Robotics Reduces Radiation Exposure in Minimally Invasive Lumbar Fusion Compared To Navigation

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INTRODUCTION:

The increased radiation exposure in minimally invasive spine surgery (MISS) and its associated risks have driven the advent of newer technologies like navigation and robotics over the last two decades. These modalities decrease the dependence on fluoroscopy and thus, have been reported to reduce surgeons' exposure to ionizing radiation. Although studies have been conducted comparing radiation exposure with robotics or navigation to that with traditional fluoroscopy, there has been no such comparative study between robotics and navigation. The purpose of this study was, therefore, to compare robotics and navigation for minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) in terms of fluoroscopy time and radiation dose. A secondary objective was to compare the operative time demand with the two modalities.

METHODS:

Study design: Retrospective cohort

Patient population: Patients who underwent elective one- or two-level MI-TLIF by a single surgeon using navigation (Stryker SpineMask, Stryker Corp., Kalamazoo, MI) or robotics (ExcelsiusGPS, Globus Medical Inc, Audubon, PA) were included (navigation 2017-19, robotics 2019-21, resulting in prospective cohorts of consecutive patients for each modality). All surgeries had the intraoperative CT workflow.

Outcome measures: 1) operative time (time of incision to time of closure), 2) time for setup and image capture (induction end time to incision time), 3) total operating room (OR) time (in room to out of room time), and 4) radiation exposure (fluoroscopy time for surgical procedure, fluoroscopy time for image capture, total fluoroscopy time, % of radiation for surgical procedure, % of radiation for image capture, and total radiation dose).

Statistical analysis: The two cohorts were compared using Chi square test and Fisher's exact test for categorical variables, and student t-test and Mann Whitney u-test for normally and non-normally distributed continuous variables respectively.

RESULTS:

244 patients (111 patients in the robotics cohort, 133 patients in the navigation cohort) were included in the study. There was no significant difference between the cohorts in terms of age, gender, body mass index, age-adjusted Charlson Comorbidity Index (CCI), American Society of Anesthesiologists (ASA) class, number of primary/revision surgeries, and number of fusion levels (Table 1).

For one-level TLIFs, the fluoroscopy time for surgical procedure, total fluoroscopy time, total radiation dose, and % of radiation for surgical procedure were significantly less with robotics compared to navigation (11 vs. 15s, $p<0.001$; 20 vs. 25s, $p<0.001$; 38 vs. 42mGy, $p=0.05$; 58 vs. 65%, $p=0.021$). There was no significant difference between the two groups in fluoroscopy time for image capture (9 vs. 9s, $p = 0.399$) (Table 2). Although the time for setup and image capture was significantly less with robotics (22 vs. 25 min, $p<0.001$) and operative time was significantly greater with robotics (103 vs. 93 min, $p<0.001$), there was no significant difference in the total OR time (145 vs. 141 min, $p=0.25$) (Table 3).

Analysis of two-level TLIFs also showed similar findings. The fluoroscopy time for surgical procedure, total fluoroscopy time, and total radiation dose were significantly less with robotics compared to navigation (18 vs. 30s, $p=0.003$; 25 vs. 39s, $p<0.001$; 38 vs. 42mGy, $p=0.05$; 58 vs. 65%, $p=0.021$). However, the % of radiation for surgical procedure, although less with robotics compared to navigation, was not significantly different (73 vs. 76%, $p=0.992$). There was no significant difference between the two groups in fluoroscopy time for image capture (9 vs. 9s, $p = 0.690$) (Table 2). Comparing the time demand for two-level TLIFs between the two groups, no significant difference was found in the time for setup and image capture, operative time, or total OR time (24 vs. 25 min, $p=0.110$; 145 vs. 132 min, $p=0.141$; 193 vs. 176 min, $p=0.645$) (Table 3).

Analysis of the robotics cases was done separately to compare the radiation exposure before (n=51) and after (n=60) the Interbody Solutions update allows for planning of cage placement and superimposes the position of the cage while preparing the disc. No significant difference was found between the two groups for both one-level and two-level TLIFs (Table 4).

DISCUSSION AND CONCLUSION:

Robotics compared to navigation leads to a significant reduction in radiation exposure both for the surgeon and the patient. Although it does lead to a slight increase in the OR time, it is not statistically significant. However, multicenter prospective trials are required to establish these findings.

