Impact of Microsurgery and Postoperative Radiotherapy on Neurological Function in Intramedullary Spinal Cord Gliomas

Xin Li[1], Zhen-Jie Liu[1], Liang Liang[1], Hai-Qing Dong[1] and Xingang Zhao[2]

[1]*Department of Neurosurgery, Baoding No.1 Central Hospital, Hebei, China*
[2]*Department of Neurosurgery, Sanbo Brain Hospital, Capital Medical University, Beijing, China*

ABSTRACT

Objective: To assess the clinical efficacy of combined microsurgery and postoperative radiotherapy for the treatment of intramedullary spinal gliomas and its impact on neurological function.

Study Design: An observational study.

Place and Duration of the Study: Department of Neurosurgery, Baoding No.1 Central Hospital, Hebei, China, between January 2020 and 2023.

Methodology: Sixty patients diagnosed with spinal cord intramedullary gliomas were divided equally into an experimental and control group. The control group received microsurgical treatment, and the experimental group received microsurgical treatment combined with postoperative radiotherapy. The treatment effectiveness, neurological function, and follow-up results of the two groups were compared.

Results: After treatment, the clinical efficacy of the experimental group treatment was significantly better than that of the control group ($p < 0.05$). The National Institutes of Health Stroke Scale (NIHSS) scores were significantly lower, and the European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire-30 (EORTC QLQ-C30) scores were significantly higher in the experimental group than in the control group ($p < 0.05$). The 1–3-year survival rate and median survival time of the experimental group were significantly higher than those of the control group ($p < 0.05$). The incidence of complications was 3.33% in the experimental group and 6.67% in the control group, but the difference was not statistically significant ($p > 0.05$). The postoperative recurrence rate was significantly lower in the experimental (0%) than in the control group (13.33%, $p < 0.05$).

Conclusion: Combined microsurgery and postoperative radiotherapy was found to be more effective than microsurgery alone. It was also more conducive to the recovery of neurological function and improved the patient's quality of life.

Key Words: *Intramedullary spinal cord glioma, Microsurgery, Neurological function, Radiotherapy.*

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INTRODUCTION

Spinal cord gliomas are relatively rare central nervous system tumours, and intramedullary spinal cord gliomas are even rarer, with an annual incidence of around 0.22 / 100000. Intramedullary spinal cord gliomas account for approximately 2% of all central nervous system tumours. The pathological types of these gliomas include astrocytoma, intramedullary ependymoma, ganglioglioma, and gangliocytoma. The former two types are the most common and usually occur in those aged 10-40.[1] Intramedullary spinal cord gliomas are generally diagnosed using magnetic resonance imaging (MRI). Following diagnosis, surgical resection is currently the preferred treatment strategy and produces good clinical results. However, because of the narrow operating space in the spinal canal, the level of invasiveness, and the large surgical resection range, postoperative complications are common.

Due to the rarity and specificity of this disease, there are currently no good diagnostic and treatment standards to follow in the clinical practice, and various studies do not have consistent exploration directions and unified treatment methods. With the widespread application of microsurgery in neurosurgery, there have been reports of microsurgical treatment for intramedullary spinal cord gliomas. Microsurgery after early diagnosis by MRI can effectively and thoroughly remove tumours.[2,3] However, it has been found that 30-40% of those who undergo microsurgery suffer recurrence during follow-up.[4] Therefore, this study aimed to determine the clinical efficacy of microsurgery followed by radiation therapy for intramedullary spinal cord gliomas and its effects on neurological function.

Correspondence to: Dr. Xin Li, Department of Neurosurgery, Baoding No.1 Central Hospital, Hebei, China
E-mail: hwhs96@163.com

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METHODOLOGY

A review was carried out on 60 individuals who had intramedullary spinal cord glioma and were admitted to Baoding No.1 Central Hospital, from January 2020 to 2023. The Ethical

Committee of the Hospital approved the study (Approval No: [2020]042, Approval Date: 21 May 2020) and all participants provided written informed consent.

The criteria for inclusion in this study were clear neurological signs and symptoms, complete follow-up data, complete MRI data, and diagnosis confirmation using pathological examination data based on the 2016 revision of the World Health Organization diagnostic criteria for spinal gliomas.[5] Those who had not undergone surgical treatment with tumours pathologically confirmed as non-gliomas, incomplete clinical data, severe underlying conditions, such as liver or kidney disease, pregnant or lactating women, and patients with immunological conditions were excluded. Using the random number method, the participants were divided into a control group and an experimental group according to different treatment methods, with 30 participants in each group. The investigation was conducted in compliance with the tenets of the 2013 revision of the Declaration of Helsinki.

Both groups of participants underwent microsurgery using the following approach. The patient was placed in a prone, lateral position, according to the location of the tumour in the cervical segment. Intravenous general anaesthesia was administered to induce anaesthesia, and the patient was intubated. An incision was made along the midline of the spinous process at the entry point, and the exposed lamina and spinous process were removed in their entirety to facilitate postoperative repositioning. The incision was of sufficient length to expose at least both ends of the parenchymal portion of the intramedullary glioma.

An incision was made in the dura mater, and the posterior median fissure of the spinal cord was identified using an operating microscope. The presence of a glioma causes thickening and twisting of the spinal cord, which makes it difficult to locate the glioma. This is overcome by identifying the location of the posterior median fissure in the bilateral posterior spinal nerve roots. To this end, the spinal cord was cut along the posterior median fissure to expose the glioma, and the blood vessels in the upper and lower margins of the spinal cord were electrocoagulated to facilitate visualisation of the glioma. Ependymomas are generally dark red or dark grey with clear boundaries, whereas astrocytomas are generally greyish-white with mixed boundaries. The glioma must be removed gently and slowly in blocks. After reducing the volume of the glioma, it was dissected and peeled along the glioma border without placing multiple strains on the spinal cord. Compression with gelatin sponges was used to stop small amounts of traumatic bleeding. In patients with ependymoma, the spinal cord white matter can be resected along the tumour boundary. However, given the vague borders of astrocytomas, careful identification based on the colour and texture of the glioma is required at the time of removal, with gradual and careful identification of the borders to avoid the removal of spinal cord tissue. Some tumours have cystic cavities in the upper and lower segments because of the expansion of the central spinal canal, and cystic fluid can appear after the glioma is removed. This indicates that the glioma has been completely removed. After removal, warm saline was used to wash the tumour bed and any small bleeds were stopped by compression. After bleeding cessation was confirmed, the dura mater was sutured; the spinous process of the lamina was replanted, fixed, and sutured; and postoperative anti-inflammatory measures were applied.

Following microsurgery, the experimental group of patients underwent postoperative radiotherapy. Prior to the initiation of radiotherapy, the patients were physically evaluated, and corrections were made for any anaemia or electrolyte imbalances present. MRI was performed before radiotherapy to determine the area of radiation exposure. The radiation dose was 50Gy for 4 weeks.

After its completion, the authors evaluated treatment efficacy, noting any significant improvements or cessation in neurological dysfunction and increases in the patient's muscle strength by >1 grade from the pre-treatment strength. Patients with no improvement in neurological dysfunction and no change in muscle strength were classified as 'no change'. Those with a postoperative decrease in limb muscle strength, further development of the degree of neurological dysfunction, and worsening of clinical symptoms were classified as 'exacerbated'.

Neurological function was evaluated using the National Institutes of Health Stroke Scale (NIHSS) before and after the treatment. This scale comprises 15 components and yields a maximum score of 42, whereby a higher score corresponds to a lesser degree of neurological impairment.[6] The European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30) was administered to evaluate each patient's quality of life. Scoring is from 0 to 100, and the score is directly proportional to the patient's self-perceived quality of life.[7]

From the date of surgery until December 2021, each patient was followed up for 36 months. Follow-up was conducted through both telephone and outpatient consultations. The authors calculated the 1-3-year survival rates and median survival times using follow-up data.

The postoperative recurrence rate and the incidence of postoperative complications, including spinal cord injury, cerebrospinal fluid leakage, and peripheral nerve injury, were recorded and compared between groups. Patient data were retrieved from the hospital's medical records.

Statistical analysis of all data was performed using SPSS v. 20.0 (IBM Corp., Armonk, NY, USA) software. Continuous data were expressed as ($\bar{x} \pm s$), and Independent-sample t-tests were used to compare differences between the two cohorts. Nominal data were presented as n (%) and χ^2 tests were employed to compare the two cohorts. A p-value of <0.05 was considered statistically significant.

