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Natural History of Progressive Adult Scoliosis

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Study Design. A retrospective analysis of the progression of adult scoliosis.

Objective. To establish an individual prognosis.

Summary of Background Data. Most studies have investigated the adolescent scoliosis after skeletal maturity, but the results are discordant.

Methods. Two senior physicians measured all the radiographs of 51 adults who had a progressive scoliosis. The mean delay between the first and last radiograph was 27 years. For each patient, a diagram was established with the Cobb angle on the y-axis and the corresponding age on the x-axis. We noted the age and Cobb angle of the first radiograph showing a rotatory subluxation and the age of menopause. We used linear regression and the analysis of variance test.

Results. The mean number of radiographs per patient was 6. The linear test was significant in 46 patients. Two main types exist. Type A is an adolescent scoliosis that continues to progress after skeletal maturity, whereas type B appears or progresses late. There were 13 type A and 20 type B of which 11 progressed around menopause. Significant differences were noted between groups A and B regarding loss of body height (group A, 5 cm and group B, 9.5 cm; $P < 0.001$), rate of progression in lumbar single and thoracolumbar single curves (group A, 0.82°/y and group B, 1.64°/y; $P < 0.004$), Cobb first radiograph (group A, 37° and group B, 20°; $P < 0.0001$), age rotatory subluxation (group A, 42 years and group B, 56 years; $P < 0.0001$), and Cobb rotatory subluxation (group A, 52° and group B, 29°; $P < 0.0001$).

Conclusions. The originality of our study is the diagram. We demonstrated that the rate of progression was linear, and it can be used to establish an individual prognosis. The diagrams visualized 2 main distinct types. There was a significantly faster rate of progression in type B. In type A, rotary subluxation occurs during progression of the curvature. In type B, it seems to be the initial event. Menopause is a period of deterioration in type B.

Key words: adult scoliosis, natural history, prognosis, rotatory subluxation. **Spine 2007;32:1227–1234**

It has been known since 1969 that scoliosis can continue to progress during adulthood after skeletal maturity.[1,2] Previous studies have investigated prognostic factors for progression after skeletal maturity.[3–6] The results, however, are discordant from 1 study to the next and cannot be used to establish an individual prognosis. Most studies on the progression of scoliosis during adulthood concern cases of adolescent scoliosis reviewed 20, 40, 50 years after skeletal maturity. Another type of scoliosis is also observed in adults and is called degenerative scoliosis or *de novo* scoliosis.[7–9] It has not been extensively studied but is becoming increasingly frequent with aging of the population and will constitute a public health problem in the future. The objective of this study was to establish an individual prognosis and define the clinical types of progressive scoliosis in adults.

Materials and Methods

A retrospective study was carried out on 51 adult patients. Criteria for inclusion are progressive idiopathic and "degenerative" scoliosis (≥7° between the first and last radiograph). We excluded other diagnoses (congenital, neuromuscular, *etc.*). At least 3 radiographs of the spine taken during at least 10 years were available. None of these subjects had a history of spinal surgery or brace in adulthood. These subjects consulted either for pain, or sagittal or coronal imbalance, or for esthetic reasons, and more rarely for follow-up of known scoliosis. The scoliosis patient arrived for consulting with many prior radiographs. Each patient underwent a quantitative clinical examination by the same senior physician, and anteroposterior and lateral standing full-spine radiographs were performed. The following clinical data were analyzed: rib hump measured with an inclinometer; loss of height in cm (former known height − current height); and coronal imbalance (distance between the C7 plumb line and gluteal crease). The senior physician was unaware of clinical follow-up before this visit. The senior physician who examined the patient measured manually all prior and recent standing radiographs, and another senior physician checked them. The senior physician who examined all the patients has 2 "specialities," being rheumatologist and rehabilitation physician, treating children and adults, with 20 years of scoliosis experience. The other senior physician is a rehabilitation physician with 40 years of scoliosis experience. Each curve was measured by the Cobb angle technique. The topography and limits of each curve and the site of rotatory subluxation were recorded. A diagram indicating the Cobb angle for each curve on the y-axis and the corresponding age on the x-axis was established for each patient. The age of menopause is also plotted on this diagram. The Cobb angle and age cor-

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Table 1. Mean and SD of the Parameters of the General Population (51 Subjects, 3 Males, and 48 Females)

	Mean	SD	Minimum	Maximum
Age 1*	37	11.06	17	60
Age 2*	64	10.48	44	80
Duration of natural history studied	27	9.51	9	53
Age of menopause	50	3.45	42	56
Time since menopause	16	8.02	2	33
Age RS†	49	9.76	29	68
Lumbar or thoracolumbar rib hump (mm)	16	7.1	4	36
Thoracic rib hump (mm)	11	6.32	4	30
Loss of height (cm)	7.1	4.04	0	17
Coronal balance (cm)	1.1	1	0	3.5
L and TL Cobb RS†	42	13.4	13	66
L and TL Cobb 1*	30	13.97	3	66
L and TL Cobb 2*	55	12.55	18	85
No. lumbar points	6	1.94	3	12
Thoracic Cobb 1*	44	14.74	17	73
Thoracic Cobb 2*	54	15.28	33	84
No. thoracic points	6	2.08	3	9
Kyphosis 2*	44	16.74	11	85
Lordosis 2*	49	12.12	17	82
No. vertebrae in lordosis	3	1.17	2	8
Sacral inclination 2*	30	10.58	7	52
Pelvic incidence	54	12.86	30	78

