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A new dorsal modular fixation device allows a modified approach in cervical and cervico-thoracic neoplastic lesions

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Abstract *Introduction.* The aim of this study was to improve the management of cervical tumor osteolysis. A new modular rod-screw implant system for the posterior instrumentation of the occipito-cervical, cervical and cervico-thoracic spine (neon occipito cervical system, Ulrich, Germany) is available since 2000. K-wire guided pedicle screws are used, CT-guided instrumentation is possible. Previous studies have demonstrated increased biomechanical stability compared to established posterior cervical systems.

Methods. The cervical and cervico-thoracic spine of 8 patients (6 males, 2 females, mean age 62 years, range 48–77 years) with osteolysis due to plasmocytoma ($n=2$), bronchial ($n=2$), mammary ($n=2$), esophageal ($n=1$) and pancreatic ($n=1$) carci-

noma were instrumentated since June 2001.

Results. A stable fixation without loosening or failure of the fixation system was achieved in all cases. No impairment of the neurological status was observed.

Conclusion. Posterior instrumentation of the cervical spine including the occipito-cervical and the cervico-thoracic region with a new modular angle-stable rod-screw implant system offers good stabilization and allows simultaneous decompression. Since tumor masses are predominantly located in the anterior portion of the spine blood loss can be reduced.

Keywords Dorsal instrumentation · Cervical spine · Osteolysis · Tumor · Malignant

Introduction

Primary bone tumors are rare, they represent only 0.4% of all tumors and 4.2% of the bone tumors are located in the spine above the sacrum. The benign form is frequently seen in the first two decades of life, whereas malignant bone tumors are often seen in the elderly [1].

Patients with cancer develop spinal metastasis in 5% of all cases, but only 8–20% of those have metastases in the cervical spine. In the cervical spine, metastasis from the breast, lungs, prostate gland, and myeloma are most prevalent. Breast cancer accounts for over 50% of all metastatic tumors lesions in the female spine. [14].

At diagnosis the average age of patients with cervical spine metastases is about 60 years with no gender pre-

dominance and 5–10% of the patients suffer from neurologic dysfunction [14].

Important factors for decision-making in surgical treatment for neoplastic lesions of the spine are age, general medical condition and overall life expectancy, degree of instability and presence of neurologic compromise, location, type, and radio-sensitivity, chemo-sensitivity and anti-hormone-sensitivity of the tumor. Accordingly, the treatment of osteolytic lesions of the cervical spine aims for prophylaxis or reduction of neurologic deficiencies and biomechanical instability and improvement of quality of life including pain relief [6, 33].

The current strategy for surgery of cervical spine metastases includes anterior decompression, restoration of the anterior column with a cage, PMMA or bone blocks combined with anterior plate instrumentation. For tumors of

the thoracic and lumbar spine, posterior instrumentation and decompression can be considered as the gold standard. For patients with a life expectancy of less than 1 year restoration of the anterior column, usually associated with high surgical risks, can be avoided by using the constrained type screw-rod connecting system for posterior instrumentation. Compared to the anterior approach, this procedure has the advantage of a lower risk of bleeding, especially in highly vascularized metastases as in hypernephroma. In addition, it is technically less demanding, especially in cases with tumor in-growth in the vertebral artery or the esophagus. The first angle stable internal fixators for the cervical spine have been described by Abumi et al. [2] and Olerud et al. [22]. However, in August 2000 a new modular angle-stable rod-screw implant system for the posterior instrumentation of the occipito-cervical, cervical and cervico-thoracic spine (neon occipito cervical system, Ulrich Medizintechnik, Germany) has been introduced. Compared to established posterior cervical systems it has the advantage of increased biomechanical stability [27, 28]. The pedicle screws are fixed to the rod by a connector. To diminish the offset of screws, rod spacers of two different heights can be interposed between screw and connector. Due to the stability of the system, posterior instrumentation is possible with a minimized risk of loss of correction and without the need for an anterior column support. Since our algorithm for the treatment of tumor osteolysis in the thoracic and lumbar spine was based on an internal fixator system [16, 17, 18], a similar approach for cervical osteolysis was challenging. In this study we present our first experience with posterior instrumentation and decompression using the new rod-screw implant system for cervical osteolysis.

