Clinical Radiology of the Spine and the Spinal Cord

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Preface

It is 20 years since my training in neuroradiology commenced at Atkinson Morley's Hospital, London, England. After 8 years as Consultant and Clinical Lecturer at the Regional Neurological Centre, Newcastle-upon-Tyne, England, I joined the Department of Radiology at the Medical School of McMaster University. In these three institutions and in several other hospitals in different parts of the world where I worked for shorter periods, I learned a great deal from colleagues, residents, students, and foremost, from the patients I examined.

In writing this book, it is my intention to share these experiences with the reader, hoping thereby to enhance the knowledge and skills they themselves gain over the years. There is no substitute for the day-to-day practice of radiology. The obligation to commit in a written report one's own interpretation of a study; the questions of medical students, nurses, and radiographers; and the discussions of problem cases with the clinicians concerned—all are essential in the making of a competent radiologist. Because we live in an era of ongoing technical advances, as attested to by the introduction of computed tomography, nonionic contrast media, digital subtraction angiography and magnetic resonance, it is neither feasible nor practical to describe every possible image of one disease entity, let alone the spine and the spinal cord in health and disease. The radiological literature is voluminous; new findings, unusual cases and recent observations continue to be published and will not cease. In mentioning some old techniques of investigating disc disease, it is with the intention that they might be useful for those who have no access to modern technology.

I have borrowed a number of illustrations from friends and colleagues whose names are appropriately mentioned, and I wish to thank them all for their help. I wish to thank my associates in the affiliated Radiology Departments of McMaster University, at McMaster Health Sciences Centre, Hamilton General Hospital, St. Joseph's Hospital, and Henderson General Hospital for allowing me access to their material. All photographic prints and many of the illustrations were made by the Audiovisual Department of McMaster University. Special thanks are due to all staff members of that department, and in particular to Mr. Geoffrey Brown for his efforts to obtain the best reproductions of the original radiographs. The secretarial assistance of Monika Ferrier and Monica Schmidt-Oak was indispensable, and to both ladies I wish to say thank you. Thanks are also due to the radiographers in our and in other institutions from which some of the illustrations were borrowed. The CT images from McMaster University Medical Centre were done on the Technicare Delta 2020 scanner. The Magnetic Resonance Images were obtained, unless otherwise stated, from Dr. A. Kuehnert, Diagnostic Imaging Clinic in Dietzenbach, West Germany, utilizing Siemens Magnetom.

To my wife Wilma and to my children, Dena and Karem, I wish to apologize for my frequent infringement upon family time while writing this book. To Berta Steiner, Director of Production at University Park Press, I express my appreciation for her cooperation and diligent attention to the production for the volume. Last but not least, I wish to thank Mrs. Ruby Richardson of University Park Press for her patience and endeavors in the formulation of this book.

M.B.

Contents

The Normal Spine

1

Cervical Spine

Routine radiographs of the cervical spine usually comprise an anteroposterior, a lateral, an open-mouth and two oblique views with 45° rotation. These may be supplemented by two lateral radiographs with head flexion and extension (Merrill, 1967). To highlight the appearance of the various vertebral elements in the different projections, a number of disarticulated vertebrae were used. Each vertebral element was covered with lead paint, and standard radiographs were made (Fig. 1.1).

Anteroposterior Radiograph

The prominent structures shown in the frontal projection are the body of the cervical vertebrae, the uncovertebral joints, the bifid spinous processes, and the transverse processes of the seventh cervical vertebra (Fig. 1.2). Note in this projection that the transverse processes are superimposed on the articular pillars, the laminae are superimposed on the vertebral bodies, and adjacent articular facets overlap one another. Note also that the pedicles are not seen end-on because they form an angle of approximately 45° with the vertebral body and are superimposed on the base of the laminae (Fig. 1.3). Particular attention should be given to the height of the interspinous spaces; widening of an interspinous distance such that it measures more than 1.5 times the interspinous distance at the contiguous levels above and below indicates an anterior dislocation. Also of particular importance is the alignment of the spinous processes along the midline; an abrupt lateral deviation is suggestive of unilateral facet dislocation.

