1. From fusion to functional fusion:
The quest for an anatomical and bio-mechanical balance of the spine

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Questions to Consider

- Have you ever wondered how much excessive force some instruments apply into constructs and ultimately the anatomy? How might that impact results?
- Have you ever thought about why some set screws are loose compared to others when performing a revision? What is causing this?
- Have you ever considered what causes implants to make a squeaking noise during assembly? Why might this matter?

Background

According to literature, fusion is achieved in 85% to 95% of cases[1], and outcomes have remained constant for comparable procedures since the 1980s. However, solid fusion alone is not a predictor of good long-term clinical outcome. Failed Back Surgery Syndrome (FBSS) has been created to "explain" the poor outcomes, with incidences reported between 10% and 40%[2,3,4,5,6]. The more complex the surgery, the higher the FBSS rate.

The revision rates reported in the literature on degenerative and deformity spine surgery are significant and have increased from 2006 to 2014[2-7]. The most common reason for re-surgery is implant failure, whereas 67% of re-interventions may be attributable to mechanical stress.

Controllable Risk Factors During Surgery

Intraoperative reasons leading to unsatisfactory results can be explained directly or indirectly by (bio)mechanical reasons. Today, much attention is paid to controlling sagittal alignment and protecting the facet joints of adjacent segments during pedicle screw placement. Risk factors that have received little attention offer the opportunity to improving outcomes: coronal and axial alignment and mechanical forces applied during instrumentation.

Recent PSS developments aim to minimize the applied forces, potentially reducing the biomechanical complication rate after instrumented posterior lumbar fusion surgery.

Mechanical Risk Factors

- Several biomechanical studies have identified risk factors for mechanical overloading:
- Screw head/rod mismatch: using a persuasion device to reduce residual gaps of 5mm generates enough force to pull out screws [8]
- Correction of rod contouring: in-situ bending creates significantly higher loads compared to cantilever bending [9]
- Rod contouring: 60% less force applied to screws during computer-assisted bending compared to manual bending [10]
- Unintentional stress: heavy instruments with high centers of gravity, blocked screw polyaxiality preventing orthogonal implant alignment, seating force pulling the spine to the rod, flat set screw design limiting orthogonal alignment and creating friction
- Screw head/rod alignment: 90° are mandatory to avoid overload, friction and cold welding.

Forced Fixation

Unknowingly applying forces and mechanical stresses during the assembly and locking of a pedicle screw construct which may result in implant loosening and hardware failure."

Possible consequences include reduced pull-out strength, creation of axial deformity, increased facet pressure, trabecular fractures and annular tearing[11].

Force Control

Force control is a surgical technique that respects the following principles

- Unique physiological screw head position
- Maintain screw head mobility throughout
- Awareness and control of mechanical force

This is supported by lightweight instruments with a balanced COG that allow screw polyaxiality, the use of real-time data, convex set screw designs and zero-friction screw driver.

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