

Chordomas, malignant spinal tumors: a 15-year experience

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Abstract: *Objective:* Spinal chordomas are rare, locally invasive, malignant neoplasm, representing 5% of all malignant tumors of the skeleton. In the majority of cases the segment involved is the sacrum. This study reviews our experience during the last 15 years at The Spinal Surgery Department of “Bagdasar-Arseni” Clinical Hospital, to determine the effects of various treatment methods on the overall course of this disease process. *Methods:* A retrospective study was performed, from 2000 to 2015, in which, 31 patients with spinal chordomas were evaluated at our institution. *Results:* Two thirds of patients were male, with a mean age of 57 years. Patients presented with local pain, radiculopathy and bladder-bowel dysfunction at hospital admission. There were 24 patients with sacral chordomas, 4 with cervical chordomas, 2 with thoracic and one with lumbar chordoma. All patients underwent at least one surgical procedure. The main goal of surgery was to achieve total resection of the tumor. *Conclusion:* Our study suggests that spinal chordomas are rare tumors with a high risk of tumor recurrence. If total resection is achieved, the risk of recurrence diminishes. If the tumor resection is subtotal, than recurrence appears in all cases. After tumor resection, the surgeon faces the problem of spinal instability that needs solving. Based on these findings, we think that, whenever possible, radical resection should be the treatment of choice for spinal chordomas.

Key words: chordomas, spine, tumor

Introduction

Chordomas are rare tumors, representing almost 5% of all malignant spinal tumors of the skeleton. They are regarded as slow growing tumors originated from the notochord which is implicated in the development of the axial

skeleton. The superior portion of the notochord approaches the future sphenoid bone and develops into the occipital bone and the inferior portions develops into the sacrum and the coccyx. So chordomas can be located all the way from the speno-occipital region to

the sacrococcygeal region. The main affected segment is the sacrum, followed by the spheno-occipital region and only in rare cases the mobile spine. (1)

Despite their slow growth treating spinal chordomas remains a challenge for neurosurgeons as tumor recurrence is very often. Radiation therapy has been used for the treatment of spinal chordomas in association with surgical treatment. (2, 3, 4)

Patients that present with sacrococcygeal chordomas are in the majority of cases between 50 and 70 years old, and, usually, patients with tumors located in the spheno-occipital region are one decade younger. The reason for this is probably less space for spheno-occipital chordomas before causing clinical symptoms. (5)

Metastases are mainly located in the lungs, liver and lymph nodes and occur in 3-48% of patients. (8-10)

Local recurrence is the main problem in spinal chordomas and the main adverse prognostic factor. They are often insensitive to chemotherapy and radiotherapy.

Epidemiological data

Chordomas are malignant tumors with a very aggressive local invasion. The incidence is 0.08 per 100.000 people and make up for almost 5% of all malignant primary tumors of the skeleton. (6) The main category affected by this disease is represented by people above 50 years. The presence of chordomas is very rare in people younger than 40 years. The median survival period is 6.29 years with a 10 year survival of 39.9% (7).

We included 31 patients with spinal chordomas, that were treated between 2000 and 2014 with a mean age of 57 years old. The

youngest patient treated was 6 years old and the oldest patient was 81 years old. We observed that 80% of patients were older than 50 years and also noted a male predominance, the sex ratio male / female being 2/1 . 67.7% of patients were male and 32.3% female.

