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Research article

Functional outcome after introduction of hemilaminectomy in management of spinal schwannomas and meningiomas

Emilia Muncan [a], Paula Klurfan [a,b], Michael Rymond [a], Asgeir S. Jakola [a,b], Alba Corell [a,b,*]

[a] Department of Neurosurgery, Sahlgrenska University Hospital, Gothenburg, Sweden
[b] Department of Clinical Neuroscience, Institute of Neuroscience and Physiology at the Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden

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ABSTRACT

Background: Schwannomas and meningiomas are intradural extramedullary spinal tumors which are regularly encountered in the neurosurgical clinic. These tumors cause neurological deficit by compression on the spinal cord and commonly pain when affecting the cauda equina. The traditional treatment with standard laminectomy (SL) can cause instability to the dorsal segments of the spinal column, and the less invasive option of hemilaminectomy (HL) has therefore been developed. We aim in this study to investigate transition from SL to HL in a population-based cohort.

Methods: Adult patients (18 years and older) undergoing primary surgery due to spinal meningioma or schwannoma between 2007 and 2022 at the neurosurgical clinic were included. Data related to clinical, surgical and outcome variables were retrospectively collected.

Results: A total of 187 patients were identified: 155 in the SL group, 26 in the HL group and in 6 patients a combination of SL and HL. The mean age of the SL group was 62.7 years (SD14.2) compared to 58.0 (SD15.7) in the HL group ($p = 0.16$). Preoperative motor deficit was more common in SL group compared to HL group (76.8 % and 61.5 %, respectively, $p = 0.14$). Thoracal location was most common for both groups (SL 65.8 % and HL 61.5 %). Postoperative change in McCormick grades and early complications were similar between groups.

Conclusion: Outcome after hemilaminectomy due to intradural extramedullary schwannoma or meningioma is comparable to standard laminectomy with regards to postoperative complications and neurological improvement. Our findings support the transition to hemilaminectomy in selected cases.

1. Introduction

Spinal meningiomas and schwannomas are the two most common intradural, extramedullary spinal tumors. Even though they have different growth pattern the surgical treatment strategy is similar between them. The surgical approach to the intradural lesions has typically been a standard laminectomy (SL). However, the traditional treatment with SL can cause instability to the dorsal segments of

* Corresponding author. Department of Neurosurgery, Sahlgrenska University Hospital, Blå stråket 5, 41345, Gothenburg, Sweden.
E-mail addresses: paula.klurfan@vgregion.se (P. Klurfan), michael.rymond@vgregion.se (M. Rymond), jakola.asgeir@gu.se (A.S. Jakola), alba.corell@gu.se (A. Corell).

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the spinal column, and the less invasive option of hemilaminectomy (HL) has therefore been developed [1,2].

In 1910 Taylor et al. presented HL as a less invasive alternative to the traditional SL as a treatment for treatment for spinal pathologies [3]. The rational for using HL are several. The procedure is not-only less invasive, it also spares the non-affected side with regards to musculature attached to the spinous process and avoids damage to the dorsal structure of the spinal column [4–7]. It also provides potentially less bleeding, is faster and less postoperative pain [8]. On the negative side, a narrower exposure and potential cost of compromising neural structures may occur. A larger study showed HL to be a safe surgical technique with regards to time of surgery, blood loss during surgery and neurological outcome [9]. Several reports on accessing particularly benign intradural tumors with HL have emerged with shorter hospital stay and better early results [5,9].

If this transition comes with a cost of worse outcome in term of neurological function and complications, surgeons must pay careful attention to the learning curve to ensure that quality of care is similar. However, we would like to elucidate case selection and clinical outcomes in this population-based cohort where a transition to HL has occurred in recent years where we investigate changes in neurological status.

2. Methods

2.1. Patient characteristics

Patients 18 years or older who underwent primary surgical treatment for spinal schwannoma or meningioma between 2007 and 2022. All the spinal intradural tumors in this health care region are treated at this neurosurgical department, which covers a population of approximately 1.7 million inhabitants. Data included were collected in a retrospective fashion.