*One corresponds to first radiograph, and 2 corresponds to the last radiograph.
†Age rotatory subluxation (RS) and Cobb rotatory subluxation correspond to the first radiographs showing a rotatory subluxation.
L indicates lumbar single; TL, thoracolumbar single.

responding to the first radiograph showing "rotatory subluxation(s)" (age rotatory subluxation, Cobb rotatory subluxation) were recorded. The number of radiographs used for this period corresponds to the number of points indicated on the diagram.

Due to the absence or inadequacy of lateral radiographs, analysis of the course of lateral views was possible for only a small number of patients and was, therefore, not included in this study. The lateral radiographs measured, therefore, corresponded to the most recent radiographs obtained at the visit. We measured the lumbar lordosis, thoracic kyphosis, sacral inclination, and pelvic incidence.[10]

Statistical Analysis. All variables are expressed as the mean, standard deviation (SD), and maximum and minimum values. Mean values were compared by analysis of variance. Linear regression analysis (Cobb/age) was performed for each curve for each subject. The limit of significance was $P < 0.05$.

■ Results

Characteristics of the Study Population (Table 1)

The study population consisted of 51 patients, 3 males and 48 females, with a mean age at the time of the first radiograph of 37 years (range 17–60) and at the time of the last radiograph of 64 years (range 44–80).

The mean duration of the natural history was 27 years (range 9–53). All but 8 of the patients reported low back pain, 22 reported nerve root pain, and 4 were pain-free. The various topographies were 30 single major curves (19 lumbar and 11 thoracolumbar), 18 double curves (double thoracic and lumbar), and 3 triple curves (in accordance with the Scoliosis Research Society classification).

The mean height of the thoracic rib hump was 11 mm (range 4–30), and the mean height of the lumbar or tho-

Table 2. Results of Linear Regression Analysis of Cobb/Age of Lumbar Single and Thoracolumbar Single Component of Double Curves

	Duration of Natural History (y)	Lumbar Cobb 1 (°)	Lumbar Cobb 2 (°)	No. Points	Lumbar Slope	R	*P*
Bar	29	52	67	7	0.68	0858	0.0134
Bi	18	52	65	7	0.76	0957	0.0007
Bog	30	45	70	4	0.8	0997	0.0031
Bour	21	49	62	8	0.64	0970	0.0001
Bo	14	24	45	5	1.41	0982	0.0029
Ch	18	39	69	3	1.64	0997	0.0479
Cou	23	50	62	7	0.48	0928	0.0009
Dar	27	34	56	4	0.76	0988	0.0119
Gef	19	37	68	9	1.65	0951	0.0001
Ha	53	46	85	9	0.62	0962	0.0001
Jea	35	24	54	4	0.94	0997	0.0034
Leb	37	6	48	9	1.67	0966	0.0001
Mar	31	66	81	5	0.47	0977	0.0041
Mau	48	22	55	7	0.65	0974	0.0002
Mic	27	17	37	6	0.93	0993	0.0001
Pi	18	28	57	8	1.55	0953	0.0003
Po	22	40	60	5	0.85	0986	0.0020
Pr	23	23	56	5	1.43	0999	0.0001
Rod	28	27	35	5	0.34	0966	0.0074
Ro	24	41	53	6	0.87	0968	0.0015
Fou	37	33	38	9	0.15	NS	NS
Mean	28	36	58	6	0.96	—	—
SD	9.95	14.28	13.20	1.90	0.43	—	—

Slope = slope of the regression line = rate of progression of the scoliotic curve.
R = regression coefficient; limit of significance $P = 0.05$.
NS indicates nonsignificant.

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Table 3. Results of Linear Regression Analysis of Cobb/Age of Lumbar Single and Thoracolumbar Single Curves