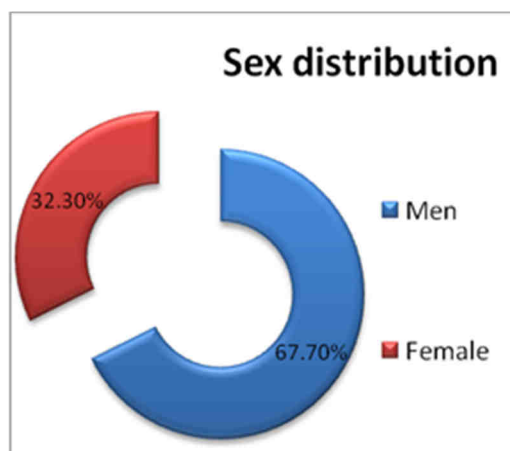


Figure 1 - Sex distribution in patients with spinal chordomas

The study did not include patients with chordomas of the spheno-occipital region, only patients with spinal chordomas being admitted. In the majority of cases, 24 patients, the tumor was located in the sacral segment of the spine. There were 7 patients with chordomas of the mobile spine, 4 in the cervical region, 2 in the thoracic region and 1 in the lumbar region of the spine. Although we observed a higher prevalence for the thoracic spine the limited number of patients did not allow us to determine the most frequent vertebral level affected in the mobile spine.

In the majority of cases with sacral chordomas, 21 cases, the tumor involved only the inferior part of the sacrum. We observed a very low percentage of tumors located at the sacro-lumbar junction.

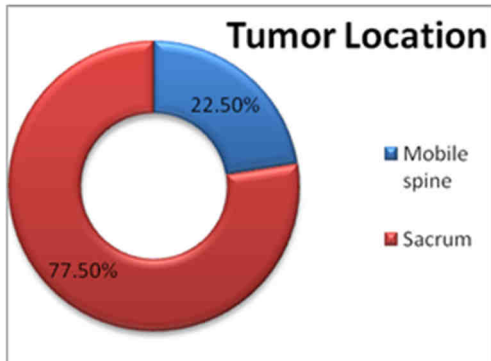


Figure 2 - Most frequent location of spinal chordomas

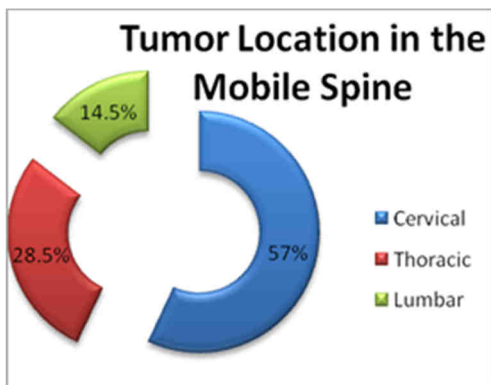


Figure 3 - Most frequent location of mobile spine chordomas

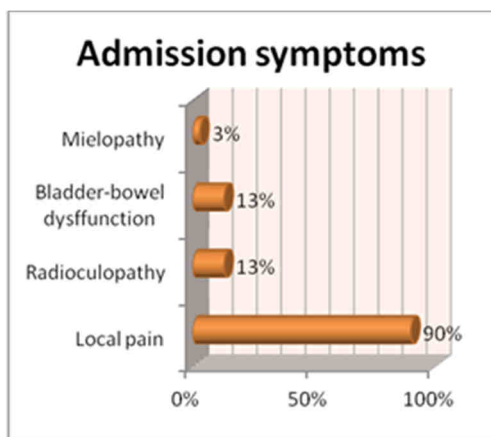


Figure 4 - Admission symptoms of patients with spinal chordomas

Patients and methods

The article represents a retrospective study that includes all patients with spinal chordomas treated in our department in the last 15 years. There were 31 patients included, 21 male and 10 female.

The majority of patients admitted presented for local pain and only in rare cases, patients presented for radiculopathy or bladder and bowel dysfunctions. Local pain was present in 28 cases, radiculopathy in 4 cases, bladder or bowel dysfunctions in 4 cases and mielopathy in only one case.

In evolution, the first symptom that occurred was local pain, which, if left untreated, lead to radiculopathy and in late stages to bladder and bowel dysfunctions. The mean duration of symptoms was 16 months, 12 months for men and 20 months for female. Symptoms presented a slow progression from initial appearance to the moment of surgery.

Clinical symptoms are not specific for these lesions and progression is slow causing late hospital presentation and late diagnosis, in advanced stages with large tumor extension.

