MINIMALLY INVASIVE PERCUTANEOUS FIXATION OF DELAYED AND NON-UNITED SCAPHOID FRACTURES

Thesis

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List of abbreviations

- AP……………………………………antero-posterior
- AVN……………………………… avascular necrosis
- CT…………………………… computed tomography
- DISI…………………………………dorsal intercalated segment instability
- FOOSH……………………………fall on outstretched hand
- MRI………………………………magnetic resonance imaging
- OP…………………………………osteogenic protein
- PA…………………………………postero-anterior
- PCSF………………………………percutaneous scaphoid fixation
- PEMF………………………………pulsed electromagnetic field
- PRWE……………………………………patient rated wrist evaluation
- ROM……………………………………range of motion
- SNAC………………………………scaphoid non-union advanced collapse
- TFCC……………………………..triangular fibro-cartilage complex
- VAS……………………………………visual analogue score
- VISI……………………………………volar intercalated segment instability

Abstract

Scaphoid nonunions pose a great challenge to surgeons because of the multiple factors that may contribute to their causation. The etiology of the nonunion may be because of anatomic variations, fracture configuration, vascular problems, underlying metabolic problems, or the inadequacy of initial treatment. Percutaneous management of scaphoid nonunions offers the advantage of inducing minimal trauma to the soft tissues while adequately stabilizing the fracture site to induce union in a high percentage of cases. This study proves that percutaneous fixation of delayed or nonunited scaphoid fractures result in predictable satisfactory union rate and functional outcome, it proves that percutaneous Herbert's screw insertion carries no risk of damage to soft tissues or vascular supply. Also, the gap is not the determinant of time to union but actually it is the time since injury; the longer the time since injury the longer the time to union as long as the scaphoid alignment is maintained i.e. no humpback deformity (Slade & Dodds grade I-V).

Key words: (Scaphoid nonunion – Percutaneous – Herbert Screw)

Introduction

Fractures of the scaphoid are common and affect predominantly young and productive individuals. The highly mobile scaphoid plays a critical role in coordinating the kinematics of the two carpal rows and is subject to considerable compressive, rotational, and shear forces during hand and wrist motion. In addition, the scaphoid has a peculiar and limited retrograde blood supply that is vulnerable to disruption by trauma; consequently, scaphoid fractures are prone to a high rate of delayed union and non-union that may advance to wrist osteoarthritis if left untreated. [1]

Open treatment and bone grafting for nonunions has an established track record. The advantage of these techniques is that they allow direct visualization of the fracture fragments for freshening, reduction, and correction of associated deformities, however, an open operative approach is well recognized for some disadvantages, including the need to expose and divide the palmar radiocarpal ligaments, the potential for interruption of the already tenuous blood supply, as well as the possibility of a hypertrophic and painful scar at the wrist crease ,so the application of minimally invasive procedures for scaphoid nonunion attempts to combine appropriate reduction and rigid fixation with minimal disruption of the soft tissues [2, 3]

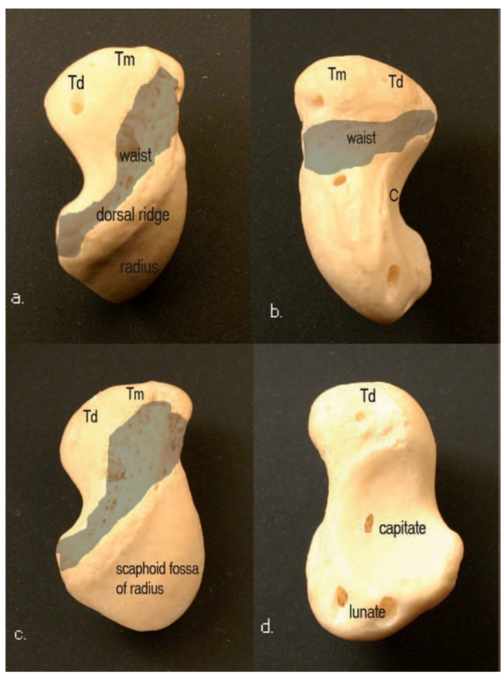
It is important to understand that minimally invasive techniques are not applicable to all types of scaphoid nonunion; essentially, minimally invasive surgery is indicated for scaphoid non unions without collapse of the scaphoid architecture, and without complete AVN of the proximal pole. These fractures usually have a cartilaginous shell intact externally and have a normal scapholunate angle without a humpback deformity allowing the use of cannulated headless screw which is the most popular method of fixation .[3, 4]

Aim of work

This study is targeting at the evaluation of the functional outcome after minimally invasive operative management of delayed or non-united fractures of the scaphoid and determining the factors on which the results depend upon and the way of determination of the suitable functional decision.