Lateral Radiograph

The lateral radiograph is the most important single film in the examination of the cervical spine. It provides information about the: (1) cervical vertebrae; (2) disc; (3) spinal canal; (4) retropharyngeal space; and (5) craniocervical area (Fig. 1.4). Each of these is separately discussed.

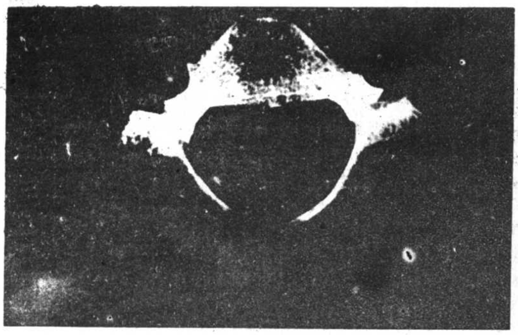
Cervical Vertebrae

The various elements of a typical cervical vertebra (C3–7) are shown in Figure 1.5. Note that in the lateral projection the pedicles are foreshortened and the laminae are largely obscured by the articular pillars.

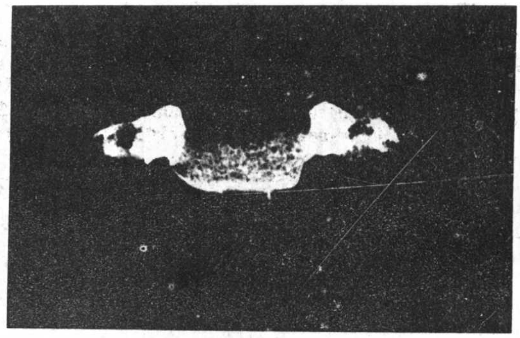
Intervertebral Discs

The width of the intervertebral disc spaces and the integrity of the vertebral end-plates should be thoroughly examined. Note that the C7–T1 disc is slightly narrower than the ones above, and there is no intervertebral disc at C1–2. The vertebral end-plate is a thin band of condensed cancellous bone at the upper and the lower ends of the vertebral body. The word "end-plate" is a literal translation from the German *Schlussplatte.*

