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# High rate of failure after magnesium bioabsorbable compression screw fixation for scaphoid fractures

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## Abstract

**Purpose** This retrospective study aimed to evaluate the clinical and radiological outcomes of magnesium (Mg) bioabsorbable compression screws in the management of scaphoid fractures and nonunion. Despite theoretical benefits, such as osteoinductive properties and gradual degradation facilitating bone remodeling of these novel implants, clinical evidence on their efficacy remains limited.

**Materials and methods** A retrospective analysis was conducted on 20 patients who underwent scaphoid fracture or nonunion surgery with Mg screws at our hospital between 2015 and 2024. Patients with a minimum of 12 months of radiological follow-up were included. Functional assessments were conducted using the Quick Disabilities of the Arm, Shoulder, and Hand (Q-DASH) and Mayo Wrist Score, while radiographic outcomes focused on union, screw integrity, and cystic changes. Statistical analysis compared grip strength and wrist range of motion to the contralateral side.

**Results** The mean clinical follow-up period was 78.3 months (SD ± 22.0; range 14–108), and the mean radiological follow-up was 59.1 months (SD ± 30.5; range 12–99). Functional assessments showed a mean Q-DASH score of 11.5 (SD ± 16.9; range 0–68.2) and a Mayo Wrist Score of 75.7 (SD ± 13.3; range 45–95), indicating moderate functional recovery. The non-union rate was 40%, with complications including screw breakage in 25% of patients and cystic lesion formation around screws in most cases. No infections were reported. Wrist range of motion and grip strength were both significantly reduced on the injured side compared to the intact side.

**Conclusions** Mg screws demonstrate potential benefits for bioabsorbable fixation, but our findings indicate a high rate of complications, including non-union and screw instability, in scaphoid fractures. The study suggests that Mg screws may not provide adequate stability for complex fractures in small bones like the scaphoid.

**Level of evidence** Level IV, retrospective cohort study.

**Keywords** Scaphoid fractures, Nonunion, Magnesium bioabsorbable screws, Osteolysis

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## Introduction

Scaphoid fractures represent approximately 60% of carpal fractures and are among the most common wrist injuries [1]. In a recent study based on a large-scale trauma data repository, Wells et al. reported an estimated annual incidence of 286 scaphoid fractures per 100,000 person-years from 968,665 trauma patients, with males being more prone to these fractures [2]. These injuries typically occur due to a fall onto an outstretched hand (FOOSH), which transmits force directly to the palm's radial side and results in a fracture of the scaphoid bone. Treatment must be prompt and effective to prevent complications such as nonunion or avascular necrosis, which is closely related to the scaphoid's unique blood supply. Surgical intervention is typically indicated for displaced fractures, nonunion, or when conservative management with casting fails to achieve bone healing [3, 4].

The conventional fixation options for scaphoid fractures include centrally placed metallic compression screws, which have been considered the gold standard due to their strength and rigidity. However, while these methods have their benefits, they also have drawbacks, including hardware-related complications, additional surgery to remove hardware, and interference with imaging modalities. The necessity for the removal of compression screws following a scaphoid fracture has been documented in up to 14% of cases in relevant literature [5–7]. Bioabsorbable screws provide a promising alternative as they gradually degrade and are replaced by native bone tissue. This could reduce stress shielding, the need for subsequent hardware removal and cumulative cost, decrease artifacts on postoperative imaging and facilitate better follow-up assessments [8].

Magnesium (Mg) and its alloys have emerged as a promising material for bioabsorbable fixation due to its osteoinductive properties, which have the potential to enhance bone healing. Furthermore, magnesium screws provide sufficient initial stability, and their gradual degradation can result in reduced stress shielding and the promotion of natural bone remodeling [9]. A number of previous studies have reported comparable clinical and radiological outcomes to those observed with metallic fixations in a range of indications [10–12]. Although Mg screws have theoretical benefits, there is limited clinical evidence supporting their use in scaphoid fractures, with only a few studies investigating their outcomes [13–15]. The scarcity of clinical data on the efficacy and safety of Mg bioabsorbable compression screw fixation for scaphoid fractures and nonunions underscores the necessity for further research. The objective of this retrospective case series was to examine the success rate following the use of magnesium screws in the management of scaphoid fractures and nonunions. It was postulated that the osteoinductive properties of magnesium, when coupled with the benefits of a bioabsorbable system, might offer a superior clinical outcome with a high union rate. Accordingly, a comprehensive assessment of failure rates is imperative to ascertain the clinical viability of this novel fixation method.

## Materials and methods

### Study design and population

A retrospective review was conducted on patients admitted to our hospital between 2015 and 2024 who underwent surgery for scaphoid fracture or scaphoid nonunion using Mg bioabsorbable compression screws. Inclusion criteria required that patients had at least 12 months of radiological follow-up to ensure adequate assessment of fracture healing and functional outcomes. Exclusion criteria included patients who received an additional fixation method along with Mg screws, such as K-wires, those who did not attend follow-up visits or undergo radiological evaluations, and individuals who declined participation in the study. A total of 30 patients were identified after the initial review. Of these, 8 patients with less than 12 months of radiological follow-up and 2 who were lost to follow-up were excluded, resulting in a final study cohort of 20 patients with complete radiological evaluations. Functional assessments were carried out based on patient availability. Thirteen patients completed a full physical examination and functional assessments, but the remaining 7 patients underwent functional assessment through a telephone interview (Fig. 1). This study followed the principles outlined in the Declaration of Helsinki and its later amendments. Informed consent was obtained from all participants, and the institutional review board approved the study protocol (Approval Date and Issue: 2024-078/4–05).