ANATOMICAL AND BIOMECHANICAL BACKGROUND

The scaphoid bone is the largest bone in the proximal carpal row with irregular shape (twisted peanut). Its proximal half is a thin concavo-convex element covered with articular cartilage except along its dorsal rim and at the attachment of the scapholunate ligament. The distal half is wider transversely, ending in an ovoid articular surface for the trapezio-trapezoidal surfaces. Palmarly, it is extended as the tuberosity for ligamentous insertions. The proximal segment appears to have been twisted into 20° of supination and 30° of ulnar angulation with respect to the distal half (Fig 1).(5)



Fig(1):Scaphoid anatomy: (a) dorsal view, (b) volar view, (c) lateral view, (d) medial view. The articular surfaces are labelled: Tm – Trapezium, Td – Trapezoid, C – Capitate. The waist (shaded area). (6)

Position:

It is an intercalated segment between the radius and the distal carpal row (Fig 2).

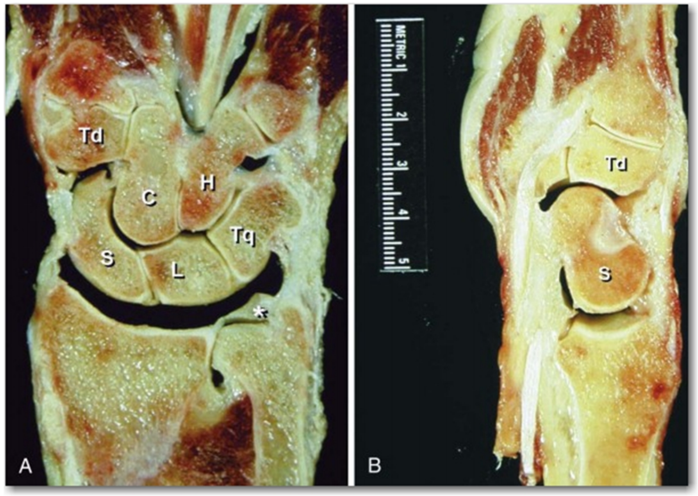


Fig (2): **A,** Frontal section of a wrist specimen, showing the proximal row of the carpus intercalated between the distal row and the two forearm bones. **B,** Sagittal section of the wrist along the lateral column. The scaphoid appears obliquely oriented relative to the long axis of the forearm. (7)

The morphological and morphometric variations of the scaphoid

Heinzelmann and colleagues performed morphometric evaluation of the human scaphoid, measuring the long axis from the proximal pole to the distal articular surface. Male scaphoids were significantly longer (by 4 mm) than female specimens and were also significantly wider in their proximal pole than the female specimens. When considering operative fixation from an antegrade approach, the authors suggested that small screw sizes may be necessary for female patients, as many of the commercially available standard screws are larger than the proximal pole of the female scaphoid. (8)

A cadaveric study used 200 scaphoid bones (100 left and 100 right) to assess morphological and morphometric parameters. The tubercle and the dorsal sulcus were present in all instances. There were significant variations in the circumferences of the waist and the height of the tubercle (Fig. 3 & 4) [9].

Fig (3): Variations of the distal articular surface of the scaphoid. (a) Wide dorsoulnar width with a tapered radiopalmar aspect. (b) Wide dorsoulnar width with a round radiopalmar aspect. (c) Narrow dorsoulnar width with a round radiopalmar aspect [9]

Fig (4): Scaphoid (a) with and (b) without a waist [9]

Vascular supply:

The scaphoid receives blood supply mainly from the radial artery. Vessels enter the limited areas dorsally and palmarly that are non-articular areas of ligamentous attachment (Fig 5).

The dorsal vascular supply accounts for 70-80% of the internal vascularity of the bone and the only vascular supply to the proximal pole. It enters the bone through foramina in the dorsal ridge which is located in the waist of the scaphoid dorsally and extends from the articular surface of the radius to that of trapezium and trapezoid. [10]

The volar blood supply is through the ligaments attached to the tuberosity originating from the palmer branch of the radial artery.

