



Review Article

## Awake spine surgery: An eye-opening movement

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### ABSTRACT

**Background:** Awake surgery is performed in multiple surgical specialties, but historically, awake surgery in the field of neurosurgery was limited to craniotomies. Over the past two decades, spinal surgeons have pushed for techniques that only require regional anesthesia as they may provide reduced financial burdens on patients, faster recovery times, and better outcomes. The list of awake spine surgeries that have been found in the literature include: laminectomies/discectomies, anterior cervical discectomy and fusions (ACDFs), lumbar fusions, and dorsal column (DC) stimulator placement.

**Methods:** An extensive review of the published literature was conducted through PubMed database with articles containing the search term "awake spine surgery." No date restrictions were used.

**Results:** The search yielded 293 related articles. Cross-checking of articles was conducted to exclude of duplicate articles. The articles were screened for their full text and English language availability. We finalized those articles pertaining to the topic. Findings have shown that lumbar laminectomies performed with local anesthesia have shown shorter operating time, less postoperative nausea, lower incidence of urinary retention and spinal headache, and shorter hospital stays when compared to those performed under general anesthesia. Lumbar fusions with local anesthesia showed similar outcomes as patients reported better postoperative function and fewer side effects of general anesthesia. DC stimulator placement performed with local anesthesia is advantageous as it allows real time patient feedback for surgeons as they directly test affected nerves. However, spontaneous movement during the placement of DC stimulators is associated with higher failure rates when compared to general anesthesia (29.7% vs. 14.9%). Studies have shown that the use of local anesthesia during ACDFs has no significant differences when compared to general anesthesia, and patient's report better tolerated pain with general anesthesia.

**Conclusion:** The use of awake spine surgery is beneficial for those who cannot undergo general anesthesia. However, it is limited to patients who can tolerate prone positioning with no central airway (i.e., normal BMI with a healthy airway), have no pre-existing mental health conditions (e.g., anxiety), and require a minimally invasive procedure with a short operating time. Future studies should focus on long-term efficacies of these procedures that provide further insight on the indications and limitations of awake spine surgery.

**Keywords:** Conscious sedation, Enhanced recovery after surgery, Minimally invasive, Neural feedback, Neuroanesthesia

### INTRODUCTION

Awake surgery is performed in multiple surgical specialties including: obstetrics, orthopedics, neurosurgery, and cardiothoracic surgery.<sup>[22,26,36]</sup> Historically, awake surgery neurosurgery was

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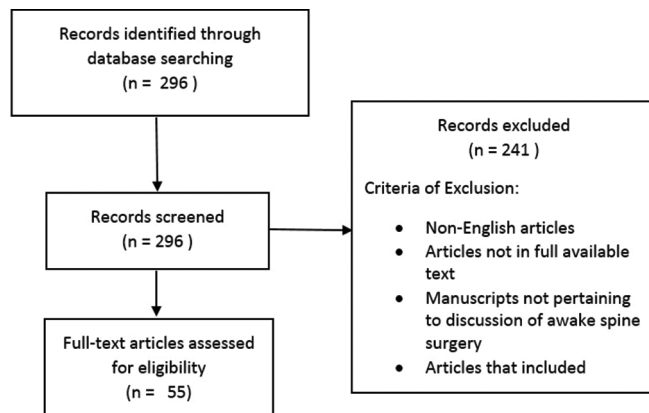
limited to craniotomies, but regional anesthesia has been used for the past two decades for lumbar spinal surgeries such as: lumbar laminectomies and discectomies.<sup>[15]</sup> But with the recent focus on minimally invasive procedures, faster recovery times, and better outcomes, neurosurgeons have pushed for techniques that only require regional anesthesia.<sup>[29]</sup> In 2016, a study done by Wang and Grossman described an endoscopic approach for one of the first minimally invasive TLIF that utilized local anesthetics.<sup>[57]</sup> Since then multiple studies have described other modifications to that technique, as well as, other types of awake spine surgery.<sup>[29]</sup> A literature search through PubMed revealed 296 results using the term “awake spine surgery” and the exclusion criteria were nonEnglish articles, articles not in full available text, manuscripts not pertaining to the discussion of awake spine surgeries, and articles that included confusing or irrelevant data regarding the topic. After exclusion criteria were applied, 55 articles remained in contention, and this process is summarized in [Figure 1].

