ROENTGENOGRAPHIC FINDINGS ASSOCIATED WITH TUMORS OF THE SPINAL COLUMN, SPINAL CORD, AND ASSOCIATED TISSUES

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In the developmental stage of surgery of "spinal tumors," which term is taken to include tumors of the spinal column, spinal cord, and associated tissues, neurologists and neurosurgeons were inclined to wait until advanced signs of compression of the cord had developed before instituting operation. However, they soon learned that earlier diagnosis and surgical treatment were necessary if the most satisfactory results were to be obtained. This stimulated further investigation, introduction of special tests, employment of roentgenograms as a routine, and studies with radiopaque oil in selected cases. As a result, it is possible to detect the presence of these lesions much earlier, so that the ratio of operable to inoperable tumors, as shown by recent studies, is now approximately 80 to 20, with a surgical mortality of 4 per cent.

Spinal tumors may arise from any of the primary tissues, and furthermore, these tissues may become the field of metastatic implants. Many tumors that arise within the spinal canal are considered amenable to operation, since those that arise from nerve roots, meninges, and blood vessels are encapsulated, usually non-malignant, and removable. Intramedullary tumors are less amenable to surgical treatment, but ependymal-cell tumors of the filum terminale frequently can be removed.

Proliferative changes in the laminae, pedicles, spines, and bodies of the vertebrae, and in the intervertebral disks, may give rise to compression of the spinal cord, simulating that caused by tumors arising within the spinal canal. If recognized early, this condition can be relieved by surgical treatment. Foreign-body giant-cell tumors and osteochondromas are benign growths of the vertebrae which are amenable to operation. Patients who have primary or metastatic malignant tumors are not considered for

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surgical treatment. Occasionally one is justified in performing laminectomy and partial removal of these tumors for decompression, but too often the temporary relief does not justify the surgical risk.

The secondary changes in bone produced by tumors that are primary in the spinal cord and associated tissues have long been recognized, but it was not until we reviewed a moderately large series of tumors arising within the spinal canal that we appreciated the frequency with which these bony changes are demonstrable roentgenographically. It is impossible to give an accurate estimate of the incidence of these changes, since many old plates, on the basis of which a negative diagnosis was given, have been destroyed. We do venture the opinion that roentgenographic changes of bone can be demonstrated in 15 to 20 per cent of cases in which tumors arise from tissues within the spinal canal.

Roentgenoscopic and roentgenographic studies with radiopaque oil have furnished additional information leading to localization of small tumors before positive neurologic symptoms have developed. These studies assist in making a diagnosis by distinguishing from the normal condition, arachnoiditis, intradural, extradural, and intramedullary tumors, and atrophic lesions of the spinal cord.

Although radiopaque oil serves a useful purpose, and although there are specific indications for its use, it occasionally sets up mechanical or chemical meningitis and radiculitis, which may exaggerate the symptoms of root pain; thus it is wise to remove all the oil at operation whenever possible. If the oil is not removed, it is slowly mobilized and passes into the tissues along the arachnoid sheaths of the nerves. We have studied movements of radiopaque oil which had been injected into the spinal canal one year previously, and in this way have demonstrated a spinal block produced by a tumor which apparently was too small to produce block at the time of injection of the oil. We advise avoidance of this procedure when the neurologic findings or roentgenograms give sufficient diagnostic and localizing evidence. More will be said on this general subject later in this paper.

In roentgen examination of patients suspected of having tumors involving the spinal cord, roentgenograms of the spine taken in the anteroposterior and lateral directions are necessary as a routine. These should be supplemented by stereoscopic and oblique views localized at the level at which the tumor is suspected to be. When the thoracic portion of the spinal column is involved and an intrathoracic mass is present, additional roentgenograms and roentgenoscopy of the thorax as a whole may be necessary before the identity of the mass is established. All roentgenograms of the spine should be made with the Potter-Bucky diaphragm and a fine-
focus tube, in order that maximal detail may be secured. Accurate placing in position of both the tube and the patient are essential to avoid distortion of the vertebral shadows, as such distortion may be a misleading factor in the subsequent interpretation.

