Understanding the Scaphoid Screw

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Cousin and Destor were the first to describe fractures of the scaphoid in 1889.[1] The scaphoid is the most common carpal bone to fracture and is usually the result of forcible extension of the wrist, although flexion and compression may also lead to a fracture of scaphoid occasionally. [1,2] The scaphoid is supplied primarily by branches of the radial artery which penetrate the bone distally and supply 70-80% of the bone proximally. This, along with the small size and presence of persistent bending forces on a fractured scaphoid, is responsible for the high rate of non-union in scaphoid fractures.[3]

The small size, asymmetrical geometry, and a large articular surface presents a challenge in internal fixation of the carpal bone. Many fixation modalities have been developed over the years for scaphoid fractures including K-wires, screws and anatomic plates. Screws are most commonly used implant to fix scaphoid fractures.

It is important to understand the design characteristics and principles of use of the various screws used in the internal fixation of scaphoid fractures.

The small-fragment AO screw (AO Foundation) was the solo available implant for scaphoid fracture fixation until the Herbert screw was introduced in the 1980s. The Asnis III screw (Stryker) was a self-tapping 4.0-mm screw, similar to the AO 4.0 mm cannulated cancellous screw.[4]

In 1984, Herbert and Fisher published their experience with a new type of bone screw which had differential pitch for leading and trailing threads for providing compression.[5] Herbert designed a single piece non-cannulated headless compression screw in order to provide internal compression and stability to the fracture while avoiding any prominence of metal on the articular surface of the scaphoid or its joint space. The Herbert screw gained popularity as subsequent studies by other authors demonstrated satisfactory outcome. The headless design minimizes the risk of soft tissue impingement and cartilage injury.[6] However, compression achieved by the Herbert screw was found to be significantly less than that achieved by the AO and alternative screw designs.[7]

The descriptive generic term headless compression screw (HCS) includes all the designs ranging from the initial Herbert and Herbert Whipple screws to the more recent modifications by various manufacturers like the Twinfix (Stryker), Acutrak (Acumed), and 2.4/3.0 HCS (Synthes).

The original screw designed by Herbert was not cannulated, however the versions currently available from Zimmer are cannulated and hence have slightly larger dimensions and self-tapping leading threads. The Herbert screw has a double thread with a 4.0 mm outside-diameter (OD) trailing thread, 3.0 mm OD leading thread, and 2 mm core diameter.[7]

Herbert screw

The Herbert-Whipple headless compression screw (Zimmer) is a cannulated screw and has a 2.5 mm smooth shank with an outer diameter of 3.9 mm of the trailing thread and a 3.0 mm outer diameter of the leading thread.
The compression in these *differential pitch* screws is achieved because of variable pitch between the leading threads and the trailing threads. [7]

Herbert Whipple screw

In 2006, the Little Grafter screw was introduced as an alternative to metallic screws. It is a polylactide screw—similar to bioresorbable screws used in the fixation of anterior cruciate ligament grafts. The proposed advantages include a similar elastic modulus to that of the bone, preservation of bone stock, and better screw fixation. Like with most bioabsorbable screws, the driver for the Little Grafter screw extends throughout the length of the screw to prevent breakage during insertion.[8]

Little Grafter screw [8]

Recent screw designs have a dual component. In addition to acting as a conventional scaphoid screws, they can achieve additional compression because of a trailing, larger-diameter, threaded component that moves independently. Currently, two of these screws available are—the Kompressor (Integra Life Sciences,) and the TwinFix (Stryker). [9]

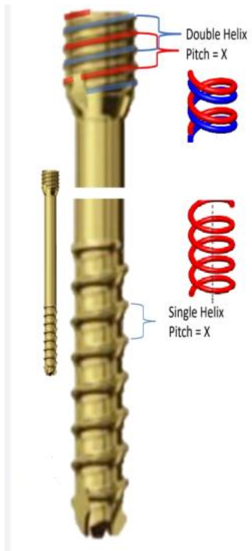
The TwinFix was introduced in the early 2000s and is a variation of the Herbert screw design. The screw is similar in shape; however, after insertion, the trailing end of the screw can be turned independently of the leading part, thereby generating additional compression. The TwinFix screw is a dual-component screw of similar shape to the Herbert screw. Its trailing thread measures 4.2 mm OD, with a leading thread of 3.2 mm OD. The leading part of the screw turns independently of the trailing part. This screw generates compression forces close to those of the Acutrak screw but offers the potential benefit of using smaller drill holes. [9]