Diagnostic procedures

The first diagnostic procedure is represented by plain x-ray demonstrating a lytic lesion or osteosclerosis in rare cases. (12, 13, 14, 15, 16, 17) The most frequent radiological finding is considered to be destruction of spine segments with soft-tissue extension. Chordomas localized in the mobile spine originate in a single vertebral body usually. The intervertebral discs are spared by tumor extension. (18, 19, 20)

Computerized tomography scanning is very important in establishing the grade of tumor extent. (12) The main tumor extension is usually anterior to the vertebral body displacing the major vessels or the ureters depending on the vertebral segment implied. CT scan is very useful for demonstrating the full extent of the tumor. (21)

Chordomas present low-intensity signal on T1- weighted MRI and high-intensity signal on T2- weighted MRI. MRI offers the best possibility of diagnosis in spinal chordomas being very valuable in preoperative assessment, accurately depicting the tumor extent. (22, 23, 24, 25, 26, 27, 28)

In our study we observed the presence of osteolytic processes in 100% of cases, being the major imagistic characteristic for spinal chordomas. We also observed the presence of soft tissue extension in 93% of cases. There were also 6% of cases that presented intratumoral calcifications. Another imagistic characteristic observed in the study was reduced uptake on bone scintigraphy.

TABLE 1
Imagistic characteristics

IMAGISTIC CHARACTERISTICS OF SPINAL CHORDOMA	
Osteolytic process	100%
Soft tissue extension	93%
Intratumoral calcifications	6%

Treatment

There are two main types of treatment for spinal chordomas, surgical treatment and radiotherapy. Surgery is the treatment of

choice, offering the best an only change of cure. (29, 30, 31)

Surgical treatment

The main goal of surgical treatment is complete tumor resection, spinal decompression (if needed), and, after tumor resection, spinal reconstruction. Any surgical procedure without complete tumor resection will lead to tumor recurrence, usually with a more aggressive behavior and with a very low chance of complete resection leading inevitable to death. (23, 32)

Complete tumor resection should be done with wide resection margins. Often, wide excision is difficult to achieve, but, the surgeon should have in mind that complete tumor resection is the only hope of total cure. In order to achieve complete resection careful preoperative case assessment is imperative. (23, 32, 33, 34, 24, 35)

Surgical treatment was applied in all cases the main goal being complete tumor resection and spinal decompression without neurologic impairment for the patient. We managed to achieve complete macroscopic tumor resection in 77% percent of cases and incomplete tumor resection in 33% of cases. None of the patients included in the study underwent spinal biopsies.

The main factor that influenced tumor resection was the vertebral level implied. Out of the 24 patients with sacral chordoma, complete tumor resection was achieved in 21 cases. There were 4 patients with cervical chordoma, 2 with complete tumor resection and 2 with incomplete resection, 2 patients with thoracic chordoma, both with incomplete tumor resection and one patient with lumbar

chordoma with incomplete tumor resection. The type of resection was evaluated macroscopic and under magnification.

TABLE 2

Resection type depending on tumor location

REGION	COMPLETE RESECTION	INCOMPLETE RESECTION
CERVICAL	2	2
THORACIC	0	2
LUMBAR	0	1
SACRAL	21	3

A thorough preoperative evaluation of each case is needed, each case being particular. We used a multidisciplinary team approach in 8 cases associating a thoraco-abdominal surgeon and sometimes even a plastic surgeon.

Only 5 cases out of the 31 patients required spinal reconstruction using autologous bone grafts, screws, rods, and intervertebral implants. The reduced number of cases with spinal reconstruction is justified by the large number of tumors located in the inferior part of the sacrum where there is no need for spinal reconstruction. In all of the cases with spinal reconstruction the tumor was located in the mobile spine, 4 in the cervical spine and one in the thoracic spine. Complete tumor resection was achieved in 2 out of this 5 cases.

Surgical treatment in sacral chordoma

The sacrum represents the main location for sacral chordomas. 77% of patients (24 cases) presented sacral chordomas. Surgical treatment was applied in all cases. In 21 cases we have chosen a posterior approach and, in 3 cases, a combined approach. We managed to achieve complete tumor resection in 21 cases

and incomplete resection in 3 cases. In these 3 cases patients presented in a very late stage of tumor evolution with large tissue invasion. In these cases the tumor presented anterior extension surpassing the retrorectal fat tissue invading the rectum. A mixed operatory team was necessary and a combined approach, anterior and posterior was used. All 3 cases required rectal excision and colostomy. Despite extensive surgical interventions, complete tumor resection was not possible.