Table I: General data comparison between both groups (%, $\bar{x} \pm s$).

Cohort	Age (years)	Gender (n)		Type of disease		Course of disease (year)
		Male	Female	Astrocytomas	Ependymoma	
Experimental group (n = 30)	28.55 ± 9.74	14 (46.67)	16 (53.33)	18 (60.00)	12 (40.00)	2.94 ± 0.46
Control group (n = 30)	28.91 ± 8.94	17 (56.67)	13 (43.33)	17 (56.67)	13 (43.33)	2.88 ± 0.76
x^2/t	0.149	0.601		0.069		0.370
p	0.882$^{\triangle}$	0.438*		0.793*		0.713$^{\triangle}$

*Notes: $^{\triangle}$Independent-sample t-test; *χ^2 test.*

Table II: Contrast of the effectiveness, complication incidence, and postoperative recurrence rates of both groups (n, %).

Cohort	Effectiveness			Complication incidence and postoperative recurrence			
	Improved	No change	Exacerbated	Spinal cord injury	Peripheral nerve injury	Cerebrospinal fluid leakage	Incidence rate of complications
Experimental group (n = 30)	27 (90.00)	2 (6.67)	1 (3.33)	0	1 (3.33)	0	1 (3.33)
Control group (n = 30)	20 (66.67)	8 (26.67)	2 (6.67)	1 (3.33)	1 (3.33)	0	2 (6.67)
x^2	4.812	4.320	0.351	-	-	-	0.351
p	0.028*	0.038*	0.554*	-	-	-	0.554

*Notes: *χ^2 test.*

Table III: Contrast between the two groups in terms of neurological function, life quality scores, 1- to 3-year survival rates, and median survival times (score, $\bar{x} \pm s$).

Cohort	NIHSS scale		EORTC QLQ-C30 scale		1- to three-year survival rate			Median survival time (month)
	Prior to therapy	Post therapy	Prior to therapy	Post therapy	1-year	2-year	3-year	
Experimental group (n = 30)	31.26 ± 4.64	11.16 ± 4.97	51.19 ± 8.97	74.58 ± 8.71	27 (90.00)	24 (80.00)	21 (70.00)	14.97 ± 1.43
Control group (n = 30)	32.54 ± 3.99	18.11 ± 4.19	50.99 ± 9.98	63.06 ± 7.73	20 (66.67)	16 (53.33)	12 (40.00)	23.11 ± 2.97
t/x^2	1.146	5.856	0.082	7.703	4.812	4.800	5.455	13.526
p	0.257	<0.001	0.935	<0.001	0.028*	0.028*	0.020*	<0.001$^{\triangle}$

*Notes: $^{\triangle}$Independent-sample t-test; *χ^2 test.*

RESULTS

Analysis of the general and baseline characteristics of the patients revealed no significant differences between the two groups (p >0.05, Table I). The clinical effectiveness of the treatment was significantly greater in the experimental group than in the control group (p <0.05, Table II).

Post-treatment NIHSS scores were significantly lower in the experimental group than in the control cohort, and EORTC QLQ-C30 scores were significantly higher in the experimental cohort (p <0.05, Table III). The 1-3-year survival rate and median survival time in the experimental cohort were significantly higher than those in the control cohort (p <0.05), as presented in Table III.

There was no statistically significant difference (p >0.05) in the frequency of complications between the experimental (3.33%, 1/30) and the control (6.67%, 2/30) groups. The incidence of postoperative recurrence in the experimental cohort was 0%, which was markedly lower than that in the control cohort (13.33%, 4/30, p <0.05), as shown in Table III.

