

# **SURGICAL MANGEMENT OF DEGENERATIVE SPONDYLOLISTHESIS**

## **Thesis**

*Submitted for the Fulfillment of the MD degree in Neurosurgery*

**By**

**Ahmed Mohamed Zaater**

*(M.B., B. Ch.) (M.Sc.)*

## **Supervisors**

**Prof. Dr. Ahmed Mohammed Ahmed Issa**

*Professor of Neurosurgery*

*Faculty of Medicine, Cairo University*

**Prof. Dr. Wael Mokthar Elmahdy**

*Professor of Neurosurgery*

*Faculty of Medicine, Cairo University*

**Prof. Dr. Mohammed M. Mohi Eldeen**

*Professor of Neurosurgery*

*Faculty of Medicine, Cairo University*

**Prof Dr. Yousri Anwar Ahmed Hassan**

*Assistant Professor of Neurosurgery*

*Faculty of Medicine, Cairo University*

**Faculty of Medicine**

**Cairo University**

**2009**

## ACKNOWLEDGEMENT

*First, I would like to express my sincerest gratitude and gratefulness to **Allah** who continues to bless and fill me with hope, faith and patience that enable me to carry out all my daily work.*

*I am greatly honored to express my thanks and gratitude to Prof. Dr. **Ahmed Issa**, Professor and Head of Neurosurgery Department, Faculty of Medicine, Cairo University, for guidance, great help encouragement and his creative support throughout the whole work up of this thesis.*

*I would like to express thanks and gratitude to Professor Dr. **Wael Elmahdy**, Professor of Neurosurgery, Faculty of Medicine, Cairo University, for his valuable help and advice for me to accomplish this work.*

*I am very much indebted to Dr. **Mohamed Mohi Eldeen**, Professor of Neurosurgery, Faculty of Medicine, Cairo University, for his kind supervision, valuable advices, constructive criticism and indispensable help throughout this work.*

*My deep gratitude and appreciation, great thanks to Prof. Dr. **Yousri Anwar**, Assistant Professor of Neurosurgery, Faculty of Medicine, Cairo University, for his generous help and continuous support throughout this work.*

*Last but not least, I would like to thank **my family** for their great help and support and every person who helped me during this work especially **my dear colleagues** in Neurosurgery Department, Faculty of Medicine, Cairo University, for their great help in this work.*

## ABSTRACT

IN A SERIES of 63 patients with degenerative spondylolisthesis, methods of surgical treatment were analyzed. Patients were divided into two groups according to surgical treatment. Two kinds of treatment: decompression only (14 patients) & decompression with instrumented (49 patients). We evaluated the surgical method of treatment, clinical and radiological outcome in the two groups. We found that fusion group has nonsignificant better outcome in improvement rate ( $P>0.05$ ) than decompression only group and significantly more hospital stay ( $P< 0.05$ ). And that decompression only group had significant more decrease in angle of lordosis than fusion group ( $P< 0.05$ ).

**KEY WORDS:** Degenerative spondylolisthesis, lumbar stenosis, posterolateral fusion, transpedicular instrumentation.

# CONTENTS

	<b>Page</b>
<b>Introduction and Aim of the work</b>	<b>1</b>
<b>Review of Literature</b>	<b>3</b>
▪ Anatomy of the lumbar spine	<b>3</b>
▪ Biomechanics of lumbosacral spine	<b>25</b>
▪ Disc Function and Dysfunction	<b>30</b>
▪ Pathophysiology of Lumbar Spondylosis	<b>36</b>
▪ Stability and instability of lumbosacral spine	<b>43</b>
▪ Pathology of Spondylolisthesis	<b>53</b>
▪ Clinical Presentation	<b>63</b>
▪ Diagnosis of degenerative spondylolisthesis	<b>68</b>
▪ Principles of treatment of degenerative spondylolisthesis	<b>72</b>
<b>Material and Methods</b>	<b>99</b>
<b>Results</b>	<b>121</b>
<b>Case Presentation</b>	<b>162</b>
<b>Discussion</b>	<b>168</b>
<b>Conclusion</b>	<b>179</b>
<b>References</b>	<b>181</b>
<b>Arabic Summary</b>	<b>196</b>

