

## Alloplasty of Thoracic and Lumbar Vertebrae in Patients with Malignant Cancer Metastases - Results, Hazards and Deviations

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### Abstract

**Background:** The increasing number of patients with malignant cancers and their prolonged survival resulting from progress in oncology contribute to development of complications in form of metastases to bones. They are usually located in the thoracic and the lumbar spine, causing tormenting pain, limiting performance, and decreasing quality of life. Correct qualifying of patients for various treatments, based on multi-specialist and comprehensive approach is of importance.

**Methods:** In this study results of surgical treatment for metastases using vertebral body prosthetic devices in the thoracic and lumbar spine were evaluated. 72 patients were operated in total. Indications for use of prostheses and selected surgical techniques were evaluated.

**Results:** The achieved results included improvement in performance assessed in accordance with the Karnofsky scale, reduction in pain intensity according to the VAS scale, and improvement in the neurological status in accordance with the Frankel scale. Complications were scarce. One patient suffered from permanent limb paralysis after the surgery.

**Conclusions:** Surgical treatment of metastases to the spine differs from standard procedures for traumatic or degenerative lesions. Different implants must be used, bone grafts are used rarely, and stabilisations are multi-segmental. The bone fusion does not guarantee a good treatment result.

**Keywords:** Metastases, Spine tumours, surgical treatment of spine, Spine tumour resection, Spine stabilisation, Vertebral body prosthetic devices

**Abbreviations:** VAS: Visual Analogue Scale, PRBC: Prefabricated Red Blood Cells, CSF: Cerebrospinal Fluid, TH5: Five Thoracic Vertebrae

### Background

The number of patients with malignant neoplasms and their survival continuously increase. Complications, such as metastases to bones, develop, which were previously rarely observed [1]. The history of surgical treatment for cancer lesions in the spine, and metastatic lesions in particular, is long, and reaches back to 1960s. Recently, its fast development has been observed, related to progress in anaesthesiology, development and use of modern biocompliant stabilisation materials and improved diagnostic imaging techniques [1-3].

Surgical treatment focuses on two areas: oncology and orthopaedics. It allows to achieve local control over cancer

tumours, and to restore or maintain motor function, reduce pain, and improve quality of life. When qualifying for treatment, numerous aspects are considered. They include patient's general condition, cancer staging and patient's prognosis [1,4,5].

Surgical procedures on the spine with metastases involve numerous deviations from generally accepted orthopaedic principles. All known surgical approaches are used. Major surgeries are used in patients with better prognosis. Bone deficiencies are filled with implants, bone grafts are used rarely. Stabilisation is usually of multi-segment type and aims at facilitating quick rehabilitation and walking. Bone spondylodesis is not the objective or a precondition for achieving good treatment results. Following the surgery, patients should undergo auxiliary treatment in form of radiotherapy [1,6,7].

## Methods

In 2010-2014, 542 patients with spine tumours were treated at the Orthopaedic Oncology Ward in Brzozowo, of which 474 patients were operated. 72 patients had vertebral body prosthetic devices implanted in the thoracic or the lumbar spine.

Qualification for the treatment was multifaceted, each time taking account of the opinions of oncologist, neurologist, orthopedist and an anesthetist. What was also taken into consideration was the general condition of the patient, the type and the stage of cancer and the expected survival time. Commonly applied scales of Tokuhashi, Tomita and Karnofsky were used. The type of surgical approach and the method of performing a surgery were determined by the location and morphology of the metastasis as well as the patient's neurological status.

The analysis covered medical records from pre- and post-operative orthopaedic and neurological examinations, together with laboratory tests results and diagnostic imaging results.

The type and location, and pain intensity according to the VAS scale were analysed. Patients' performance according to the Karnofsky's scale was also evaluated. Patients underwent neurological examinations, including signs of nerve root irritation and deficits according to the Frankel scale.

Before the surgery, each patient underwent standard X-ray scans, computed tomography and magnetic resonance imaging of the spine. The type, location and size of pathological lesions were evaluated. The assessment focused on their relation to surrounding structures, particularly to the spinal cord and nerve roots. The quality of bone tissue, deviations in the spine axis, shape and type of fractures, displacements, and stability of spine segments were also noted.