In the interpretation of the roentgenogram in these cases one is concerned chiefly with alterations in the structure of the vertebrae or adjoining ribs, and in a satisfactory roentgenogram all parts of these should be clearly shown. In the past, not enough attention has been paid to the shadows of the vertebral pedicles, laminae, and

![Fig. 1. A Neurofibroma which Originated from a Nerve Root within the Spinal Canal and Subsequently Eroded through the Intervertebral Foramen](image)

There is erosion of the pedicle and body of the vertebra and of the ribs. The relative positions of the tumor and spinal cord are noteworthy, as well as the effect of pressure on the cord.

lateral and spinous processes. These structures usually present evidence of erosion from pressure before it is discernible in the body of the vertebra. In the majority of cases the bone is secondarily involved, and in general the changes to be seen consist of erosion secondary to direct pressure, destruction due to a benign or malignant tumor, metastatic disease, or hyperostosis. These changes may occur singly or in combination, and may be localized or widespread. The characteristics of the change, its situation, and its extent, all are to be taken into consideration in determining the identity of the underlying lesion.
Primary or metastatic disease of a vertebra exhibits the same characteristics as the condition in other bones, except as these may be influenced by the contour of the vertebra and the mechanics of posture and weight bearing. Not infrequently the shadow of a soft-tissue tumor, primary within the spinal canal, is discernible in the roentgenogram when it has extended beyond the spine and into the surrounding soft tissues or into the thorax. Rarely, calcified psammoma bodies in an endothelioma within the spinal canal may be identified, and thus point to the nature of the tumor.

**Fig. 2. A Neurofibroma Which had Produced Extensive Destruction of the Spines, Laminae, Pedicles and Bodies of the Vertebrae and of the Ribs**

**Benign Tumors of Soft Tissue**

*Neurofibroma*: Neurofibromata arise from spinal nerve roots and are intrameningeal, extrameningeal, or extend along the course of the nerve, producing a tumor which has the shape of a dumbbell, with intrameningeal and extrameningeal portions (Fig. 1). The extrameningeal extensions may erode through the intervertebral foramen to form large extravertebral masses (Fig. 2). These occur more commonly in the cervical and thoracic portions of the spine than elsewhere. In the cervical regions they can be palpated along the margins of the vertebrae, whereas those within the thorax and abdomen can be recognized in roentgenograms, for they usually produce massive erosion of all adjacent bony structures. Intrameningeal neurofibroma of the lumbar region is capable of producing sufficient erosion and absorption of laminae, pedicles, and bodies to result in spontaneous fracture of the vertebrae (Fig. 3). Since these tumors grow slowly and have a tendency to degenerate and become cystic, the progress of symptoms referable
to the spinal cord is likewise slow. At the onset, all of these tumors produce root pains, which are frequently mistaken for symptoms of some obscure thoracic, abdominal, or pelvic disorder.

Owing to the benign and encapsulated nature of this tumor, the bone is involved only by direct pressure from erosion, and the defect observed in roentgenograms coincides with the site of the tumor. The earliest demonstrable roentgenographic change ac-

Fig. 3. Large neurofibroma producing extensive erosion of bodies, pedicles, and laminae of vertebrae from the eleventh thoracic to the second lumbar. Pathologic fracture of first and second lumbar vertebrae has taken place.

companying neurofibroma within the spinal canal is erosion and thinning of the mesial border of one or both pedicles of the vertebra at the site of the tumor. This is best seen in roentgenograms made in the anteroposterior direction. Later, evidence of erosion and thinning of the lamina can be discerned, and changes in the pedicles of one or several vertebrae can be observed if the tumor remains within the spinal canal and enlarges by extending up or down. Changes in the contour of the vertebral bodies are among the last to be recognized in the roentgenogram. When the tumor
extrudes through an intervertebral foramen, the pedicles and laminae on the affected side of the vertebrae are eroded and may be completely destroyed (Fig. 4). Enlargement of the intervertebral foramen also will be obvious. As the tumor increases in size, evidence of erosion of the ribs, bulging of the surrounding soft tissues, and intrathoracic extension may be seen. The characteristic feature of neurofibroma seems to be the faculty of extending along nerve roots and extruding through the intervertebral foramina; hence, when evidence of these features is observed in roentgenograms, the presence of neurofibroma is suggested.

