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PROGNOSIS IN IDIOPATHIC SCOLIOSIS

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The conservative attitude of this Clinic in the treatment of scoliosis has made it possible to accumulate a great number of cases of idiopathic scoliosis with prolonged follow-up studies, treated without surgery. These cases have been studied with the object of establishing criteria for determining the prognosis in idiopathic scoliosis.

Before an operation is undertaken in a young patient with scoliosis, the surgeon should have a thorough knowledge of the natural course of the curve he is going to treat and the probable outcome. The problem is so complex and so many abstract theoretical studies have been made that the orthopaedic surgeon is prone to overrate the dangers involved in scoliosis and to carry out surgical fusion of the spine which is often unnecessary. In many cases of idiopathic scoliosis, there is a natural tendency for the curve to stop progressing after a certain growth has been reached. Furthermore, the body posture is often well maintained in spite of sizable spinal curvatures. On the other hand, extremely deformining thoracic curves, requiring early and active treatment, may develop over a short period of time. It is the purpose of this paper to outline the course of the most common patterns of idiopathic curvature of the spine, and to give some basis for prognosis with any given curve.

Material

In a group of 444 young patients with idiopathic scoliosis, spine fusion had been performed in fifty cases. This study is based on an analysis of the 394 cases of idiopathic scoliosis which were not treated surgically. Of these, 335 cases were observed through maturity. Roentgenograms taken with the patient in the standing and supine positions, photographs, and clinical examination were employed in the study. Cases with minimal curves were not included. The average follow-up period was two years and ten months.

A great number of patients in this series received conservative treatment, consisting of exercises designed to increase muscle strength and to correct postural imbalance. Tightness of the abdominal muscles at the side of the overhang was corrected by passive and active stretching. The patients were taught to shift their thorax into proper alignment with the pelvis. Braces were often given to help maintain body posture. It is not our intention to evaluate the results of conservative treatment in this paper. While conservative therapy may improve body posture, it has never been found—or claimed—to decrease the size of a spinal curvature. As this study is based upon the characteristics of the curves, the fact that most patients received conservative treatment did not influence the results of our observations.

Measurement of Curves

The method used for determining the angle of a curve is as follows: The top and bottom vertebrae of the curve are identified by the width of the intervertebral space, the tilting, and the degree of rotation of the vertebrae. The intervertebral spaces are wider on the side of the convexity and narrower on the concave side. At the top and bottom of the curve, the intervertebral space is either of equal width or is wider toward the concavity of the curve. The rotation of a vertebra is indicated on the roentgenograms by the relationship of the spinous process to the body of the vertebra. The degree of rotation is greatest at the apex of the curve and diminishes toward each end, where a neutral vertebra—that is, a non-rotated vertebra—is frequently found. The top and bottom vertebrae

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are usually the ones which rotate the least in the curve, but an exception should be made for the cases with curves showing concave rotation. Lines are drawn parallel to the upper surface of the top vertebra and to the undersurface of the bottom vertebra. The angle formed by these lines is the angle of the curve.

**Curve Patterns**

In idiopathic scoliosis, most of the characteristics of the curve or curves are present from the onset of the deformity and do not change throughout its entire course. The size of the curvature may increase considerably, and in some cases one or two more vertebrae may be included in the curve in the late stages. However, the apex, the direction of rotation, and the location of the curve do not change. Roentgenograms taken shortly after the onset, when the curvature is still minimal, point almost unmistakably to the pattern of the scoliosis (Figs. 4-A to 4-C and 7-A to 7-D). Only in exceptional cases does a change in pattern occur during the development of the scoliosis.

It was possible to group all the cases of idiopathic scoliosis studied into five main patterns: main lumbar, main thoracolumbar, combined thoracic and lumbar, main thoracic, and main cervicothoracic. In Table I the 394 cases are classified according to the curve patterns. These groupings correspond quite closely to the ones described by Schulthess in 1905.

The course and prognosis in idiopathic scoliosis vary considerably from pattern to pattern. For this reason, each group will be considered in detail.