# LIST OF FIGURES

<b>Figure No</b>	<b>Title</b>	<b>Page</b>
<b>1</b>	The components of a lumbar vertebra	<b>5</b>
<b>2</b>	The epiphysial ring	<b>5</b>
<b>3</b>	The annulus fibrosus	<b>6</b>
<b>4</b>	The annulus is a laminated structure	<b>6</b>
<b>5</b>	Hoop stress.	<b>7</b>
<b>6</b>	A Schmorl's node	<b>8</b>
<b>7</b>	The annulus acts like a coiled spring	<b>9</b>
<b>8</b>	Diagram shows the experimental testing of vertical loading of the spine	<b>10</b>
<b>9</b>	The ligamentum flavum	<b>11</b>
<b>10</b>	The anterior longitudinal ligament (arrow) on magnetic resonance imaging (MRI)	<b>12</b>
<b>11</b>	The posterior longitudinal ligament	<b>12</b>
<b>12</b>	The correct direction of the ligamentous fibers	<b>13</b>
<b>13</b>	Six lumbar vertebrae numbered from the top down	<b>15</b>
<b>14</b>	A fixed last formed level with five lumbar vertebrae above	<b>16</b>
<b>15</b>	Five lumbar vertebrae with the last level fixed to the pelvis and non mobile	<b>17</b>
<b>16</b>	Arterial supply to the vertebrae	<b>19</b>
<b>17</b>	Venous drainage of the vertebral column	<b>23</b>
<b>18</b>	Formation and branching pattern of a typical spinal nerve	<b>24</b>
<b>19</b>	Dr. Nachemson's study that measured pressures in the L3-4 disc in varying positions	<b>27</b>
<b>20</b>	Swelling pressure balance of a disc	<b>31</b>
<b>21</b>	Disc nutrition	<b>32</b>
<b>22</b>	The three stages of disc degeneration	<b>33</b>
<b>23</b>	The phase of instability	<b>34</b>
<b>24</b>	A well-stabilized L5-S1 disc with osteophytes	<b>34</b>
<b>25</b>	On flexion-extension schematic drawn from a radiograph of an unstable segment	<b>46</b>
<b>26</b>	A schematic of a degenerative spondylolisthesis	<b>46</b>
<b>27</b>	A stair-step degenerative spondylolisthesis on flexion	<b>54</b>

<b>28</b>	The iliolumbar ligaments	<b>55</b>
<b>29</b>	A degenerative spondylolisthesis and retrospondylolisthesis	<b>55</b>
<b>30</b>	Degenerative spondylolisthesis at lateral radiograph	<b>55</b>
<b>31</b>	Diagram to show sheer through the lumbosacral disc	<b>57</b>
<b>32</b>	Diagram to show that the L5 nerve root in degenerative spondylolisthesis	<b>62</b>
<b>33</b>	Schematic drawing of a degenerative spondylolisthesis with deformation and stenosis of the spinal canal and the intervertebral	<b>63</b>
<b>34</b>	Lateral radiograph of a patient with L4-5 ischemic spondylolisthesis with an advanced slip	<b>70</b>
<b>35</b>	The lateral plain film shows a degenerative spondylolisthesis with a narrowed disc space at the level of the slip: a fairly stable situation	<b>78</b>
<b>36</b>	The sagittal (T1) MRI shows a wide disc space (L4-L5) at the slip level: a relatively unstable situation.	<b>79</b>
<b>37</b>	The method of subarticular decompression	<b>83</b>
<b>38</b>	A degenerative spondylolisthesis with the 360-degree fusion: interbody and posterolateral	<b>90</b>
<b>39</b>	An axial T1 MRI showing congenital stenosis with degenerative changes	<b>90</b>
<b>40</b>	Radiological assessment of amount of flexion angulation	<b>101</b>
<b>41</b>	Preoperative lateral extension radiograph demonstrates 5mm of subluxation of L4 on L5	<b>104</b>
<b>42</b>	Diagrams demonstrating the pedicle screw trajectory and entry sites on the vertebra	<b>110</b>
<b>43</b>	Entry points to the lumbar pedicles based on intact posterior anatomy	<b>111</b>
<b>44</b>	External landmarks for identification of the first sacral pedicles.	<b>112</b>
<b>45</b>	Posterior view demonstrating the exposure of both sides of the spine to the tips of the transverse processes	<b>113</b>
<b>46</b>	Radiologic measurements	<b>118</b>
<b>47</b>	Comparison of patient groups as regard sex	<b>130</b>
<b>48</b>	Mean age among the two groups	<b>131</b>
<b>49</b>	Age distribution among the two groups	<b>132</b>
<b>50</b>	Occupation & smokers among the two groups	<b>133</b>
<b>51</b>	Mean height, weight, BMI among the two groups	<b>134</b>
<b>52</b>	Distribution of obesity among the two groups	<b>135</b>
<b>53</b>	Clinical presentation among the two groups	<b>137</b>
<b>54</b>	Back signs among the two groups	<b>138</b>