**Endothelioma:** Endotheliomas usually arise from the arachnoid villi, but they may arise from other parts of the meninges or from blood vessels. Most commonly they are situated between the arachnoid and pia mater. Their growth is like that of neurofibromas, except that they are smaller, harder, produce greater local injury to the spinal cord, and do not extend extraspinally. In many of these tumors calcareous psammoma bodies develop. Localized root pains are early symptoms. The changes in bone
are much less marked than those produced by neurofibromas. However, if the tumor is situated lateral to the spinal cord, and has become densely adherent to the dura, erosive and proliferative changes take place. Both neurofibromas and endotheliomas may develop in any portion of the spinal canal, and may extend from the spinal canal through the foramen magnum into the cranial cavity. The surgical results are most satisfactory.

Roentgenologically these tumors, because of their encapsulated nature, will erode the bone in the same manner as neurofibromas. They do not, however, extend through intervertebral foramina, and the erosive changes are therefore confined to the pedicles, laminae, and bodies of the vertebrae. The earliest changes are seen in the pedicles and laminae (Fig. 5). Evidence of the localized, proliferative changes in bone encountered by neurosurgeons in these cases is seldom discernible in the roentgenogram. Occasionally the calcified psammoma bodies which often accompany these tumors are dense enough to cast shadows in the roentgenogram (Fig. 6), and thus the nature and site of the tumor can be diagnosed directly by the roentgenologist. Shadows of calcified portions of glands, blood vessels, and abdominal tumors may simulate those of calcified endotheliomas when roentgenograms are taken in only one plane. The nature of the lesion which causes the shadow is obvious, however, when a roentgenogram is taken in the plane at right angles to the plane of the previous roentgenogram. The tumors may be multiple.

Fibroma: Fibromas occur less frequently than neurofibromas and endotheliomas. They usually arise from ligaments of the spinal column, but they may originate from the meninges, and therefore may be found within or without the spinal canal. Those which arise within the meningeal spaces produce compression of the spinal cord similar to that produced by endotheliomas, whereas those of which the origin is without the spinal canal may produce smooth erosions of the pedicles and transverse processes before they extend into the spinal canal, where they produce compression of the spinal cord. Their growth is also slow, and may produce localized root pain similar to that of endotheliomas. Most of these tumors are removable.

This tumor, because of its rarity, will not often concern the roentgenologist. Because of its benign and encapsulated nature, the roentgenographic changes are very similar to those accompanying a neurofibroma. Calcification was not found in the few cases included in this series.

Hemangioblastoma: Hemangioblastomas arise from blood vessels in any of the spinal tissues. These tumors grow slowly and, because of their vascularity, produce erosive changes in the lami-
TUMORS OF THE SPINAL COLUMN

nae, pedicles, and bodies, which are demonstrable in roentgenograms. They are rarely malignant, and usually are operable.

MALIGNANT TUMORS OF SOFT TISSUE

Intramedullary Tumor: Intramedullary tumors arise from the substance of the spinal cord, and may extend several centimeters lengthwise of the spinal canal. They are rarely associated with root pains, and produce indefinite upper sensory levels in contrast to the well defined sensory levels produced by the tumors previously referred to. Their growth is likewise slow and may result in formation of cysts. They must be considered to be malignant tumors, in that they are not definitely encapsulated, nor are they removable. Most of these tumors fall into the group of gliomas, and those in which degenerative changes and cysts develop prove to be astrocytomas. Although it is impossible to remove these tumors, a dorsal slit of the spinal cord will allow evacuation of the contents

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**Fig. 5**

**Fig. 6**

**Fig. 5. Anteroposterior View: Erosion of Left Pedicle of Tenth Thoracic Vertebra, Produced by Contiguous Endothelioma**

**Fig. 6. Anteroposterior View: Calcified Intraspinal Endothelioma Opposite Fourth and Fifth Thoracic Vertebrae**

Erosion of the pedicles of the fifth thoracic vertebra is seen.
of cysts and permit the tumor partially to extrude, thus relieving pressure on fasciculi which are not invaded. Roentgenographic changes are rarely observed unless the tumor has produced such expansion of the spinal cord that erosion of the laminae, pedicles, and bodies may result from the pressure.

