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Use of an operating microscope during spine surgery is associated with minor increases in operating room times and no increased risk of infection

Bryce A. Basques, B.S.[1], **Nicholas S. Golinvaux, B.A.**[1], **Daniel D. Bohl, M.P.H.**[1], **Alem Yacob, M.D.**[1], **Jason O. Toy, M.D.**[1], **Arya G. Varthi, M.D.**[1], and **Jonathan N. Grauer, M.D.**[1]

[1] Department of Orthopaedics and Rehabilitation, Yale School of Medicine

Abstract

Study Design—Retrospective database review.

Objective—To evaluate whether microscope use during spine procedures is associated with increased operating room times or increased risk of infection.

Summary of Background Data—Operating microscopes are commonly used in spine procedures. It is debated whether the use of an operating microscope increases operating room time or confers increased risk of infection.

Methods—The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, which includes data from over 370 participating hospitals, was used to identify patients undergoing elective spinal procedures with and without an operating microscope for the years 2011 and 2012. Bivariate and multivariate linear regressions were used to test the association between microscope use and operating room times. Bivariate and multivariate logistic regressions were similarly conducted to test the association between microscope use and infection occurrence within 30 days of surgery.

Results—A total of 23,670 elective spine procedures were identified, of which 2,226 (9.4%) used an operating microscope. The average patient age was 55.1 ± 14.4 years. The average operative time (incision to closure) was 125.7 ± 82.0 minutes.

Microscope use was associated with minor increases in preoperative room time (+2.9 minutes, p=0.013), operative time (+13.2 minutes, p<0.001), and total room time (+18.6 minutes, p<0.001) on multivariate analysis.

A total of 328 (1.4%) patients had an infection within 30 days of surgery. Multivariate analysis revealed no significant difference between the microscope and non-microscope groups for

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Corresponding author: Jonathan N. Grauer, MD Department of Orthopaedics and Rehabilitation, Yale School of Medicine 800 Howard Avenue, New Haven, CT 06510 Tel: 203-737-7463, Fax: 203-785-7132, jonathan.grauer@yale.edu.

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occurrence of any infection, superficial surgical site infection (SSI), deep SSI, organ space infection, or sepsis/septic shock, regardless of surgery type.

Conclusions—We did not find operating room times or infection risk to be significant deterrents for use of an operating microscope during spine surgery.

Keywords

operating microscope; surgical site infection; sterility; operative time; national surgical quality improvement program, outcomes; spine; cervical; thoracic; lumbar

Introduction

The operating microscope is commonly considered for use in spine surgery. Advocates of this tool tout its ability to improve visualization for the surgeon and surgical team without increasing the size of the surgical incision.[1,2] However, others cite concerns that the use of the operating microscope may increase operating room times and increase risk of infection.[3-5]

Increased operative time has been shown to be an independent risk factor for postoperative complications in spine surgery.[6] Time spent preparing and using the microscope has the potential to lengthen operating room times compared to non-microscope cases. While some studies have found operating microscopes to be associated with increased operative time, these results may be outdated and are limited by a small sample size.[7-10] Additional information is needed about the potential effects of microscope use on operating room times.

Surgical site infections (SSIs) following spine surgery are associated with poor outcomes and high costs.[11] Several potentially modifiable risk factors for SSI include preoperative bacterial screening, skin preparation, prophylactic antibiotic administration, the degree of surgical trauma, the operating room environment, and operative equipment.[3-5,12-16] In particular, previous studies have found bacterial contamination of the operating microscope and other operating room equipment during spine surgery.[3-5,13,17] It is not clear if this reported bacterial contamination of the microscope translates into an increased risk of infection for the patient.

This study aims to use a national database to compare the operative times and rates of infections between spine procedures that have used an operating microscope and those that have not.

Methods and Materials

Data source

For this study, we used the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, which captures data from over 370 participating United States hospitals.[18] The ACS-NSQIP prospectively collects over 150 patient variables from operative reports, medical records, and patient interviews to assess 30-day adjusted surgical outcomes using specially trained clinical reviewers. The ACS-

NSQIP conducts routine auditing in order to maintain high data quality, and inter-rater disagreement is below 2% for each collected variable.[18,19] Clinical data are collected up to the 30th postoperative day, including after the patient is discharged from the hospital.

