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Artificial Intelligence and Neuroimplant Applications in Neurological Rehabilitation Following Spinal Cord Injury Surgery: A Systematic Review

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Abstract. In recent years, there has been a significant surge in discussions surrounding artificial intelligence (AI), accompanied by a corresponding increase in its practical applications across various aspects of daily life, including the medical industry. Notably, even in the highly specialized field of spine surgery, AI has been utilized for differential diagnosis, preoperative evaluation, and enhancing surgical precision. Many of these applications have begun to reduce the risk of intraoperative and postoperative complications, as well as improve postoperative care. This article aims to present an overview of studies on the use of AI in neuroregeneration and neurological rehabilitation following spinal cord injury (SCI) surgery. The methodology involves identifying highly cited papers through ScienceDirect and Google Scholar, conducting a comprehensive review of various types of studies, and summarizing neurological rehabilitation applications after SCI surgery to enhance clinicians' understanding for future utilization. Recent studies indicate that AI technologies are employed in several areas of spine surgery and neurosurgery, including traumatic brain injury and SCI. SCI presents complex physiological, psychological, and cognitive challenges. Assessment of residual neural function and post-injury functional status is conducted to evaluate the extent of recovery, though concerns remain regarding the validity and generalizability of these assessment outcomes.

Keywords: Artificial Intelligence; Cedera Spinal; Clinical Neurorehabilitation; Neurological Function; Spine Surgery

1. INTRODUCTION

Artificial intelligence (AI) has increasingly been applied across diverse scientific and medical disciplines, including neuroscience and spinal surgery. Public perceptions of AI are largely shaped by mass media, science fiction, and popular scientific narratives; however, these portrayals often oversimplify or misrepresent its actual capabilities (Danilov et al., 2020). From a technical perspective, AI refers to a set of mathematical and computational methods designed to automate intellectual tasks traditionally performed by humans (Kolasa et al., 2024). Simultaneously, AI also represents a branch of computer science focused on the development, optimization, and application of such intelligent systems in real-world problem solving (Celtikci, 2018).

In recent years, AI technologies have demonstrated significant progress in neuroscience, spine surgery, and neurosurgery. Applications such as brain–computer interfaces, neuroprosthetics, and AI-assisted surgical planning have expanded the boundaries of neurological care (Tangsrivimol et al., 2023). Advanced machine learning models, particularly convolutional neural networks, enable automated classification of neuroimaging data for the diagnosis and prognosis of neurological diseases (Izadyyazdanabadi et al., 2018). Furthermore,

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AI-powered robotic systems have been increasingly integrated into neurorehabilitation programs, providing adaptive, personalized assistance to support patient recovery. Intraoperative AI systems that combine preoperative planning with real-time microscopy and imaging have also shown promise in guiding neurosurgical decision-making and enhancing surgical precision (Senders et al., 2017).

Beyond surgical support, AI is positioned to play a transformative role in the field of neuroregeneration. Computational modeling contributes to a deeper understanding of axon guidance, neuronal growth, and synaptic plasticity, which are fundamental processes underlying neural repair (Buchlak et al., 2019). The integration of AI into high-throughput drug screening platforms accelerates the identification of potential neuroregenerative compounds and therapeutic targets (Mulpuri et al., 2024). Moreover, the convergence of AI with robotics and bioelectronic technologies enables precise neuromodulation and stimulation strategies aimed at enhancing nerve regeneration. By applying deep learning techniques to longitudinal clinical and biological data, AI can facilitate the development of personalized neuroregenerative therapies tailored to individual patient profiles, thereby improving functional outcomes (Gill et al., 2025).

Spinal cord injury (SCI) represents a major global health challenge, affecting an estimated three million individuals worldwide (Morioka et al., 2025). The prevalence of SCI has increased in recent decades, largely due to improved survival rates following acute injury. For instance, in the United States, mortality within the first two years after SCI has declined substantially, with first-year survival rates now exceeding 90% (Mensah et al., 2025). Most cases of SCI result from traumatic events such as motor vehicle accidents, sports injuries, falls, and gunshot wounds, although non-traumatic causes—including degenerative disorders, autoimmune diseases, neoplasms, and infections—also contribute significantly to disease burden.