**Age at Onset**

The final angular value of a curve is usually correlated with the age at which the scoliosis begins. However, it is often difficult to determine just when the curvature starts. In children who are well cared for, the scoliosis may be detected shortly after its onset;

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### TABLE I

**Summary of 394 Cases of Idiopathic Scoliosis Treated without Surgery**

<table>
<thead>
<tr>
<th>Curve Pattern</th>
<th>No. of Cases</th>
<th>Sex</th>
<th>When Curve First Noticed</th>
<th>At First Visit</th>
<th>At Stabilization</th>
<th>Convexity</th>
<th>At First Visit</th>
<th>At Stabilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbar</td>
<td>93 (23.6%)</td>
<td>M.</td>
<td>13 80</td>
<td>14 1</td>
<td>14 10</td>
<td>Rt. 28</td>
<td>Lt. 65</td>
<td>33.9 27.7</td>
</tr>
<tr>
<td>Thoracolumbar</td>
<td>63 (15.9%)</td>
<td>F.</td>
<td>14 49</td>
<td>13 11</td>
<td>14 11</td>
<td>51 12</td>
<td>36.3 31.6</td>
<td>42.7 35.0</td>
</tr>
<tr>
<td>Combined</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I Lumbar</td>
<td>146 (37.1%)</td>
<td>M.</td>
<td>11 135</td>
<td>12 4</td>
<td>13 1</td>
<td>15 5</td>
<td>136 10</td>
<td>44.0 39.8</td>
</tr>
<tr>
<td>I Thoracic</td>
<td>87 (22.1%)</td>
<td>F.</td>
<td>25 62</td>
<td>11 1</td>
<td>12 10</td>
<td>16 1</td>
<td>79 8</td>
<td>60.2 53.7</td>
</tr>
<tr>
<td>Cervicothoracic</td>
<td>5 (1.3%)</td>
<td></td>
<td>1 4</td>
<td>15 2</td>
<td>16 16</td>
<td>1 4</td>
<td>32.6 30.0</td>
<td>34.6 32.2</td>
</tr>
<tr>
<td>Totals</td>
<td>394 (100%)</td>
<td></td>
<td>64 330</td>
<td></td>
<td></td>
<td></td>
<td>295 99</td>
<td></td>
</tr>
</tbody>
</table>


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TABLE II
COURSE OF IDIOPATHIC SCOLIOSIS IN 335 CASES, CORRELATED WITH PATTERN
AND AGE OF PATIENT AT ONSET OF CURVE

<table>
<thead>
<tr>
<th>Curve Pattern</th>
<th>Age of Patient When Curve First Noted (Years)</th>
<th>No. of Patients</th>
<th>Angle of Curve at Maturity No. of Patients with Curves Measuring</th>
<th>Angle of Curve at Maturity No. of Patients with Curves Measuring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Under 40</td>
<td>40 to 60</td>
</tr>
<tr>
<td>Main Lumbar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apex: 1st or 2nd lumbar</td>
<td>Under 10</td>
<td>9</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Extent of curve: 11th thoracic to 3rd lumbar</td>
<td>From 10 to 12</td>
<td>12</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>From 12 to 14</td>
<td>34</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Over 14</td>
<td>33</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>88</td>
<td>52</td>
<td>59%</td>
</tr>
<tr>
<td>Thoracolumbar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apex: 11th or 12th thoracic</td>
<td>Under 10</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Extent of curve: 8th or 7th thoracic to 1st or 2nd lumbar</td>
<td>From 10 to 12</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>From 12 to 14</td>
<td>22</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Over 14</td>
<td>26</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>54</td>
<td>27</td>
<td>50%</td>
</tr>
<tr>
<td>Combined</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoracic</td>
<td>Under 10</td>
<td>14</td>
<td>T. 0</td>
<td>3</td>
</tr>
<tr>
<td>Apex: 7th or 8th thoracic</td>
<td>From 10 to 12</td>
<td>28</td>
<td>T. 3</td>
<td>10</td>
</tr>
<tr>
<td>Extent of curve: 6th to 10th thoracic</td>
<td>From 12 to 14</td>
<td>45</td>
<td>T. 12</td>
<td>23</td>
</tr>
<tr>
<td>Lumbar</td>
<td>Over 14</td>
<td>30</td>
<td>T. 13</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>117</td>
<td>T. 28</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(24°)</td>
<td>(45°)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>53</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>9°</td>
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<tr>
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<td></td>
<td></td>
<td>35</td>
<td>34</td>
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<td>35</td>
<td>34</td>
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<td>35</td>
<td>34</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Thoracic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apex: 8th or 9th thoracic</td>
<td>Under 10</td>
<td>18</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Extent of curve: 5th or 6th thoracic to 11th or 12th thoracic</td>
<td>From 10 to 12</td>
<td>16</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>From 12 to 14</td>
<td>21</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Over 14</td>
<td>16</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>71</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cervicothoracic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apex: 3rd thoracic</td>
<td>Under 10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Extent of curve: 7th cervical or 1st thoracic to 4th or 5th thoracic</td>
<td>From 10 to 12</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>From 12 to 14</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Over 14</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