	Duration of Natural History (y)	Lumbar Cobb 1 (°)	Lumbar Cobb 2 (°)	No. Points	Lumbar Slope	R	*P*
Auc	23	13	50	7	1.63	0999	0.0001
Bag	18	29	62	5	2.68	0913	0.0306
Bos	18	24	63	4	2.09	0985	0.0150
Bou	23	26	54	6	1.21	0992	0.0001
Cad	31	27	44	4	0.53	0994	0.0065
Cai	24	33	60	8	1.15	0985	0.0001
Co	19	44	76	6	1.58	0997	0.0001
Dau	31	23	55	5	1.3	0994	0.0006
Del	15	11	43	8	2.36	0978	0.0001
Des	9	27	65	5	3.82	0983	0.0027
Gen	22	24	41	8	0.82	0922	0.0011
Ger	20	48	58	8	0.48	0945	0.0004
Led. A	20	16	66	5	3.57	0977	0.0043
Led. F	33	30	48	4	0.77	0997	0.0028
Luc	25	18	55	5	1.6	0984	0.0024
Mar	27	35	47	6	0.53	0929	0.0073
Par	41	35	58	12	0.88	0968	0.0001
Per	21	30	63	7	2.05	0984	0.0001
Rit	31	10	42	7	1.62	0970	0.0003
Rob	17	6	18	4	0.89	0970	0.0297
Roc	40	12	65	5	1.38	0971	0.0056
Ted	41	32	50	6	0.46	0979	0.0007
Tel	32	14	51	8	1.25	0967	0.0001
Ty	30	42	60	10	0.51	0921	0.0002
Vau	26	3	34	7	1.14	0972	0.0003
Ver	19	29	54	6	1.32	0982	0.0005
Vas	47	38	45	5	1.8	NS	NS
Ha	39	31	43	4	0.67	NS	NS
Vac	22	55	69	4	0.84	NS	NS
Gros	12	21	45	3	1.96	NS	NS
Mean	26	26	53	6	1.45	—	—
SD	9.28	12.45	11.78	2.00	0.89	—	—

slope = slope of the regression line = rate of progression of the scoliotic curve.
R = regression coefficient; limit of significance $P = 0.05$.
NS indicates nonsignificant.

racolumbar hump was 16 mm (range 4–36). All the patients had at least 1 "rotatory subluxation," except 1. The sites of "rotatory subluxation" were as follows: 2 at T10–T11, 9 at T11–T12, 14 at T12–L1, 5 at L1–L2, 5 at L2–L3, 34 at L3–L4, and 11 at L4–L5. Overall, there were 51 thoracolumbar and lumbar curves, including 30 single major curves. The values of the studied parameters are presented in Table 1.

Results of Linear Regression Analysis Applied to Each Curve (Tables 2–4)

Linear regression analysis was very significant in all but 5 of the patients (Tables 2–4). The slope of the regression line represents the rate of progression of each curve. The mean slope for lumbar and thoracolumbar curves (single curves and lumbar component of double curves) was 1.23°/y (range 0.34° to 3.82°). The mean slope of the thoracic curve in patients with double curves was 0.68°/y (range 0.3° to 0.97°) (Table 4). The mean slope of the lumbar component in patients with double curves was 0.96°/y (range 0.34° to 1.67°) (Table 2). The mean slope of the lumbar or thoracolumbar single curve was 1.45°/y (range 0.46° to 3.82°) (Table 3). The double curves should be treated as a unit. We can only note that there were 6 cases where both curves progressed in the same way, only 1 where thoracic curve progressed more quickly than the lumbar curve. In 3 cases, lumbar curve progressed faster than thoracic curve. In 10 cases, it is difficult to conclude because the lower rate of progression of thoracic curves was not statistically significant, possibly because of a limited number of radiographs, indicating the need for longer follow-up or a larger number of radiographs. But in these 10 cases, the lumbar curve progressed faster.

Diagrams Visualizing Various Types of Progression of Scoliosis

Two main types of progression of adult scoliosis can be distinguished. Type A corresponds to adolescent scoliosis, which continues to progress after skeletal maturity at a rate specific to each curve. Thirteen patients presented this type of scoliosis (Figures 1–4, 9). Type B corresponds to a "degenerative scoliosis," which progresses late in adulthood: either a preexisting stable adult scoliosis that progresses late or a *de novo* late-onset scoliosis. Twenty patients presented this type of scoliosis (Figures 5–9). Eleven of these 20 patients progressed certainly at the time of menopause (type BM, which is scoliosis that progresses at menopause) (Figures 6–8). BM is a subtype of B.

The remaining 13 patients belonged to 1 of the aforementioned types, but the distinction between types A and

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Table 4. Results of Linear Regression Analysis of Cobb Angle/Age of Thoracic Component of Double Curves and Comparison With Their Lumbar Slope