The pathophysiology of SCI is complex and extends far beyond the initial mechanical insult. Primary injury involves direct damage to spinal cord tissue and associated vasculature, followed by secondary injury mechanisms such as inflammation, ischemia, excitotoxicity, and oxidative stress (Dietz et al., 2022). Over time, chronic pathological changes—including persistent inflammation, glial scar formation, and progressive axonal degeneration—further compromise spinal cord function, leading to long-term motor, sensory, and autonomic impairments (Halalmeh et al., 2025). Rehabilitation interventions, particularly physical therapy, play a crucial role in promoting neuroplasticity, defined as the capacity of the nervous system to reorganize neural pathways and relearn lost functions after injury (Cheng et al., 2025).

Surgical intervention for SCI aims to address the underlying structural damage and mitigate secondary injury processes. Acute spinal surgery typically focuses on decompression, realignment, and stabilization of the spine, as well as reducing intraspinal pressure caused by edema or hemorrhage (Mensah et al., 2025). Surgical techniques range from conventional open procedures to minimally invasive and robot-assisted approaches, each offering distinct advantages in specific clinical contexts.

Given the rapid advancement of AI technologies and their expanding role in neuroscience, neuroregeneration, and rehabilitation, there is an increasing need for comprehensive studies that synthesize current evidence on the application of AI in neurological recovery following spinal cord injury surgery. A consolidated understanding of recent developments is essential to guide future research, optimize clinical implementation, and ultimately improve functional outcomes and quality of life for individuals living with SCI..

2. METHOD

The systematic review adheres to the standards and principles of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2022-2025 (Figure 1)

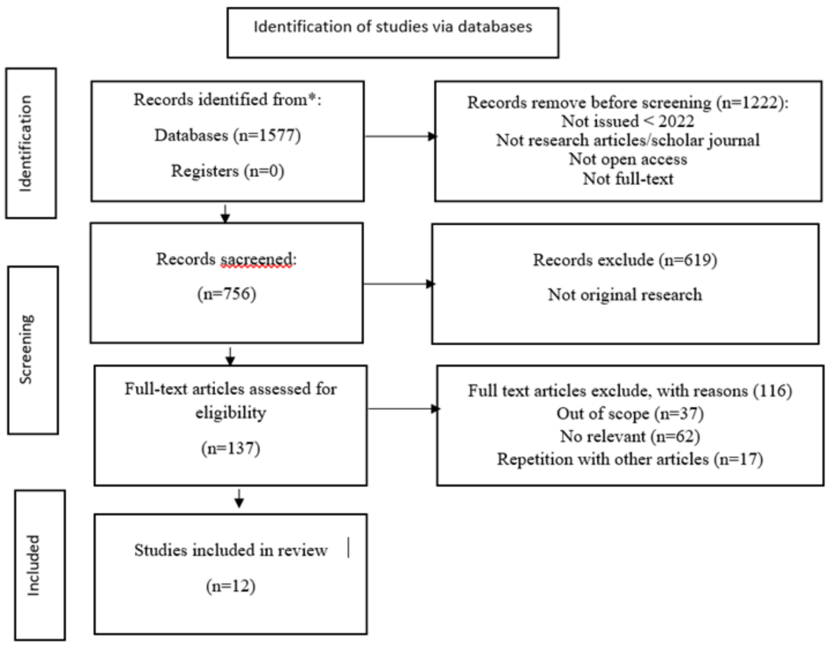

Figure 1. The summary of Identification and selection of studies.

The keywords used from the research question are Artificial Intelligence Neuroimplant Applications and Neurological Rehabilitation Following Spinal Cord Injury Surgery. The inclusion criteria for the literature search were: (1) Articles from peer-reviewed journals presenting original research findings relevant to the topic, (2) Written in English, (3) Published after 2022, and (4) Available as full-text articles. The article search was conducted in two databases: ScienceDirect and Google Scholar. After screening and adjusting the research variables, 12 articles were selected for analysis, consisting of 3 articles from Google Scholar and 9 articles from the ScienceDirect database. Our objective was to use these specific criteria to identify and combine the most relevant and well-executed original research articles directly focused on the relationship between Artificial Intelligence and neuroregeneration in Neurological Rehabilitation Following Spinal Cord Injury Surgery. By adopting this strategy, we were able to encompass a wide range of methods, applications, and discoveries in this emerging area, while emphasizing the importance of unique contributions to the research.

