5.0±0.7 | −4.7±1.2 | 0.178 |
| Δ PRWE | −32.2±20.9 | −25.6±16.2 | 0.282 |
| Δ MWS | +13.8±7.5 | +11.2±8.4 | 0.121 |
| Δ ROM (°) | +25.8±12.3 | +22.7±9.6 | 0.490 |
| Δ Grip strength (%) | +28.8±3.1 | +26.4±3.5 | 0.702 |
| Union status at final follow-up | 78.6%/21.4% | 72.4%/27.6% | 0.582 |
| Complications | 9 (21.4%) | 10 (34.5%) | 0.222 |
| Reoperation | 5 (11.9%) | 7 (24.1%) | 0.154 |

VAS: Visual Analog Scale; PRWE: Patient-rated wrist evaluation; MWS: Mayo wrist score; ROM: Range of motion.

**Table 4.** Clinical outcomes according to preoperative avascular necrosis status

| Outcome | No AVN (n=50) | AVN (n=21) | p |
|---|---|---|---|
| Δ Resting VAS | −5.2±1.2 | −4.3±1.0 | 0.031 |
| Δ Activity VAS | −6.4±1.9 | −5.6±1.4 | 0.042 |
| Δ PRWE | −16.6±8.0 | −12.8±7.5 | 0.145 |
| Δ MWS | +25.1±21.4 | +14.8±23.9 | 0.046 |
| Δ ROM (°) | +28.4±19.0 | +31.2±20.9 | 0.571 |
| Δ Grip strength (%) | +38.1±8.1 | +21.8±7.5 | 0.036 |
| Union status at final follow-up | 80%/20% | 66.7%/33.3% | 0.240 |
| Complications | 11 (22.0%) | 8 (38.1%) | 0.162 |
| Reoperation | 7 (14.0%) | 5 (23.8%) | 0.320 |

VAS: Visual Analog Scale; PRWE: Patient-rated wrist evaluation; MWS: Mayo wrist score; ROM: Range of motion; AVN: Avascular necrosis.

**Table 5.** Long-term clinical and radiological outcomes according to union status

| Outcome | Union (n=54) | Nonunion (n=17) | p |
|---|---|---|---|
| Δ Resting VAS | −5.0±1.0 | −4.6±0.7 | 0.165 |
| Δ Activity VAS | −6.3±1.0 | −5.9±1.5 | 0.437 |
| Δ PRWE | −24.1±23.4 | −17.9±20.2 | 0.581 |
| Δ MWS | +13.9±8.3 | +11.8±4.4 | 0.612 |
| Δ ROM (°) | +40.2±20.3 | +36.4±17.3 | 0.739 |
| Δ Grip strength (%) | +18.9±5.6 | +18.8±4.9 | 0.946 |

VAS: Visual Analog Scale; PRWE: Patient-rated wrist evaluation; MWS: Mayo wrist score; ROM: range of motion.

(OR: 0.47, 95% CI: 0.14–1.51; p=0.204), and preoperative SNAC stage (OR: 0.71, 95% CI: 0.32–1.56; p=0.388) were not significantly associated with union.

The preoperative SNAC stage independently increased the risk of postoperative complications (OR: 3.05, 95% CI: 1.36–6.82; p=0.007), whereas Schernberg classification and AVN were not significant predictors. Schernberg classification independently predicted reoperation risk (OR: 5.18, 95% CI:

**Table 6.** Multivariate regression analyses of clinical and structural outcomes

| Outcome | Variable | Effect size (β or OR) | 95% CI | p |
|---|---|---|---|---|
| Δ Resting VAS | Surgery <12 months | β=−0.372 | −0.754 to 0.010 | 0.056 |
| (linear regression) | Preoperative AVN | β=0.731 | 0.336 to 1.126 | <0.001 |
| | Preoperative SNAC stage | β=−0.030 | −0.289 to 0.230 | 0.820 |
| | Baseline resting VAS | β=−0.767 | −1.019 to −0.516 | <0.001 |
| Radiographic union | Surgery <12 months | OR=1.16 | 0.36–3.68 | 0.805 |
| (logistic regression) | Preoperative AVN | OR=0.47 | 0.14–1.51 | 0.204 |
| | Preoperative SNAC stage | OR=0.71 | 0.32–1.56 | 0.388 |
| Postoperative complications | Preoperative SNAC stage | OR=3.05 | 1.36–6.82 | 0.007 |
| (logistic regression) | Schernberg classifica-tion | OR=1.80 | 0.71–4.57 | 0.214 |
| | Preoperative AVN | OR=1.45 | 0.41–5.10 | 0.562 |
| Reoperation | Schernberg classification | OR=5.18 | 1.47–18.30 | 0.011 |
| (logistic regression) | Preoperative SNAC stage | OR=1.89 | 0.79–4.53 | 0.156 |
| | Preoperative AVN | OR=1.91 | 0.47–7.75 | 0.364 |

AVN: Avascular necrosis; SNAC: Scaphoid nonunion advanced collapse; VAS: Visual Analog Scale; CI: Confidence interval

1.47–18.30; p=0.011), whereas preoperative SNAC stage and AVN were not independently associated with reoperation (Table 6).

