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Surface Topography, Cobb Angles, and Cosmetic Change in Scoliosis

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Study Design: Preliminary analysis of the clinical value of surface topography in a spinal deformity clinic.

Objectives: The Cobb angle is the gold standard for the monitoring of scoliosis. This study was designed to determine whether surface topography would reflect Cobb angle status with sufficient reliability to permit its safe use as an alternative means of documentation in some circumstances.

Summary of Background Data: Surface topography offers the possibility of describing spinal deformity more fully than radiographic measures alone. To be useful, it must ignore changes due to varying posture and reliably detect differences that are clinically significant, while broadening the ability to assess deformity.

Methods: Surface topography using Quantec (Quantec Image Processing, Warrington, Cheshire, UK) was obtained routinely in all patients attending a spinal deformity unit. Intrasubject variation was reduced by taking the mean for each parameter of four repositioned scans, which gives a smallest detectable change on all measures of approximately 10 U. Fifty-nine patients with two sets of radiographs and topography scans were studied to determine the ability of the different measurements to detect significant change.

Results: There was a significant correlation between Cobb angle and Quantec spinal angle. A significant change in Cobb angle could be identified by associated change in at least one topographic measure in a significant proportion of cases.

Conclusions: It is unlikely that topography will supplant radiography for the ascertainment of Cobb angles, because the error margins of both are wide, and the two are not measuring the same aspect of the deformity. The Quantec system is useful in patient monitoring as an alternative to radiography, without diminishing the standard of care. [Key Words: scoliosis, surface topography–spinal deformity] **Spine 2001;26:E55–E63**

Scoliosis was defined by Stokes[40] in 1994 as a lateral curvature of the spine with concordant vertebral rotation. It is quantified by the Cobb angle[10] and is essentially a radiologic diagnosis, in that the minimum curvature of 10° can be confirmed only on radiograph.[6] Clinicians in earlier times who had not the advantage of radiographic technology were more accustomed to examining the whole deformity and considering the varieties of back shape. Plaster casting, drawing, and photography (see, for instance, Hoke's elegant example from 1903[24]) were used to record the deformity, but all have obvious problems with subjectivity and quantification. In comparison, the Cobb angle is simple to measure and has an agreed interobserver error.[8,30] The limiting factor to its utility is that it does not adequately describe the deformity, there being little correlation between degree of curvature and rib hump.[46] Thus, although the Cobb angle is an invaluable measure of scoliosis severity and progression, further methods of quantifying and analyzing the deformity would improve understanding and assessment of treatment.

Several methods[7,34] have been introduced to achieve this, the most enduring being Bunnell's[5] scoliometer, which has been used for school scoliosis screening programs[15,22,31] and in the analysis of back shape after surgery.[49] Techniques that use surface topography, such as Moire fringe[13,14,16,36,41,42] and the integrated shape-imaging system (ISIS)[9,17,26,44,47,48] provide an image to be interpreted as well as numbers to be understood and calibrated. These have been well described in the literature but have not been widely adopted, perhaps because they require some skill in their operation and interpretation, and the value of the information provided was, rightly or wrongly, not perceived to be overwhelming.

Nevertheless, young children with spinal deformity are destined for intensive follow-up review for many years, often into adult life.[4] This has raised fears of increased cancer risk[23,27–29,32] from exposure to ionizing radiation, and although measures have been introduced to minimize exposure, it remains a possibility that is considered by the clinician and, to an increasing extent, by the patient and her parents. Thus, a method of documentation and monitoring of deformity that is inexpensive and noninvasive, as well as repeatable and reliable, would be welcome.