Twinfix Screw (https://www.strykermeded.com/media/2338/twinfix.pdf)

The Kompressor screw was introduced later and, although it is similar in principle to the TwinFix, it has the advantage that the smaller, independently rotating component can pass down the shaft and theoretically provide more compression. The Kompressor screw is a dual-component screw with a trailing thread of 5.0 mm OD, a leading thread of 4.0 mm OD. The screw is inserted as one, as with the TwinFix, and then a separate screwdriver is used to turn the larger diameter trailing component over the inner component, thus generating additional compression. The Kompressor Mini screw has a leading thread diameter of 2.8 and a trailing thread diameter of 3.6mm. [9]

Kompressor Mini screw [8]

The 2.4 and 3.0 mm HCS from Depuy Synthes have a 2.4mm/3.0mm leading cancellous thread with self-drilling, self-tapping flutes and 3.1mm/3.5 mm trailing cortical threads separated by a 2.0 mm shaft. The screw pitch is identical in the leading threads and the trailing threads and it *does not* work as a result of differential screw pitch, like the Herbert screw. The leading threads are single helix with a pitch of 1.2 while the trailing threads are double helix, each with an individual pitch of 1.2 mm.

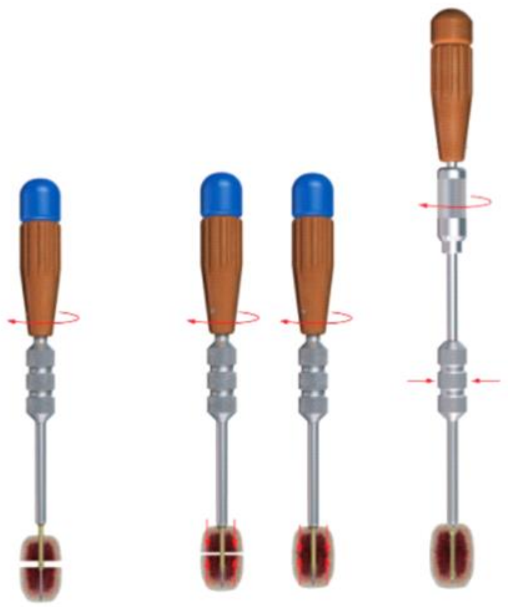


Identical pitch in leading and trailing threads of the Synthes HCS

The mechanism of action of the Synthes headless compression screw is that of a lag screw which is made possible by the use of a compression sleeve during insertion. The screwdriver has a compression sleeve whose tip acts as a conventional lag screw head against the proximal cortex providing compression while the screw is tightened. The tip of the compression sleeve is made flush with the bone and the fracture gap is closed and compressed by turning the sleeve. Once the desired compression is achieved, the screw is countersunk into the bone with the screwdriver while the compression sleeve is held stationary. During countersinking, *no* additional compression is generated. The screwdriver has three markings to enable assessment of the depth to which the screw is countersunk .[10]

Synthes Headless compression screw with insertion technique [10]

Functional principle is lag screw with compression device.



Step 1 Step 2 Step3

Step 1: *Screw insertion*- Insert the screw into the bone with the compression sleeve.

Step 2: *Closure of gap and compression*- Once the tip of the compression sleeve lies on the bone, the fracture gap is closed and compressed by turning the sleeve.

Step 3: *Countersinking*- Once the desired degree of compression is reached, the screw is countersunk into the bone with the screwdriver while the compression sleeve is held stationary. During countersinking, no additional compression is generated.