The objectives of this literature review are to provide a contemporary analysis of awake spine surgery procedures with published outcomes, discuss the benefits and limitations of awake spine surgery, and identify who are the ideal candidates for awake spine surgery.

## COMMONLY PERFORMED AWAKE SPINE SURGERIES

### Laminectomy/discectomy

Spinal anesthesia for lumbar surgery is becoming increasingly popular, as it can be performed with a variety of techniques and medication, and often yields better patient outcomes than general anesthesia. Early reports of the use of spinal anesthesia for lumbar laminectomy or discectomy have been promising. In one case-controlled study of 400 lumbar laminectomies, spinal anesthesia allowed for shorter operation time, less postoperative nausea, and lower incidence of urinary



**Figure 1:** Database search process and exclusion criteria for literature search.

retention and spinal headache when compared to general anesthesia.<sup>[38]</sup> A similar study corroborated these findings, as well as noting the average perioperative blood pressures and heart rates were lower with local anesthesia.<sup>[37]</sup> These results were further reinforced in several independent studies exploring the outcomes of local versus general anesthesia for laminectomies and discectomies. These additional studies also disclosed a lower postoperative analgesic requirement and less time spent in the post anesthesia care unit (PACU), and the results of these studies are summarized in [Table 1].<sup>[1,2,14,16,17,21,24,25,27,30,42,43,46-48,52-54,58]</sup> Overall, local anesthesia may be a better alternative for healthy patients undergoing lumbar decompression procedures or for patients at risk for general anesthetic complications.<sup>[15]</sup>

### Anterior cervical discectomy and fusion (ACDF)

Advances in awake spine surgery for ACDF are lagging behind their lumbar counterparts.<sup>[40]</sup> The type of cervical block is determined primarily by the depth of injection, intermediate and deep, with the superficial block being preferred due to fewer complications. Both modes require additional local anesthetic to subcutaneous or deep tissues during surgery due to regions innervated outside of the cervical plexus.<sup>[31]</sup> Although prolonged anesthesia during ACDF has been shown to increase the odds of complication, venous thromboembolism, increased length of stay (LOS), and return to the operating room,<sup>[45]</sup> the use of cervical plexus blocks in ACDF is not yet widely practiced and has been associated with ambivalent outcomes. One randomized clinical trial comparing general anesthesia to local anesthesia during ACDF found that the use of cervical plexus blocks has been associated with benefits that include a comparatively lower incidence of nausea and vomiting, as well as a shortened procedural, revival, and recovery time.<sup>[56]</sup> The study also noted drawbacks of local anesthesia including a greater increase in intraoperative blood pressure and heart rate, as well as higher levels of pain intra and postoperatively. Although there was no difference in surgeon and anesthetist satisfaction between the two groups, patient satisfaction was higher in the general anesthesia group, largely due to better pain control.<sup>[56]</sup> A summary of the articles that specifically studied awake protocol on anterior discectomies and fusions is shown in [Table 2]. Consequently, the local Brachial plexus block has been more commonly used as an alternative for carotid endarterectomy, parathyroidectomy, and surgery on the clavicle or thyroid.

### Lumbar fusion

Consistent with the current focus and drive of decreasing the morbidity and negative outcomes of neurological surgery, lumbar fusion surgery has more recently been performed without generalized anesthesia in an effort to improve

**Table 1:** Summarization of published trials, case series, and outcomes of patients undergoing awake laminectomies and discectomies.