The Quantec system (Quantec Image Processing, Warrington, Cheshire, UK) was designed to address this problem. The technology involved[11] and the technical and clinical trials[37,38,50] have been described. It offers good photographic images and numerical values for several deformity parameters. Because it is noninvasive, using only an electric light source, a video camera, and a computer (Figure 1) and can be operated by nonspecialist personnel, it seemed an ideal addition to the assessment and observation of spinal deformity in a pediatric orthopedic department. A Quantec system was acquired for the orthopedic unit for this purpose in April 1995 and became part of the routine assessment and follow-up of

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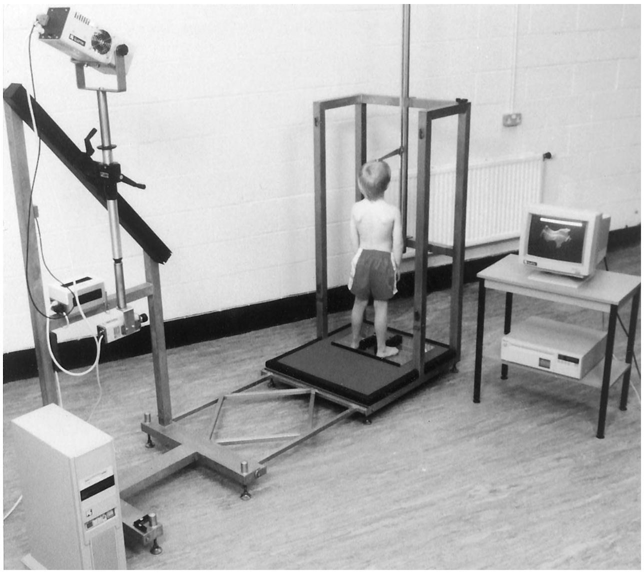


Figure 1. Quantec system of surface topography. (Photograph courtesy of Quantec Image Processing, Warrington, Cheshire, UK).

patients attending the spinal deformity clinics for observation or treatment. Early work[19–21] showed that repeated repositioning of the patient and averaging the results reduced the error margins in proportion to the number of scans taken.

■ Materials and Methods

This study was designed to examine the extent to which change in surface topographic parameters reliably detects change in Cobb angle and thus could be used to enhance monitoring of deformity and as a prerequisite for follow-up radiographs.

The Quantec Image-Processing System for Spinal Deformity. The Quantec system[11] is illustrated in Figure 1. It consists of a desktop computer (Acorn A5000; Acorn, Computer, UK [new system in preparation] and Pentium processor; Intel, Mountain View, CA) with digitizing capability, a video camera, and a slide projector that throws a specially designed shadow pattern on the child's back. The subject stands free in a customized frame, with feet separated by a standard wooden block, arms by sides and looking straight ahead. The dimples of Venus, the posterior spinous processes of T1, T12, and as many other vertebrae as thought appropriate are marked with paper stickers. The image is captured, stored on computer, and processed by the investigator who must, on screen, correct any broken lines that the computer was not able to reconstruct and then, using the mouse, indicate the line of the spine by joining the markers described and then selecting the anatomic landmarks (T1, T12, and the posterior superior iliac spines). The image is then analyzed by the customized software according to several parameters. All topography scans were performed by the same investigator (CG). These views are printed and filed in the child's record for easy and permanent access. Because the data are stored digitally, this analysis can be expanded as new measures are developed.

Quantec Measurement Parameters. The system provides several specific measures relating to the topography of the patient's back. Those that have been found most useful at this center are listed in and illustrated in Figure 2. They include the spinal or Quantec angle, which is analogous to the Cobb angle,