T. = Thoracic.  L. = Lumbar.
in other children, the curve is often well advanced before it is noticed. The age of the patient at the time the curve was first noticed is used. In Table II, the cases observed until maturity were grouped according to the age of the patient when the scoliosis was first noticed. In each of the five patterns, four groups were made, according to whether the scoliosis was first noticed: (a) before the age of ten years; (b) between ten and twelve years; (c) between twelve and fourteen years; and (d) after fourteen years of age.

In each age group, the curves were classified according to their final angular values at maturity: (a) curves over 80 degrees at maturity (very severe); (b) curves between 60 and 80 degrees (severe); (c) curves between 40 and 60 degrees (moderate); and (d) curves under 40 degrees (small).

**Curve Patterns**

**Main Lumbar Curves**

Single idiopathic lumbar curves occurred in ninety-three of the 394 cases studied (23.6 per cent.). They proved to be the most benign of all types of idiopathic curves. Eighty of the patients were females, thirteen were males. The average age at which the curvature was first noticed was thirteen years and four months. Lumbar curves became stabilized earlier than other patterns, at an average of fourteen years and ten months. Since vertebral growth in this group of cases was not complete until an average of sixteen years and eleven months, as evidenced by the completion of ossification excursion of the iliac apophyses\(^1\), it may be assumed that it is not necessary for the growth of the spine to be terminated before the lumbar type of scoliosis is arrested.

\(^1\) All the roentgenograms show the left side of the patient at the left side of the page. All were taken with patient in standing position and are anteroposterior views.
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Fig. 2-A: Thoracolumbar curve with apex at the twelfth thoracic vertebra in a ten-year-old girl. Scoliosis was first noticed at six years of age. Curve extends from the ninth thoracic to second lumbar vertebra.

Fig. 2-B: In spite of its early onset, curve had increased only slightly by the time the girl was seventeen years of age.

Fig. 2-C: Photograph of patient at seventeen years of age. Posture was good.

The lumbar curves generally included five vertebrae and extended from the eleventh thoracic to the third lumbar (Figs. 1-A, 1-B, and 1-C). The apex of the curve was at the first or second lumbar vertebra. They occurred predominantly to the left; sixty-five (70 per cent.) were convex to the left and twenty-eight (30 per cent.) were convex to the right.

Counter curves above and below the main lumbar curve were small, but constant. The two or three thoracic vertebrae above the curve were usually tilted opposite to the vertebrae in the lumbar curve, to form the upper counter curve and realign the body. These vertebrae often rotated in the same direction as the vertebrae in the lumbar curve. Thus, a concave rotation in the small thoracic counter curve was present.

The lower counter curve was formed by the fourth and fifth lumbar vertebrae. These two vertebrae were also tilted in the opposite direction to the lumbar curve, so that the undersurface of the fifth lumbar vertebra was horizontal and the sacrum was then neutral, or out of the curve. This was found in all but three of the ninety-three lumbar curves. In these three cases, the lumbar curve was lower, extending from the twelfth thoracic to the fifth lumbar, with the apex at the third lumbar vertebra. Here, the sacrum formed the counter curve.

Single lumbar curves were the least deforming of all the patterns. The gait, with the alternating rotation and oscillation of the pelvis, kept the lumbar spine limber, and extreme degrees of deformity were not seen. The average angular value after the curve had become stationary was 36.8 degrees with the patient standing, and 29.1 degrees supine. In only seven cases (8 per cent.) was the angular value of the curve over 60 degrees; but even in the more severe degrees of angulation, the curve was not very deforming.