Author (year)	Surgery	Anesthetic method	Patients	HR or ΔHR at PACU	MAP or ΔMAP across time	Blood loss (ml)	Surgery time (minutes)	PACU time (minutes)	Analgesic use or pain score	Urinary retention	Nausea rate (%)	Fusion rate (%)	Hospital stay length (days)
Greenberg et al. <sup>[21]</sup> (1988)	Lumbar laminectomy or discectomy	Epidural	40	-	-	188.3	115.2	-	1.1	10%	-	-	-
Jellich et al. <sup>[27]</sup> (1996)	Single or double level laminectomy or disc surgery	Spinal	61	GA>RA at PACU	GA>RA across time	133 (13)	67.1 (2.8)	85.4 (4.2)	26.20%	14.80%	5%	-	-
Rung et al. <sup>[47]</sup> (1997)	Lumbar disk surgery	Spinal	7	-26.6 (4.0)	-14.2 (4.0)	45±33	96±28	48±38	0%	-	0%	-	-
Tetzlaff et al. <sup>[52]</sup> (1998)	Discectomy or laminectomy for spinal stenosis	Spinal	611	-26.6 (4.0)	-14.2 (4.0)	GA=RA	-	-	-	-	-	-	-
Demirel et al. <sup>[16]</sup> (2003)	Lumbar partial hemilaminectomy and discectomy	Epidural	30	GA>RA across time	GA>RA across time	180.4±70.4	118.8±35.4	34.4±12	0.2±0.5	20%	10%	-	-
McLain et al. <sup>[37]</sup> (2004)	Laminectomy or laminotomy for spinal stenosis or herniated disk	Spinal	200	72	95	-	105	225	0.6	8%	GA>RA	-	-
Papadopoulos et al. <sup>[44]</sup> (2006)	Lumbar microdiscectomy	Epidural	27	-	-	-	65.4 (15.2)	-	4	-	20%	-	-
McLain et al. <sup>[38]</sup> (2007)	Microdiscectomy for herniated lumbar disc	Spinal	43	GA>RA	GA>RA	-	-	234	1.1	4.70%	2.30%	-	-
Demirkol et al. <sup>[17]</sup> (2009)	Lumbar stenosis/herniated nucleus pulposus	Spinal	30	-	-	-	65.2±17.4	48.5±21.5	-	-	-	-	-
Sadralsadat et al. <sup>[48]</sup> (2009)	Laminectomy for herniated lumbar disk	Epidural	50	6%	6%	465±69	94.4±17.	21.7±8.8	22%	-	10%	-	-
Nicassio et al. <sup>[43]</sup> (2010)	Lumbar microdiscectomy	Spinal	23	-	-	-	-	-	-	-	-	-	1.25±0.2
Attari et al. <sup>[4]</sup> (2011)	Discectomy or laminectomy for amniotomy or spinal cord tumor	Spinal	35	-13.2±3.9	-25.1±4.2	210±40	115.0±3.2	55±6.7	0%	-	5.70%	-	-
Chen et al. <sup>[10]</sup> (2011)	Endoscopic interlaminar discectomy	Spinal	73	-	-	-	67.1±33.9	-	-	-	-	-	-

(Contd...)

**Table 1:(Continued).**

Author (year)	Surgery	Anesthetic method	Patients	HR or ΔHR	MAP or ΔMAP	Blood loss (ml)	Surgery time (minutes)	PACU time (minutes)	Analgesic use or pain score	Urinary retention	Nausea	Fusion rate (%)	Hospital stay length (days)
Inci et al. <sup>[25]</sup> (2011)	Lumbar disk surgery	Spinal	30	-	-	-	89.5±9.8	95.8±9.7	-	-	-	-	1.7±1.3
Inci et al. <sup>[25]</sup> (2011)	Discectomy for lumbar disk herniation	Spinal	30	-	-	448.34±47.45	GA>RA	95.8±9.7	66.60%	10%	6.60%	-	-
Yıldırım	Minimally invasive lumbar disk surgery	Spinal	28	-	-	-	-	-	-	-	-	-	0.93±0.141
Güçlü et al. <sup>[58]</sup> (2014)	Lumbar disk surgery	Spinal	294	-	-	-	77.21±21.62	-	-	-	-	-	-
Karaman et al. <sup>[30]</sup> (2014)	Lumbar disk surgery	Spinal	40	-	-	-	74.06±11.8	-	-	-	-	-	-
Alim et al. <sup>[2]</sup> (2014)	Prolapse lumbar intervertebral disk (PLID) surgery	Spinal	33	82±13	81±12	-	-	-	4	0	0	-	-
Vural et al. <sup>[54]</sup> (2014)	Spine surgery for lumbar disk herniation	Spinal	90	-	-	-	71±12	-	-	-	-	-	-
Dagistan et al. <sup>[14]</sup> (2015)	Lumbar microdiscectomy	Spinal	30	-	-	-	40.36±4.88	95.8±9.7	-	-	-	-	2±0.1
Hussain et al. <sup>[24]</sup> (2015)	Single level lumbar discectomy	Spinal	573	-	-	-	67.7±19.6	-	-	-	-	-	1.09±0.38
Ulutas et al. <sup>[53]</sup> 2015	Lumbar microdiscectomy	Spinal	326	-	-	-	98.3±34.6	177±74.9	-	-	-	-	1.5±1
Agarwal et al. <sup>[1]</sup> (2016)	Lumbar discectomy and laminectomy	Spinal	361	-	-	-	97.4±15.8	178±29.5	-	-	-	-	1.5±0.2
Pierce et al. <sup>[46]</sup> (2017)	Laminectomy/Discectomy	Spinal	97	-	-	-	84.98±3.97	214±15.16	-	-	-	-	-
Morris et al. <sup>[42]</sup> (2019)	Laminectomy/Microdiscectomy	Spinal											

