

Failure of Depuy Synthes Variable Angle Curved Condylar Plate in the Management of OTA/AO 33-A3 Fractures – Does Filling Open Variable Angle Screw Holes Make a Difference?

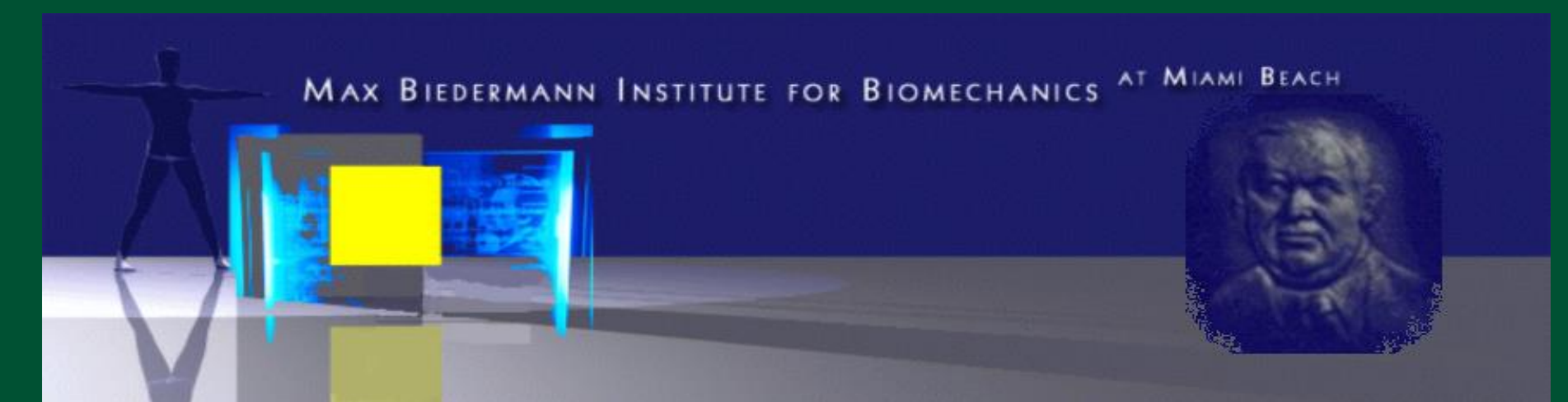
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Introduction

The development of the variable angle locking plate provides multiple advantages in the management of comminuted periarticular fractures of the distal femur. Improved maneuverability of the distal screw cluster allows the surgeon to capture fracture fragments or avoid pre-existing implants. Despite these clear advantages, the senior author of this study noted a consistent pattern of plate failure through the combination hole at the area of comminution of the fracture (fig.1) with the use of Synthes VA locking plates for management of AO type 33-A.3.3 fractures. Notably, this same failure pattern in this particular plate was reported by Tank et al in JOT, January 2016. For comminuted metaphyseal fractures, biomechanical and clinical studies have shown the benefits of bridging the fracture site by a distance of two to three screw holes, thereby decreasing rigidity and allowing for subtle bending motion and increased healing by callus formation. However, stress during loading is concentrated at the open screw holes at the fracture apex, and this is where plate failure is observed – specifically, at the periphery of the “honeycombed” holes used for VA screw placement (figure3). Previous studies in plate biomechanics have shown that such stress concentration can be reduced simply by filling the open screw holes (as with the use of threaded screw head inserts), thereby effectively increasing the cross-sectional area and stiffness of the plate. Thus we hypothesized that the honeycomb combination hole was an area of weakness of the plate and that filling the open combination hole at fracture apex in the VA locking plates would increase fatigue life of the plate when used in the management of AO type 33-A3.3 fractures.



Figure 1

Acknowledgements

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Plates were donated by Depuy Synthes.

Methods

Seven left 4th generation composite sawbones femur models had a left 10-hole Synthes VA locking plate positioned as per manufacturer surgical technique guide and locking screws inserted into the distal screw cluster, as well as in four of the first 7 proximal holes (1,3,5, and 7). A 4cm osteotomy was then created in order to simulate an AO type 33-A.3.3 metaphyseal comminuted fracture, such that the 8th and 9th holes from the proximal end of the plate were centered in the osteotomy gap (fig.2). The eccentric loading scheme shown was used throughout testing. Eccentric loading allows for a more natural loading representation during a single leg stance. The femoral head as well as the distal femur were allowed free rotation during loading to limit errant stresses that might occur in a more constrained setup. The experimental group consisted of 3 constructs, in which the honeycombed VA holes within the osteotomy gap were filled with locking screws; the control group included the remaining 4 constructs, in which the holes were left unfilled. One of the 4 control constructs was statically loaded to failure, and a value of 75% of this ultimate load to failure was used as the loading force for fatigue testing of 250,000 cycles at 3Hz - roughly simulating the healing time for this injury. Fatigue testing was carried out on the remaining 6 constructs, with total number of cycles to failure recorded for all constructs. Average number of cycles to failure of experimental and control groups was compared.