	Duration of Natural History (y)	Thoracic Cobb 1 (°)	Thoracic Cobb 2 (°)	No. Points	Thoracic Slope	R	*P*	Lumbar Cobb 1 (°)	Lumbar Cobb 2 (°)	Lumbar Slope
Ba…	29	62	80	7	0.75	0978	0.0001	52	67	0.68
Bi.	18	53	63	8	0.67	0845	0.0083	52	65	0.76
Mau.	48	22	46	4	0.49	0995	0.0047	22	55	0.65
Mic.	27	17	45	7	0.97	0955	0.0008	17	37	0.93
Pos.	22	58	78	5	0.91	0974	0.0050	40	60	0.85
Ro.	24	40	59	6	0.72	0943	0.0049	41	53	0.87
Ro.	28	57	79	5	0.76	0996	0.0003	27	35	0.34
Bou.	21	40	48	8	0.3	0.79	0.0202	49	62	0.64
Cha…	18	41	58	3	0.95	0999	0.0276	39	69	1.64
Gef…	19	42	46	9	0.32	0803	0.0091	37	68	1.65
Bo.	14		34	1	NS	NS	NS	24	45	1.41
Cou…	23	57	62	6	NS	NS	NS	50	62	0.48
Dar.	27	49	52	4	NS	NS	NS	34	56	0.76
Ha…	53	37	49	4	NS	NS	NS	46	85	0.62
Jea.	35		42	2	NS	NS	NS	24	54	0.94
Leb…	37	28	48	4	NS	NS	NS	6	48	1.67
Mar.	31	43	44	3	NS	NS	NS	66	81	0.47
Pin.	18	26	38	7	NS	NS	NS	28	57	1.55
Pre…	23		33	1	NS	NS	NS	23	56	1.43
Bo…	30	73	84	5	NS	NS	NS	45	70	0.8
Fo.	37	42	45	8	NS	NS	NS	33	38	NS
Mean	28	44	54	5	0.68	0.93	0.0081	36	58	0.96
SD	9.95	14.74	15.32	2.34	0.24	—	—	14.28	13.20	0.43

NS indicates nonsignificant.

B was impossible due to the absence of radiographs during early adulthood.

Other types of scoliosis also probably exist. For example, Figure 10 shows a very rapid progression from a small angle compared to type B but early in adulthood. Figure 10 shows a progression of 2.09°/y, with a Cobb 1 of 24° on the first radiograph at the age of 35 years. The x-intercept of these lines is also observed after skeletal maturity.

No change of slope was observed on any of the 46 progression diagrams. In particular, in 8 women with type A scoliosis with a long progression comprising menopause, no change of slope was observed at menopause (Figures 2, 3), and no change of slope was observed after the development of "rotatory subluxation" in type A (Figures 1–3).

We did not find any correlation between the initial Cobb angle and slope of progression in the overall population, as a marked scatter of the slope was observed for each angle. We also did not observe any significant correlation in patients with type A scoliosis.

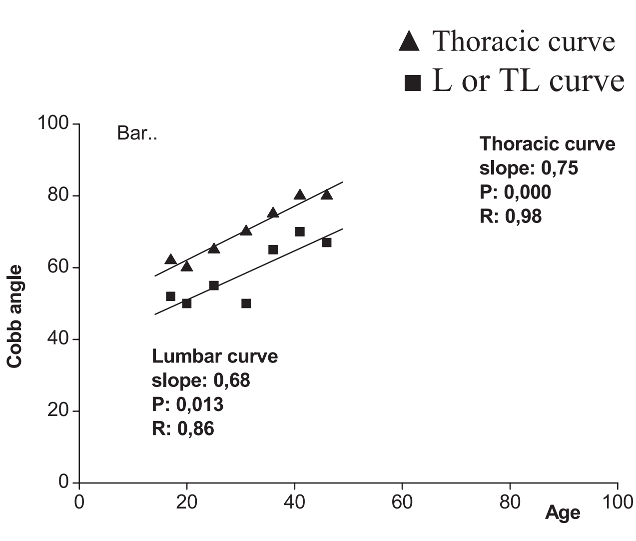

Figure 1. Type A: Female, double major, men: 0, age rotatory subluxation 32 years (n = 7).

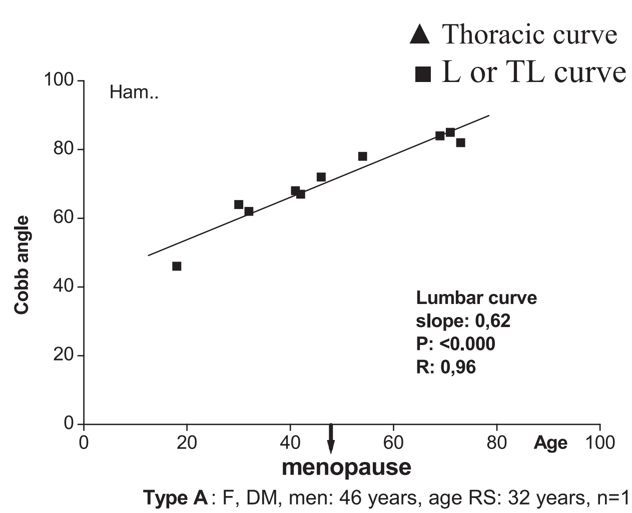

Figure 2. Type A: Female, double major, men: 46 years, age rotatory subluxation: 32 years (n = 10) (insufficient number of thoracic points). L indicates lumbar single curve; TL, thoracolumbar single curve.

