INTRODUCTION:
Implant failure is a well acknowledged complication both in human and veterinary orthopedic surgery. Various implant surface configurations, coating methods and biomaterials have been developed to improve integration between bone and implant. Wear debris formation and subsequent implant loosening are downsides of the non-resorbable bone cements such as PMMA, whereas both Ca- and Mg-cement can increase the biomechanical strength of the bone-implant interface \(^2\) and yet be resorbed during bone remodeling. A potential advantage of Mg-cement is the adhesive properties, demonstrated to increase extraction torque of screws in vitro. If these biomechanical properties could be sustained in vivo, implant failure may be reduced.

The objectives of this study was to compare biomechanical strength, interface quality and effects of bone healing on bone-implant interface treated with calcium phosphate cement, magnesium phosphate cement, polymethylmethacrylate or left untreated in horses in vivo.

METHODS:
Four 4.5mm 316L stainless steel cortical screws were inserted into the mid-diaphyseal dorsal cortex of 12 equine metacarpal and 12 equine metatarsal bones with or without bone cement. The holes were power drilled in a distal to proximal direction in a linear fashion at 2 cm intervals using a 3.5mm drill bit. After drilling, the holes were manually threaded using a 4.5mm tapping drill bit. Screws without any cement were applied first, followed by PMMA, Ca- and Mg-cement, respectively, in a controlled block design. The screws were applied immediately after cement application to a defined torque using a torque wrench. Samples were harvested for further analysis 5 days and 6 months postoperatively.

Biomechanical testing was performed by use of a Bionix 858 Servohydraulic Biaxial Materials Testing System. A constant rate of rotation was applied to the screw head and a continuous recording of the angle of displacement and torque were recorded. Peak torque to failure was recorded and interface stiffness, toughness and residual friction were calculated. Radiographs were taken to confirm implant integrity and to evaluate periosteal reaction. Histomorphometry was used to evaluate bone forming activity and characteristics of the bone-implant interface. Computed tomography was used to quantify differences in bone mineral density between the treatment groups in the remodeling interface. Radiographs were taken to confirm implant integrity and to evaluate periosteal reaction. Histomorphometry was used to analyze bone forming activity and characteristics of the bone-implant interface. Computed tomography was used to quantify differences in bone mineral density between the treatment groups in the remodeling interface.

Objective data from the biomechanical testing, µCT and bone activity analysis were analyzed with 1-way ANOVA and Tukey’s multiple comparison test. Scored data (histomorphometry) were analyzed by use of Kruskal-Wallis and Dunn’s multiple comparison post tests. Mann-Whitney test was used for the paired scored data.

The protocol for this study was approved by The Ohio State University Institutional Animal Care and Use Committee (IACUC).

RESULTS:
Biomechanical testing: Mg-cement increased the extraction torque (*peak torque to failure) compared to untreated (*p=0.019) or Ca-cement (*p=0.012) but not significantly when compared to PMMA (p>0.05).

Mg-cement increased the interface toughness (Shaded area; energy absorbed to failure) compared to untreated (p=0.007), Ca-cement (p=0.012) or PMMA (p=0.027). There were no significant differences between the treatment groups for interface stiffness or residual friction. The

DISCUSSION:
This study suggests that Mg-cement can safely and effectively improve the biomechanical strength of the bone-implant interface during the initial stages of bone healing. The results also indicate, that the Ca-cement and Mg-cement are replaced by bone at the screw interface, Mg-cement more so than Ca-cement in a time frame relevant to bone healing. The potential osteogenic properties of Mg-cement as evidenced by the µCT warrant further investigation. In conclusion, Mg-cement possessed several of the characteristics of an ideal biological fixator and when clinically available, Mg-cement may be beneficial in reducing the likelihood of implant failure.

REFERENCES: