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Selection of Surgical Approach and Clinical Significance of Lower Cervical Spine Injuries Guided by SLIC Scoring System

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Abstract

Objective: To explore the feasibility and clinical significance of surgical approach selection for cervical spine injury guided by SLIC scoring system. **Methods:** The clinical data of 75 patients with lower cervical injury surgery from January 2020 to November 2022 were retrospectively analyzed, including 48 males and 27 females. Age: 28 - 65 years old. Causes of injury: 39 cases of traffic accidents, 15 cases of ice and snow sports, 12 cases of falling from high places, 9 cases of heavy objects. There were 12 cases of C3-4, 33 cases of C4-5, 21 cases of C5-6, and 9 cases of C6-7. Time from injury to medical treatment: 4 h - 2 d. Cervical spine X-ray, MRI, MDCT examination and preoperative SLIC score were performed on admission. Anterior approach was performed by subtotal cervical vertebrae resection or discectomy, titanium Cage or cage supported bone grafting and anterior titanium plate fixation. Posterior approach was performed with cervical laminoplasty, lateral mass or pedicle screw fixation and fusion. The combined anterior-posterior operation was performed by the anterior methods+ posterior methods. The time from injury to surgery is 12 h to 3 d. The function before and after operation was evaluated by JOA efficacy evaluation criteria. The correlation between the three surgical approaches and postoperative efficacy and SLIC score was compared. SPSS 22.0 software was used for statistical analysis of the data. **Results:** In this group of 75 patients, 32 cases of anterior operation, 22 cases of posterior operation and 21 cases of combined operation were followed up for no less than 12 months. There was no significant difference in age, gender, injury cause, injury segment, time from injury to treatment, and time from injury to operation among the three surgical approaches, which were comparable. The SLIC scores of mild, moderate and severe injuries of anterior surgery, posterior surgery and combined anterior and posterior sur-

gery, They were (5.26 ± 1.24, 5.86 ± 1.67, 8.25 ± 0.21), (5.57 ± 1.43, 5.99 ± 1.85, 9.00 ± 0.25), (0, 5.98 ± 0.33, 9.44 ± 0.34), respectively. By comparing the SLIC scores and JOA scores of anterior surgery and posterior surgery, there was no difference in SLIC scores and JOA scores between the two groups for mild and moderate injuries (P > 0.05). However, the JOA scores at 3 months, 6 months and 12 months after surgery were different from those before surgery, and the postoperative efficacy and JOA scores were significantly improved (P & lt; 0.05), indicating that the two surgical methods had the same therapeutic effect, that is, anterior or posterior surgery could be used to treat mild or moderate injuries (P > 0.05). There were differences in SLIC scores among the three surgical approaches for severe injury (P < 0.05), anterior or posterior surgery was selected, and the JOA score at 3 months after surgery was not significantly improved compared with that before surgery (P > 0.05). The postoperative efficacy and JOA score of combined anterior-posterior approach were significantly improved compared with those before operation (P < 0.05), indicating that the combination of anterior-posterior surgery in the treatment of severe injury has better efficacy than anterior or posterior surgery (P < 0.05). **Conclusion:** SLIC score not only provides accurate judgment for conservative treatment or surgical treatment of cervical spine injury, but also provides evidence-based medical basis and reference value for the selection of surgical approach and surgical method. According to the SLIC score, the surgical approach is safe and feasible. When the SLIC score is 4 - 7, anterior surgery is selected for type A injury, and posterior surgery is selected for type B injury. When the SLIC score is ≥8, combined anterior-posterior surgery should be selected. It is of great significance for clinical formulation of precision treatment strategy.

Keywords

Cervical Spine Injury, Lower Cervical Injury Classification Score, Surgical Route Selection, Clinical Significance

1. Introduction

Lower cervical spine injury is the injury caused by direct violence to the cervical spine motor complex, which seriously affects the cervical spine function of patients, can reduce the quality of life of patients, and the neurological function recovery effect is not ideal [1]. In order to guide clinical treatment, the academic community has proposed a variety of classification methods, such as AO classification, Allen classification, Danis classification and so on. In 2007, foreign scholars proposed a sub-axial injury classification (SLIC) scoring system for lower cervical vertebra. The SLIC score ≥ 4 is recommended for surgical treatment, while the SLIC score < 4 is recommended for conservative treatment [2] [3]. This score has established a reliable basis for the selection of surgical and non-surgical treatment, and has been recognized by scholars at home and abroad. However, for patients with SLIC score ≥ 4, there are few studies on whether the

surgical approach should be anterior-posterior or anterior-posterior. Whether the quantitative score of SLIC for patients with lower cervical injury before surgery can be used as a guideline for clinical selection of surgical approaches remains to be clinically verified [4]. Based on this, this research group took 75 patients with lower cervical spine injury admitted to the First Affiliated Hospital of Hebei North University from January 2020 to November 2022 as the research object, and obtained evidence-based evidence by analyzing the correlation between preoperative SLIC score and surgical approach as well as postoperative efficacy, which provided scientific reference for the selection of surgical approach for cervical spine injury under correct clinical guidance. The findings are now reported as follows.

2. Materials and Methods

2.1. Inclusion and Exclusion Criteria

Inclusion criteria: 1) There was a history of trauma, cervical spine MRI, three-dimensional CT and X-ray examination before surgery, confirmed the presence of vertebral body and annex fracture or dislocation, and SLIC score ≥ 4 points; 2) The injured segments were located in the range of C3 to 7, and all showed single segment injury; 3) The time of injury is within 5 days; 4) Surgical treatment after injury; The postoperative follow-up was not less than 12 months and the data were complete. Exclusion criteria: a) non-traumatic cervical spinal cord injury; b) Patients with conservative treatment or previous cervical surgery; c) Patients with multiple segmental injuries; d) There is ankylosing spondylitis or infectious spondylitis; e) The last follow-up was less than 12 months or the follow-up data were incomplete.

2.2. Clinical Data

Patients with lower cervical spine injury admitted to the First Affiliated Hospital of Hebei North University from January 2020 to November 2022 and meeting the inclusion criteria were selected as the study objects. There were 75 patients in this group, including 48 males and 27 females; the average age was (41.46 ± 11.21) years, ranging from 28 to 65 years. Causes of injury: 39 cases of road traffic, 15 cases of ice and snow sports, 12 cases of falling from high places, 9 cases of heavy objects. There were 12 cases of $C_{3\sim4}$, 33 cases of $C_{4\sim5}$, 21 cases of $C_{5\sim6}$, and 9 cases of $C_{6\sim7}$. In this group, cervical spinal cord injury was graded according to ASIA [5]: 6 cases were grade A, 16 cases were grade B, 36 cases were grade C, and 17 cases were grade D. Time from injury to medical treatment: 4 h - 2 d.

2.3. Preoperative Examination and Evaluation Methods

All 75 patients were diagnosed with lower cervical spine injury by anterior-lateral X-ray, magnetic resonance imaging (MRI), and MDCT. The SLIC score was performed immediately after admission. In terms of vertebral injury morphology, it was mainly based on MDCT image manifestations, with 0 for no ab-

normality, 1 for compression fracture, 2 for burst fracture, 3 for stretch injury, and 4 for rotational and shear injury. If multiple bone injury forms were combined, the most severe one was used as the basis for score. In terms of injury evaluation of the intervertebral disc ligament complex (DLC), mainly based on MRI image findings, including the anterior longitudinal ligament, intervertebral disc, posterior longitudinal ligament, facet capsule, interspinous ligament, supraspinous ligament and nuchal ligament, 0 score was no injury, 1 score was suspected injury, and 2 score was broken. In terms of nerve function evaluation, the evaluation was mainly based on the ASIA scale, no injury 0 score, nerve root injury 1 score, complete spinal cord injury 2 score, incomplete spinal cord injury 3 score, and persistent spinal cord compression +1 score on the basis of nerve function injury. An SLIC score of 4 - 5 indicates mild injury, 6 - 7 indicates moderate injury, and 8 - 10 indicates severe injury [2] [3]. AO Spine classification was conducted based on X-ray and MDCT image findings [6] [7]: Type A injury mainly involved the anterior column, type B injury mainly involved the posterior structure, and type C injury involved both the anterior column and the posterior structure. The patients with inaccurate SLIC score and AO Spine classification were identified jointly by two senior imaging center physicians and reached a consensus diagnosis.