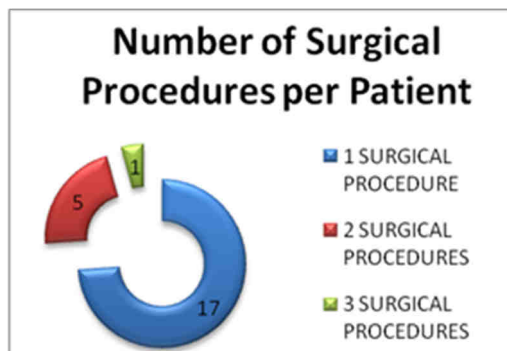


Figure 5 - Number of surgical procedures per patient with sacral chordoma

In 17 cases with sacral chordoma, only one surgical procedure was needed. It should be noted that the best chance of achieving complete tumor resection is in the first surgical procedure. Reintervention for tumor recurrence has a higher degree of difficulty and the chances of complete resection are slim. 5 patients required 2 surgical procedures and one patient required three surgical procedures.

As we reminded earlier, complete tumor resection is the main objective in treating chordomas. We observed that the tumor recurrence rate in patients with incomplete tumor resection was 100%, and only 14% in

patients with complete macroscopic tumor resection. The disease free interval was also very different between the 2 groups, 27 months in patients with complete resection opposed to only 8 months in patients with incomplete tumor resection. Although we classified it as complete tumor resection after macroscopic and magnification evaluation, 14% of patients presented tumor recurrence.

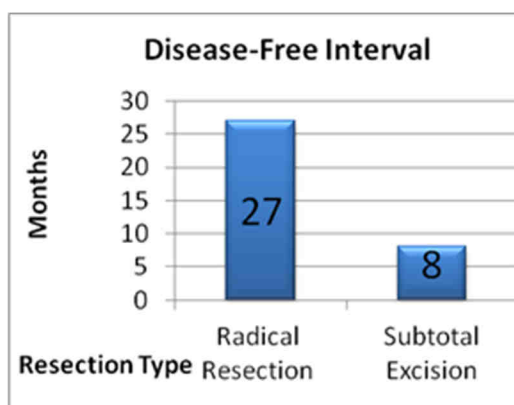


Figure 6 - Disease free interval in patients with sacral chordoma

Another challenge for the surgeon is the embedding of sacral nerve roots in the tumor mass. In the majority of cases the sacral nerves were embedded in the tumor or very adherent to the tumor mass. In 87% of cases at least one sacral nerve had to be sacrificed. From 24 patients with sacral chordoma, 4 patients presented tumors with large extend, involving bilateral sacral nerves. All 4 patients presented with bladder and bowel dysfunction from admission. Aggressive tumor resection required sacral nerve sacrifice because dissection and decompression were not possible. The tumor embedded the sacral nerves from S1 to S5. Patients remained with

permanent urinary catheter after surgical procedure.

In 17 cases the sacrifice was limited to 1 or two nerves, unilateral and below S2 sacral nerve. We observed that preserving at least one S2 sacral nerve preserved the patient bladder function.

As a general rule, if sacral nerve resection is needed in order to achieve total tumor resection, sacral nerves can be sacrificed safely, unilateral or bilateral, by preserving S1 and S2 sacral nerve roots. In cases with tumors that involved S1 and S2 nerves, preserving these nerves was impossible in order to achieve large tumor resection.

Postoperative complications were mainly represented by bladder and bowel dysfunctions. Although it was included in the preoperative planning and not considered a complication, it should be noted that rectal resection and permanent colostomy was needed in 3 cases.

29% of patient presented bowel dysfunction after the surgical procedure which varies from minor emptying difficulties to incontinence. We observed that preserving S2 and S3 sacral nerve roots preserves bowel function and, sacrificing S3 nerve roots causes a large array of bowel dysfunctions.