## DISCUSSION

Scaphoid nonunion remains a challenging clinical condition, and the existing literature is dominated by retrospective studies employing heterogeneous surgical techniques and varying definitions of union.[12,13] These methodological differences limit direct comparison across studies. In our cohort, the overall union rate of 76% falls within the broad range reported in previous systematic reviews and single-center series (53%–100%).[9,14,15] Notably, multivariate analysis demonstrated that structural disease severity, reflected by preoperative SNAC stage and Schernberg classification, independently increased the risk of complications and reoperation, whereas preoperative AVN adversely affected symptomatic recovery.

The overall complication rate of 26.8% was higher than rates reported by Slade, Delamarre, and Pinder.[2,9,16] This difference may be attributable to the relatively high proportion of structurally advanced cases and the extended follow-up period in our cohort. In multivariate analysis, preoperative SNAC stage independently increased the risk of postoperative complications (OR: 3.05, 95% CI: 1.36–6.82; p=0.007), while Schernberg classification independently predicted reoperation (OR: 5.18, 95% CI: 1.47–18.30; p=0.011). These findings suggest that adverse long-term outcomes are more strongly associated with baseline structural severity and fracture morphology than with surgical timing. The prognostic importance of degenerative progression and structural severity in scaphoid nonunion has been highlighted in previous studies.[12,17,18]

Although early surgery (<12 months) was associated with greater improvement in resting pain in univariate analysis, this association was no longer significant after adjustment for baseline pain and radiographic severity (p=0.056). The impact of surgical timing remains controversial.[9,19-21] Slade et al.[19] reported faster union in patients treated within 6 months (p<0.02), whereas Somerson et al.[20] found that treatment delays of at least one year were associated with worse DASH (Disabilities of the Arm, Shoulder and Hand) and pain scores. In contrast, other studies have reported no significant relationship between surgical timing and long-term functional outcomes.[9,21] Consistent with these findings, our multivariate analysis suggests that surgical timing may not independently determine long-term functional recovery.

Preoperative AVN independently predicted less improvement in resting pain, indicating that vascular compromise negatively affects symptomatic recovery. However, AVN was not independently associated with union, complications, or reoperation. This suggests that AVN may influence clinical recovery without necessarily determining structural healing. Higher baseline resting pain was also independently associated with greater postoperative improvement, likely reflecting the influence of initial symptom severity on the magnitude of change.

The impact of AVN on union and functional outcomes remains inconsistent in the literature. Some studies have reported lower union rates in AVN-associated nonunions treated with nonvascularized grafts,[22] whereas others have demonstrated acceptable union rates using vascularized grafts.[23,24] Fergu-

son et al.[11] reported union rates of 74% with vascularized grafts and 62% with nonvascularized grafts in patients with AVN. However, systematic reviews have not consistently demonstrated superiority of either graft type within AVN subgroups.[25] This variability may reflect differences in AVN definitions (MRI-based versus intraoperative assessment), the extent of proximal pole involvement, graft selection, and methods used to assess union.[26] Because all patients in our cohort were treated with nonvascularized bone grafting, our findings should be interpreted within this surgical context.

Multivariate analysis identified no independent predictors of radiographic union, and union status was not associated with long-term clinical or radiographic outcomes. These findings are consistent with previous studies demonstrating limited correlation between radiographic measures and patient-reported outcomes.[27-29] Restoration of osseous continuity and radiographic alignment alone may not fully capture the multifactorial determinants of wrist function, including cartilage integrity, soft-tissue adaptation, neuromuscular control, and patient perception.

Radiographic progression of degenerative changes was observed during follow-up despite structural reconstruction. This observation is consistent with long-term studies demonstrating that arthritic progression may continue even after technically successful surgery.[17,18] Therefore, achieving union does not necessarily prevent long-term degenerative evolution.

This study has several limitations. Its retrospective design introduces the potential for selection and information bias, and the single-center setting may limit generalizability. Although multivariate analyses were performed, the relatively small sample size may have reduced statistical power, particularly for subgroup analyses. Additionally, radiographic assessment was based primarily on standard radiographs, which may be subject to measurement variability.

