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Headless compression screw for horizontal medial malleolus fractures

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ABSTRACT

Background: Horizontal medial malleolus fractures are caused by the application of rotational force through the ankle joint in several orientations. Multiple techniques are available for the fixation of medial malleolar fractures.

Methods: Horizontal medial malleolus osteotomies were performed in eighteen synthetic distal tibiae and randomized into two fixation groups: 1) two parallel unicortical cancellous screws or 2) two Acutrak 2 headless compression screws. Specimens were subjected to offset axial tension loading. Frontal plane interfragmentary motion was monitored.

Findings: The headless compression group (1699 (SD 947) N/mm) had significantly greater proximal-distal stiffness than the unicortical group (668 (SD 298) N/mm), ($P = 0.012$). Similarly, the headless compression group (604 (SD 148) N/mm) had significantly greater medial-lateral stiffness than the unicortical group (281 (SD 152) N/mm), ($P < 0.001$). The force at 2 mm of lateral displacement was significantly greater in the headless compression group (955 (SD 79) N) compared to the unicortical group (679 (SD 198) N), ($P = 0.003$). At 2 mm of distal displacement, the mean force was higher in the headless compression group (1037 (SD 122) N) compared to the unicortical group (729 (SD 229) N), but the difference was not significant ($P = 0.131$).

Interpretation: A headless compression screw construct was significantly stiffer in both the proximal-distal and medial-lateral directions, indicating greater resistance to both axial and shear loading. Additionally, they had significantly greater load at clinical failure based on lateral displacement. The low-profile design of the headless compression screw minimizes soft tissue irritation and reduces need for implant removal.

1. Introduction

Ankle fractures are very common, with an approximate annual incidence of 251 for every 100,000 people in the United States (Amin et al., 2014). By incidence, one-third of all ankle fractures have a horizontal or oblique fracture of the medial malleolus, and horizontal fractures make up 97% of all fractures that have a medial malleolar component (Court-Brown et al., 1998). These fractures are caused by the application of rotational force through the ankle joint in several orientations, including pronation-external rotation, supination-external rotation, and pronation-abduction. The medial malleolus is vital for ankle stability by maintaining ankle articulation and distributing normal loads across the articular surfaces (Patel et al., 2013). Displaced fractures of the medial malleolus are best treated with accurate anatomic reduction followed by rigid internal fixation in order to optimize functional outcomes and prevent late complications, such as osteoarthritis (Griend et al., 1996; Patel et al., 2013; Shimamura et al., 2006). There are a wide variety of techniques available for the internal fixation of medial malleolar fractures, including various configurations of unicortical or bicortical screws, tension band constructs, the mini-fragment T plate, and the medial malleolar sled (Amanatullah et al., 2012; Georgiadis and White, 1995; Rovinsky et al., 2000; Toolan et al., 1994; Wegner et al., 2017). Bioabsorbable implants have been considered as well (Bucholz et al., 1994). However, the optimal method and configuration for fixation is still unclear. Clinically, two parallel 4.0 mm partially threaded cancellous lag screws oriented perpendicular to the fracture line to provide compression are the gold standard for medial malleolus fixation (Fowler et al., 2011; Patel et al., 2013). Tension band fixation is a less commonly used technique that converts tensile forces into compressive forces on the articular side of the medial malleolus, but soft tissue irritation that requires operative implant removal often result from this method of fixation (Brown et al., 2001; Jacobsen et al., 1994; Johnson and Fallat, 1997; Patel et al., 2013).

Headless compression screws have been demonstrated to be a promising alternative to traditional partially threaded lag screws for the fixation of fractures. They have most commonly been used in the

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Fig. 1. Representative anterior-to-posterior (left) and lateral (right) X-rays of the parallel unicortical (top) and headless compression screw (bottom) constructs. Dashed lines indicate osteotomy cuts.

fixation of scaphoid fractures because the screws allow for fixation and compression in cancellous bone (Fowler and Ilyas, 2010). In addition, headless compression screws have been found to provide stable fixation of Hoffa fractures of the distal femur and fractures of small bones such as the capitellum, midfoot, and talar neck (Borse et al., 2010; Elkowitz et al., 2002; Karakasli et al., 2015; Vaishya et al., 2016; Zhang et al., 2012). They have also been shown to be effective in the arthrodesis of the foot, ankle, and hand (Iwamoto et al., 2013; Lucas et al., 2014; Odutola et al., 2012). Headless compression screws produce equivalent fragment compression to partially threaded cancellous screws, while allowing less fragment displacement (Capelle et al., 2013). The absence of a head eliminates hardware exposure, which may reduce soft tissue irritation relative to partially threaded cancellous screws.

There are two types of headless compression screws currently in use: fully threaded and partially threaded. The Herbert screw, a partially threaded screw that was the first generation of headless compression screws (Fowler and Ilyas, 2010; Herbert and Fisher, 1984), have threading of different pitches at each end separated by a smooth shaft in the middle (Reimer et al., 1996). This configuration requires thread purchase in the distal fracture fragment relying on cortical integrity. Newer models of headless compression screws have variable thread pitch angle from the proximal to distal end, permitting compression and fixation of both fragments. Fully threaded headless compression screws do not require an intact distal cortex, as the wide thread diameter along the entire screw length captures cancellous bone in the distal fracture fragment, a significant improvement over the first generation Herbert screws.

Acutrak 2 headless compression screws, a newer generation of headless compression screws, are fully threaded, cannulated, tapered, titanium screws with continuously variable thread pitch and thread angle from tip to tail, which enhances compressive strength and enables the screw to apply interfragmentary compression along its entire length