50% of patients presented bladder dysfunction after surgical procedure, 33% without the need for a urinary catheter and 17% requiring permanent urinary catheter. Patients with intact S2 sacral nerves presented minor or no bladder dysfunctions.

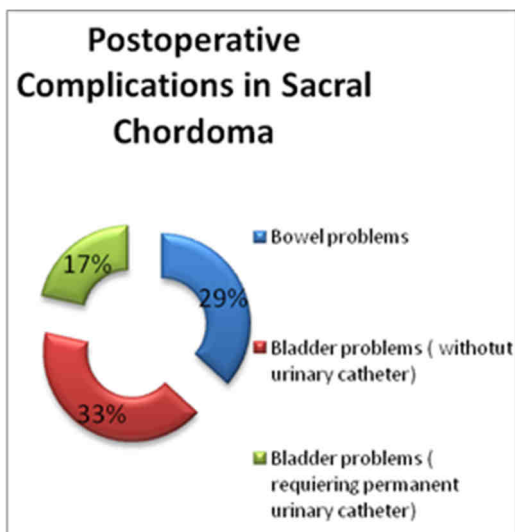


Figure 7 - Postoperative complications in patients with sacral chordoma

We could not establish a standard approach for the treatment of spinal chordomas. Each case requires preoperative planning and cautious evaluation in order to achieve the maximal resection possible. The approach was influenced by tumor location, tumor size and adjacent tissue extension. Tumors that involve the S1 segment of the sacrum with downwards extension required complete sacrectomy, raising the problem of sacro-pelvic reconstruction.

The indications for sacral reconstruction were: sacral resection above S2 vertebra, total sacral resection in which the whole sacroiliac joint is removed or partial sacral resection involving more than 50% of sacroiliac joint on each side.

The surgical procedure is very complex, requiring the participation of specialists from several areas including neurosurgery, general surgery and plastic surgery.

A variety of instrumentations has been used previously for reconstruction after total sacrectomy. From a biomechanical standpoint these devices progress in their level of sophistication as follows: the use of sacral bars spanning the ilia and connected to the spine with Harrington rods and hooks (8), the use of the more advanced Cotrel–Dubousset rods and hooks with the sacral bars (or AO plates) (37, 38), the use of transpedicular screws (and an internal spinal fixator) with iliac screws connected by plates (39) and the use of vertical Galveston rods attached to cross connecting spinal rods, plus a threaded transiliac rod.

Reviewing the literature, a variety of techniques for sacro-pelvic reconstruction are described: sacro-iliac joint screw fixation, iliac-sacral screw fixation, posterior ilio-sacral plating and screw fixation, custom-made prosthesis, Galveston rod fixation with Iliac screws and trans-iliac rods.

In the majority of cases, 21 patients, we used a posterior approach. A combined approach was used in only 3 cases. A posterior approach is suitable for the majority of patients with sacral chordomas because it provides good visibility of the sacral nerves and the rectum, allows good visibility and resection of paravertebral tissue invasion which is believed to be involved in tumor recurrence and it facilitates a complete resection using the retrorectal fat tissue as cleavage plan. It is also a more common approach because of the familiarity with sacral anatomy for neurosurgeons.

The approach strategy needs to be cautiously evaluated before the surgery. All 21 patients operated through a posterior

approach alone presented with sacral chordomas that didn't extend beyond the retrorectal fat tissue invading the rectum. All 3 cases with rectal invasion were operated using a mixed operatory team through a combined approach, anterior and posterior. All cases associated rectal resection and permanent colostomy. As a general rule, posterior approach alone is not recommended in patients with sacral chordomas with rectal invasion.

Surgical treatment in cervical chordoma

In the studied interval 4 patients with cervical chordomas were admitted in our department. The vertebral levels affected were C5 in one case, C5 and C6 in one case, C3 and C4 in one case and C4, C5, C6 in one case.. Surgical treatment was applied in all cases, with spinal cord decompression, tumor resection and reconstruction. En block resection was not possible, piecemeal tumor resection being used in all cases.