Most studies have well-defined objectives and utilize the data obtained to address these goals. Several studies employ appropriate qualitative data collection procedures and derive findings from these data. However, many studies lack clarity regarding specific aspects of randomization, baseline comparisons, and outcome assessments. Only a small number of studies use mixed-methods designs, and these studies are evaluated as having adequate justification for their design and the integration of both qualitative and quantitative elements. Nevertheless, the understanding of how qualitative and quantitative components are integrated is sometimes ambiguous or not disclosed.

3. RESULT AND DISCUSSION

Out of 137 articles, only 12 were selected for inclusion (Table 1). In terms of research methods, it is evident that nearly all articles discuss Rehabilitation Following Spinal Cord Injury Surgery using qualitative methods and comprehensive literature reviews using databases. The analysis of the publication year of the articles examined shows that the majority were written after 2022. The literature highlights various factors influencing the application of artificial intelligence neuroimplants in neurological rehabilitation following spinal cord injury surgery. The following subsections will explain each of these parameters.

Table 1. Results of literature review.

No	Authors	Title	Method	Result
1	(Cheng, Wang, and Zeng, 2025) [13]	Advances in the clinical application of noninvasive physical therapy for treating spinal cord injury: A narrative review	We conducted a literature review using PubMed, Web of Science, EMBASE, Scopus, and the Cochrane Central Register of Controlled Trials for relevant literature published before November 2024. The findings were organized and presented with a focus on noninvasive physical therapy for the treatment of human SCI.	We describe the advances in the clinical application of noninvasive physical therapy for SCI. Several studies have achieved positive results, helping individuals with SCI achieve functional recovery of the upper limbs, lower limbs, and bladder control, relieve neuropathic pain and sensory deficits and improve their quality of life. Comprehensive treatment is often employed after SCI, and the effects of exercise combined with non-invasive physical therapy or a combination of multiple physical therapies have potential. Conclusions: Noninvasive physical therapies, such as electrical stimulation, magnetic stimulation, sound, light, and vibration, have beneficial therapeutic effects and are safe for the clinical treatment of SCI; however, they may need to be combined with other treatments.
2	(Zhao et al. 2025) [14]	Building and Verifying a Prediction Model for Deep Vein Thrombosis Among Spinal Cord Injury Patients Undergoing Inpatient Rehabilitation	By convenience sampling, 558 SCI patients who were hospitalized at a tertiary-level Grade A general hospital in Anhui Province, China between January 2017 and March 2022 were chosen as the study subjects. They were split into 2 groups at random, one for training (n = 446) and the other for validation (n = 112). The ratio was 8:2. The clinical	Prothrombin time, D-dimer, age, and Caprini score were independent related factors for DVT among SCI patients undergoing inpatient rehabilitation, according to multivariate logistic regression analysis (odds ratio > 1, P < 0.05). These 4 variables selected by the multivariate logistic regression analysis were used to build a nomogram risk model, which was found to have strong predictive capacity for predicting the risk of DVT among SCI patients undergoing inpatient rehabilitation. The nomogram model's area under the receiver operating

No	Authors	Title	Method	Result
			information of patients was gathered, including sociodemographic characteristics, data about disease characteristics, and examinations pertaining to laboratories. The related factors of DVT among SCI patients undergoing inpatient rehabilitation were analyzed using both univariate and multivariate logistic regression. Using the variables identified by the multivariate logistic regression analysis, we constructed a predictive nomogram model with the aid of the R software. The model's predictive accuracy for assessing the risk of DVT was validated through the use of receiver operating characteristic curves and calibration plots.	characteristic curve in the training group and validation group was 0.793 and 0.905, and the 95% confidence intervals were 0.750~0.837 and 0.830~0.980, separately, indicating good discrimination of the nomogram model. A good calibration of the model was shown by the calibration curve, which was well consistent between the model's predicted probability and the actual frequency of DVT in both the training and validation groups.
3	(Sheikh et al.2024) [15]	Compensatory adaptation of parallel motor pathways promotes skilled forelimb recovery after spinal cord injury	This study focused on the roles of cervical propriospinal interneurons (PNs) and rubrospinal neurons (RNs) in the recovery of reaching and grasping behaviors in rats with bilateral lesions of the CST and dorsal columns at C5.	This study is limited to lesions affecting the CST in the cervical spinal cord, since a dorsal funiculus lesion was used in the study. Other forms of spinal injury such as moderate or severe contusion would injure more or different pathways and circuits, possibly the ones contributing to recovery in this model. CST lesions primarily cause deficits in skilled forelimb reaching and grasping and digit dexterity,