FIG. 7. APPEARANCE, ON EXPOSURE AT OPERATION, OF AN EPENDYMAL-CELL GLIOMA ARISING FROM THE CONUS AND FILUM TERMINALE, AND THE EROSIONS PRODUCED IN THE BODIES OF THE TWELFTH THORACIC AND FIRST, SECOND, AND THIRD LUMBAR VERTEBRAE

Lipomas of the spinal cord produce symptoms and findings similar to those produced by other intramedullary tumors.

Ependymal-cell Glioma: Ependymal-cell gliomas arise from the cells lining the central canal, and may be situated in any portion of the spinal cord, but are most commonly found in the conus
and in the filum terminale. When situated in the lumbar or sacral region, they produce symptoms similar to neurofibromas, and are characterized by bilateral sciatic pains which fail to respond to the usual treatment employed for sciatica. These tumors develop more slowly than those previously mentioned, and may require from four to seven years to produce complete paralysis of the caudal fibers. During this growth, marked bony erosion may develop before paralysis is complete. We have observed a case (Fig. 7) in which the tumor developed in the conus and filum terminale and produced extensive erosion of the laminae, pedicles, and bodies of the vertebrae. The erosion of the bodies simulated the erosion produced by aneurysm, except that the bodies were eroded on their dorsal aspects. The intervertebral disks and the median raphe of each vertebra were not eroded, and stood up in relief as marked ridges, with depressions in the vertebrae on each side of the fibrous cartilaginous ridges. The tumors which arise in the substance of the spinal cord must necessarily be treated like other intramedullary tumors, whereas those which arise from the filum terminale are frequently removable.

Ependymal-cell gliomas erode and expand the bone by direct pressure, and the margins of the eroded bone are sharp and well defined (Fig. 8). The growth may be of considerable size, and
may involve one or more lumbar vertebrae and the upper part of the sacrum. Absorption of the laminae may lead to an erroneous diagnosis of spina bifida occulta. Spina bifida occulta may accompany these tumors, and the deformity of the bone resulting from the spina bifida may obscure the early roentgenographic changes due to a tumor. When the tumor is limited to the sacral region, the secondary changes in bone may be confounded with the changes due to a large giant-cell tumor of the sacrum. In giant-cell tumor of the sacrum the multilocular cysts are a part of the bone itself, whereas in ependymal-cell glioma of the sacral region the well-defined pseudocysts are produced by expansion and erosion of the bony surroundings of the spinal canal.

Chordoma: Chordomas frequently arise in the region of the sacrum and are mesenchymal in origin. The characteristic symptoms of these tumors are localized and referred sacral pains, with disturbances of the bladder and rectum, and saddle-shaped anesthesia about the anus and genitalia. Roentgenograms reveal infiltrative erosions of the sacrum (Fig. 9). These erosions may result in complete destruction of the laminae and spinous processes, and even extend laterally into the ischium and in some instances through the body of the sacrum into the pelvic cavity. They may be imitated by metastatic malignant growths. Surgical treatment offers only partial relief, since these tumors are not encapsulated, and frequently have invaded the bone beyond the region of destruc-
tion. Roentgen therapy has offered some assistance in checking the progress of recurrence.

Dermoid tumors arising in the region of the sacrum, as well as that group of antrasacral tumors referred to as "Middeldorpf" tumors (Virchow's Arch. 101: 37, 1885), are also capable of producing localized erosions in the body of the sacrum, but they rarely invade and destroy the laminae and spinous processes.

Roentgenographically, dermoid tumors arising from the anterior portion of the sacrum erode the contiguous bone only by pressure as the tumor enlarges. The shadow of the defect in the

![Fig. 10](image1.png)  ![Fig. 11](image2.png)

**Fig. 10.** FOREIGN-BODY GIANT-CELL TUMOR INVOLVING BODY AND RIGHT LATERAL PROCESSES OF TENTH THORACIC VERTEBRA

There is secondary erosion of the head of the right tenth rib.

