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Decision Making in the Surgical Treatment of Cervical Spine Metastases

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Study Design. Qualitative systematic review of the literature.

Objective. To determine whether surgical indications and techniques are influenced by the region of the cervical spine (occipitocervical, midcervical, and cervicothoracic junctions).

Summary of Background Data. There are distinct differences in the anatomic as well as biomechanical characteristics at the occipitocervical junction (C0–C2), subaxial spine (C3–C6), and the cervicothoracic junction (C7–T2), and there is no information on whether these differences influence the decision to intervene surgically or influence the choice of surgical approach.

Methods. A systematic review was designed to answer 2 primary research questions that were determined through consensus among a panel of experts drawn from the Spine Oncology Study Group:

1. Is the decision to operate influenced by the anatomic region of the cervical spine?
2. Is the operative approach influenced by the anatomic region of the cervical spine?

Results. For C0–C2 disease, posterior approaches are favored in the majority of cases. In the subaxial cervical spine (C3–C6), anterior approaches were preferred in the majority of cases. A combined anterior/posterior approach was favored for multilevel disease, circumferential tumor involvement, and poor bone quality. At the cervicothoracic junction (C7–T1), anterior or posterior approach was used for decompression. Three column reconstruction from a single posterior approach was an increasingly commonly performed procedure.

Conclusion. Although there are no level-1 studies to guide decision-making in this area, a literature review does provide some general guidelines for clinical management. Metastatic involvement of junctional regions of the cervical spine (Occ-C2 and C7–T1) and/or kyphosis and collapse involving any region of the cervical spine are key determinants influencing the decision to stabilize the spine.Posterior techniques are favored at the occipitocervical junction, anterior techniques are generally recommended to in the subaxial cervical spine, and either anterior or posterior approaches can be used at the cervicothoracic junction.

Key words: surgical treatment, metastases, cervical spine. **Spine 2009;34:S108–S117**

Although the spinal column is the commonest site of osseous involvement in patients with metastatic cancer, the cervical spine is involved only in 8% to 20% of such patients.[1] Surgical treatment can be a consideration in situations including mechanical instability, neural compression, and the presence of a radioresistant tumor. Operative decompression and stabilization procedures have been shown to be more effective than nonoperative treatment in relieving pain, and may also reverse neurologic deficits and improve ambulatory function.[2,3]

There are distinct differences in the anatomic as well as biomechanical characteristics at the occipito-cervical junction (C0–C2), subaxial spine (C3–C6), and the cervicothoracic junction (C7–T2), and there is no information on whether these differences influence the decision to intervene surgically or influence the choice of surgical approach. The objective of the study was therefore to determine whether surgical indications and techniques are influenced by the region of the cervical spine (occipito-cervical, midcervical, cervicothoracic junction) involved.

Methods

A systematic review was designed to answer 2 primary research questions that were determined through consensus following discussion among a multidisciplinary panel of experts (Spine Oncology Study Group [SOSG]):

1. Is the decision to operate influenced by the anatomic region of the cervical spine?
2. Is the operative technique (approach) influenced by the anatomic region of the cervical spine?

A comprehensive literature search was conducted using MEDLINE, EMBASE, Paper First, Web of Science, Google Scholar, and the Cochrane Database of Systematic reviews. The MEDLINE search terms included the MeSH terms "cervical vertebrae," "neoplasm," and "neoplasm metastasis."

Inclusion criteria included the following:

Articles published between 1990 and 2008;

All articles in the following languages: English, German, French, Italian, Portuguese, English, French, Japanese, Russian, and Spanish;

Adult age group (18+ years);

Case series, review articles.

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Exclusion criteria included articles focusing on the following:

Primary tumors;

Intradural tumors;

Pediatric age group;

Case Reports;

Articles with mixed pathology (e.g., tumor + trauma + degenerative patients in the same series) where there were insufficient data to extract pertinent information about the tumor population.

The abstracts of all articles that matched the search terms and inclusion/exclusion criteria were reviewed by 3 independent reviewers, and full text versions of suitable articles were obtained. These articles were then studied for information relevant to the research questions, and their bibliographies were hand-searched for any additional references that might have been missed in the original literature search. Any disagreement on the selection of articles was resolved by consensus among the 3 reviewers. Selected articles were graded by the level of evidence according to Sackett's criteria.[4] The results were classified based on the 3 anatomic regions of the cervical spine—occipito-cervical (C0–C2), subaxial (C3–C6), and cervicothoracic (C7–T2). The results of the literature search were tabulated in the form of an evidentiary table.

The results of the literature reviews, evidentiary tables, and preliminary conclusions were subjected to a consensus-based decision-making process using a modified Delphi approach. The membership of the SOSG, which is a multidisciplinary study group encompassing neurosurgical and orthopedic spine surgeons, medical oncologists, and radiation oncologists from North America, South America, Europe, and Asia, served as the Review Panel for the modified Delphi approach.

■ Results

The literature search yielded a total of 1140 abstracts, and 44 articles were found to fulfill all the criteria specified above, which were then studied in detail. No level-1 or level-2 studies found in this search. There were 33 level of 3 studies (retrospective case series)[5–38] and 9 level of 4 articles (review/expert opinion articles).[1,39–46] The selected articles were then divided into 3 groups, depending on the anatomic area within the cervical spine about which data could be extracted. Table 1 is a summary of the literature pertaining to the C0–C2 region, and Tables 2 and 3 provide similar summaries of data pertaining to the C3–C6 and C7–T2 literature.

Craniocervical Junction (C0–C2)

There were 20 articles[6,7,9,10,12–14,17,18,20,21,23,25,27,28,30-32,37,38] with information about C0–C2 region, including a total of 173 patients. Among these, 12 articles[7,9,12,14,18,20,23,25,30,31,37,38] were focused exclusively on the occipitocervical region, whereas the remaining 8[6,10,13,17,21,27,28,32] included patients with subaxial and cervicothoracic involvement.

Refractory pain as a result of mechanical instability was the commonest indication to intervene surgically,[7,18,37] with radiation recommended for absence of instability.[12] In the articles that yielded relevant data to address the primary questions in our study, there were 134 patients of which 99 underwent surgical treatment; the choice of surgical approach in this group was: anterior, 16/99 (16.1%); posterior, 74/99 (74.7%); and combined anterior-posterior, 9/99 (9.1%). Two series[30,31] reported the results of cement augmentation of the axis (vertebroplasty/kyphoplasty) in 15 patients. Based on this review of the literature, it is apparent that pain was the most important determinant for surgery at C–C2 and that posterior stabilization techniques comprised the principle mode of treatment.

Illustrative Case of a Metastasis Involving the Craniocervical Junction (C0–C2). Case 1 illustrates a patient presenting with severe suboccipital pain secondary to a metastatic lesion involving the right lateral mass of C1 with C1/C2 subluxation (Figure 1). Treatment consisted of posterior occipitocervical instrumentation and resulted in significant pain relief.

Subaxial Cervical Spine (C3–C6)

A total of 13 articles[5,6,8,10,13,17,21,22,26–28,32,35] were identified with information on 218 patients with C3–C6 involvement by metastatic disease. Although no articles focused exclusively on the C3–C6 region, all but 2 articles[6,13] in this group had a preponderance of patients with subaxial spine (C3–C6) involvement. Although there were no sufficient data to extract information about what surgical approach was specifically used for the C3–C6 region, the overall incidence of anterior procedures, posterior procedures, and anteroposterior procedures within these 13 articles (describing results of 326 patients treated surgically) was approximately 66%, 22%, and 12% respectively. Although there was no suggestion in this group of articles that the anatomic location of the lesion influenced the decision for or against surgical intervention, the authors of 4 studies[5,8,10,21] expressed a preference for treating subaxial spine lesions using the anterior approach. Based on a qualitative systematic review of the relevant literature, one can conclude that (*a*) the subaxial cervical spine is the predominant cervical region involved by metastatic disease; (*b*) the most common approach used to treated cervical metastases in this region involved an anterior corpectomy with subsequent reconstruction; and (*c*) combined anterior-posterior surgical approaches should be strongly considered in the setting of multilevel (>1 vertebral body involvement) or with circumferential disease.

Case Illustrations—Subaxial Cervical Spine. Cases 2 and 3 illustrate the principles involved in treated metastatic lesions of the subaxial cervical spine (Figures 2, 3).

In case 2, the sagittal Figure 2 (A) and axial Figure 3 (B) MRI images show a compression fracture of C3 due to metastatic disease with retropulsion of bone into the spinal canal. A sagittal CT reconstruction Figure 3 (C) showing osteolysis of C3. Because the pathology predominantly involved the anterior column, this lesion was treated with an anterior tumor resection and instrumented reconstruction with excellent relief of pain and neurologic symptoms. The C6 lesion was treated nonoperatively.

Table 1. Evidentiary Table for Literature Related to C0–C2 (Occipitocervical) Region

Authors	Level of Evidence	Total No. Patients	C0–C2	C3–C6	C7–T2	Rx Surgery	Ant. Approach	Post. Approach	Ant + Post Approach	Vertebro-Kyphoplasty	Question 1*	Question 2†
Laohacharoensombat and Suphachatwong[23]	III	3	3	0	0	3	0	3	0	0	N	Y (Upper c-spine = POST)
Sjostrom *et al*[25]	III	4	4	0	0	4	4	0	0	0	N	Y (Ant approach for C2 lesions)
Atanasiu *et al*[21]	III	20	6	10	4	19	9	11	0	0	N	Y (C0–C2 = POST; C3–C7 = ANT)
Jonsson *et al*[17]	III	51	12	39		51	37	9	6	0	N	Y
Hertlein *et al*[18]	III	4	4	0	0	4	0	4	0	0	Y	Y (Post approach for C2 lesions)
Pospiech *et al*[27]	III	41	6	37	6	41	23	3	15	0	N	Y (Transoral approach for C2 lesions)
Seifert *et al*[28]	III	24/25	3	18	3	19	24	0	0	0	N	N
Nakamura *et al*[20]	III	13	13	0	0	11	0	10	1	0	N	Y (Upper c-spine = posterior)
Vieweg *et al*[13]	III	6	4	2	0	6	2	3	1	0	N	N
Zimmermann *et al*[14]	III	17/20	17	0	0	17	0	17	0	0	N	Y (upper cervical = posterior)
Bilsky *et al*[12]	III	33	33	0	0	13	0	13	0	0	Y	Y (upper cervical = posterior)
Kato *et al*[7]	III	11	8	0	0	8	0	8	0	0	Y	Y (upper cervical = posterior)
Heidecke *et al*[10]	III	62	1	59	2	62	62	0	0	0	N	Y (mid-cervical = anterior)
Fourney *et al*[37]	III	19	19	0	0	19	0	19	0	0	Y	Posterior for C0–C2, anterior only considered if neural compression present.
Colak *et al*[9]	III	8	8	0	0	8	0	0	8		N	Y (ant+post or post)
Huch *et al*[6]	III	14	3	3	8	14	0	14	0	0	N	N
Mont'Alverne *et al*[30]	III	12	12	0	0	0	0	0	0	12	N	Y (vertebroplasty only for C2 lesions)
Oda *et al*[32]	III	32	4	13	15	32	0	25	7	0	N	Y (posterior approach for occipitocervical lesions)
George *et al*[38]	III	10	10	0	0	10	10	0	0	0	N	N
Monterumici *et al*[31]	III	3	3	0	0	2	2	0	0	3	N	Y (transoral kyphoplasty for C2 lesions)

*Question 1: Is the decision to operate influenced by the anatomical region of the cervical spine? (Y = Yes; N = No).
†Question 2: Is the operative technique (approach) influenced by the anatomical region of the cervical spine? (Y = Yes; N = No).

Case 3 (Figure 3) illustrates a lesion involving C5–C6, which was treated with a combined anterior/posterior decompression due to the presence of significant anterior collapse and a kyphotic deformity.

Cervicothoracic Junction (C7–T2)

There were a total of 18 articles[5,6,8,10,11,15,21,22,26–28,32–36,39,47] identified with data pertaining to the C7–T2 region, reporting on a total of 234 patients. Of these 15 articles, 6[11,15,33,34,36,47] focused exclusively on the cervicothoracic junction, 9 articles[5,6,8,10,21,27,28,32,35] had patients with involvement of different anatomic locations within the cervical spine, and 1[39] was a review article. The 6 "pure cervicothoracic junction" articles had a total of 172 patients. In this group, the most preferred approach was posterior (122 patients, 70.9%), followed by anterior (44 patients, 25.5%), and formal combined anterior-posterior procedures were performed in 6 patients (3.5%). It must be remembered that several patients (up to 42%–89% of some series) who underwent posterior approaches also had anterior column reconstruction *via* the posterolateral approach,[34,36] and these were considered "posterior" procedures for the purpose of this study. Neurologic involvement (as opposed to mechanical instability) was the more common reason for surgical intervention in the C7–T2 literature.[36] Based on a review of the literature pertinent to the cervicothoracic junction, one can conclude that posterior approaches with a posterolateral approach to the vertebral body represent the mainstay of treatment for spinal metastases in this region. However, anterior approaches are a viable option particular with C7 or T1 lesions predominantly involving the vertebral body, as these can be generally approached though an extensile cervical approach without a manubrial split.