### Magnesium screws and surgical technique

A 2.7 mm diameter biodegradable magnesium screw (MAGNEZIX® CS, Syntellix AG, Hanover, Germany) was utilized in all patients (Fig. 2). It was a variable pitch (Herbert Screw), cannulated headless screw designed to provide interfragmentary compression. The screws are constructed from a magnesium alloy (MgYREZr), which is predominantly composed of pure Mg powder (> 90%). The material composition consisted of an alloy of Mg, zirconium, yttrium, and rare earth elements.

All patients underwent surgical intervention under the guidance of a supraclavicular brachial plexus block or general anesthesia and tourniquet control, with the patients positioned supine throughout the procedure. The surgical procedure was performed using either a volar or dorsal approach. Subsequently, a Kirschner wire was positioned parallel to the longitudinal axis of the scaphoid bone in the most central position feasible under fluoroscopic guidance. A cannulated drill bit was utilized

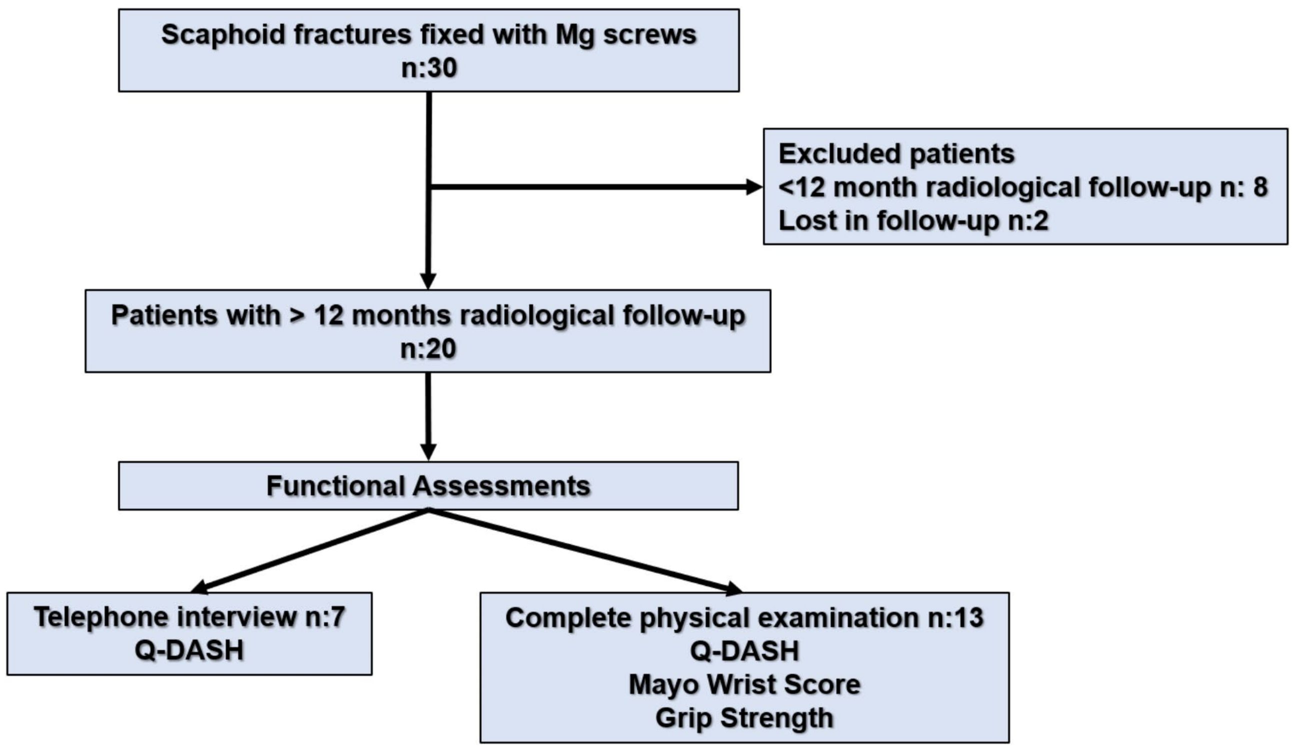


**Fig. 1** Flow chart illustrating patient selection and assessment process

to prepare the hole, and then the fracture was fixed with a single bioabsorbable Mg compression screw. No additional implants were utilized for the fixation of scaphoid fractures beyond the Mg screws. In cases of nonunion, in addition to the aforementioned procedures, the fracture line was debrided with curettage and filled with cancellous autologous bone graft harvested from the distal radius before fixation. All patients were immobilized postoperatively with a scaphoid plaster splint to ensure adequate stability during early healing. The mean duration of immobilization was 41.2 days (SD ± 21.1; range, 30–90 days) (Table 1). Immediately following the removal of the cast, patients were instructed to begin performing exercises to regain wrist mobility gradually.

### Clinical assessments

Medical information was obtained from the hospital's digital patient system and files. Patient files were reviewed to extract information on age, gender, mechanism of injury, conservative treatment history, duration of treatment, comorbidities, and smoking history. The surgical technique and approach were reviewed from the operation notes. For the seven patients who could not attend an in-person examination at the hospital due to various reasons, a functional assessment was conducted via a telephone interview using the Q-DASH questionnaire. In contrast, 13 patients were evaluated in the hospital, where a comprehensive physical examination was performed. Clinical evaluations included both the Mayo Wrist Score and the Q-DASH questionnaire [16, 17]. During the final follow-up visit, grip strength of each subject's affected hand was measured and compared to the unaffected hand, and the reduction in grip strength relative to the healthy side was calculated as a percentage. Grip strength measurements followed the protocol recommended by Roberts et al. [18]. All intraoperative and postoperative complications, including infections and revisions, were documented throughout the follow-up period.

### Radiological evaluation

Scaphoid fractures were evaluated using the Herbert classification [19]. Radiographic images were accessed through PACS to evaluate the union, gas and cyst formation, and implant failure. The formation of trabecular bridges and cortical fusion are accepted signs of bone healing on direct radiographs [20]. When available, patients' postoperative CT scans were also analyzed.

