ORIGINAL STUDY

Awake Spine Surgery: Fad or Future?

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Abstract

Background data: Awake spine surgery has been an area of increasing interest, but it is still relatively uncommon. Purpose: The article aims to review the existing literature to summarize practices, outcomes, and trends in awake spine surgery to determine if awake spine surgery is merely a fad or the future of spine surgery. Study design: A narrative literature review. Patients and methods: The authors performed primary and secondary searches of the PubMed database to reveal works relevant to awake spine surgery. These results, in addition to works known to the authorship, were subjectively selected for inclusion in the narrative review based on relevance to the authors’ aims. Results: Many types of spine surgery, from the lumbosacral to the cervical spine, can be performed in the awake patient. Anesthetic methods are varied and include, but are not limited to, spinal anesthesia, epidural anesthesia, and truncal blocks. These techniques may be used in isolation or combined. Patients that are ideal candidates for spine surgery have been well described, including patients receiving 1–2 level decompressions or fusion. Older patients may be good candidates for awake surgery. The outcomes associated with awake surgery are promising and seem superior to those associated with general anesthesia. There are multiple published protocols and instructions on selecting patients for and safely performing awake spine surgery. The incidence of awake spine surgery is increasing. Conclusion: Awake spine surgery is more than a fad and may be the future of spine surgery.

Keywords: Awake spine surgery, Elderly, Minimally invasive surgery, Regional anesthesia, Spinal anesthesia

The article does not contain information about medical device(s)/drug(s).

Introduction

The history of spine surgery is long and storied, dating back to the likes of Hippocrates, who has been regarded as the father of spine surgery [1]. While outcomes in these days were admittedly catastrophic, the first successful laminectomy had been born around 650, thanks to Paul of Aegina and his inspiration from the Egyptian tradition of trephination for a head injury [2]. Since then, the world of spine surgery has seen tremendous growth and evolution. Now, patients routinely receive safe, effective, and efficient treatments for various spinal pathologies, from simple to complex. This evolution is, of course, largely thanks to the development of surgical techniques. The nearly 2500-year evolution of spine surgery technique is well described by Momin and Steinmetz [3]. It would be wrong, though, to attribute the birth of techniques such as minimally invasive surgery (MIS) to surgical
procedures alone. For instance, no surgeon would deny the interlinked development of neurosurgery and radiology. In the spine, computed tomography and magnetic resonance imaging have been essential in understanding bony and nerve root pathologies, respectively [4]. Finally, modern surgery, spinal and otherwise, is mainly possible due to the development of general anesthesia (GA), which has allowed patients to undergo surgery while unconscious with minimal pain; this discovery grew in parallel with technologies such as the endotracheal tube [5]. These developments in surgical technique, imaging, and anesthesia have led us to the current state of modern spine surgery. Evolution in spine surgery, however, is far from complete.

Among the modern developments in MIS exists an exciting technique in surgical anesthesia: wide-awake spine surgery. Though awake surgery is a relatively new phenomenon in the spine, it is a longstanding tradition in cranial neurosurgery and has also been seen in the setting of abdominal surgery [6,7]. Moreover, coronary artery bypass grafting has been performed on an awake patient [8]. Orthopedic spine surgeons may also be familiar with awake hip and knee arthroplasties under spinal anesthesia (SA) [9]. Wide-awake spine surgery entails foregoing GA and, in its place, using regional anesthetic modalities, such as local anesthesia, epidural anesthesia, and, most often, SA [10].

There are several reasons to pursue awake surgery. However, the most important among them is the ability to circumvent the adverse effects (AEs) of GA. The negative effects of GA are well summarized by Harris and Chung [11]. Postoperative nausea and vomiting are perhaps the most common of these AEs associated with GA based on inhaled anesthetics. Cardiorespiratory complications are the most feared, including highly morbid conditions such as myocardial infarction, arrhythmia, atelectasis, and bronchospasm. Other AEs include postoperative cognitive dysfunction (POCD) and hypoperfusion injuries such as acute kidney injury. As these AEs may be more prevalent in elderly patients or those with relevant comorbidities, surgeons may choose awake surgery to avoid the risks associated with GA; however, this is not to say that SA is without associated risks. Cardiac complications have also been described in patients with SA [12]. Patients with SA also experience POCD, and while some studies show decreased POCD in these patients, others show comparable incidence [13,14].