2.4. Methods of Treatment and Evaluation of Curative Effect

After admission, all 75 patients were given short-term hormone treatment, dehydration treatment, neck support fixation, and cranial traction for cervical instability. After the completion of preoperative examinations, 75 patients underwent surgical treatment, including subtotal cervical vertebrae resection or discectomy through anterior approach, titanium Cage or cage support bone grafting and anterior titanium plate internal fixation. Posterior approach was performed with cervical laminoplasty, lateral mass or pedicle screw fixation and fusion. The combined anterior-posterior operation was performed by the anterior and posterior methods. The time from injury to surgery ranged from 12 h to 3 d with an average of 2 days. The preoperative and postoperative functions were evaluated using the Japanese Orthopaedic Society (JOA) cervical spine efficacy evaluation criteria.

2.5. Observation Indicators and Statistical Methods

To compare the correlation between the anterior, posterior and anterior-posterior approaches and the postoperative efficacy and SLIC score. SPSS 22.0 software was used for statistical analysis, and the measurement data were expressed as mean ± standard deviation ($x \pm s$). One-way analysis of variance was used for comparison between groups, and LSD-t test was used for further pair comparison. $P < 0.05$ was considered to be statistically significant.

3. Results

All patients were followed up for at least 12 months. In this group, 32 patients underwent anterior surgery, 22 patients underwent posterior surgery, and 21 pa-

tients underwent combined anterior and posterior surgery. There was no significant difference in age, gender, injury cause, injury segment, time from injury to treatment, and time from injury to operation among the three surgical approaches, which were comparable. The SLIC scores of anterior surgery patients were (5.26 ± 1.24) and (5.86 ± 1.67), respectively. The patients with posterior surgery were mainly moderately injured, and the SLIC score was 5.99 ± 1.85. Patients with combined anterior and posterior approach is given priority to with severe injury, SLIC scoring (9.44 ± 0.34), as shown in Table 1. According to the comparison of SLIC scores between posterior surgery and anterior surgery, both anterior surgery and posterior surgery could be selected for mild injury and moderate injury ($P > 0.05$), but there was a difference between anterior surgery and posterior surgery for severe injury ($P < 0.05$). According to the comparison of SLIC scores between anterior-posterior surgery, posterior surgery and anterior surgery, all three approaches could be selected for moderate injury ($P > 0.05$), while anterior-posterior surgery was different from anterior or posterior surgery for severe injury ($P < 0.05$). The corresponding table of postoperative efficacy (JOA score), three surgical approaches and injury degree (SLIC score) of 75 patients is shown in Table 2. The comparison of the JOA score between posterior surgery and anterior surgery showed that for both mild injury and moderate injury, anterior or posterior surgery could significantly improve the postoperative efficacy and JOA score in a short period of time, indicating that the two surgical methods had the same therapeutic effect, that is, anterior or posterior surgery could treat both mild injury and moderate injury ($P > 0.05$). For severe injuries, there was no significant improvement in the JOA score 3 months after anterior and posterior surgery compared with that before surgery ($P > 0.05$), indicating that anterior or posterior surgery was not effective in the treatment of severe injuries. Posterior surgery was added to anterior patients and posterior surgery was added to posterior patients, and the postoperative follow-up effect was satisfactory. One-stage combined anteroposterior and anteroposterior surgery can significantly improve postoperative JOA score in a short period of time, indicating that combined anteroposterior and anteroposterior surgery has

Table 1. Analysis of SLIC scores of 75 patients with different operation types [n (%)].

