RADIOLOGICAL STUDY OF SPINAL DEFORMITIES

THESIS

SUBMITTED FOR PARTIAL FULFILLMENT FOR

THE MASTER DEGREE IN

(RADIO-DIAGNOSIS)

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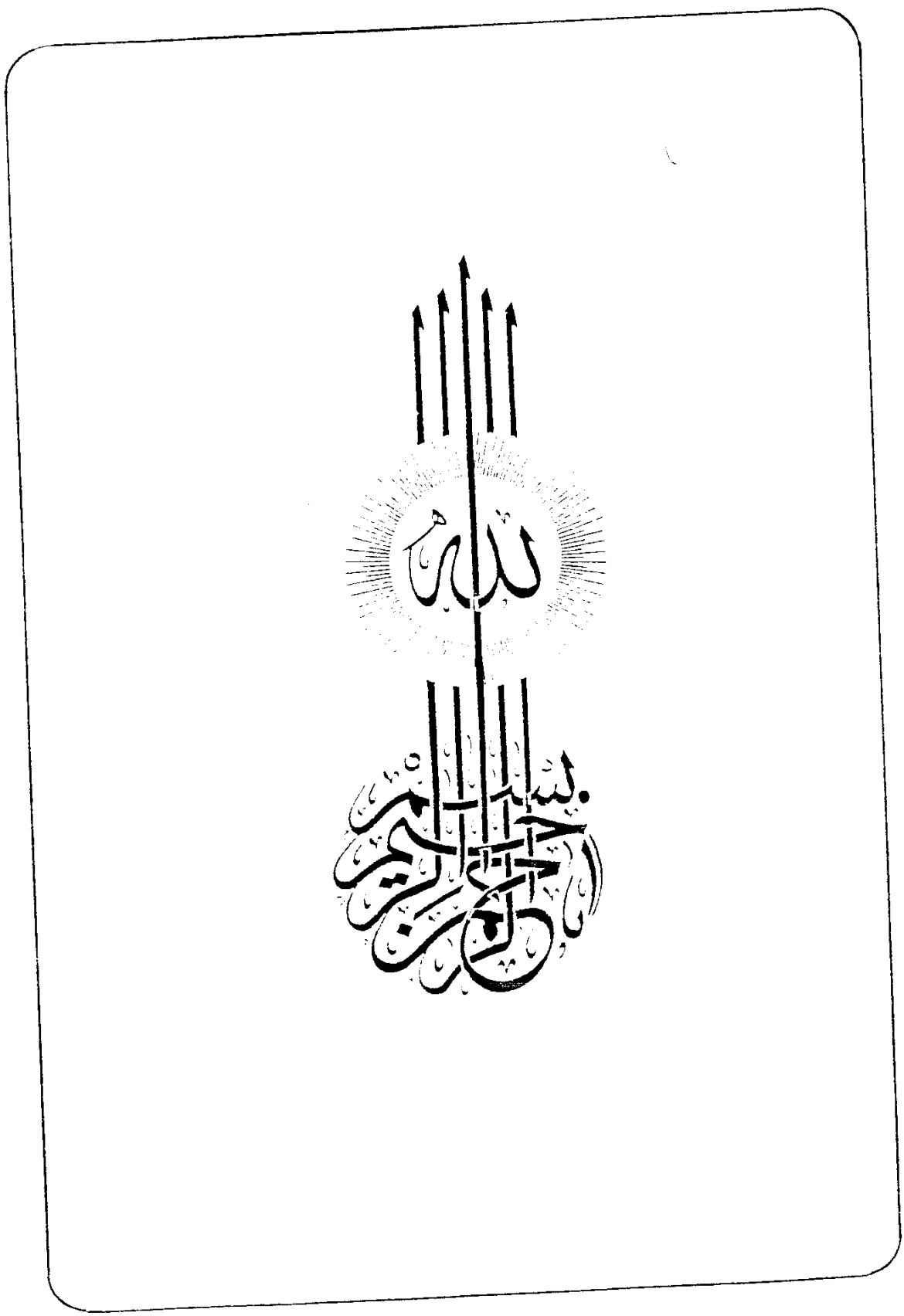
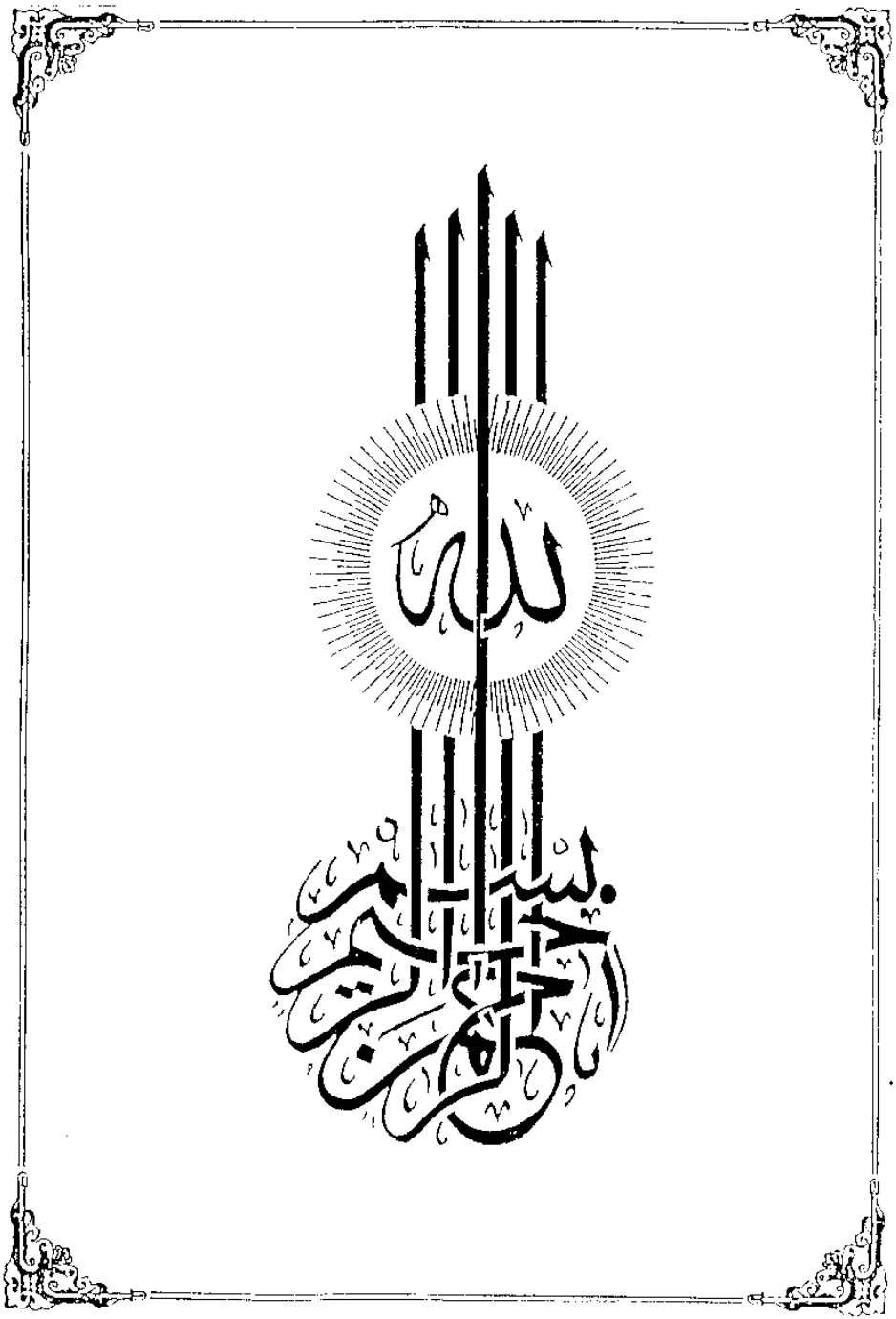
1986





ACKNOWLEDGMENT

With great pleasure, I wish to express my sincere gratitude and appreciation to **PROF.DR. MOHAMED SAMY EL BEBLAWI**,Chairman of Radio-diagnosis Department , Ain Shams University for his generous help, support and kind advices.

