A “tumor” or “suspected tumor” diagnosis is a major setback in any person’s life. Right from the start - in the initial phase of the patient’s personal confrontation with the disease, possibly characterized by fear, uncertainty and even outright despair - the situation requires intensive cooperation. The patient will probably be required to undergo a great many clinical and instrumental examinations and tests, answer questionnaires, and participate in discussions in the immediate follow-up to the suspected diagnosis “tumor,” for an exact diagnosis must be reached as quickly as possible.

The objective of all of these examinations, questions, and tests is to obtain answers to the following questions:

· Is the tumor benign or malignant (dignity)?
· Exactly what type of tumor is it?
· What is the extent of tumor spread?
· Is it the type of tumor that originates primarily in bone, or is it a metastasis (spread of tumor tissue to a new location in the body) originating from a tumor located outside the spinal column?
· Are metastases present in other organs as well (liver, lungs, lymph nodes)?
· What is the tumor’s stage of development (staging)?
· What therapies are available to treat the tumor (surgery, radiotherapy, chemotherapy)?

Not until the initial workup has answered these important questions is it possible to give the patient a reliable and consistent description of the clinical picture as a basis for a discussion of the consequences of the disease as well as possible therapeutic approaches, risks, and complications. Since tumor disease always consists of a complex clinical picture that normally concerns a number of different medical specialties, standard procedure is for a team of specialists from the medical fields involved to discuss the diagnostic and therapeutic objectives as a team. The cooperation of these specialists in a tumor conference ensures the patient the highest possible level of competence, quality and safety when it comes to deciding on and implementing diagnostic and therapeutic procedures.

What does “tumor” mean?

The term tumor is from the Latin, means “swelling or knot” and is a neutral term in medical terminology. Any mass is designated a tumor before its dignity („benign/malignant”) is known. As is the case with the other bones of the skeleton, benign or malignant tumors and malignant metastases deriving from malignant tumors with their primary location elsewhere in the body can be found in the spinal column.

What types of benign bone tumors are found in the spinal column?

The benign tumors of the bones are divided into groups based on where they develop (bone, cartilage or vessels). There are:

1. Benign tumors deriving from the bony structure (osteogenic)

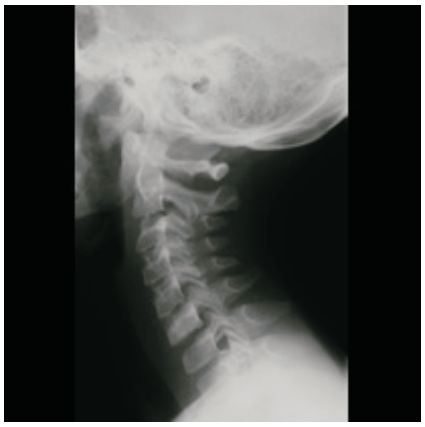
Osteoid osteoma

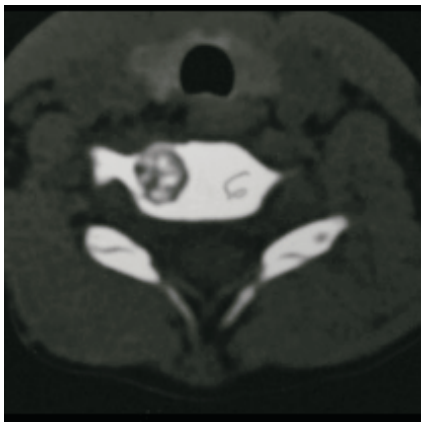
Osteoid osteomas are osteogenic, benign bone tumors featuring a trabecular (beam-like) fine structure and a highly vascularized layer of supporting tissue. A radiographically visible light spot, the nidus, is frequently found at the center of the tumor.