GA: General anesthesia, RA: Regional anesthesia, ODI: Oswestry Disability index, MAP: Mean arterial pressure, Δ: Change, PACU: Post anesthesia care unit

**Table 2:** Summarization of published trials, case series, and outcomes of patients undergoing awake anterior cervical discectomies and fusions.

Author (year)	Surgery	Anesthetic method	Patients	HR or ΔHR	MAP or ΔMAP	Blood loss (ml)	Surgery time (minutes)	PACU time (minutes)	Analgasic use or pain score	Urinary retention	Nausea	Fusion rate (%)	Hospital stay length (days)
Wang et al. <sup>[56]</sup> (2017)	Anterior cervical discectomy and fusion	Cervical plexus block	187	84.7±9.8	102.3±6.2	26.0±4.8	48.1±9.9	-	Average dose of meperidine: 0.20±0.51 average dose of metoclopramide: 0.01±0.03	-	-	-	-

GA: General anesthesia, RA: Regional anesthesia, ODI: Oswestry disability index, MAP: Mean arterial pressure, Δ: Change, PACU: Post anesthesia care unit

outcomes and accelerate recovery. The operative procedure has been discussed previously in the literature<sup>[9,33,57]</sup> The articles that analyzed awake techniques in lumbar fusions are summarized in [Table 3].<sup>[12,50,55]</sup> The current technique used within awake lumbar fusion is advantageous due to the decreased risk associated with the use and side effects of general anesthesia while also providing direct feedback to the surgeon in traversing neural structure.<sup>[57]</sup> Conclusions regarding the true success of lumbar fusion without general anesthesia have been difficult to draw due to a patient selection that may have already favored positive outcomes. A notable example is a study by Chin *et al.* (2015) which included 16 patients who reported a significant decrease in pain and increased function postoperatively.<sup>[11]</sup> However, the patients selected for this study were strictly chosen with criteria of low anesthesia risk, access to family care postoperatively, and living within 30 min from a hospital, along with other cardiac and BMI restriction.<sup>[11]</sup> Therefore, while current studies demonstrate favorable outcomes, more research is necessary to draw applicable conclusions.

**Dorsal column (DC) stimulator placement**

DC stimulation has been proven as a successful treatment option in managing neuropathic pain through its mechanism of delivering doses of electrical current. DC stimulator placement has been performed in awake and nonawake methods. While awake surgery offers the surgeon the ability to directly test the affected nerves, increasing the likelihood of a desirable outcome, nonawake surgery is associated with reduced instances of spontaneous movements.<sup>[19,38]</sup> In a procedure that is highly reliant on properly positioning the patient, with an emphasis on stabilizing the nodes, spontaneous movements present an increased risk of displacing the electrodes.<sup>[38,44]</sup> Hence, while performing DC stimulator placement surgery without general anesthesia can allow surgeons to directly test the efficiency of electrode placement, previous studies have shown a higher incidence of device failures associated with awake surgeries. Specifically, a previous study by Falowski *et al.* (2011), demonstrated a 29.7% device failure in awake DC stimulator placement compared to 14.9% device failure in general anesthesia patients.<sup>[19]</sup>

**INDICATIONS**

Awake spinal surgery is an alternative surgical technique with indications that increase the population of patients eligible for spinal procedures. There are procedures that were not listed previously, such as decompressions, that can be performed using awake protocols. The findings of these studies, along with multi-procedure data sets, are shown in [Table 4].<sup>[23,28,51]</sup> Historically, patients with multiple comorbidities and received an ASA score of III or IV were deemed ineligible for spinal