### Statistical analysis

Data were presented as means, standard deviations (SD), frequencies, and percentages. Differences in grip strength and wrist range of motion (ROM) between the injured and intact sides were analyzed using the Related-Samples Wilcoxon Signed Rank Test, due to the paired nature of


**Fig. 2** The appearance and technical specifications of the Mg screws

**Table 1** Demographic and clinical characteristics of patients

| Variables | Data |
|---|---|
| Age (years ± SD) | 26.1 ± 9.6 (range, 16–51) |
| Gender (n, %) | |
| *Male* | 19 (95%) |
| *Female* | 1 (5%) |
| Side | |
| *Dominant* | 17 (85%) |
| *Non-Dominant* | 3 (15%) |
| Smoking | |
| *Yes* | 8 (40%) |
| *No* | 12 (60%) |
| Mechanism of injury | |
| *FOOSH* | 9 (45%) |
| *Traffic accident* | 5 (25%) |
| *Sports Injury* | 5 (25%) |
| *Fall from height* | 1 (5%) |
| Herbert Classification | |
| *B2* | 3 (15%) |
| *B3* | 2 (10%) |
| *C* | 2 (10%) |
| *D1* | 4 (20%) |
| *D2* | 9 (45%) |
| The time between injury to fixation (Days ± SD) | 115.7 ± 102.5 (range, 3-360) |
| Duration of immobilization (Days ± SD) | 41.2 ± 21.1 (range, 30–90) |

the data. A $p$-value of $< 0.05$ was considered statistically significant.

### Demographic and clinical characteristics

The study cohort included 20 patients, primarily male (95%, $n = 19$), with a mean age of 26.1 years (SD ± 9.6, range 16–51). Most injuries affected the dominant hand (85%, $n = 17$). The main mechanisms of injury were falls on an outstretched hand (45%, $n = 9$), traffic accidents (25%, $n = 5$), and sports injuries (25%, $n = 5$). Based on the Herbert Classification, the most common fracture type was D2 (45%, $n = 9$). The average time from injury to surgical fixation was 115.7 days (SD ± 102.5, range 3–360), and the mean immobilization duration was 41.2 days (SD ± 21.1, range 30–90). A summary of demographic and clinical characteristics of the patients is presented in Table 1.

### Clinical outcomes

The mean clinical follow-up period was 78.3 months (SD ± 22.0, range 14–108), and radiographic follow-up averaged 59.1 months (SD ± 30.5, range 12–99). Functional assessments showed a mean Q-DASH score of 11.5 (SD ± 16.9, range 0–68.2) and a mean Mayo Wrist Score of 75.7 (SD ± 13.3, range 45–95). Grip strength of the injured side averaged 23.3 kg (SD ± 8.3, range 7.2–34.3), compared to 27.6 kg (SD ± 7.5, range 15.8–38) on the intact side, resulting in a mean grip strength loss of 16.8% (SD ± 16.5, range 0.9–55). The difference in grip strength was statistically significant ($p = 0.001$). Range of motion (ROM) measurements showed that, compared to the intact side, the injured side had significant reductions in extension (mean 50.1° ± 8.6, range 35–65; $p = 0.003$) and radial deviation (mean 14.1° ± 4.0, range 5–21; $p = 0.001$). Flexion (mean 58.5° ± 8.4, range 40–70; $p = 0.410$) and ulnar deviation (mean 32.4° ± 6.9, range 18–44; $p = 0.043$) also varied but were less affected (Table 2).

### Radiological outcomes and complications

Due to the retrospective nature of this study, radiographs were not taken at consistent time intervals for all patients, making it challenging to evaluate exact union times. Instead, final union was assessed based on the latest radiological images available. Non-union was observed in 40% of patients ($n = 8$). Of these, three patients underwent revision surgery with titanium screws, leading to successful bone healing upon follow-up, while the remaining five continued to show non-union at their last follow-up (Figs. 3, 4 and 5**).** Screw breakage was noted in five patients, four of whom experienced breakage before achieving union. In one of these cases, however, bone healing was still observed despite early screw breakage.

**Table 2** Summary of clinical outcomes. Abbreviations, SD: standard deviation, ROM: range of motion, Q-DASH: quick disabilities of the arm, shoulder, and hand

| Variables | Data | *p*-value |
|---|---|---|
| Follow-up (months ± SD) | | |
| *Clinical* | 78.3 ± 22.0 (range, 14–108) | |
| *Radiographic* | 59.1 ± 30.5 (range, 12–99) | |
| Q-DASH (score ± SD) | 11.5 ± 16.9 (range, 0-68.2) | |
| Minimal impairment (0–20) | 16 (80%) | |
| Mild impairment (21–40) | 3 (15%) | |
| Significant impairment (61–80) | 1 (5%) | |
| Mayo Wrist Score (score ± SD) (n:13) | 75.7 ± 13.3 (range, 45–95) | |
| Excellent (90–100) | 3 (23.1%) | |
| Good (80–89) | 3 (23.1%) | |
| Fair (65–79) | 6 (46.2%) | |
| Poor (< 65) | 1 (7.7%) | |
| Injured Side Grip Strength (kg ± SD) (n:13) | 23.3 ± 8.3 (range, 7.2–34.3) | 0.001* |
| Intact Side Grip Strength (kg ± SD) (n:13) | 27.6 ± 7.5 (range, 15.8–38) | |
| Grip Strength Loss (%±SD) (n:13) | 16.8 ± 16.5 (range, 0.9–55) | |
| Wrist ROM Injured side (°±SD) (n:16) | | |
| Flexion | 58.5 ± 8.4 (range, 40–70) | 0.410* |
| Extension | 50.1 ± 8.6 (range, 35–65) | 0.003* |
| Radial deviation | 14.1 ± 4.0 (range, 5–21) | 0.001* |
| Ulnar deviation | 32.4 ± 6.9 (range, 18–44) | 0.043* |
| Wrist ROM Intact side (°±SD) (n:16) | | |
| Flexion | 63.5 ± 11.0 (range, 42–80) | |
| Extension | 58.6 ± 8.4 (range, 38–70) | |
| Radial deviation | 17.3 ± 4.1 (range, 7–23) | |
| Ulnar deviation | 35.5 ± 5.8 (range, 24–47) | |
| Complications (n, %) | | |
| *Non-union* | 8 (40%) | |
| *Screw Breakage* | 5 (25%) | |
| *Revision to Titanium Screw* | 3 (15%) | |

