Failure of Depuy Synthes VA-LCP Curved Condylar Plate in the Management of OTA/AO 33-A3.3 Fractures – Does Filling Open Screw Holes Make a Difference?

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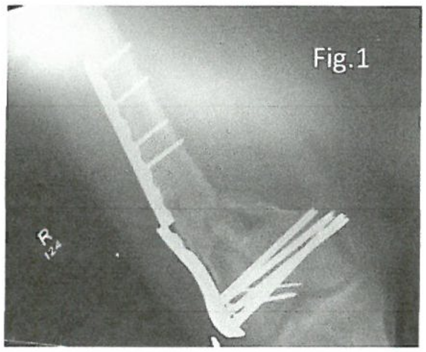
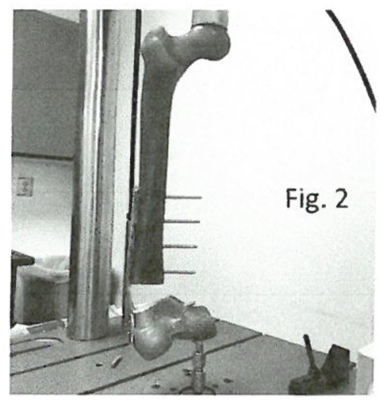
DISCLOSURES: None

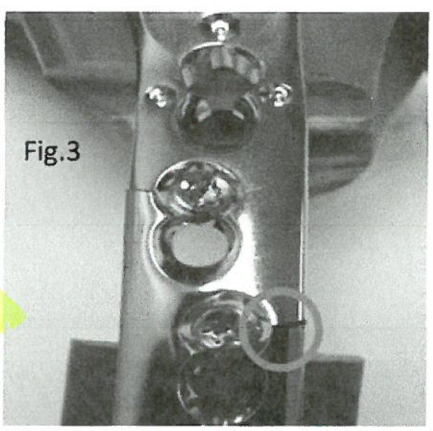


INTRODUCTION: The development of the variable angle locking plate provides multiple advantages over conventional plating techniques in the management of comminuted periarticular fractures of the distal femur: improved maneuverability of the distal screw cluster allows the surgeon to catch specific fracture fragments or avoid pre-existing implants, and the design also allows for the use of both compression and locked plating techniques within a single construct. Despite these clear advantages, the senior author of this study noticed a consistent pattern of plate failure through the combination hole at the level of comminution (fig.1) with the use of the Synthes VA-LCP Curved Condylar Plate for the management of AO type 33-A.3.3 fractures. Notably, the 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 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 filling the susceptible open screw holes 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.

METHODS: Setup shown in figure 2. Seven left 4[th] 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 in the distal screw cluster as well as in four of the first 7 proximal holes (1,3,5, and 7). Following proper plate positioning, a 4cm osteotomy was then created in order to simulate an AO type 33-A.3.3 metaphyseal comminuted fracture, such that the 9[th] honeycombed locking VA hole from the proximal end of the plate was centered in the osteotomy gap. 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.



RESULTS: The ultimate load to failure in the statically loaded control construct was 780N. The subsequent load used for fatigue testing was 585N. Average cycles to failure for the experimental and control groups were 43304 ± 23835 and 37524 ± 8187, respectively. The difference in fatigue life between groups was insignificant ($P=0.72$). Plate failure reliably occurred at the 8[th] and 9[th] holes in all plates in both groups (fig.3).



DISCUSSION: The variable angle plate design is well-suited for the management of comminuted fractures of the distal femur, however implant failure – specifically in the Depuy Synthes VA-LCP curved condylar plate – has been consistently observed at the VA locking holes when used for this purpose. While studies have implicated screw hole filling 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 leaves a thin section of plate near the outer edge of the hole which reproducibly fails under cyclic loading. Notably, due to this plate design, the periphery of the hole does not fully engage when filled with a locking screw (visible in fig. 3). This explains the statistically nonsignificant difference in fatigue life between groups, 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 mechanisms between VA and conventional 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 plate design has evolved to technically aid the surgeon in meeting this challenge, failure, non-union and malunion rates remain unacceptably high. Our study is the first to investigate the biomechanical effects of screw-hole filling on construct fatigue life in the surgical management of distal femur fractures, and the results encourage further research on the biomechanical properties of different plate designs.

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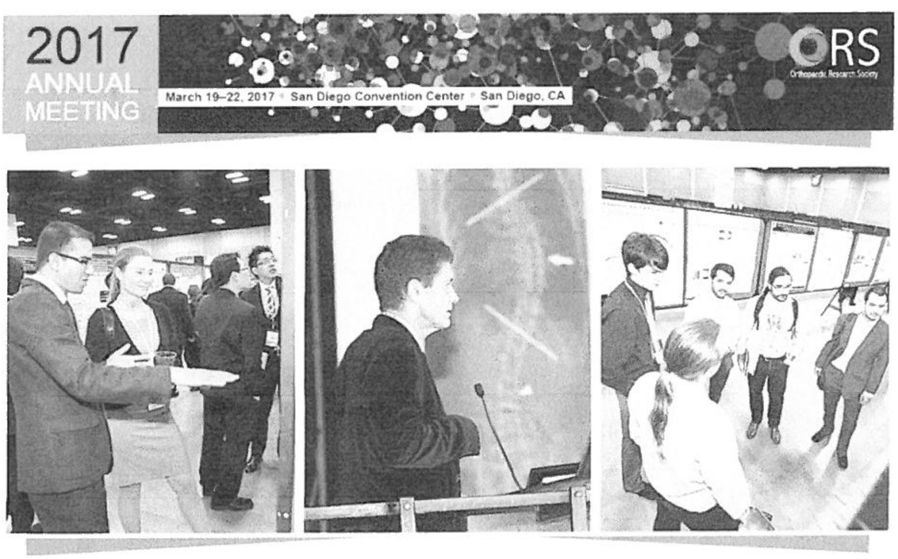

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