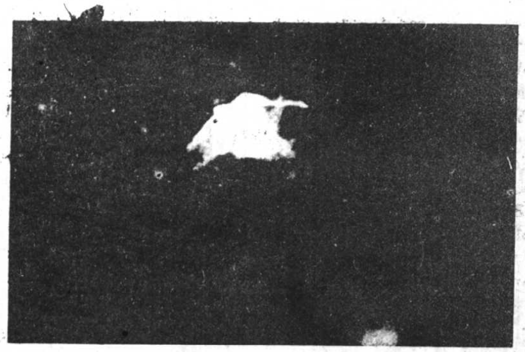
Pedicles



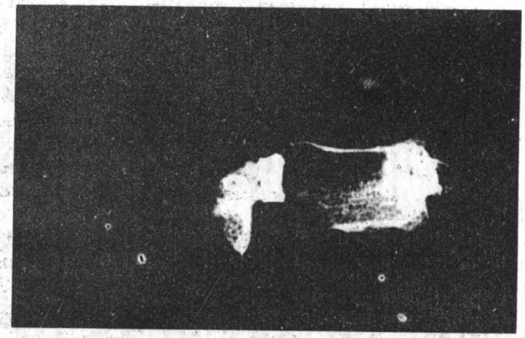
Superior-inferior view



Antero-posterior projection

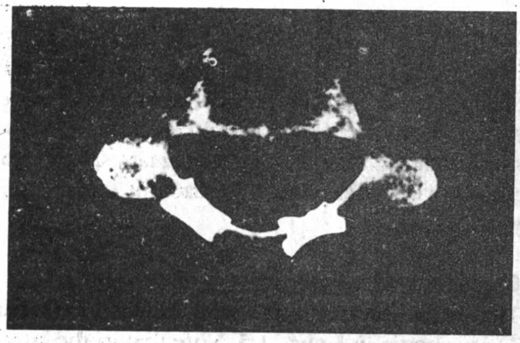


Lateral projection

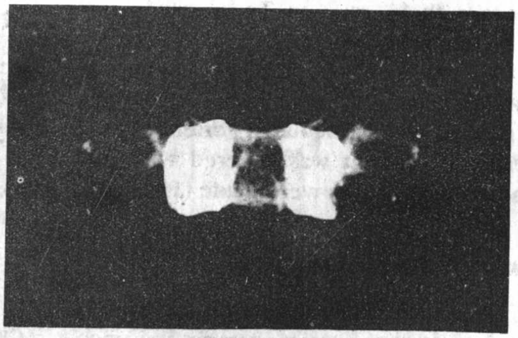


Oblique projection

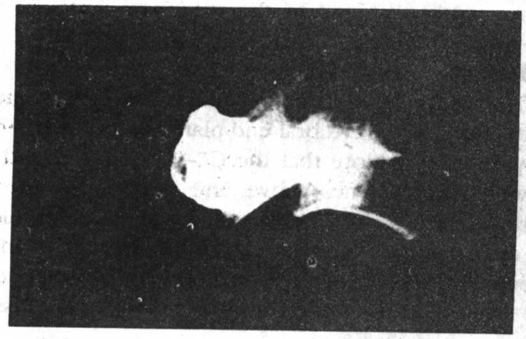
A



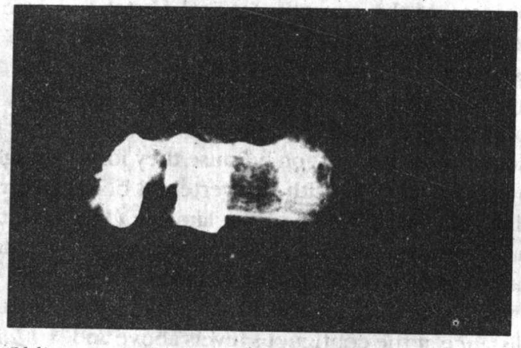
Superior-inferior view



Antero-posterior projection

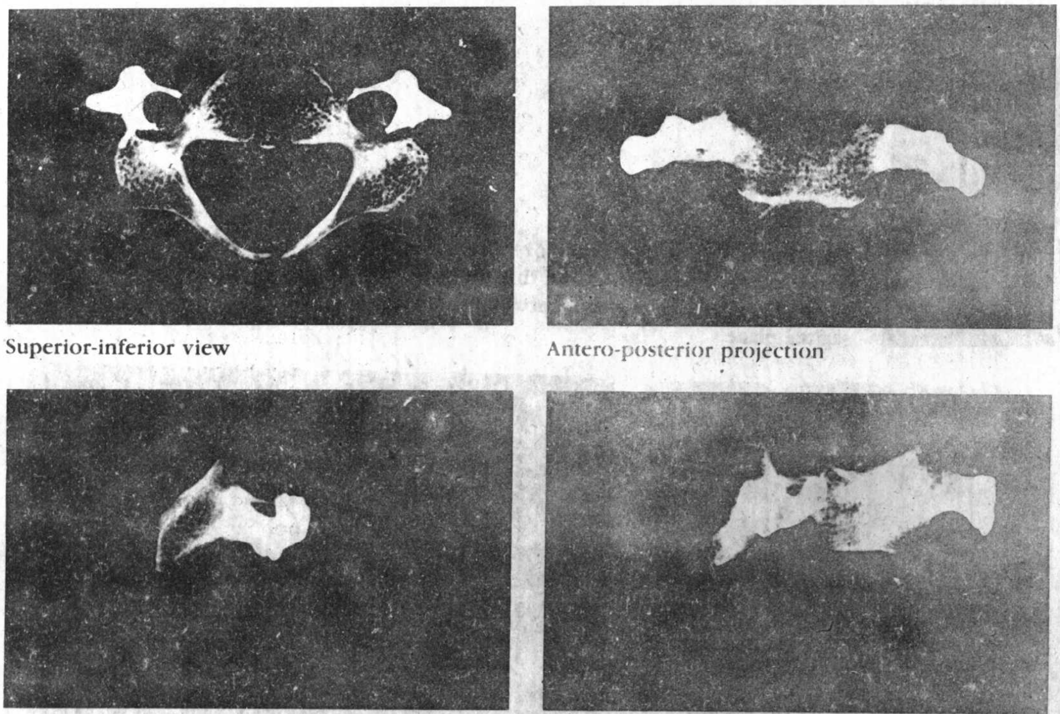


Lateral projection



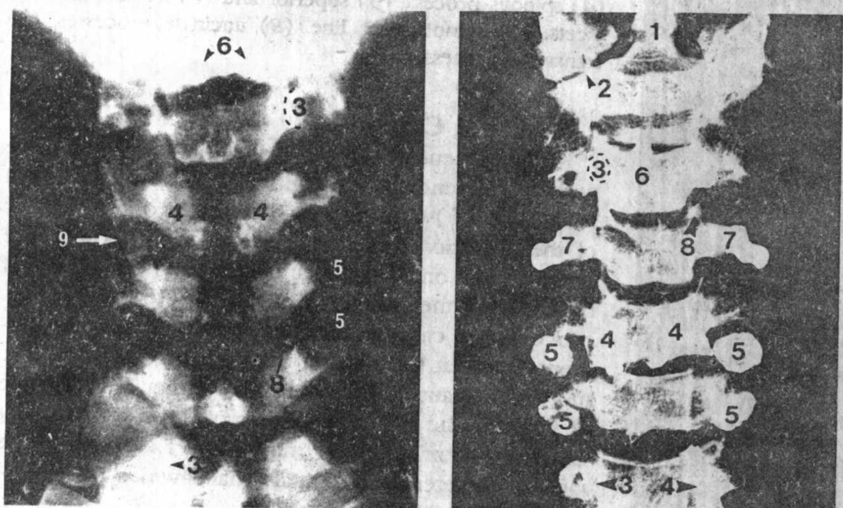
Oblique projection

B



C

Figure 1.1 Cervical vertebrae in which the posterior elements were coated with lead paint to highlight their appearances in the standard radiographic projection.



A B

Figure 1.2 Anteroposterior radiograph of the cervical spine (A) and the dry skeleton covered with lead paint (B). (*1*) odontoid process, (*2*) superior articular facets of the axis, (*3*) pedicle, (*4*) laminae, (*5*) superior and inferior articular facets, (*6*) bifid spinous process of cervical vertebra, (*7*) transverse processes, (*8*) uncinate process, (*9*) cornua of the thyroid cartilage. Note that on the seventh cervical vertebra of the dry skeleton a wire was put around the right pedicle (*3*) and the base of the left lamina (*4*).

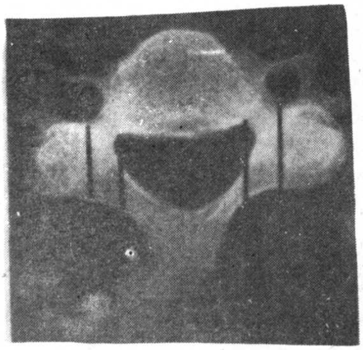


Figure 1.3 Superior inferior view of a lower cervical vertebra. Note that the pedicles and the base of the laminae are in the same sagittal plane.