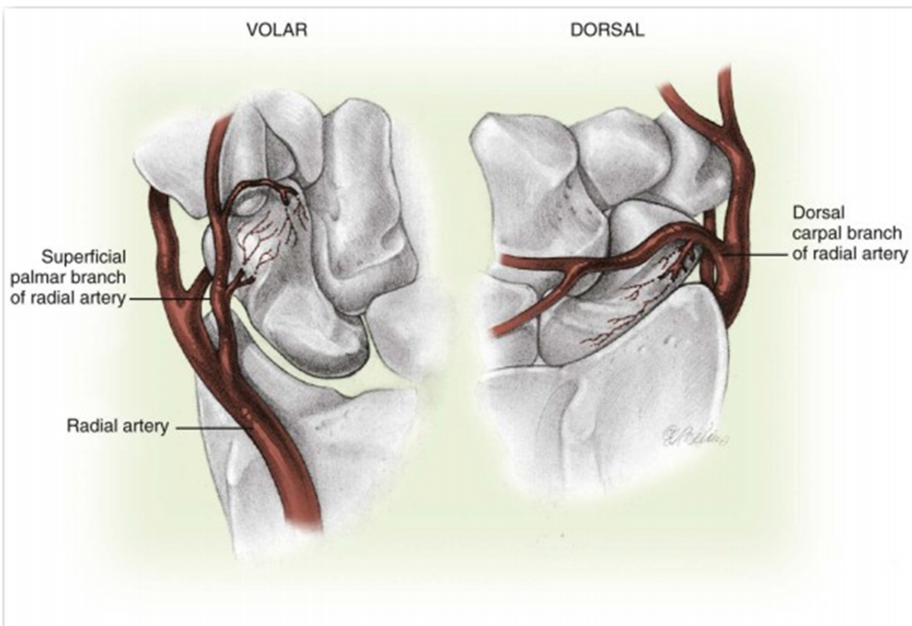


Fig 5: Schematic representation of the blood supply of the scaphoid. [7]

However some studies state that good blood supply of the scaphoid bone from palmar, dorsal and radial vessel groups with a variety of anastomoses was found which should provide sufficient collateral blood flow from adjacent regions in some patients. These studies concluded that inadequate vascularization is unlikely to be the cause of scaphoid nonunion. The palmar and dorsal side had a sufficient blood supply and even the proximal third of the scaphoid, which is prone to necrosis, was supplied by multiple branches of the palmar carpal, superficial palmar, the dorsal scaphoid arteries and was supported by branches from the styloid artery (fig 6). [11, 12]

Fig (6): Three-dimensional analysis of arteriographs of the carpus. (12)

Kinetics and kinematics:

The scaphoid bone is a mobile link between the proximal and distal carpal rows. In rocking from ulnar to radial deviation in the normal wrist, the scaphoid flexes (tuberosity palmar wards) to get out of the way of the radial styloid (fig 7).(13)

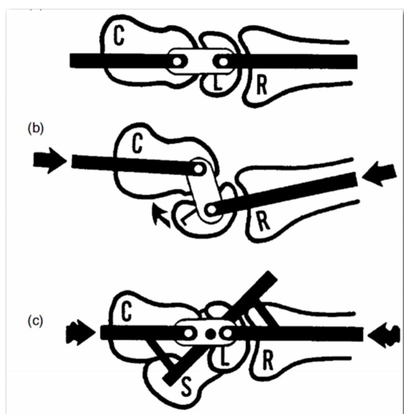


Fig (7): The first mention of a link system between the proximal and distal carpal rows was made by Gilford, Bolton and Lambrinudi (1943). The intercalated segment is the lunate bone. (14)

EVOLUTION OF GAP AND HUMPACK DEFORMITY:

Normally, compression of the scaphoid between the radius and trapezium act to flex the scaphoid and the lunate as well, through the scapholunate ligament complex. The counterbalance to this tendency is the normal action of the triquetrum for extension. If the balancing act fails, the lunate angulates under the more influential neighboring bone. A fracture disrupts the scaphoid influence and allows the lunate to assume an extended position. This Dorsal Intercalated Segment Instability (DISI) may not be immediately apparent, but during protracted inherent compressive forces, the angle between the capitate and lunate increases insidiously. The proximal pole of the scaphoid is also extended through the scapholunate ligament complex. This tends to gap open the fracture site, markedly decreasing the coaptive surfaces through which bony healing would occur. Erosion of the palmar cortices through repetitive micro motion shortens the palmar length. If it should heal in this position, it gives rise to the so-called humpback scaphoid. (Fig 8)

Angulation and displacement are also evident in the coronal plane, usually as an apex radial angulation, and in the transverse plane, as pronation of the distal fragment [7, 11, and16)

Radiographic measures of clinical importance:

Intra-scaphoid angle is suggested to assess the morphology of the scaphoid and to diagnose malunion if it occurs. There are two ways of measuring the inter-scaphoid angle to detect restoration of the accurate alignment of the proximal and distal poles (Fig 9 & 10). [17]

Fig (8): CT scan shows the typical humpback flexion deformity of a sclerotic scaphoid nonunion with cystic degeneration at the nonunion site. [16]