International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 14, No. 3, March 2025 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.3.2025.170

ORIGINAL RESEARCH

Functional outcome of Herbert screw fixation in scaphoid fracture

[1]Mohit Pabari,[2]Viraj Banker, [3]Krunal Khant, [4]Bhargav Galani,[5]Sushil Barkesia

[1,2]Assistant Professor, Department of Orthopaedics, Shri M.P.Shah Government Medical College, Jamnagar, Gujarat, India
[3,4,5]Junior Resident, Department of Orthopaedics, Shri M.P.Shah Government Medical College, Jamnagar, Gujarat, India

Corresponding Author
Dr. Mohit Pabari
Department of Orthopaedics, Shri M.P.Shah Government Medical College, Jamnagar, Gujarat, India

Received: 20Jan, 2025 Accepted: 21Feb, 2025

ABSTRACT
Introduction: Herbert screw fixation is a minimally invasive technique for treating scaphoid fractures, offering faster healing, reduced morbidity, and quicker recovery compared to traditional methods. It is ideal for active individuals, promoting early return to work and sports activities.**Material and Method:** Between 2023 and 2024, 30 patients (21 males, 9 females; mean age 28 years) underwent scaphoid fracture surgery. Most injuries were due to road traffic accidents. Right scaphoid fractures (18) were more common than left (12). Radiological evaluation included hand AP, oblique, and scaphoid stress views. Inclusion excluded complex or associated injuries.**Result:** In a study of 30 scaphoid fracture patients (28 followed), outcomes assessed via the modified Mayo wrist score showed excellent results (average score: 98). Radiologic union occurred in 27 cases, with functional recovery, grip strength, and minimal complications noted. Return to work ranged from 2-8 months, confirming effective treatment.**Conclusion:** Herbert screw fixation in scaphoid fractures demonstrates high efficacy, promoting stable union and early functional recovery. This minimally invasive technique offers reliable outcomes, reducing complications and facilitating quicker return to activities, making it a preferred choice for scaphoid management.

Key words: Herbert screw fixation, scaphoid fractures, functional recovery, radiological union, modified mayo wrist score

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

INTRODUCTION

INTRODUCTION TO FRACTURE SCAPHOID

The scaphoid is a small carpal bone located on the thumb side of the wrist, playing a critical role in wrist stability and motion. Fracture of the scaphoid is a common injury, often resulting from a fall onto an outstretched hand (FOOSH)[1]. Due to its unique blood supply, which primarily enters the bone distally, scaphoid fractures are notorious for complications such as nonunion and avascular necrosis, particularly when the fracture occurs in the proximal region[2].

This injury predominantly affects young, active individuals, often linked to sports or high-energy trauma[3]. Diagnosing scaphoid fractures can be challenging due to the subtle nature of symptoms and the potential for normal initial X-rays. Delayed or missed diagnoses can significantly impact wrist function, leading to chronic pain, stiffness, and long-term disability[4].

Effective management requires a comprehensive understanding of the fracture's location, displacement, and vascular status, typically achieved through clinical evaluation and advanced imaging modalities such as MRI or CT scans[5]. Treatment options range from conservative management with immobilization to surgical intervention, depending on the fracture's characteristics. Early recognition and appropriate treatment are essential to optimize outcomes and prevent long-term complications[6].

MODE OF TRAUMA

The scaphoid fracture is a common injury, particularly among young adults, and itsmechanism typically involves the following modes of injury:

1. **FALL ON AN OUTSTRETCHED HAND (FOOSH)**

The most common mechanism of injury. The wrist is extended and radially deviated at the time of impact. The scaphoid, located on the radial side of the wrist, absorbs much of the force, leading to a fracture. Direct Trauma A direct blow or impact to the wrist or hand. Less common compared to FOOSH but possible in high-energy trauma like sports injuries or motor

Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.3.2025.170

vehicle accidents. Repetitive Stress or Overuse Rarely, repetitive stress activities[6] (e.g., gymnastics or certain manual labor tasks) can lead to stress fractures of the scaphoid.