Data collection

The ACS-NSQIP database from 2011 and 2012 was queried to identify patients who underwent elective spine procedures. Spine procedures were selected based on the following primary Current Procedural Terminology (CPT) codes: anterior cervical discectomy and fusion (22551, 22554, and 63075), anterior cervical corpectomy (63081), posterior cervical fusion (22600), cervical laminotomy (63040), posterior thoracic fusion (22610), lumbar laminotomy (63030), lumbar laminectomy (63047), anterior lumbar fusion (22558), and posterior lumbar fusion (22612 or 22630). Cases with microscope use were identified by the presence of the CPT code 69990 in addition to one of the above-mentioned primary CPT codes. While there may be other procedures that employ the operating microscope, these were the only elective spine procedures available in the ACS-NSQIP for which microscope use was noted. Procedures that utilized the operating microscope for all or part of the operation were included in the microscope group.

The number of levels for each procedure was also available in the database. The number of levels for each procedure was determined based on the presence of procedure-specific supplementary CPT codes for each additional level. Both one-level and multilevel procedures were included in this study. Patients undergoing spinal procedures at multiple sites, patients undergoing urgent or emergent surgery, or those with previous evidence of infection were excluded from the analysis. Patients with missing perioperative data were also excluded from the analysis.

Among the variables available in the ACS-NSQIP are patient characteristics including sex, age, height, and weight. Body mass index (BMI) was calculated from height and weight. The ACS-NSQIP also includes information on medical comorbidities and American Society of Anesthesiologists (ASA) class. A modified Charlson comorbidity index (CCI)[20] was calculated for each patient based on the available comorbidity data in the database. Modified CCI calculations were performed with the statistical software, using an algorithm that has been previously used and validated with the ACS-NSQIP.[21] Such modified CCIs have been shown to be similar in efficacy to the original CCI.[22,23]

The comorbidities used to determine the modified CCI were directly available in the dataset and included (followed by corresponding point values): myocardial infarction (1), congestive heart failure (1), peripheral vascular disease or rest pain (1), transient ischemic attack or cerebrovascular accident (1), chronic obstructive pulmonary disease (1), diabetes mellitus (1), hemiplegia (2), end stage renal disease (2), ascites or esophageal varices (3), and cancer (6). One point was added for each decade greater than 40 years of age.

Operating Room Times

The ACS-NSQIP also records preoperative room time, operative time, postoperative room time, and total room time for surgical cases. Preoperative room time was defined as the minutes between the patient entering the operating room and the opening incision. Operative time was defined as the minutes from opening incision to wound closure. Postoperative room time was defined as minutes from wound closure to the patient leaving the operating room.

Preoperative room time, operative time, postoperative room time, and total room time were treated as continuous variables for analysis. Patients with missing data for any operating room time were excluded from the operating room time analyses.

Infection

The ACS-NSQIP records the occurrence of various postoperative events, including infection, for up to 30 days following the surgical procedure. The ACS-NSQIP defines surgical site infections according to the Centers for Disease Control and Prevention (CDC)/ National Nosocomial Infections Surveillance (NNIS) guidelines.[24] According to these guidelines, an SSI is defined as an infection that involves skin or subcutaneous tissue (superficial), fascia or muscle layers (deep), or any other anatomic components manipulated during surgery (organ space).

The occurrence of sepsis or septic shock was also recorded. Any infection was defined as the occurrence of a superficial SSI, deep SSI, organ space infection, or sepsis/septic shock.

Analysis

Statistical analyses were conducted using Stata® version 11.2 (StataCorp, LP, College Station, Texas, USA). Statistical significance was set at $p < 0.05$. One member of the study team conducted data extraction and statistical analyses. Pearson's chi-squared test was used to compare patient and operative characteristics between patients that underwent spine surgery with and without an operating microscope.

Operating room times were compared between microscope and non-microscope groups using bivariate and multivariate linear regression (as operating room times were treated as continuous variables), using non-microscope cases as the reference. Multivariate analysis adjusted for demographic and comorbidity variables (age, sex, body mass index, ASA class, and modified CCI) and operative variables (number of levels and procedure type). Bivariate and multivariate logistic regressions were used to compare the rates of infections that occurred with or without an operating microscope, as infections were treated as binary variables.