Case Illustration—Cervicothoracic Junction Metastasis. Case 4 illustrates the complex decision-making frequently in-

Table 2. Evidentiary Table for Literature Related to C3–C6 (Subaxial Cervical Spine) Region

Authors	Level of Evidence	Total No. Patients	C0–C2	C3–C6	C7–T2	Rx Surgery	Ant. Approach	Post. Approach	Ant+Post Approach	Vertebro/ Kyphoplasty	Question 1*	Question 2†
Atanasiu *et al*[21]	III	20	6	10	4	19	9	11	0	0	N	Y (C0–C2 = Post; C3–C7 = Ant)
Marchesi *et al*[22]	III	17/19	6	7	6	19	7	8	4	0	N	Y (mid/low - Ant; OC - Post
Jonsson *et al*[17]	III	51	12	39	0	51	37	9	6	0	N	Y
Pospiech *et al*[27]	IV	41	6	37	6	41	23	3	15	0	N	Y (transoral approach for C2 lesions)
Seifert *et al*[28]	III	24/25	3	18	3	19	24	0	0	0	N	N
Matsui *et al*[26]	III	10	0	8	2	10	10	0	0	0	N	N
Caspar *et al*[5]	III	20/30	0	15	5	20	19	0	1	0	N	Y (midcervical = anterior)
Miller *et al*[8]	III	27/29	0	17	10	27	20	0	7	0	N	Y (midcervical = anterior)
Vieweg *et al*[13]	III	6	4	2	0	6	2	3	1	0	N	N
Heidecke *et al*[10]	III	62	1	59	2	62	62	0	0	0	N	Y (midcervical = anterior)
Huch *et al*[11]	III	14	3	3	8	14	0	14	0	0	N	N
Liu *et al*[35]	III	6	0	5	1	6	4	0	2	0	N	Y (CT junction pathology requires AP approach)
Oda *et al*[32]	III	32	4	13	15	32	0	25	7	0	N	Y (posterior approach for occipitocervical lesions)

*Question 1: Is the decision to operate influenced by the anatomical region of the cervical spine? (Y = Yes; N = No).
†Question 2: Is the operative technique (approach) influenced by the anatomical region of the cervical spine? (Y = Yes; N = No).

volved in treating metastatic lesions at the cervicothoracic junction (Figure 4). The MRI (Figure 4) shows a tumor mass involving the T1 and T2 vertebral bodies, with compression fractures of T1 and T2, retropulsion of bone into the spinal canal, circumferential spinal cord compression, and associated kyphotic deformity. Due to the presence of significant ventral pathology and a cervicothoracic kyphotic deformity, a combined anterior (through an extensile longitudinal cervical approach) and posterior approach was used to treat this lesion.

Table 3. Evidentiary Table for Literature Related to C7–T2 (Cervicothoracic) Regions

Authors	Level of Evidence	No Patients	C0–C2	C3–C6	C7–T2	Rx Surgery	Ant. Approach	Post. Approach	Ant+Post Approach	Vertebro- Kyphoplasty	Question 1*	Question 2†
Atanasiu *et al*[21]	III	20	6	10	4	19	9	11	0	0	N	Y (C0–C2 = posterior; C3–C7 = anterior)
Marchesi *et al*[22]	III	17/19	6	7	6	19	7	8	4	0	N	Y (mid/low = anterior; OC = posterior)
Pospiech *et al*[27]	IV	41	6	37	6	41	23	3	15	0	N	Y (transoral approach for C2 lesions)
Seifert *et al*[28]	III	24/25	3	18	3	19	24	0	0	0	N	N
An *et al*[15]	III	9/36	0	0	9	9	4	2	3	0	N	N
Matsui *et al*[26]	III	10	0	8	2	10	10	0	0	0	N	N
Caspar *et al*[5]	III	20/30	0	15	5	20	19	0	1	0	N	Y (midcervical = anterior)
Miller *et al*[8]	III	27/29	0	17	10	27	20	0	7	0	N	Y (midcervical = anterior)
Le *et al*[34]	III	19	0	0	19	19	3	14	1	0	N	N
Heidecke *et al*[10]	III	62	1	59	2	62	62	0	0	0	N	Y (midcervical = anterior)
Mazel *et al*[11]	III	11/32	0	0	11	11	0	10	1	0	N	Y (CT junction = posterior)
Huch *et al*[47]	III	6–8	0	0	6	0	0	6	0	0	N	Y (CT junction = posterior)
Huch *et al*[6]	III	14	3	3	8	Unknown	0	14	0	0	N	N
Liu *et al*[35]	III	6	0	5	1	6	4	0	2	0	N	Y (CT junction = AP)
Oda *et al*[32]	III	32	4	13	15	32	0	25	7	0	N	Y (OC junction = posterior)
Pointillart *et al*[33]	III	37	0	0	37	37	37	0	0	0	N	Y (CT junction = Anterior)
Wang and Chou[39]	IV	0	0	0	0	0	0	0	0	0	N	Y
Placantonakis *et al*[36]	III	90	0	0	90	90	0	90	0	0	Y	

