

## 2. The impact of surgical fixation technique on pedicle screw anchorage

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### Background

Pedicle screw loosening is one of the most frequent complications of thoracolumbar posterior fixation. Incidences of up to 15% have been reported in non-osteoporotic patients and over 60% for non-cemented pedicle screws in osteoporotic bone<sup>1,2</sup>. The reported prevalence is considerably depending on definition, e.g. screw pull-out or radiolucent rim >1 mm around the screw<sup>3</sup>.

However, a recent PubMed systematic literature search confirms a patient-related loosening rate of 15.1% (CI 14.2%-16.0%, range 0%-63.4%) and a screw-related loosening rate of 3.8% (CI 3.5%-4.1%, range 0%-20.3%) on pooled data. There is evidence that 89.3% of loosened pedicle screws are pulled-out during rod connection<sup>4</sup>. Screw pull-out strength<sup>5</sup>, insertion torque (IT) and extraction torque (ET)<sup>6</sup> correlate strongly with intrapedicular bone density. The aim of this study is to investigate the effects of reduction and tightening, and the influence of additional distraction forces on pedicle screw anchorage at different bone densities during construct assembly and final locking.

### Material and Methods

Two human cadaver specimens (13 segments, T5-S1) were stabilized in direct side-by-side comparison using pedicle screw rod systems following different fixation philosophies: force control (FC: Neo Pedicle Screw System) and standard fixation (SF: CD Horizon Solera). ITs and, after assembly, final tightening and a short period of settling, ETs were measured digitally. The impact of reduction and final tightening was evaluated by comparing the losses between IT and ET. In addition, the effect of distraction forces (100N) applied across pedicle screw heads was investigated in polyurethane foam blocks of certain densities. Statistical significance at  $p < 0.05$ , Mann-Whitney U test for comparisons and correlation analyses according to Spearman.

### Results

With FC, the median torque loss was significantly lower (0.393Nm) than with SF (0.539Nm) ( $p < 0.001$ ). Despite higher ITs with SF (0.966 vs. 0.747Nm), ETs were similar (0.344 vs. 0.301Nm) (Fig.1). IT and ET correlated statistically significant (FC:  $r = 0.792$  and SF:  $r = 0.783$ ;  $p < 0.001$ ). Torque losses were higher in both groups when additional distraction forces were applied directly across pedicle screw heads ( $p \leq 0.041$ ).

### Conclusions

Reduction and tightening of the rod-screw interface have a significant impact on pedicle screw anchorage. The loss between IT and ET quantifies the loss of biomechanical behavior and consequently the load transferred to the instrumentation and the surrounding tissue. It is higher if the instrument assembly is performed with a standard fixation technique. Force control alters the biomechanical behavior to a lesser extent and results in lower forces during reduction and tightening of the pedicle screw construct. Utilizing surgical techniques that avoid unnecessary load application during screw-rod assembly could potentially decrease screw loosening, construct failure and reoperation rates, and improve clinical outcomes.

1. Galbusera F, Volkheimer D, Reitmaier S, Berger-Roscher N, Kienle A, Wilke HJ. Pedicle screw loosening: a clinically relevant complication? *Eur Spine J*. 2015 May;24(5):1005-16. doi:10.1007/s00586-015-3768-6. Epub 2015 Jan 24. PMID: 25616349.
2. El Saman, et al. (2013) Reduced loosening rate and loss of correction following posterior stabilization with or without PMMA augmentation of pedicle screws in vertebral fractures in the elderly. *Eur J Trauma Emerg Surg* 39(5):455-460
3. Marie-Hardy L, Pascal-Moussellard H, Barnaba A, Bonaccorsi R, Scemama C. Screw Loosening in Posterior Spine Fusion: Prevalence and Risk Factors. *Global Spine J*. 2020 Aug;10(5):598-602. doi:10.1177/2192568219864341. Epub 2019 Jul 25. PMID: 32677565; PMCID: PMC7359691.
4. Ohba T, Ebata S, Oba H, Koyama K, Haro H. The Risk Factors for Clinically Relevant Loosening of Percutaneous Pedicle Screws. *Spine Surg Relat Res* 2019; 3(1): 79-85.
5. Wichmann JL, Booz C, Wesarg S, Bauer RW, Kerl JM, Fischer S, Lehnert T, Vogl TJ, Khan MF, Kafchitsas K. Quantitative dual-energy CT for phantomless evaluation of cancellous bone mineral density of the vertebral pedicle: correlation with pedicle screw pull-out strength. *Eur Radiol*. 2015 Jun;25(6):1714-20.
6. Kafchitsas K, Drees P, Spanidis E, Rauschmann M. Correlation of the pedicle screw insertion torque with pedicle bone quality. Revision of the surgical technique intraoperatively: to cement or not to cement. *Eur Spine J* (2020) 29:2914/P49.