# MECHANICAL STRENGTH OF ESIN INTERLOCKING SYSTEMS TREATING PEDIATRIC FEMUR FRACTURES

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## SUMMARY
Mechanical behavior of interlocked ESIN (Elastic stable intramedullary nailing) was investigated on sheep tibiae. Nails were interlocked with five different systems: conventional cap and 3mm screw (Plug 3mm), conventional cap and 3.5mm (Plug 3.5mm), a fixation plug and a 3.5mm screw (Fix Plug) and a twin plug with two 3.5mm screws (Twin Plug) all provided by Hofer Medicals Austria and end caps provided by Synthes. As reference one series of tibiae was treated with unlocked nails. By the means of a mechanical testing machine the nail-bone-compound was stressed with cyclic axial loading. The locked systems show all significant higher axial strength than the unlocked (up to 3 times). This study shows that commonly seen complications of fracture treatment of heavy children or adolescents can be addressed by using interlocking systems with ESIN.

## INTRODUCTION
Stability and fatigue strength of an ESIN (Elastic stable intramedullary nailing) is crucial for femur fracture treatment in children. Complications like secondary fracture or nail displacement, especially in heavy children, adolescents or complex fractures is seen in clinics. To prevent this, ESIN-wires require interlocking with different systems available on the market. Prior studies mainly focused on the whole nail-bone-compound, but there is little data available regarding the interlocking system itself.

## METHODS
Six different titanium 3mm-ESIN systems (Five locked with plugs/end caps, one unlocked) were inserted in cadaveric ovine tibiae (age 3-4 weeks). After the osteosynthesis an osteotomy was performed at mid diaphysis and the distal part removed. The construct was inserted into a mechanical testing machine and subjected to cyclic axial loading, ensuring that the measured axial displacement could be directly related to the movement of the nail and interlocking system, respectively.

Axial loading started with 100N over 5000 cycles. Load was increased first to 200N and then with 200N steps with 5000 cycles each until failure. Failure of the interlocking system or an axial displacement of the nails of 10mm was defined as end point. Axial force and displacement was recorded.

## RESULTS AND DISCUSSION
Mean loads at failure range from 400N (unlocked nails) to 1400N (Twin Plug) (Figure 1). Failure modes were: Pulling out of screws (Fix Plug and Plug 3.5mm), Breaking of screws (Plug 3mm), Buckling of nails (Twin Plug), Sudden Slipping (End Caps and unlocked nails). Additionally, fatigue parameters were obtained, e.g. dissipated energy per cycle, elastic and permanent deformation, total number of cycles until failure.

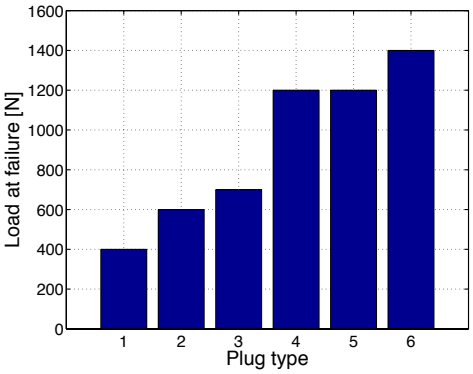


**Figure 1**: Mean failure load of the tested specimen (1-unlocked, 2-Synthes® End Caps, 3-Hofer® Plug 3mm, 4-Hofer® Plug 3.5mm, 5-Hofer® Fix Plug, 6-Hofer® Twin Plug)

## CONCLUSIONS
Interlocking systems show a high load carrying capacity and should be taking in account in treating femur fractures in childhood and adolescence especially in complex fractures or overweight situations.