

IN VITRO EVALUATION OF A NEW SYSTEM TO REDUCE PERI-IMPLANT STRAINS IN HORSES.

[S.Brianza](#)¹, [V.Brighenti](#)¹, [K.Schwieger](#)¹, [L.Boure](#)¹

¹[AO Research Institute](#), AO Foundation, Davos, CH

INTRODUCTION: The use of conventional external fixators (EF) and of the transfixation pin (TP) casts in the treatment of distal limb fractures is often associated with complications in horses. The trickiest is the development of pin loosening, a painful process that exposes the horse to further and frequently fatal pathology like laminitis. The causative mechanism can be found in the considerable bending experienced by conventional pins resulting in pain and critical strains at the inner and outer cortex of a long bone depending on material properties and geometry of the EF components¹. A novel pin-sleeve (PS) system was developed to decrease bone strains at the bone and EF pins interface. The goal of this experimental study was to model and compare the strain at the implant bone interface generated by the new system and the one generated by a commercially available transfixation pin when tested under axial compression in a bone substitute.

METHODS: Two canevasit hollow cylinders as diaphyseal bone models were instrumented with either the conventional (TP) or the new system (PS). The latter consisted of a 5-mm diameter pin running through an 8-mm diameter sleeve inserted into the canevasit. Pin and sleeve were in contact at two 1mm wide inner sleeve supports located at the centre of each cortex. The 6.3-mm diameter, positive and centrally threaded TP was applied in a standard manner. Uniaxial 120Ω strain gages (SGs) were glued on the external surface of the hollow cylinders centered above the implants. The outer support for both systems was a resin fiber 10 mm thick cast. Four different configurations of the new PS system were tested, applying an axial preload of 3, 4.5, 5.5 and 6kN to the threaded pin using nuts and maintained via a ring incorporated into the cast. The lower end of the cast was embedded in PMMA and fixed to the table of a material testing machine. The bone substitutes were loaded in axial compression (range: 50N-2500N) at 1 Hz for 2000 cycles. Each configuration was tested three times. Axial cylinder displacement and strains were recorded and compared. Finite element models (FEM) of both instrumentation methods were developed and validated

comparing strains and displacements between the experimental and the computational model. Correlation coefficients were computed between preloading and axial displacement and strains. FEMs were used to describe the distribution of strains. Significance level of statistical test was set at $p < 0.05$.

RESULTS: The PS system had always comparable axial displacement with a substantial decrease in strains as compared to the TP (*Table 1*). Preloading was found to be inversely correlated to the axial displacement ($r_p = -0.93$; $p < 0.01$) but did not correlate significantly with the measured strain ($r_p = -0.33$; $p = 0.29$). The FEMs were validated having maximum error of 14% between the experimental and FEM strain and displacement values. Based on these models (*Figure 1*) the maximum strains 2mm above the implants were 5500μstrain in the TP and 500μstrain in the PS system.

EXPERIMENTAL	Displacement (mm)	μstrain
Transfixation pin	0.99 ± 0.06	2841 ± 30
Pin-sleeve 3kN preload	1.09 ± 0.03	467 ± 2
Pin-sleeve 4.5kN preload	0.96 ± 0.02	463 ± 8
Pin-sleeve 5.5kN preload	0.92 ± 0.01	473 ± 7
Pin-sleeve 6kN preload	0.87 ± 0.02	467 ± 7

Table 1: Mechanical testing results (mean ± SD).

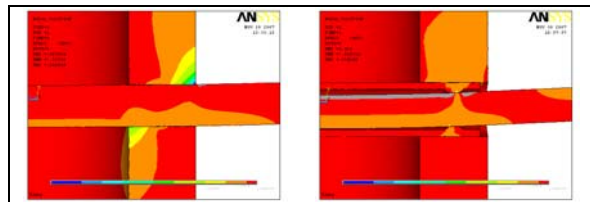


Figure 1: Axial strain distribution in one cortex for the two systems (range: -25000÷1000μstrain).

DISCUSSION & CONCLUSIONS: This study demonstrated that the novel system has the potential to reduce the risk of pin loosening and improve the clinical performance of external fixators. Further studies are required to investigate ultimate load wear and fatigue properties.

REFERENCES: ¹Huiskes,R., Chao,E.Y., and Crippen,T.E. (1985) Parametric analyses of pin-bone stresses in external fracture fixation devices. *J.Orthop.Res.*, 3:341-349.