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Cortical bone plugs to reduce stress concentration from screw holes in long bones

Bettführ, Jessica, BSc,[1]; Edward Milne, BSc,[2]; Kaimrajh, David, MS,[2]; Zych, GA,[3]; Ganga, Sarat, MD,[3]; Latta, Loren, PhD[2,3] ; H. T. Temple[3]. [1] Stryker, Switzerland; [2] MBI, Miami Beach, FL; [3]Dept. Orthop., Univ. Miami, Miami, FL

Max Biedermann Institute for Biomechanics at Miami Beach

INTRODUCTION:

Screw holes from removed plates weakens long bones by about 50%[1] causing significant risk for refracture. But leaving the hardware in the bone indefinitely also creates a risk for refracture, usually through screw holes, even after the fracture is healed. Recent studies have shown that screw holes in plates reinforced with plugs made of the same material as the plate improves their strength.[2] The objective of this study was to provide the surgeon with a simple, easy method to reinforce threaded holes in the bone after screw removal. The ideal application would be to provide a plug which can be used without lengthy preparation, can be applied rapidly and be assured to stay in place while immediately reinforcing the hole and become incorporated into the bone for long term reinforcement.

Clinical significance:

If the risk of refracture immediately after plate removal can be significantly reduced so that patients do not require extended periods of limited activity and external protection, the long term results of plate and screw fixation will bring patients much closer to their prefracture status.

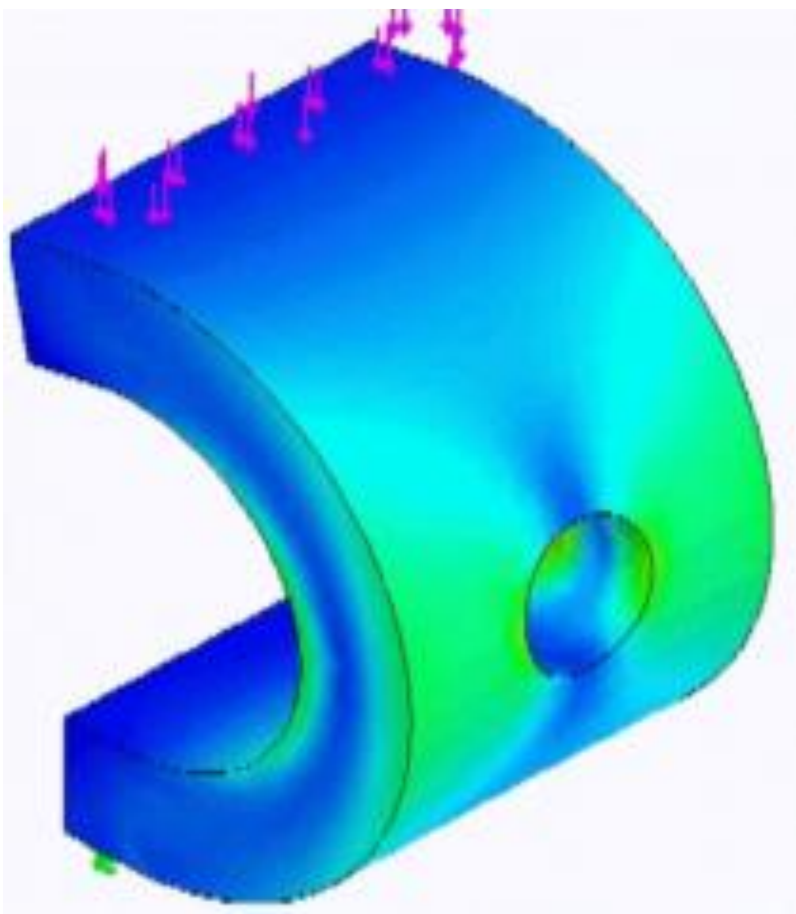

Figure 1 – Finite element model shows stress distributions in the half rings in diametral compression

METHODS:

Seven fresh-frozen cadaveric long bones were DXA scanned to determine the bone mineral density (BMD). Next, prior to cutting 2 cm thick segments along each diaphysis, each femur was marked to ensure an equal orientation for all segments and were numbered (starting distal). Every second bone segment was drilled from the lateral to medial side with a 4.0 mm drill bit. A 4.5 mm cortical self-tapping screw was screwed in and immediately removed. Three holes in each bone (segments number 2, 6 and 10 were filled with a 4.0 mm freeze dried cortical bone plug. Segments number 4, 8 and 12 were tested with unfilled screw holes. A typical example from one bone is shown in Fig. 2.

