Meta-Analysis of Randomized Controlled Trials Comparing Radiation Exposure in Robot-Guided Versus Freehand Spinal Fusion

Jordan J. Levett[1], Abdulrhman Alnasser[2], Uri Barak[2], Lior Elkaim[3], Daipayan Guha, Thien Sa Hoang[4], Alexander Weil[5], Naif M. Alotaibi[6], Michael Weber[7]

[1]Faculty of Medicine, University of Montreal, [2]Division of Orthopaedic Surgery, [3]Department of Neurology and Neurosurgery, [4]Université de Montréal Bibliothèques, [5]Division of Neurosurgery, [6]Department of Neurosurgery, [7]McGill University Health Centre

INTRODUCTION:

Robot-guided (RG) pedicle screw placement offers several advantages over freehand (FH) surgery to patients undergoing spinal fusion. Radiation exposure and detrimental risks associated with RG surgery are poorly described in the literature. We perform a systematic review and meta-analysis of randomized controlled trials comparing RG to FH spinal fusion in terms of radiation exposure.

METHODS:

Medline, Embase, Web of Science, and Cochrane Central were systematically queried. Inclusion was restricted to RCTs in adults. The primary outcome was radiation time, and dose estimates were extrapolated from this data. The secondary endpoints included pedicle screw accuracy, surgical duration, intraoperative bleeding volume, and length of hospital stay. Version 2 of the Cochrane risk-of-bias tool for RCTs (RoB 2) was used to evaluate risk of bias. Quality of the included studies was appraised using the GRADE assessment tool. Screening and grading were conducted independently and in duplicate with conflicts resolved through discussion. Continuous data were pooled across trials with inverse variance weighting to mean difference (MD) and dichotomous data were pooled with Mantel-Haenszel weighting to odds ratio (OR) with corresponding 95% confidence intervals (CI). A random effects model was used if heterogeneity was high ($I^2 \geq 50\%$). We registered the study protocol a priori (CRD42022373605).

RESULTS:

A total of 1,042 patients (RG: 651; FH: 391) from 8 RCTs were included. Radiation time was reduced in the RG group (MD: -25.65 seconds, 95% CI: -51.07 to -0.22, p=0.05, I^2=98%) with an estimated anteroposterior and lateral dose-area product in the RG group measuring 123.85 ± 73.12 cGycm^2 and 241.08 ± 142.33 cGycm^2, respectively. Estimated cancer risk and detrimental hereditary disorder risk were increased in the RG group by 3.60 x 10^{-5} ± 2.12 x 10^{-5} and 1.31 x 10^{-6} ± 7.72 x 10^{-7}, respectively. Intraoperative bleeding volume was reduced in the RG group (MD: -61.52 mL, 95% CI: -100.16 to -22.87, p=0.002, I^2=48%). However, surgical duration was significantly higher in the RG group (MD: 12.01 minutes, 95% CI: 1.63 to 22.39, p=0.02, I^2=51%). Pedicle screw accuracy and length of hospital stay differences were not significant.

DISCUSSION AND CONCLUSION:

Radiation exposure to patients undergoing spinal fusion is lower in RG surgery compared to FH surgery. These findings can be supported with long-term studies that better characterize radiation dosages associated with these procedures.

Figure 1. PRISMA preferred reporting flowchart for conducting Systematic Reviews and Meta-Analyses.

Figure 2. Forest plots of the primary and secondary outcomes of the included randomized controlled trials.

Figure 3. Risk of bias appraisal of the included studies using Version 2 of the Cochrane risk-of-bias tool for RCTs (RoB 2).