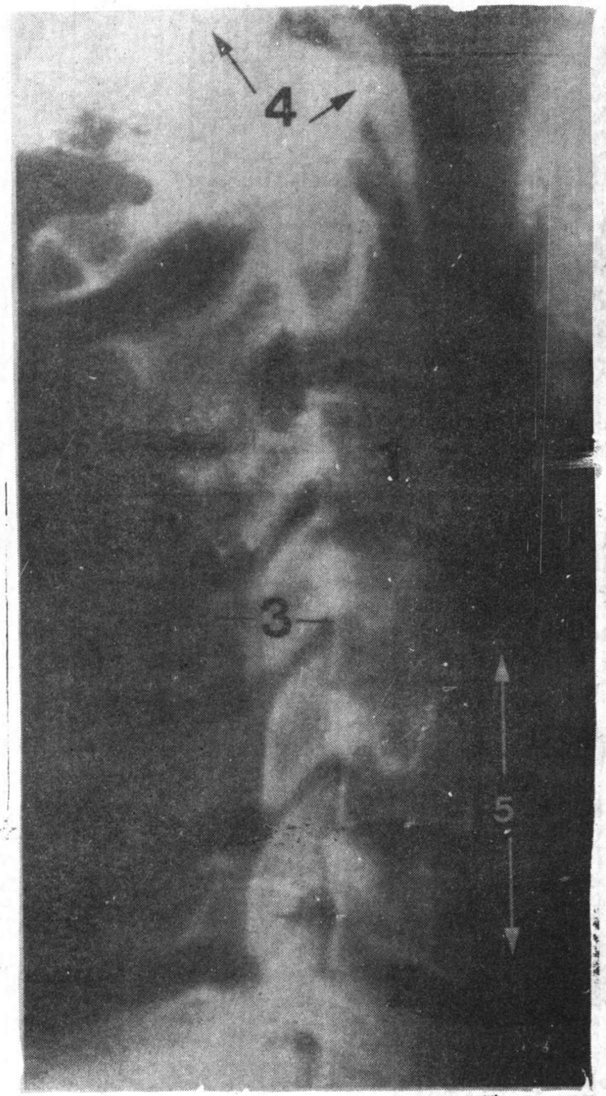


Figure 1.4 Lateral view of the cervical spine. This projection provides information related to: (*1*) the vertebrae, (*2*) the intervertebral discs, (*3*) the spinal canal, (*4*) the craniovertebral junction, and (*5*) the retropharyngeal space.

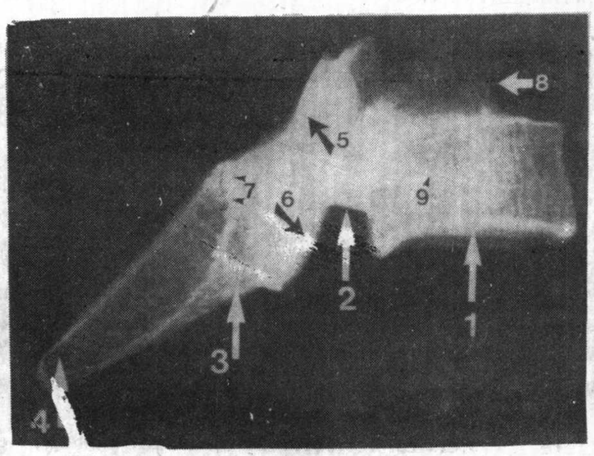


Figure 1.5 Typical lower cervical vertebra in the lateral projection. (*1*) vertebral end-plate. (*2*) pedicles, (*3*) laminae. (*4*) spinous process. (*5*) superior and (*6*) inferior articular facets. (*7*) spinolaminar line. (*8*) uncinate processes. (*9*) transverse processes.

Spinal Canal

Assessment of the cervical spine is not complete without reference to the sagittal diameter of the spinal canal (Fig. 1.6). This may be measured from the center of the posterior surface of the vertebral body to the nearest point on the spinolaminar line (the line formed by fusion of the laminae with the base of the spinous process). In cases of cervical spondylosis, measurements made at the level of the intervertebral discs are more significant. In adults, using a target film distance of 180 cm, the sagittal diameter of the spinal canal at C3–7 is approximately 17 mm (range 12–24 mm). The sagittal diameter of the spinal canal is wider at C1 (16–32 mm) and C2 (15–27 mm).

In children, the diameter of the spinal canal appears abnormally wide in relation to the size of the vertebrae. In the absence of bone erosion this is a normal finding and does not necessarily indicate an intraspinal expanding lesion (Wholey, Bruwer, and Baker, 1958).

