Treatment Strategies and Outcomes for Spinal Low-grade Gliomas

A Systematic Review of the Past Quarter Century

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KEYWORDS

• Spinal low-grade gliomas • Treatment • Outcome

KEY POINTS

- Spinal low-grade gliomas (sLGGs) are a distinct and rare subset of slow growing gliomas.
- While brain gliomas have been extensively studied, sLGG research has been limited due to the rarity of this tumor.
- The rarity of sLGGs complicates the development of standardized treatment protocols and comprehensive guidelines.
- There is a clear need for further sLGG research to consolidate data, standardize treatment approaches, and improve outcomes.

INTRODUCTION

Spinal low-grade gliomas (sLGGs) represent a distinct and rare subset of gliomas, originating from glial cells in the spinal cord.[1–3] These tumors are typically classified as grade 1 or 2 according to the World Health Organization (WHO) tumor classification system and are known for their slow-growing nature and relatively indolent course compared to higher grade gliomas.[4–6] Despite their less-aggressive biological behavior, sLGGs present significant challenges in terms of diagnosis and treatment due to their tendency to infiltrate surrounding neural tissue. The rarity of these tumors further complicates the development of standardized treatment protocols and comprehensive guidelines.

Spinal gliomas account for approximately 25% of all intramedullary spinal tumors, with an estimated incidence of 0.22 cases per 100,000 individuals.[7] However, the management of sLGGs has not been as extensively studied as their cerebral counterparts.[8] Although research on brain LGGs has led to advancements in their understanding and treatment, the knowledge base surrounding sLGGs remains limited, primarily due to the small number of reported cases and the complex nature of these tumors.[9,10] This lack of clarity is compounded by the diversity of tumor locations and histologic subtypes, as well as mixed patient

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Abbreviations

BRAF	B-Raf proto-oncogene
CD34	cluster of differentiation 34
cGy	centigray
CR	case report
CT	computed tomography
DOAJ	Directory of Open Access Journals
GFAP	glial fibrillary acidic protein
GTR	gross total resection
Gy	gray
IDH1	isocitrate dehydrogenase 1
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
Retro	retrospective study
sLGGs	low-grade gliomas
STR	subtotal resection
WHO	World Health Organization

populations in previous studies, which make it difficult to draw definitive conclusions regarding the unique prognostic factors for spinal cord gliomas.[11–14]

The clinical presentation of sLGGs is heavily influenced by the location and growth pattern of the tumor within the spinal cord.[15,16] Most commonly, these tumors are found in the cervical and thoracic segments with a lower incidence in the lumbar region, likely due to anatomic variations in the spinal cord and the absence of medullary tissue in the lower segments.[17,18] Early symptoms often involve nonspecific axial pain, including back pain, nerve root pain, and central pain, which can be easily mistaken for other less serious conditions. As the tumor progresses, patients may experience slow-developing motor and sensory deficits.[19,20] In more advanced cases, bladder or gastrointestinal dysfunction may arise, although these symptoms are less common.[21,22]

Despite the recognition of various factors influencing the prognosis of sLGGs—including the tumor's histologic features, the extent of surgical resection, and patient age—the rarity of these tumors has hindered the identification of consistent prognostic markers. In the past 25 years, there were several systematic reviews about primary spinal cord gliomas[23–25]; however, these studies included mixed cohorts of low-grade and high-grade spinal cord astrocytomas. There is a clear need for systematic reviews and further research to consolidate data, standardize treatment approaches, and improve the outcomes for patients suffering from this rare form of spinal cord neoplasm. This systematic review aims to analyze the advancements made over the past 25 years in the treatment of sLGGs.

METHODS

Study Design and Registration

A systematic review was carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[26] The study has been registered in the Open Science Framework database under the identifier 2U6TN.

Search Strategy and Eligibility Criteria

The literature search was conducted using the MEDLINE (PubMed), Web of Science (Clarivate), Scopus (Elsevier), Directory of Open Access Journals (DOAJ), and Google Scholar databases on July 20, 2024, with a repeat search conducted during the study writing process on January 7, 2025. The search strategy adhered to the PICOS guidelines (**Table 1**)[27] and included the following keywords: "spinal low-grade gliomas," "sLGG," "glial tumors of spinal cord," "spinal intramedullary low-grade glioma," "surgery," "radiotherapy," "conservative treatment," using the Boolean operators "OR" and "AND" (Appendix 1).

Inclusion criteria for this systematic review were clinical trials, observational studies, and case reports involving adult patients diagnosed with sLGG. Eligible studies reported on treatment modalities, such as surgery, radiotherapy, or conservative treatment (eg, observation and pharmacologic management), and included outcomes. Only studies published in English, available in open access, and published between 2000 and 2025 were reviewed. Exclusion criteria were books, book chapters, reviews, meta-analyses, conference proceedings, abstracts, non-English literature, and studies lacking histopathologically confirmed sLGG subtypes.

Table 1
PICOS search strategy[27]

Acronym	Search Strategy
P (population or problem)	Spinal low-grade gliomas OR sLGG OR glial tumors of spinal cord OR spinal intramedullary low-grade glioma
I (intervention or investigation)	Surgery OR radiotherapy OR conservative treatment
C (comparison)	None
O (outcome)	None
S (study design)	Original research studies OR case reports

Study Selection and Data Extraction

The study selection process began with the identification of 1781 records from Scopus (n = 427), Web of Science (n = 98), MEDLINE (n = 284), DOAJ (n = 381), and Google Scholar (n = 591; Fig. 1). After removing duplicate records through both manual and automated deduplication using EndNote software (Clarivate, Philadelphia, PA, United States) (n = 973), 808 unique records were screened for eligibility. Out of these, 46 records could not be retrieved due to inaccessible full texts, paywall restrictions, missing publications, or technical issues with journal databases, leaving 762 records to be assessed for eligibility.

Following evaluation, 403 records were excluded due to being off-topic, 85 were conference proceedings, 14 had unclear methodology of histologic verification, 76 were books or book chapters, 27 were reviews, 29 were non-English literature, and 2 were retracted articles. Ultimately, 63 studies met the eligibility criteria and were included in the review. All duplicated cohorts were excluded.

Data were extracted from the included studies to cover key aspects related to sLGGs, including the year of publication, study design, countries from where studies were conducted, and total study sample size (N). Additional demographic information included age and the male-to-female ratio calculated from available data. Tumor characteristics, such as localization and histologic findings, were extracted along with patients' clinical status and radiological findings. Information on treatment modalities and outcome measures were also collected.

To ensure consistency and minimize bias, 2 authors independently screened the records (E.H. and E.B.) and any discrepancies were resolved through discussion and consensus with senior authors (M.P. and K.A.).

Statistical Analysis

Statistical analysis was carried out using MedCalc software (Ostend, Belgium), with results presented in terms of frequencies (n) and percentages (%). Performing a meta-analysis was not possible due to considerable heterogeneity in the data and differences in the approaches used to diagnose and treat sLGGs, along with variability in how outcomes were reported.