**Fig. 11.** LATERAL VIEW: FOREIGN-BODY GIANT-CELL TUMOR ARISING FROM SPINOUS PROCESS OF THIRD CERVICAL VERTEBRA, AND ERODING SPINOUS PROCESS AND LAMINA OF SECOND AND LAMINA OF FOURTH CERVICAL VERTEBRA

bone is rounded in outline and the margins are clean cut and well defined. The amount of bone involved may be exceedingly small compared to the size of the tumor in the pelvis. When the pelvic tumor contains calcified material or dental remnants the diagnosis is obvious. Roentgenologically the deformity may be simulated by an anterior meningocele.

**Benign Tumors of the Vertebrae**

Benign tumors of the vertebrae include osteomas, osteochondromas, chondromas, fibrochondromas, foreign-body giant-cell tu-
mors and hemangiomas. These frequently produce localized pain and limitation of motion, but rarely produce compression of the spinal cord. Foreign-body giant-cell tumor in a vertebra assumes the characteristics assumed by the same tumor elsewhere. It is characterized by multilocular, cystic expansion of the vertebral body (Fig. 10), and is the tumor that most frequently produces neurologic symptoms. The pedicles, laminae, and bony processes (Fig. 11) may also be involved. Because of loss of bone substance compression occurs early, and after this has occurred the usual

![HEMANGIOMA OF NINTH THORACIC VERTEBRA](image_url)

The so-called characteristic striated appearance is evident

roentgenographic picture is obscured. The tumor may extend into the paravertebral structures and give rise to an abnormal paravertebral shadow in the roentgenogram. This tumor may be simulated by myelosarcoma, metastatic hypernephroma, ostitis fibrosa, and occasionally by Paget's disease. The surgical results are satisfactory, since the lesions are usually recognized before serious symptoms of compression of the spinal cord develop.

Pure osteomas arising from vertebrae are rare.

Osteochondroma, when arising from a vertebra, has the same roentgenographic features as it has when arising from other bones. The majority of these tumors have been found to arise from the various bony processes of the vertebrae rather than from the vertebral bodies, although osteochondromas arising from bodies of vertebrae have been observed. They may distort contiguous bony
structures, and may erode them as the tumor increases slowly in size.

Evidence of the rare chondroma or fibrochondroma which arises as a primary tumor from the body of a vertebra is not visible, *per se*, in a roentgenogram. The tumor will erode the bone by pressure, just as any other benign tumor does, and has no distinguishing roentgenographic features.

The roentgenographic features of hemangioma of the vertebra have been well described by Bailey and Bucy, and by Bucy and Capp. They produce irregular absorption of bony trabeculae and thickening of the remaining vertical trabeculae, with resulting parallel vertical striations in the bodies of the vertebrae, together with loss of the normal homogeneous bony structure (Fig. 12). The abnormal trabeculations may extend into the vertebral arches and laminae. One or more vertebrae may be involved and the thoracic vertebrae are more commonly implicated than others.

Roentgenographically this tumor must be distinguished from Paget's disease involving the vertebrae, osteitis fibrosa, and osteoporosis, especially osteoporosis of the senile type. Involvement of other bones in Paget's disease and osteitis fibrosa will assist in dif-
ferential diagnosis. The involvement of the entire spine in osteoporosis should distinguish it from hemangioma which is localized to one or several vertebrae.

**Malignant Tumors of the Vertebrae**

Myelomas arise from the bone marrow; sarcomas from the bone, periosteum, and soft tissues, whereas metastatic tumors may

![Figure 14](image)

**Fig. 14. Appearance of a Primary Osteogenic Sarcoma of Second Thoracic Vertebra Which Had Extended into the Spinal Canal and Produced Compression of the Spinal Cord**

develop in the vertebrae or surrounding tissues. Myeloma rarely produces compression of the spinal cord, whereas sarcomas and metastatic tumors develop rapidly and are frequently associated with severe localized or root pain and early neurologic symptoms. Exploratory laminectomy is rarely employed, since only temporary relief is obtained.
Myeloma is revealed roentgenographically as a purely destructive process involving one or more vertebrae. Although this lesion may involve all parts of the vertebrae, it is best recognized by destructive changes in their bodies. The structure of the bone is gradually replaced by tumor tissue, and deformities from compression are frequent. Occasional cases of involvement of a single vertebra have been seen (Fig. 13), and under such conditions the roentgenographic picture may be confounded with metastatic hypernephroma, metastatic carcinoma, giant-cell tumor, and osteitis fibrosa. In the usual case, however, the vertebral changes are but a part of the generalized skeletal involvement. To distinguish myeloma from metastatic carcinoma of the osteoclastic type is seldom possible roentgenologically.