Anterior approach was used in 2 cases and a combined, anterior and posterior approach in the other 2 cases. All 4 cases required anterior reconstruction using bone graft fusion harvested from the iliac crest or from the fibula associated with anterior metallic fusion. Patients that were treated through a combined approach benefited also from posterior fusion using transarticular screws and rods.

Total tumor resection was achieved in 2 cases using a combined approach. In the other 2 cases treated through an anterior approach only incomplete tumor resection was possible associated with spinal cord decompression. In one case, the tumor invaded the cervical nerves

from C4 to C6, and in the other case both vertebral arteries were involved in the tumor mass. The tumor was very adherent to the adjacent tissues and we could not find a cleavage plan to separate these structures from the tumor mass. As complete tumor resection was never an option in these cases only palliative surgery was used with spinal cord decompression and anterior spinal reconstruction without a secondary posterior approach.

The only complication observed was transitory dysphonia in 2 cases.

Radiotherapy for spinal chordomas

Radiotherapy was recommended in all cases treated in our department. The value of radiotherapy in chordomas is long debated. Radiation doses of 30 to 50 Gy are indicated as palliative treatment with minimal risks. There are studies that report no difference in survival, duration of symptoms and progression in a heterogeneous group of patients that underwent radiotherapy with 50 to 60 Gy compared with conventional fractions of less than 50 Gy. (40) Higher doses of 60 to 70 Gy are required for potentially curative intent. (41) To achieve this high doses the technique implies the association of conventional radiotherapy and proton-beam irradiation. Although the biological properties of proton beam are not significantly different from x-ray beams, their physical characteristics exhibited by a finite range of energy deposition with only minimal exit dose beyond the target region are significantly advantageous. These advantages are particularly important in achieving high-dose delivery to sacral chordomas. Using this

approach of x-ray and proton beam therapy combined with optimal surgery, improved local control was achieved at doses greater than 77 CGE. (42)

All patients admitted in the study were treated after surgery with conventional radiotherapy. Unfortunately, proton beam therapy was not available. The results were disappointing. Although treated with radiotherapy patients developed tumor recurrence in all cases with incomplete resection and in 14% of cases with radical tumor resection.

Case presentation

A 65 year old woman presents to our department for local pain localized in the thoraco-lumbar junction, and neurologic deficit, graded Frankel D below T11, and radicular pain in T12 and L1 dermatomes on the right side. Plain X-RAYS were not helpful for diagnosis. After spinal MRI, we revealed a tumor with extension into the spinal canal, very adherent to the dura mater and severe cord compression with massive paravertebral extension and anterior extension to the limit of the retroperitoneal space, coming in close contact with the right kidney without invading it. We used a posterior approach through L1 complete laminectomy and partial T12, L2 laminectomy. Almost all structures of L1 vertebra were destroyed by the tumor mass. An L1 corpectomy was necessary with T12 and L1 discectomy. For spinal reconstruction we used an expandable cage, PMMA and posterior metallic fusion with transpedicular T12 and L2 screws.

We managed to achieve complete tumor resection under optic magnification. The

patient was released from the hospital without with minimal neurologic deficit, and was without neurologic deficit at the 2 months follow-up.



Figure 8 - Initial MRI image of L1 spinal chordoma

After 1 year, she presented with Frankel D paraplegia, and radicular pain in L1 and L2 dermatomes on the left side. Spinal MRI shows tumor recurrence situated on the left side with spinal cord compression. A second surgical procedure was necessary focused on the left side this time with dissection and in-block resection of the tumor mass. The intersomatic

cage was left in place and we used reconstruction with PMMA also in T12 and L2 for better stability. Complete tumor resection under optic magnification was achieved. The patient was released with no neurologic deficit and no symptoms of spinal instability. At the 5 year follow-up patient presented without tumor recurrence.

