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Comparison of cortical vs. pedicle screw loosening in normal and osteoporotic vertebrae

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Introduction: Cortical screw fixation has been developed as an alternative to pedicle screw fixation for spinal constructs with anterior support. Previous studies have shown that the cortical screws with the proper trajectory provide superior bone anchoring to pedicle screws in cadaver spines. But the question of their mechanical performance after cyclic loading has not been addressed as well as their performance in osteoporotic bone.

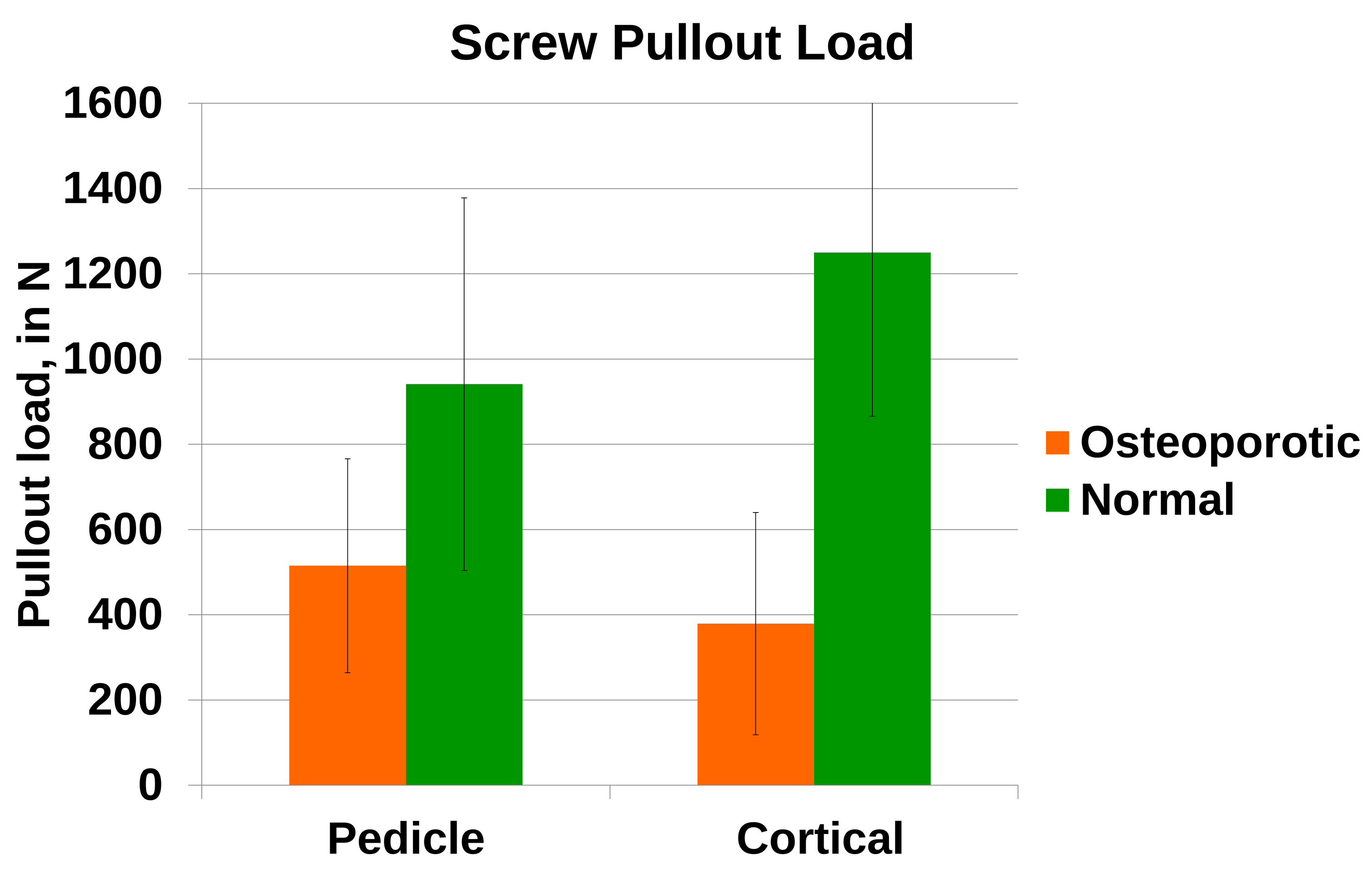
Purpose: The purpose of this study was to measure screw loosening and screw anchoring after cyclic loading, comparing two methods of screw insertion in both normal and osteoporotic lumbar vertebrae.