<b>55</b>	Pre operative (JOA score)	<b>140</b>
<b>56</b>	Level of spondylolisthesis in both groups	<b>141</b>
<b>57</b>	Parameters of sagittal alignment among both groups	<b>142</b>
<b>58</b>	The presence of instability and lateral stenosis in the two groups	<b>143</b>
<b>59</b>	The compressing element found intraoperative in the two groups	<b>144</b>
<b>60</b>	Post operative radiological change in sagittal alignment among the two groups	<b>146</b>
<b>61</b>	Preoperative & postoperative slip angle in the two groups	<b>147</b>
<b>62</b>	Preoperative & postoperative slip % in the two groups	<b>148</b>
<b>63</b>	Preoperative & postoperative disc height in the two groups	<b>148</b>
<b>64</b>	Preoperative & postoperative lordosis angles in the two groups	<b>149</b>
<b>65</b>	Analysis of JOA score pre & post operative of the two groups	<b>151</b>
<b>66</b>	Rate of improvement of the two groups	<b>152</b>
<b>67</b>	Comparison between the pre operative & post operative JOA score of the two groups	<b>154</b>
<b>68</b>	Comparison between the pre operative & post operative JOA score of the two groups	<b>155</b>
<b>69</b>	Mean change in JOA score among the two groups	<b>156</b>
<b>70</b>	Comparison of postoperative Status among the two groups	<b>157</b>
<b>71</b>	Comparison of improvement rate among both groups	<b>158</b>
<b>72</b>	Fusion rate in group A	<b>159</b>
<b>73</b>	Comparison of complication rate among both groups	<b>160</b>
<b>74</b>	Comparison of mean hospital stay among both groups	<b>161</b>
<b>75</b>	Case no 32, Preoperative dynamic X-rays	<b>163</b>
<b>76</b>	Case no 32, Preoperative MRI	<b>163</b>
<b>77</b>	Case no 32, Post operative X-ray A-P & Lateral view	<b>164</b>
<b>78</b>	Case no 13, Preoperative dynamic X-rays	<b>166</b>
<b>79</b>	Case no 13, Preoperative MRI	<b>166</b>
<b>80</b>	Case no 13, Post operative X-ray A-P & Lateral view	<b>167</b>