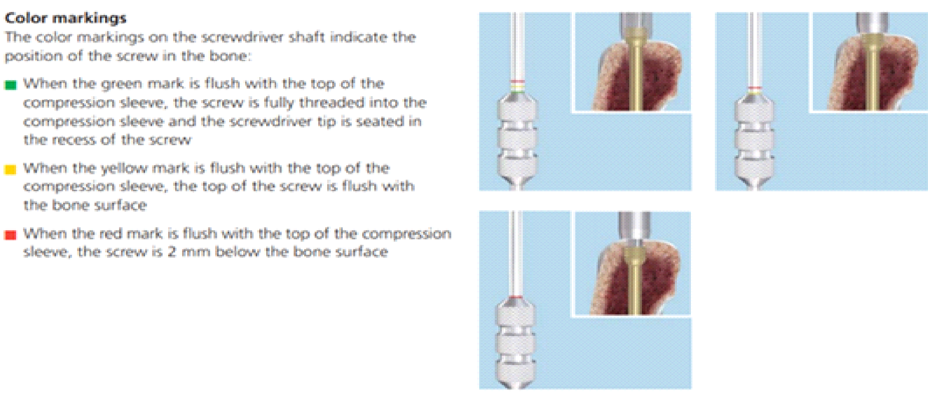
Steps of countersinking: The compression sleeve handle is then removed from the compression sleeve and the cannulated star drive screwdriver is inserted through the compression sleeve to the screw recess.

From this point, the colour markings on the screwdriver can be used to determine depth of countersinking of the screw.

When the green mark is flush with the top of the compression sleeve, the screw is fully threaded into the compression sleeve and the screwdriver tip is seated in the recess of the screw.

The screwdriver is turned slowly till yellow mark is reached against the top of the compression sleeve. When the yellow mark is flush with the top of the compression sleeve, the screw head is flush with the bone surface.

The screwdriver is turned gently to advance the screw till the red mark. When the red mark is flush with the top of the compression sleeve, the screw head is buried 2mm below the bone surface. Further advancement of the screw is halted and the final screw position is verified under image intensifier.[10]



The Acutrak Standard screw (Acumed), introduced in the 1990s, is a conically shaped, self-tapping, fully threaded, cannulated titanium screw with a *variable thread pitch spanning the entire screw*. It has a 4.4-mm OD trailing thread and a 3.0 mm OD leading thread. Increased compression is achieved with each progressive turn.

The large size of this screw somewhat limited its application in cases with small bone fragments and thereafter the Acutrak Mini (Acumed) which is a smaller version of the Acutrak Standard with 2.8 mm leading thread OD and 3.5 mm trailing thread OD was developed. Compression is achieved throughout its insertion because of variable thread pitch and a tapered profile. [11,12]

Acutrak Screw

The second generation headless compression screws, like the Twinfix, Kompressor, Acutrak, and the 3.0/2.4 HCS, generate greater compressive forces and supposedly have improved biomechanical characteristics as compared to the first-generation screws like the Herbert and the Herbert-Whipple. [13]

While Twinfix and Kompressor mini demonstrate loss of compression on overtightening, the Mini-Acutrak2 generates maximum compressive forces without any loss on overtightening. The fastening torque applied by the surgeon may be a misleading estimate of compression across fracture site as there is loss of compression on overzealous tightening in certain screw designs. AO Synthes HCS 3.0 and Herbert-Whipple screws generate the lowest compression. For osteoporotic bones, it is preferred that the second generation HCS are introduced without predrilling as that improves the compressive forces across fracture site.[13]

Conclusion

It is evident that there are a variety of different screws available for scaphoid fracture fixation. All second generation HCS demonstrate greater biomechanical characteristics than the first generation Herbert and Herbert-Whipple screw. Mini-Acutrak2 is estimated to generate the maximum compression and showed no reduction due to over-fastening. All second generation HCS provide increased compression force without pre-drilling, suggesting that a “no predrilling approach” may be preferred in osteoporotic bone.

The surgeon must be familiar with the design features and principles of use of the commonly available screws.

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