RESULTS

Characteristics of Included Studies and Patients

Geographically, most studies originated from the United States (25 studies, 39.7%), followed by Japan (7 studies, 11.1%) and China (5 studies, 7.9%) (Table 2). Other countries represented included Germany (3 studies, 4.8%), Korea (4 studies, 6.3%), and Turkey (3 studies, 4.8%) with several countries contributing 1 study each

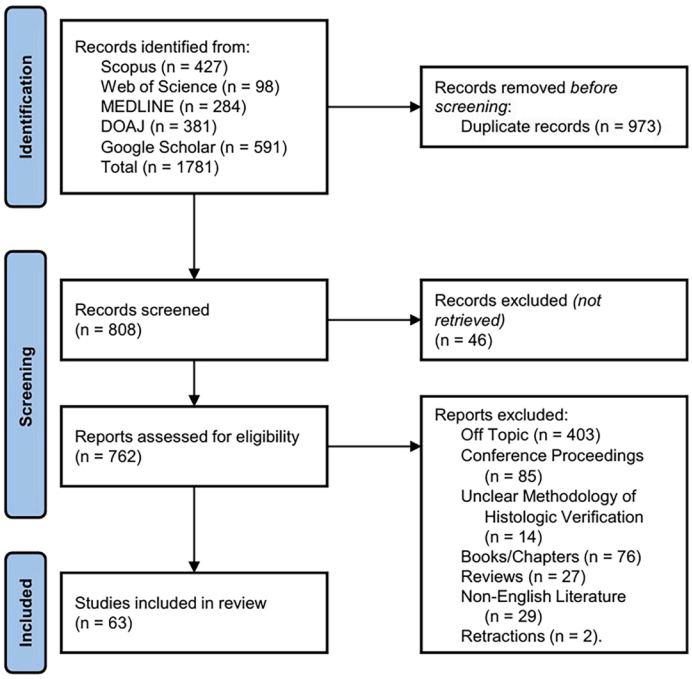

Fig. 1. PRISMA flow-diagram. DOAJ, Directory of Open Access Journals.

Table 2
Characteristics of included studies

Reference Year	Study Design	Countries	Sample Size[a]	Age	Male-to-female Ratio
El-Hajj et al,[66] 2025	Retro	Sweden	600	9–57 y	325/275
Uchi et al,[32] 2020	CR	Japan	1	69 y	1/0
Tabibkhooei et al,[43] 2019	CR	Iran	1	9 y	1/0
Carey et al,[30] 2019	Retro	USA	40	Median age at diagnosis, 7 y	18/16
Baran et al,[51] 2019	CR	Turkey	1	29 y	0/1
Tadele et al,[33] 2019	CR	USA	1	28 y	0/1
Daoud et al,[90] 2019	CR	USA	1	49 y	1/0
Jackson et al,[44] 2018	CR	USA	1	5 y	1/0
Takai et al,[45] 2017	CR	Japan	1	44 y	0/1
Bansal et al,[34] 2017	CR	India	1	29 y	1/0
Lavrador et al,[50] 2017	CR	Portugal	1	69 y	0/1
Rangwala et al,[91] 2017	CR	USA	1	5 y	0/1
Hong et al,[35] 2017	CR	USA	1	31 y	1/0
Dunn-Pirio et al.[92] 2016	CR	USA	1	23 y	0/1
Zhao et al,[46] 2015	CR	China	1	60 y	1/0
Mascelli et al,[77] 2014	CR	Italy	1	9 y	1/0
Das et al,[40] 2014	CR	Canada	1	15 y	1/0
Wu et al,[64] 2013	CR	China	1	40 y	0/1
Garber et al,[36] 2013	CR	USA	1	11 y	1/0
Prayson et al,[56] 2013	CR	USA	1	19 y	0/1
Gold et al,[57] 2013	CR	USA	1	17 y	0/1
Marzbani et al,[37] 2013	CR	USA	1	25 y	1/0
Ratnarajah et al,[38] 2012	CR	UK	1	28 y	0/1
Lim et al,[83] 2012	CR	Korea	1	58 y	1/0
Rasalkar et al,[47] 2012	CR	China	1	18 y	0/1
Harraher et al,[29] 2013	CR	USA	1	78 y	0/1
Gill et al,[52] 2010	CR	India	1	23 y	0/1
Paraskevopoulos et al,[41] 2011	CR	Greece	1	12 y	0/1
Matsuzaki et al,[54] 2010	CR	Japan	1	15 mo	0/1
Jang et al,[69] 2009	CR	Korea	1	45 y	1/0
O'Brien et al,[39] 2009	CR	USA	1	5 y	1/0
Schittenhelm et al,[70]	CR	Germany	1	11 y	0/1
Arulrajah et al,[42] 2008	CR	USA	1	13 y	0/1
Sajadi et al,[53] 2008	CR	Switzerland	1	45 y	0/1
Saad et al,[49] 2008	CR	USA	1	42 y	1/0
Chen et al,[28] 2008	CR	Taiwan	1	9 mo	1/0
Abel et al,[48] 2006	CR	USA	1	2 y	1/0
Mora et al,[55] 2007	CR	Spain	2	19 mo and 10 mo	1/1
Larson et al,[93] 2006	CR	USA	1	12 y	0/1
Magilner et al,[94] 2006	CR	USA	1	6 y	0/1
Nakamura et al,[95] 2006	CR	Netherlands	1	66 y	1/0
Hida et al,[58] 2006	CR	Japan	3	62 y, 25 y, and 10 y	2/1

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Table 2
(*continued*)

Reference Year	Study Design	Countries	Sample Size[a]	Age	Male-to-female Ratio
Chamoun et al,[84] 2006	RCT	Lebanon	2	7 y and 5 y	1/1
Robinson et al,[65] 2005	Retro	USA	14	Median age at diagnosis, 40.5 y	7/7
Komotar et al,[85] 2005	CR	USA	3	6 y, 8 y, and 3 wk	3/0
Shimizu et al,[96] 2004	CR	Japan	1	10 y	0/1
Peraud et al,[97] 2004	CR	Germany	1	14 y	1/0
Furlan et al,[59] 2003	CR	Canada	1	61 y	1/0
Tekkok et al,[63] 2003	CR	Turkey	1	20 y	0/1
Sandalcioglu et al,[61] 2002	CR	Germany	1	4 mo	1/0
Hassal et al,[62] 2001	CR	Australia	2	41 mo and 26 mo	0/2
Ng et al,[98] 2001	CR	China	1	9 y	0/1
Chai et al,[8] 2020	Retro	China	51 (83)	Median age, 31 y	49/34
Inoue et al,[31] 2018	Retro	Japan	6 (14)	Median age, 48.5 y	8/6
Seki et al,[99] 2016	Retro	Japan	20 (33)	Median age, 36 y	15/18
Ryu et al,[67] 2016	Retro	Korea	14 (26)	Mean age, 38.9 y	17/9
Xiao et al,[100] 2016	Retro	USA	10 (13)	Mean age, 42 y	8/5
Babu et al,[68] 2014	Retro	USA	29 (46)	Median age, 15 y	32/14
Guss et al,[60] 2013	Retro	USA	24 (29)	Median age at diagnosis, 7.1 y	20/9
Fakhreddine et al,[71] 2013	Retro	USA	45 (83)	Median age at diagnosis, 28.3 y	42/41
Seo et al,[72] 2010	Retro	Korea	16 (19)	Mean age, 27.84 y	11/8
Zorlu et al,[101] 2005	Retro	Turkey	20 (24)	Median age, 19 y	11/13
Lee et al,[73] 2003	Retro	USA	15 (25)	Median age 40 y	13/12

Abbreviations: CR, case report; Retro, retrospective study.
[a] Subjects with low-grade gliomas (ie, WHO grades I and II) are counted; total study sample sizes indicated in parentheses if different from glioma subtotals.

(including Australia, Canada, Greece, India, Iran, Italy, Lebanon, Netherlands, Portugal, Spain, Sweden, Switzerland, Taiwan, and the United Kingdom; **Fig. 2**A). Publication of the studies spanned from 2001 to 2025 with the highest number of studies published in 2013 (8 studies, 12.7%) and 2006 (6 studies, 9.5%). Other notable years included 2017 (6 studies, 9.5%) and 2010 (4 studies, 6.3%), while the years 2002, 2007, 2015, 2018, and 2025 each contributed 1 study (1.6%; **Fig. 2**B). The study designs of the included research predominantly featured case reports (48 studies, 76.2%), followed by retrospective studies (14 studies, 22.2%) with only 1 randomized controlled trial (1.6%; **Fig. 2**C).

The total number of patients included in the studies is 954, with 599 (62.7%) being male individuals, resulting in a male-to-female ratio of 1.68. The age range across studies varied from 9 months[28] to 78 years[29] with median ages ranging from 7[30] to 48.5 years.[31]

Tumor Localization

The distribution of sLGG localization across studies, ranked from most to least frequent, showed that cervical localization is the most studied, appearing in 18 studies (28.6%), followed closely by thoracic localization in 17 studies (27.0%). Cervicothoracic localization is noted in 13 studies (20.6%), while diffuse involvement is reported in 7 studies (11.1%). Thoracolumbar tumors are addressed in 4 studies (6.3%). Localizations in the lumbar and lumbosacral regions are rare, with each appearing in only 1 study (1.6%), and 2 studies (3.2%) did not specify tumor localization (**Fig. 3**).

Clinical Presentation

The clinical presentation of sLGG is diverse, reflecting the tumor's location and progression. Pain is a predominant symptom with back pain being commonly reported and sometimes described

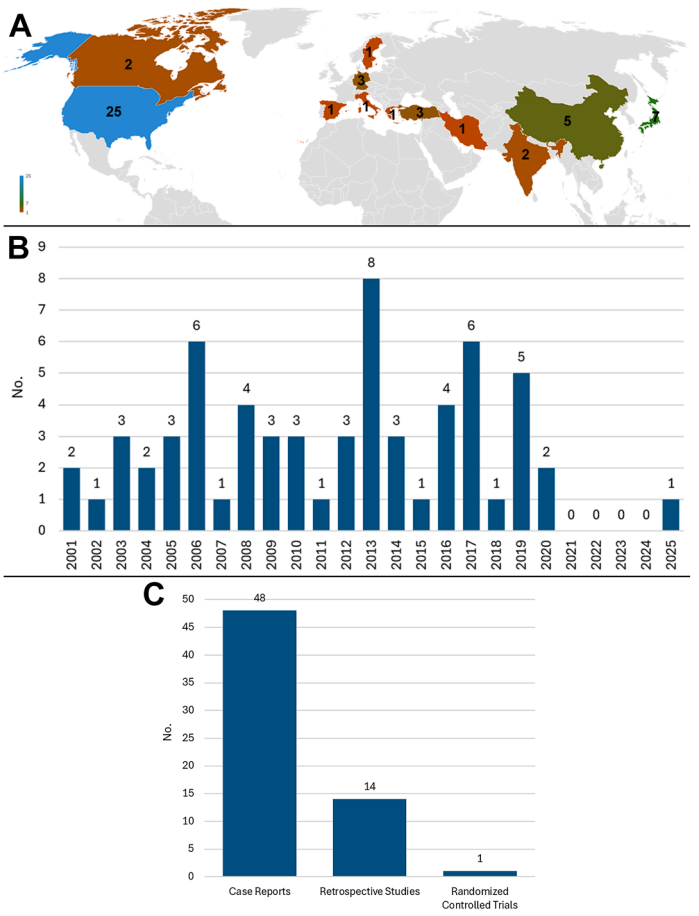

Fig. 2. (*A*) Geographic distribution of included studies. (*B*) Temporal distribution of included studies. (*C*) Study design of included studies. (*Map lines delineate study areas and do not necessarily depict accepted national boundaries).*

as severe.[32–39] Lumbar pain accompanied by urinary symptoms has been noted in certain cases,[38] while neck pain and associated discomfort are frequently observed.[40–42] Motor weakness is a prominent feature, often progressive in nature, which significantly affects patients.[32,34,43–48] Sensory deficits, including numbness and paresthesia, are also commonly encountered.[34,35,45,49] Spasticity and gait abnormalities are recurrent clinical signs, with spastic paraparesis and ataxia being notable symptoms.[34,43,47] These motor impairments often manifest as gait disturbances and balance difficulties, causing substantial functional limitations.[48,50]

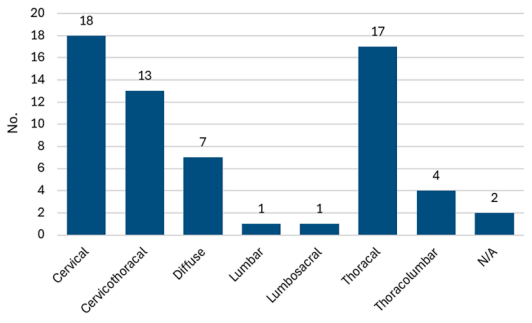

Fig. 3. Tumor localizations among included studies.

Bowel and bladder dysfunctions are frequently reported, particularly in advanced stages of the disease, and include urinary and fecal incontinence or increased frequency.[34,44,51,52] Neurologic deterioration is another significant aspect with serious manifestations, such as quadriparesis, paraplegia, and tetraparesis, indicating extensive tumor involvement.[45,51,53] In pediatric populations, specific features like developmental delays, scoliosis, torticollis, and vision changes are often observed, highlighting the impact on growth and development.[30,54,55] Additional symptoms include headaches, which are common across all age groups and often accompany other neurologic signs.[42,56,57] Abdominal pain has been reported in some cases, sometimes alongside other systemic features.[39,44] In children, irritability and excessive crying are

early indicators of the disease, underscoring the need for careful clinical assessment in younger patients.[28,55]

Treatment Modalities and Outcomes

Surgery is the primary treatment of sLGGs, with gross total resection (GTR) or subtotal resection (STR) improving survival outcomes. STR followed by radiotherapy has demonstrated prolonged progression-free survival, often exceeding 55 months (**Table 3**).[58–60] Laminoplasty, performed to maintain spinal stability, has shown favorable outcomes in specific cases.[61] Conversely, partial resection or biopsy frequently leads to recurrence or progression, despite occasional neurologic stabilization.[46,62,63]

Radiotherapy plays a key role in managing sLGGs, particularly for incomplete resections or recurrent tumors. Fractionated doses (45–50 Gy) have shown disease stabilization and neurologic improvement, with 5 year progression-free survival rates of 93% and overall survival rates of 100% reported in some cases.[8,64,65] Effective, higher doses may lead to neurologic toxicity, such as progressive paraparesis.[63] Studies on adjuvant radiotherapy showed mixed results with no significant survival benefit in some reports but delayed progression in others, particularly for low-grade tumors.[60,66]

Chemotherapy is generally reserved for recurrent or progressive sLGGs. Regimens such as temozolomide, vincristine, and carboplatin have produced variable outcomes. Temozolomide demonstrated a median survival of 29.1 months but was less effective in preventing intracranial dissemination.[31] Other regimens improved neurologic symptoms but did not consistently prevent tumor progression.[36,54,55] Adjuvant chemotherapy in low-grade tumors has shown better survival rates with some reports indicating 100% survival during follow-up.[67]

Combining surgery, radiotherapy, and chemotherapy yields the best outcomes for sLGGs, improving survival, reducing recurrence, and enhancing neurologic recovery. For example, the combination of radiotherapy and temozolomide has achieved stable neurologic conditions and long-term survival.[68,69] In asymptomatic or minimally symptomatic low-grade tumors, observation alone has resulted in stable disease over several years.[40,70] This approach is less suitable for symptomatic or progressive tumors, which typically require aggressive intervention.

Prognosis depends on tumor histology and treatment modality. Pilocytic astrocytomas have excellent 1 year survival rates (97%), whereas infiltrative gliomas exhibit poor 5 year survival (36.4%).[71,72] Recurrence and progression remain significant challenges, particularly in high-grade tumors, despite multimodal treatment.[60,73]

DISCUSSION

To the best of our knowledge, this is the first systematic review examining current advancements in the diagnosis and treatment of sLGGs, which, according to Perilongo and colleagues,[74] represent a poorly understood phenomenon. Therefore, the aim of this systematic review was to further elucidate the significance of the diagnosis and treatment of sLGGs. The total number of included studies was 63, which supports the rarity of these tumors,[12] as well as the need for specialized and focused expertise in their treatment. Additionally, the majority of the included studies is case reports, further highlighting the fact that the existing knowledge about these tumors has been limited to individual cases.

The distribution of sLGG localization in this systematic review differed from the general distribution of all spinal cord tumors reported in a retrospective study by Kane and colleagues.[75] We found that cervical localization was most frequently studied (28.6%), followed by thoracic (27%) and diffuse involvement (27%). In contrast, Kane and colleagues[75] found that the cervical spine is the most common location overall (33%), followed by thoracic (26%) and lumbar (24%). The sLGG distribution highlights a greater focus on cervical and thoracic regions.

Surgical resection remains the primary treatment of sLGGs, with GTR or STR associated with improved survival outcomes. Our systematic review indicated that STR followed by radiotherapy often leads to prolonged progression-free survival, frequently exceeding 55 months.[58–60] This approach supports findings from other studies in which surgery is emphasized as essential for long-term survival, particularly in pediatric cases.[76] However, partial resection or biopsy, while occasionally stabilizing neurologic symptoms, is less effective in preventing tumor recurrence and progression.[41,53,77] This finding is consistent with previous observations that incomplete resection or biopsy often leads to recurrence or progression, especially in low-grade gliomas of the spinal cord.[76]

Radiotherapy is an important treatment modality, particularly for patients with incomplete resections or recurrent tumors. Fractionated radiotherapy doses (45–50 Gy) can stabilize the disease and improve neurologic outcomes with 5 year progression-free survival rates as high

Table 3
Tumor, clinical, treatment, and outcome characteristics of low-grade spinal gliomas

Reference	Tumor Localization	Histologic Findings	Clinical Status	Radiological Findings	Treatment Modality	Outcome
El-Hajj et al,[66] 2025	N/A	WHO grade II tumors more frequent in radiotherapy group	Surgery alone group: median age 24 y; surgery with radiotherapy group: median age 40 y	No specific radiological findings provided	Surgery alone vs surgery with adjuvant radiotherapy	No significant overall survival benefit for adjuvant radiotherapy after matching; higher initial mortality in radiotherapy group due to confounders
Uchi et al,[32] 2022	T12, extended to T11–L1, and neurofibromatosis 1	Grade II, GFAP, and S100	Severe back pain, bilateral lower extremity numbness	Initial MRI: Spinal cord swelling with intramedullary edematous change; later MRI showed severe swelling and enhancement predominantly at the periphery	Radiotherapy: 46.8 Gy	Died 1 y and 10 mo after treatment
Tabibkhooei et al,[43] 2019	T5–T11	Grade II/pleomorphic medullary astrocytoma, GFAP	Scoliosis, severe motor/sensory spastic paraparesis	Intra-axial intramedullary lesion extending from the cervicothoracic junction to conus medullaris, with heterogeneous enhancement	Radiotherapy: alive after 2 y with significant improvement in paraparesis; no further progression on follow-up MRI	Alive at 2 y; no progression observed on MRI
Carey et al,[30] 2019	Cervicomedullary, cervical, and thoracic	Pilocytic astrocytoma (24), fibrillary astrocytoma (2), oligoastrocytoma (2), pleomorphic xanthoastrocytoma (1), and astrocytoma NOS (5); BRAF (V600 E: 2; duplication: 10; wildtype: 1; not tested: 21)	Symptoms: pain, weakness, ataxia, torticollis, scoliosis, nausea, developmental delays, and vision changes	Various levels of involvement with tumor subtypes and enhancements	Surgery (partial resection, near total resection, STR), and radiotherapy for select cases	Median follow-up of 9.05 y; varying survival and outcomes
Baran et al,[51] 2019	C4–CM	Grade I; markers: GFAP, synaptophysin, neuronal nuclei, Wilms' tumor 1, CD34, and BRAF	Progressively worsening quadriparesis, urinary and fecal incontinence	Intramedullary lesion with necrotic/cystic foci from C4 level; T1 hypointense and T2 hyperintense signals with strong contrast fixation	None noted for treatment modality	Continued symptoms, no clear therapeutic interventions mentioned

Tadele et al,[33] 2019	T8–T12	Grade II, infiltrative astrocytoma NOS; GFAP, Ki-67 ~7%, focal p53 positivity, IDH1 intermediate	Back pain for 2 y, leg weakness (worse on the left); unable to ambulate independently for 1 wk	Intramedullary mass extending T8–T12 with syrinx; peripheral T1 isointense, central T2 hyperintense with central cystic component; extensive vertebral destruction noted	Open biopsy with partial debulking, fenestration of cyst; radiotherapy: 44 Gy in 22 fractions	Alive at 4 mo postsurgery, mild improvement in weakness; postradiation MRI showed minimal tumor size decrease
Daoud et al,[90] 2019	C3–C7	Xanthoastrocytoma (grade II)	Traumatic injury to right arm; shaking episodes, loss of coordination, numbness, and decreased coordination	MRI showed intradural extramedullary mass from C3–C7 with enhancement of spinal cord and nerve roots	None	Stable at 7 mo
Jackson et al,[44] 2018	T6–L1	Grade II	Severe abdominal pain, foot drop, urinary incontinence, and motor weakness	MRI showed intramedullary spinal cord mass from T6–L1 with syrinx extending to brainstem	Debulk tumor	Significant neurologic improvement
Takai et al,[45] 2017	C1–C4	Grade II a diffuse astrocytoma	Right upper extremity paresis and motor weakness	MRI disclosed an intramedullary mass in the cervical spinal cord	50 Gy radiation, Temozolomide	Tumor progression and deterioration postsurgery
Bansal et al,[34] 2017	Cervicomedullary junction to T10	Grade I pilocytic astrocytoma	Back pain, numbness, spastic quadriparesis	CT and MRI revealed an intramedullary mass from cervicomedullary junction to T10	None for tumor, methylprednisolone for quadriplegia	Quadriplegia improvement after steroids, awaiting further response
Lavrador et al,[50] 2017	Conus medullaris	Pilocytic astrocytoma (WHO)	Bilateral lower limb pain, gait disturbance	Cystic lesion centered to the conus medullaris	Posterior-lateral fusion with internal fixation	Urinary catheter removed after 1 mo, gait disturbance resolved, and mild dysesthesia
Rangwala et al,[91] 2017	C7–T4	Pilocytic astrocytoma (Grade I, WHO)	Drowsiness, irritability, and emesis	T2 hyperintense cord-enhancing lesion	Laminectomy and ventriculoperitoneal shunt	Stable appearance of the intramedullary mass after surgery, 8 mo alive
Hong et al,[35] 2017	T12–L1	Pleomorphic xanthoastrocytoma (WHO)	Right leg numbness, back pain	Nodules of enhancement along cauda equina and roots	T11–T12 laminectomy, chemotherapy	Progressive disease after multiple treatments, died 5+ years after initial surgery
Dunn-Pirio et al,[92] 2016	T1–T12	Pleomorphic medullary astrocytoma (grade II, WHO)	Acute onset of back pain and numbness	Enhancing lesion with cystic changes	T4–T8 laminectomy, carboplatin	Partial radiographic response, neurologic baseline restored after 11 mo

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Table 3
(*continued*)

Reference	Tumor Localization	Histologic Findings	Clinical Status	Radiological Findings	Treatment Modality	Outcome
Zhao et al,[46] 2015	L2–L3	Pleomorphic xanthoastrocytoma (grade II, WHO)	Waist pain and leg weakness	Isointense signal on T1, hyperintense on T2 at L2–L3	Partial resection and GTR	Postoperative decline in muscle strength and sensation, no rehabilitation after 3 mo
Mascelli et al,[77] 2014	N/A	Pilocytic astrocytoma (grade I, WHO)	Gait disturbance and right leg pain	Solid tumor with mild contrast enhancement	Surgical resection	Neurologically stable after 4 y
Das et al,[40] 2014	C5–C6	Pleomorphic xanthoastrocytoma (grade II, WHO)	Shoulder, neck pain, and numbness	Solid mass at C5–C6 with homogeneous gadolinium enhancement	Near total resection	Mild residual sensory deficits and clumsiness after 1.5 y
Wu et al,[64] 2013	T11–L1, ill-defined margins	Pleomorphic medullary astrocytoma (grade II) WHO 2007	Intermittent burning pain and progressive numbness	MRI: abnormal intramedullary lesion, cord swelling, and heterogeneous enhancement	Radiotherapy: 40 Gy in 25 fractions	Postop: Pain relief, gradual improvement in numbness, no recurrence after 3 y
Garber et al,[36] 2013	T5–10, multiple enhancing nodules in lungs	pleomorphic medullary astrocytoma (grade II), WHO	Back pain, scoliosis, and lower extremity weakness	MRI: intramedullary, enhancing tumor from T5–T10, fluid collection above lesion, and lung nodules	Radiotherapy and chemotherapy (vincristine and carboplatin)	Worsening scoliosis, recurrence 14 mo postoperation, 20 mo alive
Prayson et al,[56] 2013	Thoracic spine	Low-grade astrocytoma, WHO	Sharp headaches, normal neurologic examination	MRI: abnormal enhancement in thoracic spine and surface nodular enhancement	Surgery and radiotherapy	No recurrence or progression after treatment
Gold et al,[57] 2013	Cervical	Juvenile pilocytic astrocytoma	Worsening headaches and left-sided hemiparesis	MRI: nonenhancing cervical cord tumor	Surgery: STR	Postoperative partial recovery from hemiparesis
Marzbani et al,[37] 2013	T4	Low-grade astrocytoma	Back pain and paraparesis	MRI: intramedullary mass at T4	Surgery (partial resection) and radiotherapy	Partial recovery, recurrence 5 y after surgery
Ratnarajah et al,[38] 2012	T6, syringomyelia C4–L2	Pilocytic astrocytoma (grade I)	Lumbar pain, incontinence, and urinary frequency	MRI: large syrinx from C4–L2	Surgery: T5–T7 laminectomy	Postoperative reduced sensation, able to walk, and syrinx size reduced
Lim et al,[83] 2012	T1–T4, solid mass with cystic portion	Pilocytic astrocytoma (grade I), WHO	Hypesthesia, ataxia, and pathologic reflexes	MRI: enhanced solid mass at T1–T4, cord edema from medulla to T11	Surgery and radiotherapy	Postoperation: no significant neurologic changes, recurrence 9 mo after surgery

Rasalkar et al,[47] 2012	T7–T8, associated syrinx from T6 to T9	Desmoplastic astrocytoma	Bilateral lower limb weakness and frequent falls	MRI: intramedullary lesion at T7–T8, associated syrinx from T6 to T9	Surgery: partial resection with debulking	Postoperation: can walk with stick and no sphincter disturbance
Harraher et al,[29] 2013	C7–T1, adjacent cyst caudal to the lesion	Pilocytic astrocytoma (grade I), WHO	Progressive numbness, weakness, and ataxic gait	MRI: T2 prolongation, cord edema from C6 to T4, 12 mm enhancing intramedullary lesion at C7–T1	None	Postsurgery recovery of neurologic function, and stable lesion
Gill et al,[52] 2010	T11–L2, tumor adherent to meninges	Pleomorphic xanthoastrocytoma, WHO 1993, and GFAP	Symptomatic for 1 mo, paraplegia, and bladder-bowel incontinence	MRI: Intramedullary lesion extending from D11–12 (ie, T11–12) to L1–2	Laminectomy D12 (ie, T12)–L2 and temozolomide	6 mo postsurgery: regained sphincter control, and no recurrence
Paraskevopoulos et al,[41]	C2–C7, posterior aspect of the thecal sac, and anterior displacement	Pleomorphic medullary astrocytoma initially, glioblastoma multiforme recurrence	Neck pain, progressive weakness, numbness, and neurologic deterioration 12 wk after surgery	MRI: intradural intramedullary lesion from C2 to C7, hyperintense on T2 weighted image, hypointense on T1-weighted image	Chemotherapy: vincristine, etoposide, and carboplatin	Neurologic improvement and slight residual symptoms
Matsuzaki et al,[54] 2010	Craniocervical junction to C6, associated with syringobulbia	Grade II pleomorphic medullary astrocytoma, and GFAP	Dysphagia, tetraparesis, and failure to develop	MRI: intramedullary mass, syringobulbia with ring-like enhancement	Chemotherapy: cisplatin and etoposide	Syringobulbia and tumor size reduced, alive at 64 mo
Jang et al,[69] 2009	C2–C4, infiltrating cervical spinal cord	Grade II, WHO, GFAP positive, MIB-1 proliferation index 1%	Pain, weakness, kyphosis, and gait difficulty	MRI: mass infiltrating cervical cord, multiple small lesions in cerebellum	Craniospinal irradiation, chemotherapy (temozolomide, lomustine [CCNU], and carboplatin)	Alive 7+ years, stable neurologic condition
O'Brien et al,[39] 2009	T4–T8, intramedullary tumor ($6 \times 1.4 \times 1.5$ cm^3)	Low-grade astrocytoma	Back pain, abdominal pain, and constipation	MRI: intramedullary tumor from T4 to T8 and associated edema	None	No recurrence for 4 y, full recovery, and active in sports
Schittenhelm et al,[70] 2009	Holocord, large cyst at superior pole of tumor	Grade I, WHO, and MIB-1 index 3%	Neurologic symptoms and brainstem involvement	MRI: inhomogeneous enhancement in T2 and large fluid-filled cyst in obex	None	None
Arulrajah et al,[42] 2008	C2–C3 to C6–C7	Pleomorphic medullary astro, WHO	Headache, neck pain, knee pain, and lethargy. Papilledema	MRI shows extensive mass in cervical cord and brain with subarachnoid metastasis, including abnormal enhancement in midbrain, pons, medulla, and cerebellar fissures	Radiotherapy (5.4 Gy to spine, 39.6 Gy craniospinal, boost 5.4 Gy)	Died about 2.5 y after diagnosis; neurologic deterioration with bilateral lower extremity weakness, positive Babinski reflex