ANATOMY

The scaphoid is one of the carpal bones located in the wrist. It plays a crucial role in the stability and movement of the wrist joint. Shape of the scaphoid is boat-shaped, which is reflected in its name, derived from the Greek word "skaphos", meaning boat. It has a complex shape with concave and convex surfaces, making it prone to fractures. Articulations The scaphoid articulates with the following bones: Proximally: Radius Medially: Lunate Distally: Trapezium and trapezoid Laterally: Occasionally with the capitate The scaphoid facilitates wrist motion, including flexion, extension, and radial/ulnar deviation.It acts as a link between the proximal and distal rows of carpal bones, playing a key role in load transmission across the wrist.Fractures: Commonly occur at the waist of the scaphoid. These fractures can disrupt blood supply, leading to delayed healing or nonunion. Avascular Necrosis (AVN): Most often affects the proximal pole due to its limited blood supply. Tenderness in the Anatomical Snuffbox: Often indicates a scaphoid fracture.

PARTS OF SCAPHOID

The scaphoid, a small carpal bone located on the thumb side of the wrist, has several anatomical regions critical for its function and clinical significance. These regions include: Proximal PoleLocated closer to the forearm. Articulates with the radius. Has limited vascular supply, making it prone to avascular necrosis in case of fractures. Distal Pole Located farther from the forearm, toward the hand. Articulates with the trapezium and trapezoid bones. Has a better blood supply compared to the proximal pole. Waist The narrowest part of the scaphoid, located between the proximal and distal poles. The most common site of scaphoid fractures.TubercleA small projection on the palmar surface of the scaphoid near the distal pole. Serves as an attachment point for ligaments and contributes to the carpal tunnel structure.Each part of the scaphoid plays a vital role in wrist motion and stability, and fractures or injuries to specific areas can affect function and healing differently.

BLOOD SUPPLY OF SCAPHOID

The scaphoid bone, located in the wrist, has a unique blood supply that is crucial for its function and healing potential. Its vascularity is primarily derived from two sources:

1. **DORSAL BRANCH OF THE RADIAL ARTERY:**The majority of the blood supply to the scaphoid comes from branches of the radial artery.The dorsal carpal branch of the radial artery enters the scaphoid through its dorsal surface, supplying about 70-80% of the bone, particularly the proximal pole.
2. **PALMAR BRANCH OF THE RADIAL ARTERY:**A smaller portion of the blood supply comes from the palmar carpal branch of the radial artery, which supplies the distal pole and some of the scaphoid's waist.

CLINICAL RELEVANCE

The retrograde blood flow from the dorsal branches is significant. This means blood flows from the distal to the proximal pole.The proximal pole is particularly susceptible to avascular necrosis (AVN) following fractures, as its blood supply is limited and depends heavily on retrograde flow.Fractures at the waist or proximal pole of the scaphoid are at higher risk of non-union or delayed healing due to compromised vascularity.Understanding this unique blood supply is critical for diagnosing and managing scaphoid fractures effectively.

WHY TO OPERATE SCAPHOID

Operating on a scaphoid is typically necessary in cases where the bone, located in the wrist, is fractured or injured and cannot heal properly without surgical intervention. Here are the main reasons for operating on the scaphoid:Poor Blood Supplythe scaphoid has a limited blood supply, particularly to its proximal pole. This makes it prone to delayed healing (delayed union) or failure to heal (nonunion) if fractured.Surgery ensures stabilization and promotes blood flow to aid healing.

2.DISPLACED FRACTURE

If the bone fragments are misaligned (displaced), they need to be realigned (reduced) and stabilized with screws or pins. Surgery ensures precise alignment to restore wrist function.Nonunion or Malunionif a scaphoid fracture does not heal (nonunion) or heals improperly (malunion), surgery may be required to correct the issue. These conditions can lead to chronic pain, stiffness, and arthritis if left untreated.Avascular Necrosis (AVN)Poor blood supply to the scaphoid can result in the death of the bone tissue (AVN). Surgical intervention, such as a vascularized bone graft, can restore blood flow and save the bone.Chronic Pain or InstabilityPersistent pain, weakness, or instability in the wrist due to an untreated or improperly healed scaphoid fracture may necessitate surgery to improve function.Prevention of Long-Term ComplicationsA poorly healed scaphoid fracture can lead to scaphoid non-union advanced collapse (SNAC) wrist, characterized by progressive arthritis. Surgery can help avoid or delay these complications.