Results

Patient and Operative Characteristics

A total of 23,670 elective spine procedures were identified in 2011 and 2012 in the ACS-NSQIP. A total of 2,226 patients (9.4%) underwent surgery with an operating microscope. A summary of patient demographics and comorbidities can be found in Table 1. The average age was 55.1 ± 14.4 years. The cohort was 51.6% male. Among all patients, 36.8% were ASA 3-4, and 43.5% had a modified CCI of 3 or greater.

Comparison of patient characteristics using Pearson's chi-squared analysis found statistically significant differences between the microscope group and non-microscope group for age, BMI, modified CCI, and the number of levels. P-values reported in Table 1 are for comparisons between all categories of each given demographic group. Patients undergoing spine surgery with a microscope were younger, had a lower BMI and modified CCI, and had fewer operative levels compared to the non-microscope group. Although these differences were statistically significant, due to the relatively small magnitude of most differences, it is unclear if they were clinically significant. Nonetheless, these differences in patient and operative characteristics were controlled for in subsequent multivariate analyses.

Table 2 describes the types and frequencies of spinal procedures in the population. The most-represented spinal procedure type was lumbar laminotomy (8,149 cases or 34.4% of all procedures), followed by anterior cervical fusion (6,964 cases or 29.4% of all procedures), and lumbar laminectomy (4,138 cases or 17.5% of all procedures). Cervical laminotomy had the greatest percentage of cases where an operating microscope was used (22.0%), followed by lumbar laminotomy (14.1%).

Operating Room Times

Operating room times were compared between microscope and non-microscope groups using bivariate and multivariate linear regression. Multivariate analyses controlled for all demographics, comorbidities, and procedure characteristics (number of levels and procedure type) listed in Table 1 and Table 2. This was done in order to enable comparisons between similar patients and surgeries. Table 3 reports the average operating room times for the microscope and non-microscope groups, along with unstandardized beta coefficients and p-values of the bivariate and multivariate linear regressions for each operating room time. The unstandardized beta coefficient indicates the average increase or decrease in minutes associated with microscope use for each operating room time.

On bivariate analyses, microscope use was found to be associated with only a very minor decrease in postoperative room time (-1.4 minutes, $p = 0.004$). This association disappeared after controlling for patient and operative characteristics using multivariate analysis. For other operating room times, microscope use was found to be associated with increases in preoperative room time (+2.9 minutes, $p = 0.013$), operative time (+13.2 minutes, $p < 0.001$), and total room time (+18.6 minutes, $p < 0.001$) on multivariate analysis.

Infections

Overall, 328 patients (1.4%) had any infection following spine surgery, with the most common type of infection being superficial SSI (0.7%). The results of bivariate and multivariate logistic regressions for risk of infection can be found in Table 4. Different from the unstandardized beta values in Table 3, Table 4 reports odds ratios and p-values for each logistic regression, with odds ratios indicating the strength of the association of microscope use with each category of infection.

With bivariate analyses, microscope use was not found to be significantly associated with superficial SSI, deep SSI, organ/space infection, sepsis/septic shock, or any infection.

Similarly, multivariate analysis found no association between microscope use and any category of infection.

Discussion

Operating microscopes have become increasingly common tools for visualization during spine surgery.[1,2] However, concerns exist regarding the potential for increased operating room times and infection risk associated with microscope use.[3-5,9] By examining the risks associated with microscope use, spine surgeons can make more informed decisions about when to incorporate this tool into their practice.

This study analyzed a national sample of more than 23,000 spine surgery patients from 2011 and 2012 in order to identify any differences in infection rates and operative time in this population. Contrary to our hypothesis, we found no significant difference in the rates of any type of infectious complication between microscope use and no microscope use. In terms of operative time, use of a microscope was found to be significantly associated with increases in preoperative room time, operative time, and total room time after adjustment for patient and operative characteristics.

