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Current surgical strategies for treating spinal tumors: Results of a questionnaire survey among members of the German Spine Society (DWG)

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ABSTRACT

Purpose: Questionnaire survey among the members of the German Spine Society (Deutsche Wirbelsäulen-Gesellschaft, DWG) to objectify oncological infrastructure and current standard of care in spinal tumor treatment in Germany.
Methods: All DWG-members were contacted via the society's e-mail and asked to respond in anonymized form to a related questionnaire. Questions were asked regarding surgical specialty, type of institution involved, numbers of spinal procedures, as well as questions on treatment for primary tumors, whether the respondent belonged to a tumor center, decision-making procedures for surgery, and the type of procedure.
Results: 84 centers providing surgical treatment for spinal tumors in their departments were identified. 52.6% were carrying out more than 500 spinal procedures per year. There was a significant association ($P \leq 0.05$) between the numbers of spinal surgeries, the number of treated tumor patients per year, the organisation in a tumor center and the treatment of primary tumors. 76% are part of a local tumor center for interdisciplinary decision making (i.e.surgical treatment and adjuvant therapy). 74% of the institutions stated that conventional postoperative radiotherapy is standardly administered in the case of secondary lesions, with 24% of them referring patients to external services for radiotherapy.
Conclusion: In spite of often large numbers of spinal operations, the centers perform relatively small numbers of tumor operations, particularly for primary tumors. A nearly three-quarter majority of the departments are integrated into interdisciplinary tumor care. However, there is a marked number that do not belong to an interdisciplinary organisation. Further advances in multidisciplinarity and oncology training are a continuous issue to increase treatment quality in spinal tumor patients.

Introduction

The diagnosis of a tumor on the spine is a severe and momentous event for those affected and represents an equally great challenge for the specialist disciplines treating these lesions. There is controversy regarding the value, necessity, options and extent of surgical interventions and on whether they are lastingly effective [1]. Oncological treatment is now primarily based on and guided by the biology of the underlying tumors, and currently a paradigm shift in surgical therapy is observed. Among the involved disciplines, the spinal surgeon is usually the first who is contacted either by the symptomatic patient or diagnostic radiologist. However, to provide the complete range of treatment, other disciplines as radiooncology, pathology, pain therapy, internal oncology etc. as well as the necessary infrastructure also have to be available locally

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to consecutively guarantee the patient a oncological treatment in accordance with the latest standards and guidelines. The treatments are mainly palliative in nature due to secondary lesions developing in 10–20% of all cancer patients [2]. Surgical procedures are aimed at relieving neurological complications, severe pain or restoring spinal integrity and vertebral stability in order to ensure an acceptable quality of life for the period remaining. With regard to primary tumors or so called „solitary“ metastases in definded constellations, the current data in the literature show that radical resection combined with adjuvant therapy is markedly superior to intralesional procedures [3–5].

The questionnaire survey among the members of the German Spine Society (*Deutsche Wirbelsäulen-Gesellschaft,* DWG) was the first of its kind and aimed to focus on the nationwide issues of treatment responsibilities and the disciplines involved, the spread and implementation of recognized diagnostic procedures, and the resulting therapeutic implications. The survey was initiated by the Spine Tumor Group of the Spine Section of the German Society for Orthopedics and Trauma Surgery (DGOU) and its results are presented and discussed here.

Materials and methods

Following consent from the Spine Section members of the DGOU, an inquiry was made to the Scientific and Research Committee of the DWG about conducting an online study among DWG members on the topic of “surgical treatment of spinal tumors,” and a positive response was received. According to local ethics committee standards based on the Helsinki protocols the primary goal of the mentioned study is to objectify quality managment in spinal tumor care without any relation to patient data. Therefore, an ethics committee approval is not necessary.

The DWG is Europe's largest interdisciplinary spine association of orthopaedic/trauma surgeons, neurosurgeons and also scientists involved in basic research. At the time of the questionnaire surgery, the DWG had approximately 1250 members. The questionnaire was distributed to the members via the society's e-mail list. The deadline for responses was set at 6 months after the date of issue. Responses could be returned online, by fax, or by post.