Common Surgical Techniques:

- **INTERNAL FIXATION:** Using screws or pins to stabilize the bone.
- **BONE GRAFTING:** Transplanting bone tissue to stimulate healing.

©2025Int. J. LifeSci.Biotechnol.Pharma.Res.

International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 14, No. 3, March 2025 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.3.2025.170

- **ARTHROSCOPY:** Minimally invasive surgery to address complex fractures.

Timely surgical intervention ensures proper healing, reduces complications, and restores wrist function and strength.

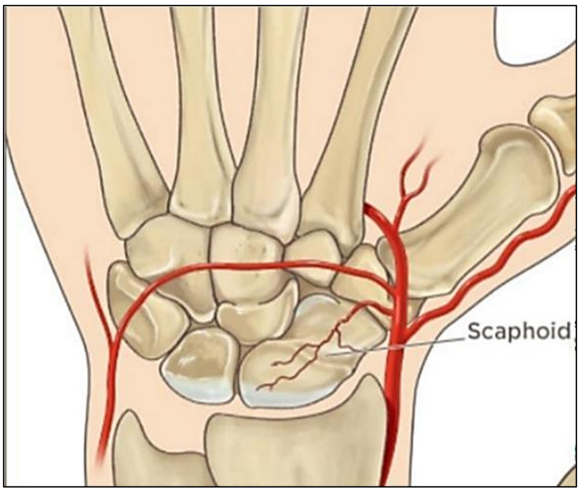

Fig 1: Blood Supply of Scaphood

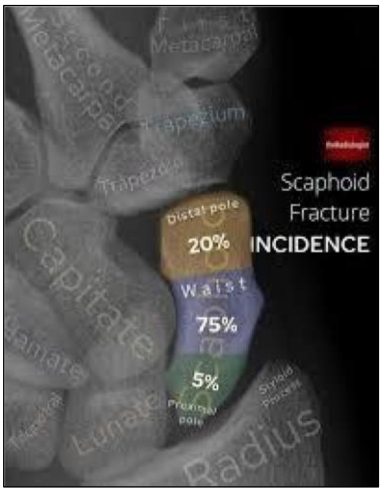

Fig 2: Parts of Scaphoid

Fig 3: X-rays of Herbert screw fixation in scaphoid

MATERIALS AND METHODS

Between 2023 to 2024,30 Patients underwent operative procedure forfracture scaphoid in our department.21 Male and 9 Female withmean age of 28 years (Range,20-40Years) of which 2 patients lost to follow UP,with dominant hand 18 patients,non-dominant hand 10, were available for clinical andradiological assessment.

Involvement in road traffic accidents was the most common modeof injury followed by simple fall.The right scaphoid was injuredin 18 patients and left scaphoid in 12 patients. Initial radiological investigation consisted of 3 views; Hand (AP and Oblique view) andscaphoid stress view.Acute traumatic cases were taken with injury less than in a week.

INCLUSION CRITERIA

- Isolated scaphoid fractures.
- Age less than 50 years.
- Isolated scaphoid waist fractures.

EXCLUSION CRITERIA

- Age more than 50 years.
- Scaphoid fractures with perilunate fracture, scaphoid fractures with distal end radius.
- Scaphoid fractures with nerve injury, compartment syndrome.

©2025Int. J. LifeSci.Biotechnol.Pharma.Res.