*Related-Sample Wilcoxon Signed Rank Test. (Comparison of Injured and Intact sides)

Almost all patients showed varying degrees of gas formation and the development of cystic lesions adjacent to the screw. Overall, complications included non-union in 40% ($n = 8$) of patients and screw breakage in 25% ($n = 5$). No cases of superficial or deep infection were reported throughout the study.

There were no significant differences in nonunion rates ($p = 0.251$), screw breakage rates ($p = 0.664$), or revision rates ($p = 0.730$) when comparing patients with acute fractures and delayed unions (Herbert types B2, B3, and C) to those with established nonunions (Herbert types D1 and D2) (Fig. 6)**.**

## Discussion

The present study evaluated the clinical outcomes of Mg bioabsorbable compression screws in the management of scaphoid fractures and nonunions, a topic of growing interest due to the potential advantages of bioabsorbable materials. Our study observed a notably lower union rate in patients treated with magnesium (Mg) bioabsorbable screws for scaphoid fractures compared to the rates reported in previous studies. While earlier research has shown high union rates and favorable clinical outcomes with Mg screws in various orthopedic applications [10–12], including scaphoid fractures [13–15], our findings reveal a 40% rate of non-union, which contrasts with the typically high success rates observed in similar studies. This discrepancy highlights the challenges and complexities associated with Mg-based fixation in certain fracture types, possibly due to factors such as bone quality, fracture location, and Mg degradation characteristics. Understanding these variations is critical to assessing the long-term clinical applicability of Mg screws in scaphoid fracture management.

There are only three previous studies in the literature reporting on the use of Mg bioabsorbable compression screws for scaphoid fractures and nonunions (Table 3) [13–15]. The first study, published by Meier and Panzica in 2017, evaluated the use of Mg screws in five patients with acute scaphoid fractures. They reported excellent wrist scores and successful union in all patients at the one-year follow-up. However, complications such as cyst formation, implant loosening, early implant absorption, delayed union, and delayed return to work were observed, leading the authors to advise cautious use of Mg screws in scaphoid fractures. Polat et al. conducted a study to assess the mid-term functional and radiological outcomes of Mg-based screws in acute scaphoid fractures. Their study included 21 patients with scaphoid waist fractures and achieved a 100% union rate with no reported complications, with a mean union time of 11.2 weeks. Könneker et al. documented their experience with Mg-based screws in both acute scaphoid fractures and nonunions, reporting successful bone healing in all eight patients with acute fractures and in three of four patients with nonunions, yielding an overall union rate of 91.6%. They observed excellent clinical outcomes for acute fractures and good to moderate outcomes for nonunions. In contrast to these studies, our findings indicate a notably higher rate of nonunion and implant failure. Several factors may account for this elevated nonunion rate in our series. Notably, the distribution of fracture types according to the Herbert classification revealed a significant number of complex fractures (D1 and D2), which are more challenging to treat and carry a higher risk of complications, including nonunion. In contrast, Meier et al. and Polat et al. primarily included patients with simpler,