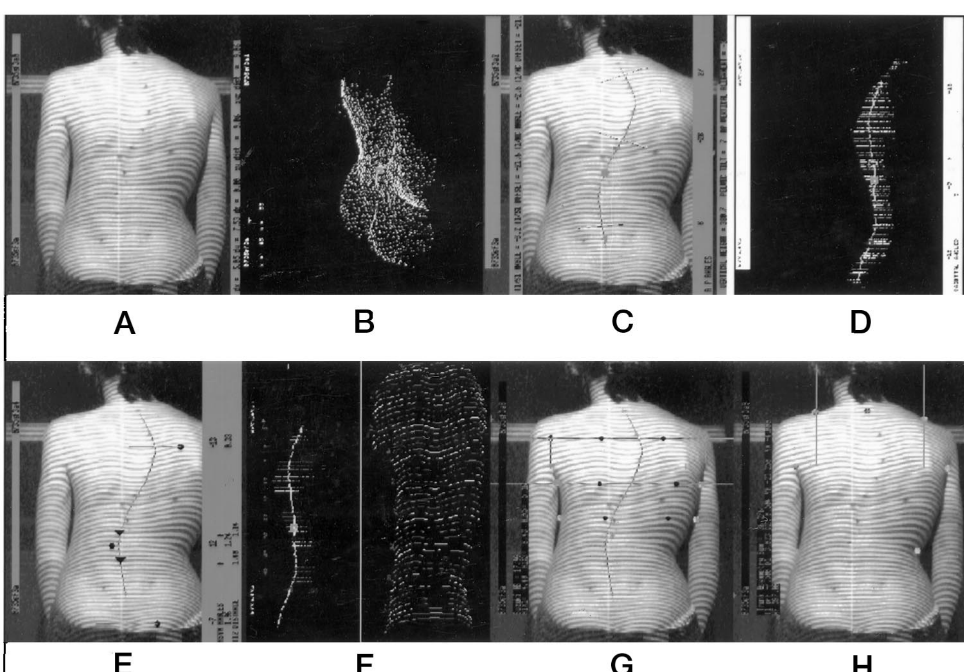


Figure 2. Quantec surface topography measures. **A,** Image, no analysis. **B,** Three-dimensional reconstruction of back surface. **C,** T_1S_1O - displacement of first thoracic vertebra over sacrum; Q1A - upper spinal angle; Q2A - middle spinal angle; Q3A - lower spinal angle. **D,** TK = thoracic kyphosis; LL = lumbar lordosis. **E,** AS1A - inclination at upper maximum asymmetry point (rib hump); AS2A - inclination at middle asymmetry point; AS3A - inclination at lower asymmetry point. **F,** Sagittal line and transverse sections. **G,** SHS = Suzuki hump sum.[1,33] **H,** POTSI = posterior trunk symmetry index.[1,25,43]

but is derived from the spine line (vide supra) and is calculated automatically; sagittal angles are derived in a similar fashion. Asymmetry angles represent rib and loin humps. The Suzuki hump sum[33] (SHS, a measure introduced originally by Inami et al[25] for Moiré topography and adapted to Quantec by the manufacturers) is a numerical expression of the overall asymmetry of the back and is calculated by the system from the position of the first thoracic vertebra, the angle of the more prominent scapula, and the most lordotic point of the lumbar spine. It is the total sum of the hump indexes at three levels of the back. Trunk balance is measured by the offset of the first thoracic vertebra over the sacrum (T1S1O) and by the posterior trunk symmetry index (POTSI).[1,25,43] The latter is the only measure that does not use the line of the posterior spinous processes and is thus particularly relevant in children who have had prior posterior spinal fusion. It expresses trunk balance, waist asymmetry, and shoulder elevation in a combined numerical score.

All parameters are in degrees, except the offset of the first thoracic vertebra, which is expressed as millimeters, and the Suzuki hump sum and POTSI, which were designed to be independent of size and so have no units.

Radiographic Measurement. Standard erect, posteroanterior radiographs taken for clinical purposes were measured (Cobb method[10]) by the first author (CG) whose intraobserver error, following exactly the method described by Carman et al[8] on the basis of two measurements on each of eight radiographs (the number also used by Carman et al[8]) was calculated to be 8°). Clinically significant change on radiographs was taken as 10°, according to Risser,[35] and allowing for personal intraobserver error. The other option, 5°, although commonly used, has been shown to underestimate the possible measurement error.[8,30] The authors have found 10° to be of greater clinical significance and usefulness and prefer to use it in practice.