Another factor that may impact a surgeon’s desire to pursue awake surgery is resource availability. It has been shown that, in lumbar spine surgery, SA is associated with reduced cost compared to GA [15]. In resource-scarce settings, this may make spine surgery more accessible. Following COVID-19, awake surgery was noted in several specialties for reducing resource burden and the length of stay, thereby making hospital admission more feasible [16–18]. This is also true in spine surgery [19]. Finally, a significant advantage to awake spine surgery is that the awake patient may provide insight into intraoperative changes in their pain. It is the authors’ experience that the patient can sometimes convey to the surgeon when the extent of decompression is sufficient. This phenomenon has been recorded since at least the 1980s when Zigler et al. [20] described the awake patient as “the ultimate spinal cord monitor.”

In surgical fields, some techniques stand the test of time while others are abandoned; spine surgery is no exception to this phenomenon [21]. As such, it is unsurprising that many spine surgeons are resistant to utilizing SA over the more traditional GA [22]. Despite the demonstrated hesitancy of some surgeons, the outcomes associated with spine surgery under SA have been positive, albeit limited [23]. Therefore, the authors set out to perform a narrative review of the literature on the utility of awake spine surgery to help answer the question: Is awake spine surgery a fad or the future?

Patients and methods

English-language literature relevant to the topic was reviewed with no restriction on the publication date. The literature review was performed with a primary search of the PubMed database with the simple search term, “Awake Spine Surgery.” Secondary advanced searches were performed using the Boolean search function with terms, such as “AND (Fusion),” or “AND (Decompression OR Laminectomy OR Discectomy OR Foraminotomy).” Additional articles were sought using the term “Spine Surgery AND Spinal Anesthesia.” Articles were selected based on the discretion of the authors, important studies, and the contents of prior literature reviews. With this combination of literature obtained via PubMed search and literature known to the authorship, a narrative review on the evolution, state, and potential future of awake spine surgery was constructed.

Results and discussion

Spine surgeries performed without general anesthesia

Multiple types of spine surgery can be performed with the patient wide awake. Identified manuscripts
described surgeries such as lumbar spinal decompression (laminectomies, discectomies, foraminotomies), lumbar spinal fusions (transforaminal lumbar interbody fusion, percutaneous lumbar interbody fusion, spinal cord stimulator placement, as well as cervical spine surgeries such as anterior cervical discectomy and fusion (ACDF). Consistently, meta-analysis has revealed that lumbar decompressive procedures are the most commonly performed awake spine surgery \[10,23–26\]. While less studied, awake spine fusion is also relatively well researched \[27,28\]. The lumbar spine is not the only region where degenerative spinal disease can be treated while awake. Both ACDF and posterior cervical fusion have been performed with wide-awake patients, using cervical plexus blocks, and local anesthesia, respectively \[20,29,30\]. The cervical plexus block is described well by Hipskind and Ahmed \[31\]. Notably, the posterior cervical fusion was the earliest instance of awake spine surgery revealed by the PubMed search, with results dating back to 1987 \[20\]. Posterior cervical fusion has also been performed with local anesthesia between muscle planes \[32\].