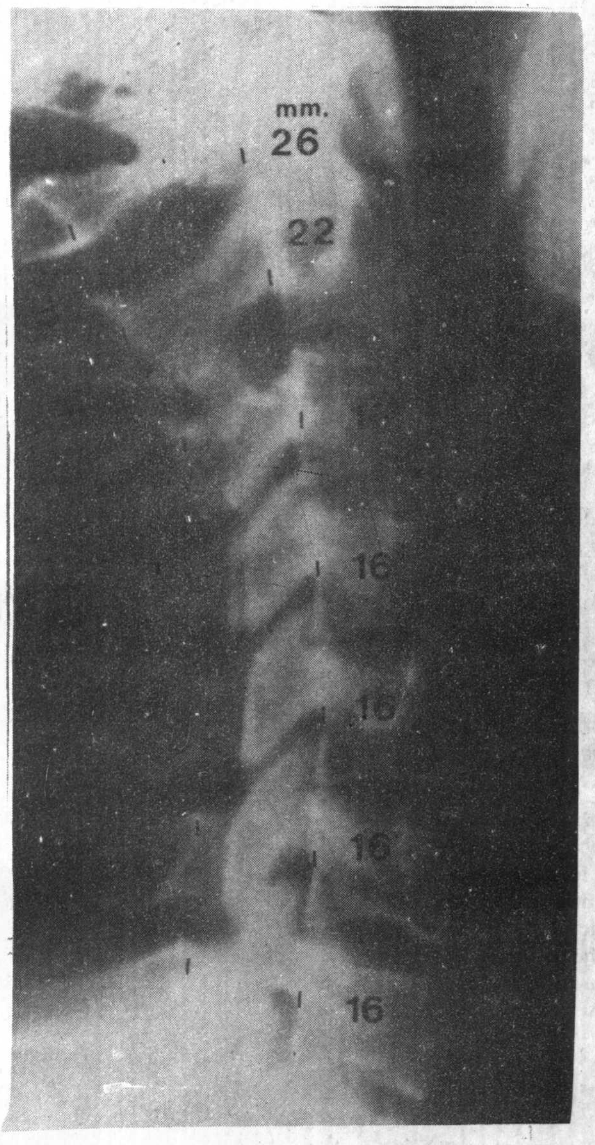


Figure 1.6 Spinal canal. Measurements of the spinal canal are made from the center of the posterior surface of the vertebral bodies to the nearest point on the spinolaminar line. Note that the sagittal diameter of the spinal canal is widest at C1 and C2, and there is a uniform diameter of the spinal canal from C3 to C7.

Craniocervical Area

Several lines and measurements have been devised to assess the craniovertebral relation (Wackenheim, 1974). The majority of these lines are of limited value when correlated with the patient's symptomatology. Slight deviation from the set standards is not invariably symptomatic, and symptoms from hind-brain herniation may develop in the absence of bony abnormality (Burrows, 1981). The lines which are probably in use more than others are Chamberlain's line, McRae's line, and the basilar line (Fig. 1.7).

Palatooccipital Line (Chamberlain's Line) The palatooccipital line is drawn from the posterior margin of the hard palate to the posterior rim of the foramen magnum. The tip of the odontoid process normally lies 1–7 mm above this line. In pointing out the limitations of this measurement, McRae showed that the position of the odontoid process is influenced by the length of the clivus and the size of the occipital condyles. If the clivus is short or the occipital condyles are small, the atlas and axis are high in position and may be thought to be abnormal.

Sagittal Diameter of the Foramen Magnum The normal sagittal diameter of the foramen magnum measures 27–40 mm. McRae (1960) estimated the size of the foramen magnum in cases of occipitalization of the atlas by measuring the shortest anteroposterior diameter of what he called the *effective foramen magnum.* In cases of basilar invagination the effective foramen magnum may lie between the posterior surface of the dens and the posterior rim of the foramen magnum or the fused posterior arch of the atlas if the latter is occipitalized. Patients showing an anteroposterior diameter of the effective foramen magnum of less than 19 mm had symptoms or signs of disease in the lower medulla or upper spinal cord.