Surface Topography: Within-Subject Variation. Smallest detectable change (the smallest real change that can be detected and declared statistically significant *i.e.*, that is measurable) for each Quantec measurement at this center was calculated soon after acquisition of the system.[19] For this, 105 scans in 103 consecutive patients, 74 girls and 29 boys, either attending the scoliosis clinic or admitted to the hospital for assessment or surgery with all types of spinal deformity were scanned eight times, repositioning once after the fourth scan. Skin markers were not replaced between scans. Their diagnoses were: normal (n = 5), nonscoliosis asymmetry or Cobb angle less than 10° (n = 10), adolescent idiopathic scoliosis (n = 29), infantile idiopathic scoliosis (n = 3), juvenile idiopathic scoliosis (n = 9), congenital vertebral anomaly (n = 28), scoliosis associated with an underlying condition (n = 12), and miscellaneous spinal problems, such as juvenile kyphosis or spondylolisthesis (n = 7). In 80 scans, the patients had not had surgery and in 25, surgical correction of scoliotic deformity had been performed. Two girls with adolescent idiopathic scoliosis appear twice, with both pre- and postoperative scans.

It was postulated that there are two components of error in determining the Quantec parameters. First, there are changes in position of the subject with reference to the fixed frame of reference, and second, changes due to the postural sway within that position. Nested analysis of variance was used to estimate the components attributable to positioning (series) and postural sway (replicates) of the means of the variance of all parameters. The estimated variance is calculated by[39]:

$$V_{(X)}=V_{(S)}/N_{(S)}+V_{(R)}/(N_{(S)}{}^{*}\ N_{(R)}) \tag{1}$$

where: $V_{(X)}$ is variance of parameter X; $V_{(S)}$ is that part of the variance attributable to positioning (series); $N_{(S)}$ is the number of repositionings (series of scans); $V_{(R)}$ is that part of the variance attributable to sway (replicate scan); and $N_{(R)}$ is the number of replicate scans within a position.

This was calculated for all the key parameters. It is then possible to estimate the parameters to a specified precision by selecting a combination of the number of repositionings and scan replicates per positioning. The smallest detectable change (δ) can then be calculated from the formula[39]:

$$V_{(X)} = \delta^2/15.6, \tag{2}$$

where $V_{(X)}$ is the variance of the average of the parameter X, δ is the smallest detectable change, and 15.6 is the constant, for $P < 0.05$ and power = 0.8. Statistical analysis was performed by the second author (MK) by computer (Minitab, ver. 11; University Park, PA).

Correlation of Cobb and Quantec Angles. The major Cobb angle in 155 patients (132 girls and 23 boys, selected only on the basis of availability of records) was compared with the corresponding major Quantec spinal angle from a topographic scan taken at the same hospital visit. The diagnostic groups were normal spine (n = 1), nonscoliosis asymmetry with Cobb angle less than 10° (n = 6), adolescent idiopathic scoliosis (n = 118), infantile idiopathic scoliosis (n = 3), juvenile idiopathic scoliosis (n = 11), scoliosis associated with another condition (n = 13), and miscellaneous back problems (n = 3). None had undergone surgery. Mean age was 13.95 ± 2.72 (range, 2.67–20.58). Mean Cobb angle was 41.16° ± 22.0° (range 0–114°). Mean topographic spinal angle was 24.2°± 14.0° (range, 1.5–61.25°). Pearson's correlation coefficient was calculated by computer (SPSS for Windows98 ver. 8; SPSS, Chicago, IL). The mean of four repositioned topographic measures was used in all cases.

Scoliosis Monitoring. Children attending the orthopedic department for assessment or treatment of noncongenital scoliosis (*i.e.*, idiopathic or associated with another significant condition) were considered. Pairs of radiographs and Quantec scans taken for the same clinical visit were compared for clinically significant change, either progression or regression.

