Review Article

BLEED-LESS: a scoping review on blood loss elimination in endoscopic decompression—lessons and literature on endoscopic spine surgery

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Background: Endoscopic spine surgery has emerged as a significant advancement in minimally invasive spinal procedures, with advantages including reduced tissue trauma, faster recovery, and improved patient outcomes. A critical component of these surgeries is effective haemostasis, essential for maintaining visual clarity, ensuring surgical efficiency, and minimising perioperative complications. A scoping review was conducted to examine current clinical practices and research on haemostasis in endoscopic spine surgery, with the aim of synthesising existing knowledge into a practical framework to guide surgeons in managing intraoperative bleeding in endoscopic spine surgery.

Methods: A comprehensive literature search was conducted across PubMed, Embase and Cochrane Library, guided by the Population-Concept-Context (PCC) framework. Studies were included if they reported on techniques to achieve haemostasis in endoscopic spine procedures. Data were extracted on study design, surgical technique, haemostatic tools or agents used, and bleeding-related outcomes.

Results: The review identified various haemostatic methods including bipolar and radiofrequency cautery, tranexamic acid, gelatin-thrombin matrix sealants, bone wax, irrigation pressure modulation, and absorbable hemostatic agents. The review highlights that no single haemostatic method can be applied to all cases of endoscopic spine surgery. Instead, a multimodal approach is necessary to effectively achieve haemostasis. Based on this synthesis, we propose the FIBRE protocol, encompassing fluid management, initial exposure, bone bleeding control, red-out scenarios, and extra considerations, as a practical framework for managing haemostasis.

Conclusions: The proposed FIBRE protocol is a framework for controlling bleeding, improving visualisation, and enhancing surgical outcomes. By integrating these practices, surgeons can refine their techniques and contribute to enhanced patient outcomes in minimally invasive spine surgery.

Keywords: Neuroendoscopy; haemostasis; haemostatics; minimally invasive surgical procedures

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Introduction

Background

Endoscopic spine surgery represents a pivotal advancement in the minimally invasive management of spinal disorders, offering the potential for reduced tissue trauma, faster recovery, and improved patient outcomes (1-3). However, endoscopic spine surgery relies on small incisions and specialised instruments for visualisation and access to the spine, resulting in unique challenges for haemostasis. The importance of haemostasis is further amplified by the limited operative field, need for continuous fluid irrigation to maintain clear visibility, and close proximity of neurovascular structures (4).

Rationale and knowledge gap

Proficient haemostatic techniques are integral to enhancing surgical efficiency, reducing perioperative morbidity, and improving patient outcomes (5). Conversely, inadequate haemostasis can compromise the surgical field, increase the risk of complications, and prolong operative times (6). Prolonged bleeding may also require the use of high irrigation pressures, which introduces further risks to the procedure. While a variety of haemostatic tools and agents are employed in practice and current literature describes techniques in isolation, there is currently no systematic and structured protocol for achieving haemostasis.

Objective

Through a comprehensive review of current literature and clinical practices, this article aims to explore key strategies for achieving haemostasis in endoscopic spine surgery including fluid management, cautery techniques, topical agents, and pressure control. This scoping review aims to consolidate current literature and clinical practices related to haemostasis in endoscopic spine surgery and to synthesise this information into a practical, multimodal framework for surgical application. We present this article in accordance with the PRISMA-ScR reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-25-11/rc).

Highlight box

Key findings

- This scoping review identified a diverse range of haemostatic techniques used in endoscopic spine surgery.
- The literature lacks standardised protocols, and most evidence is observational, highlighting significant variability in clinical practice.

What is known and what is new?

- Haemostasis is critical in endoscopic spine surgery but achieving it remains technically challenging. Various tools and agents have been described in isolated studies.
- This is the first review to comprehensively synthesise current haemostatic strategies into a structured, foundational framework. The proposed framework is designed to guide surgeons by combining evidence from the literature with practical techniques based on clinical experience.

What is the implication, and what should change now?

- The foundational framework presented can serve as a practical reference for endoscopic spine surgeons to achieve haemostasis. While promising, the framework should be applied cautiously given the current limitations in evidence. Moving forward, research efforts should focus on validating specific haemostatic techniques and establishing consensus protocols to support best practices in this rapidly evolving field.