Eighty-eight patients with lumbar scoliosis were observed until after they had reached
maturity (Table II). In nine cases (10.2 per cent.), the curve was first noticed before the age of ten. In spite of the early onset, in only one case did the curve increase beyond 60 degrees. In twelve cases, the scoliosis was first noticed between the ages of ten and twelve years; in two of these cases, the curve progressed beyond 60 degrees. Of the sixty-seven cases in which the scoliosis was first noticed after the age of twelve, only four had curves greater than 60 degrees, the highest value being 67 degrees. In no case, regardless of the age at which the curve was first noticed, was clinically severe deformity observed.

Minimal lumbar curves are quite common and were not included in these statistics. They are often not discovered until roentgenograms are taken to investigate the cause of low-back pain in adult life.

Thoracolumbar Curves

Thoracolumbar patterns occurred in sixty-three cases, or 16 per cent. of the total number of idiopathic curves studied. Of these, forty-nine were females, fourteen were males. The thoracolumbar curve had a great tendency to be convex toward the right, as did thoracic curves. Fifty-one or 80.9 per cent. were convex to the right, and twelve or 19.1 per cent. were convex to the left.

Six to eight vertebrae were included in the thoracolumbar curve, which extended from the sixth or seventh thoracic vertebra to the first or second lumbar. The apex was at the eleventh or twelfth thoracic; it was at the twelfth thoracic vertebra in forty cases and at the eleventh thoracic in twenty-three cases (Figs. 2-A to 3-C).

Although there proved to be no major differences in their eventual outcome, notable differences in the characteristics of these curves were found, depending upon the location.
of the apex. The curves with an apex at the eleventh thoracic vertebra had a tendency to grow larger and to penetrate into the thorax more than did the curves with an apex at the twelfth thoracic vertebra. When the apex was at the eleventh thoracic, the counter curves above and below the main curve were usually well developed and the vertebrae rotated toward the convexity of each curve (Figs. 3-A, 3-B, and 3-C). The sum of the angular values of the counter curves usually equaled the value of the main curve. The counter curves in the thoracolumbar scoliosis with an apex at the twelfth thoracic were very small or even non-existent. Usually the entire spine rotated toward the convexity of the main curve, and, if the counter curves existed, they showed a slight degree of concave rotation (Figs. 2-A, 2-B, and 2-C).

The thoracolumbar scoliosis started late. The average age at which the curve was first noticed was fourteen years. Fifty-four patients with thoracolumbar scoliosis were observed until they reached maturity. Spontaneous stabilization of the curve occurred at an average age of sixteen years, whereas the ossification excursion of the iliac apophysis of the patients in this group was not completed until an average age of seventeen years and four months. The average angular value after the curve had become stationary was 42.7 degrees with the patient standing, and 35.0 degrees when supine.

In six cases, the scoliosis was first noticed before the age of twelve years (Table II). In three cases of this group, the angle of the curve progressed beyond 80 degrees; in one case it was 67 degrees. The curve was small in the other two cases. In none of forty-eight cases in which the scoliosis was first noticed after the age of twelve years, did the curve reach 80 degrees; eleven had curves of from 60 to 80 degrees, and in twenty-five the curve did not increase beyond 40 degrees.

The thoracolumbar curves were, as a whole, not very deforming. The lower thoracic and the lumbar segments remained limber, and a good body posture was maintained in
all except eight cases. In only two of these was a major loss of body alignment observed. The scoliosis appeared at a very early age in both cases.

Fig. 5-A: Combined thoracic and lumbar scoliosis in an eight-year-old girl. Curvature had been noticed for four months. Apex is at eighth thoracic vertebra in upper curve, and at second lumbar in lower curve.

Figs. 5-B and 5-C: Roentgenograms taken at nine and eleven years show gradual increase of both curves. The curves reached great size at maturity, as is seen frequently in the combined pattern when it starts at an early age.

Figs. 5-D and 5-E: Roentgenograms taken at twelve and fifteen years of age show further increase of the curves.

Fig. 5-F: Photograph of patient at fifteen years of age, showing deformity.
Combined Thoracic and Lumbar Curves

Combined scoliosis was the most frequent form in this series, with an incidence of 37 per cent. Of the 146 cases, 135 were girls and eleven were boys.