*Question 1: Is the decision to operate influenced by the anatomical region of the cervical spine? (Y = Yes; N = No).
†Question 2: Is the operative technique (approach) influenced by the anatomical region of the cervical spine? (Y = Yes; N = No).

Figure 1. Sagittal MRI (**A**) and coronal CT (**B**) showing a metastatic lesion in the right lateral mass of C1 with C1/C2 subluxation. Treatment consisted of posterior occipitocervical instrumentation (**C, D**).

■ Discussion

Although the studies reporting on the surgical treatment of cervical metastases all were limited to retrospective case series, our systematic review suggests that the anatomic region of the cervical spine does influence both the decision to intervene surgically, as well as the choice of surgical approach. This is not entirely surprising, given that the cervical spine has unique biomechanical properties in its 3 component regions: occipitocervical (C0–C1), subaxial (C3–C7), and cervicothoracic (C7–T1).

Impact of the Anatomic Region of the Cervical Spine on the Indications for Surgical Intervention in Patients With Cervical Metastases

The first question we attempted to answer was whether the anatomic location of the metastatic cervical spine lesion influenced the decision to intervene surgically. Although this question has not been specifically addressed in the literature, a review of the indications for surgery often gives an indication of how this question can be answered. Two of the main reasons for surgical intervention have traditionally been the onset of neurologic deficits, and the development of instability (as evidenced by mechanical pain, deformity, or both). Postoperative relief of mechanical pain was an almost universally mentioned achievement in patients who underwent surgery, although the amount of pain relief could not be related to the choice of surgical approach. The spacious spinal canal in the region of C0–C2 make cord compression and neurologic deficits an uncommon occurrence; however, mechanical instability and pain can be an early indicator of disease.[7] In a retrospective review of 33 patients with metastatic atlanto-axial involvement, Bilsky *et al*[12] advocated nonoperative measures (external beam radiation and/or the use of a hard collar) for patients with "normal alignment and minimal subluxation," regardless of tumor histology and radiosensitivity. Kato *et al*[7] reported the use of sublaminar Luque instrumentation in patients with upper cervical spine metastasis, and concluded that rigid stabilization for mechanical instability is a worthwhile undertaking to alleviate pain, even in late stages of the disease, provided the general condition of the patient