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Table 3
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Reference	Tumor Localization	Histologic Findings	Clinical Status	Radiological Findings	Treatment Modality	Outcome
Sajadi et al,[53] 2008	Foramen magnum to C5	Pleomorphic medullary astro, WHO	Rapidly progressive cervical myelopathy	MRI shows diffuse cervical intramedullary tumor, intramedullary hyperintense lesion with partial enhancement and pial enhancement in spinal cord and posterior fossa	Radiotherapy (C1–C2) and chemotherapy (vincristine and carboplatin)	Neurologic symptoms worsened with tetraparesis and bulbar symptoms
Saad et al,[49] 2008	C5–C6	WHO, grade I	Progressive numbness and paresthesias in upper and lower limbs, no bowel/bladder involvement	MRI (6–9 mo) shows T2 prolongation and cord edema with enhancing intramedullary lesion at C5–C6	Radiotherapy and chemotherapy (vincristine and carboplatin)	Stable postsurgery with some numbness and weakness, no progression observed
Chen et al,[28] 2008	C1–T8	Low-grade astrocytoma	Irritable crying, neck stiffness, decreased arm movement, flaccid upper limbs, and spastic paraplegia	MRI shows long segment intramedullary mass from C1 to T8	Chemotherapy (vincristine and carboplatin)	Tumor progression observed 6 mo after diagnosis despite chemotherapy
Abel et al,[48] 2006	C7–T10	Pilocytic astrocytoma, WHO, Ki67 <1%	Unsteadiness, balance loss, inability to walk; bilateral lower extremity weakness and sensory loss after multiple surgeries	MRI shows intradural intramedullary tumor from C7 to T10, syrinx formation with enhancing lesions from T2 to T7	Chemotherapy (vincristine and carboplatin) and STR	Postoperative improvement in lower extremity function. Tumor metastasis and leptomeningeal spread after third surgery, stable metastasis observed
Mora et al,[55] 2007	C4–T4 and C2–T3	Fibrillary grade II	Cervical pain, torticollis, and disuse of both arms; irritability and painful cervical spine manipulation	MRI shows large intramedullary tumor from C4–T4 and C2–T3 with enlarged spinal cord and blockage of perimedullary space	Chemotherapy (vincristine and carboplatin)	Tumor growth after 2 mo of treatment, clinical signs worsened with tumor progression
Larson et al,[93] 2006	C3–upper C7	Well-differentiated juvenile pilocytic astrocytoma	Progressive motor loss in upper extremities with atrophy of left arm	Intramedullary spinal cord mass from C3 to C7, slightly hypointense on T1, and hyperintense on T2	Observation and radiotherapy	Immediate improvement in upper extremity strength after surgery, 2 y alive without progression

Magilner et al,[94] 2006	C1–C5	Grade I pilocytic astrocytoma	Neck pain, sensory disturbance in legs, and respiratory compromise	5.3 × 1.3 cm^2 cystic and solid mass from C1 to C5 with heterogeneous enhancement	Surgery (resection)	Immediate postoperative improvement; prolonged ventilation, no movement of limbs, and still alive at 34 d after operation
Nakamura et al,[95] 2006	T2–T4	Pleomorphic xanthoastrocytoma	Sensory disturbance, gait disturbance, and increasing sexual dysfunction	Diffusely infiltrating hypointense lesion in spinal cord, enhancing on T2 and gadolinium diethylene triamine penta-acetic acid	Surgery (debulking)	Postsurgery, slight improvement in mobility; able to walk with aid, progression-free for 8 mo
Hida et al,[58] 2006	C7–T5, C6–T11, and C6–T4	Grade II	Numbness in feet, neck pain, and spastic gait	Spinal cord swelling from C7–T5 and T1–T11 with enhancement at T6–T7	Surgery and radiotherapy	Neurologically stable 55 months after second surgery, no recurrence of tumor on MRI
Chamoun et al,[84] 2006	Upper thoracic spine tumor, intradural, and intramedullary	Low-grade astrocytoma	Weakness and back pain	Spinal cord lesion at upper thoracic level and MRI with recurrent lesions	Biopsy, radiotherapy (45 Gy), and temozolomide	9 y postdiagnosis, normal neurologic examination, recurrence at 3 and 6 y
Robinson et al,[65] 2005	Thoracic spine, grade II astrocytoma	WHO grade II	Weakness, sensory disturbances, and pain	Spinal MRI with abnormal signal and syrinx formation	Radiotherapy (5020 cGy)	93% 5 y progression-free survival, 100% 5 y overall survival, progression in 4 patients
Komotar et al,[85] 2005	T9–T12, diffuse signal abnormalities	Pleomorphic medullary astrocytoma, WHO grade I	Nocturnal back pain, constipation, and flaccid left arm	Spinal cord lesion from T9 to T12, syrinx	Biopsy and radiotherapy	5 y follow-up: stable neurologic status, and scoliosis
Shimizu et al,[96] 2004	C5–T5	Grade II, MIB-1 labeling index 7.4%	Hyperreflexia and scoliosis	MRI with infiltrative tumor at T5–T6 level	Surgery (second operation) and chemotherapy	No change in neurologic status, stable postsurgery
Peraud et al,[97] 2004	T11–T12	Low-grade astrocytoma	Weakness and back pain	Spinal cord lesion at upper thoracic level, MRI with recurrent lesions	Biopsy, radiotherapy (45 Gy), and temozolomide	9 y postdiagnosis, normal neurologic examination, and recurrence at 3 and 6 y
Furlan et al.[59] 2003	C4–T2	Low-grade (pilocytic) astrocytoma	Incomplete paraplegia	Syrinx and intramedullary tumor, moderate enhancement on MRI	Subtotal microsurgical resection, radiotherapy (50 Gy)	Partial neurologic recovery, worsening paraparesis after 3 y, and alive 6.5 y postop
Tekkok et al,[63] 2003	C3–T5	Grade I pilocytic astrocytoma	Progressive weakness and claw hand deformity	MRI: hypointense on T1, hyperintense on T2, marked enhancement at C5–C6, and no cystic component	STR, laminoplasty and radiotherapy (3500 cGy)	Progressing paraparesis, no further growth in cord postop, and alive 14 mo postop