Perhaps a more familiar instance of awake spine surgery is the placement of a spinal cord stimulator. This is, admittedly, an area of mild discourse. Awake surgery allows the patient to provide feedback to the surgeon; however, some studies cite lower complication rates and superior outcomes with GA for stimulator placement \[33,34\]. This, again, is not the case for awake surgery for degenerative disease of the lumbar spine, for which outcomes appear equivocal, if not superior, with regional anesthetic modalities \[24,35\]. Unsurprisingly, due to the nature of the surgical exposure, there were no identified instances of awake surgery for deformity/scoliosis based on the use of the Boolean addition “AND (Scoliosis OR Deformity).” Though epidural anesthesia was described in scoliosis surgery, it was in conjunction with GA \[36\]. Conversely to scoliosis, it has been noted that the advent of minimally invasive techniques ultimately drove surgeons to push for techniques requiring only regional anesthesia \[10\]. An example of such minimally invasive techniques is demonstrated in Fig. 1. Moreover, illustrative case reports of awake spine surgery are shown in Table 1. The remainder of this discussion will focus on lumbar spine surgery for degenerative spinal disease.

Anesthetic strategies for awake spine surgery

Anesthetic modalities for awake spine surgery are well described by Garg et al. \[37\]. Regional anesthetic modalities can be broadly categorized into intraspinal and paraspinal blocks. SA, an intraspinal technique, was the most frequently cited modality in

Fig. 1. Anteroposterior (left) and lateral (right) intraoperative X-rays demonstrating endoscope placement in percutaneous endoscopic foraminotomy.
our search and those by Garg and Fiani [10,27]. SA is a neuraxial technique in which a local anesthetic drug is injected directly into the thecal sac [38]. Although classical teaching of SA uses anatomical landmarks to deliver the medication of choice appropriately, ultrasound is now frequently used to identify the lumbar interspace. It has been suggested that this may be safer than landmark-driven placement [39]. Regardless of the method of interspace identification, the technique of SA administration is described by Olawin and Das and is not dissimilar from performing a lumbar puncture [38]. A typical SA needle trajectory is shown in Fig. 2. Severe complications associated with SA are rare; more common complications include back pain, postdural puncture headache, and lower limb pain, known as transient neurological syndrome [38,40,41].

Another intraspinal modality used in lumbar spine surgery is epidural anesthesia. Compared to SA, epidural anesthesia is less studied and has several advantages and drawbacks. As SA has a limited duration of action, epidural anesthesia can be used to increase the time of analgesia. However, it has a longer time to onset, a less predictable distribution, and less reliable pain control [42]. The use of epidural anesthesia in addition to SA has been referred to as the combined spinal epidural technique; it has been studied in multiple surgical domains and is described well by T.M. Cook [43]. The epidural saline injection may also be performed to enhance an intrathecal block through a technique known as epidural volume extension [44].

Alternatively, or in addition to intraspinal regional anesthesia, several paraspinal or truncal block techniques exist. Noteworthy examples of these include the erector spinae plane (ESP) and thoracolumbar interfascial plane. The ESP functions by blocking the dorsal rami and has been the subject of RCTs evaluating its role in lumbar spine surgery, with positive results, noting decreased

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<td>A. Kaydu, M. Akdemir [27]</td>
<td>A safe regional technique in a high-risk patient: cervical plexus blockage</td>
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<td>I. Barrenechea, C. Dumont [29]</td>
<td>Awake C1–C2 laminectomy, instrumentation, and fusion: case report</td>
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<td>D. Babici, T. Miller [22]</td>
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<td>Awake Minimally invasive transforaminal lumbar interbody fusion with a pedicle-base retraction system</td>
<td>Lumbar fusion</td>
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Table 1. Illustrative case reports.

Fig. 2. Spinal anesthesia needle trajectory.
postoperative pain and subsequent reduction in opioid requirement [45,46]. The thoracolumbar interfascial plane similarly seeks to block the dorsal rami and has the theoretical advantages of an undisturbed plane of injection during surgery and reduced impact on neuromonitoring. However, the literature has not reliably shown the superiority of either method [47,48]. Other techniques such as the multifidus cervicis plane block, superficial cervical plexus block, and transversus abdominis plane block have been described to lesser degrees [37].