Materials and methods

Patient population

Between June 2001 and February 2003 we have treated 8 patients with osteolytic metastasis of the cervical or cervico-thoracic spine (Figs. 1, 2 and 3). Details are given in Table 1.

Imaging

Preoperatively, imaging studies by radiography, computer tomography (CT-scan) and magnetic resonance imaging (MRI) were obtained for all patients of this study. The CT-scans were especially used to screen the cervical spine for anatomic variations of the vertebral artery. The follow-up included radiography and CT-scans.

Internal occipito-cervico-thoracic fixator system

To achieve a good stabilization of the lytic cervical segment(s) we used a new modular angle-stable rod-screw implant system (titanium alloy) for the posterior instrumentation of the occipito-cervical, cervical and cervico-thoracic spine (Fig. 1, neon occipito cervical system, Ulrich Medizintechnik, Germany) [27, 28]. This consists of 4.5 mm rods, closed connectors with 4 different lengths and 4.0 mm cannulated self-tapping and self-drilling screws for C1/2 transarticular instrumentation (lengths 38–50 mm), 4.0 mm cannulated self-tapping screws for transpedicular, massa lateralis and transarticular instrumentation from C2 to C7, and self-tapping cannulated 5.0 mm screws for the upper thoracic spine. For occipital instrumentation cortical screws (3.5 mm diameter, lengths 8–16 mm) or toggles are used to anchor a closed occiput plate or two single occiput rods. The toggles are threads with a T-shaped end inserted into a rectangular punched hole of the skull, rotated by 90° and locked in this position by a toothed disc and a hex nut. Due to improved fixation strength compared to screws, toggles are used if the thickness of the occipital bone is below 6 mm. For C1-fixation an atlas claw is available. The heads of the screws are spherical with an angulation of 45° between screw-axis and the connector

Fig. 1 Components of the neon system (Ulrich, Germany): **a)** Self-drilling and self-tapping screws, connector, different spacers, rod, easy fit and hex nut for the cervical instrumentation. **b)** Transarticular (C1/2) screws and atlas claws and additional components for the instrumentation C1/2

Fig. 2 66-year old male with multilocular plasmacytoma. **a)** Radiograph (lateral view) of the upper cervical spine with osteolysis of C2. **b)** Axial view of a CT-scan of C1/2 showing the osteolysis in the dens (*left*) and in the vertebral body of the axis (*right*). **c)** Lateral (*left*) and ap (*right*) radiograph of the cervical spine 7 months postoperatively showing the dorsal instrumentation of C1–3 (atlas claw C1, transarticular screws C1/2, massa lateralis screws C3)

fixation area. This angulation itself preserves variable screw-rod stability without toothing the ball's surface, and avoids tooth-related angular steps. A cross-linking device is also available to improve rotational stability especially in long instrumentations.

Due to the significantly improved biomechanical stability and the reposition possibilities we prefer pedicle screws over lateral mass screws in the subaxial spine. For C1/2 instrumentation [25] we use transarticular screws in the Magerl technique. Especially for the instrumentation with pedicle screws, but also for the transarticular screws C1/2, we recommend the use of a computer assisted surgery system (CAS system) to reduce the risk of screw malplacement [26]. The pedicles are prepared with an 2.6 mm (4.0 mm screws) or 3.5 mm (5.0 mm screws) drill under lateral fluoroscopic control with or without a CAS system. After probing the pedicle a blunt 1.5 mm k-wire is installed to direct the cannulated screw. The use of the k-wire reduces the risk of a screw breakout of the pedicle.

Since the vertebrae of C3–C6 reveal an average angle of their pedicles of about 45° pedicle, instrumentation by an open technique is only possible using a long skin incision to retract the paravertebral muscles and to expose the entrance for the screw. However, the use of the k-wire in combination with a trocar system allows the percutaneous screw implantation.