Surgery protocols and post-surgery radiograms were analysed. The analysis also covered a method for and size of tumour resections, surgical approach and a method for bone deficit repair used, and a spine stabilisation method and size.

After the surgery, pain intensity, rehabilitation course and neurological status were evaluated. The study did not assess the impact of the surgery on the overall survival of patients with metastases to the spine due to the fact that it was impossible to select the control group. Many authors highlight the prolonged survival time in cancer patients after the spine surgery due to lower incidence of thromboembolic, infectious and cardiovascular complications.

## Results

The majority of 72 surgically treated patients were women, representing 62% of patients. The mean age was 63 years for women and 68 years for men.

The patients with metastases of diagnosed and treated malignant neoplasms represented the majority (47 cases - 65%). Undiagnosed patients, in which the spinal tumour was the first symptom of cancer, represented 25 (35%) patients. Postoperative histopathological examination confirmed metastatic character of lesions in 22 patients. The remaining 3 were diagnosed with

aneurysmal cysts in 2 cases and with eosinophilic granuloma in 1 case.

Amongst metastases, breast cancer dominated (39%), followed by myeloma (22%), prostate cancer (7%), lung cancer (11%), kidney cancer (6%), lymphoma (3%), thyroid cancer (3%), and other rare cancers (9%).

Neurogenic pain was observed in 25 (34%) patients, usually of sciatic or femoral neuralgia type. Biological night pain affected 42% of patients. The predominant symptom was pain resulting from the spine instability, affecting 62% of patients. Frequently, various types of pain coexisted. Before the surgery, pain intensity in the VAS scale ranged from 3-10, with mean intensity being 7.2.

Patients' independence and performance according to Karnofsky scale ranged from 30-10, with mean result of 50.26. The Tokuhashi scoring system facilitates patient qualification for surgical treatment considering its extent. The patients evaluated with that system scored 8-15 points, with a mean of 10.23.

The neurological examination found neurologic deficits in 20 (28%) patients. Complete lower limb paralysis was found in 2 patients (Frankel A). Sensory function only below the injury level was observed in 11 patients (Frankel B), Frankel C was recorded in 5 patients, while slight motor function impairments (Frankel D) affected 2 patients. Our material did not include patients with four-limb paralysis.

Metastases were located in the thoracic spine in 45% of the cases, and in the lumbar spine in 30% of the cases. In 25% of cases metastases involved more than one spine section.

In 71% of the cases lesions involved two or more vertebrae, while only 29% of lesions involved just one vertebra. Most common were lesions in the anterior part of the spine, found in 63% of patients. Both posterior and anterior parts were involved in 37% of patients.

89% of patients were diagnosed with pathological fractures, while in 11% of patients metastases did not result in fractures. The spine instability was evaluated in accordance with the Kostiuik's and the Taneichi scales, and diagnosed in 84% of the patients. In diagnostic imaging scans, 78% of patients were diagnosed with the spinal stenosis, and 11% of patients were diagnosed with dura mater infiltration. Intraoperatively, the dura mater infiltration was confirmed only in 2 patients.

In 6 patients, resection of the metastatic tumour was preceded by selective embolisation of the metastasis. The primary cancer involved the kidney in 4 patients, and in 2 patients it was extensive myeloma. In one of those patients, the intraoperative bleeding was so copious (1500 ml/30 min) despite previous embolisation that tumour removal was not possible.

11 surgeries in the upper thoracic spine were performed from the posterior-lateral approach with resection of rib tips on 1 or 2 levels. Each time this approach allowed tumour removal from the vertebral body and implanting of a vertebral body prosthetic device. This approach was selected for single metastases, and when the vertebra size allowed implanting of the prosthesis. The procedure always involved posterior stabilisation of the spine.