Questionnaire

On a voluntary basis, it was possible to include details of the respondent's name and the name and address of the clinical institution concerned. In addition to a question about specialist discipline, the questionnaire inquired into the type and size of the institution and the body responsible for it, as well as the estimated number of spinal procedures carried out (tiered in five steps from <100 to >1000 per year) and numbers of cases of tumor surgery (tiered in four steps from <10 to >50 per year).

The proportion of cancer patients treated who had primary spinal tumors, the tumor entities concerned, and intra/- extradural locations were recorded. Respondents were able to state the biopsy technique used in primary tumors and the decision-making process following a tumor diagnosis - stating, if relevant, the type of interdisciplinary structure which was locally available and the way in which the treatment regimen was established. The choice and type of surgical procedure and the availability of intraoperative histopathological rapid-section diagnosis were also asked about. Details could be given on the number of palliative procedures relative to procedures with curative intent, as well as the percentages of open surgical and percutaneous procedures. Questions were also asked about the indication for adjuvant therapy and the site at which it was carried out, as well as about routine use of conventional postoperative radiotherapy [6] for radiation-sensitive metastases and the site where it was carried out.

Analysis and statistics

The completed questionnaires were evaluated by the two clinical researchers who initiated the study. As the identity of the hospital concerned was stated by all of the participants, double-counting per hospital was avoided The responses were then analyzed in an anonymized form.

The results of the descriptive statistics were expressed as means with standard deviation. Significant differences on Fisher exact test were noted at a significance level of $P \leq 0.05$. For independent variables the Kruskal-Wallis test and Mann-Whitney-U-test were used ($P \leq 0.05$). IBM SPSS Statistics for Windows, version 23.0, was used for statistical analysis (IBM Corporation, Armonk, New York, USA).

Results

Clinical institutions

Out of 304 responses (24% response rate) a total of 84 clinical institutions were identified after exclusion of centers that were not enrolled in spine tumor care. The proportion of neurosurgical institutions was 29.8% (n = 25). Fifty-nine departments for orthopedic and trauma surgery were included (Figs. 1,2). The regional distribution across Germany of the participants in the survey was largely homogeneous (Fig. 1). There were significant associations ($P \leq 0.05$) between the type of institution the number of tumor operations carried out and the treatment of primary tumors (the results are displayed in Table 1).

Diagnosis and indications

The majority of the respondents (n = 51) stated that they preferred an open incisional surgical biopsy to a CT-based percutaneous procedure (39%) to confirm the diagnosis in patients with

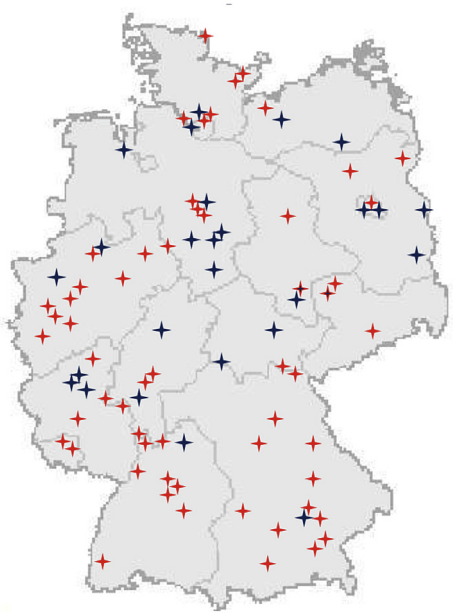

Fig. 1. The regional distribution of participants in the survey across Germany. Blue crosses represent neurosurgical centers, orthopaedic and trauma surgery centers are red.