Surgical approach (number of cases)	Mild injury	Number of cases (%)SLIC score	Moderate injury	Number of SLIC score cases (%)	Mild injury	Number of SLIC score cases (%)
Anterior surgery (32)	12 (37.5)	4 - 7 (5.26 ± 1.24)	16 (50.0)	4 - 7 (5.86 ± 1.67)	4 (12.5)	8 - 9 (8.25 ± 0.21)
Posterior Surgery (22)	2 (9.1)	4 - 7 (5.57 ± 1.43)†	14 (63.6)	4 - 7 (5.99 ± 1.85)†	6 (27.3)	8 - 10 (9.00 ± 0.25)††
Anterior and posterior Surgery (21)	0		5 (23.8)	4 - 7 (5.98 ± 0.33)*	16 (76.2)	8 - 10 (9.44 ± 0.34)**

Note: 1) Comparison of SLIC scores between posterior surgery and anterior surgery $^{\dagger}P > 0.05$ or $^{\dagger\dagger}P < 0.05$; 2) Comparison of SLIC scores of anterior-to-anterior-to-posterior surgery, posterior surgery and anterior surgery $*P > 0.05$ or $**P < 0.05$.

Table 2. Analysis of SLIC scores of 75 patients with different operation types [n (%)].

Surgical approach (number of cases)	JOA score for Mild injury				JOA score for Moderate injury				JOA score for severe injury			
	Before Operation	Three months after surgery	6 Months	12 Months	Before Operation	Three months after surgery	6 Months	12 Months	Before Operation	Three months after surgery	6 Months	12 Months
Anterior surgery (32)	9.34 ± 2.13	12.31 ± 0.89	17	17	7.15 ± 1.23	12.16 ± 1.07	16.27 ± 0.64	17	5.56 ± 1.26	6.02 ± 1.16		
Posterior Surgery (22)	9.78 ± 2.25	12.85 ± 1.44	17	17	6.96 ± 0.58	11.89 ± 1.44	16.64 ± 0.59	17	5.82 ± 1.45	6.56 ± 1.02		
Anterior and posterior Surgery (21)					6.23 ± 0.48	11.56 ± 1.02	16.55 ± 0.36	17	2.92 ± 0.34	7.21 ± 1.62	10.52 ± 1.26	14.05 ± 1.92

Note: 1) The JOA scores at 3 months, 6 months and 12 months after anterior surgery (mild injury and moderate injury) and posterior surgery (mild injury and moderate injury) were compared with those before surgery ($P < 0.05$), and the JOA scores at 3 months after anterior surgery (severe injury) and posterior surgery (severe injury) were compared with those before surgery ($P > 0.05$). The comparison between mild injury and moderate injury group was $P > 0.05$, and the comparison between severe injury group was $P < 0.05$.

better efficacy in the treatment of severe injuries than anteroposterior or posterior surgery ($P < 0.05$).

4. Discussion

Lower cervical vertebra injury is a common type of cervical spinal cord injury, mostly caused by traffic accidents and sports injuries, mostly in men around 40 years old, and mostly manifested as fracture or dislocation symptoms and spinal cord nerve injury, especially in most patients over 60 years old, who have pathological basis such as disc herniation, hypertrophy of ligamentum yellow and cervical spinal stenosis. Minor external force may cause the cervical spinal cord without fracture and dislocation, and should be treated with surgery as soon as possible. In recent years, with the development of social economy, the development of transportation and the popularity of sports, the number of cervical spinal cord injury patients has increased year by year, among which X-ray examination, MRI examination and CT examination are the main methods for diagnosing cervical spine injury. In order to reduce the rate of disability and complications, active implementation of spinal surgery is necessary. Precision treatment is based on classification, and correct classification or score is conducive to guiding the standardization of surgery. The classification of lower cervical spine injuries is still controversial in the academic community. Holdsworth [8] analyzed more than 2000 patients and developed the first comprehensive classification system for spinal cord injuries. Denis [9] proposed the three-column theory based on Holdsworth's two-column theory and combined with his own experience. Allen [10] took 165 patients as research objects. Through analysis and research, lower cervical spine injuries were divided into six basic types: vertical

compression, flexion compression, compressive extension, flexion extension, lateral flexion extension and posterior extension. The above classification method has clinical practicability for selecting the internal fixation for surgery, but lacks reference value for selecting the surgical approach [11].