Frequent locations:
· Vertebra, frequently on the pedicles and spinous processes (processus spinosus)
· Thigh bone (femur)
· Neck of femur
· Shinbone (tibia)
· Upper arm bone (humerus)

Incidence and distribution acc. to sex
An osteoid osteoma generally occurs between the 10th and 25th year of life, in men three times as frequently as in women. Osteoid osteomas account for approximately 6% of all spinal tumors.

• Osteoid osteoma of the 6th cervical vertebra





Osteoblastoma
Osteoblastomas are benign, osteogenic bone tumors with a structure similar to that of spongiosa (young bone substance), with a soft, blood-rich consistency. Osteoblastomas are involved in the buildup and breakdown of bone due to the active osteoclasts (giant cells that break down bony substance within the framework of bone metabolism) and osteoblasts (cells that build up bony substance within the framework of bone metabolism).

Frequent locations:
· Vertebrae, frequently pedicles and spinous processes
· Large tubular bones (femur, shinbone, humerus)
· Ribs
· Carpal and tarsal bones

Incidence and distribution acc. to sex
Usual onset of osteoblastomas is between the 10th and 30th years of life, and men are affected somewhat more frequently than women. Osteoblastomas account for about 5% of all vertebral tumors.

2. Benign tumors deriving from cartilaginous structure (chondrogenic)

Chondroma
Chondromas are chondrogenic, benign bone tumors that grow very slowly and consist of mature hyaline cartilage tissue.

Osteochondroma (cartilaginous exostosis)
Osteochondromas are chondrogenic, benign tumors that consist of cartilage and bone tissue. The bony structures of the tumor often contain cartilaginous islets that may calcify.

Frequent locations:
· Large tubular bones (femur, humerus, shinbone)
· Shoulder blades
· Rarely fingers and toes
· Vertebrae seldom affected, if so, then generally in the lumbosacral transition area

Incidence and distribution acc. to sex:
Chondromas and osteochondromas are frequently diagnosed between the 20th and 40th year of life and account for approximately 4-5% of all vertebral tumors.

Occurrence of numerous osteochondromas at various locations in the bony skeleton significantly increases the probability of degeneration into a malignant tumor.

Chondroblastoma
Chondroblastoma are benign, chondrogenic tumors characterized by a structure consisting of young chondroblasts (cells responsible for cartilage production) that is very rich in cells and highly vascularized. The tumor is hard and elastic, and giant cells are visible under the microscope that may lead to confusion with a genuine giant cell carcinoma, which is malignant.

Frequent locations
· Large tubular bones (femur, humerus, shinbone)
· Vertebral tumors of this type are fairly rare

Incidence and distribution acc. to sex:
Chondroblastomas occur with notable frequency in the 2nd decade of life and account for approximately 0.5-1% of all vertebral tumors.
There is no apparent change in frequency according to sex.

Chondromyxoid fibroma
Chondromyxoid fibromas are benign, chondrogenic tumors consisting of mainly myxoid (containing mucous) tissue. Tumefactions (puffy or swollen parts) and deformations of the bony structure are often observed in the vicinity of the tumor.

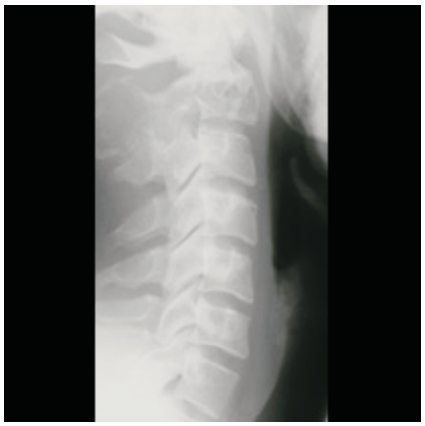
Frequent locations:
· Large tubular bones (femur, humerus, shinbone)
· Vertebral tumors of this type are very rare

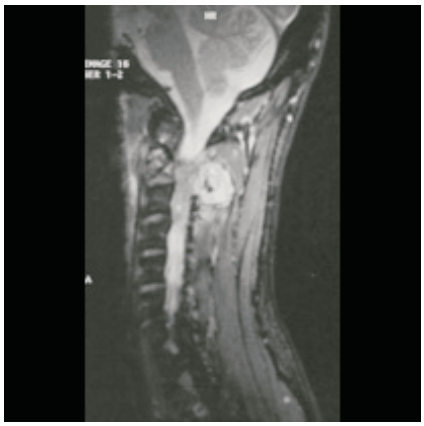
Incidence and distribution acc. to sex:
The tumor affects mainly adolescents in the second decade of life and is very rare, accounting for only 0.5% of all vertebral tumors.