No	Authors	Title	Method	Result
				but not locomotion. Since the severity and location of the spinal cord location can dramatically affect the number and types of pathways damaged, further studies are required to examine circuit modifications leading to recovery in other spinal cord injury models.
4	(Mulpuri et al. 2024) [16]	Artificial Intelligence and Machine Learning in Neuroregeneration: A Systematic Review	Adhering to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations, 19 English-language papers focusing on AI/ML in neuroregeneration were selected from a total of 247. Two researchers independently conducted data extraction and quality assessment using the Mixed Methods Appraisal Tool (MMAT) 2018.	Eight studies were deemed high quality, 10 moderate, and four low. Primary goals included diagnosing neurological disorders (35%), robotic rehabilitation (18%), and drug discovery (12% each). Methods ranged from analyzing imaging data (24%) to animal models (24%) and electronic health records (12%). Deep learning accounted for 41% of AI/ML techniques, while standard ML algorithms constituted 29%. The review underscores the growing interest in AI/ML for neuroregenerative medicine, with increasing publications. These technologies aid in diagnosing diseases and facilitating functional recovery through robotics and targeted stimulation. AI-driven drug discovery holds promise for identifying neuroregenerative therapies. Nonetheless, addressing existing limitations remains crucial in this rapidly evolving field.
5	(Morioka et al. 2025)) [9]	Disuse plasticity limits spinal cord injury recovery	Quantitative synaptoneurosome analysis of lumboventral spinal cords revealed shifts in AMPA receptor (AMPAR) subunit GluA1 localization and serine 881 phosphorylation,	Automated confocal analysis of motoneurons revealed persistent shifts toward GluA2-lacking, calcium-permeable AMPARs in disuse subjects. Unsupervised machine learning associated multidimensional synaptic changes with persistent recovery deficits in SCI. The

No	Authors	Title	Method	Result
			reflecting enduring synaptic memories of early disuse stored in the spinal cord.	results argue for early aggressive rehabilitation to prevent disuse plasticity that limits SCI recovery.
6	(Martin, et al. 2024) [17]	Long-term clinical and safety outcomes from a single-site phase 1 study of neural stem cell transplantation for chronic thoracic spinal cord injury	We report the long-term results for a phase 1 study of neural stem cell transplantation for chronic spinal cord injury. The trial was registered on ClinicalTrials.gov as NCT01772810.	The primary outcome of the trial was to test the feasibility and safety of human spinal cord-derived neural stem cell (NSI-566) transplantation for the treatment of chronic spinal cord injury in four subjects with thoracic two to thoracic twelve spinal cord injury. Here, we report that all four subjects tolerated the stem cell implantation procedure well, and two subjects had durable electromyography-quantifiable evidence of neurological improvement as well as increased neurological motor and sensory scores at five years post-transplantation.
7	(Tangsrivimol et al. 2023) [4]	Artificial Intelligence in Neurosurgery: A State-of-the-Art Review from Past to Future	The method involved identifying high-cited seminal papers using PubMed and Google Scholar, conducting a comprehensive review of various study types, and summarizing machine learning applications to enhance understanding among clinicians for future utilization.	Recent studies demonstrate that machine learning (ML) holds significant potential in neuro-oncological care, spine surgery, epilepsy management, and other neurosurgical applications. ML techniques have proven effective in tumor identification, surgical outcomes prediction, seizure outcome prediction, aneurysm prediction, and more, highlighting its broad impact and potential in improving patient management and outcomes in neurosurgery. This review will encompass the current state of research, as well as predictions for the future of AI within neurosurgery.
8	(Ma, Guo, and Hu 2025) ([18]	Mapping Theme Trends and Recognizing Hot Spots in Acute Spinal Cord Injury:	Scientific publications on acute spinal cord injury were collected from PubMed and the Web of Science Core	Two thousand five hundred thirteen publications on acute spinal cord injury were published, with the number of articles increasing annually