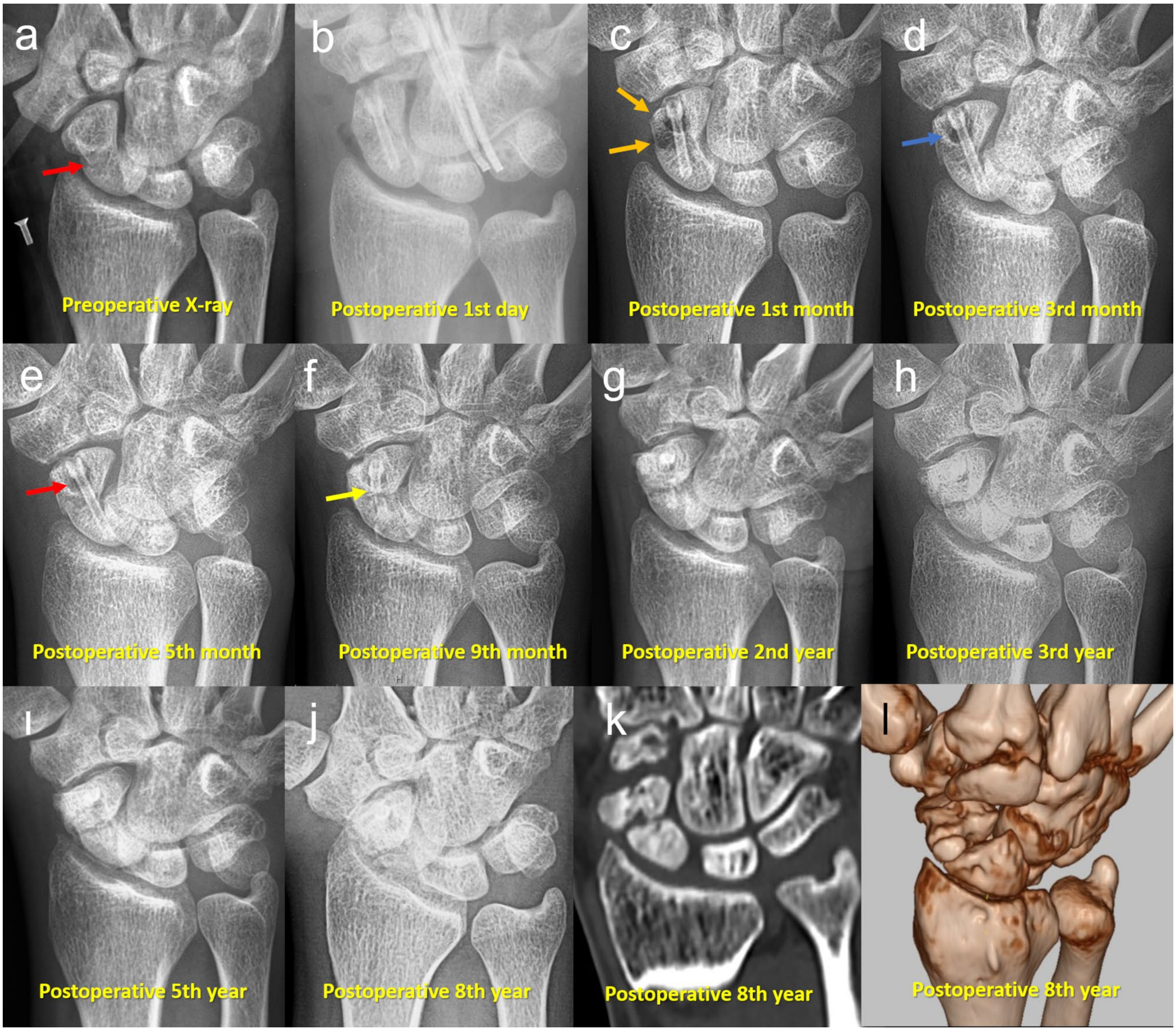


**Fig. 3** Serial radiographic and imaging follow-up of a 22-year-old male patient with a scaphoid fracture, treated with Mg screw fixation. The patient presented to our clinic after a motorcycle accident and underwent surgery on the 4th day post-injury. He is a non-smoker, and the fracture type is classified as Herbert B2 (Complete fracture of the waist). (**a**) Preoperative X-ray showing an acute scaphoid fracture (red arrow). (**b**) X-ray on the first postoperative day demonstrating the position of the Mg screw fixation. (**c**) Postoperative X-ray at the 1-month follow-up, with gas formation within the bone (orange arrows). (**d**) X-ray at the 3-month follow-up showed reduced gas formation (blue arrow). (**e**) X-ray at the 5-month follow-up indicated the presence of gas within the bone, particularly around the screw head (red arrow). (**f**) X-ray at the 9-month follow-up showed screw breakage and signs of non-union (yellow arrow). (**g**) X-rays at the 2-year, (**h**) 3-year, and (**i**) 5-year follow-ups showed established non-union and fading silhouette of the screw. (**j**) At the final follow-up 8 years after the surgery, the X-ray showed scaphoid nonunion advanced collapse (SNAC) and fragmentation of the scaphoid. (**k**) CT scan and (**l**) 3D CT reconstruction at the 8-year follow-up also confirmed the radiographic findings

acute waist fractures, which are generally associated with more favorable outcomes.

Achieving union in cases of established scaphoid nonunion is particularly challenging due to the biologically compromised environment of the fracture site, which often exhibits significantly diminished vascularity in the fracture fragments [21]. Advanced surgical techniques are often necessary to address these cases. While cancellous bone grafting is a commonly employed technique, the use of vascularized local bone grafts may be required to enhance the biological environment and support healing [22]. Ensuring optimal union in scaphoid fractures necessitates not only adequate stability but also the creation of a biologically conducive environment, i.e., both biological and mechanical factors must be addressed to provide the ideal conditions for healing [8]. Additionally, the prolonged healing time associated with scaphoid nonunions compared to acute fractures raises concerns about the mechanical adequacy of magnesium (Mg) screws. As bioabsorbable implants, Mg screws undergo