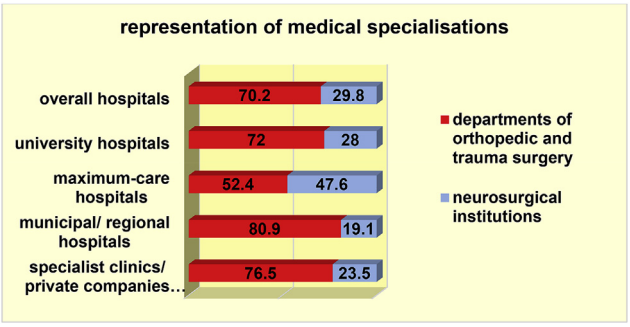

Fig. 2. Representation of medical specialisations among the participants of the survey.

primary spinal tumors. Eighty-six percent of the departments were also able to use rapid-section diagnosis intraoperatively to ensure representative tissue sampling and to preliminary assess the histopathological findings.

The majority (76%) of the participating departments were organised on an multidisciplinary basis in a tumor center. More than 90% of these centers permanently included pathologists, oncologists, radiologists, and radiotherapists in addition to the surgical disciplines. In the overwhelming majority of cases (95%), the indication for carrying out a surgical intervention was accordingly established through an multidisciplinary decision. The indication for adjuvant therapy is established in the local tumor center (77%), by locally based oncological colleagues (16%), or by oncologists in external institutions (7%).

Details of surgical procedures

Just under a quarter of the respondents stated that more than 1000 spinal interventions per year were in their institutions, although 82.6% carry out more than 300 procedures per year (Fig. 3a). The number of tumor interventions was higher than 20 per year in around 68% of cases, although this represented only a small proportion of the total interventions (Fig. 3b). Fewer than one-third of the respondents stated that they carried out more than 50 tumor interventions per year (Table 1). The overall number of surgeries was significantly related ($P \leq 0.05$) to the number of treated patients suffering from a spinal tumor.

Table 1
Type of institution and surgeries per year compared to the number of tumor surgeries per year/the treatment of primary tumors/and the participation in a tumor center displayed in absolute numbers and percent. Larger institutions/institutions with higher overall surgery numbers per year demonstrate significant ($P \leq 0.05$) higher numbers of spine tumor surgeries and more treated primary spine tumors. These hospitals were significantly ($P \leq 0.05$) more frequent involved in a local tumor center.

		no. of tumor surgeries per year								treatment of primary tumors				part of tumor center			
		<10		10–20		21–50		>50		yes		no		yes		no	
type of institution	university hospital	0	–	5	20.0%	6	24.0%	14	56.0%	24	96.0%	1	4.0%	25	100.0%	0	–
	maximum care hospital	1	4.8%	3	14.3%	12	57.1%	5	23.8%	16	76.2%	5	23.8%	16	76.2%	5	23.8%
	private hospital	3	14.3%	7	33.3%	11	52.4%	0	–	11	52.4%	10	47.6%	13	61.9%	8	38.1%
	specialist clinic	0	–	0	–	4	80.0%	1	20.0%	4	80.0%	1	20.0%	2	40.0%	3	60.0%
	other	1	8.3%	7	58.3%	1	8.3%	3	25.0%	7	58.3%	5	41.7%	9	75.0%	3	25.0%
	overall	**5**	**6.0%**	**22**	**26.2%**	**34**	**40.5%**	**23**	**27.4%**	**62**	**73.8%**	**22**	**26.2%**	**65**	**77.4%**	**19**	**22.6%**
surgeries per year	< 100	1	50.0%	1	50.0%	0	–	0	–	1	50.0%	1	50.0%	2	100.0%	0	–
	100–300	3	23.1%	4	30.8%	6	46.2%	0	–	5	38.5%	8	61.5%	9	69.2%	4	30.8%
	301–500	1	4.0%	10	40.0%	8	32.0%	6	24.0%	20	80.0%	5	20.0%	21	84.0%	4	16.0%
	> 500	0	–	5	20.0%	14	56.0%	6	24.0%	18	72.0%	7	28.0%	19	76.0%	6	24.0%
	> 1000	0	–	2	10.5%	6	31.6%	11	57.9%	18	94.7%	1	5.3%	14	73.7%	5	26.3%
	overall	**5**	**6.0%**	**22**	**26.2%**	**34**	**40.5%**	**23**	**27.4%**	**62**	**73.8%**	**22**	**26.2%**	**65**	**77.4%**	**19**	**22.6%**