# LIST OF TABLES

<b>No.</b>	<b>Title</b>	<b>Page</b>
<b>1</b>	Forward displacement	<b>57</b>
<b>2</b>	Summary of the JOA system for low-back pain	<b>116</b>
<b>3</b>	Master Table A	<b>123</b>
<b>4</b>	Master Table B	<b>125</b>
<b>5</b>	Master Table C	<b>127</b>
<b>6</b>	Master Table D	<b>129</b>
<b>7</b>	Comparison of patient groups as regard age	<b>130</b>
<b>8</b>	Comparison of patient groups as regard mean age and duration of symptoms	<b>131</b>
<b>9</b>	Age distribution among the two groups	<b>132</b>
<b>10</b>	Occupation & smokers among the two groups	<b>133</b>
<b>11</b>	Obesity among the two groups	<b>134</b>
<b>12</b>	Distribution of obesity among the two groups	<b>135</b>
<b>13</b>	Clinical presentation among the two groups	<b>136</b>
<b>14</b>	Preoperative JOA score of both groups	<b>139</b>
<b>15</b>	Level of spondylolisthesis in both groups	<b>141</b>
<b>16</b>	Parameters of sagittal alignment among both groups	<b>142</b>
<b>17</b>	The presence of instability and lateral stenosis in the two groups	<b>143</b>
<b>18</b>	Indication of surgery in the two groups	<b>144</b>
<b>19</b>	The compressing element found intraoperative in the two groups	<b>144</b>
<b>20</b>	Post operative radiological change in sagittal alignment among the two groups	<b>145</b>



<b>21</b>	Post operative radiological change in sagittal alignment	<b>146</b>
<b>22</b>	Analysis of JOA score pre & post operative of the two groups	<b>150</b>
<b>23</b>	Comparison between the pre operative & post operative JOA score of the two groups	<b>152</b>
<b>24</b>	Mean change in JOA score among the two groups	<b>155</b>
<b>25</b>	Comparison of Postoperative Status among the two groups	<b>156</b>
<b>26</b>	Comparison of improvement rate among both groups	<b>157</b>
<b>27</b>	Fusion rate in Group A	<b>159</b>
<b>28</b>	Comparison of complication rate and hospital stay among both groups	<b>160</b>

# LIST OF ABBREVIATIONS

<b>% slip</b>	Degree of the slip
<b>ALIF</b>	Anterior lumbar interbody fusion
<b>ALL</b>	Anterior longitudinal ligament
<b>AP</b>	Anteroposterior
<b>BMI</b>	Body mass index
<b>BMP</b>	Bone morphogenic protein
<b>CT</b>	Computerized tomography
<b>EZ</b>	Elastic zone
<b>FSU</b>	Functional spinal unit
<b>h</b>	Disc height
<b>H</b>	Posterior wall height of the proximal vertebral body
<b>h/H</b>	Disc height%
<b>Ht</b>	Body height
<b>JOA</b>	Japanese orthopedic association
<b>LL</b>	Lumbar lordosis
<b>MRI</b>	Magnetic resonance image
<b>Mo</b>	Months
<b>n</b>	Number
<b>No</b>	Number
<b>NS</b>	Non Significant
<b>NZ</b>	Neutral zone
<b>P</b>	Probability Value
<b>PLIF</b>	Posterior lumbar interbody fusion
<b>PLL</b>	Posterior longitudinal ligament
<b>PZ</b>	Plastic zone
<b>RCT</b>	Randomized control study
<b>rhBMP-2</b>	Recombinant human bone morphogenetic protein-2
<b>S</b>	Slippage
<b>SA</b>	Slip angle
<b>SCS</b>	Spinal canal stenosis
<b>TENS</b>	Transcutaneous electrical nerve stimulation
<b>TLIF</b>	Transforaminal lumbar interbody fusion
<b>Wt</b>	Body weight
<b>yr</b>	Years

## **INTRODUCTION**

Spondylolisthesis refers to the forward displacement of one vertebra relative to another. Five types of listhesis have been described according to the Wiltse-Newman-MacNab classification system and include the isthmic, degenerative, dysplastic, traumatic, and pathologic forms. (*Guiot & Mendel, 2005*)

Degenerative spondylolisthesis was first described by Junghans in 1931 as a specific form of listhesis with an intact neural arch. (*Bennett, 2004*)

Degenerative spondylolisthesis typically occurs at the level of L4-L5. It is then most likely at L3-L4, followed by L5-S1. Older people are most commonly affected; the average age at presentation being 60 years. It is four times more likely to occur in women than men, Parity has been associated with an increase incidence of spondylolisthesis. (*Guiot & Mendel, 2005*)

Clinically patients frequently complain of intermittent low back pain, symptoms of neurogenic claudication, occasionally radicular pain from compression by the degenerative facet. (*Guiot & Mendel, 2005*)

