44 MINIMAL INVASIVE APPROACHES IN SPINAL TUMORS

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Developments in diagnostic imaging and systemic therapies for oncologic diseases have brought large numbers of spinal tumors to our attention. Following this process, there has been a great evolution in minimally invasive surgical techniques for the spinal surgery. By combining modern medical technology to traditional spinal approaches minimally invasive spinal approaches have been popular.[76]

Standard treatment options for spinal tumors include radiotherapy, radionuclide therapy, radiotherapy and chemotherapy together, hormonal therapy or radiotherapy after surgical approaches including decompression and stabilization.[32,35] Most of the patients with spinal metastases are debilitated and under high risk of major surgical morbidity and mortality. Limited life expectancies, high surgical complication rates and decrease in quality of life are most unacceptable.[32,93,95] Because of these reasons, minimally invasive techniques have been explored and used for the treatment of spinal tumors.

Spinal Tumors

Spinal tumors are classified as; extradural (50-55%), intradural-extramedullary (35-40%) and intramedullary (5-10%).[73,77,91] %90 of all spinal tumors are metastases.[26,86] One-third of all cancer patients develop spinal metastases including postmortem diagnosis.[16,64] 70% of these tumors are located in the thoracic spine followed by lumbar spine (20%) and cervical spine (10%). Multiple metastases have a ratio of 10-40% of all metastatic spinal tumors. Half of these metastases have their primer tumors from breast, lung and prostate cancers.[16,64,92]

Evaluation of the Patient with a Spinal Tumor

Back pain is the primary presentation of patient with vertebral column tumors. Intradural tumors mostly present with neurological deficits from spinal cord or root compromise.[73,86]

The diagnosing procedure is mostly evaluated by magnetic resonance imaging (MRI). CT is helpful for vertebral column tumors. It is a better choice for detecting vertebral bone destruction or osteopenia diagnosis and surgical planning. CT myelography should be used for patients who are unable to undergo MRI. Radioisotope bone scanning is an important and highly sensitive option for vertebral column tumors. It is helpful for demonstrating osteoblastic or osteolytic activity. This can give us information about the characteristics of the lesion such as metastases with a known malignancy or osteoid osteoma. Plain and dynamic radiographs are important for diagnosing instability and deformity.[73,86] Another method is angiography that is used for diagnosis and treatment such as determining the vascular

supply of a tumor and also embolizing it intraoperatively to reduce blood loss.[11,41,65,86]

Treatment Procedures

The main objective must be defined before planning the treatment procedures. For some patients, diagnosis may be the primary goal. This may be accomplished by CT-guided biopsy for most of the extradural tumors with a diagnostic accuracy of 71-96%.[9] But intramedullary spinal cord tumors require open surgery for safe biopsy obtaining and correct diagnosis.

Metastatic lesions must be carefully explored. Common goal is symptomatic relief and palliation. Surgery, radiotherapy or both may be considered depending on the patient's quality and expectancy of life.[4,45,56,57,73,86,98] Patient selection is important. Surgical intervention may offer the best chance of improved life quality with spinal metastases.[73,83,94] Klimo and coll.[58] analyzed the literature for neurologic function improvement after treatment for metastatic epidural cord compression. The found out that surgery has a better ratio of 85% over radiotherapy (64%) for stabilization and improvement of ambulation. Patchell and coll.[78] worked on a prospective trial and reported it in 2005. They mentioned that the patients had a life expectancy of minimal 3 months and were high functioning. After surgical treatment they found out that 84% of the cases had improved ambulatory rates. But 57% of the patients treated with radiotherapy alone had an ambulatory improvement. The median time to loss of ambulation is higher in the surgical group (122 versus 13 days).