International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 14, No. 3, March 2025 Online ISSN: 2250-3137
Print ISSN: 2977-0122
DOI: 10.69605/ijlbpr_14.3.2025.170

PROCEDURE: PERCUTANEOUS HERBERT SCREW FIXATION FOR SCAPHOID FRACTURE

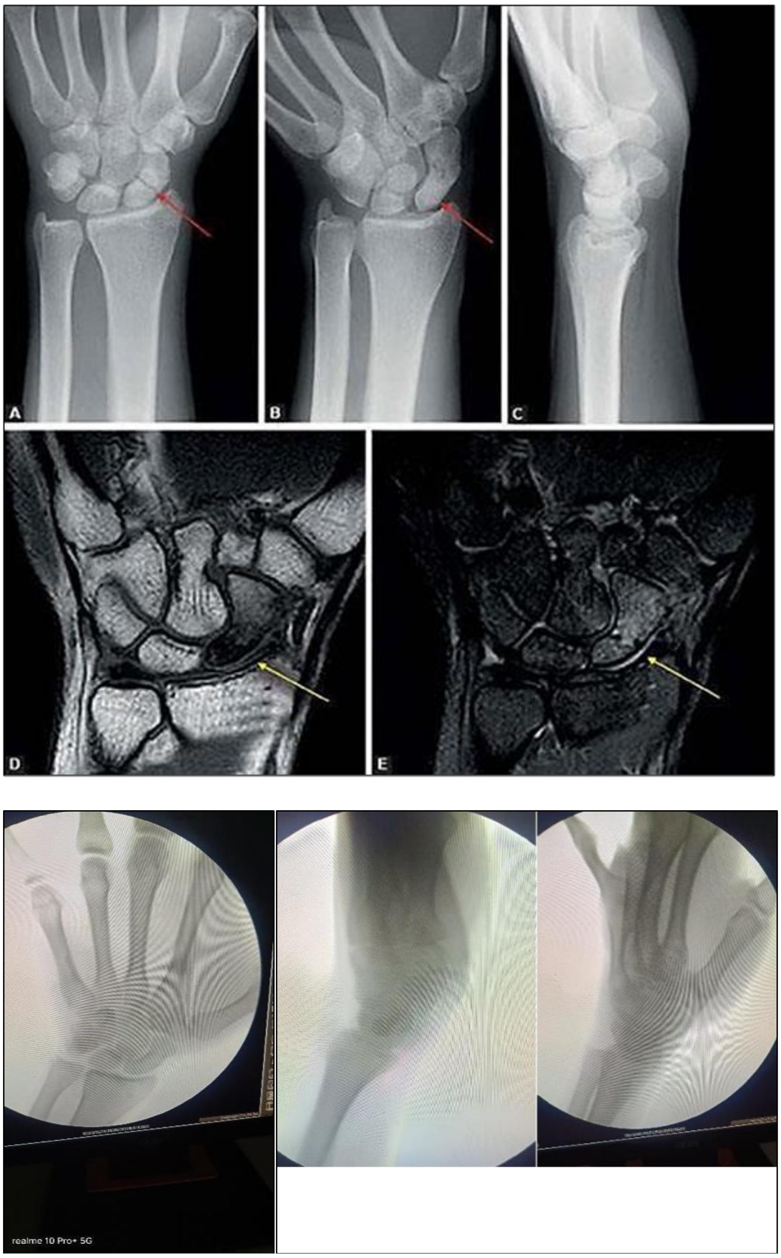

Fig 4: Fracture scaphoid

POSITIONING AND ANESTHESIA

- The patient was positioned supine on the operating table.
- Under strict aseptic precautions and a brachial block, the procedure was performed.

PREOPERATIVE PLANNING AND MARKING

- Skin markings were made on the volar aspect of the wrist, aligned with the central axis of the scaphoid.
- In a mid-prone position, an additional marking was made on the dorsal aspect of the hand along the scaphoid's central axis.
- The intersection of these lines determined the entry point for the guidewire.

SURGICAL TECHNIQUE

1. INCISION AND EXPOSURE

- A skin incision was made at the marked entry point.

2. REDUCTION MANEUVERS

- Hyperextension and ulnar deviation of the wrist, combined with thumb traction, facilitated fracture reduction.
- Ulnar deviation of the wrist also slid the scaphoid out from the radial styloid process. In this position, under image intensifier control, a 0.5-cm longitudinal incision was made at its most distal radial aspect.