Some interesting differences in patient and operative characteristics were found between the microscope and non-microscope groups. Patients undergoing procedures with a microscope were found to be generally younger and healthier than those undergoing procedures without an operating microscope. This is likely due to the distribution of spine procedures in the two samples. Microscope use was most common in the cervical and lumbar laminotomy procedure groups, which are generally performed on younger, healthier patients. In addition, microscope cases had a decreased number of operative levels compared to non-microscope cases. However, these differences were controlled for in multivariate analyses.

After adjusting for patient and operative characteristics, microscope use was found to be associated with increases in operating room times. Preoperative room time was increased by approximately 3 minutes on average with microscope use, operative time was increased by approximately 13 minutes, and total room time was increased by approximately 19 minutes. Microscope use has similarly been associated with prolonged operative time in the literature. A 2012 study by Kumar et al compared loupes to microscope use for microdiscectomy and microdecompression in 102 patients, and found that microscopes were associated with an increased average operative time of 4 minutes.[10] Older studies that compared microscope cases to non-microscope cases have similarly found increased average operating room times with microscope use, ranging from 5 minutes to 29 minutes.[7-9] However, these previous studies were generally small, single-institution case series with differing surgical techniques, making it difficult to compare results among them. In addition, while the increased operating room times described in the current study and previous studies were statistically significant, their clinical significance is less clear.

In terms of infectious risk, there was no significant difference associated with microscope use for any individual category of infection, or any infection in aggregate. While bacterial contamination of an operating microscope by the end of a case has been reported to be high,[4,5] our results suggest that this does not necessarily translate to an increased rate of postoperative infection. These results are additionally supported by similar findings in the above-mentioned studies that found no difference in the rates of postoperative infection between non-microscope and microscope groups.[3,5,7,10] However, due to the low patient numbers and the relatively rare incidence of postoperative infection, these earlier studies may not have been adequately powered to detect differences in infection rates between groups. For example, Kumar et al reported one postoperative infection in the non-microscope group and zero infections in the microscope group, concluding that the infection rate was similar between groups. The large number of patients included in the current study lends adequate power to the conclusion that infection rates do not differ based on microscope use during spine surgery.

This study was limited by the characteristics of the ACS-NSQIP database. Factors that could potentially affect infection rates following spine surgery, such as timing of antibiotic prophylaxis, were not available. Postoperative follow-up was also limited to 30 days, so infectious complications occurring after this time period would not be recorded. In addition, there is the possibility of inter-rater bias with regard to capturing the occurrence of postoperative infections. However, due to the standardized, prospective collection of data by trained clinical reviewers, the strict definitions of infection, and the rigorous auditing performed by the ACS-NSQIP, the magnitude of this bias would be expected to be low. This systematic collection of data is an advantage of the ACS-NSQIP database over other databases such as the National Inpatient Sample (NIS), which are generated from billing data and only capture inpatient adverse events. In addition, open and MIS cases are not differentiated in this database, so these approaches could not be controlled for. The complexity of each case could also not be well assessed based on the available data. Additionally, previous studies have suggested that there is a learning curve associated with microscope use, with an observed decrease in operative time and postoperative adverse events for later cases as a surgeon gains experience with the technique.[25] As the ACS-NSQIP does not include any identifiers for individual surgeons or institutions, this potential learning curve was unable to be controlled for in the present study. However, with the inclusion of over 23,000 elective spine surgeries performed by a national sample of surgeons with varying levels of experience, the potentially confounding influence of this learning curve was thought to be minimized.

Overall, surgical microscope use in spine surgery has been increasing across the United States. We found that on average, the operating microscope adds a relatively small amount of time to spinal procedures. Furthermore, despite previous studies that have found bacterial contamination of the operating microscope during spine procedures, the results of this study indicate that this does not appear to translate into increased infection risk to the surgical patient. Based on these findings, the use of operating microscopes can be considered a safe and efficient option for visualization of structures during spine surgery if clinically indicated.

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Table 1

Patient characteristics.