Minimally Invasive Techniques and Approaches

A. Advantages

Primary objectives of these procedures are; a shorter operative time, reduced blood loss, shorter hospital stays, less complications and postoperative pain, reduced medication use, decreases medical resource use and faster recovery times.[24,25,51,55,73,91]

B. Diagnosis

The first report of percutaneous biopsy of the spine was in 1935 by Robertson and Ball.[80] Craig improved it in 1956 with the development of a core biopsy needle.[15] In the following years, image guidance with fluoroscopy or computed tomography (CT) has significantly increased the precision of percutaneous biopsies.[3,6,12,36,66,88,89] The rates of tissue diagnosis with these techniques are 71-100%.[10,17,36,49,59] Fine needle biopsies are good for cytology but must not be the first choice for determining tissue architecture. It is recommended to use a trocar for percutaneous biopsies. Some studies pointed out that CT guided biopsies have a less ratio of complications compared to fluoroscopy-guided biopsies .[26,72]

C. Treatment

First of all, we must plan our goal for the patient depending on the survey and clinical findings. The realistic objective must be clearly defined. For some cases, the primary target may be diagnosis.

We may use different ways and algorithms for treatment as described below.

Radiofrequency Ablation:

It's an image-guided technique for tissue ablation mostly used for osteoid osteomas. High-frequency oscillation of alternating electrical current produces thermal injury when applied to the tissue of an electrically grounded patient.[28] At temperatures of 60-100°C immediate protein coagulation, tissue death and irreversible cellular damage is performed. A cytotoxic dose of heat must be delivered to the entire lesion for tumor eradication. Different probes have been developed.[28,31] Rosenthal *et al.*[82] first reported the radiofrequency ablation applied to a spinal tumor in 1992 for osteoid osteomas. This technique requires image guidance. General anesthesia or local anesthesia with conscious sedation may be used. Lesions greater than 4cm in diameter require repositioning of the probe for full tissue coverage.[28] Pain control rates are reported as 80-95%.[13,30,37,40] The most important contraindications include close proximity to the spinal cord (<1cm) and predominantly blastic lesions.[13,37,40,97]

Interstitial Laser Photocoagulation:

It's similar to radiofrequency ablation but the main difference is that the energy is delivered by light rather than electricity. It is good for small osteoid osteomas with a clinical success of 91-100 %.[29,69,96]

Intralesional Alcohol Injection:

It's used for osteoid osteomas[2] and vertebral hemangiomas.[38,42,43] The alcohol causes lesional thrombosis and sclerosis when applied to the tumor. But it may also leave a bony defect that may produce spinal instability by vertebral collapse.[38,42,43] This technique should also be used after percutaneous drilling and curettage of the spinal osteoid osteoma.[1,2,20,22,26]

Transarterial Embolization:

It has been successfully used in the treatment of giant cell tumors, aneurysmal bone cysts and hemangiomas.[18,60,63]

Stereotactic Radiosurgery (SRS):

This method is used for most of the spinal tumors especially for the patients who cannot undergo surgical treatment. Different systems are available like the Gamma knife or the Cyber knife. These focus high doses of radiation on a neoplasm under frameless image guidance. The treatment accuracy is approximately 1 mm.[8,34] The success rates for pain relief and neurologic stabilization range from 90% to 94% and from 63% to 89%.[7,34] SRS is also used for the treatment of intradural tumors. It's typically used for nerve sheath tumors and mengiomas but has also been applied to some kinds of paragangliomas, hemangioblastomas and hemangiopericytomas.[7,8,34] In a follow-up radiologic imaging after SRS, 75% to 100% of benign intradural-extramedullar tumors have stopped growing and some of them reduced in size.[7,34] Bhatnagar and coll. reported a series of 59 benign extra cranial tumors in 2005.[8] 49 of them were spinal and treated with Cyber knife. Symptomatic improvement was seen in %78 of the cases. The choice for SRS must be preserved for those patients who cannot undergo surgical treatment for the benign intradural tumors.[34] (figure 1)

Vertebroplasty and Kyphoplasty:

These methods are percutaneous procedures for the augmentation of the painful fractured or invaded vertebral body.[16,27,39,48,54,71,74,90] Galibert and coll. published the first report for vertebroplasty in 1987.[27] The pain control results were excellent for vertebral hemangiomas. (figure 2) In 1989, Kaemmerlen and coll. reported the results for malignant diseases of the vertebral column, which were treated with percutaneous vertebroplasty.[52,54] Transpedicular approaches are used under local anesthesia. Polymethylmetacrylate (PMMA) mixed with barium sulfate for radiopacity is injected into the vertebral body.[44,88] Cement volumes are maximum 2 cm^3 for high thoracic spine, 4 cm^3 for low thoracic spine and 6 cm^3 for the lumbar spine.[5,16,88] The main difference between kyphoplasty and vertebroplasty is the insertion of an inflatable bone tamp into the vertebral body. It's then inflated and creates a cavity within the corpus of the vertebra. The cavity is filed with PMMA under low

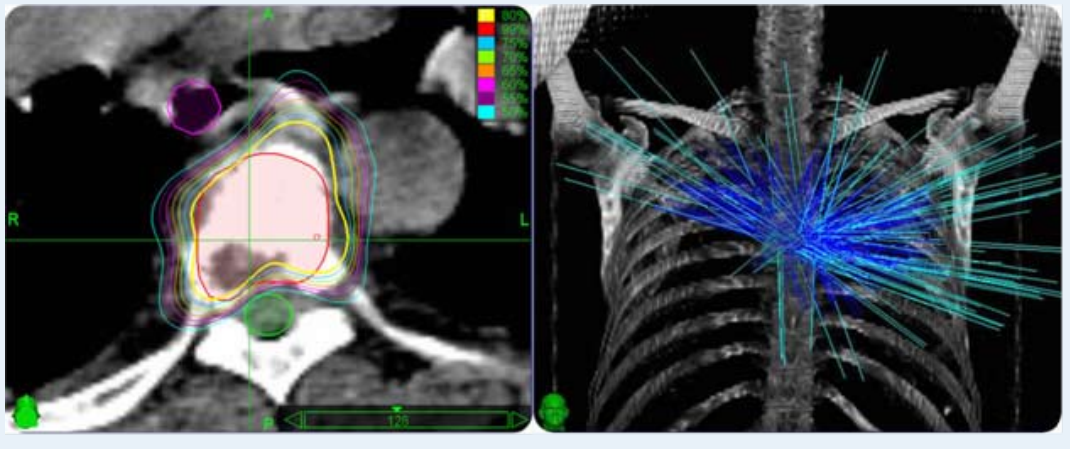

Figure 1: *Stereotactic radiosurgery. Marking and planning with CT*

pressure. The advantages are vertebral body height restoration and lower rate of cement extravasation.[16,21,62] (figure 3) The most common complication for both of the vertebral augmentation techniques is the cement extravasation. A large series of vertebroplasty and kyphoplasty cases show us that cement leakage occurred in 41% of 2283 patients in vertebroplasty and9 % of 1486 patients who were treated with kyphoplasty.[47] But in another report, the cement leakage is 28% for vertebroplasty and 23% for kyphoplasty.[39] Most of the leakages are asymptomatic.[47] Approximately 90% of patients recovered from pain. Another systematic review by Hulme and colleagues shows us that vertebroplasty and kyphoplasty are statistically equivalent in vertebral height and kyphotic angle restoration.[47] Vertebral augmentation techniques may also be paired with other minimally invasive treatment modalities. Gerszten and colleagues reported that radiosurgery could be used effectively after kyphoplasty.[33]

Figure 2: *36 year old female patient. C6 haemangioma and pathologic compression (above). Anterior percutaneus vertebroplasty. Preoperative and postoperative images (below). Postoperative 5th year.*

