Powered Pedicle Screw Placement Decreases Screw Wobble and Insertion Time

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Objective

Measure differences in pedicle screw wobble and insertion time between pedicle screws placed with manual technique and screws placed with powered technique.

Background

Pedicle screw loosening is reported in up to 21% of patients[1] between three- to six-months post-op[2], and pedicle screw loosening is partially attributed to insertion technique[3]. Pedicle screws can be placed manually with a traditional driver or with a power-assisted driver. Intra-operative efficacy and safety of power-assisted instruments for pedicle screw placement are shown to be equivalent[4,5] to superior[6] to manual technique, and a retrospective review of posterior fusion cases showed that pedicle screws placed with power-assisted instruments fail less than those placed with manual technique[4].

Wobble during pedicle screw placement may contribute to screw loosening, where wobble is defined as the deviation of the screw from its intended trajectory. Wobble during screw insertion may compromise the bone-screw interface, decrease screw purchase and reduce pullout strength. We hypothesize that pedicle screws are inserted faster and with less wobble using power-assisted tools compared to pedicle screws inserted manually.

Methods

Pedicle preparation and screw placement was performed bilaterally from T5-L5 in four cadaver torsos with both manual and power-assisted technique (n=52 pedicles/technique) by two spine surgeons. Manual technique proceeded with the Vitality® Spinal Fixation System and included developing the pedicle tract with a Lenke probe, undertapping by Ø1.0 mm, and driving Ø5.5 mm Vitality polyaxial pedicle screwsa.

Power-assisted technique proceeded with the Vital™ Power Instrumentation Set and included the use of the flexible drill bit (Ø2.4 mm), the blunt-tip reamer probe (Ø3.2 mm), and the short threaded driver. Within a vertebra, one pedicle was prepared and instrumented using manual technique and the contralateral pedicle with power-assisted technique, which yielded bone quality an internal control. Pedicle screw length was predetermined by level, therefore matched within a vertebra and between techniques as follows: T5-T8: 3 5 mm, T9-T12: 40 mm, L1-L5: 45 mm. All three steps within each technique were executed before advancing to the next pedicle and order of manual versus power-assisted technique was varied to reduce bias.

An inertial measurement unit (IMU) recorded the real-time angular rotation of the manual driver and the power-assisted driver during screw insertion (Figure 1). Measuring the rotation of the driver is

synonymous with measuring the rotation of the screw because the screw is rigidly connected to the driver. The real-time angular rotation data was processed to yield three outcome metrics: path length, wobble area, and insertion time)

For each outcome metric, data for all screw lengths were pooled by insertion technique (manual or power assisted). Paired t-tests assessed differences within outcome metrics between manual and powered insertion. Significance set to $p<0.05$.

Figure 1. IMU fixed to manual driver

OUTCOME METRICS

Path Length

Total distance the screw head travels. Wobble path length is normalized to the length of a screw. For example, a 40 mm length screw with no wobble would travel 40 mm total and yield a path length of 100%. A 40 mm length screw with 40 mm of wobble (extraneous motion) would travel 80 mm total and yield a path length of 200%. All path length >100% means there is extraneous motion during screw insertion.

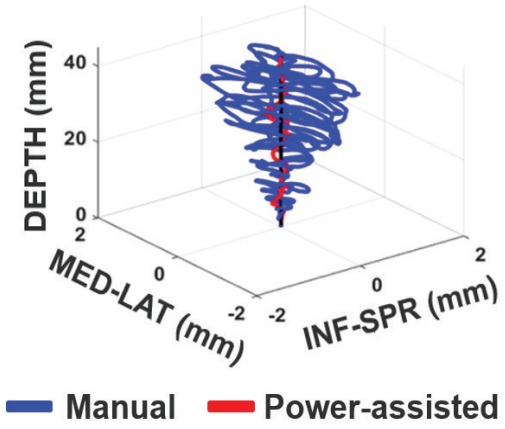


Figure 2. Representative path length

Wobble Area

Total area the screw head covers; the trace of wobble area is the top-down view of the wobble path length. An ellipse is fit to the data to measure the total area the screw head travels.