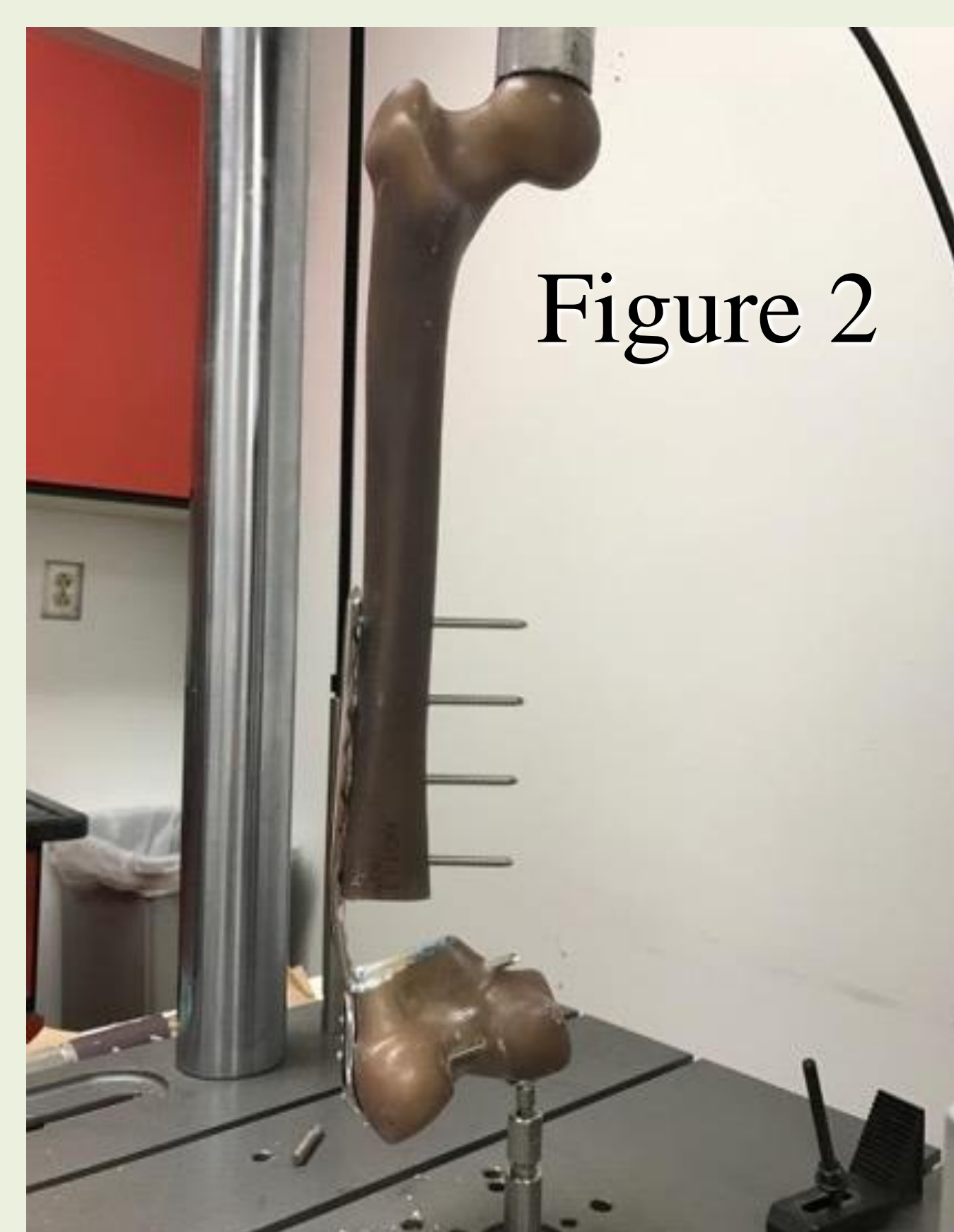


Figure 2

Results

The ultimate load to failure in the statically loaded control construct was 780N. The subsequent load used for fatigue testing was 585N (75% failure load). Average cycles to failure for the experimental and control groups were 43,304±23,835 and 37,524±8,187, respectively. The difference in fatigue life between groups was not statistically significant (P=0.72) and would not be clinically significant. Plate failure reliably occurred at the 8th and 9th holes in all plates in both groups. (fig.3).



Figure 3

Discussion

The variable angle plate design is well-suited for the management of comminuted fractures of the distal femur when variable angles are needed to accomplish fixation of fracture fragments or avoid previous hardware. However implant failure – specifically in the Depuy Synthes VA curved condylar plate – has been consistently observed at the combination holes at the area of comminution. While studies have implicated screw hole filling with locking screws at the area of comminution as a potential clinical solution to this problem, the current biomechanical study suggests that there is no increase in fatigue life or alteration in failure mechanism when this technique is used in the Synthes VA plate for the management of AO type 33-A3.3 fractures of the distal femur. The VA hole design with four distinct thread columns is necessary to prevent cross-threading of angled screws, however, the design creates a thinned section of plate near the outer edge of the honeycomb hole which is a site of weakness and reproducibly fails under cyclic loading. Notably, due to plate design, the periphery of the hole does not fully engage with the locking screw (visible in fig. 3). This may explain the statistically nonsignificant difference in fatigue life between groups, whether or not the VA hole is filled with a locking screw as these non-engaged sections are still prone to increased stress concentration during loading. The results of this study highlight the unique design characteristics of the variable angle plate and raise further questions with respect to its potential implication in implant failure in the clinical management of comminuted distal femur fractures. Additional biomechanical studies are necessary to compare failure rates and mechanism of failure between VA plate designs and non VA plate designs and to further investigate the utility of screw-hole filling in implant failure prevention.

Significance

Successful surgical management of distal femur fractures remains a significant challenge for the orthopaedic surgeon, and while VA plate design has evolved to technically help the surgeon meet this challenge, failure non-union and malunion rates remain unacceptably high. Our study is the first to demonstrate the negligible biomechanical effects of screw-hole filling of VA hole on construct fatigue life in the surgical management of distal femur fractures and also highlights the issue that the VA holes in these plates have an inherent weakness and are prone to failure.