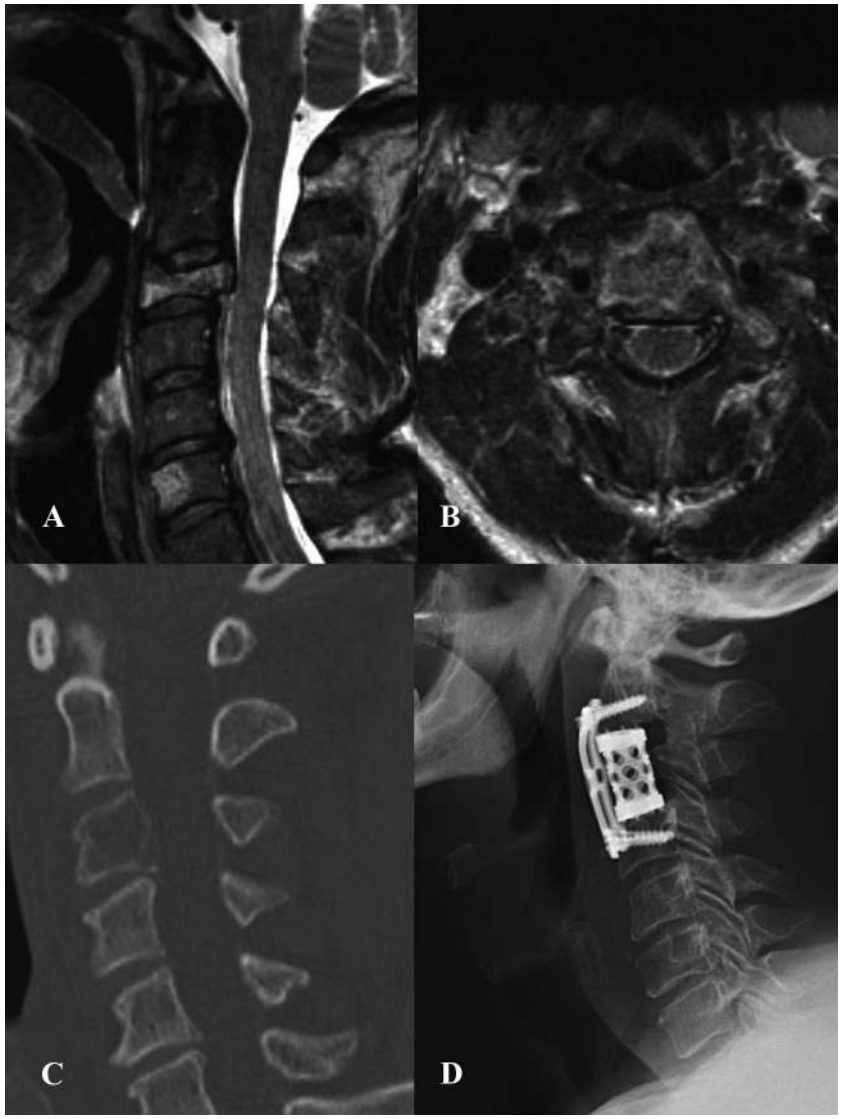

Figure 2. Subaxial spine metastatic involvement involving C3 and C6. Sagittal (**A**) and axial (**B**) MRI images show a compression fracture of C3 with retropulsion of bone into the spinal canal. Sagittal CT reconstruction (**C**) showing osteolysis of C3. Postoperative (**D**) lateral radiographs following anterior reconstruction with cage and plate from C2 to C4. The C6 lesion was treated nonoperatively.

permits surgical intervention. Fracture subluxation of >5 mm, 70% unilateral condylar destruction, or >50% bilateral destruction have been used as criteria for instability and subsequent dorsal stabilization.

In the subaxial spine, both mechanical instability as well as cord compression can influence the decision for/against surgery. The presence of mechanical instability has often been inferred from the radiologic finding of vertebral body collapse resulting in sagittal plane deformities. Some have used the phrase "acute instability" to refer to a kyphotic deformity with/without subluxation with spinal cord compression accompanied by pain and/or myelopathy, and this situation was considered to almost always involve the need for surgical stabilization.[48] Others[44] considered radiologic instability in the cervical spine to be most commonly encountered in the setting of a metastatic burst fracture with extension into a unilateral facet joint.

The unique biomechanical properties of the cervicothoracic junction come in part from a progression of cervical lordosis to thoracic kyphosis, resulting in increased stress at this level. Instability at this level with a resultant kyphosis can often compromise the spinal canal,[11] although there is no consensus on what are the clinical and/or radiologic findings that constitute instability. Placantonakis *et al*[36] reported that "instability pain" was rare in patients with burst or compression fractures, even with kyphosis, unless the fracture extended laterally into a facet joint. Unlike the occipitocervical region, where neurologic deficits secondary to metastases are uncommon, cervicothoracic involvement can result in a much higher likelihood of neurologic deficits, with some series reporting a 100% rate of myelopathy[15,34] probably due to the propensity for kyphosis and the relatively small spinal canal. The vascular supply to the lower cervical spinal cord may also make it more prone to ischemic injury, thereby possibly lowering the threshold for surgical intervention. Recent advances in posterior cervical instrumentation have made the occipitocervical as well as the cervicothoracic junction technically easier to stabilize and more biomechanically sound, making surgical stabilization a much more feasible and effective procedure that it may have been before.