The cases of this group had two main recognizable curves from the very onset. One curve was thoracic, usually extended over a distance of five vertebrae from the sixth to the tenth thoracic vertebra, and had an apex at the seventh or eighth thoracic level. The other curve of opposite direction was lumbar, with an apex at the second lumbar, and included five vertebrae from the eleventh thoracic to the fourth lumbar. A few cases with six or seven vertebrae in each curve were seen. A neutral or non-rotated vertebra was often present between the two curves. The convexity of the thoracic curve was predominantly to the right and that of the lumbar curve was most commonly to the left. In the 146 cases, all but ten were right-thoracic, left-lumbar combinations (Figs. 4-A to 6-B).

Usually both the thoracic and lumbar curves had the same number of vertebrae, and the rotation in each was toward the convexity of the respective curve. The degree of rotation of the vertebrae of one of the curves matched that of the other curve from the very beginning of the scoliosis. The thoracic curve usually measured several degrees more than the lumbar curve. The vertebral rotation and the angular value of both curves increased at about the same rate, so that the basic pattern changed very little. In this series, only rare instances were seen where one curve grew more than the other.

In forty cases (27 per cent.), the apex of the thoracic curve was lower than the seventh or eighth thoracic vertebra,—that is, at the ninth or tenth thoracic. The lumbar curve was, of necessity, short. When this scoliosis increased, an overhang of the body to the side of the convexity of the thoracic curve occurred and there was an upper cervicothoracic counter curve, opposite to the thoracic curve, which helped realign the body posture.

The average age of the patient when the scoliosis was first noticed was twelve years and four months. The average age at which the curve became stabilized was fifteen years and five months. The ossification excursion of the iliac apophysis in this group of cases was complete at an average of sixteen years and four months. One hundred and seventeen cases of the combined pattern were followed through maturity (Table II).

The prognosis in cases of combined scoliosis, in general, was good. The thoracic and lumbar curves were similar in length, rotation, and angular values. Consequently, the body was well aligned even when both curves reached considerable size. In many cases, curves of 60 or 70 degrees (Figs. 4-A, 4-B, and 4-C) were not detectable when the patient was dressed.
Fig. 7-A: Main thoracic curve in a thirteen-year-old girl, shortly after onset.
Figs. 7-B and 7-C: Roentgenograms taken at fourteen and seventeen years. In spite of its late onset, curve increased greatly. Cases of this pattern usually follow a similar course.
Fig. 7-D: Photograph of patient at seventeen years of age, showing the deformity.

Fig. 8-A: Main thoracic curve in a seven-year-old girl. Scoliosis was first noticed when patient was six. Apex was at eighth thoracic, and curve extended from fourth to eleventh thoracic vertebra.
Fig. 8-B: Same curve when patient was eleven years of age, showing some increase.
Fig. 8-C: Roentgenogram taken when patient was fifteen years of age shows great increase of the curve. The scoliosis progressed irregularly; it increased more rapidly during the period between eleven and fifteen years.
Angle of curvature at maturity in each curve pattern, as related to the patient's age at onset of scoliosis. The solid lines represent the average angle; the broken lines, the extremes. In the graph of the combined thoracic and lumbar pattern, there are two solid lines. The upper one represents the thoracic component, the other represents the lumbar; only the extremes of the thoracic curve are shown. The small number of cases of cervicothoracic scoliosis were not included in the graph.
The most important prognostic feature in this scoliosis pattern was the age of the patient when the scoliosis began (Table II). In seven of the fourteen cases in which the scoliosis was first noticed before the age of ten years, the curves increased to angular values of more than 80 degrees (Figs. 5-A to 5-F). This tendency of progression to extensive deformity dropped off sharply when the scoliosis began after the age of ten years (Figs. 6-A and 6-B).

Several important prognostic signs were observed in the roentgenograms (Figs. 9-A and 9-B). The thoracic vertebrae adjacent to the apex of the thoracic curve were osteoporotic and hazily outlined. The intervertebral spaces were irregularly outlined and narrow. A translatory shift was often seen, more pronounced at the transition vertebrae between the thoracic and lumbar curves. This is a sign of relaxation of the ligamentous apparatus of the spine. These roentgenographic signs were present during the progression of the curve; they were not seen in the scoliosis which remained stationary.

When all these features were taken into consideration, a fairly accurate prognosis of most of the combined curves could be made.