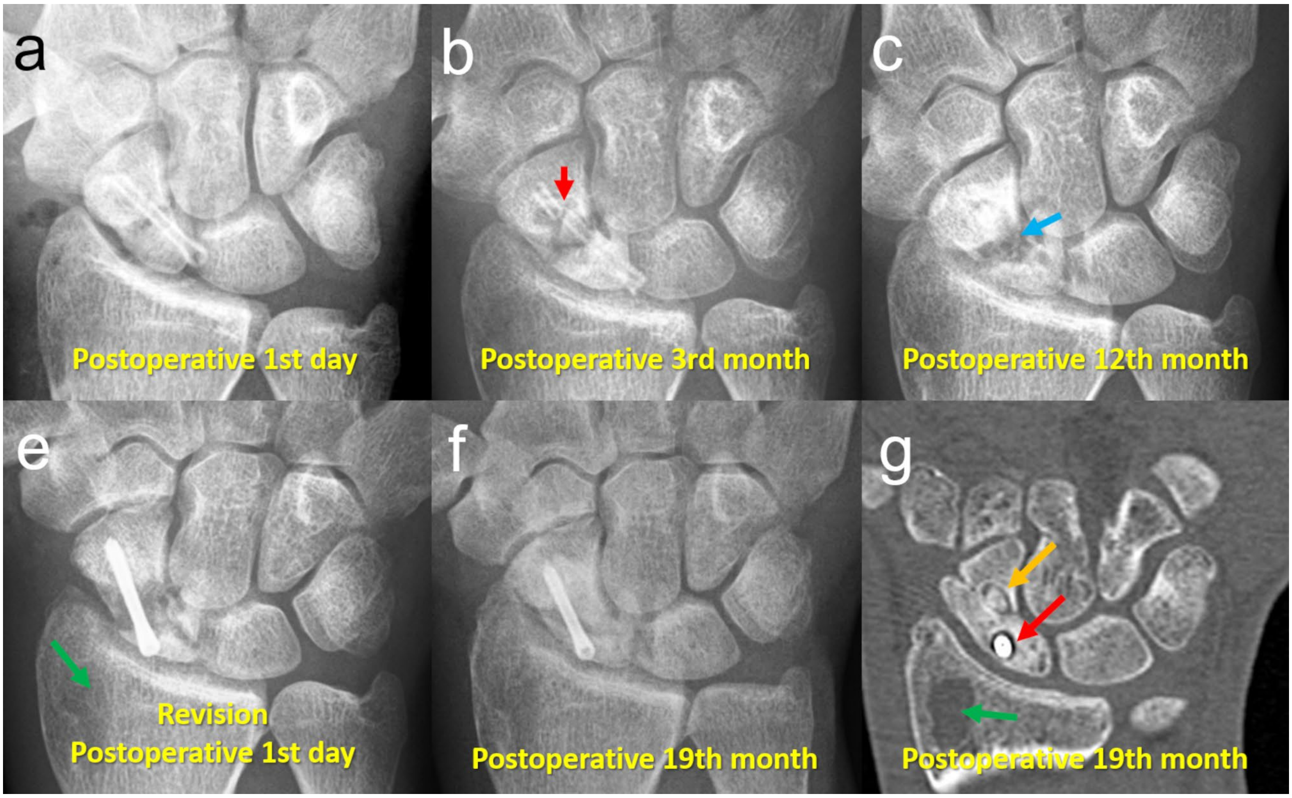


**Fig. 4** Serial radiographic and imaging follow-up of a 20-year-old male patient with a scaphoid fracture, treated with Mg screw fixation. The patient presented to our clinic following a sports injury. He was first treated with conservative treatment for three months. The fracture type is classified as Herbert D2 (Pseudoarthrosis). (**a**) Initial postoperative radiograph showing the positioning of the Mg screw and the gas formation at the tip of the radial styloid. (**b**) Postoperative 3rd month: Increased cystic gas formation within the scaphoid and screw breakage (red arrow). (**c**) Postoperative 12th month: Almost complete disappearance of Mg screw at the fracture plane and pseudoarthrosis (blue arrow). (**e**) Revision, Postoperative 1st day: Following revision surgery with autologous bone grafting. (**f**) Postoperative 19th month: Stable appearance of the fixation hardware and well-healed bone at the fracture site. (**g**) Postoperative 19th month CT scan: Detailed CT image showing positioning and osseous integration of the hardware. The orange arrow indicates the previous Mg screw. The red arrow points to the Ti screw. The green arrow highlights the graft donor site

degradation over time, which can compromise their mechanical strength during the critical early phase of fracture healing [9]. This suggests that the mechanical stability provided by Mg screws may be inadequate to support the prolonged healing process required for scaphoid nonunions. Nonunion is a multifactorial condition influenced by a combination of implant-related, patient-specific, and surgical factors. Patient-related variables, such as comorbidities and smoking status, and surgical techniques play critical roles in determining outcomes [23]. These considerations emphasize the importance of a comprehensive approach that integrates both biological and mechanical strategies, tailored to the unique challenges presented by scaphoid nonunion cases.

Beyond scaphoid fractures, two case reports in the literature have documented the use of Mg screws in carpal fusion cases (Table 3) [24–25]. Wichelhaus et al. performed a scaphotrapezotrapezoideal (STT) arthrodesis on a 42-year-old manual laborer, who subsequently presented with significant pain and mechanical instability six weeks post-surgery. Imaging revealed osteolysis surrounding the screws and evidence of screw thread degradation. During revision surgery, large voids were noted around the screws, indicating poor osseous integration [24]. Similarly, Siala et al. used Mg screws in a 35-year-old male undergoing lunocapito-hamate arthrodesis for scapholunate dissociation. Although initial alignment was adequate, imaging at one month revealed screw failure, partial bone resorption, and sclerosis. Revision surgery confirmed non-union and extensive screw degradation [25]. Both case reports underscore significant complications associated with Mg screws in wrist arthrodesis. The screws underwent rapid degradation shortly after surgery, leading to mechanical instability and non-union, ultimately necessitating revision surgeries. Osteolysis and inflammatory responses further compromised the screws' structural integrity, allowing for screw migration and necessitating traditional metallic implants to secure proper bone consolidation. These cases highlight the current limitations of Mg-based screws for wrist arthrodesis, as their rapid