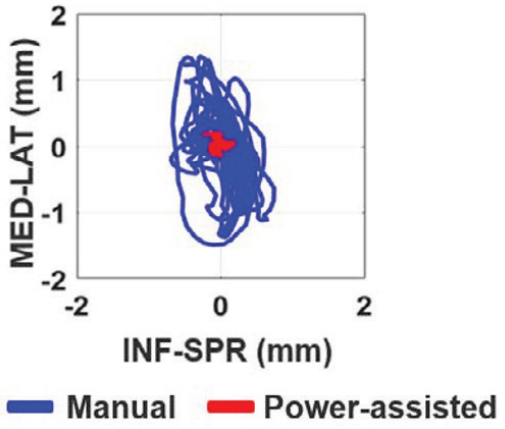


Figure 3. Representative wobble area

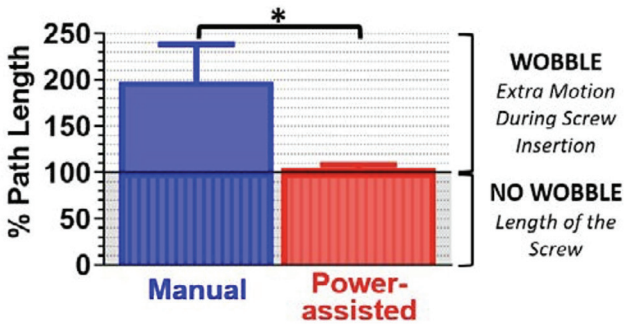
Insertion Time

Length of the real-time rotation data signal converted to physical time.

RESULTS

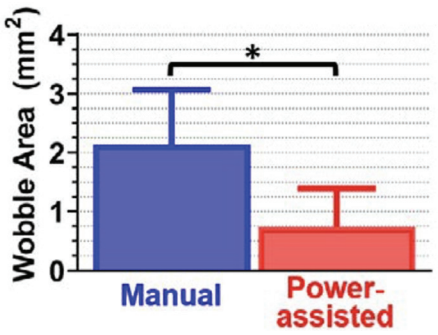
Path Length

The average path length of a screw inserted with power is 105%; the screw has almost negligible wobble (extraneous motion). On the other hand, screws inserted with manual technique undergo a large amount of extraneous motion, on average 200%. This means the amount of extraneous motion using manual technique is equal to the length of a whole extra screw. Power-assisted technique reduces wobble path length by 95%.



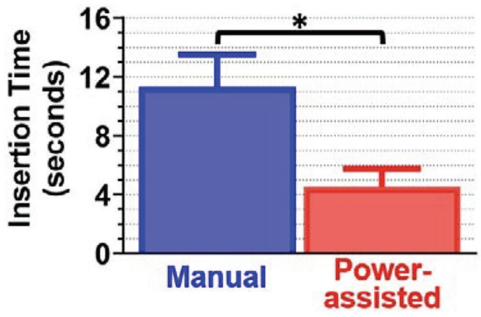
Wobble Area

Power-assisted technique decreases wobble area from that of manual technique. Wobble area is 3x smaller using power-assisted technique (0.73 mm2 vs. 2.1 mm2). Average wobble area per screw reported here.



Insertion Time

Screws were placed in 4.5 seconds with power-assisted technique, 2.5x faster than screws were placed with manual technique (11.3 seconds). Average insertion time per screw reported here.



CONCLUSIONS AND DISCUSSION

Power-assisted pedicle screw placement decreases extraneous screw motion via metrics of path length (by 95%), and wobble area (by 66%). Further, power-assisted pedicle screw placement reduces screw insertion time by 60%. Clinically, pedicle screws placed manually fail more than those placed with power. Findings from this non-clinical study demonstrate that the reduction in screw wobble with use of power-assisted tools may preserve adjacent bone integrity and decrease the propensity of screws to loosen.

Footer

[a]Pedicle screws of the Vital™ Spinal Fixation System and the Vitality® Spinal Fixation System share the same dual-lead thread form. Data on file.

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