DISCUSSION

Intramedullary spinal gliomas are generally located in the cervical thoracic and cervical segments, with a very small number located in the thoracic and conical segments.[7,8] The age of onset is usually between 10 and 40 years, and astrocytomas and ependymomas are the most common pathological types seen in clinical practice. Early clinical symptoms of intramedullary spinal cord gliomas are often hard to detect; however, as the tumour grows, significant symptoms of spinal cord central canal injury develop. Patients may exhibit motor weakness and gait disorders, with some suffering significant sensory impairments, typically in the upper limbs. Adolescent patients with intramedullary gliomas commonly experience nerve root and limb pain.[9] However, none of the patients in the present study showed these symptoms. The guidelines of the International Cancer Medicine Network recommend surgical resection of spinal gliomas where possible. However, the location of the tumour, the structure of the spinal cord, and the narrow scope can make total resection difficult without causing neurological damage and in practise, conservative treatment is often chosen. Yet, this often has only moderate clinical effects.[10] Despite limited effects, the accepted practise is surgical biopsy followed by radiation therapy.[11]

The boundary between the spinal cord glioma and normal tissue is often unclear. Traditional surgery relies on the surgeon's experience to determine the surgical resection range. This can cause significant errors, leading to a large amount of residual tumour tissue and recurrence or damage to surrounding tissues, resulting in unsatisfactory surgical results. The progress of microsurgery has allowed significant advancement in the treatment of intramedullary spinal cord gliomas, with fewer drawbacks than traditional surgery, increased volume of tumour resection, reduced peripheral tissue damage, and improved patient outcomes.

The use of microsurgical techniques to treat intramedullary spinal cord glioma can successfully treat patients while minimising surgical nerve damage.[12,13] In this study, postoperative radiation therapy was administered to the experi-

mental cohort after microsurgery, with good therapeutic effects. However, there is some controversy over the value of radiotherapy after surgery for intramedullary gliomas, with no consensus on the benefits to patients. It is generally believed that radiotherapy / chemotherapy is unnecessary when surgery achieves complete resection. However, this study's results show that the clinical efficacy of microsurgery with postoperative radiotherapy was significantly higher than that of microsurgery alone. The post-treatment NIHSS scores were significantly lower in this study's experimental group than in the control group ($p < 0.05$). This indicates that microsurgery combined with postoperative radiotherapy can significantly improve clinical efficacy and patients' neurological function. Microsurgery can clearly distinguish tumour tissue, effectively protect nerves, reduce iatrogenic damage and intraoperative bleeding, shorten the surgical time, shorten postoperative recovery time, and avoid excessive stress on surrounding tissues during surgery, reducing the degree of damage to surrounding tissue, and controlling the surgical trauma.[14]

In the treatment of spinal cord glioma, the aim is to improve survival time and quality of life. These results showed significantly higher 1-year and 3-year survival rates and median survival time in the experimental group than in the control group. The recurrence rate was 0% in the experimental group, significantly lower than the control group (13.33%). In addition, the experimental group scored significantly higher on the EORTC QLQ-C30 scale than the control group. These findings suggest that combining microsurgery with postoperative radiotherapy can effectively reduce the risk of recurrence, prolong the survival time and improve patients' quality of life. However, it is worth noting that the patients included in this study had only mild neurological damage at the time of diagnosis, and their neurological abnormalities remained mild at the time of their surgery. Some of the patients with neurological abnormalities gradually recovered within 2 months after radiotherapy.

The prognoses of patients with intramedullary spinal cord gliomas vary depending on the results of pathological tests. In patients with high malignancy, microsurgery can remove gliomas but cannot significantly improve patient symptoms.[15] At this point, chemotherapy may be indicated to compensate for the shortcomings of surgical treatment. However, the toxic side effects of chemotherapy can be intolerable. The authors found no significant difference in the incidence of complications between the groups. Thus, in contrast to postoperative chemotherapy, postoperative radiotherapy for intramedullary spinal gliomas does not increase the incidence of adverse reactions in patients.

This study had some shortcomings. Specifically, there was no long-term follow-up, and the sample size was small. Further validation of the results is necessary for future research that addresses these issues.

CONCLUSION

In conclusion, compared with microsurgery alone for the treatment of intramedullary spinal cord gliomas, microsurgery combined with postoperative radiotherapy has superior therapeutic effects. This treatment method can promote postoperative nerve recovery, improve patient survival and quality of life, and reduce the risk of tumour recurrence.

ETHICAL APPROVAL:
The Ethical Committee of the hospital approved the study (Approval No: [2020]042, Approval Date: 21 May, 2020).

PATIENTS' CONSENT:
All patients provided written informed consent.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
XL, ZJL: Designed the study and prepared the manuscript.
LL, HQD: Collected and analysed the clinical data.
XZ: Acquired, analysed, or interpreted the data and drafted the manuscript.
All authors approved the final version of the manuscript to be published.

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