3. Benign bone tumors deriving from vascular dysplasias (vasogenic)

Hemangioma
Hemangiomas are benign vasogenic tumors consisting of newly formed cavernous and capillary blood vessels. About 40% of all hemangiomas of the bony skeleton are located in the spinal column, frequently affecting several vertebrae. Women are affected more frequently than men.

• Hemangiopericytoma





4. Benign bone tumors of other origins

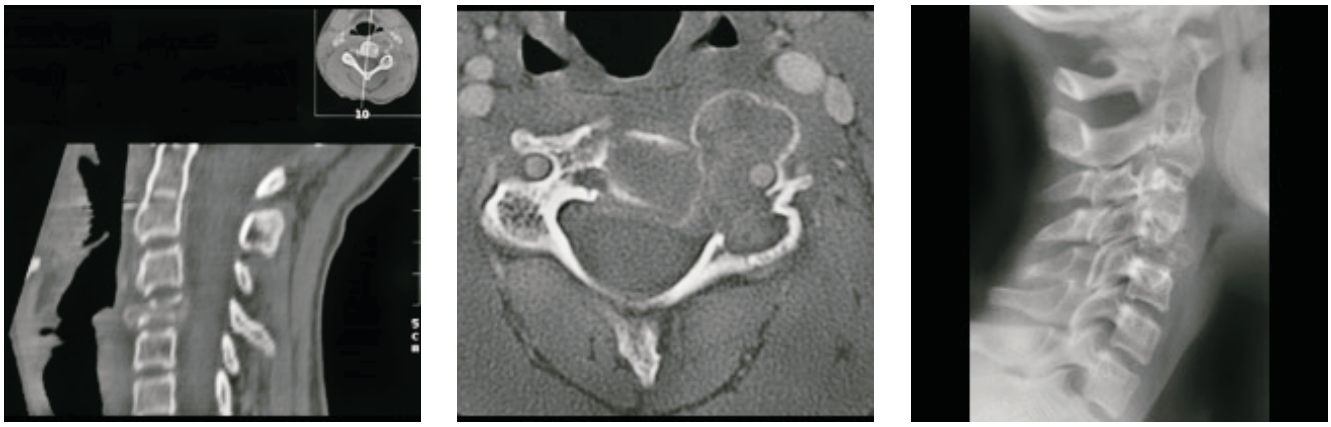
Benign fibrous histiocytoma
This is a rare, benign, fibrous bone tumor that accounts for only about 0.1-0.2% of all vertebral tumors.

Giant cell carcinoma
Giant cell carcinomas are bone tumors that are semi malignant, meaning they can manifest in both a benign and a malignant form. Differentiation at the cellular level is very difficult. This type of tumor frequently grows anew (recidivation) following surgical removal called extirpation (surgical removal).

5. Tumor-like benign changes in bones

Aneurysmatic bone cyst
This is a benign bony process that leads to the destruction of bone through the formation of cystic cavitations. These cavitations are usually filled with blood and bordered by newly-formed bone lamellae.
Aneurysmatic bone cysts occur relatively frequently in the spinal column, accounting for about 10% of all vertebral tumors.