*Thoracic Curves*

Main thoracic curves accounted for eighty-seven cases or 22 per cent. of the total. Sixty-two were in females, twenty-five in males. This curve was first noticed at an average age of eleven years and one month,—earlier than in any of the other patterns. The thoracic curves became stabilized at an average age of sixteen years and one month,

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**Fig. 9-A**

Fig. 9-A: Roentgenogram showing lesions of the vertebrae in a main thoracic curve. Defects of the vertebral bodies on the concave side of the curve may be seen.

**Fig. 9-B**

Fig. 9-B: Roentgenogram of the thoracic component of a combined thoracic and lumbar scoliosis. The vertebral bodies adjacent to the apex of the curve are osteoporotic, wedge-shaped, and poorly outlined.
thus allowing five years during which this curve increased. The ossification excursion of the iliac apophyses was complete at an average of seventeen years and one month.

Of the eighty-seven cases in this group, all but eight had curvatures convex to the right. Six of the eight patients with left convex thoracic scoliosis were boys.

The apex of the thoracic curve usually was at the eighth or ninth thoracic vertebra. Six vertebrae were generally included in the main curve, which extended from the sixth to the eleventh thoracic; extreme degrees of rotation were observed in the vertebrae. Smaller counter curves were present above and below the main curve. The rotation of the vertebrae in the counter curves was relatively mild (Figs. 7-A to 8-C).

The roentgenograms showed significant changes in the three or four vertebrae located in the center of the main thoracic curves (Figs. 9-A and 9-B). The bodies of these vertebrae appeared osteoporotic, their outlines were hazy, and early in the evolution of the curve they showed marked wedging. The intervertebral spaces were irregularly outlined and very narrow at the site of the concavity. Often disc herniations into the vertebral body were seen. Translatory shift between the vertebral bodies was often evident. These changes were seen before and during the progression of the curve. There was a direct relationship between the intensity of these lesions and the increase of the curve. These changes were much more pronounced than, but similar to, the ones seen in the thoracic component of the combined type of scoliosis.

Thoracic curves progressed more rapidly, grew to a greater size, and produced a greater deformity than any other type of scoliosis. The curve penetrated deeply into the thorax early in its course, producing an irreversible deformity.

When main thoracic curves started before the age of twelve years, the outlook was poor (Table II). Of thirty-four cases in which thoracic scoliosis was noticed prior to this age, in twenty-four or 70.6 per cent. the curve progressed to a final angular value greater than 80 degrees. In half of these cases, the deformity was extreme, with curves of angular values well over 100 degrees. The thoracic curve often had a tendency to progress to extensive deformity, even when it started late. About one-third of the patients whose scoliosis was detected after twelve years of age had curves measuring more than 80 degrees at maturity. However, in slightly less than half of the patients in this age group, the curves did not increase beyond 60 degrees and were not very deforming.
Cervicothoracic Curves

In the present series there were only five cases with this type of curve. The scoliosis was first noticed when the patient was about fifteen years of age, and never became pronounced. The angular value of the curve at maturity varied from 20 to 58 degrees. The curve was convex to the left in all the cases but one. Four of the patients were girls and one was a boy.

The apex of the cervicothoracic curves was at the third thoracic vertebra. From four to six vertebrae were included in the curve, which extended from the seventh cervical or first thoracic to the fourth or fifth thoracic. The curve penetrated somewhat into the upper thorax, and its vertebrae were wedge-shaped and markedly rotated. A long, low thoracic counter curve was usually present (Figs. 10-A and 10-B).

The scapula was elevated and the shoulder was higher at the side of the convexity of the curve. In spite of these visible deformities, the body alignment was well preserved in all the cases seen by us.

Discussion

The study of the course of idiopathic scoliosis in a sizable number of cases has given valuable data upon which to base the prognosis. Four main factors were found significant.

1. The pattern of the curve;
2. Age of the patient at onset of the scoliosis;
3. Alterations in the density of the vertebrae and abnormalities of the disc spaces, as seen in the roentgenograms;
4. Rapidity of increase in the size of the curve.

Pattern of the Curve

The classification of idiopathic scoliosis into five main curve patterns was found to be fundamental in the determination of prognosis. These curve patterns were well established shortly after the onset of the scoliosis and, with a few exceptions, did not change throughout its course.

