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Biomechanical evaluation of a second generation headless compression screw for ankle arthrodesis in a cadaver model

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ABSTRACT

Background: Many types of screws, plates, and strut grafts have been utilized for ankle arthrodesis. Biomechanical testing has shown that these constructs can have variable stiffness. More recently, headless compression screws have emerged as an evolving method of achieving compression in various applications but there is limited literature regarding ankle arthrodesis. The aim of this study was to determine the biomechanical stability provided by a second generation fully threaded headless compression screw compared to a standard headed, partially threaded cancellous screw in a cadaveric ankle arthrodesis model.

Materials and methods: Twenty fresh frozen human cadaver specimens were subjected to simulated ankle arthrodesis with either three standard cancellous-bone screws (InFix 7.3 mm) or with three headless compression screws (Acumed Acutrak 2 7.5 mm). The specimens were subjected to cyclic loading and unloading at a rate of 1 Hz, compression of 525 Newtons (N) and distraction of 20 N for a total of 500 cycles using an electromechanical load frame (Instron). The amount of maximum distraction was recorded as well as the amount of motion that occurred through 1, 10, 50, 100, and 500 cycles.

Results: No significant difference ($p = 0.412$) was seen in the amount of distraction that occurred across the fusion site for either screw. The average maximum distraction after 500 cycles was 201.9 μm for the Acutrak 2 screw and 235.4 μm for the InFix screw. No difference was seen throughout each cycle over time for the Acutrak 2 screw (p-value = 0.988) or the InFix screw (p-value = 0.991).

Conclusion: Both the traditional InFix type screw and the second generation Acumed Acutrak headless compression screws provide adequate fixation during ankle arthrodesis under submaximal loads.

Clinical relevance: There is no demonstrable difference between traditional cannulated partially threaded screws and headless compression screws studied in this model.

1. Introduction

Ankle arthrodesis was first described in 1879 by Albert and has proven to be an effective means to treat ankle arthritis [1]. There have been numerous modifications to the surgical technique, with one of the most significant coming from Charnley in 1951 who noted the importance of compressing the joint surfaces to decrease the rate of nonunion [2]. While total ankle arthroplasty is gaining in popularity for the treatment of end stage arthritis of the ankle, many consider ankle arthrodesis the gold standard, providing predictable and consistent pain relief after solid fusion has been achieved [3,4]. Multiple techniques have been described for ankle arthrodesis. Historically, external fixation techniques were utilized with relatively high rates of nonunion, infection and amputation [5–8]. A recent meta-analysis reported the average nonunion rate for ankle arthrodesis to be 10% while utilizing modern surgical technique [9]. The anatomic compression arthrodesis technique using cancellous screws was introduced by Holt in 1991 and emphasized preservation of bony anatomy, minimal bone resection, drilling of the subchondral plate, and rigid multiplanar screw fixation. They reported a 93% union rate in their series of ankles undergoing arthrodesis [10]. Similarly, Zwipp et al. reported a union rate of 99% with favorable functional results at midterm follow-up using four cancellous screws [11].

Many types of screws, plates, and strut grafts have been utilized for ankle arthrodesis and biomechanical testing has shown that

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these constructs can have variable stiffness depending on the bone quality [12–17]. More recently, headless compression screws have emerged as an evolving method of achieving compression in various applications but there is limited literature regarding ankle arthrodesis [18–21]. The objective of this study was to investigate the biomechanical stability provided by a second generation fully threaded headless compression screw (Acumed Acutrak 2 7.5 mm Hillsboro, OR) compared to a standard headed, partially threaded cancellous screw (InFix 7.3 mm partially threaded cancellous screw, Gulf Breeze, FL) in a cadaveric ankle arthrodesis model (Figs. 1 and 2).

2. Methods

Simulated surgical arthrodesis was performed on matched pairs of cadaveric ankle specimens using a standardized multi-planar screw technique. Twenty-two cadaver ankles that ranged in age from 50 to 75 years with no history of previous ankle surgery or deformity were utilized as 11 matched pairs. All specimens were transected through the middle third of the tibia and fibula and distally the talus was disarticulated from the foot. The remaining specimens were then stripped of all soft tissue except for the ankle ligaments including ATFL, AITFL, PITFL and deltoid. The head of the talus was then transected from dorsal to plantar using an oscillating saw to create a flat surface for later mounting. Three screws were utilized for each arthrodesis. The screw configuration starting points on the tibia were posteromedial, anterolateral and posterolateral (Fig. 3). Screw lengths for the first ankle of each pair were determined using a cannulated measuring guide designed for that screw system. Matching screw lengths of each screw used in the first ankle were utilized in the second ankle of each pair, using the other screw system. Each matched pair had one procedure performed using either the Acumed Acutrak 2 (AM) 7.5 mm fully threaded headless compression screws, or the InFix (IF) 7.3 mm partially threaded cancellous cannulated screws. All procedures were performed by a single surgeon. After the three screws were placed, the specimen was firmly clamped proximally on the shaft of the tibia and distally on the talus and subjected to cyclic loading and unloading at a rate of 1 Hz, compression of 525 N and distraction of 20 N for a total of 500 cycles using an Instron Electromechanical Load Frame Model #5565 (Norwood, MA). Five