• Aneurysmatic bone cyst of the cervical spine



Eosinophilic granuloma (EG)

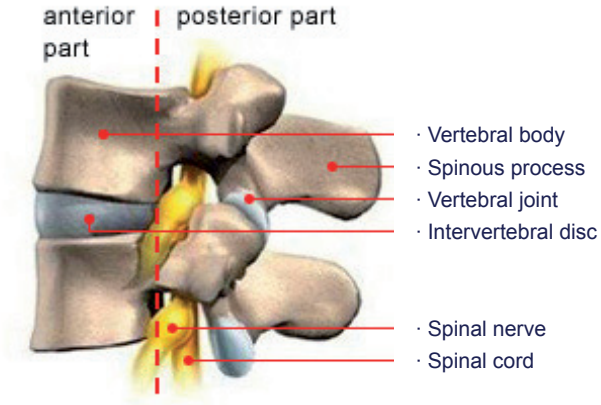
Eosinophilic granulomas are usually benign granulomas that may occur in the bone, stomach mucosa, small intestine, lungs or skin.

When bones are affected, the bony structure is attacked and destroyed (osteolysis) starting from the medullar space.

The granulomas usually occur singly, although there are courses involving numerous concurrent granuloma foci. Disease onset is mainly between the 5th and 10th year of life and is rare in later years. Men and women are affected with equal frequency. The cause of granuloma development is not known to date.

Where do benign bone tumors of the spinal column occur?

• Location of vertebral tumors



Benign bone tumors, such as osteoblastomas, osteoid osteomas, or bone cysts, are often located in the posterior parts of the vertebra.

Benign bone processes, such as hemangiomas and eosinophilic granulomas, are often localized in the front (anterior) parts of the vertebra.

Primary malignant bone tumors and metastases deriving from tumors with a different primary localization occur frequently in the anterior parts of the vertebra.

What symptoms may be caused by benign tumors of the spinal column?

The type and severity of the symptoms depend on tumor spread and location. Since the presence of a tumor does not cause specific symptoms, it can prove difficult to differentiate back pain caused by tumor disease from pain deriving from other causes, such as diseases of the spinal column involving wear, simply because the symptoms may be similar.

· Pain with different causes and qualities
  · Periosteal pain (periosteum) caused by raising and stretching of the periosteum as a result of the destruction of the cortical layer (outer wall of the vertebra) by the tumor
  · Local pressure or percussion pain
  · Pain at rest
  · Stress-dependent pain
  · Nocturnal pain
  · Constant pain
  · Painful spinal column movement restrictions

· Neurological disturbances due to compression of the spinal cord or spinal nerves
  · Radicular symptoms resulting from pressure exerted by the tumor on the spinal nerve roots. Compression of the posterior spinal nerve root results in sensory defects in the corresponding area of distribution with painful dysesthesias (impairment of sensation). Pressure on the anterior spinal nerve root causes sensomotor defects with paralyses and atrophy of the muscles in the corresponding areas of distribution.
  · Paraplegic symptoms
    Pressure on the posterior white columns of the spinal cord results in disturbances in depth sensitivity and gait, and changes in sensation of pain and temperature.
    If the pyramidal (corticospinal) tract is damaged by tumor pressure on the spinal cord, a muscular weakness may develop in the legs accompanied by a sense of tiredness and temporary paralytic symptoms.
  · Dysfunctions of bladder and colon function
  · Sexual dysfunction
  · Changes in reflexes (enhanced, reduced, absent)

· Instability of affected mobile segment due to
  · Increasing destruction of the vertebra affected by tumor disease
  · Pathological fracture of the destabilized vertebra

How are benign tumors of the spinal column diagnosed?

Benign tumors of the spinal column usually grow gradually and are often diagnosed “incidentally” within the framework of other examinations. Since not every benign tumor can be reliably diagnosed as benign on an x-ray, it is important to do a complete diagnostic workup until the dignity (benign/malignant) of the vertebral finding can be confirmed. This information then serves as the basic for any further therapy.