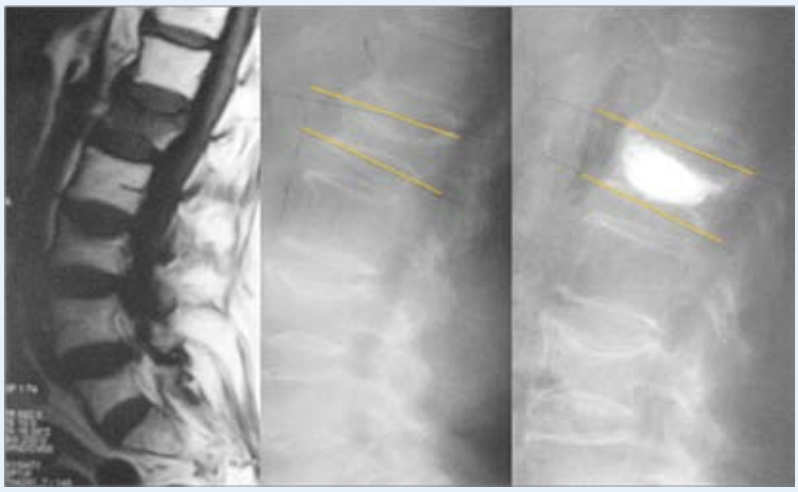

Figure 3: *70 year old female patient. Multiple myeloma, L1 pathologic fracture, images are preoperative and postoperative. Preoperative VAS is 2, postoperative 3rd month VAS is 0. Corpus height restoration is %52.4.*

Surgical Techniques:

There are different methods for surgical approaches. First one is the endoscopic surgery.

Endoscopic approaches: The endoscope can be used for all segments of the spinal column. Thoracoscopic surgery represents a major advance in minimizing approach related morbidity in the treatment of spinal tumors.[19,79,81,85] Three to four incisions are made in the chest wall for the endoscope. The visualization of the ventral thoracic spine from Th3 to Th12 is acquired for performing corpectomy and reconstruction.[51] There are many advantages for this procedure like less incisional pain, earlier ambulation, shorter hospital stays, decreased intercostal neuralgia, pulmonary complications and post thoracotomy syndrome.[9,23,73,79,81,85]

Endoscopy assisted approaches: Endoscopy assisted posterolateral thoracal corpectomy is another option for the use of the endoscope. This technique allows the transpedincular or the costotransversectomy approaches, which are less morbid than the lateral extracavitary (LEC) or thoracotomic surgeries. The angled endoscope is capable of exploring the corpectomy defect with light, magnification and direct view. These options are not available when using the classical transpedincular or costotransversectomy approaches for the ventral dural decompression.[56,67,68,73]

Minimal approaches: The modifications for the open surgery give an oppurtunity to minimize the surgical trauma. Mini – thoracotomies and mini – retroperitoneal approaches allow us to decrease the surgical injury of thoracal corpectomy. Le-Huec and colleagues described a "mini-open" retrosternal approach to the upper thoracic spine (C7-Th3) through a 6 to 8 cm anterior incision that does not require a bone resection.[61] Retroperitoneal access to the lumbar spine with a minimal access is described by Huang *et al.*[46] and Muhlbauer *et al.*[70] in different studies. Corpectomy, bone grafting and instrumentation procedures can all be achived with this technique.[26,46,61] The patient is positioned in lateral decubitis and the incision is made on the anterolateral flank. Tubular retractor systems can reduce approach related trauma and allow good visualization. This method is applied to the posterolateral transpedicular approach.[73] A 4-5 cm incision is made 6 cm lateral to the midline. Under fluoroscopic guidance, the tubular retractor is docked laterally of the transvers process. Rib head is removed. Thoracic nerves are followed back to the neural foramina. These roots are then cut. The transverse process, facets and pedicle are removed. Disc spaces can be dissected and corpectomy is performed.[73]

We use minimal approaches with the operation microscope. The advantages are; coaxial light, three dimensional viewing, a very wide range of zooming capabilities, no need for additional equipment except the microsurgical tools and a safe approach because of the comfortable haemostasing possibilities. (figure 4) We may use this approach to any level between the craniovertebral junction and sacrum. (Figure 5-13)

Minimal approaches can also be used for one to two levels of hemilaminectomy for the removal of intradural tumors. Unilateral open approaches are also used to reduce surgical trauma in intradural tumors. Jho described an anterior cervical approach. A unilateral partial corpectomy was performed in 2 patients.[50] Similarly, many authors reported cases with open posterior hemilaminectomy approaches for intradural tumors.[14,75,84,87]