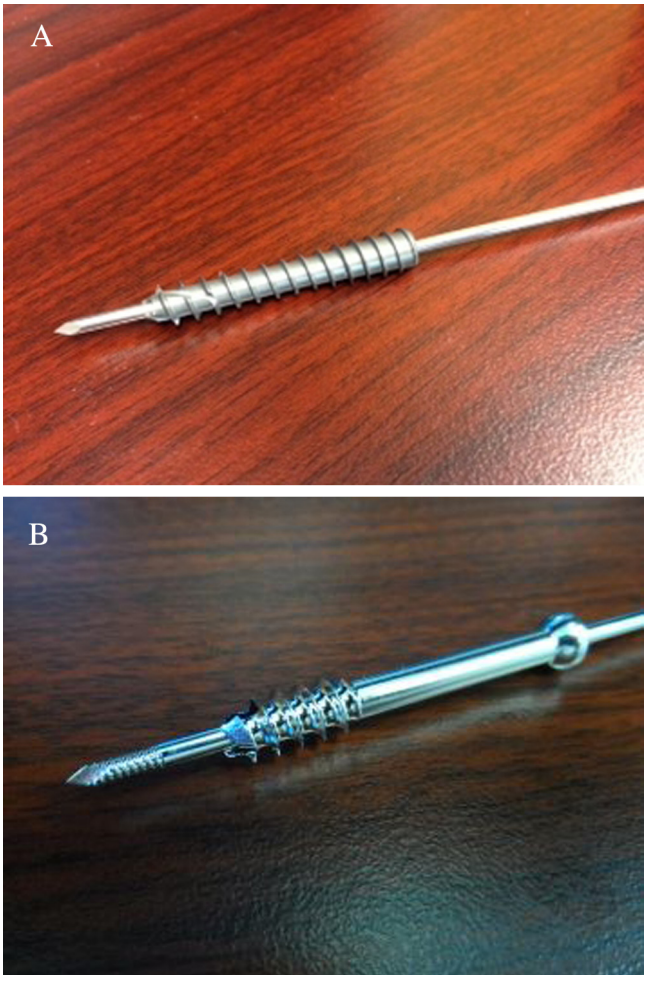

Fig. 1. (A) Acumed Acutrak 2 7.5 mm screw and (B) InFix 7.3 mm screw.

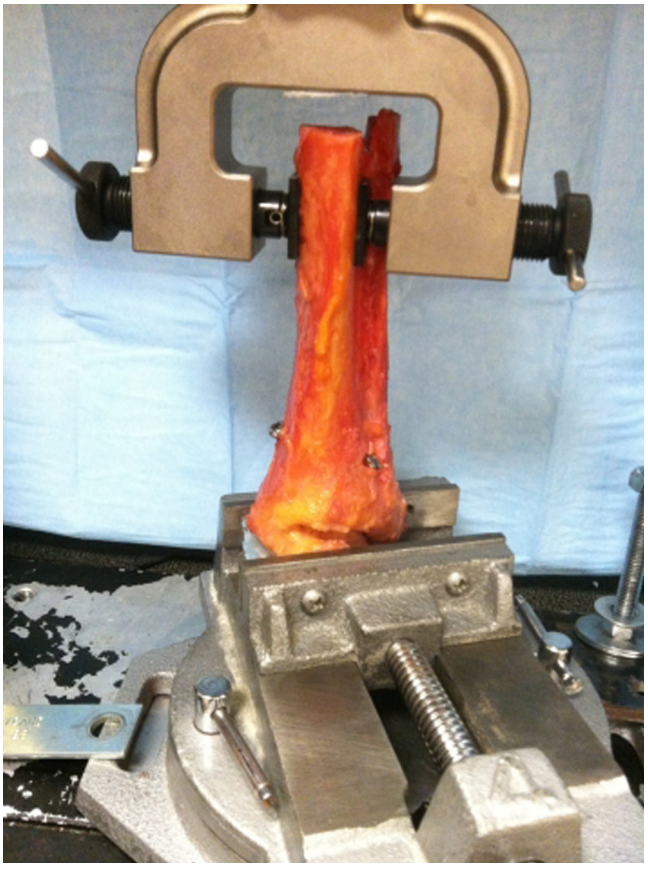

Fig. 2. Testing set-up for ankle arthrodesis cadaver model in Instron machine.

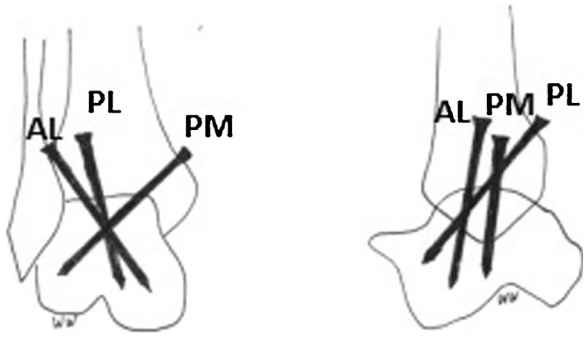

Fig. 3. Screw configuration for ankle arthrodesis: anterolateral (AL), posterolateral (PL), and posteromedial (PM).