©2025Int. J. LifeSci.Biotechnol.Pharma.Res.

DOI: 10.69605/ijlbpr_14.3.2025.170

- Blunt dissection was used to expose the distal pole of the scaphoid.

3. GUIDEWIRE PLACEMENT

- Under fluoroscopic guidance (IITV), a guidewire was inserted through the proximal pole of the scaphoid.
- A 1.1-mm percutaneous guidewire was introduced into the scaphoid, with great care taken to avoid bending the thin wire. It was directed in two views toward the center of the proximal pole of the fractured scaphoid and advanced until it arrived in an adequate position on both views.
- This required an appreciation of the 45° obliquity of the scaphoid in both anteroposterior and lateral planes. The guidewire track was angled 45° dorsally and 45° medially, along the mid-axis of the scaphoid.

4. DRILLING AND REDUCTION

- Drilling was performed over the guidewire.
- The length of the guidewire within the scaphoid was determined by a depth gauge. The drill was inserted using a guide to protect the soft tissues. Central screw placement is crucial because it is more biomechanically stable.
- Traction and manipulation ensured accurate fracture reduction.

5. FIXATION

- A Herbert screw was inserted to maintain alignment and stabilize the fracture.
- A self-tapping, 3-mm Herbert screw was introduced under intensifier control, and the guidewire was removed. Compression was confirmed by image intensifier.
- The end of the screw was buried beneath the distal surface of the scaphoid to avoid damage to the scaphotrapezial joint. A 20-mm screw was sufficient in almost all cases, with an 18-or 22-mm screw used in a few.

CLOSURE AND POSTOPERATIVE CARE

- The surgical site was irrigated with saline to ensure cleanliness.
- Skin closure was performed using appropriate sutures.
- The procedure was completed with intact distal neurovascular status confirmed.

INTRAOPERATIVE IMAGING

- Fluoroscopic imaging was used throughout the procedure to confirm the guidewire trajectory, reduction quality, and screw placement.

OUTCOME

- The fixation achieved stable alignment of the fracture, with no intraoperative complications.

Fig 5: Herbert screw fixation in scaphoid

Fig 6: Anatomical landmarks of scaphoid

POSTOPERATIVE CARE

A volar thumb slab splint was applied for approximately 2 weeks. Patients were advised to elevate the operated-on limb during the first days postoperatively to control swelling.

Nonsteroidal anti-inflammatory drugs and pain

©2025Int. J. LifeSci.Biotechnol.Pharma.Res.

DOI: 10.69605/ijlbpr_14.3.2025.170

medications were prescribed for postoperative swelling and pain control, respectively. The first postoperative follow-up visit occurred at 2 weeks. Active wrist range of motion was begun and was accompanied by hand grip exercises, provided no weight lifting occurred. After that, follow-up visits occurred every 4 weeks. At each follow-up visit, radiographs were obtained to assess fracture healing. The duration of follow-up depended on radiographic fracture healing and clinical evaluation.

RESULTS

A total of 30 patients were included in our study. Among these, 2 patients were lost to follow-up,reducing the final study population to 28 patients. The study utilized the modified Mayo wrist score to evaluate outcomes, providing a comprehensive assessment of wrist function and patient recovery. Fractures were considered consolidated based on follow-up radiographs taken in multiple planes, showing significant trabeculation crossing the fracture site and an absence of pain at the affected area. Radiologic confirmation of union was observed in 27 cases, and 1 patient show non-union.

The duration for patients to return to work ranged from 2 months, depending on the nature of their occupation. For more physically demanding activities, such as active sports, the return period ranged from 6 to 8 months. This delay was attributed primarily to the need for clear radiographic evidence of fracture union before resuming high-impact activities. At the 6-week follow-up, all patients achieved full flexion, extension, and ulnar deviation. Radial deviation, initially lagging behind, was equal to the contralateral side by 3 months in 12 patients and by 4 months in 3 patients, reflecting a gradual but consistent recovery pattern.