In addition to these intraspinal and paraspinal modalities, it is worth noting that local anesthesia alone can be done for procedures such as endoscopic lumbar discectomy, percutaneous vertebroplasty, or kyphoplasty [49,50].

The authors’ preferred practice pattern entails a combination of intraspinal and paraspinal blocks, utilizing both SA and the ESP for maximum efficacy.

Associated patient outcomes in awake spine surgery

Outcomes associated with awake lumbar spine surgery are best described by two large meta-analyses by Perez-Roman et al. and Urick et al. [23,24]. Perez-Roman et al. showed that awake surgery under SA was associated with reduced operative time, reduced postoperative complications, and reduced postoperative pain [24]. Urick et al. found that surgery under SA was associated with reduced operative time, blood loss, postoperative nausea and vomiting, time in the post-anesthesia care unit, and length of stay [23], as shown in in Table 2. Additionally, a recent propensity-score matched analysis comparing regional anesthesia to GA in lumbar spine surgery revealed reduced complications and shorter lengths of stay [51]. These findings were revealed through meta-analysis, as these metrics were commonly reported in individual case studies, case series, and cohort studies. However, some studies have reported interesting outcomes with not enough peer literature in order for them to be confirmed via meta-analysis. For instance, Olmos et al. [52] demonstrated that periprocedural polypharmacy surrounding lumbar fusion is reduced in patients receiving spinal versus GA. SA, compared to GA, has also shown the capacity to reduce the incidence of postoperative urinary retention [53]. From an economic perspective, Agarwal et al. [15] have found that lumbar decompression under SA is associated with reduced cost. This was due to reduced direct operating costs and indirect costs, such as those associated with the patients’ stay in the hospital, which was shorter in patients with SA.

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<tr>
<td>R. McLain, M. Rana [23]</td>
<td>Comparison of spinal and general anesthesia in lumbar laminectomy surgery: a case-controlled analysis of 400 patients</td>
<td>Lumbar laminectomy</td>
<td>Reduced operative time, reduced postoperative nausea and pain medications, reduced complications</td>
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<tr>
<td>R. Perez-Roman, M. Wang [21]</td>
<td>Spinal anesthesia in awake surgical procedures of the lumbar spine: a systematic review and meta-analysis</td>
<td>Lumbar discectomy, lumbar laminectomy, lumbar fusion, combined decompression and fusion</td>
<td>Reduced operative time, reduced pain, reduced length of stay, reduced complications</td>
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<td>D. Urick, M. Abd-El-Barr [20]</td>
<td>Perioperative outcomes of general versus spinal anesthesia in the lumbar spine surgery population: a systematic review and meta-analysis of data from 2005 through 2021</td>
<td>Lumbar discectomy, lumbar laminectomy, lumbar fusion, combined decompression and fusion</td>
<td>Reduced operative time, reduced postoperative nausea and vomiting, reduced time in post-anesthesia care unit</td>
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In the cervical spine, awake techniques have also shown some promising results, though these are not without drawbacks. A randomized trial demonstrated that wide-awake ACDF leads to a reduced procedural and recovery time; however, this came at the expense of greater intraoperative and postoperative pain [29]. This study also revealed greater intraoperative blood pressure in the awake cohort, which may be a byproduct of the patients’ pain. When compared to GA, regional anesthesia is associated with favorable perioperative and intraoperative hemodynamic stability [54–56].

Awake anesthesia and outpatient/ambulatory spine surgery

At least in the United States, facility fees appear to be a major driver of increasing healthcare costs. The cost of inpatient care exceeds that of outpatient care [57]. As such, there have been trends toward performing certain surgeries in the outpatient setting [58–60]. It is a long-standing opinion that ambulatory surgery is associated with excellent patient outcomes with low readmission rates [61]. The COVID-19 pandemic may have accelerated the adoption of outpatient, as clinicians began to question the status quo on what constitutes grounds for extended hospital admission [62].