Methods

This scoping review was conducted using the Population-Concept-Context (PCC) framework to systematically map the literature on haemostatic strategies in endoscopic spine surgery and identify current challenges and solutions used to minimise bleeding and maintain optimal intraoperative visualisation.

- ❖ Population: patients undergoing endoscopic spine surgery.
- ❖ Concept: haemostatic agents, tools, and strategies used to manage intraoperative bleeding.
- ❖ Context: endoscopic spine surgery across various clinical settings.

A comprehensive literature search was conducted across multiple electronic databases, including PubMed, Embase and Cochrane Library. The search strategy for PubMed is outlined in Appendix 1 and included the following terms ("endoscopic spine surgery" OR "minimally invasive spine surgery" OR "endoscopic spine") AND ("haemostasis" OR "bleeding control" OR "blood loss" OR "electrocautery" OR "hemostatic agent" OR "hemostatic"), and equivalent adaptations were applied to other databases. Searches were limited to English-language articles published up to 2025, and no restrictions were placed on study design or geographic setting to ensure comprehensive coverage.

Titles and abstracts were screened independently by two reviewers. Full-text screening was performed for all

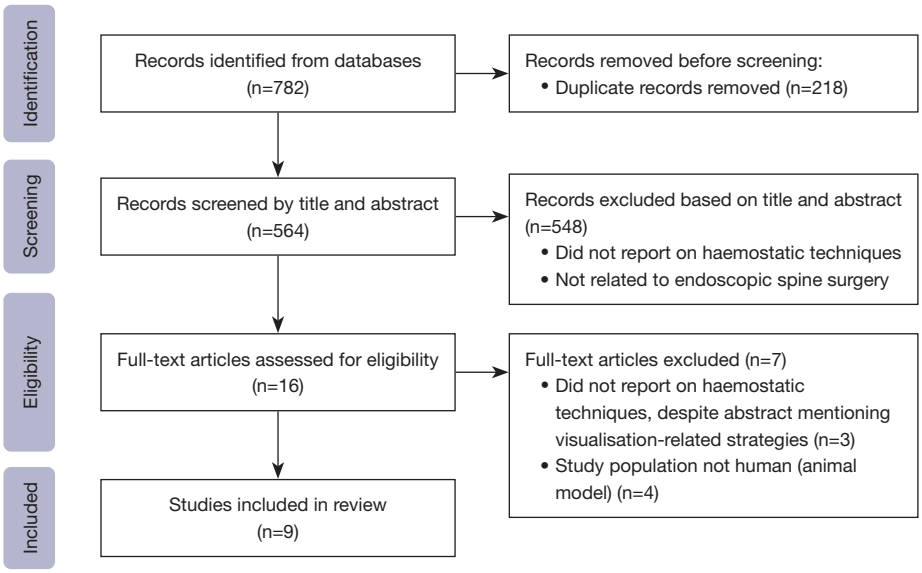

Figure 1 PRISMA-ScR flow diagram.

potentially relevant articles. Studies were included if they reported on haemostatic techniques, tools, agents, or intraoperative strategies used in endoscopic spine surgery. *Figure 1* shows the identification, screening, eligibility, and inclusion stages of the scoping review process.

Data was extracted and tabulated including study characteristics (author, year, country, study design), surgical technique and haemostatic strategies, as shown in *Table 1*. Results were synthesised thematically to identify common practices, emerging technologies, and knowledge gaps.

Results

Study characteristics

Nine studies were included in the final scoping review. These comprised one randomized controlled trial, four cohort studies, one case series, and three technical reports conducted across various countries including China, Japan, Italy, Korea and United States. The studies involved endoscopic spine procedures such as discectomies and laminectomies, and sample sizes ranged from 29 to 206 patients.

Haemostatic techniques

Bipolar and radiofrequency electrocautery

Bipolar and radiofrequency cautery was used as a method for achieving soft tissue haemostasis during endoscopic decompressions, including coagulation of epidural veins and perforating vessels. Additionally, it can be used as an initial technique for bone bleeding, followed by adjunct methods (7-9).

Topical haemostatic agents

Topical agents including gelatin-thrombin matrix sealants (e.g., Floseal) and oxidized cellulose materials (e.g., SURGICEL), were commonly used to manage venous oozing and diffuse epidural bleeding. These agents were allowed to set under low-pressure irrigation or with momentary fluid suspension, and were reported to reduce the incidence of postoperative haematomas and improve visualisation (8,10-13).