2.2. Clinical, surgical and outcome variables

Different variables related to clinical, surgical and outcome were included. Clinical variables included gender, age, symptoms, Karnofsky performance status [10], time to follow-up, symptoms and pre- and postoperative McCormick score, in addition to radiological variables such as location of lesion and size (largest diameter). This scoring system has previously been used in patients with intradural extramedullary spinal tumors to classify neurological deficit prior to and after surgery and was selected as a marker of neurological outcome in this study [11,12]. The McCormick score ranges from grade I which implies intact neurology, through grade II (mild motor deficit), grade III (moderate deficit) and grade IV (severe motor deficit) to grade V indicating paraplegia or quadriplegia. Complications were studied and classified according to Landriel-Ibanez classification system for neurosurgical procedures [13].

Table 1
Comparison of patient cohorts operated with SL and HL (n = 181).

	Standard laminectomy n = 155	Hemilaminectomy n = 26	P-value
Age, mean years (SD)	62.7 (14.2)	58.0 (15.7)	0.16
Female, n patients (%)	111 (71.6)	15 (57.7)	0.17
Time to follow-up visit, mean months (SD)	3.4 (3.0)	3.6 (3.4)	0.95
Preoperative symptoms, n (%)[a]			
Motor deficit	119 (76.8)	16 (61.5)	0.14
Sensory disturbance	112 (72.3)	13 (50.0)	0.04
Gait disturbance or imbalance	106 (68.4)	17 (65.4)	0.82
Back pain	67 (43.2)	11 (42.3)	1.00
Urinary or fecal incontinence	51 (32.9)	11 (42.3)	0.38
Asymptomatic	4 (2.6)	1 (3.8)	0.54
Location in spinal canal, n (%)			
Craniocervical	7 (4.5)	1 (3.8)	1.00
Cervical	32 (20.6)	7 (26.9)	0.45
Thoracal	102 (65.8)	16 (61.5)	0.66
Lumbar	22 (14.2)	2 (7.7)	0.54
Sacral	1 (0.6)	0 (0.0)	1.00
Levels operated, n (%)			
1	41 (26.5)	9 (34.6)	0.48
2	82 (52.9)	13 (50.0)	0.83
3	27 (17.4)	4 (15.4)	1.00
4	2 (1.3)	0 (0.0)	1.00
5	2 (1.3)	0 (0.0)	1.00
7	1 (0.6)	0 (0.0)	1.00
Largest diameter mm, mean (SD)	22.9 (9.9)	21.3 (7.8)	0.37
McCormick score preoperative, n (%)			0.51
I	5 (3.2)	1 (3.8)	
II	71 (45.8)	12 (46.2)	
III	37 (23.9)	3 (11.5)	
IV	26 (16.8)	6 (23.1)	
V	16 (10.3)	4 (15.4)	

[a] More than one symptom can occur per patient.

Furthermore, variables related to the surgical procedure was collected, if laminectomy or laminoplasty was performed, in addition to laminoplasty and/or spinal fixation.

2.3. Surgical techniques

Standard laminectomy (SL); removal of the bony arch (laminae) of the vertebra, including the spinous process. This procedure requires removal of the supraspinous ligament and muscle attachments to the spinous process [14].

Hemilaminectomy (HL; the lamina is removed on one side of the bony arch of the vertebra, sparing the spinous process with associated ligaments and muscle attachments, but usually with undercutting of the spinous process [4].

2.4. Statistics

All analyses were made using SPSS, version 29.0.1.1 (Chicago, IL, USA). Statistical significance level was set to $p < 0.05$ and all tests were two-sided. Central tendencies were presented as mean with standard deviation (SD), or median and interquartile range (IQR) if skewed. Fisher exact test was used in 2x2 tables. Other categorical data were analysed with Pearson's chi square test. Independent sample *t*-test or Mann-Whitney *U* test were used when appropriate based on data type and sample distribution. Kendall's Tau correlation test was used to analyse linear correlation between variables with skewed distribution.

2.5. Ethical considerations

This study has been approved by the Swedish Ethical Review Authority (Dnr 2022-00160-01). The need for informed consent was waived.