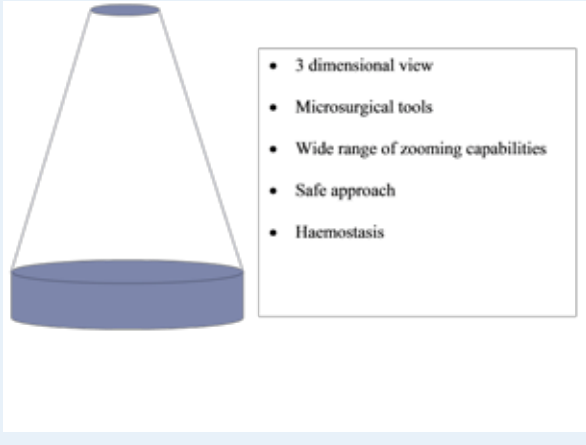

Figure 4: *"Minimal Access" microsurgical approach*

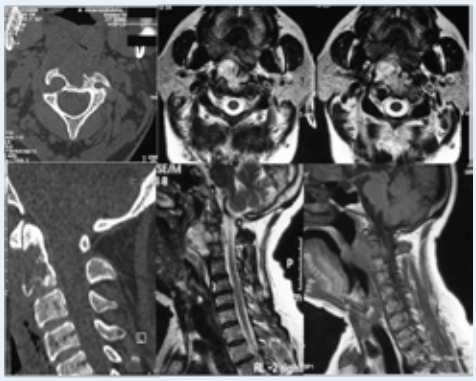

Figure 5: *56 year old female patient. C2 chordoma.*

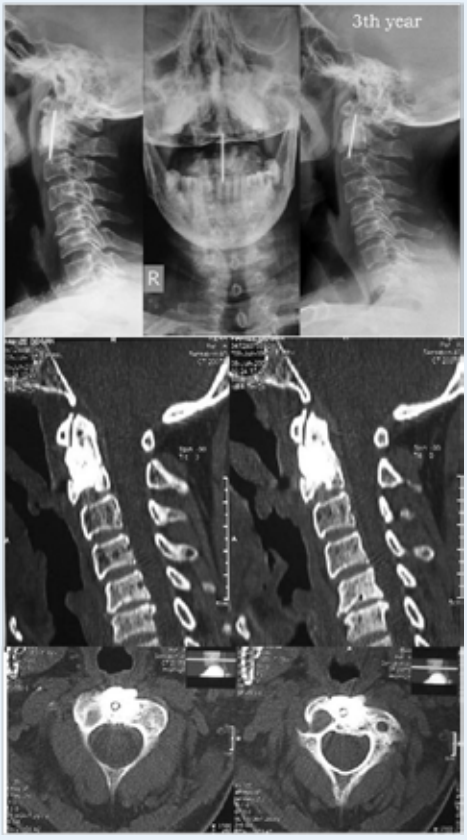

Figure 6: *Total tumor resection with anterior transoral microsurgical approach. Reconstruction with Kirshner wire and PMMA. No complaints 4 years after the operation.*

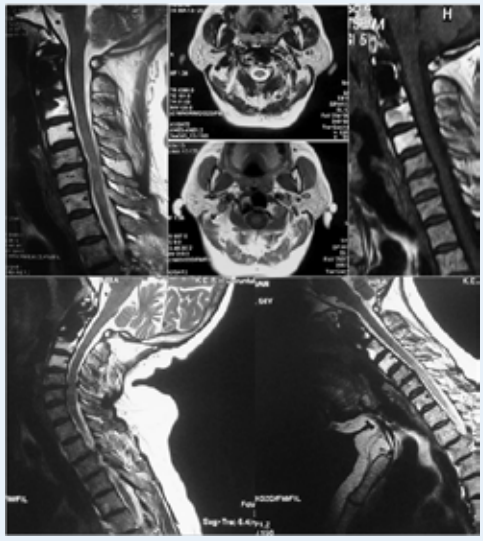

Figure 7: *Postoperative neutral and dynamic MRI (late). No instability and recurrence.*