**Table 3:** Summarization of published trials, case series, and outcomes of patients undergoing awake lumbar fusions.

Author (year)	Surgery	Anesthetic method	Patients	HR or ΔHR	MAP or ΔMAP	Blood loss (ml)	Surgery time (minutes)	PACU Time (minutes)	Analgasic use or pain score	Urinary retention	Nausea	Fusion rate (%)	Hospital stay length (days)
Cohen et al. <sup>[12]</sup> (1997)	Lumbar spine fusion	Spinal	21	-	-	-	-	-	-	-	-	-	5.3±0.3
Schroeder et al. <sup>[80]</sup> (2011)	Anterior lumbar interbody fusion	Spinal	19	-	-	-	101.9±10.2	113.3±64.4	-	-	-	-	1.075±0.424
Walcott et al. <sup>[55]</sup> (2015)	Lumbar spondylosis surgery	Spinal	81	-	-	-	159.93±32.75	-	-	-	-	-	2.02±0.98
Kolcun et al. <sup>[33]</sup> (2019)	Minimally invasive transforaminal lumbar interbody fusion	Sedation was accomplished using a combination of propofol and ketamine	100	-	-	65.476.6 ml for 1 level fusion and 74.7±33.6 ml for 2 level fusion	84.5±21.7 for 1 level fusion and 128.1±48.6 for 2 level fusion	-	Preoperative ODI score 29.6±15.3 Postoperative ODI score 17.2±16.9.	-	-	-	1.4±1.0

GA: General anesthesia, RA: Regional anesthesia, ODI: Oswestry Disability index, MAP: Mean arterial pressure, Δ: Change, PACU: Post anesthesia care unit

procedures under general anesthesia. However, following patient cases with an ASA of III or IV, Khan *et al.* found that surgeries using local anesthetic were as safe, and comparably efficacious to procedures performed to subjects who qualified for general anesthesia.<sup>[32]</sup> Due to reduced levels, occurrence, and duration of postoperative nausea, local anesthetic is indicated in elderly patients, or patients who are sensitive to nausea. As a result, elderly patients are prime candidates due to local anesthesia presenting with fewer respiratory, cardiovascular, and psychological symptoms during postoperative recovery.<sup>[3,39]</sup> Endoscopic, laparoscopic and other minimally invasive procedures strongly benefit from the live neurofeedback achieved with local anesthetics, as it aids surgeons in gauging the proximity of instruments to critical neural elements, reducing the risk of neural damage.<sup>[13]</sup> Bajwa *et al.* found the use of regional anesthetic in minimally invasive procedures presented with the same benefits as those in more invasive techniques, with both showing a decreased incidence in nausea, respiratory, and cardiovascular complications.<sup>[5]</sup> Should a patient be deemed eligible for minimally invasive strategies, the use of local anesthetic is subject to the same indications as more invasive techniques.<sup>[18,49]</sup> The combination of all these technique provides patients with markedly reduced, and shorted duration, of postoperative pain, giving favorability over general anesthesia.<sup>[3,10,13,29]</sup>

### CONTRAINDICATIONS

While the use of spinal anesthesia expands the patient population eligible for spinal surgery, it is still limited by contraindications of any surgical procedure. The option of spinal anesthesia is eliminated outright by patient's refusal, coagulopathy, or infection within proximity of the surgical site.<sup>[4]</sup> Patients who present as morbidly obese, have COPD, or obstructive sleep apnea are at risk for pulmonary complications, and may be contraindicated from spinal anesthesia due to concerns of protecting the airway. In addition, general anesthesia is heavily indicated over localized in patients under 15 years of age or individuals who may become restless or agitated over the course of a long procedure.<sup>[3,13]</sup> Ames *et al.* found that patients struggled to lie still during procedures lasting longer than 90 min, significantly reducing patient satisfaction and outcome, even though some local anesthesia can allow for procedures up to 2.5 h.<sup>[3,29]</sup> Consequently, procedures with a long or unpredictable duration (e.g., degenerative pathologies and involvement of more than 2 vertebrae) are better suited for general anesthesia.<sup>[29]</sup>

An operating complication of using spinal anesthesia is the occurrence of a hypotensive crisis during the procedure, and high-risk patients should considering pursuing other anesthetic options. Most notably, chronic alcohol



**Table 4:** Summarization of published trials, case series, and outcomes of patients undergoing awake decompressions and studies combining data for multiple procedures into single data sets.