3. Results

A total of 187 patients was identified and included in this study. SL was performed in 155 (81.2 %) patients, HL was selected in 26 (13.6 %) patients and in 6 patients a combination of SL on one or more levels and HL on one or more levels. Statistical comparisons were performed between the SL and HL cohort, see Table 1. There were no differences in age (62.7 respectively 58.0 years, $p = 0.16$), gender (female 71.6 % respectively 57.7 %, $p = 0.17$) or time to first follow-up (3.4 respectively 3.6 months, $p = 0.95$).

As for clinical presentation, motor deficit was the most common symptom in the SL group (76.8 %) and the second most common symptom in the HL group (61.5 %, $p = 0.14$). The most common symptom in the HL group was gait disturbance or imbalance (65.4 %). Sensory disturbance was a symptom which occurred more frequently in the SL group; 72.3 % in SL and 50.0 % in HL ($p = 0.04$). McCormick score preoperatively was similar between cohorts, see Table 1. For an overview of changes in McCormick grade for SL and HL see Figs. 1 and 2, respectively.

Between the years 2007 until 2013 SL was the standard approach. In 2014 14.3 % of surgeries was with HL approach and increased up to 22 % during the years 2015–2017. In 2021 a total of 50 % of patients were operated on with HL. See Fig. 3 for an overview.

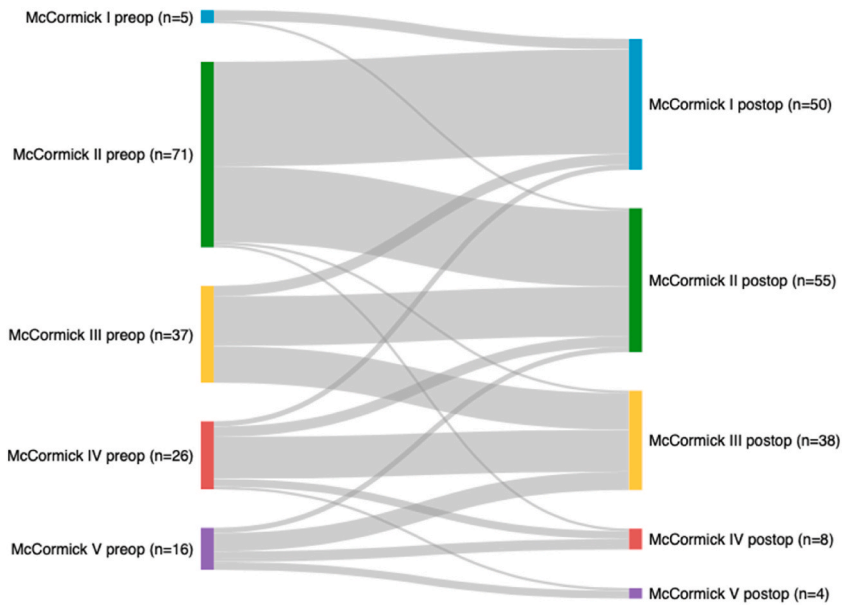

Fig. 1. Pre- and postoperative McCormick score for SL group (n = 155).