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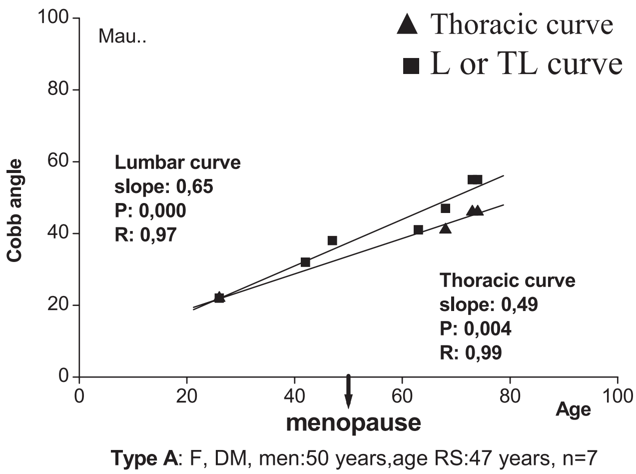

Figure 3. Type A: Female, double major, men: 50 years, age rotatory subluxation: 47 years (n = 7).

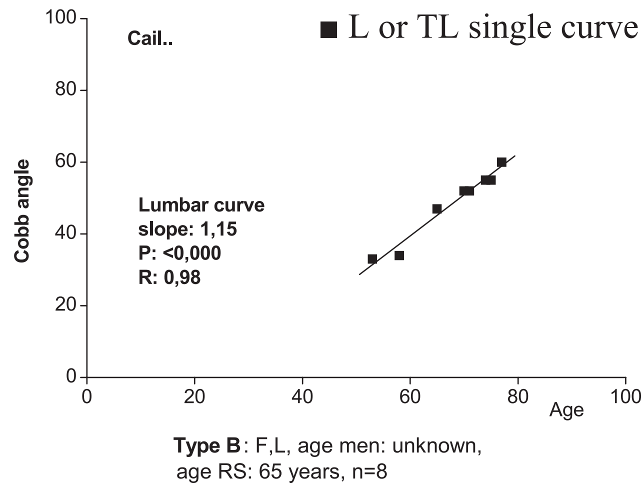

Figure 5. Type B: Female, lumbar single curve, age men: unknown, age rotatory subluxation: 65 years (n = 8).

Comparison of the Parameters of Types A and B Scoliosis (Tables 5, 6)

Patients with type B scoliosis were all women and exclusively presented a lumbar or thoracolumbar single curve. Type A patients predominantly presented double curves, in 9 cases, with 1 triple curve, and 3 single curves (3 lumbar). The delay between the first radiograph and last radiograph was not significantly different between type A (mean 30 years; range 18–53) and type B (mean 24 years; range 9–41). The number of radiographs per patient was also not significantly different between type A (mean 7; range 3–10) and type B (mean 7; range 4–12). However, the following parameters were found to be significantly different between types A and B:

1. Loss of height: 5 cm for type A (0.18 cm/y) and 10 cm for type B (0.46 cm/y) ($P = 0.001$).
2. Lumbar or thoracolumbar slope (or rate of progression): 0.82°/y (0.34–1.65) for type A and 1.64°/y (0.77–3.82) for type B ($P = 0.004$).
3. Mean age at the time of the first radiograph (age 1): 24 years for type A and 46 years for type B.
4. Mean Lumbar and thoracolumbar Cobb angle of first radiograph (lumbar single and thoracolumbar single Cobb 1): 37° for type A (range 22° to 52°) and 20° for type B (range 3° to 35°) ($P = 0.000$).
5. Mean age of first rotatory subluxation (age rotatory subluxation): 42 years for type A and 56 years for type B ($P = 0.000$).
6. Mean Cobb angle of first rotatory subluxation (Cobb rotatory subluxation): 52° for type A and 29 for type B ($P = 0.000$).

The lumbar single and thoracolumbar single Cobb angle of the last radiograph and thoracic kyphosis were at the limit of significance for type A *versus* type B. No significant difference was observed for the other parameters: coronal imbalance, sacral inclination, lumbar lordosis, number of vertebrae involved in the lordosis, and pelvic incidence.

The first rotatory subluxation occurred after an average of 18 years of progression in type A but was present

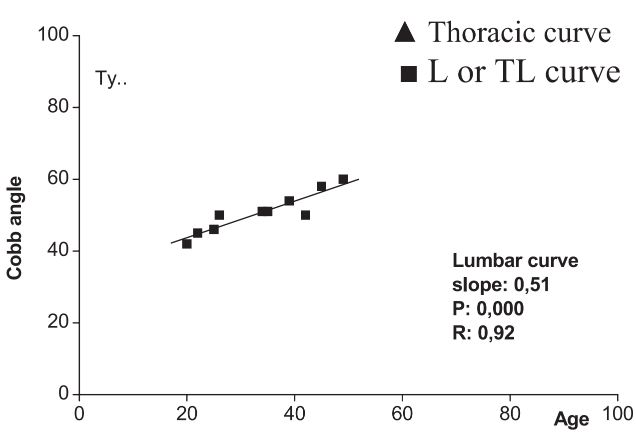

Figure 4. Type A: Male, lumbar single curve, age rotatory subluxation: 45 years (n = 10).

