Evaluation of the Results of Surgical Management of Idiopathic Scoliosis by Posterior Instrumentation with Anterior Release in Adolescents and Older Children

Thesis

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By

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This work is dedicated to

My Parents,

My wife, and

My Kids

INTRODUCTION

Historical Aspect of Scoliosis

Scoliosis is derived from the Greek word meaning curvature. When used in the medical literature, it is signifies a lateral curvature of the spine. It is recognized since antiquity **(Moe, 1987)**. The first who described the deformity was Hippocrates in 300 BC. The possible relationship between spinal deformity and pulmonary diseases was also mentioned. No distinction was made between the deformity due to infection and true scoliosis. The treatment was by forcible horizontal traction and leg distraction in suspension. The words kyphosis, lordosis and scoliosis were coined by Galen (131-201 AD). His treatment of spinal deformities followed that of Hippocrates **(Moe, 1987).**

In his book "The Canon of Medicine" Ibn Sina (Avicenna) 980-1037 AD distinguished spinal deformities secondary to infection and reported the cold abscess and gibbous. He used a special instrument to correct scoliosis (Fig1) **(Iqubal, 1991).**

Ambrosie Pare (1510-1590) was first to describe congenital scoliosis, and he also recognized cord compression as a cause of paraplegia. His treatment of scoliosis adherent closely to Hippocrates method, but he was given a credit for inventing a steel corset (Para A1589). Andre, who first coined the word orthopedia in 1741, wrote about spinal curvature. He recommended corset and exercises as a method of treatment **(Andre, 1741).**

Myotomies, the first surgical technique for correction of scoliosis, were advocated by Guerin in 1839 **(Guerin, 1839).** Volkmann resected protruded rib deformity in 1889.

The discovery of the x-ray by Wilhelm Konard Rontegen in 1895 opened the gate for better understanding of etiologic factors in scoliosis **(Moe, 1987).**

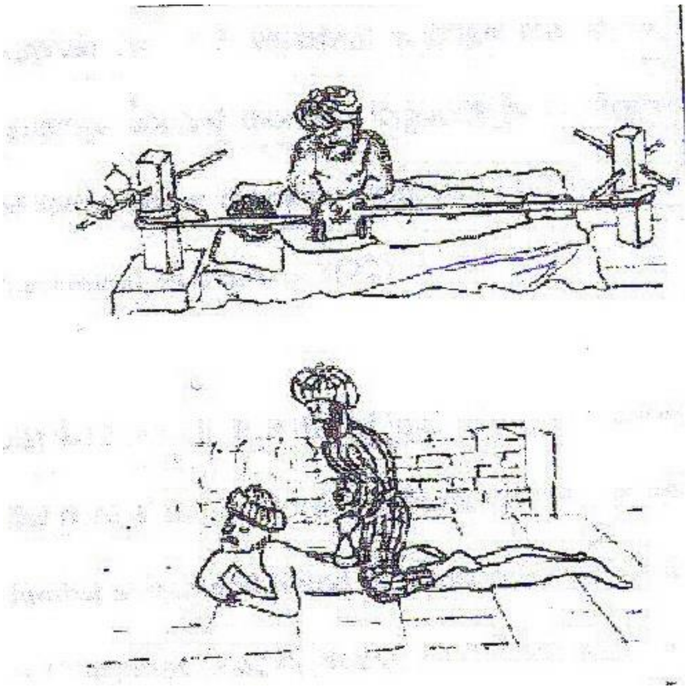

Fig. 1: Ibn Sena method of correction of spinal deformities (Iqubal QA, 1991).

The 20th Century

Codvilla in 1901 described the technique of hemivertebral resection in congenital scoliosis. **Hibbs** in 1911 described the method of spine fusion in tuberculosis and suggested its possible use in scoliosis. In 1914 he performed the first fusion for scoliosis. With **Risser** and **Ferguson**, he published the end result study of fusion of 360 scoliosis cases. In the same article the use of turnbuckle corrective cast was described, to which the name of Risser is commonly ascribed **(Hibbs et al., 1931).** Radiological measurement of scoliosis was first described in 1945. His method was suggested to **Cobb** by radiologist called Lippman **(Cobb, 1948).**

The post-war period

This period was characterized by better understanding of pathogenesis and the development of osteosynthesis. The technique of grafting was improved by **Goldstein, (1966)** and **Moe,** (1958). The real and practical osteosynthesis started in 1952 by **Paul Harrington.** This represented the milestone for the correction of scoliosis **(Harrington, 1960).** The anterior instrumentation has introduced by **(Dwyer et al., 1969)** and later by (**Zielke and Pellin, 1976).**