Primary osteogenic sarcoma, when involving a vertebra, has the usual roentgenologic features of the tumor in other bones. Roentgenographically the usual picture is one of dissolution and destruction of bone, with secondary involvement of the paravertebral soft tissues (Figs. 14 and 15). The destructive changes in the vertebrae cannot be distinguished from the destructive changes in bone resulting from a sarcoma arising in the intraspinal or paraspinal soft tissues.
The roentgenographic characteristics of metastatic malignant growths in the spine are too well known to warrant a detailed discussion here. The most common lesions are metastatic carcinoma, metastatic hypernephroma, myeloma, and lymphoblastoma.

**Tuberculous Lesions Simulating Spinal Tumors**

Extensive destruction of the bodies of the vertebrae, inflammatory reaction, and spinal deformity frequently have been responsible for the development of compression myelitis, but only occasionally is the lesion localized to the dorsal portion of the intervertebral foraminal margin. In one case that we observed the history and neurologic findings were similar to those produced by neurofibroma (Fig. 16). The onset was characterized by local tenderness and root pains in addition to pathologic reflexes, and motor and sensory disturbances. The lesion was not recognized until at operation, when it was observed that the periosteum, ligaments, and dura had been elevated by a postvertebral abscess producing compression of the caudal roots.

Roentgenographically, destruction by tuberculosis in the body of a vertebra may simulate malignant disease or even erosion from
a benign tumor, but involvement of the intervertebral space should point to the infectious nature of the lesion. The intervertebral disk is so resistant to erosion from pressure, and malignant invasion, that when it is affected, tumor should be the last lesion considered. A paravertebral abscess may simulate paravertebral extension of a spinal tumor, but the primary lesion in the body of one or more vertebrae, and involvement of the intervertebral disks, should point to the diagnosis of tuberculosis.

**SPINAL EROSIONS SECONDARY TO ANEURYSM**

By virtue of their situation, aneurysms erode the vertebral bodies from the ventral or lateral aspects. The extent of the erosion depends on the size of the aneurysm, which because of its continued pulsations erodes the vertebral bodies in a concave fashion. The intervertebral disks are resistant to the pressure and remain intact, so that the segment of the spine affected has a scalloped appearance. In cases of long standing the bodies may be markedly eroded, and collapse under continued weight bearing. The posterior masses of the vertebra are seldom involved except in the rare instance of aneurysm of the vertebral artery. The pulsation of the aneurysm, if within the abdomen, and roentgenoscopic studies of the thorax, if the thoracic portion of the spine is affected, should facilitate the diagnosis. Calcification within the walls of an aneurysm is not unusual, and if present will further facilitate the diagnosis.
The ventral or lateral aspects of vertebral bodies may also be eroded by retroperitoneal tumors, and in some instances the bone will be invaded and destroyed by paravertebral malignant masses.

BONY AND CARTILAGINOUS PROLIFERATIONS, PRODUCING COMPRESSION OF THE SPINAL CORD

Fibrochondromas, sometimes denoted by the term "ecchondrosis," arise from the intervertebral disks and may result from trauma. Their rate of growth is rather rapid, and they may pro-

FIG. 18. COMPRESSION OF SPINAL CORD IN A CASE OF HYPERTROPHIC OSTEOARTHRITIS

do slight widening of the intervertebral space, which is difficult to demonstrate by a roentgenogram. They invariably grow in the line of least resistance, and therefore extend into the spinal canal and produce symptoms of intraspinal tumor (Fig. 17). The masses can be removed, but have been known to recur and to produce recurrent neurologic symptoms. They are most common in the cervical region. Because of the cartilaginous nature of these tumors, direct roentgenographic examination is negative. It is possible that with careful studies with radiopaque oil, the situation of these tumors may be detected by the roentgenologist.

