Anterior decompression and stabilization using a microsurgical endoscopic technique for metastatic tumors of the thoracic spine

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ADVANCES in systemic therapy and diagnostic methods have significantly improved the life expectancy of patients with metastatic disease of the spine; however, controversy arises over the type of surgical procedure. Fifteen years ago laminectomy with or without radiotherapy was still considered the treatment of choice for the management of vertebral metastatic disease. In 1973 Hall and MacKay analyzed the results obtained after laminectomy in relation to tumor location. They found that more than 30% of patients with posteriorly or laterally located tumors had sustained neurological improvement compared to only 9% of those cases in which the growth was located ventrally. Gilbert and Kagan in 1977 and Young, et al. in 1980 suggested that radiotherapy alone was as effective as laminectomy combined with radiotherapy, questioning the role of surgery. Because of the shortcomings of laminectomy for anteriorly located masses in the thoracic spine, anterolateral approaches were developed that led to better outcomes. However, there is still some resistance to using transthoracic approaches, mainly because a second team of surgeons (thoracic surgeons) is needed and the risk of perioperative morbidity is higher, resulting in longer hospitalization time.

Reports of endoscopically aided approaches that have been developed to overcome problems arising from thoracotomy have been published in the past 2 years. The microsurgical endoscopic technique, based on the transthoracic approach and originally developed for removal of herniated thoracic discs, was modified so that vertebrectomy, vertebral body reconstruction, and stabilization can be performed endoscopically. We report the technical aspects, clinical implementation, and early results achieved using this technique.

KEYWORDS • spinal cord compression • spinal metastasis • vertebrectomy • spinal stabilization • endoscopic surgery • microsurgical endoscopic technique

Clinical Material and Methods

Patient Population

Between December 1992 and December 1994, 28 patients with different pathologies involving the thoracic spine were operated on using microsurgical endoscopy. Twelve patients underwent decompression, vertebral body reconstruction, and stabilization using this technique, and metastatic disease of the thoracic spine was diagnosed in four of them. Sex, age, location of the growth, diagnosis, and treatment are summarized in Table 1. All patients were in good general condition and presented with pro-
gressive neurological impairment, including loss of sensation or strength in the lower limbs and increasing back pain in all cases. Neuroradiological evaluation showed bone destruction of one or more vertebrae of the thoracic spine and cord impingement due to ventrally located tumor masses. All patients had a complete preoperative neurophysiological examination including somatosensory evoked potentials (SEPs) and magnetic evoked potentials (MEPs).

The postoperative diagnosis was consistent with the primary tumor in the first three cases; the histological examination revealed a plasmacytoma in the last case. The two women with a history of breast carcinoma had had chemotherapy and local radiotherapy after mastectomy 2 and 6 years before admission. Surgery was indicated because of progressive neurological dysfunction and untreatable pain in all cases. Written consent was given by the patients at least 24 hours before surgery.

### Technical Aspects

**Operating Room Setup, Anesthesia, and Patient Positioning.** Surgery is performed in a standard operating room with the patient receiving general anesthetic via a double-lumen endotracheal tube inserted under endoscopic guidance, so that selective lung collapse can occur during surgery. The patient is positioned in a stable lateral decubitus orientation with the enlarged tumor mass side directed upward. If stabilization is expected to occur we prefer to approach the spine from the right side because the working space between the head of the ribs and the azygos vein is increased, and the risk of harming mediastinal structures is lower than on the left side (aorta). Positions of the surgeons, scrub nurse, and anesthetist are schematically drawn in Fig. 1.

**Surgical Instruments.** Early in the development of microsurgical endoscopy the only instruments available were those used for laparoscopic surgery. Specially designed instruments have a minimum length of 30 cm and vary in width between 0.3 and 1 cm. A variety of scissors, graspers, retractors, rongeurs, curettes, and dissectors have been adapted to our requirements (Fig. 2A). The microsurgical endoscopic technique is a gasless procedure that uses a natural cavity resulting from the iatrogenic pneumothorax and unilateral ventilation. This gives the surgeon brightly illuminated access to the thoracic spine, similar to thoracotomy. Consequently, the trocar used is blunt (to protect the lung parenchyma) and open, allowing air to enter and leave the chest cavity freely. We prefer the silicon trocar because it is smooth, completely radiolucent (avoiding interference with fluoroscopy), and permits curved instruments to be introduced into the chest (Fig. 2B). Additionally, it does not excessively compress the surrounding muscles and nerves, thus reducing the possibility of intercostal neuralgia.

A variety of bipolar coagulation forceps has been designed as well, allowing the surgeon to operate microsurgically (Fig. 2C).

We use a rigid scope with a 30° angle optic (Fig. 2D). This allows the surgeon to focus the operative field the same way from varied positions, and also avoids “fencing” with other instruments, which often happens when 0° scopes are used.