METHODS: lumbar vertebral bodies from cadavers over the age of 55 were separated into 2 groups by DEXA scan, below 0.9 g/cm^2 bone density was osteoporotic, and above was normal. Each lumbar vertebral body had a 6x55mm pedicle screw inserted on one side and on the contralateral side, a cortical trajectory pedicle screw, measuring 5.5x30mm, was inserted via a path through cortical surfaces. The vertebra was gripped using screws seen in Figure 1. A 5.5 mm titanium rod was applied to each screw and also to a screw 8 cm above which was attached to a rod end connector to simulate a corpectomy and create a "worst case" model of a motion segment unit with posterior construct. The reason for using a corpectomy model was to avoid the large sample variances due to degenerative changes at the facets and vertebral discs in different cadavers as well as the variations related to lumbar levels. One screw of each type was placed in each vertebral body so that sampling could be paired. Note that both these screw designs were FDA approved only for use in constructs with anterior support. So this test would be considered too severe for FDA approved use and is not intended to simulate a clinical application.

These motion segment constructs were tested in flexion/extension by applying a sinusoidal cyclic load in load control by the MTS Model 858 MiniBionix II servohydraulic system. The load cycles continued for 5,000 cycles at 1 Hz (about 1.5 hours/specimen), or until a gross failure occurred. For the vertebral bodies with a normal DXA reading we applied ±100 N at a distance of 50 mm from the rod through the rod end connector, to simulate a ±5 N-m moment on the construct. For the vertebral bodies with an osteoporotic DXA reading, load was applied ±50 N since a 100 N load caused immediate failure in some of the specimens. The connector applying the load was applied from the rod which was attached to a linear bearing on the MTS ram to allow the load point to travel with the construct as it moved, thus avoiding any side-loading.

The construct was positioned so that a lateral view of the vertebral body could be monitored by the Hologic Premiere Mini-C-arm. A video of the fluoroscopic images was recorded at cycle increments of 1, 100, 250, 500, 1000, 2500, and 5000. Relative motions of the screws in the bone were analyzed by ImagePro software from the videos of each interval. This analysis technique had an intra-observer error in the range of 0.5º combined with an accuracy of image resolution of approx. 0.5º, so motion below 1º was considered too small to be detected by this method. After cyclic testing, the vertebra was gripped with insertion instrumentation to align the pedicle screw to the axis of the MTS ram and the screw was pulled out of the bone at a rate of 1 mm/sec until failure. Differences in measured values from each vertebral body were analyzed by paired Student's t-test.