Proliferative changes in the laminae, spines, pedicles, and bodies, sometimes referred to as lesions of hypertrophic osteitis, may involve one vertebra or may affect several vertebrae. It is believed that these conditions result from trauma, localized infec-
tion, and rarely from increased vascularity produced by adjacent intraspinal tumors within the spinal canal. These lesions vary in degree, from localized hypertrophy (Fig. 18) with narrowing of the spinal canal, to massive fusion of several spines, laminae, and vertebrae, producing marked compression of the spinal cord (Fig. 19). Complete relief has been accomplished by laminectomy and decompression in the early stages of the disease, but recurrence is prone to develop; so it is necessary that wide and extensive laminectomy be performed to prevent it.

![Image](image_url)

**Fig. 19. Fusion of Laminae and Spines as a Result of Hypertrophic Osteoarthritis, with Complete Compression of the Spinal Cord**

The symptoms produced by these lesions simulate those of intraspinal tumors, since the onset of motor and sensory disturbance is characterized by local pains and progressive loss of function. Roentgenograms may or may not demonstrate evidence of the early changes in the laminae, whereas signs of later changes of proliferation and extensive fusion are readily seen. This evidence may be seen too late to be of surgical value, since permanent destruction of the spinal cord may have been produced.
These changes which are manifest about the margins of the intervertebral or lateral articulations may exist as localized reactions from previous trauma or as part of a so-called hypertrophic arthritis or spondylitis deformans. Intraspinal extension of marginal vertebral hyperostosis, and narrowing of the intervertebral foramina by proliferative changes about destroyed lateral articulations, are best studied by stereoscopic films, in both the anteroposterior and lateral positions. Bony spurs developing after operative procedures on the spine are also best demonstrated in this manner.

Spondylitic exostosis at the edges of one or more vertebral bodies, the rest being normal, has been described as a frequent accompaniment of tumor of the spinal cord. The presence of such changes in this series, however, was not sufficiently consistent to warrant such a general statement.

Occasionally one encounters proliferation of bone from the cut end of a lamina, following laminectomy, but only rarely do these new knobs of bone grow sufficiently into the spinal canal to produce compression of the spinal cord. In the presence of recurrent symptoms, repeated roentgenograms offer material assistance in explanation of the lesion.

Compression fractures without dislocation may cause development of bony callus and give rise to late signs of compression of the spinal cord which are difficult to distinguish from those produced by intraspinal tumors. At the onset, localized pain may be present without any accompanying neurologic symptoms, but as the condition progresses, such symptoms may appear. The roentgenogram, at first, may not give evidence of the fracture, but as the callus is formed the changes are demonstrable; even then, however, a study with radiopaque oil may be necessary to clarify the diagnosis. Again, these symptoms are relieved by decompression.

The roentgenographic features of fracture and fracture dislocation of the vertebrae are usually such that the diagnosis is obvious, in spite of occasional confusing clinical phenomena. In questionable cases, a careful stereoscopic examination in both planes should be made to determine the condition of the lateral articulations and laminae.

Examination by means of radiopaque oil

When the original roentgenograms are negative or inconclusive, and clinical localization of the lesion is uncertain, it may be desirable to attempt localization by means of a radiopaque oil injected into the spinal subarachnoid space. The warmed, heavy, opaque oil may be introduced into the cisterna cerebellomedullaris, or into the lumbar portion of the spinal canal, after removal of an
amount of spinal fluid equal to the amount of oil that is to be introduced. No less than 5 c.c. of oil should be used. Making of a cisternal injection is not devoid of danger, and this procedure is not recommended for use as a routine unless the operator is familiar with the technic for cisternal puncture. From the standpoint of the roentgenologist cisternal injection has some advantages, since the oil passes downward more easily than upward, and false blocks and defects are less likely to be produced. The examination should be made on a tilting roentgenoscopic table. If the oil is not in-

FIG. 20. OPAQUE OIL IN NORMAL CAUDAL SAC

FIG. 21. DEFECT IN SHADOW OF OPAQUE OIL PRODUCED BY INTRAMEDULLARY GLIOMA

The central defect and the streaking of opaque oil on the lateral margins of spinal cord are noteworthy.

jected while the patient is on the table, care should be taken to see that he is kept recumbent between the time of injection and that of the roentgenoscopic examination, so that movement of the oil will not commence before it can be observed. The head should be raised to keep the oil from passing above the cisterna.