Basilar Line The basilar line, also called the clivoaxial line, is a downward extension of a line drawn along the posterior surface of the clivus. It passes at an angle tangential to, or intersecting the tip of, the odontoid process.

Width of the Atlantoaxial Predental Space

With the head in a flexed position, the distance between the posterior surface of the anterior arch of the atlas and the anterior surface of the dens should not exceed 3 mm in adults or 5 mm in children (Fig. 1.8).

Posterior Cervical Line

On a true lateral projection, a line is drawn from the anterior cortex of the posterior arch of C1 to the spinolaminar line of C3. Normally, this line touches, lies just behind, or is up to 1.5 mm in front of the anterior cortex of the posterior arch of C2 (Fig. 1.9). Dislocation of C2 on C3 is almost certainly present if the posterior cervical line lies 2 mm or more in front of the anterior cortex of the posterior arch of C2 (Swischuk, 1977). This line is useful in children with questionable C2 dislocation or fracture of the neural arch of the axis. If a fracture is present the body of the axis, carrying the atlas and the cranium, moves forward but its laminae remain attached to C3. Thus the line connecting the spinolaminar junction of the displaced C1 to the spi-

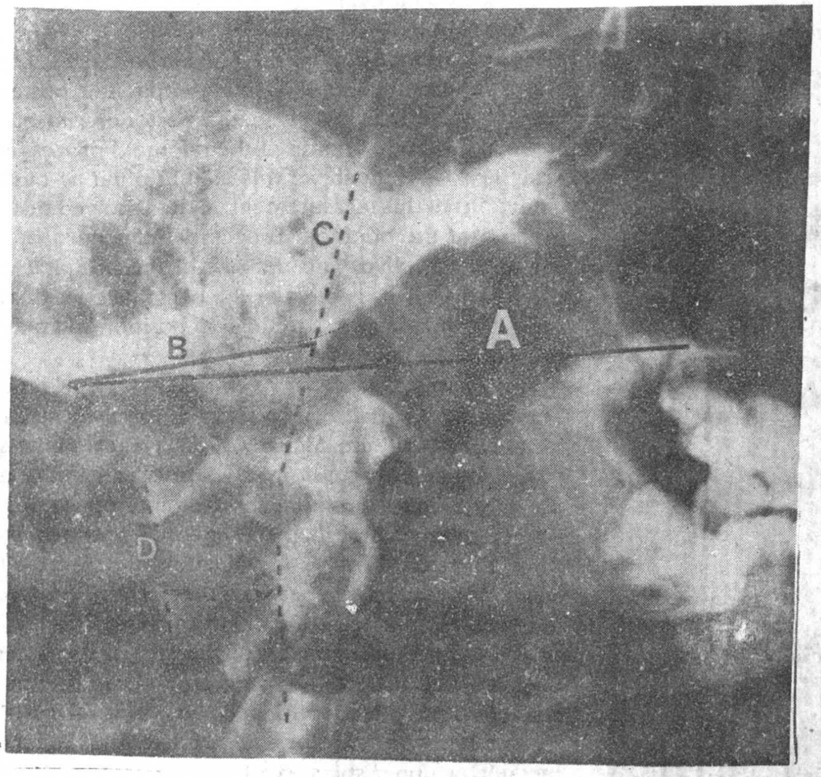
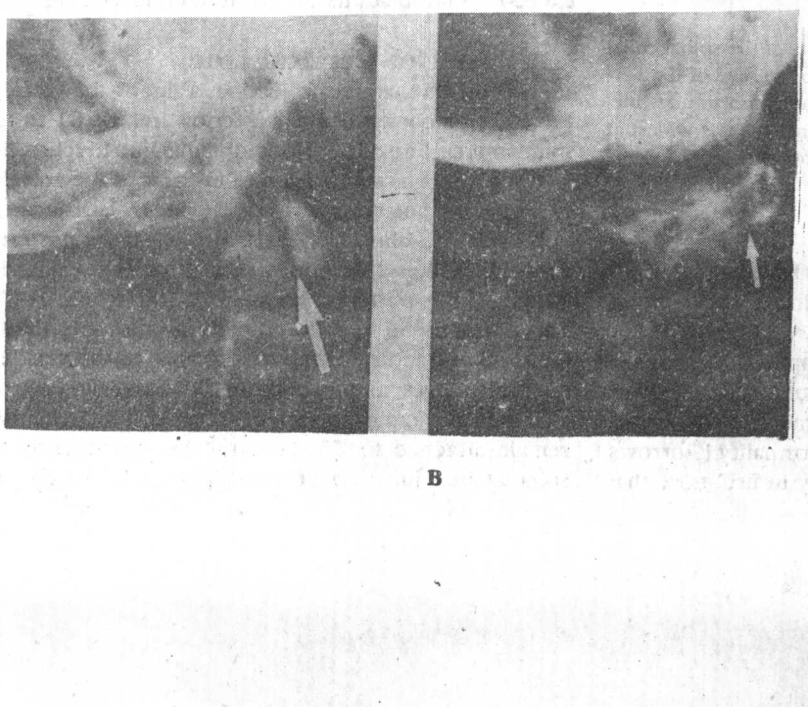