The SLIC score is an evaluation system for lower cervical spine injury proposed by the spinal trauma research team led by Vaccaro in 2007 [2] [3], which mainly includes: 1) Morphological changes of bone in lower cervical spine injury; 2) Integrity of DLC; 3) Neurological function status. The quantitative evaluation of the degree of lower cervical spine injury through the description of three main aspects is highly reliable and reproducible, which can effectively guide the selection of clinical treatment direction [5] [6] [12] [13]. The SLIC system stipulates that for the total score < 4, non-surgical treatment can be selected, for the total score > 4, surgical treatment is the main treatment, and for the total score = 4, surgical or non-surgical treatment can be selected. This standard only provides quantitative indicators for elective surgery or conservative treatment of lower cervical spine injury, and provides reference value for clinical treatment strategy. As to whether the surgical approach can be selected based on SLIC score, there is a lack of evidence-based medical support and few researches at home and abroad.

In this study, 75 patients with cervical spinal cord injury surgery were retrospectively analyzed, and all of them were quantitatively scored according to the SLIC scoring system (see **Table 1**). In the anterior surgery group, 12 cases had mild injury, 16 cases had moderate injury and 4 cases had severe injury, and the SLIC scores were 5.26 ± 1.24, 5.86 ± 1.67, 8.25 ± 0.21, respectively. In the posterior surgery group, there were 2 cases of mild injury, 14 cases of moderate injury and 6 cases of severe injury, and the SLIC scores were 5.57 ± 1.43, 5.99 ± 1.85 and 9.00 ± 0.25, respectively. Posterior joint scores 0 mild injury in 5 cases, moderate damage, severe injury in 16 cases, SLIC scoring respectively 0, 5.98 ± 0.33, 9.44 ± 0.34 mm. As can be seen from **Table 1** and **Table 2**, for mild and moderate injuries, as long as the SLIC score is 5 - 7, anterior surgery or posterior surgery or combined anterior and posterior surgery can be selected, and the postoperative efficacy and JOA score are good, but combined anterior and posterior surgery is more traumatic than posterior and anterior surgery. Therefore, anterior or posterior surgery was the best choice. Combined with AO Spine classification, anterior surgery was selected for type A injuries. If there is no anterior spinal compression, posterior surgery is chosen for type B injuries. It can be seen from **Table 1** and **Table 2** that for SLIC score ≥ 8 with severe injury, different surgical approaches have differences in postoperative efficacy and JOA score ($P < 0.05$, see **Table 2**). The JOA score 3 months after surgery was compared with that before surgery ($P > 0.05$), and the treatment effect was not good. Surgery was performed again, and posterior surgery was added to anterior patients, and posterior surgery was added to posterior patients. As can be seen from **Table 2**, one-stage combined anteroposterior and anteroposterior surgery can signifi-

cantly improve postoperative JOA score in a short period of time, indicating that combined anteroposterior and anteroposterior surgery has a better therapeutic effect on severe injuries than anteroposterior or posterior surgery ($P < 0.05$). Therefore, when the SLIC score is ≥8, there is a C-type injury classified by AO Spine, and combined anterior-posterior surgery is preferable, and in terms of biomechanical strength of cervical internal fixation, posterior surgery is superior to anterior surgery [14] [15] [16].

In summary, this paper conducted a retrospective study on the correlation between preoperative SLIC score, surgical approach and postoperative efficacy in 75 patients undergoing surgery for cervical spinal cord injury, and scientifically demonstrated the feasibility of SLIC score as a basis for selecting surgical paths. For lower cervical spine injury, SLIC score can accurately reflect the injury degree of patients, and it is safe and feasible to formulate surgical approach according to SLIC score before surgery. According to the actual situation of AO Spine injury classification and the imaging findings of patients, when the SLIC score is 4 - 7, anterior surgery should be selected for type A injury, and posterior surgery should be selected for type B injury. When the SLIC score is ≥8, combined anterior-posterior surgery should be selected. The clinical application of SLIC quantitative scoring system not only provides accurate judgment for conservative treatment (SLIC < 4) or surgical treatment (SLIC ≥ 4) of cervical spinal cord injury, but also provides evidence-based medical basis and reference value for the selection of surgical approach and operation method. It is of great clinical significance for the Department of Spinal surgery to develop accurate treatment strategies for lower cervical spinal cord injury [17].

5. Limitations

The number of clinical cases was relatively small and the follow-up time was short. In the future, multi-center studies will be carried out, related studies will be conducted between type classification and operation timing, and more cases will be selected to obtain more convincing data.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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