	All Patients	Without microscope	With microscope	*p* †
Overall	23670 (100%)	21444 (90.6%)	2226 (9.4%)	
Age				**0.002**
15-39	14.8%	14.5%	17.2%	
40-49	20.8%	20.6%	21.9%	
50-59	25.7%	25.9%	23.9%	
60-69	21.2%	21.4%	19.8%	
≥70	17.5%	17.5%	17.2%	
Male sex	51.6%	51.6%	51.4%	0.828
Body mass index				**0.033**
18-25	21.1%	10.9%	22.7%	
25-30	34.7%	34.6%	35.9%	
30-35	25.3%	25.3%	24.1%	
≥35	19.0%	19.2%	17.4%	
ASA 3-4	36.8%	35.1%	37.0%	0.078
Modified CCI				**0.001**
0-1	33.4%	33.1%	37.0%	
2	23.0%	23.2%	21.5%	
≥3	43.5%	43.7%	41.5%	
Number of levels				**<0.001**
1	80.4%	79.5%	88.9%	
2	15.0%	15.7%	8.0%	
≥3	4.6%	4.8%	3.1%	

ASA = American Society of Anesthesiologists; CCI = Charlson comorbidity index.

† Bolding indicates statistical significance ($p < 0.05$).

Table 2

Procedure types.

Procedure	Total	Without microscope	With microscope
Anterior cervical fusion	6,964	6,468 (92.9%)	496 (7.1%)
Anterior cervical corpectomy	74	65 (87.8%)	9 (12.2%)
Posterior cervical fusion	542	523 (96.5%)	19 (3.5%)
Cervical laminotomy	41	32 (78.1%)	9 (22.0%)
Posterior thoracic fusion	148	143 (96.6)	5 (3.4%)
Lumbar laminotomy	8,149	7,005 (86.0%)	1,144 (14.0%)
Lumbar laminectomy	4,138	3,703 (89.5%)	435 (10.%)
Anterior lumbar fusion	955	937 (98.1%)	18 (1.9%)
Posterior lumbar fusion	2,659	2,568 (96.6%)	91 (3.4%)

Table 3

Association of microscope use with operating room times in elective spine surgery patients.

	Non-microscope Mean ± SD	Microscope Mean ± SD	Bivariate linear regression		Multivariate linear regression[*]	
			Beta[†]	***p***	**Beta**[†]	***p***
Preoperative room time (minutes)[**]	44.8 ± 31.0	45.3 ± 17.4	+0.6	0.635	**+2.9**	**0.013**
Operative time (minutes)[**]	127.9 ± 83.0	121.8 ± 80.9	−6.1	0.062	**+13.2**	**<0.001**
Postoperative room time (minutes)[**]	18.0 ± 12.0	16.6 ± 9.9	**−1.4**	**0.004**	−0.7	0.110
Total room time (minutes)[**]	183.9 ± 97.4	180.3 ± 95.5	−3.6	0.346	**+18.6**	**<0.001**

SD = standard deviation. Bolding indicates statistical significance ($p < 0.05$).

[*] Each line represents a separate multivariate analysis for each variable in order to give an adjusted unstandardized beta coefficient and p-value by controlling for all demographics, comorbidities, and operative characteristics found in Table 1 and Table 2.

[**] Operating room times were only simultaneously available for 8,210 patients, of which 701 (8.4%) underwent surgery with an operating microscope.

[†] Unstandardized beta coefficient represents unit change in the outcome variable if the predictor variable is positive. For example, a statistically significant coefficient of +13.2 for operative time means that on average, microscope use is associated with an increase in operative time of 13.2 minutes.

Table 4

Association of microscope use with infection rates in elective spine surgery patients.

	Without microscope		With microscope		Bivariate logistic regression		Multivariate logistic regression[*]	
	Number	Percent	Number	Percent	OR	*p*	OR	*p*
Any infection	307	1.4%	21	0.9%	0.7	0.063	0.7	0.191
Superficial surgical site infection	152	0.7%	11	0.5%	0.7	0.246	0.7	0.344
Deep surgical site infection	73	0.3%	5	0.2%	0.7	0.368	0.8	0.578
Organ space infection	25	0.1%	3	0.1%	1.2	0.812	1.3	0.714
Sepsis/septic shock	85	0.4%	7	0.3%	0.8	0.555	1.0	0.971

[*] Each line represents a separate multivariate analysis for each variable in order to give an adjusted OR and p-value by controlling for all demographics, comorbidities, and operative characteristics found in Table 1 and Table 2.