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**TABLE 1**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Level of Tumor</th>
<th>Preop Status</th>
<th>Follow-Up Status (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46, F</td>
<td>breast carcinoma</td>
<td>T9–11</td>
<td>progressive paraparesis, severe back pain, hypesthesia in both lower extremities</td>
<td>independent, no motor or sensory deficits, free of pain (16)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50, F</td>
<td>breast carcinoma</td>
<td>T8–9</td>
<td>moderate paraparesis, pathological fracture of T-8, nonambulatory because of severe back pain</td>
<td>independent, completely free of pain, returned to normal activities 5 wks postsurgery (14)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>41, F</td>
<td>multiple myeloma</td>
<td>T-9</td>
<td>severe paraparesis &amp; hypesthesia, intense back pain due to pathological fracture of T-9, bedridden</td>
<td>returned to work 6 wks postsurgery, completely independent &amp; asymptomatic (9)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>57, M</td>
<td>plasmacytoma</td>
<td>T-8</td>
<td>severe back pain, no neurological deficits, marked kyphotic deformity due to destruction of T-8</td>
<td>returned to work 5 wks postsurgery, no neurological deficits (5)</td>
<td></td>
</tr>
</tbody>
</table>

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*Fig. 1.* Schematic drawing showing positioning of the patient and the distribution of equipment and personnel in the surgical theater. The surgeon (S1) and scrub nurse (N) are standing in front and looking at the monitor (M1), which is placed in back of the patient. The assistant (S2) is standing opposite the surgeon and looking at the second monitor (M2), which is placed in front of the patient. The anesthetist (A) is standing at the head of the patient.
Surgical Technique

Insertion of the Trocars. Surgery begins with the insertion of a trocar (diameter 1.0 cm) at approximately 3 to 4 cm paramedial in the seventh intercostal space. As this working channel is the only one that is inserted without visual control, we prefer to use the seventh intercostal space because we have seen cases with hepatomegaly in which the diaphragm extended to the eighth intercostal space. Immediately after insertion unilateral ventilation is started, allowing the lung to collapse and exposing the right anterolateral portion of the spine. Inspection of the thoracic cavity is performed followed by the release of pleural adhesions using bipolar cautery and sharp dissection if necessary. After identifying the individual affected segment (either by visual control or intraoperative use of the image intensifier) the table can be tilted approximately 30° toward the surgeon. This maneuver increases displacement of the mediastinal structures toward the contralateral side, thus making lung retraction unnecessary. The next trocars are positioned along the midaxillary line (Fig. 3), one above each healthy vertebra (cephalad and caudad to the lesion) and the third immediately above the tumorous process. These “working channels” have 0.7- or 1-cm diameters and are introduced under visual control, minimizing the chance of complications. After all trocars have been inserted the lights in the operating room are dimmed, increasing the quality of the endoscopic images and allowing the surgeon to focus completely on the video monitor.

Exposure and Resection of the Affected Structures. The parietal pleura is sectioned, starting at the medial aspect of the affected vertebral body and extending cranially and caudally until healthy structures have been reached, followed by discectomy of the segments above and below the tumorous process (the discs are avascularized structures and are rarely infiltrated). Because the normal anatomical landmarks have been destroyed by the tumor, this step gives the surgeon an approximate orientation regarding the distance to and position of the spinal canal and dural sac. Tumor removal begins from the periphery (interrupting the vascular supply of the neoplasm) and continues toward the center of the vertebral body. Localized bleeding can be controlled using bipolar forceps or Gelfoam, whereas bone wax or the high-speed drill is used for hemostasis of the infiltrated bone. When the posterior longitudinal ligament has been reached, the resection includes the head and approximately 2 cm of the proximal rib, most of the right pedicle (profuse bleeding can arise here from the epidural space; control can be achieved with Gelfoam) and the infiltrated part of the vertebral body. The posterior longitudinal ligament is now opened and resected so that full decompression of the dural sac and spinal cord is achieved, reducing the chances of recurrence.

Vertebral Body Reconstruction and Stabilization. Reconstruction can be performed with homologous bone or polymethylmethacrylate (PMMA). Semiliquid PMMA is injected from a 50-ml syringe through a suitable tube into the decompressed area and polymerized in situ. For stabilization we use a ventral plating device with a set of modified instruments developed for handling the plate and...
screws securely inside the chest (Fig. 4A). The table must be tilted back to the exact lateral decubitus position (this step is important for obtaining accurate fluoroscopic control of the direction and depth of the screws). It is useful to analyze the magnetic resonance (MR) images preoperatively to measure the size of the vertebral bodies and locate the aorta on the contralateral side. Bolts are implanted in the upper and posterior aspect of the upper and lower healthy vertebrae, preferably in front of the pedicles. The plate is inserted into the thoracic cavity by widening one of the working channels with a dilator used for laparoscopic cholecystectomy (Fig. 4B and C). It should be placed on top of the bolts and the nuts loosely adjusted. Compression can now be applied externally using the specially designed instruments (Fig. 5), and the construct can be locked into its final position. Additional cortical screws are placed ventrally at the upper and lower ends of the plate, increasing torsional stability. Figure 6A and B shows the resected area and the plate in position after reconstruction.