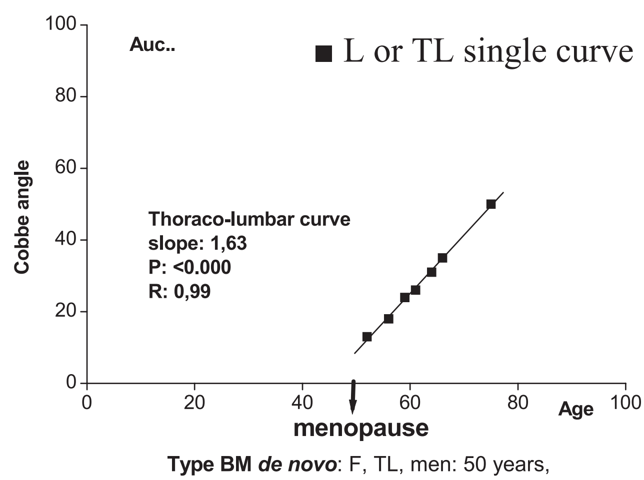

Figure 6. Type BM *de novo*: Female, thoracolumbar single curve (TL), men: 50 years, age rotatory subluxation: 52 years (n = 7). L indicates lumbar single curve.

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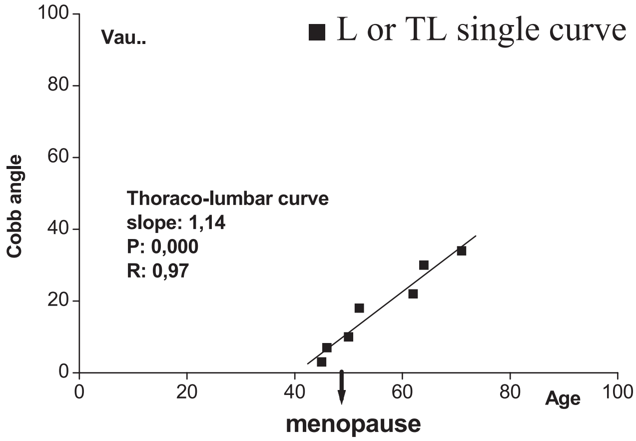


Type BM *de novo*: F, TL, men: 51 years,
age RS: 52 years, n=6

Figure 7. Type BM *de novo*: Female, thoracolumbar single curve, men: 51 years, age rotatory subluxation: 52 years (n = 6).

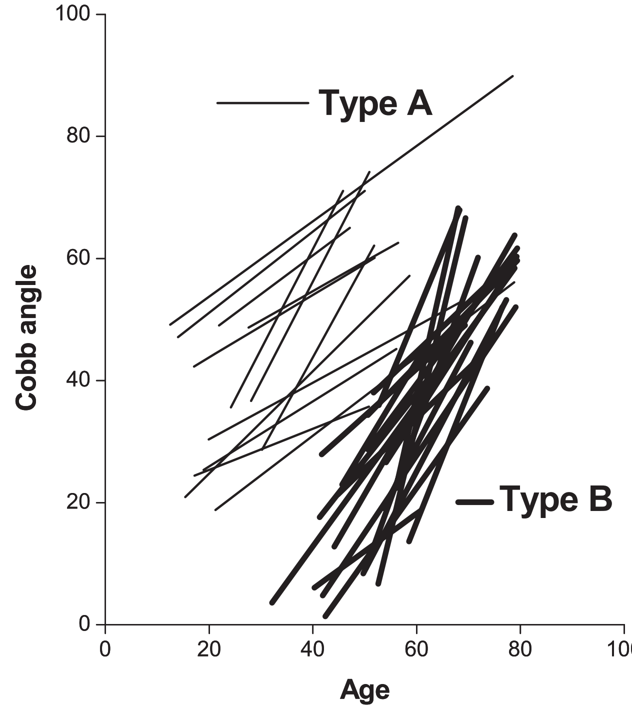
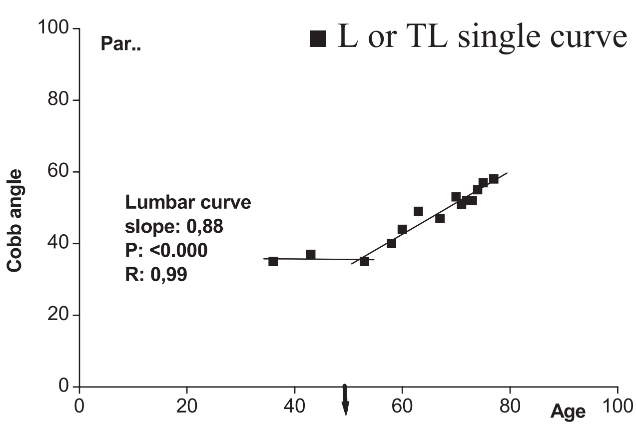


Figure 9. Graph of all the curves type A and B.

at the time of onset of type BM. The only patient without rotatory subluxation presented type A scoliosis.