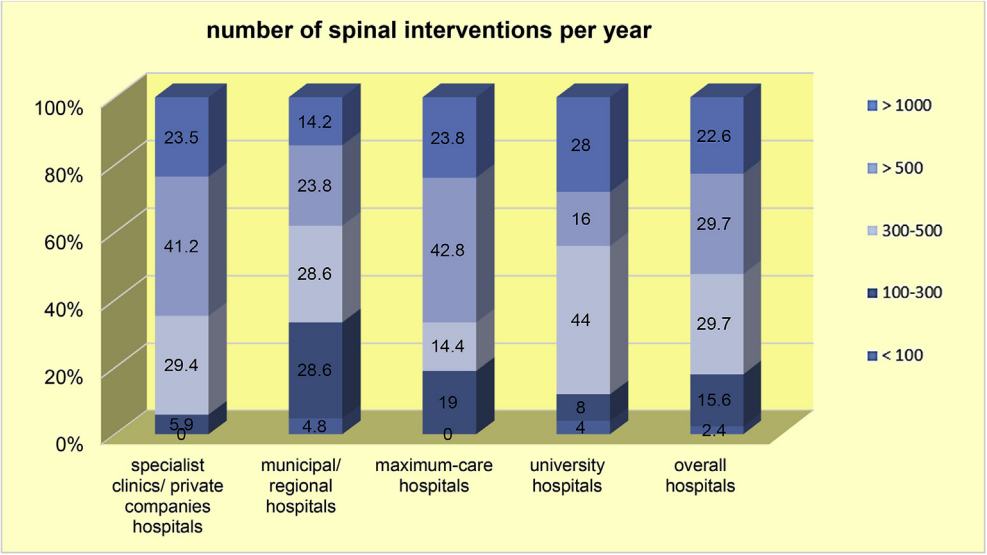

Fig. 3a. Number of spinal interventions per year (<100, 100–300, 300–500, >500, >1000) in relation to the type of institution.

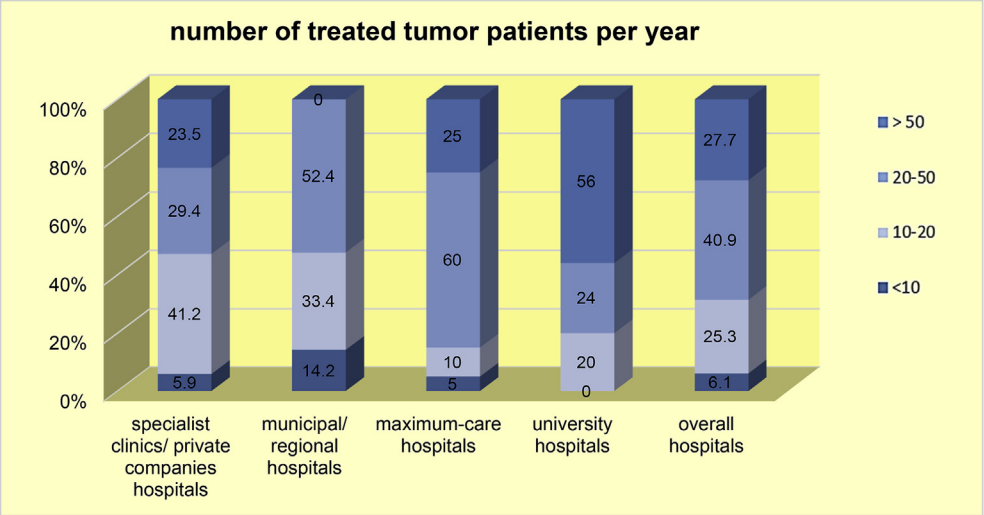

Fig. 3b. Number of tumor surgeries per year (<10, 10–20, 20–50, >50) in relation to the type of institution.