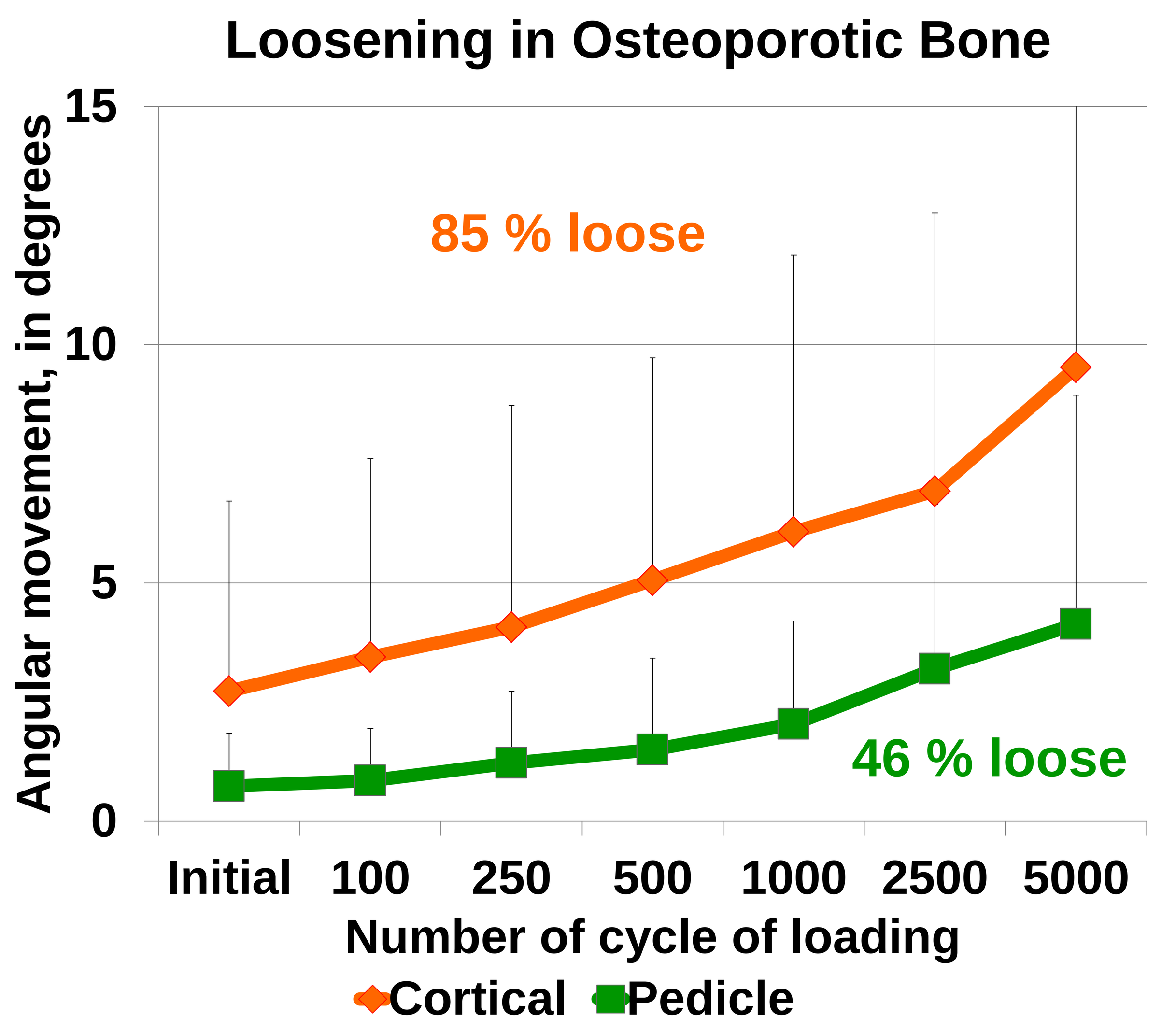
Results: In vertebral bodies with normal bone density, 11.1% of cortical screws and 44.4% of the pedicle screws loosened in the same vertebral bodies ($P < 0.01$ by Chi Square). The pullout strength was significantly greater for the cortical screws, 1,494.3 ± 460.2 N, compared to pedicle screws, 1150.6 ± 458.2 N, ($P < 0.05$ for paired samples), see Figure 3. In osteoporotic bone, the incidence of loosening was 46% for pedicle screws and 85% for cortical screws, see fig. 2. The degree of loosening for all samples had a dramatic effect on pull-out strength, 672.6 ± 333.5 N for pedicle screws and 372.6 ± 248.3 N for cortical screws, $P < 0.01$ for paired samples.



Discussion: After cyclic loading in a "worst case" scenario, cortical screws out performed pedicle screws in vertebral bodies having normal bone, similar to mechanical studies that did not cyclically load the screws. But in osteoporotic bone, the cortical screws loosened more readily than pedicle screws, and once loosened, their bone anchoring strength was significantly compromised.

Conclusions: While cortical screws show improved resistance to loosening and strength of bone anchoring over pedicle screws in this type of severe test in normal bone, in osteoporotic bone pedicle screws are more resistant to loosening and once loose, have significantly less pull out strength

Significance: While the cortical screw technique has advantages in normal vertebral bodies, it clearly is at a disadvantage mechanically in osteoporotic vertebral bodies.



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