In 61 patients the procedure was performed from the anterior approach, in the thoracic spine in 27 patients and in the lumbar spine in 34 patients. Ready expandable prostheses were used, filling post-resection deficits in 1-2 vertebral bodies. Resection covered 2 or 3 vertebral bodies in 8 and 2 patients, respectively, and required use a titanium prosthesis in form of a cement-filled cylinder. Modular spine prostheses were not available; also use of custom-made prostheses was not possible.

In 18 patients posterior percutaneous spine stabilisation was performed at the same time as the vertebral body resection and prosthesis implanting. In 17 patients two approaches, posterior and anterior, were used during the procedure. First, the posterior stabilisation was performed, followed by tumour resection and implanting of the vertebral body prosthetic device 5 to 9 days later.

Directly after the surgery all patients had their neurological functions evaluated. In 42%, 2 units of PRBC were transfused during the surgery. Full blood count was monitored on the day of the surgery, and on the following morning. 60% of patients in total required transfusion of blood substitutes after the surgery. Drainage was maintained for 3 days, and prolonged when bleeding exceeded 80 ml/day. Pleural drainage was maintained for 5 days, and before its removal patients underwent a chest X-ray scan. When there were no general contraindications or deep paralysis, verticalisation of patients was performed in the 2 day from the surgery.

After surgical treatment, increase in pain intensity was observed and evaluated according to the VAS scale. The mean result in the 7 day from the surgery was 4.1. Patient performance was evaluated before they were discharged from the hospital. The mean score according to the Karnofsky scale was 60.43 (Table 1).

Of 13 patients with paresis or extensive function impairment not able to walk before the surgery, 5 were mobilised and they started to walk with crutches or with a walking frame. In total, improvement in neurological function was achieved in 11 out of 20 patients (Table 2).

No additional orthopaedic immobilisation was used in patients after surgeries. The majority of patients (80%) underwent radiotherapy of the spine, ordered 2-3 weeks after the surgery wound fully healed.

**Table 1** A comparison of the mean pain intensity score and the functioning of patients before and after the surgery.

	VAS pain score	The Karnofsky scale
Before the surgery	7,2	50,26
After the surgery	4,1	60,43

**Table 2** Preoperative and postoperative evaluation of the patients' neurological status using Frankel scale.

	Frankel A	Frankel B	Frankel C	Frankel D	Frankel E
Before the surgery	2	11	5	2	52
After the surgery	2	6	8	-	56

The most common intraoperative complication was damage to a meninx with CSF leak. All 3 cases occurred when bone fractions were removed from the spinal canal. In each case the meninx was sutured, and TachoSil was applied. No clinical symptoms of fluid leak or fistulas were observed after the surgery. No intraoperative damage was observed in the chest or the abdominal organs, as well as in the large vessels and nerves.

In 1 patient, removal of the Th5 vertebral tumour resulted in complete paralysis of lower limbs. The procedure was performed from the posterior-lateral approach. The symptoms of paralysis were diagnosed directly when patient recovered from anaesthesia. A revision surgery was performed immediately. Laminectomy was expanded and the spinal cord structure was verified. No mechanical damage to the spinal cord was found. In the MRI scans performed immediately after the surgery no anomalies or causes of the paralysis were found. The patient's condition did not improve despite treatment with steroids.

In postoperative period, 3 patients suffered temporary deterioration in their neurological condition, which was resolved following 2-3 days of a steroid therapy.

No problems with healing of surgical wounds were observed; all healed by primary healing, and sutures were removed in 14-17 days from the surgery. In patients monitored at the outpatients' clinic no damage to implants was observed. Prostheses penetrated slightly into the vertebral body above or below the lesion, in 4 and 3 cases, respectively. However, this did not result in the spine destabilisation, and patients did not suffer any deterioration in their health or increase in pain intensity. 4 cases of local recurrence were observed after the surgery and irradiation of the metastasis. However, patients did not require a repeated surgery.

In the postoperative period, 1 case of massive pulmonary embolism was observed, confirmed in a computed tomography scan with a contrast agent. The patient was treated at the Intensive Care Unit, and his condition improved quickly. 2 patients suffered from acute kidney failure, and underwent temporary dialysis. No cases of sepsis or venous thrombosis were observed after the surgery.