The segmental spinal instrumentation was introduced by **Luque, (1982)** and later by **Cotrel** and **Dubousett, (1988).** Nowadays, Rapid progress in the instrumentation and technique of surgery has taken place. Some of them have well evaluated, whereas, others are too recent to have been properly evaluated **(Newton et al., 1997 and Fricka et al., 2002).**

ANATOMICAL AND BIOMECHANICAL ASPECTS OF SCOLIOSIS

Normal curves of the spine

1- Curves in sagittal plane

A- Cervical lordosis:

It is present in intrauterine life. It is discal in origin, as the vertebral bodies are rectangular and not wedge shaped **(Bangall KM et al., 1977).**

B- Thoracic kyphosis:

It is present in intrauterine life. It is vertebral in origin due to the wedge shaped vertebral bodies. The average normal thoracic kyphosis is 35degrees **(Bangall et al., 1977).** In the study of Gelb et al, the mean upper thoracic kyphosis (T1-T5) was 14 degrees and lower thoracic kyphosis average 34 degrees **(Gelb et al., 1995).**

C- Lumber lordosis:

It is begin to develop at 9-12 months. It is discal in origin **(Bangall et al., 1977).** Various authors have attempted to quantify the normal lumber lordosis. Farfan et al measured the lordotic curve (L1-L5) of 182 lumber spines and found the most common lordotic angle to be 42 degrees (range from 10-67 degrees) **(Farfan et al., 1995)**. In the study of Tan et al, the measurement of the mean lumber lordosis angle was 55.6 degrees with range from 38-70 degrees **(Tan et al., 1994).**

D- Sacral kyphosis:

It is present in intrauterine life. It is due to the fused sacral and coccygeal segment **(Gelb et al., 1995).**

Those curves merge gradually from one another except for sharp bend at the lumbosacral junction due to forward slanting of the top of the sacrum at about 45 degrees from horizontal plane.

The significant of those curves are:

- They account for upright posture of the humans (The human spine).
- They provide shock absorbing capacity.
- Their flexibility makes it possible to balance the weight in sitting and standing **(Bangall et al., 1977; Dickson et al., 1984 and Normell et al., 1986).**

2- Curves in the coronal plane

The spine is straight in the coronal plan. There may be a slight right thoracic curve. The origin of this curve is unknown and could be attributed to following:

- The pressure of the aorta on vertebral bodies.

- The pull of the trapezium and rhomboids on the right side in right handed people.

- Increase vascularity of the right breast female. This will lead to stimulation of growth of the rib and costochondral junction **(Normell et al., 1986 and Deans and Duthie, 1973).**

The functional spinal unit (FSU)

The functional spinal unit (FSU), consisting of two vertebrae and the interconnecting soft tissue can be considered the smallest working unit in the cervical and lumber spine; however the biomechanical aspects of the thoracic spine are different from those of the cervical and lumbar spine, because of additional structural stability may be provided to thoracic spine by costovertebral joints and rib cage **(Oda et al., 1996).**

Biomechanics

Spinal biomechanics is the study of direction of forces (vectors) that produce equilibrium, motion, and deformity of the vertebral column. An understanding of force application to the spine clarifies the kinematics of normal motion, and the pathogenesis of scoliosis, and it assists in the development of instrumentation and orthoses for treatment of spine disorders **(Ogilvie, 1987).**

Humans possess an axial skeleton uniquely adapted to bipedal ambulation. Sagittal plane contours permit the centre of mass for the head and upper torso to remain in the line with vertical axis through the centre of mass for the pelvis, therefore a minimum expenditure of energy is required to keep the trunk upright. Various pathologic conditions causing abnormal sagittal plane contour, for example, loss of lumber lordosis, excessive thoracic kyphosis, or coronal plane deviation of spine (e.g., scoliosis), may alter balance and coordination, interfere with visceral function, allow premature degenerative of the spinal column, and cause deterioration of neurologic function **(Ogilvie, 1987).**

Axis system (A 3- dimensional concept)

Biomechanics of the spine sometimes deals with the individual vertebrae (for which local axis system is defined) and some times with the entire trunk (for which a spinal axis system is defined). For considerations of spinal deformity, a regional axis system is also defined **(Stokes, 1994)**.

1. Local axis system (vertebral axis system X, Y, Z)

In this system the origin is at the center of the vertebral body (half way between the center of the two end plates), the local ‘Y’ axis passes through the centers of the upper and lower end plates, and ‘X’ axis is parallel to a line jointing the bases of the right and left pedicles. The ‘Z’ axis passes through the center of the body similar to a line dividing the vertebrae to two symmetrical parts in sagittal plane (Fig. 2) **(Stokes, 1994)**.