Fifty-nine children, a subgroup of those described earlier, had two such pairs of radiographs and scans. There were 47 females and 12 males. The diagnoses were adolescent idiopathic scoliosis (n = 39), infantile idiopathic scoliosis (n = 2), juvenile idiopathic scoliosis (n = 7), and scoliosis associated with a second condition (n = 11). None had undergone surgery. Mean age at first observation for this part of the study was 12.688 ± 3.2 years, (range, 2.67–19.584). At second observation, mean age was 13.797 ± 3.112 years (range, 4.912–20.58). The mean time gap was 1.108 ± 0.635 years (range, 0.266–2.453). As described, the mean of four scans was used

Table 1. Variance of Parameters Due to Positioning (Series) and to Sway Within that Position (Replicate). Smallest Detectable Change (δ) for Each Parameter Calculated for a Single Scan, for Four Repositioned Scans, and for 10 Repositioned Scans
For legend, see Table 1.

Variable	Replicate $V_{(R)}$	Series $V_{(S)}$	δ $N_{(S)} = 1$ $N_{(R)} = 1$	δ $N_{(S)} = 4$ $N_{(R)} = 1$	δ $N_{(S)} = 10$ $N_{(R)} = 1$
T_1S_1O	15.70	8.33	19.36 mm	9.68 mm	6.12 mm
Q1A	10.00	2.10	13.74°	6.87°	4.34°
Q2A	17.70	3.28	18.09°	9.05°	5.72°
Q3A	12.10	1.97	14.82°	7.41°	4.68°
TK	20.20	2.55	18.84°	9.42°	5.96°
LL	17.20	0.95	16.83°	8.41°	5.32°
AS1A	20.37	4.15	19.56°	9.78°	6.18°
AS2A	11.70	2.28	14.77°	7.38°	4.67°
AS3A	13.87	3.92	16.66°	8.33°	5.27°
SHS	10.60	9.39	17.66	8.83	5.58
POTSI	14.00	11.55	19.94	9.98	6.31

$V_{(X)} = V_{(S)}/N_{(S)} + V_{(R)}/(N_{(S)}*N_{(R)})$.[39]
$V_{(X)} = \delta^2/15.6$.[39]
δ = smallest detectable difference.
T_1S_1O = displacement of first thoracic vertebra over sacrum; Q1A = upper spinal angle; Q2A = middle spinal angle; Q3A = lower spinal angle; TK = thoracic kyphosis; LL = lumbar lordosis; AS1A = inclination at upper maximum asymmetry point (rib hump); AS2A = inclination at middle asymmetry point; AS3A = inclination at lower asymmetry point; SHS = Suzuki hump sum; POTSI = posterior trunk symmetry index.

as the actual value of each parameter (statistical analysis by SPSS).

The major Quantec angle was chosen to match the major curve of the spine as determined on radiograph. The incidence of change of at least 10 units (vide supra and Table 1) on any Quantec parameter was then related to change of at least 10° in Cobb angle of the major scoliotic curve (paired *t* test, Pearson's correlation coefficients, Fisher's exact test and ϰ statistic). All significance was two-tailed. Radiographs were not ordered specifically to facilitate this study but solely on clinical decision at the time, and none of the patients had had spinal surgery.

Results

Within-Subject Variation

The results of the study are given in Table 1. The within-subject variation for positioning (series) and sway (replicate) for each parameter are itemized in the first two columns. Formulas 1 and 2[39] were used to calculate the smallest detectable change to be accepted as real when only a single scan is used and if the average of 4 or 10 completely repositioned scans were taken as the final measurement. It shows that, although increasing the number of repositioned scans to 4 reduces this considerably, a further increase to 10 does not give an increase in accuracy that is commensurate with the increase in patient and operator time. The limiting factor is always the variation that is due to the positioning of the child for the scan, which, despite best efforts, never exactly reproduces the previous positioning.