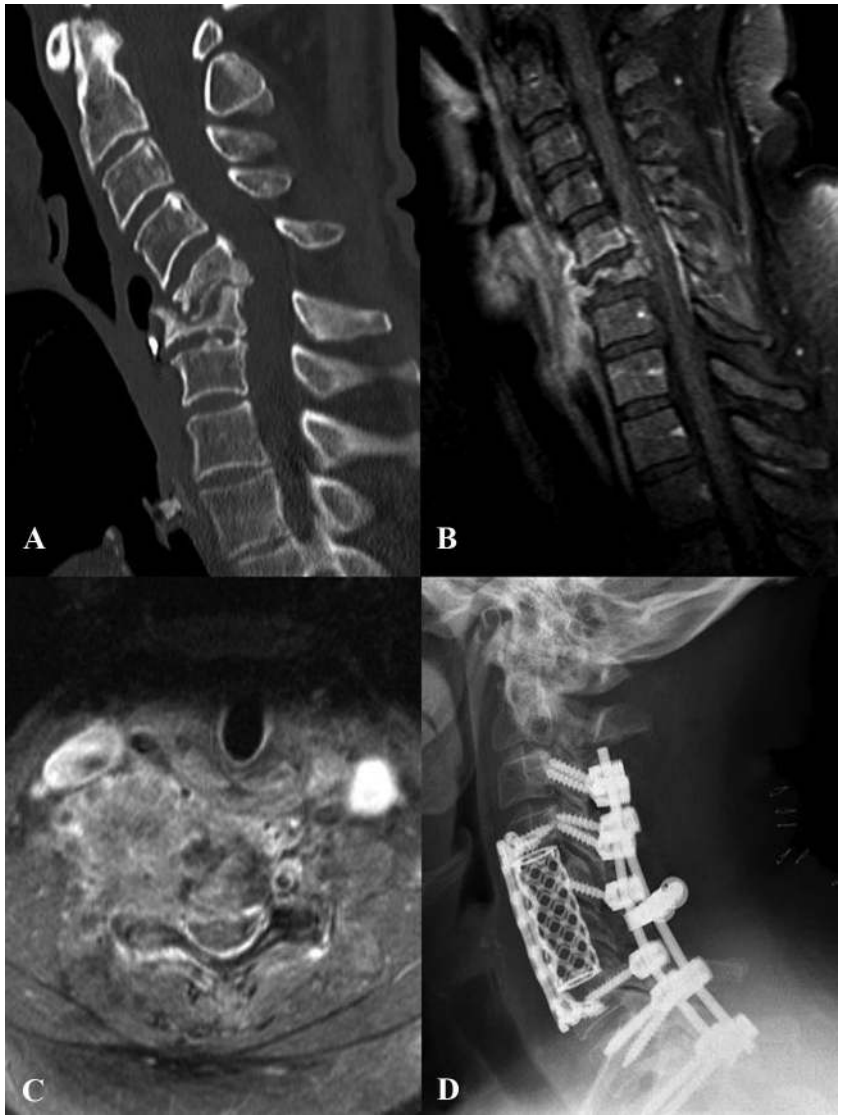

Figure 3. Metastatic involvement of C5–C6 with a resultant subaxial kyphotic deformity. Sagittal CT (**A**) shows bony collapse and deformity. Contrast MRI images (**B, C**) showing the large C5–C6 tumor encasing the right vertebral artery and epidural disease without high grade spinal cord compression. **D,** Postoperative lateral radiographs of the spine show anterior reconstruction with cage and plate from C4 to C7 and posterior instrumentation with lateral mass/pedicle screw rod system from C3 to T1.

The Impact of Anatomic Region on Decision-Making in the Surgical Approach Used for Cervical Metastases

The second question this review attempted to address was whether the surgical approach was influenced by the anatomic region of the cervical spine. Although the literature provided more information on this issue as compared to the first question, there was by no means consensus among authors on the decision-making process. For cervical metastases, involving C0–C2, the majority of reports in the literature advocate posterior decompression and stabilization with the occasional use of combined anterior/posterior approaches. Stand-alone anterior approaches are rarely advocated in this region. Our review identified 18 articles[6,7,9,10,12–14,17,18,20,21,23,25,27,28,30–32] that had information pertaining to occipitocervical (C0–C2) extradural metastatic disease. Zimmerman *et al*[14] reported pain relief in 100% of 20 patients after palliative posterior occipitocervical stabilization using precontoured loops and sublaminar wires. Anterior approaches for C0–C2 involvement are less commonly employed, although cement augmentation has been described in this setting.[30,31]