	Robotics	**Navigation**	**p**
Age (in years)	59.45 ± 12.81	57.81 ± 13.25	0.327
Gender – Female – Male	56 (50.4%) 55 (49.6%)	59 (44.4%) 74 (55.6%)	0.343
BMI (in kg/m²)	27.6 ± 5.1	27.88 ± 4.21	0.701
ASA class – I – II – III	10 (9%) 96 (86.5%) 5 (4.5%)	14 (10.5%) 115 (86.5%) 4 (3%)	0.775
Age-adjusted CCI	2.11 ± 1.83	2 ± 1.79	0.595
Surgery type – Primary – Revision	79 (71.2%) 27 (28.8%)	94 (70.7%) 21 (29.3%)	0.194
Fusion levels – 1 – 2	86 (77.5%) 25 (22.5%)	109 (81.2%) 24 (18.8%)	0.385

Table 1: Comparison between the robotics and navigation cohorts in terms of demographics, surgery type, and number of fusion levels. BMI, body mass index; CCI, Charlson Comorbidity Index

		Fluoroscopy time for surgical procedure (in seconds)	Fluoroscopy time for image capture (in seconds)	Total fluoroscopy time (in seconds)	% of radiation for surgical procedure	% of radiation for image capture	Total radiation dose (in mGy)
1-level TLIF	Robotics (n=86)	11 [8 – 14]	9 [9 – 9]	20 [17 – 23]	58% (22 mGy)	42%	38 [33.15 – 55.75]
	Navigation (n=109)	15 [10 – 22]	9 [9 – 9]	24.5 [20- 31]	65.5% (31 mGy)	34.5%	41.7 [33.05 – 65.3]
	p	**<0.001**	0.399	**<0.001**	**0.021**	**0.047**	**0.005**
2-level TLIF	Robotics (n=25)	18 [13 – 20.5]	9 [9 – 9]	25 [18.5 – 34.5]	73% (29 mGy)	27%	48.4 [31.15 – 57.6]
	Navigation (n=24)	30 [14 – 40]	9 [8 – 9]	39 [29 -49]	76% (50 mGy)	24%	66.4 [55.8 – 85.3]
	p	**0.043**	0.690	**0.001**	0.992	0.992	**0.001**

Table 2: Comparison between the robotics and navigation cohorts in terms of fluoroscopy time and radiation dose for one- and two-level TLIF surgeries. TLIF, transforaminal lumbar interbody fusion

	1-level (n, robotics= 86 navigation=109)			**2-level (n, robotics=25 navigation=24)**			**Overall (n, robotics=111 navigation=133)**		
	Time for setup and image capture	Op time	Total OR time	Time for setup and image capture	Op time	Total OR time	Time for setup and image capture	Op time	Total OR time
Robotics	22 [17.75 – 25]	103.5 [89.75 – 79]	143 [132 – 157.5]	24 [20.5 – 28]	145 [131.5 – 171.5]	193 [166 – 213.5]	22 [19 – 25]	108 [94 – 131]	151 [134 – 174]
Navigation	25 [21 – 30]	93 [79 – 104]	141 [125.5 – 154]	25 [22.25 – 28.75]	132.5 [122 – 139.25]	176 [167 – 214.5]	25 [21.5 – 30]	96 [80.5 – 121.5]	146 [129.5 – 169.5]
p	**<0.001**	**<0.001**	0.25	0.11	0.141	0.645	**<0.001**	**<0.001**	0.165

Table 3: Comparison between the robotics and navigation cohorts in terms of time demand for one- and two-level TLIF surgeries. TLIF, transforaminal lumbar interbody fusion

	1-level (n, before: 45; after: 41)	**2-level (n, before: 6; after: 19)**
Fluoroscopy time for surgical procedure (in seconds)	Before: 10.96 ± 6.49 After: 12.78 ± 4.36 p = 0.134	Before: 14.67 ± 4.08 After: 17.53 ± 6.67 p = 0.335
Fluoroscopy time for image capture (in seconds)	Before: 8.84 ± 2.36 After: 8.34 ± 3.11 p = 0.399	Before: 6.17 ± 4.4 After: 10.42 ± 4.63 p = 0.127
Total fluoroscopy time (in seconds)	Before: 19.61 ± 5.3 After: 21.07 ± 4.28 p = 0.062	Before: 21 ± 4.29 After: 28.16 ± 9.66 p = 0.095
Total radiation dose (in mGy)	Before: 40.19 ± 16.51 After: 49.13 ± 72 p = 0.415	Before: 33.16 ± 11.67 After: 42.24 ± 22.12 p = 0.08

Table 4: Comparison of the robotics cases before and after the Interbody Solutions update in terms of fluoroscopy time and radiation dose for one- and two-level TLIF surgeries. TLIF, transforaminal lumbar interbody fusion