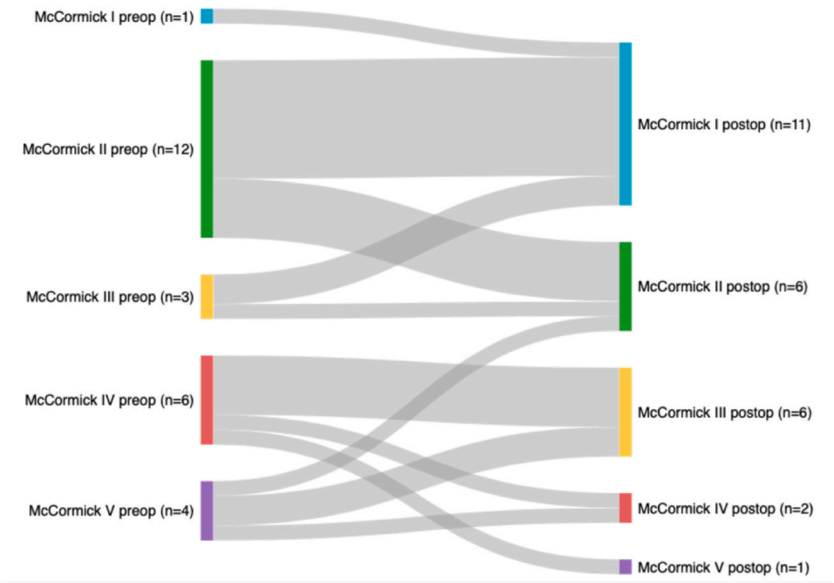

Fig. 2. Pre- and postoperative McCormick score for HL group (n = 26).

A comprehensive overview of variables related to the perioperative phase and postoperative period can be found in Table 2. Additional surgical treatment such as laminoplasty and posterior fixation was performed in additional 3 patients each in the SL cohort. Posterior fixation was performed in patients operated on 3 levels (n = 1), 4 levels (n = 1) and 7 levels (n = 1). Laminoplasty was performed in two-level (n = 1) of three-level (n = 1) SL cases.

Meningioma grade 1 was the most common diagnosis in both groups (SL 71.6 % and HL 76.9 %, p = 0.64). Meningioma grade 2 was found in the SL group only. Also, schwannomas were similarly distributed between groups. Days at a neurosurgical ward from admission to return to home or local hospital was median 5.0 days (Q1-Q3 4.0–7.0) in SL group and median 5.0 days (Q1-Q3 3.0–6.0) in the HL group (p = 0.14). The median days at the neurosurgical ward significantly decreased from year 2007 (6.5 days, Q1-Q3 4.5–17.8) to year 2021 (4.0 days, Q1-Q3 3.0–5.3) for the standard laminectomy group (p < 0.01), see Fig. 3. There was no significant linear correlation in the hemilaminectomy group (p = 0.17).

The rate of complications was comparable between groups, see Table 2. Grade IIa complications included two patients in the SL group needing lumbar drain due to CSF leakage compared to none in the HL group, without statistical significance (p = 1.00). There were five grade IIb complications in the SL group (one surgery for diverticulitis, one patient requiring VP-shunt, one patient undergoing surgical repair for CSF leakage and two patients with subcutaneous CSF leakage needing surgical treatment). For the HL group one patient suffered from grade IIb complications with suspected gastrointestinal bleeding needing gastroscopy. There were no significant differences between the groups regarding complications.

4. Discussion

In this study we investigated patient cohorts undergoing SL and HL for intradural meningioma or schwannoma. The neurological

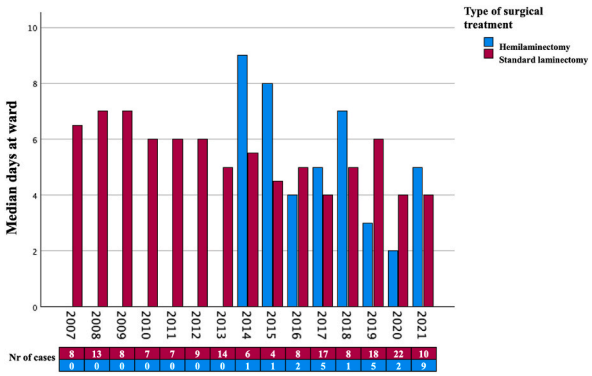

Fig. 3. Postoperative days at the neurosurgical ward per year of the study period. The SL cohort can be seen in red and HL cohort in blue. A statistical significance could be seen in the SL cohort with Kendall's Tau correlation test (p < 0.01), although not in the HL cohort (p = 0.17).

Table 2
Peri- and postoperative variables (n = 181).