Imaging includes plain X-ray standing lateral, anteroposterior, oblique & flexion/extension views of the lumbar spine are helpful in demonstrating a slip, CT or MRI of lumbar spine. (*Bennett , 2004*)

Treatment includes nonoperative care and operative intervention indicated for patients with progressive neurological deficit and those who fail to improve on proper nonoperative treatment, specifically, those people with persistent pain, either radicular or claudicatory, that interferes with professional and personal activity as well as quality of life. (*Schnake et al, 2006*)

### **Aim of work**

- Review of literature and recent publication on degenerative spondylolisthesis and its management.
- Comparing different modalities for surgical management of degenerative spondylolisthesis as regard indications and outcome.
- Finding out optimal surgical management for degenerative spondylolisthesis.

## **Functional Musculoskeletal Anatomy**

There are five lumbar vertebrae and the sacrum making up the lumbar spine. We can consider each vertebra as having three functional components: the vertebral bodies, designed to bear weight; the neural arches, designed to protect the neural elements; and the bony processes (spinous and transverse), designed as outriggers to increase the efficiency of muscle action. (*Wong & Transfeldt, 2007 A*)

The vertebral bodies are connected together by the intervertebral discs, and the neural arches are joined by the facet (zygapophyseal) joints (Fig. 1). The discal surface of an adult vertebral body demonstrates on its periphery a ring of cortical bone. This ring, the epiphysial ring, acts as a growth zone in the young and in the adult as an anchoring ring for the attachment of the fibers of the annulus. The hyaline cartilage plate lies within the confines of this ring (Fig. 2). The size of the vertebral body increases from L1 to L5, which is indicative of the increasing loads that each lower lumbar vertebral level has to absorb. (*Wong & Transfeldt, 2007 A*)

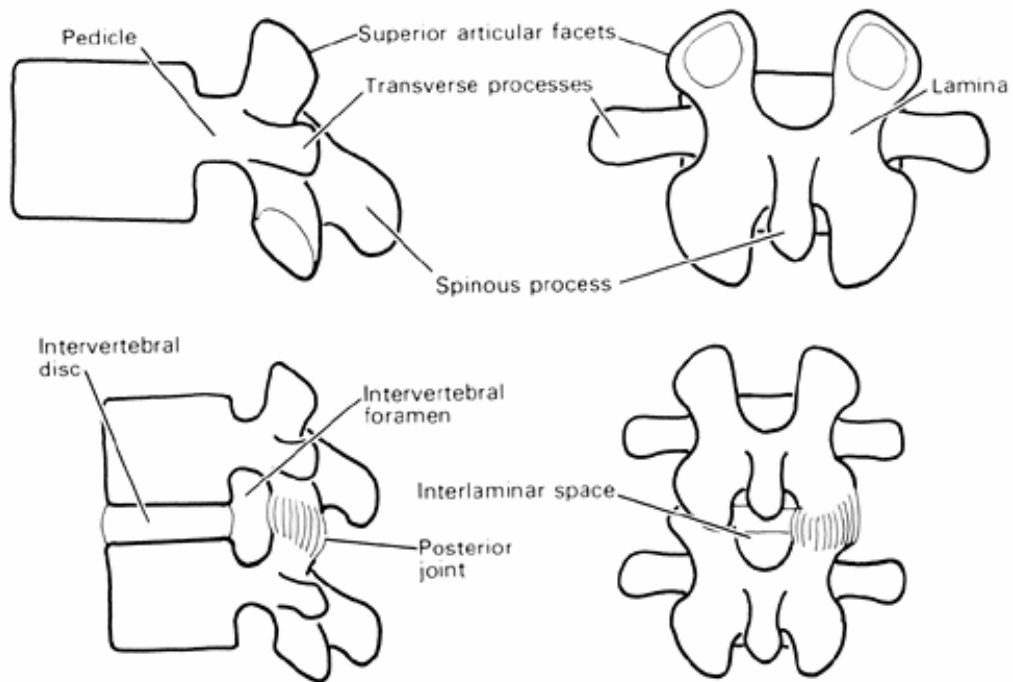
The neural arch is composed of two pedicles and two laminae (Fig. 1). The pedicles are anchored to the cephalad half of the vertebral body and form a protective cover for the cauda equina contents of the lumbar spinal canal. The ligamentum flavum (yellow ligament) fills in the interlaminar space at each level.