Grip strength also demonstrated a significant recovery trajectory. The mean power grip reached 90% of the contralateral hand by 6 weeks postoperatively and improved further to 98% by the 12-month mark. Pinch grip strength, on the other hand, showed a rapid return to normal levels, with the mean value equaling the contralateral side by 6 months. These findings underscore the efficiency of the treatment and rehabilitation process in restoring functional hand strength.

The average postoperative modified Mayo wrist score was 98, with a range of 95 to 100, indicating excellent outcomes for the majority of the patients. No postoperative complications, such as wound infection, reflex sympathetic dystrophy, scar-related pain or hypertrophy, hardware failure or loosening, malunion, or avascular necrosis, were observed during the follow-up period. Furthermore, there was no radiographic evidence of scapholunate instability or osteoarthritis at the site of screw insertion.

Mild postoperative pain was reported by 4 patients at the 6-month mark, specifically during terminal full flexion and extension of the wrist. However, this discomfort resolved entirely by the end of the 12-month follow-up. These results reflect not only the technical success of the surgical intervention but also the overall safety and efficacy of the approach in facilitating recovery and minimizing long-term complications.

DISCUSSION

The Herbert screw has proven to be an effective method for treating scaphoid fractures that have failed to unite or exhibit features indicating a poor prognosis with conservative treatment[7]. While conservative management achieves union in approximately 90% of cases (Böhler, Trojan, and Jahna, 1954; London, 1961; Cooney, Dobyns, and Linscheid, 1980), the process requires prolonged immobilization lasting several months[8]. In cases where conservative treatment fails, the Matti-Russe bone graft procedure is a reliable alternative, with an 85% success rate.(russe1960;D green 1985, Mulder, 1968; Trojan, 1974)However, this method also demands extended immobilization, often up to six months[9]. The Herbert screw facilitates quicker union, significantly reduces postoperative immobilization periods, and allows patients to return to their daily activities much earlier[10].

To ensure optimal results with the Herbert screw, careful attention must be given to the alignment of the apparatus during surgery[11]. Specifically, the distance between the tip of the drill and the spike on the fixation arm should not exceed 2 mm when the drill is fully inserted[12]. Testing of the surgical equipment has occasionally revealed gaps of over 4 mm due to either a deformed jig or a shortened drill. If such errors occur, the use of a shorter screw may lead to inadequate fracture compression, as the leading thread fails to grip the proximal pole effectively[13]. Therefore, surgeons are advised to verify the distance between the fully inserted drill tip and the fixation spike before each procedure.

Radiological union following Herbert screw fixation has been consistently successful, as demonstrated in 27 of 28 cases in this series and supported by similar findings in the literature (Herbert and Fisher, 1984; Bunker *et al*., 1987)[14]. Internal fixation not only expedites bone healing but also reduces the need for extensive postoperative immobilization. Percutaneous, minimally invasive techniques offer additional benefits by preserving thepalmar ligament complex and local vascularity. This method avoids complications associated with open surgical approaches, such as reflex sympathetic dystrophy, painful scars, and prolonged immobilization[15]. In a study of percutaneous treatment, union was achieved in all patients within a mean of 57 days, ranging from 35 to 70 days[16]. Post-union outcomes included restored range of motion, grip strength at 98% of the contralateral side within three months, and return to sedentary work within four days and manual labour within five weeks[17].

©2025Int. J. LifeSci.Biotechnol.Pharma.Res.