## Discussion

Surgical treatment of spine tumours mainly concerns patients with malignant cancer metastases. Metastases to the spine usually occur in elderly people, in their sixth or seventh decade of life [1,8].

Surgical treatment of spine tumours is rarely radical. Due to a difficult surgical access to the spine, vicinity of important structures, and usually delayed diagnosis, tumour resection maintaining appropriate margin of healthy tissues is not possible. Radical procedures usually concern accidentally diagnosed, well-defined tumours, not passing through the cortical bone. Each time when the patient's general condition allows, it is worthwhile to attempt resection of spine tumours. Pain is visibly reduced, while the motor function improves. The neurologic deficiencies often resolve. By combining surgical treatment with post-operative

radiotherapy, local control over tumour may be significantly improved, and remission prevented [1,7,9,10].

A very important problem is correct qualification of patients for surgical treatment, and selection of the best technique. A holistic approach to patients is necessary, considering their general condition, cancer type, disease staging, options for oncological treatment, possible complications, and prognoses. Various scoring systems are used to qualify patients for various treatments; however, they all are affected by imperfections. The most reasonable approach seems to be individual qualification of each patient, in cooperation with their oncologist and radiotherapist [1,11-14].

Surgical treatment of spine tumours differs from surgeries for injuries or degenerative changes in many aspects. These patients belong to a group with the highest risk of cardiovascular, thromboembolic and infectious complications [1]. Chemotherapy causes extensive disruptions in the haematopoietic and immune systems, patients are generally exhausted and emaciated, require additional feeding to reverse catabolism and facilitate healing of tissues. Repeatable irradiations in a period before the surgery contribute to infections, problems with healing of tissues, and may lead to myelopathy in the spinal cord [1]. Blood vessels are fragile, particularly difficult to tie off or coagulate. Some tumours predispose to very copious intraoperative bleeding. It is most common during resection of metastases of kidney cancer, myeloma, lymphoma or thyroid cancer. Thus, it becomes necessary to prepare a patient for the surgery by selective embolisation of tumour vessels [1,15].

Bone grafts are usually avoided in patients with cancers. This results from a risk of stimulating recurrence at the surgery site, and a high infection risk. Bone fusions in the tumour resection site can hardly be expected, due to lytic factors effects and relatively short survival of the patients. Therefore, the aim is to achieve primary efficient stabilisation effective to the end of patient's life [1]. The principle is to stabilise long sections of the spine, contrary to a procedure applied for injuries. Stabilisation should involve at least two segments above and two segments below pathology. Bone deficiencies are filled with implants - vertebral

prosthetic devices or bone cement. Vertebral body prosthetic devices should have a wide base, covering the whole base of the vertebral body; this way their migration and penetration into vertebrae is prevented. It should also be noted that in case of metastases, mechanical resistance of apparently healthy vertebrae is also significantly lower [1,16]. Extensive resections involving more than 2 vertebrae require special, customised or modular prosthetic devices, allowing restoration of spinal curvature. All types of implants used should allow magnetic resonance imaging scans. Carbon composites, with good x-ray permeability, are used increasingly often, allowing post-operative patient monitoring and early detection of remission [1,17].

Post-operative care provided to patients must include orthopaedic procedures and early rehabilitation. Usually orthoses are not used, but frequently assistance of two rehabilitation specialists, and use of standing frames, walking frames or crutches is necessary when learning to walk. Use of bisphosphonates in patients with breast or prostate cancer, or myeloma is a standard procedure. Radiotherapy is recommended in a period of 3 weeks following the procedure, when the wound is completely healed. Usually, it is a single palliative radiation of 8 Gy [1,18,19].

## Conclusions

1. Surgical treatment for metastases to the spine should become a standard treatment procedure supplemented with radiotherapy.
2. The surgical technique differs significantly from the one used normally for spine surgeries for injuries or degenerative lesions.
3. Treatment of metastases should be comprehensive and conducted in specialist centres.
4. Results of surgical treatment with a vertebral body prosthetic device are good; however, large tumours involving 2 and more vertebrae are problematic. They often require use of expensive, custom-made prostheses or modular systems.

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