After cleaning the chest cavity with saline, two chest tubes are advanced into the thorax (one cranially for air drainage and one on the diaphragm for draining secretions) and set under water-sealed suction. The lung is reinflated under endoscopic control. The remaining wounds are closed with one or two sutures, giving a very good long-term cosmetic result (Fig. 6C and D). Postoperative care is generally uncomplicated. Patients are allowed to walk on the 1st postoperative day; pain improved dramatically; she was able to discontinue analgesic medications after the second chest drainage tube had been removed at 48 hours postoperatively. Temperature and vibration sensation improved also. The control MR images on the 4th postoperative day showed no residual tumor and a correction of the kyphosis (Fig. 7C and D). Two months after surgery SEPs and MEPs were normalized as well.

Illustrative Case

This 50-year-old woman (Table 1, Case 2) underwent a radical mastectomy (mamma carcinoma) 6 years previously. She received a complete chemotherapy cycle and had local radiation therapy. One week before admission she experienced back pain, mainly localized at the dorsolumbar area.

Examination. The patient reported severe pain in the dorsolumbar area, with dysesthesia (constriction) on the left hemithorax. Vibration and temperature sensations were impaired at the left lower extremity.

Spinal x-ray films showed the destruction of T-8 and MR imaging revealed cord compression at the same level due to tumor invasion and kyphotic deformation of the spinal canal (Fig. 7A and B). Results of SEP and MEP tests showed malignancy.

Operation. Surgery was performed on July 7, 1993; vertebrectomy of T-8 and T-9 with cord decompression, reconstruction using PMMA, and stabilization of T7–10 were performed using the technique outlined above.

Postoperative Course. The patient was able to walk 24 hours after surgery, wearing a modified Jewett brace. Two months after surgery SEPs and MEPs were normalized as well.
The patient was transferred to the oncology department on the 7th postoperative day to start chemotherapy and radiotherapy. One year after surgery she was still leading a fully independent life.

Results

Neurological Examination
All patients treated were independent, ambulatory, and free of pain at time of discharge and follow-up examinations (average 11 months). Three of the patients were discharged on the 7th and one on the 8th postoperative day to start adjuvant therapy.

Extent of Vertebrectomy and Intraoperative Blood Loss
Of the four cases treated, one vertebral body was resected in one, two in two, and three in the last case. The amount of blood loss correlated with the size of vertebrectomy and duration of operation. No uncontrollable bleeding occurred during surgery. The mean blood loss using microsurgical endoscopic technique was 1450 ml. The mean duration of surgery was 6.8 hours.

Postoperative Morbidity
All patients were extubated between 3 and 6 hours after surgery. They all complained of end-inspiratory pain while the chest drains were in place, but after removing the tubes (between the 2nd and 3rd postoperative day) all patients were free of pain. None of the patients complained of wound-related pain, and thus analgesic medications could be reduced. Wound healing was uncomplicated and there were no respiratory complications such as pneumonia or atelectasis. All patients were mobilized with assistance on the 1st postoperative day and a modified Jewett brace was used for the first 4 weeks. There were no hardware failures in this small group of patients.

Discussion
Until 1980 the surgical management of patients with metastatic disease of the thoracic spine was restricted to dorsal decompression by means of laminectomy.1,8,14,22,28,29 Because the vast majority of these tumors (85%) are epidural and ventrally located,1,6,23 decompressive laminectomy has proven to be ineffective and can even increase spinal instability when anterior vertebral elements have been previously destroyed by the tumor.20 As a result, dorsolateral approaches were used for tumor removal, ventral decompression, reconstruction, and dorsal stabilization from the same incision.5,13 However, the preparation of the paravertebral muscles is tedious and the articular
process is sacrificed, even if it is intact, demanding dorsal stabilization. Thus the exposure of the vertebral body seems to be less satisfactory than with thoracotomy, sometimes resulting in incomplete resections if the exposure is not bilateral. Anterior decompression is considered the therapy of choice for ventrally-located metastases; the best results reported in the literature were achieved using this technique. However, many surgeons are reluctant to use it because thoracotomy is more painful than posterior incisions, resulting in a higher percentage of morbidity mainly due to respiratory complications like pneumonia, pneumothorax, and atelectasis. Others argue that if dorsal stabilization is needed, alternative incisions or even a second surgical intervention may be necessary.