The outriggers for muscle attachment are the transverse processes and spinous process. (*Wong & Transfeldt, 2007 A*)

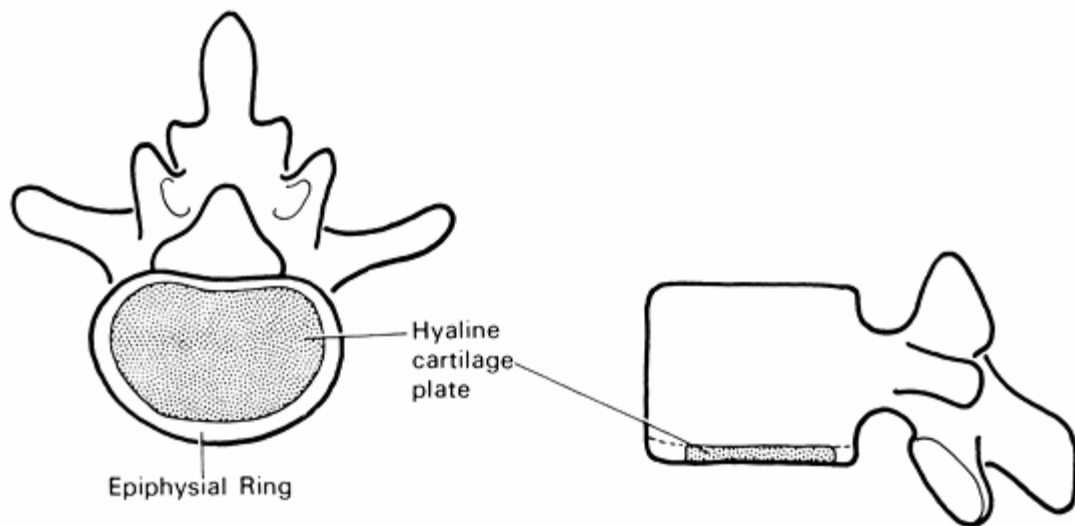
## **The Intervertebral Disc**

The intervertebral discs (Fig. 3) are complicated structures, both anatomically and physiologically. Anatomically, they are constructed in a manner similar to that of a car tire, with a fibrous outer casing, the annulus, containing a gelatinous inner tube, the nucleus pulposus. The fibers of the annulus can be divided into three main groups: the outermost fibers attaching between the vertebral bodies and the undersurface of the epiphysial ring; the middle fibers passing from the epiphysial ring on one vertebral body to the epiphysial ring of the vertebral body below; and the innermost fibers passing from one cartilage endplate to the other. The anterior fibers are strengthened by the powerful anterior longitudinal ligament. The posterior longitudinal ligament affords only weak reinforcement, especially at L4-5 and L5-S1, where it is a midline, narrow, unimportant structure attached to the annulus. The anterior and middle fibers of the annulus are most numerous anteriorly and laterally but are deficient posteriorly, where most of the fibers are attached to the cartilage plate (Fig. 3). (*Wong & Transfeldt, 2007 A*)

The fibers of the annulus are firmly attached to the vertebral bodies and arranged in lamellae, with the fibers of one layer running at an angle to those of the deeper layer (Fig. 4). This anatomic arrangement permits the annulus to limit vertebral movements. This important function is reinforced by the investing vertebral ligaments. (*Wong & Transfeldt, 2007 A*)



**Figure 1: The components of a lumbar vertebra: the body, the pedicle, the superior and inferior facets, the transverse and spinous processes, and the intervertebral foramen and its relationship to the intervertebral disc and the posterior joint.**



**Figure 2: The epiphysial ring is wider anteriorly and surrounds the hyaline cartilaginous plate.**