I would also like to express my faithful gratitude and thanks to **DR. HEBA MOHAMED KHALIL EL DEEB** , Lecturer of Radio-diagnosis, Ain Shams University for her continuous help, guidance and valuable advices throughout the preparation of this work.

I wish to thank deeply my senior staff and colleagues in Radiology Department for their assistance during this work.

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CONTENTS

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INTRODUCTION

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Spinal deformities represent a major problem for the orthopedic surgeon as well as for the patient and his family. Deformities of the spine affect patient's gait, stature and cosmotic appearance.

An important factor that has contributed to improvements in spinal surgery is the accurate pre-operative diagnosis which resulted from the considerable advances in radiological technique and has made spinal operations both easier and less traumatic for the patient and surgeon.

Roentogenology plays an important role in the dagnosis of abnormal spinal curvatures as regards the curve pattern, its flexibility, vertebral rotation and skeletal maturity. A good radiological investigation is therefore essential and influencing management of spinal deformities.

The aim of the present thesis is to study the causes and radiological appearances of the different types of spinal deformities and the role of radiology in their diagnosis.

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EMBRYOLOGY

DEVELOPMENT OF VERTEBRAE

The development of the vertebral column passes through four stages: 1) Stage of non-segmented notochord. 2) Stage of membranous or precartilaginous vertebral column. 3) Stage of cartilaginous vertebral column. 4) Stage of ossification of the cartilaginous vertebral column. (Mahran et al.,1973).

THE STAGE OF NON-SEGMENTED NOTOCHORD :

The first evidence of the developing axial skeleton is the notochord. It is a midline rod mainly of mesodermal origin, which appears at around the 17th day of embryonic life. It is situated between the paired lateral mesodermal plates. (Hawkins, 1984)

THE STAGE OF MEMBRANOUS OR PRECARTILAGINOUS VERTEBRAL COLUMN:

The lateral mesodermal plates differentiate to form segmental somites around the 22nd day with the appearance of intersegmental blood vessels. Now,there are 42-44 pairs of somites : 4 occipital, 8 cervical , 12 thoracic, 5 lumbar, 5 sacral and 8-10 coccygeal. These paired mesodermal somites develop a central cavity and form a lateral myotome and a ventro-medial sclerotome. The sclerotomes migrate towards the notochord, surrounding it to form part of the membranous or precartilaginous vertebral column. Each sclerotome is formed of a caudal condensed cell mass and a cranial less

condensed portion. The condensed cell mass moves cranially and partially differentiates into intervertebral disc. At the same time the rest of this condensed cell mass proliferates and moves towards the less condensed cranial portion of the sclerotome below, with which it fuses to form the membranous vertebral body. A 2nd mass of proliferating sclerotome migrates dorsally to give the membranous neural arch, and another group migrates ventrolaterally to give the transverse and costal processes.

THE STAGE OF CARTILAGINOUS VERTEBRAL COLUMN :

The intersegmental blood vessels are situated in the denser portion of the developing membranous vertebrae, and around these vessels, chondrification satarts at about 6 weeks, heralding the formation of cartilaginous vertebral column. The cartilage cells proliferating around the segmental blood vessels constrict the notochord which regresses at the level of the developing vertebral bodies but persists at the level of the developing discs and gives rise to the nucleus pulposus. The fibrous and fibrocartilaginous ring, the annulus fibrosus, which develops around the nucleus pulposus is formed from part of the sclerotome which does not chondrify.

Six centres of chondrification develop in the membranous vertebrae : 2 centres to form the cartilaginous centrum, 2 centres for the neural arches and transverse

processes and 2 centres develop to form the costal elements except in the lower sacrum and coccygeal regions . The costal elements in the thoracic region give rise to fully developed ribs but elsewhere , they form part of the transverse processes of the vertebrae or lateral mass of the sacrum. Any failure of development during this stage gives rise to deformities of the vertebral bodies and neural arches.