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Table 3
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Reference	Tumor Localization	Histologic Findings	Clinical Status	Radiological Findings	Treatment Modality	Outcome
Sandalcioglu et al,[61] 2002	Holocord, extending from cervicomedullary junction to conus	Pilocytic astrocytoma	Transient ataxia	MRI: heterogeneous enhancement, intramedullary mass from T5–T9	Osteoplastic laminoplasty	Transient ataxia of lower extremities, resolved at discharge, and alive 4.5 y postoperation
Hassal et al,[62] 2001	T7/8–L2/3	Pilocytic astrocytoma	Gait disturbance and upper motor neuron signs	MRI: Intramedullary mass from T7–T8 to L2–L3 and syrinx extending to C7 level	STR, carboplatin chemotherapy	Improved lower limb function postsurgery, progression of tumor at primary site 6 mo later
Ng et al,[98] 2001	C5–C7, extensive cystic formation	Pilocytic astrocytoma	Progressive paraparesis	Spinal cord swollen with intramedullary tumor from C5–C7, measuring 4 cm; cystic and edematous changes extending to T9	STR	Minor disabilities, patient returned to school, and 2.5 y later still stable
Chai et al,[8] 2020	Tumor localization: C-29, C/t-13, T-34, and TL-7	Grade II (51), grade III (20), and grade IV (12)	IDH Wildtype (58), Ki-67 <10% (44)	BRAF V600 E Wildtype (50), Ki-67 $\geq$10% (46)	Radiotherapy (50–60 Gy) and surgery	Median survival of 40.13 mo; recurrence risk higher in high-grade tumors
Inoue et al,[31] 2018	Tumor localization: C-2, CT-3, T-8, and TL-1	Fibrillary astrocytoma (36%), anaplastic astrocytoma (36%), glioblastoma (21%), and pilocytic astrocytoma (7%)	Motor weakness (71%) and sensory loss (29%)	Spinal CT, MRI with T1 enhancement, and cyst formation	Radiation (50–60 Gy), chemotherapy (temozolomide, nimustine, and methotrexate)	Median survival of 29.1 mo; intracranial dissemination associated with poor survival
Seki et al,[99] 2016	Tumor localization: cervical (25%), thoracic (38.5%), and thoracolumbar (30.8%)	Pilocytic astrocytoma (5) and grade II Astrocytoma (15)	Low-grade (5%) and high-grade (23.1%)	CT and MRI showed T1 enhancement and syrinx formation	Surgery (GTR and STR) and chemotherapy (temozolomide and vincristine)	High-grade spinal cord astrocytoma survival: 15 mo median; low-grade survival: 91 mo
Ryu et al,[67] 2016	Cervical (11), thoracic (8), and thoracolumbar (5)	Grade I (4), grade II (8), and grade III (6)	Low-grade (0–48 mo), high-grade (0.25–36 mo)	MRI showed enhanced images, cyst formation, and syrinx	Chemotherapy (temozolomide and vincristine)	High-grade survival: 9 mo, low-grade: 100% survival at follow-up
Xiao et al,[100] 2016	Cervical (5), cervicothoracic (1), and thoracic (6)	WHO grade I (1), grade II (9), grade III (2), and grade IV (1)	p53 positive immunohistochemistry status; neurologic symptoms	MRI, no significant change in treatment approach	Surgery (resection) and radiation	Outcome: survival based on histologic grade, with grades I and II showing better survival

Babu et al,[68] 2014	Thoracic (47.8%), cervical (28.3%), cervicothoracic (15.2%), and thoracolumbar (8.7%)	Pilocytic astrocytoma grade I (41.3%), grade II (21.7%), anaplastic astrocytoma grade III (19.6%), and glioblastoma multiforme grade IV (17.4%)	Weakness (52.2%), back/neck pain (45.7%), and paresthesia/dysesthesia (41.3%)	MRI: mixed (hyperintense T2)	Surgery: biopsy, partial resection, laminoplasty, and radiotherapy (47.5 Gy)	65.2% overall survival; progression rate 65.2% and high-grade tumors had poor prognosis
Guss et al,[60] 2013	Cervical (9), cervicothoracic (7), thoracic (11), and holocord (2)	Low-grade (24), anaplastic astrocytoma (high grade) (4), and glioblastoma multiforme (high grade) (1)	Pain (12), weakness (9), and headache (3)	MRI: mixed findings	Surgery: biopsy, partial resection, STR, and radiotherapy (47.5 Gy)	Low-grade tumors show excellent survival (median 55 mo), high-grade have shorter survival (median 17 mo)
Fakhreddine et al,[71] 2013	Cervical (47), thoracic (57), and lumbar (12)	Pilocytic (15) and infiltrative (42)	Sensory deficit (47), motor deficit (46), and pain (44)	MRI: hyperintense T2, edema, intratumoral cysts, and hemorrhage	Surgery: partial resection and radiotherapy	Pilocytic astrocytomas associated with better overall survival (97% 1 y overall survival), infiltrative tumors have poorer survival (36.4% 5 y overall survival)
Seo et al,[72] 2010	Cervical (53%), thoracic (26%), cervicothoracic (11%), and thoracolumbar (5%)	Grade I (pilocytic astrocytoma), grade II (fibrillary astrocytoma), and grade III (anaplastic astrocytoma)	Symptoms: edema, intratumoral cysts, and hemorrhage	MRI: T2 hyperintense, syringohydromyelia absent, edema (37%), and intratumoral cysts (21%)	Surgery: biopsy and radiotherapy	Overall survival: pilocytic tumors have better prognosis (mean 16 y), infiltrative tumors show poorer outcomes
Zorlu et al,[101] 2005	Thoracic (47.8%), cervical (28.3%), cervicothoracic (15.2%), and thoracolumbar (8.7%)	Pilocytic astrocytoma grade I (41.3%), grade II (21.7%), anaplastic astrocytoma grade III (19.6%), and glioblastoma multiforme grade IV (17.4%)	Weakness (52.2%), back/neck pain (45.7%), and paresthesia/dysesthesia (41.3%)	MRI: mixed (hyperintense T2)	Surgery: biopsy, partial resection, laminoplasty, and radiotherapy (47.5 Gy)	65.2% overall survival; progression rate 65.2%, high-grade tumors had poor prognosis
Lee et al,[73] 2003	Cervical (9), cervicothoracic (7), thoracic (11), and holocord (2)	Low-grade (24), anaplastic astrocytoma (high grade) (4), and glioblastoma multiforme (high grade) (1)	Pain (12), weakness (9), and headache (3)	MRI: mixed findings	Surgery: biopsy, partial resection, STR, and radiotherapy (47.5 Gy)	Low-grade tumors show excellent survival (median 55 mo), high-grade have shorter survival (median 17 mo)