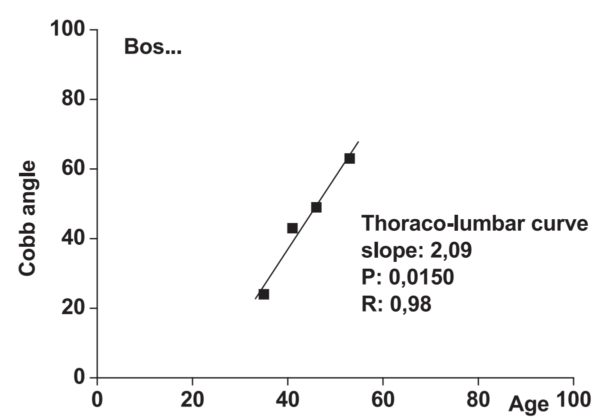
■ Discussion

Most studies in the literature concern progression of childhood or adolescent scoliosis during adulthood, and are based on comparison between the Cobb angle at skeletal maturity and the Cobb angle measured 20, 40, or 50 years later, depending on the study.[3–6] The annual progression is calculated by the difference between these 2 angles divided by the duration of follow-up. This method of determination of progression is less precise than that used in our study, as it does not take into account the interval of measurement of the Cobb angle, and it is unable to visualize progression. Weinstein and Ponseti[4] showed that 68% of cases of scoliosis progress, with a minimum difference of 5°, particularly curves measuring more than 30°. However, this cutoff value of 5° appears to be insufficient to conclude formally on progression. Various authors[3–6] have tried to define risk factors for progression: initial Cobb angle >30°, L5 vertebra not well seated in the pelvis, and rotation >33% according to Nash. Results according to site are discordant. Ascani *et al*[3] showed that the risk of progression in relation to the site of the curve decreased in the following order: thoracic, lumbar, thoracolumbar, and finally double curves and that the risk of progression was correlated with the initial Cobb angle. Danielson and Nachemson[6] found that 36% of adolescents with scoliosis had progressed by more than 10° after 22 years but that single curves did not progress more than double curves. In our study, we did not compare progression of scoliosis as a function of site, and we did not find a significant correlation between the initial Cobb angle and slope of pro-



Type BM : F,L, stable adolescent scoliosis then progressing at menopause, men: 50 years, age RS: 53 years, n=13

Figure 8. Type BM: Female, lumbar single curve, stable adolescent scoliosis then progressing at menopause, men: 50 years, age rotatory subluxation: 53 years (n = 13).



Other type : F,TL, men:0, age RS: 46 years, n=4

Figure 10. Other type: Female, thoracolumbar single curve, men: 0, age rotatory subluxation: 46 years (n = 4).

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Table 5. Mean and SD of the Parameters for Types A, B, and Scoliosis that Progresses at Menopause (BM)

	Type A (n = 13)				Type B (n = 20)				Type BM (n = 11) Subgroup B			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Age 1	24	4.91	17	32	46	7.96	33	60	46	8.49	33	60
Age 2	54	10.1	44	74	72	6.4	59	80	74	4.74	67	80
Duration of natural history studied	30	11.34	16	53	24	8.14	9	41	25	8.98	9	41
Age RS	42 (12)	8.81	29	58	56	4.51	47	65	57	4.3	52	64
Loss of height (cm)	5	1.99	2.5	9	10	3.9	2.5	17	10.8	3.93	5	17
Lumbar Cobb RS	52 (12)	7.19	38	62	29 (19)	8.35	13	47	29 (10)	9.89	13	46
Lumbar Cobb 1	37	10.59	22	52	20	9.79	3	35	19	10.17	3	35
Lumbar Cobb 2	59	12.47	35	85	50	11.92	18	66	52	10.28	34	66
No. lumbar points	7	2.18	3	10	7	1.96	4	12	7	2.53	5	14
Lumbar slope	0.82	0.47	0.34	1.65	1.64	0.87	0.77	3.82	1.88	1.01	1.63	3.82
Thoracic Cobb 1	41 (8)	13.63	22	62	—	—	—	—	—	—	—	—
Thoracic Cobb 2	55 (10)	14.77	38	80	—	—	—	—	—	—	—	—
Thoracic slope	0.6 (10)	0.26	0.3	0.95	—	—	—	—	—	—	—	—
Age RS: age 1	18 (12)	9.68	5	34	—	—	—	—	4.4 (10)	3.92	0	10
Kyphosis 2	37	16.32	11	79	52 (16)	15.02	31	85	49 (9)	13.44	31	73
Lordosis 2	52	10.64	41	82	47 (18)	14.89	17	65	42 (10)	14.84	17	65
No. vertebrae in lordosis	4	1.04	2	6	4 (18)	1.42	2	8	3 (10)	0.79	2	5
Sacral inclination 2	32	10.16	16	52	28 (18)	10.55	7	47	24 (10)	11.31	7	45
Pelvic incidence	53 (11)	13.79	32	77	56 (18)	11.86	36	75	53 (9)	10.95	36	68

Max indicates maximum; Min, minimum; RS, rotatory subluxation.

gression, either in the overall population or in the subgroups, particularly in type A, but our sample size may have been too small. Few published studies are available on the other forms of adult scoliosis, called degenerative or *de novo* scoliosis.[7,9,11] Korovessis *et al*[7] proposed a predictive equation of progression based on the degree of rotatory subluxation, the Harrington factor and disc index. These investigators reported a mean progression of 2.4° per year for a mean follow-up of 5 years, which is much higher than the rate of progression observed in our study. They proposed the hypothesis that rotatory subluxation is an initial phenomenon of "degenerative" scoliosis.[7] Chopin and Mahon[8] studied progression of all types of scoliosis during adulthood, and showed that lumbar curves presented the most marked progression (1.8°/y) followed by thoracolumbar curves (1.4°/y) and thoracic curves (1.2°/y), then double curves (thoracic 0.8°/y, lumbar 0.9°/y), but without distinction of the various types.