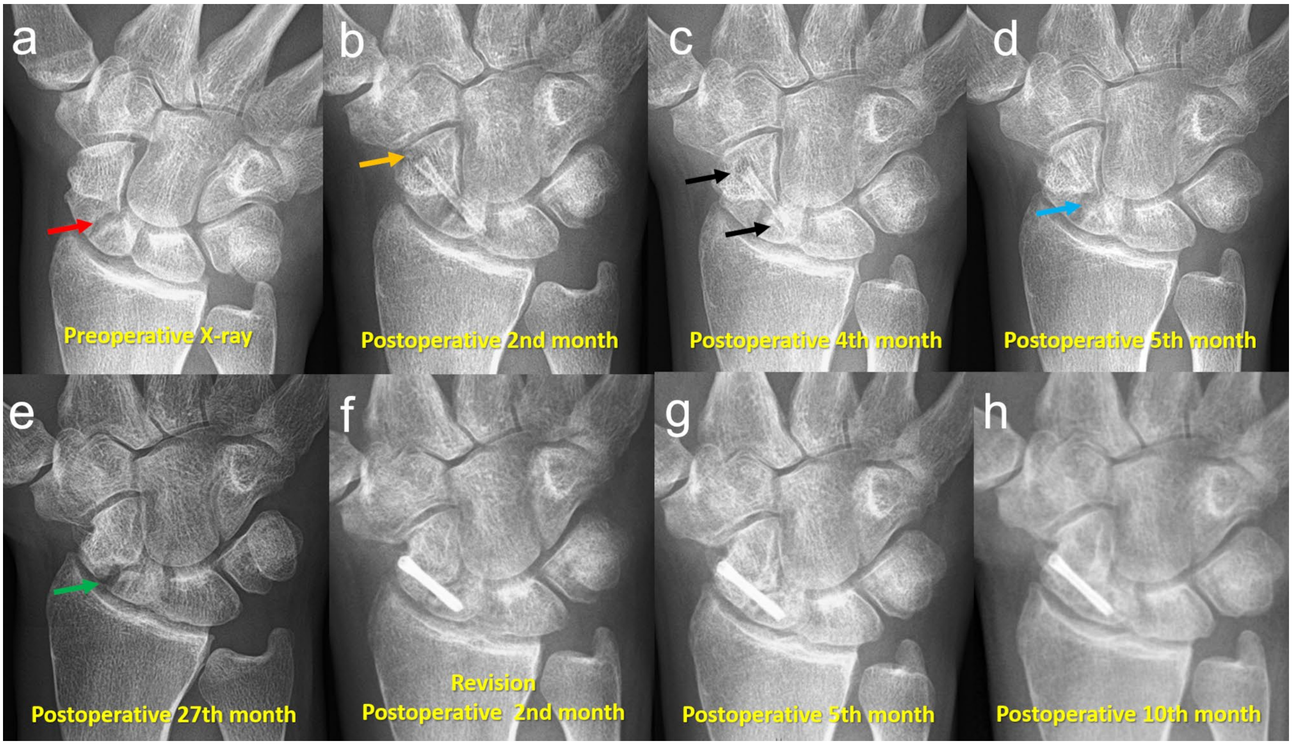


**Fig. 5** Radiographic progression of a scaphoid fracture initially fixed with a magnesium screw, which later required revision with a titanium screw due to nonunion. (**a**) Preoperative X-ray: Scaphoid fracture identified (red arrow). (**b**) Postoperative 2nd month: Early postoperative X-ray following initial fixation. The orange arrow shows the gas formation around the screw head. (**c**) Postoperative 4th month: Continued observation shows lack of healing at the fracture site and loosening of the screw (black arrows). (**d**) Postoperative 5th month: Persistence of the fracture line with no evidence of union (blue arrow). (**e**) Postoperative 27th month: Nonunion of the scaphoid fracture remains visible (green arrow) and the resorption of the screw. (**f**) Revision, Postoperative 2nd month: X-ray after revision surgery with titanium screw fixation. (**g**) Postoperative 5th month: The presence of delayed union. (**h**) Postoperative 10th month: Continued follow-up shows progression towards union with titanium screw in place

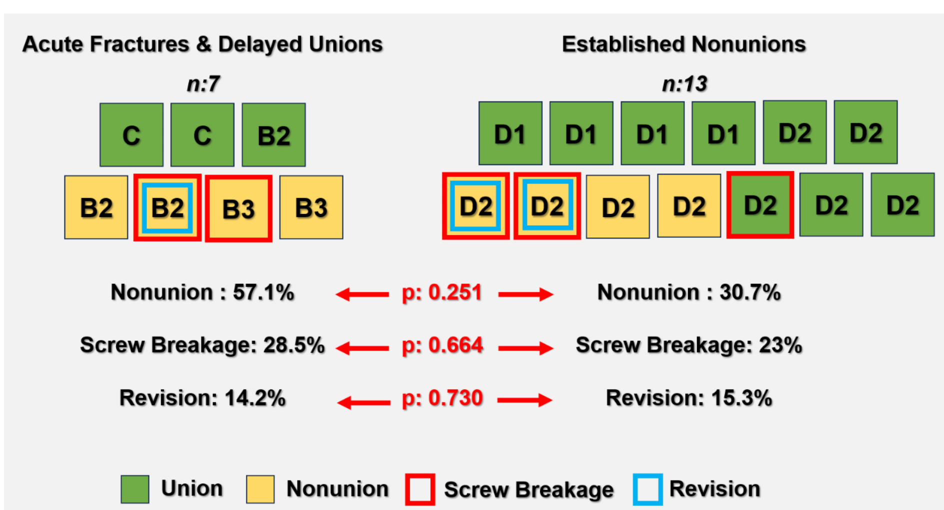


**Fig. 6** The figure illustrates the distribution of complications in patients with acute fractures and delayed unions (Herbert types B2, B3, and C; $n = 7$) and established nonunions (Herbert types D1 and D2; $n = 13$). Each box represents a single patient and indicates the corresponding Herbert classification type. Green boxes represent cases with successful union. Yellow boxes indicate cases of nonunion. Red borders signify the presence of screw breakage. Blue borders highlight cases that required revision surgery

**Table 3** List of previously published studies that used magnesium screws for carpal bone fixation

| Author | Year | Design | # of patients | Indication | Follow-up (months) | Union Rate | Complications |
|---|---|---|---|---|---|---|---|
| Wichelhaus et al. | 2016 | Case report | 1 | Scapho-trapezo-trapezoideal arthrodesis | 7 | Nonunion | Cystic formation, severe synovitis, revision |
| Meier et al. | 2017 | PCS | 5 | Scaphoid fracture | 11,4 | 100% | Severe cystic lesions, delayed return to work |
| Siala et al. | 2019 | Case Report | 1 | Luno-Capito-Hamate arthrodesis | 12 | Nonunion | Cystic formations and bone resorption, revision |
| Polat et al. | 2021 | RCS | 21 | Scaphoid fracture | 43.3 | 100% | None |
| Konneker et al. | 2023 | RCS | 12 | Scaphoid fracture | 32 | 91.6% | None |
| Current Study | 2024 | RCS | 20 | Scaphoid fracture | 60 | %60 | Cystic formation, bone resorption, implant failure |

Abbreviations, PCS: Prospective cohort study, RCS: Retrospective cohort study

breakdown undermines the mechanical stability required for successful outcomes.