Assuming that the oil has been introduced into the cisterna, the patient is placed prone on the horizontal table. This position al-
There is a well defined concavity corresponding to the upper surface of the tumor.

FIG. 23. BLOCK EVIDENCED BY SHADOW OF OPAQUE OIL, PRODUCED BY FRACTURE DISLOCATION OF SIXTH CERVICAL VERTEBRA ON THE SEVENTH; OVERRIDING OF LATERAL ARTICULATIONS

FIG. 24. OPAQUE OIL RETAINED IN INFLAMMATORY POCKETS PRODUCED BY CHRONIC ADHESIVE ARACHNOIDITIS
lows examination of the posterior aspect of the spinal canal, for the oil will rise to the posterior surface. The descent of the oil is observed roentgenoscopically as the head of the table is raised. The speed of descent may be governed by the degree of elevation. The outline of the column of oil should be carefully observed for persistent defects and retained droplets. If no block is encountered, the oil is traced to the sacrum. The patient is now turned to a supine position, and the return flow of the oil to the cisterna is observed. This permits inspection of the anterior portion of the spinal canal. The oil will ascend more slowly than it descends, and an extreme Trendelenburg position may be required to hasten its excursion. When a filling defect or block is encountered, a roentgenogram should be made of the involved region, without disturbing the position of the patient or the angle of the table. It is unusual to get complete or partial blocking of the opaque oil without there being clinical evidence of a block of spinal fluid. Transitory delays and even false blocks may be observed in cases of kyphosis, lordosis, or scoliosis, but the deformity of the spine should draw the attention of the examiner to that possible source of error.

Normally, the radiopaque oil will pass to the caudal sac without delay. As it moves along there is depicted a silhouette of the subarachnoid space, the shape of which is influenced by the nerves and ligaments contained therein. At the caudal sac the oil normally
collects in an elongated mass, the inferior end of which tapers gradually to a point opposite the first and second sacral segments (Fig. 20). There may be a transitory delay at the cervicothoracic juncture, due to the change in spinal curvature, but this is easily overcome by increasing the tilt of the table.

Fundamentally the examination is concerned with the interpretation of filling defects in the contour of the shadow cast by the oil, and complete or partial arrest of the opaque medium. Lesions within the spinal canal that occupy space and are large enough to deform the subarachnoid space will produce variations in contour of the oil, and theoretically, because of their different relations to the subarachnoid space, the lesions depicted can be identified as intramedullary (Fig. 21), subdural (Fig. 22), and extradural (Fig. 23). Practically, these distinctions cannot always be made, although it is frequently possible to discern whether the lesion is related to the ventral, dorsal, or lateral aspects of the spinal cord. Although the shape of the filling defect will permit the diagnosis of tumor, the probable nature of the growth cannot be determined from the study with opaque oil alone.

Complete arrest of the oil may be due to any lesion within the spinal canal which obstructs the subarachnoid space, such as tumors, fracture dislocations (Fig. 23), intraspinal tuberculous abscess, and so forth. Complete block is rarely a result of inflammatory lesions, but because of the inflammatory bands the oil is usually arrested in small, rounded or irregular pockets. The persistent arrest of such shadows of oil is usually seen in cases of chronic adhesive arachnoiditis (Fig. 24). Smaller droplets may be arrested temporarily in normal cases, especially if too small an amount of oil is injected and is allowed to separate into numerous globules before the downward excursion is started.

Technical errors that interfere with a successful examination include the following: (1) injection of the oil in the soft tissues before the spinal canal is reached (this is more likely to occur in association with cisternal injection), (2) epidural injection instead of subarachnoid injection. Repeated lumbar punctures may result in intraspinal hematoma (Fig. 25), which will produce a tumor-like defect in the shadow of the cauda when radiopaque oil is injected soon afterward.

References