Table 6. Comparison of Means of Types A and B (Analysis of Variance Test)

	No.	Mean	SD	F	*P*	
Age 1	33	37.12	12.94	80.41	0.000	*
Age RS	31	50.26	9.38	33.67	0.000	*
Loss of height (cm)	32	7.66	3.94	14.85	0.001	*
L and TL Cobb RS	31	37.97	13.81	62.03	0.000	*
L and TL Cobb 1	33	26.45	12.93	21.35	0.000	*
L and TL Cobb 2	33	53.42	12.81	4.65	0.04	†
Lumbar slope	33	1.32	0.83	9.72	0.004	‡
Kyphosis 2	29	45.07	17.15	6.78	0.02	†
Lordosis 2	—	—	—	—	—	NS
No. vertebrae	—	—	—	—	—	NS
Sacral inclination 2	—	—	—	—	—	NS

L indicates lumbar single; NS, nonsignificant; RS, rotatory subluxation; TL thoracolumbar single.

Our study had different objectives: to define the type of scoliosis and its mode of progression, and to establish an individual progression profile. The originality of our study concerns the progression diagram comprising several points to minimize fluctuations of Cobb angle measurements and to visualize progression. The interval of measurement used in the various studies ranges from 4° to 7°, especially when old, nonstandardized radiographs are used, bearing in mind that the distance from the source does not modify angular measurements. Progression diagrams demonstrated the linearity of progression of the Cobb angle over time in 46 out of 51 patients, regardless of the type of scoliosis. Duval-Beaupère[12,13] demonstrated the linearity of progression of both paralytic and idiopathic childhood scoliosis. This linearity can be used to provide an individual prognosis of progression when at least 3 separate points are available by defining a rate of progression for each patient and each curve.

No cases of single thoracic curve were observed in our series, either because they have a lower tendency to progression, major curves were operated on at the end of adolescence, or they are better tolerated, and these patients, therefore, do not consult.[5]

We distinguished 2 main groups that have already been described by other authors: adolescent scoliosis, which continues to progress regularly during adulthood, but at a slower rate, and lately progressive adult scoliosis ("degenerative scoliosis"). However, "degenerative scoliosis" does not always correspond to *de novo* scoliosis and probably comprises several subgroups: *de novo* (Figures 6, 7) or scoliosis present during adolescence, which subsequently progresses late in adulthood (Figure 8). Type B is called degenerative because of the presence of disc degeneration and facet arthrosis, but there is probably also another cause related to ligaments and muscles.

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The onset of some of these *de novo* forms of scoliosis corresponds to menopause (Figures 6–8). Chopin and Mahon[8] observed more marked deterioration after menopause than before, as confirmed in our series for type B. However, no change in the slope of progression was observed for type A at menopause.

These 2 main types, A and B, appear to be very distinct entities. The initial lumbar single and thoracolumbar single Cobb angle is lower in type B, but the slope of progression is higher. It should be noted that in type A, we compared predominantly lumbar component of double curves to single lumbar curves of type B. However, the slope of progression in type B of 1.64°/y is much higher that the rate of progression of single curves in young adults, as Weinstein and Ponseti[4] reported values of 0.24°/y for lumbar single curves and 0.46°/y for thoracolumbar single curves. Kyphosis was slightly more severe in type B, but the subjects in this group were older. The loss of height was much greater in type B, which can be explained by the fact that these patients were older, but also presented a higher slope of progression and deterioration of kyphosis. Rotatory subluxation occurs during the course of type A scoliosis, while it is visible from the onset or soon after the onset of type B scoliosis. Like Korovessis *et al*,[7] we believe that rotatory subluxation is probably the initial element of progression of type B scoliosis. Rotatory subluxation occurs at small and even very small angles in type B in contrast with type A. We consider that the term "rotatory subluxation" is selective and does not correspond to all the lateral rotatory olisthesis. A pattern of lateral rotatory olisthesis should be established.

■ Key Points

- The progression of adult scoliosis is linear. It can be used to establish an individual prognosis.
- Two main types exist: adolescent scoliosis, which continues to progress (type A); or late onset scoliosis, either preexisting scoliosis either *de novo* (type B).
- These 2 types are distinct entities. Rotatory subluxation seems to be the initial element of progression for type B, while it is the consequence of progression for type A.
- Menopause constitutes a period of deterioration for type B.

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