Treatment

The absolute majority of the procedures carried out in the departments were palliative (85% ± 18.7%), corresponding to the incidence of multiply disseminated secondary tumors. Currative surgery for primary tumors was not associated to a preoperative open biopsy ($P = 0.285$) or histopathological rapid-section diagnosis ($P = 0.426$) at the same clinic indicating treatment at several institutions. In three-quarters of the departments that responded, most of the tumor operations were open surgical procedures and a minority of 25% were percutaneous.

Neo- or/and adjuvant chemotherapy was locally organised in 65 institutions. A minority of 23% of the respondents had to send patients to institutions outside their hospital for further treatment.

Conventional postoperative radiotherapy for secondary radiosensitive tumors was administered as part of standard postoperative treatment in only 62 of the 84 departments that responded, representing at least 74% of all particapating clinics. The use of standard postoperative radiotherapy for tumor patients correlates significantly here with the size of the hospital and the number of tumor operations carried out ($P \leq 0.05$). As an explicit sign of an existing infrastructure at the institutions, pathological rapid-section diagnosis and regular postoperative radiotherapy were significantly ($P \leq 0.05$) related, while the existence of a regional tumor board and the treatment of primary tumors were not. Due to non-availability of a radio-oncological treatment in 20 hospitals, radiotherapy had to be externally administered at other institutions.

Treatment of primary tumors of the spine

Overall, three-quarters (74%) of the respondents stated that they carried out surgery for primary tumors of the spine in their departments. In the case of extradural entities benign primary tumors represented 51(±27)% of surgical procedures, sarcomas 36(±23)%, and chordomas 13(±9)%. The treatment of primary tumors was significantly ($P \leq 0.05$) related to the type of institution and overall number of surgeries per year, i.e. primary tumor therapy is more frequent in institutions with higher overall numbers of surgery.

Intradural pathologies were exclusively treated surgically in neurosurgical institutions. The proportion of intradural lesions relative to the total number of primary tumors in these departments was 26(±35)% and also significantly associated ($P \leq 0.05$) to the number of surgeries per year.

Discussion

The decisive developments in oncological therapy make the presence and availability of a well-functioning infrastructure in institutions performing surgical treatment a necessity to offer the best available standard care to all patients with spinal malignancies. This would suggest that the treatment of spinal cancer primarily takes place in centers with the corresponding facilities, which can ensure or at least organize the entire further oncological follow-up care.

The data of the present survey, however, are in sharp contrast to this notion as three-quarters of all respondent institutions are involved in treating primary tumors and data is indicating treatment for this entities in various institutions. This raises the question of whether further centralization of treatment is needed, particularly for primary tumors, in order to achieve the highest possible treatment standard for these rare entities. Reports of multicenter studies about significant decreased survival in favor of patients with intralesional surgical margins (contaminated cases) and who received a previous spine tumor operation highlight the need for concentrations of ressources in experienced and large spinal tumor centers [3,5,7–9]. The overriding aim must therefore be to intensify awareness of these rare tumors by providing a wide range of further teaching programs and advanced training courses, thereby linking the periphery to the center. In addition, central recording of all of these cases in registries is an absolute necessity.

The key step in the diagnostic investigation is carrying out a tumor biopsy, which is decisive for the subsequent treatment and for the patient's prognosis. In a meta-analysis, open biopsy continues to be regarded as the “gold standard,” as it is able to obtain sufficient amount of tissue samples from various parts of the tumor for histopathological examination. As minimally invasive techniques, the CT-guided procedures have a much lower general risk profile and are less expensive in the cost analysis in comparison with open surgical/incisional biopsy [10]. Their greatest advantage is regarded as lying in the lower risk of local tumor dissemination, which is thought to lead to a higher rate of local recurrency. However, prior to CT-guided biopsy of primary spinal tumors close multidisciplinary crosstalk and consultation is mandatory to avoid interference of the biopsy tract with the subsequent surgical resection (e.g. no violation or tresspassing of uninvolved