**Why Microsurgical Endoscopy?**

The microsurgical endoscopic technique is essentially a transthoracic approach that uses endoscopy to reduce the approach-related trauma on skin, muscles, and ribs, which is excessively high compared to the size of the operative field at the spine. Although we developed this procedure for the thoracic spine, we have used it as a gasless, retroperitoneal approach in the lumbar region as well, with good results. To simplify terminology we call the technique microsurgical endoscopy. With the combination of microsurgery and endoscopy, trauma to soft tissues is minimized without losing surgical effectiveness when compared with open procedures. Thus microsurgical endoscopy, with or without stabilization, can be used to treat those patients who otherwise would undergo thoracotomy.

**Advantages of the Microsurgical Endoscopic Technique**

The results obtained with these first 28 consecutive cases, which included discectomy, discitis, trauma, and tumor, with a mean follow up of 14.5 months, seem to indicate that microsurgical endoscopy is as effective as thoracotomy. Due to the lack of spreaders applied to the chest wall, the small size of skin incisions and muscle divulsion, our technique diminishes the postoperative pain caused by thoracotomy, thus reducing analgesic requirements and postoperative pulmonary complications as well. First reports of studies comparing outcome of patients undergoing thoracoscopic surgery with those having the equivalent operation performed by thoracotomy confirm this assumption. However, definite conclusions can only be drawn after a large clinical trial.

Classically, when thoracotomy is used for tumors located between T-3 and T-6, the scapula has to be luxated out of the operative field. With microsurgical endoscopy, trocars are placed more cephalad along the middle or anterior axillary line, thus easily reaching the upper thoracic spine and minimizing the risk of functional shoulder deficit. Microsurgical endoscopy respects all posterior structures, which are generally compromised uni- or bilaterally when dorsal or dorsolateral techniques are used. Our technique reduces the intraoperative manipulation of the compressed spinal cord and the risk of overlooking ventrally located tumor rests. The endoscope replaces the microscope, providing a brightly illuminated area; magnification is achieved by zooming the scope down to the operative field, enabling the neurosurgeon to use microsurgery for delicate dissection or tumor removal.

Early mobilization achieved because of the reduced
Microsurgical endoscopic technique

operative stress should lower the risk of postoperative thromboembolic complications as well. A short hospitalization time is certainly important for these patients, who have a mean survival time of between 8 and 12 months.\(^4\)\(^,\)\(^6\) Using the transthoracic approach, Cooper, et al., reported a mean hospitalization time of 22 days; Shaw, et al.,\(^19\) using a posterolateral approach were able to reduce this time to a mean of 12 days. Our patients were discharged between the 7th and 8th postoperative day, starting immediately with adjuvant therapy.

Disadvantages of the Microsurgical Endoscopic Technique

Patients with severe pulmonary problems may not be suitable candidates for intraoperative unilateral ventilation. Patients who have previously undergone thoracotomy on the side on which microsurgical endoscopy is proposed are not ideal candidates; in these patients scars and adherences will probably prevent the lung from collapsing. Devices that will permit surgeons to work freely on the spine under bilateral ventilation are in the experimental phase and will become available in the near future.

Stabilization can only be achieved between T-4 and T-12 because the mediastinum and the large cranial vessels along with the insertion point of the diaphragm caudally are the natural limits for endoscopic fixation. In cases in which stabilization was not needed we were able to operate between T-2 and L-1. We are now working on a combined approach that we hope will allow us to stabilize thoracolumbar lesions using microsurgical endoscopy.

Because the learning curve is very steep, a training period is obligatory for the neurosurgeon to feel comfortable and competent with the camera, the long instruments, and with operating while looking at a monitor; this should not be a major problem for those who are used to working using a microscope.

Dorsal stabilization cannot be performed using the same incisions; however, microsurgical endoscopy can be combined with any type of dorsal procedure. By doing so dorsal repositioning, reconstruction, and alignment can be controlled and corrected endoscopically at the ventral site, improving results and reducing invasiveness and operating time.

Conclusions

The main goal of surgical therapy for neoplastic disease of the dorsal spine is to return patients to their normal activities as quickly as possible, free of pain and functionally independent. Unfortunately the comparison between the different treatment modalities is complicated due to the wide variety of procedures and lack of uniformity in measuring outcome in these patients.

Early results suggest that a reduction in surgical trauma, increased pain relief due to restoration of spinal stability and alignment, quicker recovery, and a shorter convalescence period can be achieved using microsurgical endoscopy and endoscopic stabilization. We have experience using this technique for stabilization of the lumbar spine as well; however this last step is in a very early phase of development, too early to deduce any sort of conclusions as yet. This technique should not be considered as a substitute for other approaches, but as a valuable alternative in the treatment of thoracic spine disease.

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References


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