Abbreviations: BRAF, B-Raf proto-oncogene (serine-threonine kinase); CD34, cluster of differentiation 34; cGy, centigray (unit of radiation); CT, computed tomography; GFAP, glial fibrillary acidic protein; Gy, gray (unit of radiation); IDH1, isocitrate dehydrogenase 1; Ki-67, proliferation marker (MIB-1); MIB-1, marker used for Ki-67 assessment; N/A, not available; NOS, not otherwise specified; S100, S100 protein (calcium-binding proteins); WHO, World Health Organization.

as 93%.[48,49,55] While radiotherapy offers benefits in some cases, it is also associated with risks, such as progressive paraparesis and particularly neurologic toxicity.[42] The broader literature offers a similar perspective, acknowledging the mixed findings regarding the impact of radiotherapy on survival with some studies indicating no significant survival benefit.[78–81] In contrast, other large multi-institutional studies have shown that radiotherapy can increase progression-free survival, particularly when used as adjuvant therapy following surgery.[76] However, it is crucial to balance these benefits with the risks of long-term sequelae, such as thyroid disorders, growth abnormalities, and secondary malignancies.[37,82] These considerations highlight the need for careful patient selection and the potential need for close monitoring following radiotherapy.

Chemotherapy is typically reserved for recurrent or progressive sLGGs. Our review highlighted the variable outcomes associated with chemotherapy regimens, such as temozolomide, vincristine, and carboplatin. Temozolomide, for instance, demonstrated a median survival of 29.1 months but was less effective in preventing intracranial dissemination.[76] Similarly, other chemotherapy regimens improved neurologic symptoms but did not consistently prevent tumor progression.[33,45,83] These findings align with the broader literature, which also noted that chemotherapy is often used in recurrent or progressive cases, although its effectiveness in preventing tumor progression is inconsistent.[76]

The combination of surgery, radiotherapy, and chemotherapy has been shown to offer the best outcomes for sLGGs, improving survival, reducing recurrence, and enhancing neurologic recovery. This is consistent with findings in the systematic review in which the combination of radiotherapy and temozolomide was associated with stable neurologic conditions and long-term survival.[76] In cases of asymptomatic or minimally symptomatic low-grade tumors, observation alone has been shown to result in stable disease over several years, as seen in both the systematic review and other studies.[46,84] This approach, however, is less suitable for symptomatic or progressive tumors, which generally require more aggressive intervention.

The prognosis for sLGGs is largely influenced by tumor histology and the treatment modality employed. Pilocytic astrocytomas, a common subtype of low-grade gliomas, have excellent 1 year survival rates (97%), whereas infiltrative gliomas demonstrate poorer outcomes, with a 5 year survival rate of just 36.4%.[65,85] These findings are consistent with other findings in which survival rates for sLGGs vary, depending on histologic subtype, with infiltrative gliomas having a higher likelihood of progression and poor outcomes, especially in adult populations. As noted by other studies, the malignant transformation of low-grade gliomas into high-grade gliomas is a significant concern, particularly in adults in which more than 50% of low-grade gliomas undergo transformation into high-grade gliomas over time.[86–88] Conversely in pediatric patients, fewer than 10% of these tumors undergo malignant transformation.[89] This reinforces the notion that prognosis for pediatric patients with sLGGs is generally favorable, although adult patients face greater risks of tumor progression and transformation.

This systematic review has limitations, particularly the heterogeneity among studies, which prevented the use of a meta-analytic approach, and the predominance of case reports, which lack statistical power for generalizable conclusions. Given the rarity of sLGGs, there is a clear need for standardized diagnostic criteria, treatment protocols, and reporting practices to improve data consistency and enable reliable comparisons across studies. Standardization would facilitate better outcome evaluations, improve patient care, and support larger, multicenter studies to provide more definitive evidence on treatment efficacy and long-term prognosis for patients with sLGG.

SUMMARY

The treatment and prognosis of sLGGs remain complex. While surgery, radiotherapy, and chemotherapy have been shown to improve survival and neurologic function, significant challenges persist, particularly due to the rarity of these tumors and the limited data available. Surgical therapy, especially with regard of GTR of these tumors, leads to improved survival and can be potentially curative. The individualized treatment plans are essential, with careful consideration of the risks and benefits associated with each treatment modality. While radiotherapy and chemotherapy can provide significant benefits, especially for recurrent or progressive tumors, further research is needed to define treatment protocols better and provide more robust recommendations for managing sLGGs. The mixed evidence regarding the role of radiotherapy and the risks of long-term sequelae highlights the need for ongoing research to refine treatment strategies and improve patient outcomes.

CLINICS CARE POINTS

- The prognosis for sLGGs is largely influenced by tumor histology and the treatment modality employed.
- Malignant transformation of low-grade gliomas into high-grade gliomas is a significant concern for adults but is much less likely to occur in pediatric patients.
- Surgical resection remains the primary treatment of sLGGs, with GTR or STR associated with improved survival outcomes when followed by radiotherapy, which can stabilize the disease and improve neurologic outcomes; however, radiotherapy is associated with risks, such as progressive paraparesis and particularly neurologic toxicity.
- Chemotherapy is typically reserved for recurrent or progressive sLGGs, improves neurologic symptoms but did not consistently prevent tumor progression.
- The combination of surgery, radiotherapy, and chemotherapy has been shown to offer the best outcomes for sLGGs, improving survival, reducing recurrence, and enhancing neurologic recovery.

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APPENDIX 1: DATABASE SEARCH STRATEGY

Database	Search Syntax	Filters
Scopus	(TITLE-ABS-KEY("spinal low-grade gliomas" OR "sLGG" OR "glial tumors of spinal cord" OR "spinal intramedullary low-grade glioma") AND TITLE-ABS-KEY("surgery" OR "radiotherapy" OR "conservative treatment"))	TITLE-ABS-KEY(clinical study OR clinical trial OR observational study OR randomized controlled trial OR case report)
Web of Science	(TS=("spinal low-grade gliomas" OR "sLGG" OR "glial tumors of spinal cord" OR "spinal intramedullary low-grade glioma") AND TS=("surgery" OR "radiotherapy" OR "conservative treatment"))	(DT=(Article) OR DT=(Clinical Trial) OR DT=(Case Report))
PubMed	("spinal low-grade gliomas" OR "sLGG" OR "glial tumors of spinal cord" OR "spinal intramedullary low-grade glioma") AND ("surgery" OR "radiotherapy" OR "conservative treatment")	Classical Article, Clinical Study, Clinical Trial, Observational Study, Randomized Controlled Trial, Case Report
Directory of Open Access Journals	("spinal low-grade gliomas" OR "sLGG" OR "glial tumors of spinal cord" OR "spinal intramedullary low-grade glioma") AND ("surgery" OR "radiotherapy" OR "conservative treatment")	not applicable
Google Scholar	"spinal low-grade gliomas" OR "sLGG" OR "glial tumors of spinal cord" OR "spinal intramedullary low-grade glioma" AND "surgery" OR "radiotherapy" OR "conservative treatment"	not applicable