Author (year)	Surgery	Anesthetic method	Patients	HR or ΔHR	MAP or ΔMAP	Blood loss (ml)	Surgery time (minutes)	PACU Time (minutes)	Analgesic use or pain score	Urinary retention	Nausea	Fusion rate (%)	Hospital stay length (days)
Hodel et al. <sup>[23]</sup> (2013)	Decompressions, discectomies and transpedicular instrumentation	Spinal	361	-	-	-	64.6±68.3	-	-	-	-	-	-
Singelsen et al. <sup>[51]</sup> (2013)	Decompressions, discectomies and transpedicular instrumentation	Spinal	369	-	-	-	56.8±12.3	-	-	-	-	-	-
Kahveci et al. <sup>[28]</sup> (2014)	Lumbar spinal surgery	Spinal	40	-	-	126.5±40.0	70.70±22.2	19.55±4.58	3 (7.5%)	-	6 (15%)	-	2.50±0.93
Chin et al. <sup>[11]</sup> (2015)	Discectomy and lumbar fusion	-	16	-	-	161±32	124.85±7.10	-	Reduction of VAS pain score by 2 or more in 81.25% of patients at final f/u. Mean lower back VAS score of 8.4±0.37 preoperatively reduced to 4.96±0.73 postoperatively; (P=0.001)	-	-	87.5% (14/16 patients)	-

GA: General anesthesia, RA: Regional anesthesia, ODI: Oswestry Disability index, MAP: Mean arterial pressure, Δ: Change, PACU: Post anesthesia care unit

consumption, or administration of spinal anesthesia in an acute setting, increases the occurrence of a hypotensive episode  $\times 3$  that of a patient with no risk factors. While individually these are not direct contraindications, combinations of these comorbidities increase the risk of a hypotensive episode and other pathologies that ultimately suggests the use of general anesthesia over localized.<sup>[32]</sup>

Other operational concerns stem from the short and often variable duration of action of local anesthetic, which can result in the patient feeling mild discomfort or pain during the procedure.<sup>[3]</sup> If severe, this can result in having to rotate the patient into a supine position and place them under general anesthesia. Consequently, general anesthesia may be preferential to patients with a low sensitivity to regional anesthetics.<sup>[29]</sup> Patient anxiety is another factor that can prove problematic to conscious operations, as the sounds of the equipment and the duration can prove stressful and cause hypertension and tachycardia, resulting in a switch to general anesthesia. Therefore, candidates for local anesthesia need to be screened for anxiety and use alternative options for patients who have pre-existing anxiety disorders.<sup>[13]</sup> A summary of both indications and contraindications for awake spine surgery is shown in [Table 5].<sup>[8]</sup>

### ADVANTAGES AND LIMITATIONS

Awake spine surgery offers numerous benefits to the patient. The most glaring benefit is the elimination of general anesthesia and its associated risks and potential negative

outcomes. General anesthesia is associated with side-effects such as postsurgery delirium, opioid use and bleeding complications, with further exacerbation in elderly patients and patients with multiple comorbidities.<sup>[5,57]</sup> With the awake alternative, these side effects are significantly reduced or eliminated and provide an optimal recovery route for elderly or significantly ill patients. Elimination of general anesthesia in patients that undergo awake spine surgery can also decrease postoperative LOS, which can lead to higher patient satisfaction, decrease risk of surgical site infection (SSI), and reduced cost of treatment.<sup>[18,49]</sup> With the increased ease and feasibility of utilizing awake techniques, these can be further adapted to outpatient and ambulatory models of surgical care, providing opportunity to reduce costs for both patients and health-care institutions.<sup>[20]</sup>

Neurosurgeons can also benefit greatly from utilizing awake methods for spine procedures. With patients awake, they are able to provide real-time feedback of any tension, discomfort, or neurologic sequelae due to operating in close proximity to neural structures.<sup>[6]</sup> In addition, neurosurgeons can administer adjunct conservative intraoperative therapies, such as music therapy and nature sound therapy, to reduce postoperative anxiety and pain and help patients tolerate the unpleasant sounds of tools being used.<sup>[7,35]</sup> In addition, the aforementioned reduced LOS and subsequent diminished risk of SSI reduces rate of reoperation and improves overall patient outcome and satisfaction.

