"Pedicle screw placement accuracy and image-guided intraoperative breach detection in spine surgery"

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ABSTRACT

Introduction Pedicle screw placement, through relevant biomechanical properties, is a widely used procedure for the treatment of spine pathologies including trauma, scoliotic deformities, infection, degenerative and malignant diseases [1]. Inaccurate screw placement with a pedicle breach can lead to spinal cord, visceral and vascular injuries, with complications in terms of patient survival [2]. This retrospective study aims to assess accuracy of pedicle screw placement using a new intra-operative cone-beam CT (CBCT) imaging technique, and to compare the efficacy of this technique with conventional postoperative CT scans for pedicle breach detection. Methods In 102 patients, 586 pedicle screws were inserted over a 21 month period. In all patients, intraoperative CBCT scans (Fig. 1) were acquired after all screws were inserted, and retrospectively reviewed by orthopaedic surgeons for pedicle breach detection and grading. Of the 586 inserted screws, placement assessment of 239 screws w...

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PEDICLE SCREW PLACEMENT ACCURACY AND IMAGE-GUIDED INTRAOPERATIVE BREACH DETECTION IN SPINE SURGERY

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Introduction
Pedicle screw placement, through relevant biomechanical properties, is a widely used procedure for the treatment of spine pathologies including trauma, scoliotic deformities, infection, degenerative and malignant diseases [1]. Inaccurate screw placement with a pedicle breach can lead to spinal cord, visceral and vascular injuries, with complications in terms of patient survival [2]. This retrospective study aims to assess accuracy of pedicle screw placement using a new intra-operative cone-beam CT (CBCT) imaging technique, and to compare the efficacy of this technique with conventional postoperative CT scans for pedicle breach detection.

Methods
In 102 patients, 586 pedicle screws were inserted over a 21 month period. In all patients, intraoperative CBCT scans (Fig. 1) were acquired after all screws were inserted, and retrospectively reviewed by orthopaedic surgeons for pedicle breach detection and grading. Of the 586 inserted screws, placement assessment of 239 screws were also carried out in conventional postoperative CT scans using the same grading system. Reliability tests computing Cohen’s Kappa coefficient and Gwet’s coefficient were performed to compare the CBCT imaging technique with the conventional postoperative CT scans for assessing screw placement accuracy and detecting pedicle breach. Sensitivity, specificity, positive and negative predictive values of the CBCT imaging technique to assess screw placement accuracy were measured, assuming that postoperative CT scanning is the gold standard for assessing such accuracy.

Results
Of the 586 inserted pedicle screws (Fig. 2), 496 (84.6%) were placed within the pedicle without any breach, 24 (4.1%) were in-out-in screws with a lateral breach but with the screw tip inside the vertebral body, 21 (3.6%) had a medial breach <2 mm, 10 (1.7%) had a medial breach between 2 and 4 mm, 4 (0.7%) had a medial breach of >4 mm, 5 (0.9%) had a lateral breach, and 26 (4.4%) had an anterior breach. Seventeen screws (2.9%) were revised intraoperatively. Kappa and Gwet’s coefficients on screw placement assessment carried out in intraoperative CBCT and in conventional postoperative CT scans were 0.80 and 0.93, respectively. Sensitivity and specificity of the intraoperative CBCT imaging technique, considering that the postoperative CT imaging is the gold standard, were 0.77 and 0.98, respectively. Positive and negative predictive values were 0.91 and 0.96, respectively.

Discussion
Intraoperative CBCT allows for accurate assessment of pedicle screw placement and presents the clinically relevant potential for direct repositioning of misplaced screws, thereby helping to reduce the radiation dose by eliminating the need for postoperative CT scans.

References

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