	Standard laminectomy n = 155	Hemilaminectomy n = 26	P-value
Complications according to Landriel-Ibanez, n (%)			
Grade Ia	1 (0.6)	0 (0.0)	1.00
Grade 1b	24 (15.5)	4 (15.4)	1.00
Grade IIa[a]	2 (1.3)	0 (0.0)	1.00
Grade IIb[b]	5 (3.2)	1 (3.8)	1.00
Grade IIIa	0 (0.0)	0 (0.0)	1.00
Grade IIIb	0 (0.0)	0 (0.0)	1.00
Grade IV	0 (0.0)	0 (0.0)	1.00
Histopathology, n (%)			
Meningioma grade 1	111 (71.6)	20 (76.9)	0.64
Meningioma grade 2	3 (1.9)	0 (0.0)	1.00
Schwannoma grade 1	41 (26.5)	6 (23.1)	0.81
Postoperative McCormick, n (%)			
McCormick postoperative improved	97 (62.6)	19 (73.1)	0.38
McCormick postoperative unchanged	53 (34.2)	6 (23.1)	0.37
McCormick postoperative worsened	5 (3.2)	1 (3.8)	1.00
Additional surgical treatment, n (%)			
Laminoplasty	2 (1.3)	0 (0.0)	1.00
Posterior fixation	3 (1.9)	0 (0.0)	1.00

[a] SL group: two patients needed lumbar drain due to leakage of cerebrospinal fluid (CSF). HL group: None.
[b] SL group: one patient operated due to diverticulitis, one patient had high ICP and needed a VP-shunt, one patient with CSF leakage needing surgical repair, two patients with subcutaneous CSF leakage needed surgical management. HL group: one patient underwent gastroscopy and dilatation of distal duodenum.

burden was similar with regards to urinary or fecal incontinence and gait disturbance or impaired balance. However, motor deficit was more common in SL group, 76.8 % compared to the HL group. This may indicate that in cases with most neurological compromise, in this initial learning period SL was chosen over HL. The level of neurological worsening classified according to McCormick scale was similar between groups (SL 3.2 % and HL 3.8 %, p = 1.00). The rate of patients unchanged after surgery was slightly higher in SL compared to HL group (34.2 % versus 23.1 %, p = 0.37). The rate of unchanged neurology after HL was lower compared to a larger study [9].

Transition from open to less invasive surgical approaches have occurred in surgery for a wide range of surgical indications [15–18]. With the dawn of technical improvements in the field of neurosurgery the progress to less invasive treatment options have been successful [19]. In spinal neurosurgery examples include the treatment of lumbar spinal stenosis with minimally invasive approach which have been shown equal to SL [20]. As we see in our material, the introduction of newer surgical techniques is usually a stepwise introduction with no patients undergoing HL in 2013 and 50 % of the patients undergoing surgery in 2021. We found that after the introduction of HL steadily a larger number of patients was operated with HL approach. Patients undergoing surgery with HL experiences less frequent sensory disturbances prior to surgery compared to SL (p = 0.04). The outcome regarding complications and neurological status was not different between the groups.

SL was performed in a wide range of levels, extending from one level up to seven levels. HL was confined to one level or two levels in most cases (34.6 % and 50.0 %, respectively) and more rarely in three levels (15.4 %). This is similar to previous study on HL on spinal stenosis [21]. When numerous levels are involved SL with posterior fixation or laminoplasty is the method of choice [22].

The rate of early complications was comparable between the two surgical techniques. Additionally, no CSF leakage was observed in the HL group. Improvement in neurological function was similar when compared to literature [9,23].

5. Strengths and limitations

Strengths of this study include the population-based cohort with a long inclusion period and few missing data, as electronical health records have been used during the whole study period. Limitations include those associated with a retrospective study design. Additionally, as no preoperative longitudinal data were available, our material lacks data regarding rate of meningioma growth, a likely important factor in the development of neurological deficit.

6. Conclusion

The outcome after hemilaminectomy due to intradural extramedullary schwannoma or meningioma was comparable to standard laminectomy with regards to postoperative complications and neurological improvement during the transition to hemilaminectomy occurred over the study period. Our findings suggest the transition to hemilaminectomy in selected cases was safe.

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Emilia Muncan: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **Paula Klurfan:** Writing – review & editing, Writing – original draft, Data curation. **Michael Rymond:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Asgeir S. Jakola:** Writing – review & editing, Writing – original draft, Investigation, Data curation, Conceptualization. **Alba Corell:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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