Spine surgeries, much like cholecystectomies, appendectomies, or thyroidectomies, can be performed in the outpatient setting. Spine surgeries routinely performed in the outpatient setting include 1–2 level ACDFs and lumbar decompressions [63,64]. There is a demonstrated, gradual trend toward performing more spine surgeries in the outpatient setting [65]. Though the terms “outpatient” and “ambulatory” are somewhat nebulous (23-h observation period vs. same-calendar-day discharge), both outpatient and true ambulatory spine surgery are increasing in frequency [66]. This trend will likely continue with the development and adoption of percutaneous techniques. Awake spine surgery, as described above, was shown by meta-analysis to reduce the time to discharge [23]. Furthermore, SA has been described as an ideal technique for ambulatory anesthesia [67]. This makes awake spine surgery, particularly under SA, an ideal strategy for surgeons performing outpatient spine surgery.

Ideal patients for awake spine surgery

Not all patients are equal candidates for awake spine surgery. There are certain patient populations for whom it is especially beneficial, and conversely, there are patients for whom SA is contraindicated. GA is associated with numerous AEs, which are well described by Harris and Chung [11]. Some patients, such as octogenarians and patients with cardiopulmonary disease, are at increased risk of experiencing these AEs [68]. As such, these patients might benefit particularly from awake spine surgery’s capacity to reduce postoperative complications. An example of this can be seen in the work of Telfeian et al. [69], who describe a series of successful awake lumbar spine surgeries performed in octogenarians. Wang et al. [70] have also demonstrated the feasibility of awake spine surgery in patients over 80. Patients in whom awake surgery is contraindicated are those with ongoing infections at the site of injection, those with severe anxiety, those with disturbed hemostasis, or those receiving surgeries of uncertain duration [10]. Other traits that may complicate awake lumbar spine surgery include the history of airway compromise, degree of stenosis/disc herniation, degree of central stenosis, presence of facet cysts, and the number of levels intended for decompression or fusion [71]. Ultimately, a major deciding factor in whether or not a patient can receive awake spine surgery will come down to the patient’s choice. Fortunately for proponents of awake spine surgery, De Biase et al. [72] found that 52% of surveyed patients would be “definitely willing” to participate in a trial that would randomize them into SA vs. GA. The proportion of patients who were “probably” or “definitely” willing was even higher. This suggests that more than half of spine surgery patients would be willing to receive their surgeries wide awake.

Learning curves and starting an awake practice

It is generally understood that in any practice, surgery being no exception, that performance tends to improve with experience. As such, surgeons have often described a so-called “learning curve” associated with any given procedure [73–75]. The learning curves related to minimally invasive spine surgery techniques are complex and challenging to characterize, though they are well reported in the literature [76–78]. One might expect that this would be true of wide-awake spine surgery. For instance, in one survey, 54% of spine surgeons who did not use SA cited the fact that they “have always used GA,” suggesting hesitancy associated with the perceived learning curve [22]. However, West et al. [79] have demonstrated that there may be no learning curve associated with awake spine surgery. More importantly, in this study, the anesthesia team was familiar with SA for other indications, and the
surgical team was familiar with the minimally invasive technique used in conjunction with SA. In line with this, the authors suggest that awake surgery be adopted by surgeons only once they are proficient with the intended surgical approach for a given case.

That being said, the authors’ literature review revealed multiple resources to aid those aspiring to perform awake spine surgery. Letchuman et al. [71] have proposed a patient selection algorithm to assist surgeons in picking the appropriate patients to receive awake spine surgery. Their algorithm, developed using a multidisciplinary approach, emphasized selecting 1–2 level decompressions of moderate stenosis and single-level fusions in patients with moderate stenosis. Moreover, Waguia et al. [80] have published a manuscript describing “how to start an awake spine program.” In addition to describing ideal patients for awake surgery, this work describes preoperative, intraoperative, and postoperative anesthetic and analgesic strategies, important notes for discharge planning, and tips for nursing and physical therapy staff.