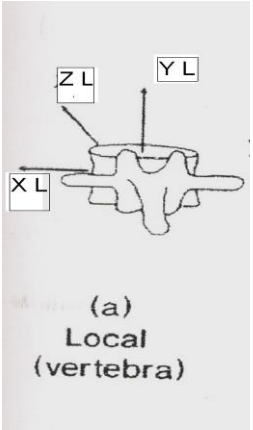

Fig. 2: Local axis system (Stokes, 1994).

2. Regional axis system (Regional X, Y, Z):

A curve based axis system (e.g. ‘z’ axis passing through end vertebrae of a curve) (Fig. 3).

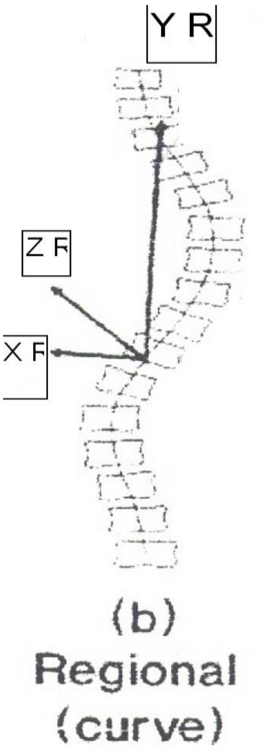

Fig. 3: Regional axis system (Stokes, 1994).

3. Spinal axis system.

It is an axis system for entire spine. This system has its origin at the center of upper end plate of S1, the 'Y' axis passes through the center of the vertebral body to be specified (usually C7 or T1), and the 'X' axis parallel to the vertebral plane containing the ASIS.

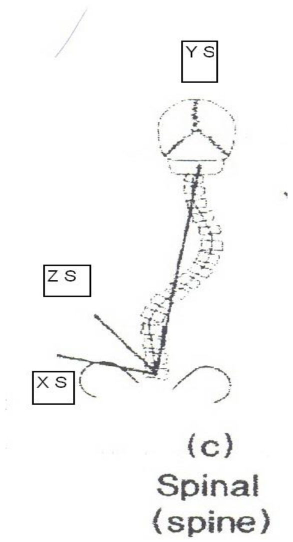

Fig. 4: Spinal axis system

4. Global Axis system (Global X, Y, Z)

This system has its origin at the center of the upper end plate of S1. The 'Y' axis is vertical (gravity line) and the 'X' axis parallel to the vertical plane containing the ASIS (Fig. 5).

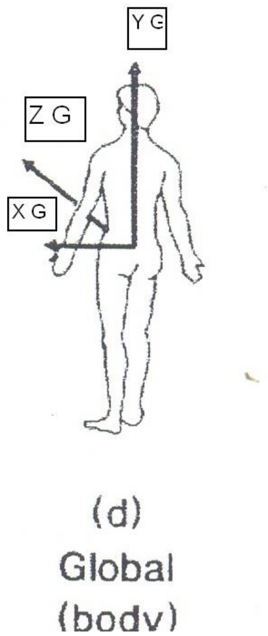

Fig. 5: Global body axis system (Stokes, 1994).

Biomechanical concept of balance and compensation

The word balance, from the point of view of the spine, implies that, in both the frontal and sagittal planes, the head is positioned correctly over the sacrum and pelvis. In sagittal planes, the correct balance is not necessarily zero, and it changes continuously as a result of postural sway **(Mc Glashen et al.,1991).**

Regarding the trunk, balance implies that the shoulders are horizontal, and that the mass of the trunk is evenly distributed about the vertical line passing through the sacrum (the vertical global axis). Thus the "balance" implies a static alignment of a person in standing or unsupported seated position **(Mc Glashen et al.,1991, Stokes, 1994).** "Compensation" signifies the active process of becoming balanced, and "decompensation" signifies a failure to achieve balance, especially after an intervention such as surgery **(Mc Glashen K et al., 1991 and Stokes, 1992).**

Offset (balance) dose not exist at local level, but it is usually a property of the whole spine. However, at a regional level, a failure of both the end vertebrae of a curve to lie on global vertical axis could signify a regional lack of balance **(Mc Glashen et al., 1991 and Stokes, 1992).**

Offset (balance) can be defined both as a distance and an angle. The displacement of the most cephalad vertebra from the global vertical axis can be measured as a distance from the global axis system or as an offset angle between the global and spinal axis systems. Angular offset is the lateral angulation of the most cephalad vertabra. (Fig 6) **(Mc Glashen et al., 1991 and Stokes, 1992).**

The balance of the vertebral column is obtained by continuous minimal muscle contractions, designated as postural tone. Constant postural tone depends on proprioceptive sensory impulses (sense of position and stretch) from muscles and tendons, vestibule of the inner ears and eyes to central nervous system which reflexly stimulates the muscles **(Farfan,1995).**