DOI: 10.69605/ijlbpr_14.3.2025.170

Central screw placement is crucial for achieving optimal results, with both volar and dorsal portals available for entry[18]. The volar approach is often preferred due to its ease of entry point detection, reduced risk of damage to the radiocarpal joint and extensor tendons, and stabilization of fractures in extension. This approach is particularly advantageous for fractures near the distal pole, whereas the dorsal approach may be better suited for proximal fractures[19]. Nevertheless, each approach carries specific risks. The dorsal approach may endanger the extensor tendon and posterior interosseous nerve, while the volar approach poses risks to the superficial palmar arch and recurrent branch of the median nerve. A mini-incision technique can mitigate these risks[20]. Research suggests no significant difference in clinical outcomes, union times, and gripping or pinching strength between volar and dorsal approaches (Polsky *etal*., 2016; Jeon *et al*., 2017).
Controversy exists over the entry point for volar screw placement-whetherto enter through the trapezium or avoid it. Cadaveric studies indicate that the transtrapezial approach reliably achieves central positioning of the screw in both proximal and distal poles, offering biomechanical advantages[21]. However, this technique risks scaphotrapezial joint damage, leading many to advocate for an entry point that bypasses this joint[22]. Open techniques are generally recommended for treating delayed scaphoid fractures, as bone grafts are often necessary Kamineni S, LAW C. Percutaneous fixation of scaphoid fractures: An anatomical study. Journal of Hand Surgery. 1999 Feb;24(1):85-8.
Defining union remains a topic of debate, with many studies relying on radiological evidence at the end of immobilization or shortly thereafter (Stewart, 1954; London, 1961; Eddeland*et al*., 1975; Cooney *et al*., 1980; Leslie and Dickson, 1981; Morgan and Walters, 1984; Langhoff and Andersen, 1988; Gellman *et al*., 1989). Some researchers accept cases where the fracture line remains visible (Goldman, Lipscomb, and Taylor, 1969)[23]. The findings presented here confirm that internal fixation provides superior functional outcomes compared to traditional bone grafting techniques (Warren-Smith and Barton, 1988). This improvement is attributed to the precise reconstruction of the scaphoid and the benefits of early postoperative mobilization. Notably, functional improvements are maintained even in cases of persistent nonunion (Dent *et al*., 1992), supporting the use of internal fixation, even for ischaemic nonunion (D3). In our study we found only 1 case underwent in non-union which needed revision surgery of bone grafting[24].
There are certain limitation of our study as it is retroscpective study. Scaphoid fractures are the most common fractures of the carpal bones, accounting for approximately **70% to 80% of all carpal fractures** and **2% to 7% of all fractures** in the body. Due to this we have small sample size. There is no any radiological confirmation for early detection of union. Limited choices of implants[25].

CONCLUSION

Percutaneous screw fixation of scaphoid fractures has become increasingly popular due to advancements in instrumentation, low morbidity, and excellent clinical outcomes. This technique eliminates the need for prolonged cast immobilization, enabling a quicker return to work and sports activities compared to conservative treatment. It is particularly advantageous for young, active individuals, offering faster union times and an accelerated recovery process.

REFERENCES

1. Cooney WP, Linscheid RL, Dobyns JH. Scaphoid fractures: problems associated with nonunion and avascular necrosis. Orthopedic Clinics of North America. 1984 Apr;15(2):381-91.
2. Böhler L, Trojan E, Jahna H. The results of treatment of 734 fresh, simple fractures of the scaphoid. Journal of Hand Surgery. 2003 Aug;28(4):319-31.
3. Mulder JD. The results of 100 cases of pseudarthrosis in the scaphoid bone treated by the Matti-Russe operation. The Journal of Bone & Joint Surgery British Volume. 1968 Feb;50(1):110-5.
4. Stark A, Broström LK, Svartengren G. Scaphoid nonunion treated with the Matti-Russe technique long-term results. Clinical Orthopaedics and Related Research®. 1987 Jan;214:175-80.
5. Ford DJ, Khoury G, El-Hadidi S, Lunn PG, Burke FD. The Herbert screw for fractures of the scaphoid. A review of results and technical difficulties. The Journal of Bone & Joint Surgery British Volume. 1987 Jan;69(1):124-7.
6. Kamineni S, Law C. Percutaneous fixation of scaphoid fractures: An anatomical study. Journal of Hand Surgery.1999 Feb;24(1):85.
7. Barton NJ. Twenty questions about scaphoid fractures. Journal of hand surgery. 1992 Jun;17(3):289-310.
8. Evans S, Brantley J, Brady C, Salas C, Mercer D. Structures at risk during volar percutaneous fixation of scaphoid fractures: a cadaver study. The Iowa orthopaedic journal. 2015;35:119.
9. Herbert TJ, Fisher WE. Management of the fractured scaphoid using a new bone screw. The Journal of Bone & Joint Surgery British Volume. 1984 Jan;66(1):114-23.
10. Cooney WP, Dobyns JH, Linscheid RL. Nonunion of the scaphoid: analysis of the results from bone grafting. The Journal of hand surgery. 1980 Jul;5(4):343-54.
11. Gehrmann SV, Grassmann JP, Wild M, Jungbluth P, Kaufmann RA, Windolf J,*et al*. Treatment of scaphoid waist fractures with the HCS screw. GMSInterdisciplinary Plastic and Reconstructive Surgery DGPW, 2014, 3.