No	Authors	Title	Method	Result
		A Bibliometric Analysis	Collection between 2000 and 2022. Data were analyzed using Bibliometric, CiteSpace, and Bibliographic Item Co-occurrence Matrix Builder, with gCLUTO applied for co-word bicluster analysis based on MeSH term matrices.	from 38 to 268. Spinal cord has emerged as the leading journal in this field, and the United States maintains its dominant position in global research impact. The University of Toronto ranks first among research institutions, with significant contributions from researchers such as Fehlings and Kwon. Research on acute spinal cord injury primarily focuses on 7 key areas: metabolism, pharmacology, surgical timing, rehabilitation, pathology, clinical predictors, and diagnostic imaging.
9	Cucarian et al. 2025) [19]	No impact of anti-inflammatory medication on inflammation-driven recovery following cervical spinal cord injury in rats	Statistical analysis and data visualization were implemented using R (version 4.2.1) using R Studio (version 2022.07.2). Longitudinal data with repeated measures SPRGR, horizontal ladder, open field, elevated plus maze, Von Frey, and IBB scale were analyzed using linear mixed models with group, time, and experiment. Time interaction is a fixed term and animal is a random term. Time was considered discrete in the analysis. A type III Analysis of Variance (ANOVA) table was constructed using Satterthwaite's method for estimating degrees of freedom. The hypothesis testing for the fixed terms' significant effect was conducted using an F-	In this study, we demonstrate that mitigating the inflammatory response with DPH or MP at the subacute stage following an SCI does not affect, whether positively or negatively, the extension of tissue damage or functional recovery when combined with task-specific training. This therapeutic approach induces multiple beneficial effects that might counteract the negative impact of pharmacologically reducing inflammation on neuroplasticity after SCI. Nevertheless, the isolated impact of anti-inflammatory agents on repair and recovery following spinal cord damage was not explored. Further research is needed to understand to what extent and how inflammation modulates recovery and the efficacy of rehabilitation strategies in the subacute stage after SCI. Studying this phenomenon, at the subacute stage will clarify the long-term impact of pharmacological inflammation management on neuroplasticity

No	Authors	Title	Method	Result
			test.	and post-SCI rehabilitation.
10	(Gill et al. 2025) [8]	The diagnostic and prognostic capability of artificial intelligence in spinal cord injury: A systematic review	Subsequent systematic searching of seven databases identified studies evaluating AI models. PROBAST and TRIPOD tools were used to assess the quality and reporting of included studies (PROSPERO: CRD42023464722). Fourteen studies, comprising 20 models and 280,817 pooled imaging datasets, were included. Analysis was conducted in line with the SWiM guidelines.	For prognostication, 11 studies predicted outcomes including AIS improvement (30%), mortality and ambulatory ability (20% each), and discharge or length of stay (10%). The mean AUC was 0.770 (range: 0.682–0.902), indicating moderate predictive performance. Diagnostic models utilising DTI, CT, and T2-weighted MRI with CNN-based segmentation achieved a weighted mean accuracy of 0.898 (range: 0.813–0.938), outperforming prognostic models.
11	(Halalmen et al. 2025) [11]	The Role of Neuropsychology in the Management of Spinal Cord Injury: A Comprehensive Literature Review	This narrative review was conducted by searching multiple databases, including PubMed, Scopus, and Google Scholar, for peer-reviewed articles published between 2000 and 2023. Keywords such as “spinal cord injury,” “neuropsychology,” “cognitive impairment,” “psychological consequences,” and “mental health rehabilitation” were used in various combinations to identify relevant studies.	Neuropsychology plays a crucial role in advancing our understanding of the complex consequences and adaptive processes associated with SCI, particularly in addressing the cognitive, emotional, and behavioral aspects of rehabilitation and management. It underscores the importance of a multidisciplinary approach to effectively tackle the challenges posed by SCI. Integrating neuropsychological assessment and intervention into a comprehensive treatment plan has the potential to significantly improve patients’ overall quality of life and functional outcomes.
12	(Mensah et al. 2025) [12]	Traumatic spinal cord injury: a review of the current state of art and future directions – what	Through a comprehensive literature review of articles published in the PubMed, MEDLINE, Embase,	Current management strategies include pre-hospital care, acute clinical interventions, surgical decompression and spine destabilization, and neurorehabilitation. Despite