compartments, etc.). Among the respondents in the DWG, open surgical biopsies are carried out in the majority of cases, but with a still significant proportion of CT-guided biopsies, at 40%. From the tumor surgery point of view, the latter are indicated above all cases of multiple metastases. When there is a suspicion of a primary tumor or only one evident metastasis, open biopsy should be recommended. This obtains sufficient tissue samples from different tumor areas for histopathological processing to allow both: additional immunohistological, molecular-pathological, cytogenetic examination as well as tissue sampling für research purpose and tissue banking/reference pathology diagnosis.

Radiotherapeutic approaches are showing extremely dynamic development and have been the subject of various publications. Intensity-modulated radiotherapy (IMRT) [6], carbon ion and proton-beam radiotherapy provide not only high precision but also a very high effective tissue dose, and initial publications on the technique have shown promising results [11,12]. Stereotactic body radiotherapy (SBRT) for spinal metastases shows good local tumor control, favorable pain response and low rates of serious adverse events [13]. The combination of SBRT with separation surgery is especially recommended in radioresistant or already irradiated metastases with spinal canal involvement [14] while conventional radiotherapy (EBRT) is still treatment of choice in radiosensitive entities. Recommendations that involve the mentioned techniques are based on frameworks/algorithms [14,15] that cover the question for stability (e.g. SINS [16,17]) of metastastic lesions, accompanying neurological deteriotation by epidural tumor involvement (i.e. ESCC grading scale [18]), radioresponsiveness based on the underlying tumor histology and the idividual life expectancy. This concept offers a standard for the use of actual surgical (i.e. open, MIS, radical) and radiotherapeutical (SBRT, EBRT, proton beam etc.) tools that are combined by systemic adjuvant therapies.

However, these procedures are not only extremely cost-intensive, but are also currently only sparsely available and provided by only few specialized centers. Therefore only conventional radiation therapies were subject of the mentioned questionnaire.

Among the DWG respondents, 25% of patients are not standardly referred for postoperative radiotherapy. With a direct association between the size of the institution and the number of tumor operations carried out, there is a noticeable and obvious deficiency in oncological aftercare and follow-up treatment in smaller institutions with lower numbers of interventions. Particularly, in the case of nearly most of the metastases, inclusion of radiotherapy must be required for purposes of local tumor control [19].

Although the proportion of percutaneous and surgically “less invasive” techniques represented less than a quarter of the tumor procedures in the questionnaire survey, there have been increasing numbers of publications emphasizing the strong value of these techniques for spinal surgery for metastatic disease [20–22]. Along with other indications for the use of minimally invasive procedures in the spine, less invasive techniques offer the advantage of less soft-tissue trauma, more rapid mobilization for the patients, and fewer wound healing disturbances [22,23]. This can shorten the time to the start of postoperative radiotherapy and thereby reduce the overall complication rate [22,24].

More than three-quarters of the DWG members who responded have a tumor center on their own site, indicating that in accordance with the accepted standards the complex range of care services for the patients appears to be ensured in large parts of Germany. Most of the required treatment decisions are made in a multidisciplinary setting. Conversely, however, this also implies that it cannot be provided in one-quarter of the centers. Only one in ten of the respondents stated that they made the treatment decision to carry out a surgical intervention independently. These data impressively show the clear need, that in these institutions therapeutic algorithms and decision making need to be adapted to an multidisciplinary level, involving all associated disciplines in order to provide all quality-oriented standards of spinal oncology and surgery, including individually adjusted regimens or enrollment of patients into multicenter studies.