Each segment was tested to failure with an anterior to posterior compression force by a diametral half ring test (Fig. 1). Undrilled control segments were used to create a profile of diametral strength along the femur. The segments in between were compared to the extrapolated value from the control segments for its location along the bone, (Fig. 3). The difference between the measured value for each open hole or plugged hole segment from the extrapolated value from the control profile of intact segments was expressed in % of loss. This method of testing provides for a significant number of samples with a test that produces similar results to bending and torsion tests of whole bones, without the need to test 30 – 40 bones to define an answer to the question of stress concentration effects.[3]

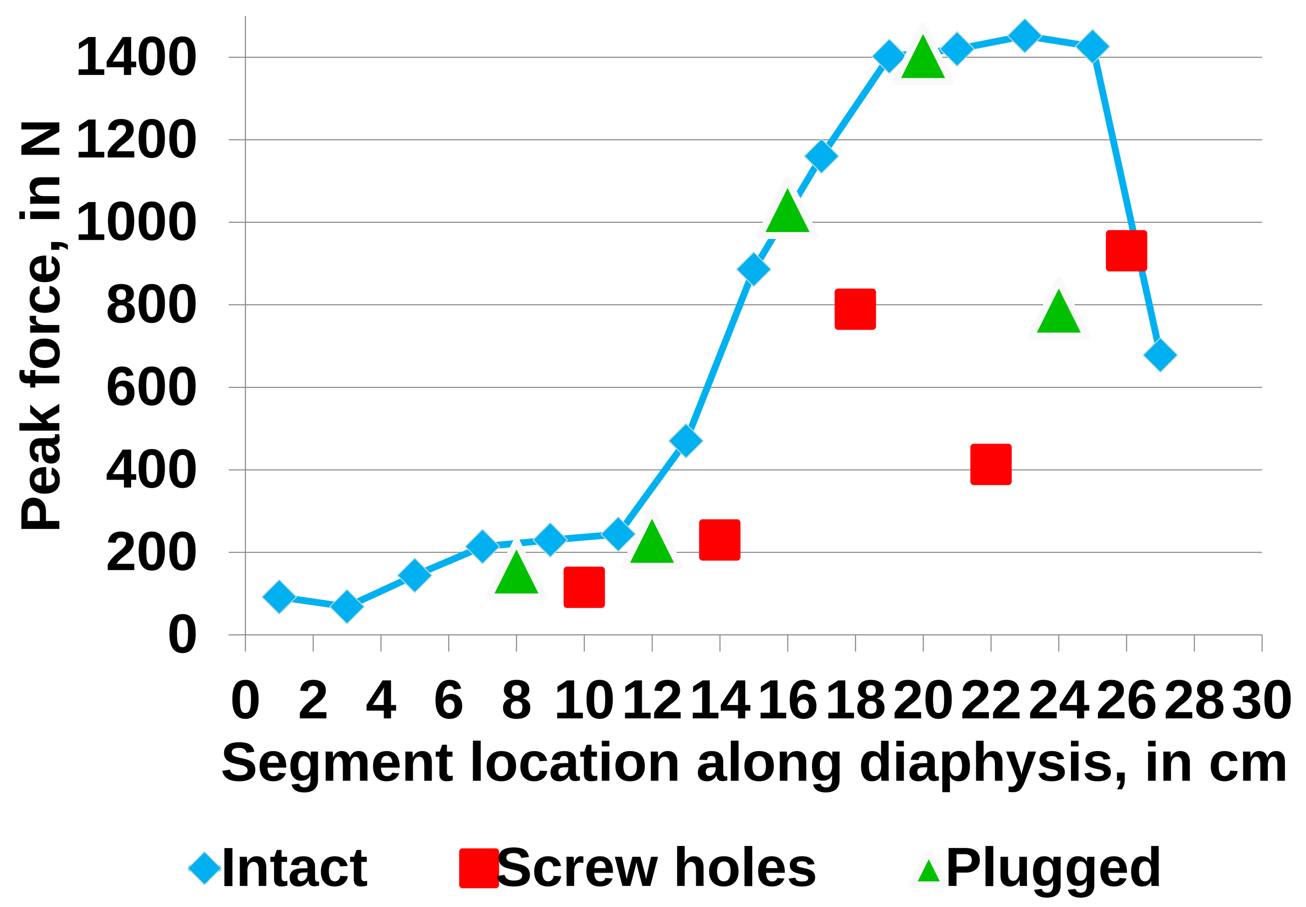

Figure 2 – The odd numbered half rings with no holes defined the profile along the diaphysis to which the holed segments were compared.

Figure 3 – The difference between strength of intact segments and those with screw holes averaged over all the bone segments tested, (right).

