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Proposal of a new radiological classification system for spinal meningiomas as a descriptive tool and surgical guide

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ABSTRACT

Objectives: 1) To provide neurosurgeons and radiologists with a new quantitative and anatomical method to describe spinal meningiomas (SM) consistently.

2) To provide a guide to the surgical approach needed and amount of bony resection required based on the proposed classification.

3) To report the distribution of our 58 cases of SM over different Stages and Subtypes in correlation to the surgical treatment needed for each case.

4) To briefly review the literature on the rare non-conventional surgical corridors to resect SM.

Patients and methods: We reviewed the literature to report on previously published cohorts and classifications used to describe the location of the tumor inside the spinal canal. We reviewed the cases that were published prior showing non-conventional surgical approaches to resect spinal meningiomas. We proposed our classification system composed of *Staging* based on maximal cross-sectional surface area of tumor inside canal, *Typing* based on number of quadrants occupied by tumor and *Subtyping* based on location of the tumor bulk to spinal cord. Extradural and extra-spinal growth were also covered by our classification. We then applied it retrospectively on our 58 cases.

Results: 12 articles were published illustrating overlapping terms to describe spinal meningiomas. Another 7 articles were published reporting on 23 cases of anteriorly located spinal meningiomas treated with approaches other than laminectomies/laminoplasties. 4 Types, 9 Subtypes and 4 Stages were described in our Classification System. In our series of 58 patients, no midline anterior type was represented. Therefore, all our cases were treated by laminectomies or laminoplasties (with/without facetectomies) except a case with a paraspinal component where a costotransversectomy was needed.

Conclusion: Spinal meningiomas can be radiologically described in a precise fashion. Selection of surgical corridor depends mainly on location of tumor bulk inside canal.

1. Introduction

Spinal meningiomas account for approximately 12% of meningiomas of the central nervous system and 25–46% of the primary spinal tumors [1,2]. These tumors are usually benign, slow growing and well-circumscribed neoplasms located in the intradural – extramedullary compartment of the spinal canal and result in compression of the spinal cord [3,4]. Only a few meningiomas (about 4.5–13%) may have an additional extradural component or can be entirely confined to the extradural space [5–7]. Although spinal meningiomas usually originate from the dural sleeve of a particular nerve root travelling laterally, resulting symptoms are usually from cord compression rather than isolated root compression [7,8].

Although usually not needed [5], further lateral access via bone removal (including partial facetectomy or pedicle resection) has been reported to facilitate resection and to improve the angle and visualization during exposure of more anteriorly located lesions [9]. One of the challenges remains that incomplete tumor removal of anteriorly

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Table 1
Different methods and strategies to classify anatomical location of tumor in previously published cohort studies.

Author	Year	Number of cases	Classification/Relation to spinal cord	Cases with extradural growth
Levy et al.	1982	97	• Anterior (36%) • Lateral (13%) • **Posterior (51%)**	7 (7.2%) with intra- and extradural components, 3 of which were invasive, 2 having destroyed both vertebral arch and pedicle
Solero et al.	1989	174	• Anterior (15%) • **Lateral (68%)** • Posterior (18%)	8 (5%) with intra- and extradural components, 9 (5%) completely extradural
King et al.	1998	78	• Anterior (19%) • Anterolateral (19%) • **Lateral (29%)** • Posterolateral (22%) • Posterior (10%)	2 (3%) with intra- and extradural components, 2 (3%) completely extradural, 2 cases of pedicle thinning and 1 case of bone invasion
Gezen et al.	2000	36	• Anterior (19%) • **Lateral (50%)** • Posterior (31%) determined intraoperatively	5 (14%) extradural
Cohen-Gadol et al.	2003	41	• Anterior (7%) • Anterolateral (24%) • Lateral (27%) • **Posterolateral (29%)** • Posterior (5%) • Circumferential (2%) • Hemicircumferential (5%)	7 (17%) with extradural extension, 3 of which had a large en plaque component, 4 of these seven required reoperation highlighting challenge of surgery and worse prognosis
Schaller et al.	2005	33	• Anterior (18%) • **Lateral (58%)** • Posterior (24%)	no information
Setzer et al.	2007	80	• Ventral (7.5%) • **Ventrolateral (41.2%)** • Lateral (13.8%) • Dorsolateral (21.2%) • Dorsal (3.8%) based on dural attachment intra- operatively	5 (6.3%) with extradural extension
Yoon et al.	2007	38	• Anterior (13%) • **Lateral (32%)** • Posterolateral (10%) • Posterior (3%) • Ten cases were not applicable	2 (5.3%) in intra- and extradural space, 2 (5.3%) in epidural space
Sandalcioglu et al.	2008	31	• Ventral (9%) • Ventrolateral (29%) • **Lateral (35%)** • Dorsolateral (17%) • Dorsal (10%) + • **Ventral to dentate ligament (73%)** • Dorsal to dentate ligament (27%) determined by intraoperative exploration	no information
Postalci et al.	2011	46	• Ventral (15%) • Lateral (20%) • **Dorsal (65%)**	2 (4.3%) with intra- and extradural components
Arima et al.	2014	23	• **Ventral (65.2%)** • Dorsal (34.8%) determined intraoperatively based on dural attachment	no information
Maiti et al.	2016	38	• Ventral (5.26%) • Ventrolateral (31.58%) • **Lateral (52.63%)** • Dorsal/Dorsolateral (5.26%) • Extraforaminal extension/dumbbell-shaped (5.26%)	no reported case

Table 2
Staging System.

Stage 1	less than 25% of the spinal canal is occupied
Stage 2	25 to 50% of the spinal canal is occupied
Stage 3	50 to 75% of the spinal canal is occupied
Stage 4	more than 75% of the spinal canal is occupied

located tumors may lead to poor outcome, high recurrence rates and increased risk of neurological damage especially from calcified lesions [6,7,9].

MRI is the diagnostic modality of choice for spinal meningiomas and it is not uncommon to discover and diagnose incidental cases early during the course of disease with unrelated or rather subtle symptoms (such as non-specific back pain and/or mild dysesthesias) before any significant neurological deficit (motor or sphincter dysfunction) occurs.

We therefore undertook this responsibility to propose a classification system that adequately and precisely describes yet developing smaller lesions within the spinal canal and to find a system that is better suited to classify large lesions that present with compression of the spinal cord.

To the best of our knowledge, there is no established radiological classification system in any of the previously published case-series and cohort studies. We therefore propose a system that relies only on post-contrast MRI studies as the decisive tool to categorize each spinal meningioma and assign it to a precisely-defined category (with Type, Subtype and Stage). Such a classification system can be appealing and of relevance for both neuroradiologists and neurosurgeons to unify our language by applying consistent descriptive terms instead of using overlapping terms that can be either confusing or occasionally misleading.