The following examination methods can be used to obtain an exact diagnosis:

· Medical history and clinical examination
  · Onset and nature of symptoms? (acute/gradual onset)
  · Did the symptoms occur without any apparent cause?
  · Accident traumas in medical history?
  · Any history of spinal column or back symptoms?
  · Is spinal mobility restricted?
  · Where is the pain?
  · Describe the quality of the pain (dull, burning, continuous, intermittent, dependent on stress load or postural position)?
  · Any soft tissue swelling?
  · Any lymph node swelling?
  · Has any unintentional weight loss occurred?
  · Does clinical examination of the organ systems reveal any abnormalities?

· Neurological examination
  · Are there any sensory or motor dysfunctions?
  · Does patient limp in an attempt to relive pain, or due to paralysis, or leg shortening?
  · Are there any signs of bladder, colon or sexual dysfunction?
  · Are the muscles normal or is muscular atrophy evident?
  · Have the reflexes changed?

· Instrumental imaging diagnostics
  · Conventional x-ray images
    Conventional x-ray images in 2 planes with oblique or direct images may provide valuable initial information for an first diagnosis.
    It is possible to assess the location and spread of the tumor, the nature of the bony structure of the vertebra, and the height of the intervertebral space. The location of the tumor within the vertebra provides initial evidence of its dignity (benign/malignant), since benign processes, with the exception of hemangioma and eosinophilic granuloma, are usually found in the posterior portions of the vertebrae and malignant tumors are usually found in the anterior portions.
  · Computer tomography (CT)
    Using this layered imaging technique, tumorous changes in the bony vertebral structure can be visualized. Different sectional image layers are combined to create three-dimensional reconstructions of local findings. Computer tomography is used in precision puncturing of the suspicious tissues or for imaging of narrowed spinal canal sections with the help of a contrast agent (CT myelography).
  · Magnetic resonance tomography (MRT, MRI)
    Magnetic resonance tomography is highly suitable for assessing the location of the tumor in relation to the spinal cord and spinal nerves, possible infiltration of neighboring soft tissues, and mass displacement or ingrowth of the tumors into vessels in fine-layered images.
    This technique is now considered the most useful of all for diagnosing tumor diseases, and also for differential diagnostics to distinguish them from other diseases of the spinal column. Another important field of application for MRT is in monitoring the disease's course after surgery, radiation therapy, or chemotherapy.

- Nuclear medicine examination methods
  - 3-phase skeletal scintigraphy
    In this method, the patient is injected with a radioactive marker (technetium-99m methylene diphosphonate) that then accumulates in bones at areas where metabolic activity levels are elevated. The entire bony skeleton is portrayed and the areas with elevated metabolic levels are clearly distinguishable from normal structures, thus providing an overall simultaneous view of all areas with raised metabolic activity levels.
    This method is nonspecific, i.e. any and all areas of high-level bony metabolism are shown. Differentiation between benign and malignant tumors, active arthrosis, or an infection of a vertebra can only be obtained using the other diagnostic methods.
  - Positron emission tomography (PET)
    Preceded by administration of a radioactively marked substance, this method renders increased levels of metabolic activity in the body (e.g. the elevated metabolic levels in a tumor) visible. Modern PET devices are coupled with CT scanners. This “two-in-one scanner” creates images using both CT and PET technology that are then compiled by computer to create an image that provides the needed information.
  - Single photon emission computer tomography (SPECT)
    This nuclear medicine examination method, combined with spiral computer tomography and the administration of various agents with low-level radioactivity, can make changed metabolic processes in the body down to the molecular level visible. This combination of the two methods unifies the data obtained in the SPECT examination with the layered spiral CT images, allowing for the exact localization of regions of the body with pertinent anomalies.
- Myelography
  With the injection of a contrast agent into the spinal canal, myelography can make changes that are narrowing or compressing the spinal nerves (e.g. tumor compression, intervertebral disc prolapse) visible. The contrast agent is distributed throughout the entire spinal canal by shifting the position of the patient on the examination table. A dynamic examination in motion can be done using fluoroscopy. Myelography is usually followed by a CT scan.