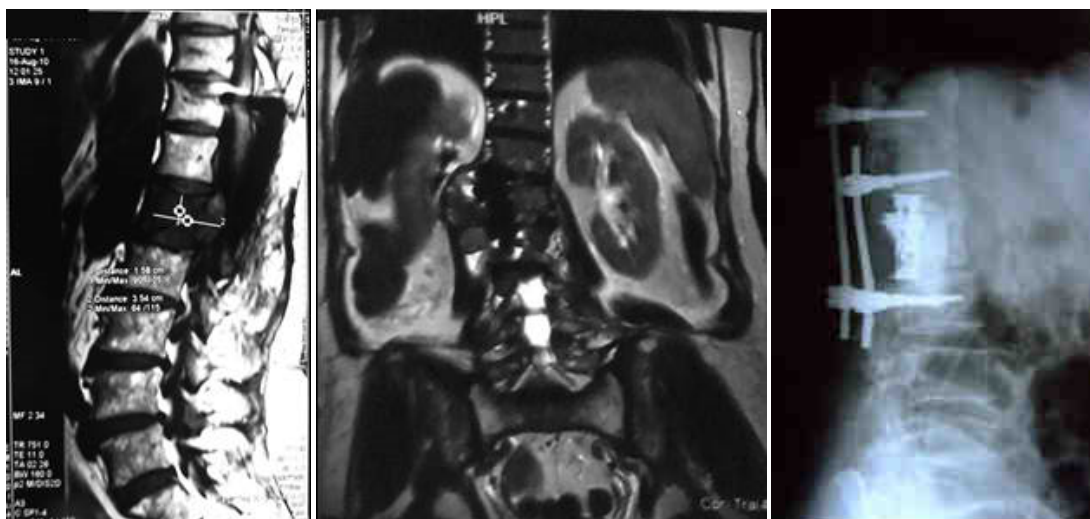


Figure 9 - MRI image showing tumor recurrence after 1 year and postoperative control image after second surgical intervention

Prognosis factors

Because of the low incidence, only 0.5 cases per million people, there are few centers with large experience in treating this type of tumors, the majority of studies presenting very small series of patients or case presentations. (43, 44)

The majority of earlier studies reported a very high rate of local recurrence and metastasis in up to 60% of sacral chordomas. (10, 24) The reported rates of local recurrence and metastasis depend on the quality of the

initial surgery, the length of follow-up, and the autopsy rate. (44, 45)

Tumor control in spinal chordomas improved significantly with more aggressive surgery. Local recurrence was almost a rule in the past, but, in our last 15 years we observed a tumor recurrence rate of 32%. Based on the type of tumor resection, the recurrence rate was 14% in cases considered with complete tumor resection and 100% in cases with incomplete tumor resection.

The resection margins appear to be a critical factor in the final outcome of patients.

Based on our study we concluded that the main adverse prognosis factors in the treatment of spinal chordomas are:

- Incomplete resection of the tumor with inadequate surgical margins
- Large tumor size
- Surgical procedures for tumor recurrence
- Presence of metastases
- Presence of microscopic tumor necrosis

We noted some differences observed in 15 years of treating spinal chordomas. The incidence increased over time, which we believe is mainly associated with an increased accessibility for CT and MRI imaging over the years. We also observed that postoperative neurologic impairment after surgery decreased in time. Although the percentage of patients with total tumor resection increased, the surgical procedures that were used were less invasive over time. Another thing that benefits complete tumor resection even if that means complete corpectomy or vertebrectomy is the evolution of spinal implants, restoring stability after complete tumor resection being no longer a problem.

Conclusions

Chordomas are rare tumors, affecting mainly the sacral segment of the spine. Patients present with unspecific clinical symptoms causing late hospital presentation and late diagnosis. The biggest concern is represented by tumor recurrence and local invasion if gross total resection is not achieved. The treatment of chordomas requires both aggressive resection and caution in achieving

marginal tumor resection. If total resection is not achieved, tumor recurrence is a rule. Extensive tumor resection above S2 vertebra raises the problem of sacral reconstruction. From a histopathological point of view, chordomas are considered benign tumors, but, thanks to their aggressive recurrence they are classified as malignant tumors. Metastasis are rare but can occur, mainly in the lungs, liver and lymph nodes. Adjuvant therapy is controversial but known to contribute to long-term disease control and survival.

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