THE STAGE OF OSSIFICATION OF THE CARTILAGINOUS VERTEBRAE :

It starts around the 3rd month of foetal life and is still incomplete at birth. Ossification of vertebral column takes place from both primary and secondary centres. Each typical vertebra is ossified from 3 primary centres : one in each half of the neural arch appears at about the 3rd month and one in the body which appears at about the same time. ((Hawkins,1984). At birth , a vertebra consists of 3 pieces, the centrum and the halves of the neural arch, joined to each other by 2 joints called the neurocentral joints (Mahran et al.,1973) . The two halves of the arch unite during the first year. The centrum unites with the neural arch at about the third year.(Warwick and Williams ,1973). At puberty five secondary centres appear : one for the tip of each transverse process, one for the end of the spinous process and two annular epiphyseal discs for the circumferential parts of the upper and lower surfaces of the body. These secondary centres fuse with the rest of te bone about the age of 25

years. The centrum of the vertebra is occasionally ossified from bilateral centres which sometimes fail to unite. The suppression of one of these centres leads to the formation of a wedge-shaped vertebra and is a well recognised cause of lateral curvature of the spine. The condition is frequently multiple. Exceptions to this mode of ossification occur in the first, second and seventh cervical and in the lumbar vertebrae. (Warwick and Williams,1973)

The first cervical vertebra, the atlas, is ossified from three centres : one centre for each lateral mass appears at about the second month. They extend posteriorly to form the posterior arch and they unite between the 3rd and 4th year. One centre for the anterior arch appears at about the end of the first year and unites with the lateral masses between the 6th and 8th year .(Mahran et al.,1973).

The second cervical vertebra, the axis, is ossified from 5 primary and 2 secondary centres. One centre for the body appears at about the 4th or 5th month. Two centres for the neural arch appear at about the 2nd month. Two centres for the sides of the dens [the odontoid process-which represents the centrum of the atlas] appear at 6th month and joins each other before birth. An additional centre for the tip of the odontoid process appears about the 2nd year and joins the rest at 12 years. The base of the dens is joined to the body by cartilaginous disc which gets ossified at about the same age [12 years].

The seventh cervical vertebra shows an additional feature in that the costal processes are usually ossified from separate centres, which appear about the 6th month and join the body and transverse process at the 6th year. The costal processes may remain separate and grow laterally and forwards as cervical ribs.

The lumbar vertebrae have two additional centres, one for each mamillary process.(Warwick and Williams,1973)

In the sacrum, each of the 5 sacral segments ossify from 3 primary centres. One for the body and two for the neural arches. But in addition, the upper 3 sacral segments each have two costal centres for the anterior parts of the alae of the sacrum.

In the coccyx, each coccygeal segment ossifies from a single centre, therebeing no neural arch.

The 5 sacral segments fuse into a single mass during adolescence or early adult life [25 years] , and fusion of the coccygeal segments occurs at about the same age.(Warwick and Williams, 1973)

ANATOMY

ANATOMY OF THE VERTEBRAL COLUMN

The vertebral column or the spine forms the central axis of the body and is built up of : 1)A series of vertebrae, 7 cervical, 12 thoracic, 5 lumbar, 5 sacral [fused into the sacrum] and 4 or 5 coccygeal [fused into the coccyx] 2) Intervertebral discs of fibrocartilage, in between the bodies of the vertebrae. They constitute about 20% of the length of the vertebral column . [The average length of the vertebral column is about 70 cm in the adult male and 60 cm in the female](Mahran et al.,1971)

STRUCTURE OF A TYPICAL VERTEBRA [FIG. 1]

Each vertebra consists of an anterior part, the body , and a posterior part,the neural arch, which encloses the vertebral foramen occupied in life by the spinal cord, the meninges and associated vessels. The neural arch is subdivided into paired pedicles, laminae, transverse processes, superior and inferior articular processes and a single spinous process. (Warwick and Williams, 1973) The body is strong and cylinderical and forms the weight bearing portion of the vertebra. Therefore, the size of the body increases as we go downwards towards the lumbar region. The body has un upper and a lower surface articulating with the vertebra above and below by the intervening intervertebral disc. The pedicles arise from the posterolateral aspect of the body and form the superior and inferior margins of the