RESULTS:

There were 289 half ring samples from the 7 bones tested, of which 153 were used to create the profiles of the 7 cortices, of the 136 samples with screw holes, 64 had plugs and 72 were left open. The strength profile for the bones with this diametral half ring test shows a curve which is roughly related to the cortical thickness along the bones (Fig. 2). The effect of the stress concentration at the screw holes is greater for the open holes compared to the plugged holes. The average loss of strength for all the segments was 40.0 ± 17.3% for open holes and 30.0 ± 20.2% for plugged holes, ($P < 0.01$).

CONCLUSIONS:

Cortical bone plugs do reduce the weakening effect of screw holes in the diaphysis, but the immediate gain is about 25%. In order to see how rapid the strength can be regained, a study of the rate of healing comparing plugged and open holes will be required.

REFERENCES:

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ACKNOWLEDGEMENTS:

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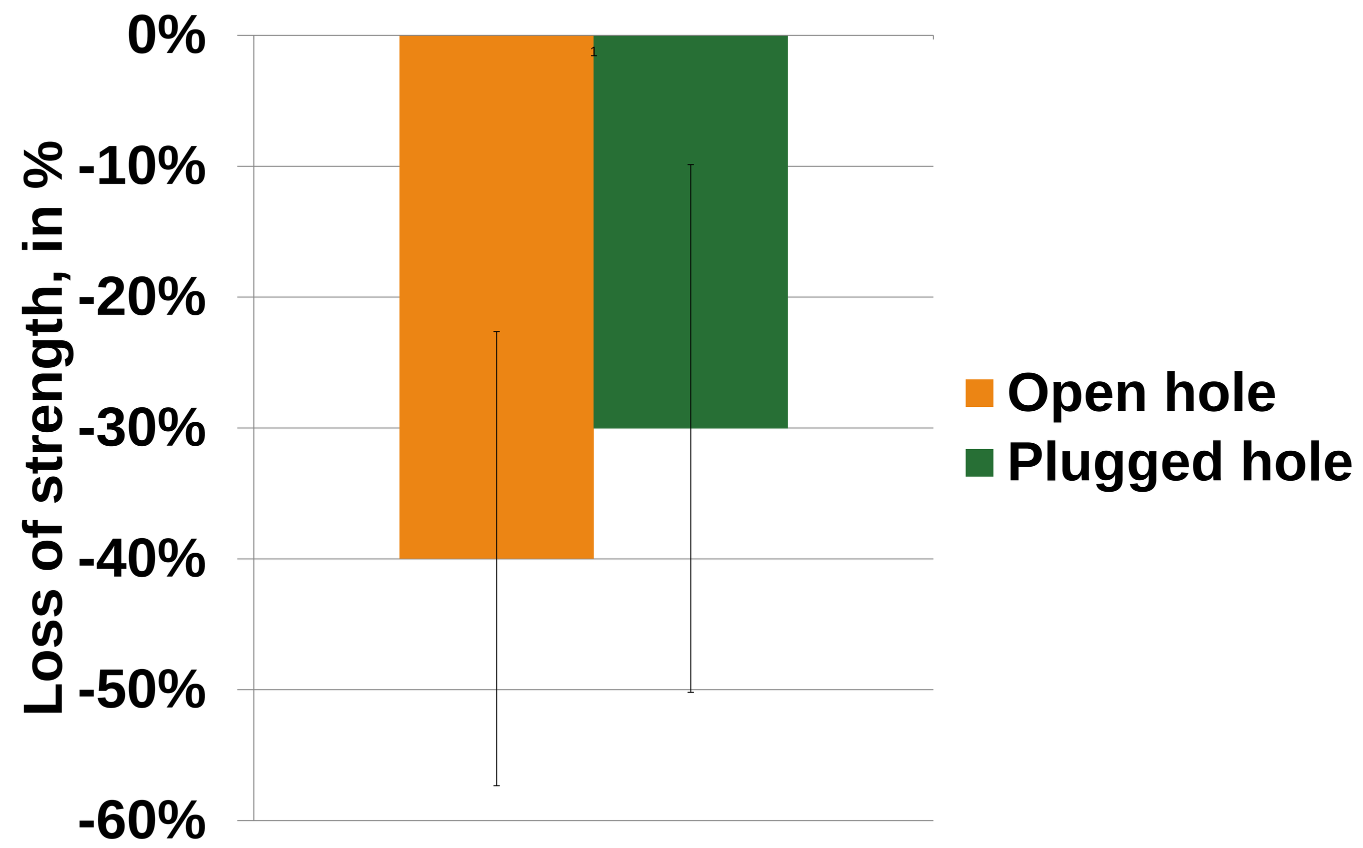

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