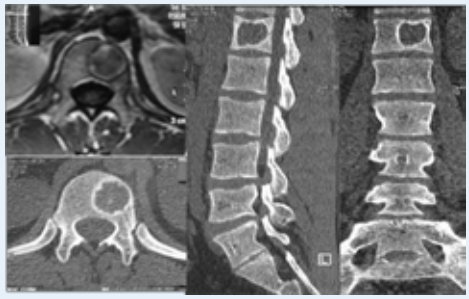

Figure 8: *28 year old male patient with back pain. Th12 benign bone tumor. CT and MRI images.*

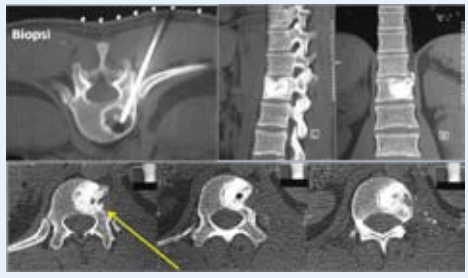

Figure 9: *CT guided biopsy (above, left). Total curettage by lateral extracaviter microsurgical approach. Reconstruction with rib and bone graft. No recurrence or complaints 4 years after the operation.*

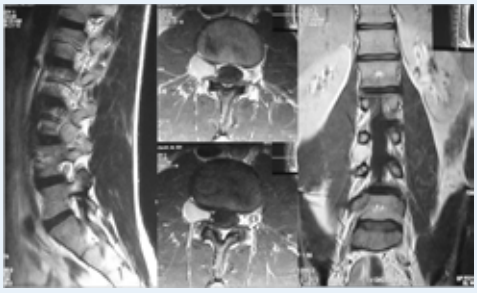

Figure 10: *25 year old male patient. A schwannoma arising from the L3 nerve root, located in the foramina. MRI images.*

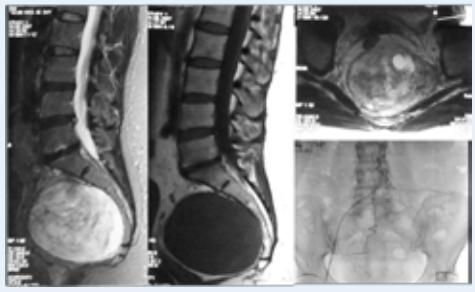

Figure 12: *54 year old female patient. A giant nerve sheath tumor located in the presacral region. MRI and DSA images.*

Figure 11: *Tumor excision with the transmuscular transforaminal microsurgical approach using the Landolt retractor. The incision is 7cm laterally located from the midline and 2,5cm in length. Preoperative, peroperative and postoperative images. No neurological deficit 5 years after surgery.*

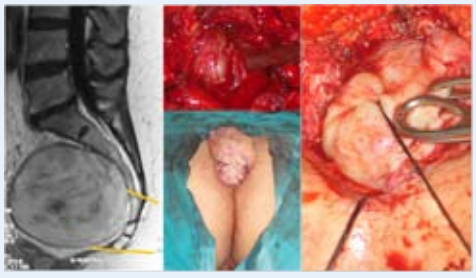

Figure 13: *Total tumor resection with trans-coccygeal presacral mini opening microsurgical posterior approach. Skin insicion is 4cm. Tumor is reached after the removal of S5 and coccyx. Tumor is excised following internal decompression.*

Outcomes

Minimally invasive surgical techniques have many advantages compared with the standart open approaches. But in conclusion, it is left to the surgeon to compare every advantage and disadvantage of the procedures and to perform the best approach that is suitable for the patient.

The characteristics of minimal invasive surgical approaches in spinal tumors:[73]

Advantages:

- Less perioperative pain
- Less blood loss
- Less hospitalization time
- Fast recovery
- Less morbidity in medically debil patients
- Decrease in CSF leakage in intradural cases and good wound recovery
- Protection of the spine biomechanics
- Postoperative instability and deformity is less

Restrictions:

- Long segment resections are not possible
- Technological restrictions for percutaneus fixation tools
- Full marginal spondylectomy is not possible

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