Mg alloys undergo a unique degradation process in tissues. When Mg encounters water ($H_2O$) within the tissue, a reaction occurs that produces magnesium hydroxide (MgOH) and hydrogen ($H_2$) gas. This hydrogen gas accumulates within the bone, leading to cystic lesion formation in the early stages. Over time, the gas dissipates, and these cystic changes typically resolve [26–27]. While previous studies suggest that this gas formation does not hinder fracture union [10–12, 28], the scaphoid's small bone volume makes it particularly susceptible to issues of stability. We believe that the cystic lesions forming around the screws in the scaphoid may cause screw loosening and compromise initial stability. Additionally, rapid resorption of Mg screws at the nonunion site could lead to fractures within the screw itself, resulting in a complete loss of fixation stability. The results of this study support the need for caution when using Mg screws in small bones like the scaphoid. Our findings are corroborated by other studies. For example, Haslhofer et al. reported a high complication rate associated with Mg bioabsorbable screws, including a high initial rate of radiolucency around the screws (55.6% at 3 months), which reduced to 11.1% by the 9-month follow-up, suggesting limited long-term significance. Nevertheless, material failure was observed in 22.2% of cases, predominantly due to screw breakage, and an infection rate of 11.1% was documented [29]. While magnesium screws have the potential to be a valuable addition to the field of orthopaedic applications, the challenges they present, including early degradation and high complication rates, emphasize the necessity for further research to enhance our understanding of their clinical reliability.

This study has several limitations that should be acknowledged. The small sample size of 20 patients restricts the generalizability of the findings, and a larger cohort would provide more robust data to validate the conclusions. The retrospective design introduces potential biases and limitations inherent in retrospective data collection, including possible gaps or inaccuracies in medical records. Additionally, the single-center nature of the study may limit the applicability of these findings to other settings or populations with differing demographic or clinical characteristics. A key limitation is the inclusion criterion requiring a minimum of 12 months of radiological follow-up. While this threshold ensured adequate observation of union status and implant-related complications, it may have introduced a sampling bias. Patients with persistent nonunion or other complications are more likely to continue follow-up visits, potentially leading to an overestimation of the nonunion and complication rates. However, our inclusion criterion was uniformly applied to all patients, regardless of their clinical progress, and those lost to follow-up before 12 months were excluded due to incomplete data rather than favorable or unfavorable outcomes. Moreover, given the progressive degradation of magnesium screws, certain complications, such as cyst formation and screw instability, may not become apparent until later stages. A shorter follow-up period might have underestimated these adverse effects rather than overestimated them. The absence of a control group treated with conventional metallic screws prevents a direct comparison, making it difficult to attribute observed outcomes specifically to magnesium screws. Moreover, variability in surgical technique and surgeon experience with magnesium screws could have impacted outcomes, contributing to inconsistencies in results. A notable strength of this study is its relatively long follow-up period (mean of 5 years), which enabled a thorough assessment of both clinical and radiological outcomes following Mg bioabsorbable screw fixation for scaphoid fractures. This extended follow-up facilitated a detailed evaluation of functional outcomes, including grip strength and range of motion, as well as a comprehensive analysis of complications such as nonunion and screw-related issues, adding valuable insights to the limited literature on Mg-based fixation. Additionally, comparisons with prior studies on Mg screws in carpal bones contextualize our findings within the broader orthopedic literature on bioabsorbable fixation techniques.

This study highlights significant challenges in using magnesium (Mg) bioabsorbable screws for scaphoid fractures and nonunions, with a high complication rate, including a 40% nonunion rate and notable occurrences of screw breakage and cystic lesion formation. While Mg screws offer theoretical benefits such as bioabsorbability and osteoinductive potential, our findings suggest limited effectiveness in achieving union in small bones like the scaphoid. These results underscore the need for cautious use of Mg screws in such applications, especially in complex fracture types. Moving forward, further research is needed to refine Mg screw technology and assess alternative materials or designs that address issues related to rapid degradation, early mechanical instability, and osteolytic responses. Additionally, studies with larger sample sizes, standardized protocols, and direct comparisons with conventional metallic screws would provide more robust data to evaluate the viability of Mg bioabsorbable screws for scaphoid fractures and other small bone applications.

**Abbreviations**

| | |
|---|---|
| CT | Computed Tomography |
| FOOSH | Fall on an Outstretched Hand |
| Mg | Magnesium |
| MRI | Magnetic Resonance Imaging |
| PACS | Picture Archiving and Communication System |
| Q | DASH–Quick Disabilities of the Arm, Shoulder, and Hand |
| ROM | Range of Motion |
| SD | Standard Deviation |
| STT | Scaphotrapezotrapezoidal |

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**Author contributions**
O.F.E. and F.D. wrote the main manuscript text. H.C. conducted the formal analysis and wrote the initial draft. M.B.E. contributed to the methodology and reviewed the manuscript. A.Y. supervised the formal analysis and reviewed the manuscript. O.K. conceptualized the study and supervised the manuscript preparation. All authors reviewed the manuscript.

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**Data availability**
No datasets were generated or analysed during the current study.

## Declarations

**Ethics approval and consent to participate**
This study followed the principles outlined in the Declaration of Helsinki and its later amendments. Informed consent was obtained from all participants, and the institutional review board approved the study protocol (Approval Date and Issue: 2024-078/4–05).

**Consent for publication**
Written informed consent was obtained from all participants for publication of this study.

**Competing interests**
The authors declare no competing interests.

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