The pattern was easy to identify in the majority of cases. However, about 5 per cent. of the curves represented transition forms between two patterns, and had characteristics of each. Care was taken to classify these cases according to the pattern to which they bore closest resemblance. For example, nine cases had a main lumbar curve with a pronounced low-thoracic counter curve. These cases resembled the combined thoracolumbar patterns. However, they were classified with the lumbar curves for three reasons: First, the thoracic curve was a good deal smaller than the lumbar curve, whereas in the combined pattern, the lumbar curve is usually smaller. Second, the vertebrae of the thoracic curve were only slightly rotated, in contrast to the advanced degree of rotation usually noted in the thoracic curve of the combined pattern. Third, in the combined pattern there is a small, high thoracic or cervicothoracic counter curve, not present in these nine cases.

Transition forms were also seen between the lumbar and thoracolumbar patterns, the thoracolumbar and combined, and the combined and main thoracic. A careful study of each of these cases was necessary for their proper classification.

As a whole, the main thoracic curves increased to greater deformities than the other patterns. The prognosis in the main lumbar, thoracolumbar, and cervicothoracic curves was usually favorable. The prognosis with the combined thoracolumbar curves was usually good if they developed after ten years of age, and poor if they started earlier.

Age at Onset of the Scoliosis

The prognosis in cases of scoliosis depended in great measure upon the age of the patient when the curvature appeared. The most deforming curves originated at an early age. Conversely, the curves which were detected when the maturity of the patient was well advanced increased only slightly or not at all. The age of the patient when the scoliosis
became apparent varied within each pattern. The main thoracic curves usually appeared at an earlier age than the other curves. The curves in the lumbar, thoracolumbar, and the cervicothoracic patterns appeared late,—often after the age of thirteen years. It is possible that these curves may have been present for many months without becoming clinically apparent, because they were usually not very deforming.

It would be desirable to evaluate the skeletal age of the patients and to correlate it with the growth of the scoliosis. The idiopathic curves almost always increase during growth of the skeleton, and they cease to progress about one year before the completion of ossification excursion of the iliac apophyses. Unfortunately, we were not able to determine accurately the skeletal age of most of our patients, and thus the chronological age was used instead.

Idiopathic scoliosis is much more frequent in girls than in boys. In the group of cases with main thoracic curves, however, there were many males. The scoliosis often progressed in boys about two years longer than in girls. This was probably due to the fact that the skeleton reaches maturity later in males than in females. Otherwise, there were no major differences in the course of scoliosis in boys and girls, and the data were compiled together in the tables.

**Alterations in the Density of the Vertebræ and Abnormalities of the Disc Spaces**

Changes in the vertebrae and in the intervertebral spaces were often seen in the roentgenograms of the scoliotic patients. The vertebrae adjacent to the apex of the thoracic curves were most frequently affected (Figs. 9-A and 9-B).

Most of these changes were apparent in the thoracic curves when the first roentgenograms were taken, shortly after the onset of the scoliosis. They were seen during the entire progress of the curve. The intensity of these vertebral alterations was usually directly related to the rapidity of increase of the curve. Thus, these spinal changes were of major prognostic significance. The texture of the bone of the lumbar vertebrae appeared to be fairly normal, even in the most extensive lumbar curves. Translatory shift, however, was often seen between the lumbar vertebrae.

**Rapidity of Increase in the Size of the Curve**

When the scoliosis started after ten years of age, the increase was gradual in most of the patients. The prognosis, then, could often be best evaluated after two or three successive examinations, taken at intervals of three months. If the roentgenograms showed marked increase of the curve, the prognosis was usually poor. On the other hand, if there was only a minor progression of the curve during this period of observation, the prognosis was much better.

When the scoliosis started in children under ten years of age, it often did not increase much for a few years and then increased suddenly. This scoliosis of early onset usually carried a poor prognosis, in spite of its slow increase during the first years.

For practical usage, a graph was constructed for each curve pattern, to show the size of the curvature which might be expected at maturity, as related to the age of the patient at the onset of the scoliosis (Chart I). The central line represents the average angular value; the secondary lines, the extreme curves. Data for this chart were obtained from the study of the 330 cases of idiopathic scoliosis followed through maturity. Angular values of the curves in the standing position were recorded. The ages referred to in the graph are the chronological ages of girls.

**REFERENCES**

