

•The Effect of Hydroxyapatite Coating on Anterior Vertebral Screw Fixation

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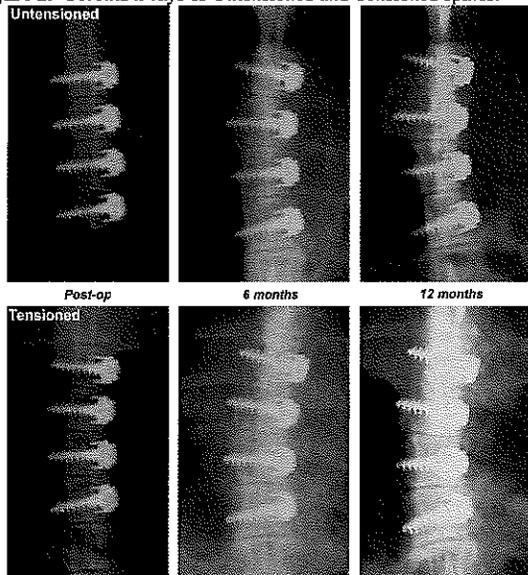
INTRODUCTION:

Spinal growth modulation using an anterolateral tether has been proposed as an alternate non-fusion treatment strategy for idiopathic scoliosis. The tether is anchored to the vertebral bodies utilizing anterior screws and a staple construct. Current investigation of this tethering technique has revealed that it can induce spinal deformity in a porcine model. Given the non-fusion nature of this instrumentation, optimizing screw integration may improve long-term outcomes. The purpose of this study was to evaluate the effect of hydroxyapatite (HA) coating of the vertebral body screws and intra-operative tensioning of the tether on screw integration as measured by torque required to remove the screw.

METHODS:

Eight 7-month-old male Yucatan mini-pigs were instrumented anteriorly with a screw-staple construct placed in four consecutive vertebrae (T8-T11). The screws were mono-axial 32mm long, 7.5mm maximal diameter titanium screws placed by two authors. The animals were randomized to screws coated with hydroxyapatite or uncoated screws. A woven ultra-high molecular weight polyethylene (UHMWPE) tether ribbon connected the four screws. Intra-operative tensioning of the tether to 250N was performed in half of the pigs, giving four experimental groups: coated screws and tensioned tether, uncoated screws and tensioned tether, coated screws and untensioned tether and uncoated screws and untensioned tether. After 12 months of growth (Figure 1), the 8 spines were harvested in bloc (from T6-T13) and stored frozen for biomechanical testing.

Figure 1: Coronal x-rays of Untensioned and Tensioned spines.



After harvest, uncoated screws were placed in the two levels proximal and two levels distal to the instrumented vertebral bodies. These screws were used to evaluate the fixation of a screw in bone before any osseous integration occurred (time zero).

Torque out testing to evaluate the mechanical holding strength of each vertebral body screw was performed, as the authors felt this evaluated the strength of the screw-bone interface more specifically than pullout testing. Each spine segment was potted in epoxy resin and affixed in a bi-axial materials testing machine (MTS) using custom fixtures, so that the screw to be tested was aligned with and directly below the machine actuator. A custom fabricated driver tip mounted in a drill chuck was inserted into the screw ensuring optimal alignment and zero axial load or torque prior to the testing. The screws were extracted at a uniform rate (0.1 degrees/second) to a maximum excursion of 30 degrees. Angular displacement (degrees of rotation) and torque were sampled at 200 Hz for the duration of each test. Biomechanical data

were analyzed using a custom Matlab processing script (The MathWorks, Inc., Natick, MA) to define the yield torque (Nmm) and the angle at yield torque (degrees).

The four 12 month groups were compared with two-way ANOVA using vertebral level as a covariate ($p < 0.05$), to evaluate the effects of tensioning and screw coating on yield torque and yield angle. These four groups were then compared to the time zero group with one-way ANOVA ($p < 0.05$) to evaluate the change in fixation over time.

RESULTS:

Results of biomechanical testing are summarized in Table 1. Two-way ANOVA revealed that tensioning of the tether had a significant effect on both yield torque and yield angle ($p < 0.001$, and $p < 0.05$). Hydroxyapatite screw coating had a significant effect on yield angle ($p < 0.05$) and a near significant effect on yield torque ($p = 0.09$).

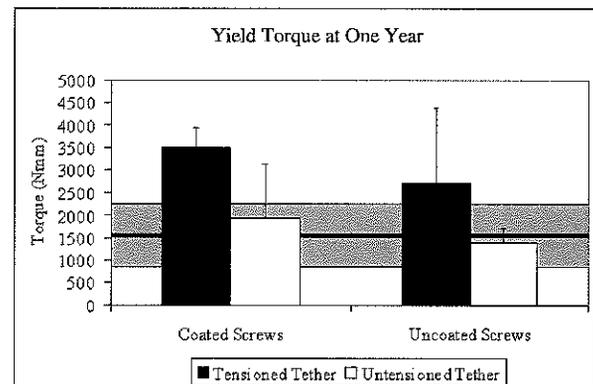
Yield torque is summarized in Figure 2. One-way ANOVA revealed that the time zero screws had a significantly lower yield torque than either the tensioned coated or the tensioned uncoated ($p < 0.001$, $p < 0.05$), however the untensioned coated and untensioned uncoated groups were not different from the time zero group ($p = 0.9$, $p = 0.9$). The time zero screws also had a lower yield angle than the coated, tensioned screws ($p < 0.05$).

Table 1: Results of Biomechanical Testing

Results of Biomechanical Testing	Yield Torque (Nmm)	Yield Angle (degrees)
Coated, Tensioned	3500±500	27±3
Coated, Untensioned	2700±1600	20±10
Uncoated, Tensioned	1900±1200	20±10
Uncoated, Untensioned	1400±300	14±2
Time Zero Control	1600±700	19±7

Figure 2: Mean Failure Torque

The grey bar is the torque for the time zero controls ± one standard deviation.



DISCUSSION:

Use of a spinal tether to modulate spinal growth as a means of controlling or even correcting scoliosis is an exciting potential treatment on the horizon that may reduce the need for long spinal fusions. Pre-tensioning the tether has the advantage of creating immediate (intraoperative) correction of the deformity, but theoretically risks loosening the screws. In this experiment, not only was this not the case, in fact the early loading improved the screw-bone interface strength. Coating the screws with HA had a modest effect, reducing the torsional angle to failure of the coated screws compared to those without the osseointegrative layer. Despite the non non-fusion condition, the vertebral body screws remained well fixed, with the coated screws in animals with the pretensioned tether having an extraction torque over two times greater than that of the initial time zero screws.