Tranexamic acid

Two studies reported the use of tranexamic acid. It was administered either intravenously or as a topical irrigation solution. The addition of tranexamic acid to saline irrigation fluid was associated with reductions in blood loss (10,14).

Bone wax and mechanical methods

Bone bleeding was controlled using bone wax in multiple studies. A custom-designed applicator for bone wax delivery was introduced as a method of bone wax delivery. Mechanical adjuncts including diamond burrs

Table 1 Summary of included studies

Study	Country	Study design	Sample size, n	Surgical technique	Haemostatic strategies used
Wang *et al.*, 2025 (7)	China	Prospective cohort study	29	Biportal endoscopic surgery	Water pressure modulation
Koga, 2023 (8)	Japan	Technical note	–	Full-endoscopic spine surgery	Absorbable gauze (SURGICEL), bipolar/ monopolar cautery, Kerrison rongeur
Amato, 2023 (9)	Italy	Technical note	–	Full-endoscopic spine surgery	Turbo bipolar cautery, diamond burr, bone wax
Upfill-Brown *et al.*, 2024 (10)	USA	Prospective cohort study	84	Biportal endoscopic decompression	IV tranexamic acid
Ko *et al.*, 2024 (11)	Korea	Retrospective case-control study	204	Biportal endoscopic spinal surgery	Thrombin-containing local haemostatic
Takami *et al.*, 2021 (12)	Japan	Randomized controlled trial	41	Microendoscopic lumbar laminectomy	Topical gelatin-thrombin matrix sealant
Kim *et al.*, 2020 (13)	Korea	Retrospective cohort study	206	Biportal endoscopic decompression	Gelatin-thrombin matrix sealant (Floseal)
Zhang *et al.*, 2024 (14)	China	Retrospective cohort study	89	Percutaneous endoscopic interlaminar discectomy	Topical saline irrigation with tranexamic acid
Inoue *et al.*, 2023 (15)	Japan	Case series	121	Full-endoscopic lumbar laminotomy	Bone wax via novel applicator, diamond drill burr

IV, intravenous.

and Kerrison rongeurs were used to manage bleeding from bony surfaces. A combination of mechanical compression and bone wax was used for persistent bone bleeding to ensure adequate visualisation of the operative field (9,10,15).

Irrigation pressure

Irrigation system settings were identified as a critical factor in both haemostasis and visualisation. Lower pressures result in more bleeding, while excessive pressures increase the risk of tissue swelling and postoperative discomfort (7,14). The authors emphasised the importance of dynamic control of pressure, including lowering pressure during precise dissection and increasing pressure temporarily to manage bleeding.

Surgical technique and operative planning

Literature emphasises the importance of technical precision and proactive haemostasis planning, including early identification of bleeding sources and addressing bleeding before proceeding further. Additionally, surgeon experience and familiarity with endoscopic instrumentation is associated with better haemostatic control (8,12,15).

Outcomes measures

Reported outcomes included: intraoperative and total blood loss, visual field clarity, postoperative haematoma formation and postoperative clinical outcomes.

Gaps in literature

The literature review highlights the scarcity of evidence-based recommendations for achieving baseline haemostatic control, as well as managing soft tissue and bone bleeding. No study directly compares the effectiveness of different haemostatic techniques. Most evidence is descriptive or observational in nature, with one randomised controlled trial. There was no evidence of a standardized protocol to guide surgeon decision making in achieving haemostasis in endoscopic spine surgery.

Discussion

While this scoping review identified a range of haemostatic techniques used in endoscopic spine surgery, there is lack of a standardized protocol that can be used to guide