## CONCLUSION

Neither surgical timing nor radiographic union was independently associated with long-term functional recovery after scaphoid nonunion surgery. In contrast, preoperative AVN predicted reduced symptomatic improvement, whereas structural disease severity, reflected by SNAC stage and Schernberg classification, was associated with postoperative complications and reoperation.

**Ethics Committee Approval:** Ethical approval was obtained from the Ondokuz Mayıs University Clinical Research Ethics Committee (Date: 12.09.2024, Decision No: 2024/360).

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ORİJİNAL ÇALIŞMA - *ÖZ*

## Skafoid kaynamamada uzun dönem sonuçlar: Yapısal hastalık şiddeti, avasküler nekroz ve cerrahi zamanlamanın rolü

AMAÇ: Bu çalışmanın amacı, skafoid kaynamama nedeniyle cerrahi tedavi uygulanmış hastaların uzun dönem klinik ve radyolojik sonuçlarını değerlendirmek ve cerrahi zamanlama ile preoperatif avasküler nekrozun (AVN) postoperatif iyileşme üzerindeki bağımsız etkilerini analiz etmektir.
GEREÇ VE YÖNTEM: Bu retrospektif kohort çalışmasına, 2011–2020 yılları arasında skafoid kaynamama nedeniyle cerrahi tedavi uygulanmış ve en az 5 yıl takip süresi bulunan 71 erişkin hasta dahil edildi. Değerlendirilen değişkenler arasında demografik özellikler, cerrahi zamanlama, preoperatif AVN ve radyografik şiddet yer aldı. Klinik sonuçlar Vizüel Analog Skala (VAS), Hasta Tarafından Değerlendirilen El Bileği Ölçeği (PRWE) ve Mayo El Bileği Skoru (MWS) ile değerlendirildi. Radyolojik incelemede skafoid kaynamama ileri kollapsı (SNAC) evrelemesi, skafo-lunat açı (SLA), radio-lunat açı (RLA) ve karpal yükseklik indeksi kullanıldı. Fonksiyonel iyileşme, kaynama, komplikasyon ve reoperasyon için bağımsız belirleyicileri saptamak amacıyla çok değişkenli lineer ve lojistik regresyon analizleri yapıldı.
BULGULAR: Hastaların ortalama yaşı 34.4±7.1 yıl, ortalama takip süresi 78.4±10.3 ay idi. Preoperatif AVN hastaların %29.6'sında mevcuttu. Kaynama, komplikasyon ve reoperasyon oranları sırasıyla %76.1, %26.8 ve %18.3 idi. Tek değişkenli analizde, 12 ay içinde uygulanan cerrahinin istirahat ağrısında daha fazla azalma ile ilişkili olduğu saptandı (p=0.046). AVN bulunmaması, ağrı skorlarında ve MWS'de daha fazla iyileşme ile ilişkiliydi (p<0.05). Ancak başlangıç ağrısı ve radyografik şiddet için düzeltme yapılan çok değişkenli analizde, cerrahi zamanlama ağrı iyileşmesi ile bağımsız olarak ilişkili bulunmadı (p=0.056), buna karşılık AVN varlığı semptomatik iyileşmenin daha sınırlı olması ile bağımsız olarak ilişkiliydi (p<0.001). Kaynamayı bağımsız olarak öngören herhangi bir değişken saptanmadı. Preoperatif SNAC evresi komplikasyonları (p=0.007), Schernberg sınıflaması ise reoperasyonu (p=0.011) öngördü. Radyolojik parametreler fonksiyonel sonuçlarla ilişkili değildi. Bu bulgular, cerrahi zamanlamadan ziyade biyolojik ve yapısal hastalık yükünün uzun dönem iyileşmede daha belirleyici olabileceğini göstermektedir. Vasküler bozulmanın cerrahi müdahaleye rağmen semptomatik iyileşmeyi sınırlayabileceği, yapısal şiddetin ise olumsuz sonuç riskini artırabileceği anlaşılmaktadır. Radyografik iyileşme ile fonksiyonel sonuçlar arasındaki ilişkinin olmaması, skafoid kaynamama cerrahisi sonrasında iyileşmenin karmaşık ve çok faktörlü bir süreç olduğunu göstermektedir.
SONUÇ: Cerrahi zamanlama ve radyografik kaynama uzun dönem fonksiyonel iyileşme ile bağımsız olarak ilişkili değildir. Buna karşılık preoperatif AVN daha sınırlı semptomatik iyileşmeyi öngörmekte, yapısal şiddet ise komplikasyon ve reoperasyon ile ilişkili bulunmaktadır.

Anahtar sözcükler: Avasküler nekroz, kaynama oranı, kaynamama, Skafoid, SNAC.

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