No	Authors	Title	Method	Result
		do we know and where are we going?	and Cochrane Reviews Library databases, this article provides an update on the current management of traumatic SCI with a focus on these emerging therapeutic strategies that hold potential for future advancements in the field.	these interventions, SCI patients often fail to fully restore lost functions. Emerging therapies focus on neuroprotection, neuroregeneration, and neuromodulation, leveraging advances in molecular biomarkers, imaging techniques, and cell-based treatments. Neuroprotective agents, including the sodium-glutamate antagonist riluzole, aim to keep cells alive through the secondary injury phase, while regenerative strategies utilize neurotrophic factors and stem cell transplantation or approaches to target inhibitor molecules such as NOGO or RGMa to regenerate new cells, axons, and neural circuits. Neuromodulation techniques, such as electrical and magnetic field stimulation, offer promising avenues for functional recovery. Combining these novel therapies with traditional neurorehabilitation holds potential for improved outcomes.

In the table above, the authors present the ranking of the top 12 authors based on the number of articles, citation count, first authors, corresponding authors, and co-citations. The literature highlights various factors influencing the application of artificial intelligence neuroimplants in neurological rehabilitation following spinal cord injury surgery.

Discussion

Artificial Intelligence (AI) and Neuroimplant

Recently, there has been an exponential increase in the number of publications related to AI in the fields of medicine and spine surgery. This rise likely coincides with the growing public interest in AI-supported tools. Its widespread adoption in spine surgical practice promises a continuous shift towards greater reliance on AI-based diagnostic aids, image interpretation, and decision-making processes. This can be envisioned as a transition from a human-vs-machine approach to a human-and-machine approach [20].

Based on a review of the most cited and impactful publications related to AI in the field of spine surgery, we first found that spine, endovascular, and neuro-oncology are the most represented areas among the included studies. The most popular use of AI is in predictive modeling, followed by its use as an aid in diagnostics and imaging. Studies in the field of spinal surgery show a higher interest in the use of AI for predictive modeling (62%) compared to diagnostic and/or imaging assistance (15%), while studies representing endovascular utilize AI equally for predictive modeling (42%) and for imaging and/or diagnostic assistance (42%). Studies in neuro-oncology predominantly use AI for imaging and/or diagnostic assistance (56%), but also as a tool for enhancing other technologies (33%) [21]. Second, there is no significant correlation between the increased number of citations or the average number of citations per year for articles and journals' impact factor (IF) or the number of contributing authors [22]. This is consistent with previous literature, which suggests that, when it comes to subspecialty areas, high-impact publications do not always originate from journals with the highest impact factors.

AI has demonstrated its potential in various aspects of spine surgery, such as surgical planning, navigation, and image analysis. Looking ahead [4], AI is expected to play an increasingly significant role in spine surgery, with the potential to revolutionize the field. First, as a tool for precision medicine, AI can assist neurosurgeons in developing personalized treatment plans. By analyzing large datasets, including patient groups, medical records, imaging, and genomics, machine learning (ML) can identify patterns that predict treatment responses for individual patients. Second, AI supports surgical planning and navigation. Patient imaging can be processed to enable more accurate surgical guidance and real-time feedback during procedures, thereby reducing surgical errors. Third, AI enhances the efficiency and accuracy of big data processing, improving diagnosis and uncovering new therapies. Finally, AI has significant implications for medical education, providing new ways to access data repositories, such as surgical videos, to personalize learning and enhance patient education. As anticipated, the overrepresentation of review articles and Open Access publications was detected among the most cited articles. Open Access publications, which have remained stable at around 68% over the years, were significantly associated with an increase in citation count (P = 0.036). As known, the goal of Open Access publishing is to increase the reach of an article by enabling free access, which, in turn, has been linked to more citations. The large representation of review articles (14%) in this list may reflect the growing interest in AI in spine surgery [20]. Reviews are essentially created to synthesize and summarize the body of evidence in an emerging research field and to build a coherent narrative. However, reviews have been repeatedly criticized for leading to a decrease in citations of original papers. Recent analyses, however, indicate that reviews can draw significant attention to an emerging research area, influencing its growth in the future. In fact, the inclusion of reviews in review articles has been shown to significantly increase citations in the future, thus playing an important role in determining the reach and impact of research. Lastly, although representing the highest level of evidence, the only randomized controlled trial in the material had the lowest ranking. However, this may reflect the recent publication date rather than its relative contribution to the field.