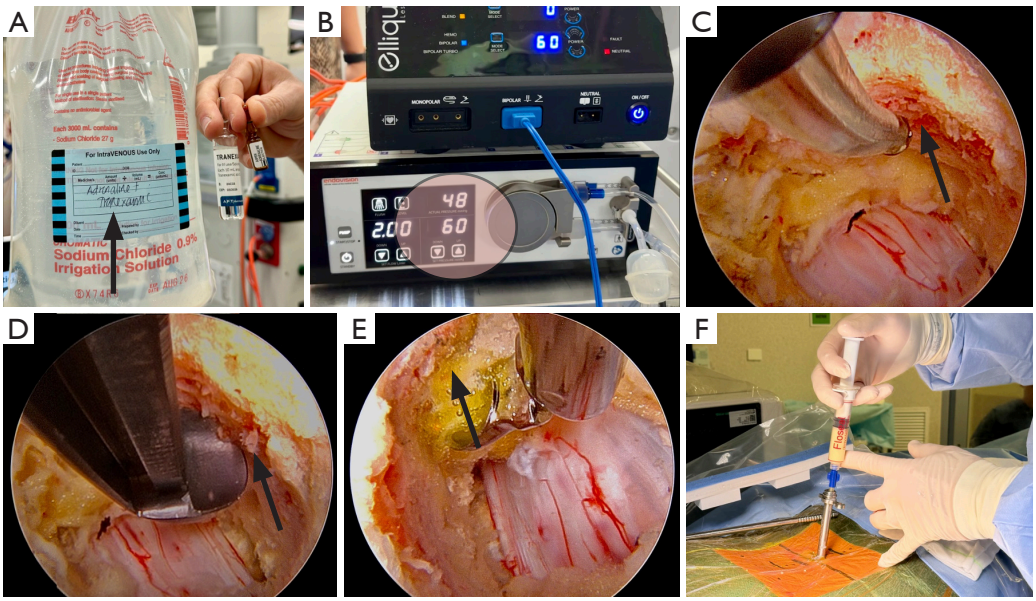

Figure 2 Various techniques to achieve haemostasis. (A) A solution of 3 L of warmed irrigation fluid with 1,000 mg tranexamic acid and 1 mg adrenaline. (B) Flushing with increased irrigation pressure. (C) Bipolar cautery for bone bleeding (arrow). (D) Compression with Kerrison rongeur for bone bleeding. (E) Small amount of Tachosil for bone bleeding. (F) Floseal applied to the surgical site through the working channel. Informed consent was obtained from the patient for the use of these images in the publication.

surgeon decision making. Consequently, we aim to provide a foundational framework for spine surgeons who are transitioning into the field of endoscopic spine surgery by synthesizing the techniques identified in the scoping review with those applied in clinical practice, informed by surgeon experience.

The authors propose the FIBRE protocol as a structured framework to assist in preparation and management of haemorrhage in endoscopic spine surgery to ultimately achieve a clear surgical field and maximise patient outcomes.

F = fluid management

Constant saline irrigation is the primary modality for vision and haemostasis in endoscopic spine surgery (16). Continuous irrigation not only allows for a clear operative view and assists in hydrodissection, but also helps to prevent cautery burns, infection and adhesions (17). The TAP mnemonic—Temperature, Adjuncts (adrenaline and tranexamic acid) and Pressure—can be used as a guide for fluid preparation and management considerations.

Temperature

Maintaining irrigation fluid at body temperature has been shown to optimise natural haemostatic processes (18). As shown in various orthopaedic arthroscopies, this can help to maintain core body temperature, preventing hypothermia and coagulopathy (19,20).

Adjuncts

Three litres of warmed irrigation fluid (normal saline/Ringer's lactate) is combined with 1,000 mg tranexamic acid (100 mg:1 mL) and 1 mg adrenaline (1 mg:1,000 mL) to assist in local haemostasis within the operative field (*Figure 2A*) (10).

Pressure

Pressure management is important for achieving local haemostasis in endoscopic spine surgery by forming a hydrotamponade of small venous bleeding. Additionally, it assists in the dissection of spinal tissues, allowing for development of a tissue plane without extensive destruction to normal tissues (7). Different pressure settings can be utilised in endoscopic spine surgery, including temporary increases in pressure during flushing (*Figure 2B*), or the use of a small cap to restrict fluid output from the working channel. Additionally, small incisions that minimise fluid escape outside the cannula, can allow for more optimal control and modulation of the pressure settings, and enhanced visualisation. The optimal pressure setting utilised in our practice is 50 mmHg and a flow rate

of 0.350 L/min. While increased pressure can improve visualisation, prolonged durations of elevated pressure must be avoided as this may lead to increased intracranial pressure, particularly in the setting of an incidental dural tear (21).

I = initial exposure

Optimal initial exposure and minimal disruption to healthy tissue is necessary for clear endoscopic vision and enhanced haemostasis in endoscopic spine surgery. A small exposure that prevents external irrigation loss and allows for more complete seal within the working channel, improves control of fluid pressure and haemostasis. This is best achieved with sharp initial dissection and utilisation of the blunt dilator to allow for passage through soft tissue without vascular disruption or shearing of perforating vessels, prior to the passing of the working channel (22).