©2025Int. J. LifeSci.Biotechnol.Pharma.Res.

Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.3.2025.170

12. Smith EJ, Ellis RE, Pichora DR. Computer-assisted percutaneous scaphoid fixation: concepts and evolution. Journal of wrist surgery. 2013 Nov;2(04):299-305.
13. Haddad FS, Goddard NJ. Acute percutaneous scaphoid fixation: a pilot study. The Journal of Bone & Joint Surgery British Volume. 1998 Jan;80(1):95-9.
14. Vanhees M, Van Riet RR, 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. Journal of wrist surgery. 2017 Aug;6(03):183-7.
15. Gurbuz Y, Kayalar M, Bal E, Toros T, Kucuk L, Sugun T. Comparison of dorsal and volar percutaneous screw fixation methods in acute Type B scaphoid fractures. Acta Orthopaedica et Traumatologica Turcica; 2012.
16. Polsky MB, Kozin SH, Porter ST, Thoder JJ. Scaphoid fractures: dorsal versus volar approach. Orthopedics. 2002 Aug;25(8):817-9.
17. Jeon IH, Micic ID, Oh CW, Park BC, Kim PT. Percutaneous screw fixation for scaphoid fracture: a comparison between the dorsal and the volar approaches. The Journal of hand surgery. 2009 Feb;34(2):228-36.
18. Wozasek GE, Moser KD. Percutaneous screw fixation for fractures of the scaphoid. The Journal of Bone & Joint Surgery British Volume. 1991 Jan;73(1):138-42.
19. Iacobellis C, Baldan S, Aldegheri R. Percutaneous screw fixation for scaphoid fractures. Musculoskeletal surgery. 2011 Dec;95:199-203.
20. Chen AC, Lee MS, Ueng SW, Chen WJ. Management of late-diagnosed scaphoid fractures. Injury. 2010 Jun;41(6):e10-4.
21. McQueen MM, Gelbke MK, Wakefield A, Will EM, Gaebler C. Percutaneous screw fixation versus conservative treatment for fractures of the waist of the scaphoid: a prospective randomised study. The Journal of Bone & Joint Surgery British Volume. 2008 Jan;90(1):66-71.
22. Rankin G, Kuschner SH, Orlando C, McKellop H, Brien WW, Sherman R. A biomechanical evaluation of a cannulated compressive screw for use in fractures of the scaphoid. The Journal of hand surgery. 1991 Nov;16(6):1002-10.
23. Rankin G, Kuschner SH, Orlando C, McKellop H, Brien WW, Sherman R. A biomechanical evaluation of a cannulated compressive screw for use in fractures of the scaphoid. The Journal of hand surgery. 1991 Nov;16(6):1002-10.
24. Adla DN, Kitsis C, Miles AW. Compression forces generated by Mini bone screws-a comparative study done on bone model. Injury. 2005 Jan;36(1):65.
25. Ledoux P, Chahidi N, Moermans JP, Kinnen L. Percutaneous Herbert screw osteosynthesis of the scaphoid bone. Acta Orthopaedica Belgica. 1995 Jan;61(1):43-7.

©2025Int. J. LifeSci.Biotechnol.Pharma.Res.