- Biopsy and examination of tissues at the cellular level
  In a biopsy, various methods are employed to remove tissue from a suspicious area. These tissue samples can then be examined under a microscope.
  This examination method facilitates a reliable assessment of the dignity (benign or malignant) of a tumor, so that further therapeutic steps can then be taken.
  There are various biopsy methods:
  - Closed methods
    In fine needle or punch biopsy, a small amount of the suspected tissue is removed under anesthesia. By examining this tissue sample under a microscope, it is possible to arrive at an exact histological (microscopic structure of tissue) diagnosis (tumor type, benign/malignant).
    These punctures are minimally invasive in nature and are usually done under CT monitoring.
  - Open methods
    Excision or incision biopsy involves partial or complete removal of tissue portions altered by tumor activity under anesthesia, followed by histological analysis of the tissue.

- Laboratory diagnostics
  Laboratory diagnostics are generally not suited to the confirmation of the presence of a tumor. Some laboratory parameters are nonspecific, i.e. they can also be changed by other diseases.
  - Blood sedimentation rate (BSR)

· C-reactive protein (CRP)
· White blood cell count (leukocytes)

These inflammation parameters can be elevated in tumor diseases, but this may also be the case with other kind of infection.

Tumor markers are proteins that occur in low concentrations in blood plasma, where they can be measured. They are produced by tumor cells, but sometimes by normal cells as well.

While elevated concentrations of various tumor markers may be an indicator of the potential presence of certain type of tumor, this evidence is not conclusive.

Known tumor marker include:

· Alpha-fetoprotein (AFP) as an indicator for hepatic (liver) carcinoma
· Neuron-specific enolase (NSE) as an indicator for a parvicellular bronchial carcinoma or neuroendocrine tumors
· Prostate-specific phosphatase (PSA) as an indicator for prostate carcinoma
· Monoclonal antibodies from the group of cancer antigens (CA) may, depending on the existing CA type, provide evidence of tumors of the mammary glands, the pancreas or the stomach. Carcinoembryonal antigen (CEA) is an indicator for tumors of the gastrointestinal tract.

How are benign tumors of the spinal column treated?

Benign tumors of the spinal column are rare, may be small and hardly noticeable, and are occasionally incidentally found within the framework of an x-ray examination done for other reasons. Yet they can alter the stability of a given mobile segment, destroy specific structures such as bone and ligaments, or exert pressure on the spinal cord and spinal nerves. The reliable and exact determination of the dignity (benign/malignant) of the tumor is essential to the planning of further therapeutic steps.

Once growth of the benign tumor has advanced to the point where the destruction of the bony vertebral structure and ligamentous apparatus have pathologically altered the biomechanical functionality of the mobile segment, or if neurological dysfunction due to pressure on the spinal cord and spinal nerves is imminent or has already occurred, surgery is indicated.

The choice of the surgical method to be used and access route is based on both the localization of the tumors, and any tumor spread in the bone and the adjacent soft tissues. If surgery should become necessary, various methods are available for tumor removal and subsequent stabilization of the mobile segment.

Even in the case of benign tumors, en bloc resection is desirable, since otherwise a large number of tumor recidivations are likely to occur, which then also significantly increase the level of surgical risk. This applies to aneurysmatic bone cysts in particular, which show much higher levels of recidivation in the spinal column than when located in the extremities. In recidivation, primarily monosegmentally localized aneurysmatic bone cysts may spread extensively to adjacent spinal sections, where they then create significant problems for both patient and surgeon in terms of the required surgical technique.

The following surgical methods are frequently used for surgical treatment of benign vertebral tumors in our department.

Tumors of the cervical spine:
· Transoral dens resection with dorsal spondylodesis
· Dorsal decompression with cervical fusion
· Ventral corpectomy with cervical spondylodesis

Tumors of the thoracic and lumbar spine:
· Corpectomy with dorsal spondylodesis

Tumors of the sacrum (os sacrum)
· Sacrum surgery with special instrumentation