Intramedullary(20–30%)/extramedullary(70–80%) primary tumors [25] and the much rarer intradural metastases [26] were treated by a third of the departments in this survey. As expected within the DWG, the treatment situation in view of intradural tumor management seems to be clear-cut, since all intradural tumors are surgically treated in neurosurgical departments. In these centers, intradural, extramedullary and intramedullary space-occupying lesions represent over a quarter of the tumors that are treated. However, the ratio of intradural malignancies to the total frequency of surgeries was inhomogeneous and shows a wide range in the responses. This again highlights the notion that not all patients are referred to a center for intradural tumor treatment. Here again, efforts are needed to establish homogeneous treatment and centralization of case numbers.

The necessary provision of comprehensive oncological centers and the sometimes complex and elaborate therapeutic schemes with associated costs for treating spinal tumor patients are a tremandous socio-economic challenge for the national health-care system. However, only limited data are available on this issue. Noteably, a meta-analysis by Fehlings et al. [1] clearly revealed two findings. The treatment of patients with epidural compression caused by spinal metastases is less cost-intensive with radiotherapy alone in comparison with a combination of surgical treatment and radiotherapy. However, if clinical success rates (i.e. survival, HRQOL) are regarded as the most relevant target value that needs to be achieved, the cost-effectiveness ratio converses as the combination of both forms of treatment is superior. For other treatment strategies in spinal tumor treatment - neither for carrying out stabilization of a tumor-related instability alone, nor for the complex treatment of primary spinal tumors, are as yet data available. Therefore, an objective estimation of a social value independent from the treatment target is hard to achieve.

Data that are obtained using questionnaire surveys are subject to serious and well-known limitations. Although the DWG is the largest specialist society for spinal surgery in Europe, with a large number of qualified members, questionnaires in particular are subject to error due to insufficient representativeness resulting from an arbitrary sample. It is not possible to check whether or not the responses are true, nor can one check whether the responses may have been distorted by pressures for conformity of opinion or overemphasis of individual characteristics and opinions. The familiar problem of the low response rate in voluntary questionnaires is another limitation, as is topic-related self-selection (i.e. one will not take the questionnaire if he is not mainly involved in the topic). The possibility of multiple responses was prevented by analyzing only one representative and authorized respondent per center. Although the above mentioned limitations, however, a questionnaire is one possible tool for comprehensively and nationwide assessing the current care structures.

The results of this DWG survey give a brief inside view of the current treatment situation. There is a strong demand for pooling and concentration of needs, efforts, technical equipment and expertise in well selected and few centers. Those centers have to be equipped in terms of continuously providing these technical and multidisciplinary personnel capacities and also are experienced in performance of complication management. The survey shows that there is already a strong trend toward achieving this goal. With regard to purely intradural pathology, the situation is much more varied. Despite the very good structural conditions in the

departments that participated, there continues to be a low percentage of departments that do not use an interdisciplinary forum as a basis for treatment decisions. There is also a group in which not all adjuvant treatments are consistently implemented. Specialist societies such as the DWG have recognized those shortcomings and health care deficits in spinal oncology. Training programs for individual spine surgeons and organisational quality assurance and certification of spine centers with focus on spine tumor surgery are initiated and continuously updated and recertified. These efforts are additionally supported by further interaction of the participating disciplines. Multidisciplinary knowledge-sharing and establishment of both, overarching comprehensive cancer centers or interdisciplinary comprehensive spine centers with focus on spinal oncology are a continuous challenge. All these efforts are directed towards ensuring and further increasing high-quality therapy for spinal tumors. In pursuing this appraoch spine tumor patients may rightly expect to be offered the best possible treatment in the future.

Declaration of interest

None.