Figure 1.7 Lateral radiograph of the craniocervical junction illustrating some of the lines used for assessment of this area. (*A*) Chamberlain's line from the posterior rim of the hard palate to the posterior rim of the foramen magnum. (*B*) McRae's line from the posterior lip of the foramen magnum to the nearest bony surface across the foramen magnum. The latter may be formed by the clivus or, in cases of basilar invagination, by the posterior surface of the dens. (*C*) The clivoaxial line drawn along the clivus and the posterior surface of the dens and body of the axis. Line (*D*) represents the upward continuation of the spinolaminar line, which normally ends at the posterior rim of the foramen magnum.



A B

Figure 1.8 Lateral view of the craniocervical junction illustrating the normal predental space (*arrows*). This should not exceed 3 mm in adults (*A*) or 5 mm in children (*B*).

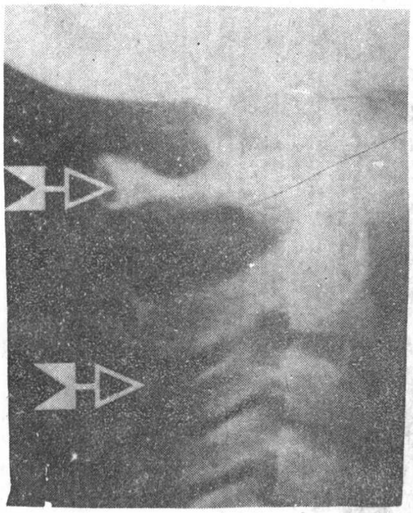


Figure 1.9 Posterior cervical line. ***Arrows*** **indicate the points from which the line is drawn to assess any displacement of the axis (see text).**

nolaminar junction of C3 will lie in front of the undisplaced spinolaminar junction of C2.

Prevertebral Space

The radiological prevertebral space, projected between the vertebral column and the air shadow of the pharynx and trachea, is an important part of the routine examination of the cervical spine. Lesions that may occur in this area include: prevertebral hematoma, nasopharyngeal and retropharyngeal tumors, lymphoma, tumors of the sphenoidal air sinuses, and chordoma.

The prevertebral space is divided anatomically into (1) a retropharyngeal space behind the pharynx and (2) a retrotracheal space behind the trachea (Fig. 1.10). In adults, the width of the retropharyngeal space at C3 is approximately 3.2 mm (range 2–7 mm). The retrotracheal space at C6 measures approximately 15 mm (range 11–20 mm). These measurements are made along lines perpendicular to the air shadow of the pharynx and trachea (Penning, 1981). In children, buckling of the trachea makes assessment of the prevertebral space much more difficult.

A

B

Figure 1.10 Prevertebral space. (A) The prevertebral space in adults indicated by the horizontal lines, measures approximately 2–7 mm at C3 and 11–20 mm at C6. (B) In children buckling of the trachea makes assessment of the prevertebral space much more difficult.