The trajectory of awake spine surgery

There is reluctance among spine surgeons to use awake techniques. However, this may not always be the case [22]. A high-powered registry study by Azad et al. [81] revealed increased utilization of non-GA anesthetic techniques in spine surgery from 2005 to 2019. This study found that the incidence of non-GA modalities increased from nearly 0% in 2005 to 2.1% in 2019; the increase was true for both cervical and lumbar spine but was more prominent in lumbar spine operations. Although this is a promising trend for proponents of awake spine surgery, the proportion of non-GA patients is still small compared to that of GA.

Conclusion

While awake spine surgery is not currently a commonly utilized strategy, it is increasing in frequency and is associated with excellent patient outcomes. There are many techniques by which awake surgery may be performed; however, published, validated descriptions of standardized protocols and workflows exist for establishing an awake practice, selecting the right patients, and delivering excellent care. As awake spine surgery is becoming more standardized, more utilized, and better characterized, the authors believe that awake spine surgery is no fad but the future.

Conflict of Interest

The authors report no conflict of interest.

Abbreviations

ACDF Anterior Cervical Discectomy and Fusion
AE Adverse Effects
CT Computed Tomography
COVID-19 Coronavirus Disease of 2019
ESP Erector Spinae Plane Block
GA General Anesthesia
MIS Minimally Invasive Surgery
MRI Magnetic Resonance Imaging
percLIF Percutaneous Lumbar Interbody Fusion
POCD Post-Operative Cognitive Dysfunction
SA Spinal Anesthesia
TLIF Transforaminal Lumbar Interbody Fusion
TLIF Thoracolumbar Interfacial Plane

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المملوک خاص
جراحة العمود الفقري في حالة اليقفة - بدعة أم مستقبل؟

البيانات الخلفية
كانت جراحة العمود الفقري في حالة اليقفة - مجال اهتمام متزايد، لكنها لا تزال غير شائعة نسبيا.

الغرض
مراقبة الأدبيات الموجودة تلخيص الممارسات والنتائج والانهجات في جراحة العمود الفقري في حالة اليقفة لتحديد ما إذا كانت جراحة العمود الفقري اليقفة مجرد بدعة أو مستقبل جراحة العمود الفقري.

تصميم الدراسة
مراقبة الأدب السردي.

المريض والطريق
أجري الالتوافع عمليات بعث أولئك ثانوية لقاعدة بيانات PubMed للكشف عن الأعمال ذات الصلة بمشكلة جراحة العمود الفقري في حالة اليقفة. تم اختراع هذه النتائج، بالإضافة إلى الأعمال المعروفة للمؤلف، بشكل شخصي لإدارة في المراجعة السردي بناءً على حسنها بمعايير المقتني.

النتائج والمناقشة
يمكن إجراء العديد من أنواع جراحة العمود الفقري من العمود الفقري القطني الجليزي إلى العھود الفقريات في المريض المستقبلي. تتضمن مساحة التخدير، وتشمل، على سبيل المثال لا الحصر، التخدير النخاعي والتخدير فوق الحافة والنهاية الجذعية. يمكن استخدام هذه التقنيات بمفردتها أو مجتمعة. تم وصف المريض المريض المريض المريض المريض في جراحة العمود الفقري بشكل جيد ويعتمدون العھود الذين ينتمون 2-3 سنوات من تحفيز الضغط أو البدء. قد يكون العھود Bordax الساق مرضى جيدين لإجراء جراحة البطن. النتائج المترتبة جراحة البطن وأعدت منها أفضل من تلك المترتبة بالتخدير العھود. هناك العديد من البروتوكولات والتعليمات المتنوعة حول كيفية اختيار العھود وإجراء جراحة العمود الفقري في حالة اليقفة بأمان. حدثت جراحة العمود الفقري مع اليقفة أخذ في الارتباط.

الخلاصة
جراحة العمود الفقري في حالة اليقفة هي أكثر من مجرد بدعة وقد تكون مستقبل جراحة العمود الفقري.