B = bone bleeding

Bone bleeding can be difficult to control in endoscopic spine surgery due to continuous irrigation within a small working channel, which makes it challenging to use and place materials such as bone wax. The techniques used in our practice mirror those previously described by Amato (9), Inoue and Joko (15), Koga (8), and Hofstetter *et al.* (23), including bipolar cautery (*Figure 2C*), low-speed drilling and compression with a Kerrison rongeur. Bipolar cautery is effective for small to medium-sized vessels, but less effective for bone bleeding as vessels are located within the bone trabeculae and cannot be easily compressed (9). Low-speed drilling with a diamond burr helps to seal small blood vessels from drilled bone surfaces. Additionally, grasping of bone with a Kerrison rongeur squeezes blood vessels within the bone (*Figure 2D*) (8). For persistent bone bleeding, the bone wax and diamond burr drill technique can be utilised. Inoue and Joko (15) demonstrated that the use of a bone wax applicator allows for precise application of bone wax directly to bleeding points, preventing any contact with the working channel or dislodgement by irrigation. This technique also significantly reduces the incidence of dural tears. Due to the lack of a bone wax applicator within our practice, techniques such as applying a small volume of bone wax or Tachosil (*Figure 2E*) to a drill burr or endoscopic dissector has been utilised with effect, and administered with a short pause of irrigation to reduce the risk of misplacement.

R = red-out

"Red-out" is a phenomenon that describes sudden complete lack of visualisation due to uncontrolled haemorrhage, often due to bleeding epidural plexus from decompression of the thecal sac or flavotomy (24,25). This phenomenon is difficult to manage with bipolar cautery and increasing irrigation, and is not affected by bone wax or diamond burr techniques. In the instance of a red-out, haemostatic agents including Floseal or Surgiflo should be administered to the surgical bed, followed by tamponade with a blunted tissue dilator (*Figure 2F*). These flowable haemostats adapt easily to the contours of the underlying tissues (11-13). After the endoscope is reintroduced, intermittent pressure flushing with increased irrigation pressure can assist in regaining visibility (7). Under direct vision, bipolar cautery can then be used on any bleeding points as necessary.

E = extra tips/tricks

Preoperatively, drugs that increase intraoperative bleeding risk should be reviewed and withdrawn where appropriate, including nonsteroidal anti-inflammatory drugs, anticoagulant drugs, antiplatelet agents and herbal supplements (26-28). Additionally, hypotensive anaesthesia can reduce blood loss, with Verma and Lonner (29) reporting that maintaining a mean arterial pressure of 65 mmHg or less, reduced blood loss in deformity cases by 33%. However, reducing blood pressure can result in poor perfusion and increased risk of ischaemic events. Consequently, cooperation between surgeons and anaesthesiologists is required to regulate mean arterial pressure during surgery to balance control of intraoperative bleeding and perfusion demands of vital organs. Additionally, appropriate surgical positioning can decrease intraoperative blood loss including considerations of the relative positions of the surgical site and right atrium, and intraabdominal pressure (27). Nursing staff also assist in managing the pressure and flow rates of fluid irrigation and play a critical role in monitoring the patient's status. As such, haemostasis in endoscopic spine surgery requires a coordinated effort among the surgical team, including the surgeon, anaesthesiologist, and nursing staff, so that any haemostatic challenges can be promptly identified and managed.

Overall, while there are unique challenges including the confined space and continuous irrigation required in endoscopic spine surgery, the FIBRE protocol provides a comprehensive, multimodal approach to achieving

haemostasis. This structured method can be used as a guide to achieve haemostasis for enhanced visibility, reduced operative times, and minimisation of complications. The article highlights the importance of integrating mechanical, thermal, and pharmacological strategies in a multimodal approach to optimise outcomes.

Strengths and limitations

A key strength of this scoping review is its comprehensive and systematic approach to mapping current haemostatic strategies in endoscopic spine surgery. The review not only summarises existing techniques but synthesises them into a practical framework to guide surgeons—particularly those transitioning from open or microscopic approaches into endoscopic spine surgery.

However, there are various limitations. First, the overall quality of evidence remains low, with most included studies being observational, descriptive, or technical in nature. Only one randomised controlled trial was identified, and no direct comparative studies between haemostatic techniques were available.