In contrast, in the subaxial region of the cervical spine (C3–C6), most cervical metastases in the literature appear to be addressed by an anterior approach, although anterior-posterior techniques do play an important role in the setting of circumferential disease. Although no studies were clearly focusing exclusively on C3–C6 involvement, there were several that included a majority of C3–C6 patients in their cohorts, and in all of these, the anterior approach was the preferred approach. Heidecke *et al*[10] reported one of the largest series of metastatic subaxial lesions treated operatively in which all 62 patients were treated using the anterior approach. In another large series of 39 patients with C3–C6 involvement,[17] the authors employed the anterior approach alone in 37 patients, with combined anterior-posterior approaches being performed when there was 2 or more levels of involvement in the spine. Given the fact that most metastatic lesions tend to occur with the anterior column and that the vertebral artery makes it difficult to

Figure 4. Cervicothoracic metastatic disease. **A, B,** MRI shows a tumor mass involving the T1 and T2 vertebral bodies, with compression fractures of T1 and T2, retropulsion of bone into the spinal canal, circumferential spinal cord compression, and associated kyphotic deformity. Postoperative CT scan (**C**) and plain radiographs (**D**) rays of the cervicothoracic junction show anterior column reconstruction with cage and posterior instrumentation from C6 to T6.

access the anterior column through a posterior approach in the C3–C6 zone, it is understandable that the preferred approach to the subaxial cervical spine is anterior, with additional posterior stabilization procedures recommended if there is radiographic involvement of all 3 columns, patients who need to undergo a >2 level anterior corpectomy, as well as in the situation of a solitary metastatic lesion where a complete spondylectomy is being contemplated.[35]

At the cervicothoracic junction (C7–T2), there was a trend toward more anterior decompressive/reconstructive procedures, but the relative use of anterior-posterior procedures was also highest in this group, which may reflect the unique biomechanical properties of this anatomic region. Of the 6 articles,[6,8,15,32,33,36] which had a significant proportion of patients with C7–T2 involvement, the anterior-alone approach was favored in only 1 series,[33] with combined anterior-posterior approaches being used in 2 series,[8,15] and the posterior-alone approach was chosen in 3.[6,32,36] High failure rates (up to 35%–66%[34,49]) have been reported in the literature with anterior stand-alone reconstruction procedures performed for cervicothoracic junctional pathologies. Biomechanical studies have shown that posterior-only constructs are unable to resist abnormal motion in a model with anterior column involvement,[50] thus supporting the premise for combined anterior-posterior approach of such situations. The ability to perform a 3-column reconstruction through a posterior (posterolateral) approach is an attractive option, with the immediate benefit of avoiding a second formal anterior procedure in a population that is more likely than not to have additional comorbidities. Placantonakis *et al*[36] reported the largest series of such procedures in the cervicothoracic tumor population, and successfully used the posterolateral approach for anterior column reconstruction in 84% (37/44) of their patients, reserving a formal anterior procedure for situations such as an attempted *en bloc* resection for a primary tumor.

■ Conclusion

Although there are no level-1 or level-2 studies to guide clinical decision-making in metastatic cervical spine dis-

ease, our systematic review of the literature in combination with a modified Delphi consensus-based approach of the SOSG does allow recommendations and conclusions to be made:

1. Metastatic tumor involvement of the junctional regions of the cervical spine (Occ-C2 and C7–T1) positively influences the decision to stabilize the spine (weak recommendation, very low evidence).
2. Kyphosis and collapse involving any region of the cervical spine positively influences the decision to stabilize the spine (weak recommendation, very low evidence).
3. For C0–C2 disease, posterior approaches are favored in the majority of cases (strong recommendation, very low evidence).
4. In the subaxial cervical spine (C3–C6), anterior approaches should be done in the majority of cases. A combined anterior/posterior approach is favored for multilevel disease, circumferential tumor involvement, and poor bone quality (strong recommendation, very low evidence).
5. At the CT junction (C7–T1) anterior or posterior approach may be used for decompression. Consideration should be given to supplemental posterior stabilization in cases of circumferential involvement and multilevel disease (strong recommendation, very low evidence).

■ Key Points

On the basis of a systematic review of the literature, we conclude that:

- Metastatic tumor involvement of junctional regions of the cervical spine (Occ-C2 and C7–T1) and/or kyphosis and collapse involving any region of the cervical spine are key determinants influencing the decision to stabilize the spine (weak recommendation, very low evidence).
- Posterior techniques are favored at the occipitocervical junction, anterior techniques are generally recommended to manage lesions of the subaxial cervical spine, and either anterior or posterior approach can be used at the cervicothoracic junction.
- In the subaxial cervical spine and cervicothoracic junction, combined anterior-posterior approaches should be considered in the setting of circumferential disease and compromised bone quality.

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