Surgical technique

Surgery was performed by one of the authors (MR). The patient's head was placed in a Mayfield cranial fixation device. If necessary, the shoulders were pulled caudally by a heavy bandage (2 kg) to secure a clear lateral visualization of the lower cervical spine. The occipito-cervical spine was exposed by a standard midline incision. The nuchal ligament was divided and the muscles stripped from their bony attachments through subperiosteal dissection with an ultrasound knife (Ultracision, Ethicon GmbH, Germany) and retracted laterally to expose the bony structures of the occiput/cervical spine. A biopsy from the tumor was taken if visible or transpedicular from the cervical vertebral body. Screw insertion was always performed prior to laminectomy or laminoplasty for posterior decompression of the spinal cord.

Fig. 3 58-year old male with bronchial carcinoma; **a)** The postoperative CT-scan with sagittal reconstruction (*left*) lateral roentgenogram (*right*) shows the nearly complete destruction of the vertebral body of C4 and the osteolysis of C5. The pedicle screws were fixed in C2/3 and C6/7. To increase rotational stability a connector was used. A dorsal decompression has been performed. **b)** Roentgenograms (lateral and anterior-posterior view) revealing a sclerotic reaction of C4/5 after radiation with 40 Gy, chemotherapy, and bisphosphonates (8 months after dorsal fusion). The multi-level instrumentation does not show failure or loosening of the screws

Postoperative management

All patients had to wear a hard collar for 2 weeks (wound healing period) and a soft collar for 2–4 weeks (supportive). Depending on the type and extent of metastasis a postoperative radiation or chemotherapy was performed. Clinical and radiological follow-up was carried out at 6 weeks, 3, 6 and 12 months.

Pain assessment

The verbal rating scale (VRS) [9] was administered before and after surgery to measure changes in pain intensity.

Table 1 Patients with cervical osteolysis

Initials	Gender	Age (years)	Diagnosis	Location	Fusion	Blood loss (ml)	Operation time (min)	ASIA (preop)	ASIA (postop)	Follow-up (months)	Hospitalization (days)	Figures
GM	Male	66	Plasmocytoma IIIa (IgG kappa)	C2	C1–3	800	130	E	E	>22	7	2a–c
JS	Male	58	M (bronchial ca right, TxNxM1)	C4/5	C2/3–C6/7	1800	300	E	E	>20	14	3a–b
JH	Male	53	M (pancreatic ca and pleural m)	C6/7	C5–D1	150	130	E ¹	E ¹	8	8	
MJ	Male	59	M (esophageal ca)	D1/2	C7–D4/5	1200	260	E	E	4	9	
JS	Female	48	M (mamma ca)	Diffuse	C2–7	1200	160	E	E	3	7	
HK	Male	77	Plasmocytoma	D1	C7–D2	1200	140	D	D	9	20	
RH	Female	70	M (mamma ca)	C7	C6–D1	300	180	E	E	>3	18	
AG	Male	65	M (bronchial ca)	C7	C6–D1 ²	450	204	E	E	3	7	
Average		62.0				888	188				11	
Standard deviation		9.4				562	63				5	

M metastasis.

Ca carcinoma.

ASIA American Spinal Injury Association Impairment Scale [29].

¹Left radiculopathy C6/7.²Computer navigated (see [25]).

ASIA

The American Spinal Injury Association Impairment Scale (ASIA) [30] was used to classify the neurological status pre-operatively and postoperatively.

Results

Operation time was 188 min (range 130–300 min), the average intraoperative blood loss in 8 patients was 888 ml (range 150–1,800 ml). We did not see a neurological deterioration (ASIA, Table 1) or a vascular (vertebral artery) complication during or after surgery.

The minimum follow-up was 3 months post-operatively. However, in the 2 patients with a follow-up of at least 20 months no infections, implant failures or loosening were observed. Local (cervical) pain due to cervical osteolysis was improved in 6 out of 8 patients according to the verbal rating scale [9], 2 out of 8 patients with mild pre-operative pain did not change their score post-operatively.