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References

[1] Fehlings MG, et al. Cost-effectiveness of surgery in the management of metastatic epidural spinal cord compression: a systematic review. Spine (Phila Pa 1976) 2014;39:S99–105.
[2] Barron KD, et al. Experiences with metastatic neoplasms involving the spinal cord. Neurology 1959;9:91–106.
[3] Sciubba DM, et al. Clinical, surgical, and molecular prognostic factors for survival after spinal sarcoma resection. Neurosurg Focus 2016;41:E9.
[4] Charest-Morin R, et al. En bloc resection versus intralesional surgery in the treatment of giant cell tumor of the spine. Spine (Phila Pa 1976) 2017;42:1383–90.
[5] Schaser KD, et al. Bone sarcoma of the spine. Recent Results Cancer Res 2009;179:141–67.
[6] Folkert MR, et al. Comparison of local recurrence with conventional and intensity-modulated radiation therapy for primary soft-tissue sarcomas of the extremity. J Clin Oncol 2014;32:3236–41.
[7] Bettegowda C, et al. Spinal column chordoma: prognostic significance of clinical variables and T (brachyury) gene SNP rs2305089 for local recurrence and overall survival. Neuro Oncol 2017;19:405–13.
[8] Charest-Morin R, et al. Ewing sarcoma of the spine: prognostic variables for survival and local control in surgically treated patients. Spine (Phila Pa 1976) 2018;43:622–9.
[9] Lador R, et al. Treatment of spinal tumors in a high volume center has direct impact on local recurrence, morbidity, and mortality. Clin Spine Surg 2017;30:E1074–81.
[10] Mankin HJ, et al. The hazards of the biopsy, revisited. Members of the Musculoskeletal Tumor Society. J Bone Joint Surg Am 1996;78:656–63.
[11] DeLaney TF, et al. Long-term results of Phase II study of high dose photon/proton radiotherapy in the management of spine chordomas, chondrosarcomas, and other sarcomas. J Surg Oncol 2014;110:115–22.
[12] Igaki H, et al. Clinical results of proton beam therapy for skull base chordoma. Int J Radiat Oncol Biol Phys 2004;60:1120–6.
[13] Husain ZA, et al. Stereotactic body radiotherapy for de novo spinal metastases: systematic review. J Neurosurg Spine 2017:1–8.
[14] Laufer I, et al. The NOMS framework: approach to the treatment of spinal metastatic tumors. The Oncologist 2013;18:744–51.
[15] Spratt DE, et al. An integrated multidisciplinary algorithm for the management of spinal metastases: an International Spine Oncology Consortium report. Lancet Oncol 2017;18. e720-e30.
[16] Fisher CG, et al. Reliability of the Spinal Instability Neoplastic Score (SINS) among radiation oncologists: an assessment of instability secondary to spinal metastases. Radiat Oncol 2014;9:69.
[17] Fox S, et al. Spinal instability neoplastic score (SINS): reliability among spine fellows and resident physicians in orthopedic surgery and neurosurgery. Glob Spine J 2017;7:744–8.
[18] Bilsky MH, et al. Reliability analysis of the epidural spinal cord compression scale. J Neurosurg Spine 2010;13:324–8.
[19] Redmond KJ, et al. Postoperative stereotactic body radiation therapy (SBRT) for spine metastases: a critical review to guide practice. Int J Radiat Oncol Biol Phys 2016;95:1414–28.
[20] Kim CH, et al. Less invasive palliative surgery for spinal metastases. J Surg Oncol 2013;108:499–503.
[21] Hansen-Algenstaedt N, et al. Minimal-invasive stabilization and circumferential spinal cord decompression in metastatic epidural spinal cord compression (MESCC). Eur Spine J 2013;22:2142–4.
[22] Zuckerman SL, et al. When less is more: the indications for MIS techniques and separation surgery in metastatic spine disease. Spine (Phila Pa 1976) 2016;41(Suppl 20):S246–53.
[23] Mesfin A, et al. Changing the adverse event profile in metastatic spine surgery: an evidence based approach to target wound complications and instrumentation failure. Spine 2016;41(20S). PP S262-9.
[24] Massicotte E. The role of minimally invasive techniques in the management of spinal neoplastic disease: a review. J Neurosurg Sci 2013;57:193–201.
[25] Samartzis D, et al. Intramedullary spinal cord tumors: Part II-management options and outcomes. Glob Spine J 2016;6:176–85.
[26] Merhemic Z, et al. Neuroimaging of spinal tumors. Magn Reson Imag Clin N Am 2016;24:563–79.