The proposed framework should therefore be regarded as foundational, rather than definitive. It is intended to provide structured guidance based on current literature and clinical experience but should be applied with caution. Surgeons are advised to tailor their approach based on individual patient and procedural factors, and to remain critical of emerging evidence as the field evolves. Further high-quality, comparative studies are needed to validate and refine the recommendations presented in this review.

Conclusions

The advent of endoscopic spine surgery represents a significant leap forward in spinal care, offering reduced tissue trauma, shorter recovery times, and improved patient satisfaction. Achieving effective haemostasis in endoscopic spine surgery is essential to enhancing surgical outcomes and minimising perioperative complications. However, there are challenges to achieving sufficient haemostasis due to the confined operative field, constant irrigation and proximity of critical neurovascular structures.

This scoping review identified a range of haemostatic techniques and reveals the absence of a standardized protocol. Rather than a single method, the evidence supports a multimodal approach to bleeding control, integrating electrocautery, topical agents, irrigation strategies and bone haemostasis methods.

To bridge the gap between literature and practice, the article proposes a foundational framework, the FIBRE protocol, for managing haemostasis, including fluid management, initial exposure, bone bleeding control, management of red-out scenarios and extra considerations. While the framework is grounded in current evidence and clinical practice, it should be applied cautiously and be used as a guide, since literature still remains limited.

Further research into the development of novel haemostatic agents and technologies holds the potential to revolutionise the field, reducing surgical risks and enhancing the overall safety profile of endoscopic spine procedures. Moreover, the continued education and training of surgeons in the application of these techniques are crucial to maximising their benefits and minimising adverse events.

As we move forward, it is imperative that the medical community remains committed to the ongoing evaluation and refinement of haemostatic techniques in endoscopic spine surgery. By fostering a culture of innovation and evidence-based practice, we can continue to improve surgical outcomes and patient care in this rapidly evolving field.

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Footnote

Reporting Checklist: The authors have completed the PRISMA-ScR reporting checklist. Available at https://jss.amegroups.com/article/view/10.21037/jss-25-11/rc

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Ethical Statement: The authors are accountable for all

aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Written informed consent was obtained from the patient for publication of this article and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