Discussion

Reports about the treatment of neoplasms of the cervical spine are very limited and authors include extensive time intervals for retrospective analysis. This implies a change of diagnostic (imaging) and surgical (implants) techniques during their study period. Constans et al. [7] reported 34 surgical cases of cervical metastasis from 2 departments between 1965 and 1980. Bohlman et al. [5] published 23 cases treated in 2 institutions between 1953 and 1970 and between 1965 and 1983. Atanasiu et al. [4] described 20 cases treated between 1974 and 1991.

So far the anterior approach is considered as standard in tumor disease of the spine between C2 and Th 1 [8, 11, 20, 23]. Atanasiu et al. [4] found that two out of three posterior instrumentations for metastatic lesions of C7 became unstable. They stated that they prefer the anterior approach since the posterior procedure is assumed to be illogical and a source of instability, because the anterior site of the tumor leaves the posterior column as the sole element of stability. Constans et al. [7] preferred the posterior approach for surgery of cervical metastasis with neurological manifestation. In only 4 of their 34 cases was a Roy-Camille plate for posterior stabilization used, but they did not describe on which levels the cervical lesion was apparent. Nicholls and Jarecky [21] did not recommend laminectomy as the sole treatment since 76% of the patients did not show a benefit from the procedure. Only 4 out of 38 patients in this study suffered from cervical metastasis (28 thoracic, 6 lumbar).

After first describing transpedicular screw fixation for traumatic lesions of the cervical spine in 1994 [2], Abumi et al. [3] reported 8 cervical tumor patients (total of 46 patients) who underwent posterior decompression and stabi-

lization with a pedicle screw fixation system (Steffee VSP screws and a newly designed cervical pedicle screw system). However, no further analysis of these patients was presented.

Encouraged by our well established tumor algorithm for the thoracic and lumbar spine [16, 17, 18], we have treated 8 patients with osteolysis of the cervical or cervico-thoracic spine by a posterior approach using a new modular angle-stable rod-screw implant system for spinal fusion, which offers a high biomechanic stability compared to other systems used for dorsal fusion of the cervical spine [27, 28].

Advantages of this approach include a relative blood and time saving procedure since the main tumor mass is regularly located in the anterior region of the spine, and a rigid fusion even for polysegmental distances. Korge and Kluger [18] found a blood loss of 1850 ml for the posterior (operation time of 212 min) and of 2550 ml for the anterior approach (251 min) to the thoracic or lumbar spine in tumor patients, representing a difference of 38% (18%). Decompression of the spinal cord by laminectomy is possible after posterior instrumentation in a one stage-procedure and often offers a tumor-free approach with a relatively low risk of spinal injuries.

The management of cervical osteolysis remains very challenging especially due to a difficult and individual decision-making process. This is mainly influenced by the life expectancy, which is dependent on several factors including supportive treatment options. One important factor is the primary tumor. The survival of lung tumors with bone metastases is on average close to 8 months, the sur-

vival of breast carcinoma with skeletal metastasis about 30 months.

Several authors have described attempts to classify the disease to facilitate the decision-making. They regularly include bone destruction, instability and neurologic compromise [10, 13, 19, 24, 31]. Since all studies are only based on a very limited number of patients with cervical osteolysis and many factors influence prognosis in every single patient, our decisions can only consider different classification systems, but have to be individual [14].

For patients with a life expectancy of more than 18 months and an osteolysis below the C2-level we still perform an additional anterior approach with corpectomy for tumor reduction and reconstruction of the anterior column with tricortical iliac crest bone graft or expandable cage, since this offers the best chance to prevent spinal cord or nerve root compression. Additionally, this manoeuvre allows a durable stabilization of the spine preventing screw loosening or instrumentation failure. In cases of high perfusion as visualized by magnetic resonance imaging with gadolinium, we consider preoperative embolization [12, 15, 29, 32].

The development of a new modular angle-stable rod-screw implant system for the posterior instrumentation of the occipito-cervical spine has offered us the extension of our established lumbar and thoracic spine algorithm to the cervical spine. Our first results are very encouraging: The posterior instrumentations did not show a loosening or a failure of the implant, blood loss and operation time were limited, mobility and local pain of the patients were improved, no neurologic impairment was observed.

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