While there are many advantages to implementing awake spine procedures into practice, there are limitations that must be considered. Compared to general anesthesia, local anesthesia has a limited duration of action, thus narrowing the window of time to operate for the surgeon. In addition, this reduced time narrows the spectrum of possible surgical techniques that could be performed with local anesthesia.<sup>[20]</sup> Spinal anesthesia also exposes the patient to increased risk of symptomatic CSF leak on administration and introduces possibilities of infectious and operative complications.<sup>[34]</sup> Finally, awake procedures may increase feelings of anxiousness in patients. Anxiousness is usually due to, but not limited to: the thought of being awake, possibly feeling the surgeon, potentially seeing their body cut open, the thought of the numbness wearing off too quickly or that local anesthesia may be more.<sup>[41]</sup> Because of this, patients with anxiety should be re-evaluated before utilizing awake techniques for spine surgery.

### PATIENT SELECTION

Candidates for spinal anesthesia should be able to tolerate lying prone for the duration of the surgery and not indicate possible difficulties in airway management. Although there has been an extensive amount of research done on new techniques for awake spine surgery, there have been no

**Table 5:** Indications and contraindications for awake spine surgery.

Indications	Contraindications
<ul style="list-style-type: none"> <li>• Surgeries involving a maximum of two vertebrae levels<sup>[29]</sup></li> <li>• Surgeries that are minimally invasive or utilize endoscopic techniques<sup>[29]</sup></li> <li>• Surgeries requiring neural feedback<sup>[29]</sup></li> <li>• Aging populations<sup>[57]</sup></li> <li>• Patients deterred from general anesthesia</li> </ul>	<ul style="list-style-type: none"> <li>• Surgeries involving more than two vertebrae levels<sup>[29]</sup></li> <li>• Surgeries with unpredictable durations<sup>[29]</sup></li> <li>• Surgeries requiring the use of expandable cages and osteobiologics<sup>[29]</sup></li> <li>• Patients with risks of respiratory compromise<sup>[29]</sup></li> <li>• Degenerative spinal pathologies<sup>[29]</sup></li> <li>• High BMI<sup>[29]</sup></li> <li>• Obstructive sleep apnea<sup>[29]</sup></li> <li>• Pre-existing anxiety or depression<sup>[4,29]</sup></li> <li>• Bleeding disorders or coagulopathies<sup>[29]</sup></li> <li>• Intracranial hypertension<sup>[36]</sup></li> <li>• Failed back syndrome<sup>[22,29]</sup></li> <li>• Radiological demonstration of arachnoiditis or severe spinal stenosis<sup>[29]</sup></li> <li>• Smoking<sup>[8]</sup></li> </ul>



direct studies to look at ideal candidates. For that reason, candidates should be selected with the limitations of these techniques in mind. Patients who are morbidly obese have a high BMI, have pre-existing respiratory issues (e.g., COPD or obstructive sleep apnea), should be excluded from the study. Furthermore, patients with pre-existing anxiety should also be excluded as they may be unable to tolerate the operation due to the unpleasant loud sounds produced by the instruments. Finally, due to the operative time limitation of local anesthetics, many types of spinal procedures at this time cannot be performed with this technique. For these reasons, the ideal candidate would be a patient with a healthy BMI, no respiratory issues, no pre-existing mental health issues (e.g., anxiety), and a nonsevere stenosis that requires operation on one or two spinal levels.<sup>[20]</sup>

## CONCLUSION

In a field dominated by general anesthesia, “awake spine surgery” is a new method that utilizes regional anesthesia and minimally invasive surgical techniques. At present, the field of spinal surgery neglects to provide suitable options for patients who are otherwise not eligible for general anesthesia. However, awake spine surgery can attend to this patient population and make surgery more accessible to a wider patient population. Its advantages lie in its ability to provide live neural feedback during surgery and reduce the side effects associated with general anesthesia. Thus far, multiple studies have shown its ability to reduce surgical costs, postoperative stays and in-hospital complications while providing patients with an overall greater quality of life. Moving forward, future studies should focus on expanding the evidence available supporting this technique and defining its long-term efficacy. Larger cohort studies will be crucial in more narrowly defining its limitations and contraindications to ensure the safety of patients.

## Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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## Conflicts of interest

There are no conflicts of interest.

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