The recent rise of generative AI has the potential to catalyze AI for spine surgery in various ways [1]. First, generative AI can synthesize new data, enabling training for rare conditions and facilitating the sharing of such synthetic data across centers for multi-center dataset design. Second, generative baseline models show significant improvement in the ability to understand multimodal longitudinal patient data from medical records and integrate this data into current predictive models for outcome prediction, surgical planning, and decision-making support. Lastly, large language models like GPT-4 can facilitate ease of use for both doctors and patients. Doctors can interact with AI-assisted research by generating code with GPT-4 as requested in simple English, along with automatic dataset analysis. Patients can benefit from these models, as language generation can support doctor-patient communication, where patient education is tailored to the individual. One specific use of large language models is transparency, where the model can be queried about the data in its training set used to make specific predictions, which can address the current 'black box' issue while also enabling active bias mitigation when AI is applied to spinesurgical practice.

Neurological Rehabilitation Following Spinal Cord Injury Surgery

Spinal Cord Injury (SCI) presents a series of complex physiological, psychological, and cognitive challenges that significantly impact an individual's quality of life [23]. Spinal cord injury is typically evaluated indirectly through the assessment of residual nerve function, which generally includes motor function as well as sensory responses to pinpricks, light touch, and deep pain sensations [18]. These measurements are repeated periodically after the injury to monitor the level of recovery. Post-injury functional status assessments are also conducted to evaluate the extent of recovery, and significant efforts have been made in recent years to standardize these outcomes; however, concerns regarding their validity and generalizability persist.

These measurements are repeated periodically after the injury to monitor the level of recovery. Post-injury functional status assessments are also conducted to evaluate the extent of recovery, and significant efforts have been made in recent years to standardize these outcomes; however, concerns regarding their validity and generalizability persist [14], [24]. The rationale for the analysis is as follows: First, compared to normal plasma, a PT exceeding 16 seconds or less than 11 seconds indicates an abnormality, but several factors, such as sample collection and handling, disease status, medication use, nutritional status, etc., can affect the test results for this indicator. Prolongation or shortening of PT indicates dysfunction in the coagulation system, with prolongation being more clinically significant than shortening, generally indicating that the patient's exogenous coagulation mechanism is abnormal or that anticoagulant medications are being used. Second, the "Expert Consensus on the Systematic Management and Care of Common Complications of Traumatic Spinal Cord Injury," the "Guidelines for Major Orthopedic Surgery in China Regarding the Prevention of Venous Thromboembolism," and related studies all emphasize the importance and necessity of scientifically, rationally, and accurately applying anticoagulant therapy [12], [17]. The use of a combination of pharmacological treatment and recommended physical rehabilitation interventions is currently the routine approach to prevent DVT among SCI patients undergoing inpatient rehabilitation in clinical practice.

In the 1990 National Acute Spinal Cord Injury Study, Bracken et al. reported a slight improvement in neurological function recovery among patients with traumatic SCI when high doses of methylprednisolone (MP) were administered within 8 hours post-ASCI [25]. Several ongoing studies indicate that the use of steroids in ASCI is associated with a significant increase in clinically proven gastrointestinal complications, which ultimately leads to higher mortality rates [26]. Meta-analysis findings indicate that high-dose MP administration does not contribute to better neurological recovery compared to no steroid treatment and may potentially increase the risk of adverse events in patients with ASCI. Numerous randomized controlled trials, double-blind, multicenter studies have raised uncertainties regarding the use of glucocorticoids in ASCI cases [27]. Enthusiasm for glucocorticoid therapy following ASCI is currently declining. Various neurotrophic factors, such as insulin-like growth factor 1 and epidermal growth factor, along with chemotherapeutic and biological drugs, are considered effective therapeutic strategies to enhance functional recovery post-SCI [28].

4. CONCLUSION

The use of AI technology in surgery has been applied in five major areas: neuro-oncology, functional neurosurgery, vascular surgery, spinal surgery, and traumatic brain injury. Spinal Cord Injury (SCI) can present a range of complex physiological, psychological, and cognitive challenges that significantly impact an individual's quality of life. Spinal cord injuries are typically assessed indirectly through the evaluation of residual neural function, which usually includes motor function as well as sensory responses to pinpricks, light touch, and deep pain sensations. Post-injury functional status assessments are also conducted to evaluate the level of recovery, and significant efforts have been made in recent years to standardize these outcomes; however, concerns regarding their validity and generalizability remain.

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