References

1. Gibson JNA, Subramanian AS, Scott CEH. A randomised controlled trial of transforaminal endoscopic discectomy vs microdiscectomy. Eur Spine J 2017;26:847-56.
2. Komp M, Hahn P, Oezdemir S, et al. Bilateral spinal decompression of lumbar central stenosis with the full-endoscopic interlaminar versus microsurgical laminotomy technique: a prospective, randomized, controlled study. Pain Physician 2015;18:61-70.
3. Zhang B, Liu S, Liu J, et al. Transforaminal endoscopic discectomy versus conventional microdiscectomy for lumbar discherniation: a systematic review and meta-analysis. J Orthop Surg Res 2018;13:169.
4. Ishikawa T, Takeuchi K, Yamamoto T, et al. Importance of Hydrostatic Pressure and Irrigation for Hemostasis in Neuroendoscopic Surgery. Neurol Med Chir (Tokyo) 2021;61:117-23.
5. Le Huec JC, AlEissa S, Bowey AJ, et al. Hemostats in Spine Surgery: Literature Review and Expert Panel Recommendations. Neurospine 2022;19:1-12.
6. Ramirez MG, Niu X, Epstein J, et al. Cost-consequence analysis of a hemostatic matrix alone or in combination for spine surgery patients. J Med Econ 2018;21:1041-6.
7. Wang QL, Chen JP, Peng YJ, et al. Managing water dynamics for optimal outcomes in unilateral biportal endoscopic surgery: preliminary results in a new operative channel. BMC Musculoskelet Disord 2025;26:394.
8. Koga H. A new hemostatic procedure for full-endoscopic spine surgery (FESS). J Spine Surg 2023;9:17-8.
9. Amato MCM. Bone wax technique and hemostatic procedures in endoscopic spine surgery. J Spine Surg 2023;9:19-20.
10. Upfill-Brown A, Olson T, Adejuyigbe B, et al. Does the use of tranexamic acid intraoperatively reduce postoperative blood loss and complications following biportal endoscopic lumbosacral decompression? J Spine Surg 2024;10:68-79.
11. Ko YR, Ahn DK, Lee JS, et al. Effect of Thrombin-Containing Local Hemostatics on Postoperative Spinal Epidural Hematoma in Biportal Endoscopic Spinal Surgery. Asian Spine J 2024;18:87-93.
12. Takami M, Yoshida M, Minamide A, et al. Does prophylactic use of topical gelatin-thrombin matrix sealant affect postoperative drainage volume and hematoma formation following microendoscopic spine surgery? A randomized controlled trial. Spine J 2021;21:446-54.
13. Kim JE, Yoo HS, Choi DJ, et al. Effectiveness of Gelatin-Thrombin Matrix Sealants (Floseal®) on Postoperative Spinal Epidural Hematoma during Single-Level Lumbar Decompression Using Biportal Endoscopic Spine Surgery: Clinical and Magnetic Resonance Image Study. Biomed Res Int 2020;2020:4801641.
14. Zhang Y, Zhao W, Hu M, et al. The Efficacy and Safety of Topical Saline Irrigation with Tranexamic Acid on Perioperative Blood Loss in Patients Treated with Percutaneous Endoscopic Interlaminar Diskectomy: A Retrospective Study. J Neurol Surg A Cent Eur Neurosurg 2024;85:280-7.
15. Inoue T, Joko M, Saito F, et al. Bone wax technique for full-endoscopic lumbar laminotomy. J Spine Surg 2023;9:98-101.
16. Ju CI, Lee SM. Complications and Management of Endoscopic Spinal Surgery. Neurospine 2023;20:56-77.
17. Hong YH, Kim SK, Hwang J, et al. Water Dynamics in Unilateral Biportal Endoscopic Spine Surgery and Its Related Factors: An In Vivo Proportional Regression and Proficiency-Matched Study. World Neurosurg 2021;149:e836-43.
18. Nagarajah D, Kueh YC, Lazim NM, et al. The hemostatic effect of hot saline irrigation in endoscopic sinus surgery: a systematic review and meta-analysis. Syst Rev 2022;11:246.
19. Campbell G, Alderson P, Smith AF, et al. Warming of intravenous and irrigation fluids for preventing inadvertent perioperative hypothermia. Cochrane Database Syst Rev 2015;2015:CD009891.
20. Lin Y, Zhou C, Liu Z, et al. Room Temperature Versus Warm Irrigation Fluid Used for Patients Undergoing Arthroscopic Shoulder Surgery: A Systematic Review and

Meta Analysis. J Perianesth Nurs 2020;35:48-53.
21. Vargas RAA, Hagel V, Xifeng Z, et al. Durotomy- and Irrigation-Related Serious Adverse Events During Spinal Endoscopy: Illustrative Case Series and International Surgeon Survey. Int J Spine Surg 2023;17:387-98.
22. Choi G, Pophale CS, Patel B, et al. Endoscopic Spine Surgery. J Korean Neurosurg Soc 2017;60:485-97.
23. Hofstetter C, Ruetten S, Zhou Y, et al. Atlas of Full-Endoscopic Spine Surgery. 1st ed. ed. New York: Thieme; 2020.
24. Scholz M, Hofmann M, Breede M, et al. An optical evaluation of the phenomenon of red out in neuroendoscopic surgery: what is the physical background? Childs Nerv Syst 2007;23:73-7.
25. Lewandrowski KU, Telfeian AE, Hellinger S, et al. Difficulties, Challenges, and the Learning Curve of Avoiding Complications in Lumbar Endoscopic Spine Surgery. Int J Spine Surg 2021;15:S21-37.
26. Baschera D, Oberle J, Grubhofer F, et al. Perioperative Use of Anticoagulant and Platelet-inhibiting Medications for Elective Spine Surgery: Results of a Nationwide Survey. J Neurol Surg A Cent Eur Neurosurg 2018;79:398-407.
27. Mikhail C, Pennington Z, Arnold PM, et al. Minimizing Blood Loss in Spine Surgery. Global Spine J 2020;10:71S-83S.
28. Hu SS. Blood loss in adult spinal surgery. Eur Spine J 2004;13 Suppl 1:S3-5.
29. Verma K, Lonner B, Dean L, et al. Reduction of Mean Arterial Pressure at Incision Reduces Operative Blood Loss in Adolescent Idiopathic Scoliosis. Spine Deform 2013;1:115-22.

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