Correlation Between Cobb and Quantec Angles

For the 155 patients studied with matched radiographs and topographic scans, Pearson's correlation coefficient between Cobb angle and major topographic angle was 0.812. This is shown graphically, with 95% confidence intervals, in Figure 3. The equation gives the spinal angle as 2.91 + 0.52*Cobb angle and r^2 is 0.66, indicating that 66% of the topographic curve (visible deformity) can be explained by the spinal curve (Cobb angle) alone, and the remainder must be due to other variables as yet not fully known or analyzed but including the measurement error of both Cobb and topographic angles as well as the noncorrespondence between spinal curvature and back surface shape.[46]

Change in Cobb Angle and Matched Major Spinal Angle

For the subgroup of 59 with a repeat set of radiographs and scans, the mean for the first Cobb angle was

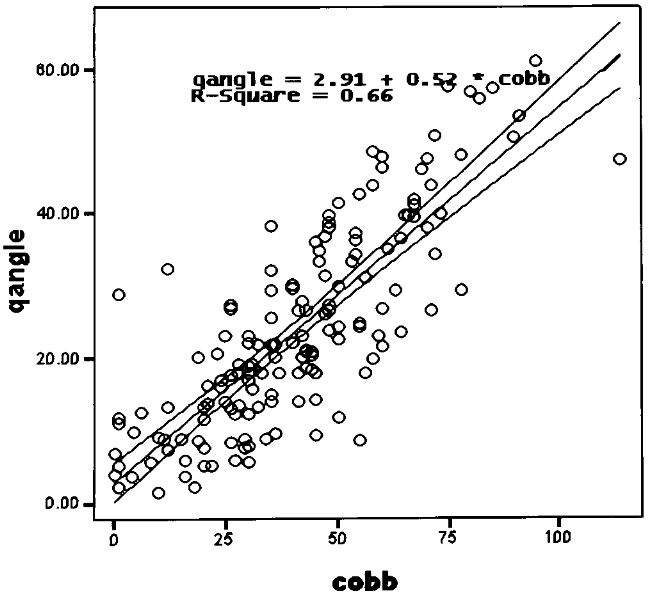


Figure 3. Correlation of Cobb angle and corresponding topographic spinal angle (n = 155). Cobb = Cobb angle of the major curve on radiography; qangle = corresponding major surface topographic angle.

Table 2. Association Between Significant Cobb Angle Change (+/−10° or More) and Change in Topography Parameter (+/− >10 Units)

Cobb angle		No change 0 N = 31	Change 1 N = 28	Fisher's Exact Test	Kappa
Matched angle	0	26	20	0.348 NS	1.28
	1	5	8		$P = 0.250$ NS
T_1S_1 offset	0	24	20	$P = 0.766$ NS	.061
	1	7	8		$P = 0.598$ NS
Upper spinal angle	0	24	19	$P = 0.559$ NS	0.098
	1	7	9		$P = 0.409$ NS
Middle spinal angle	0	26	20	$P = 0.348$ NS	0.128
	1	5	8		$P = 0.25$ NS
Lower spinal angle	0	29	23	$P = 0.240$ NS	0.118
	1	2	5		$P = 0.176$ NS
Any QA change	0	22	13	$P = 0.068$ NS	0.247
	1	9	15		$P = 0.055$ NS
Thoracic kyphosis	0	26	14	$P = 0.011$*	0.344
	1	5	14		$P = 0.005$†
Lumbar lordosis	0	26	22	$P = 0.285$ NS	0.122
	1	5	6		$P = 0.210$ NS
Upper rib hump	0	29	24	$P = 0.409$ NS	0.082
	1	2	4		$P = 0.320$ NS
Lower rib hump	0	31	26	$P = 0.221$ NS	0.075
	1	0	2		$P = 0.130$ NS
Loin hump	0	30	25	$P = 0.337$ NS	0.078
	1	1	3		$P = 0.253$ NS
Suzuki hump sum	0	28	17	$P = 0.013$*	0.303
	1	3	11		$P = 0.008$†
POTSI	0	25	14	$P = 0.026$*	0.311
	1	6	14		$P = 0.013$*
Any Q change	0	14	0	<.001‡	0.439
	1	17	28		<.001‡

N = 59.
NS = not significant.
* $P < 0.05$
† $P < 0.01$
‡ $P < .001$

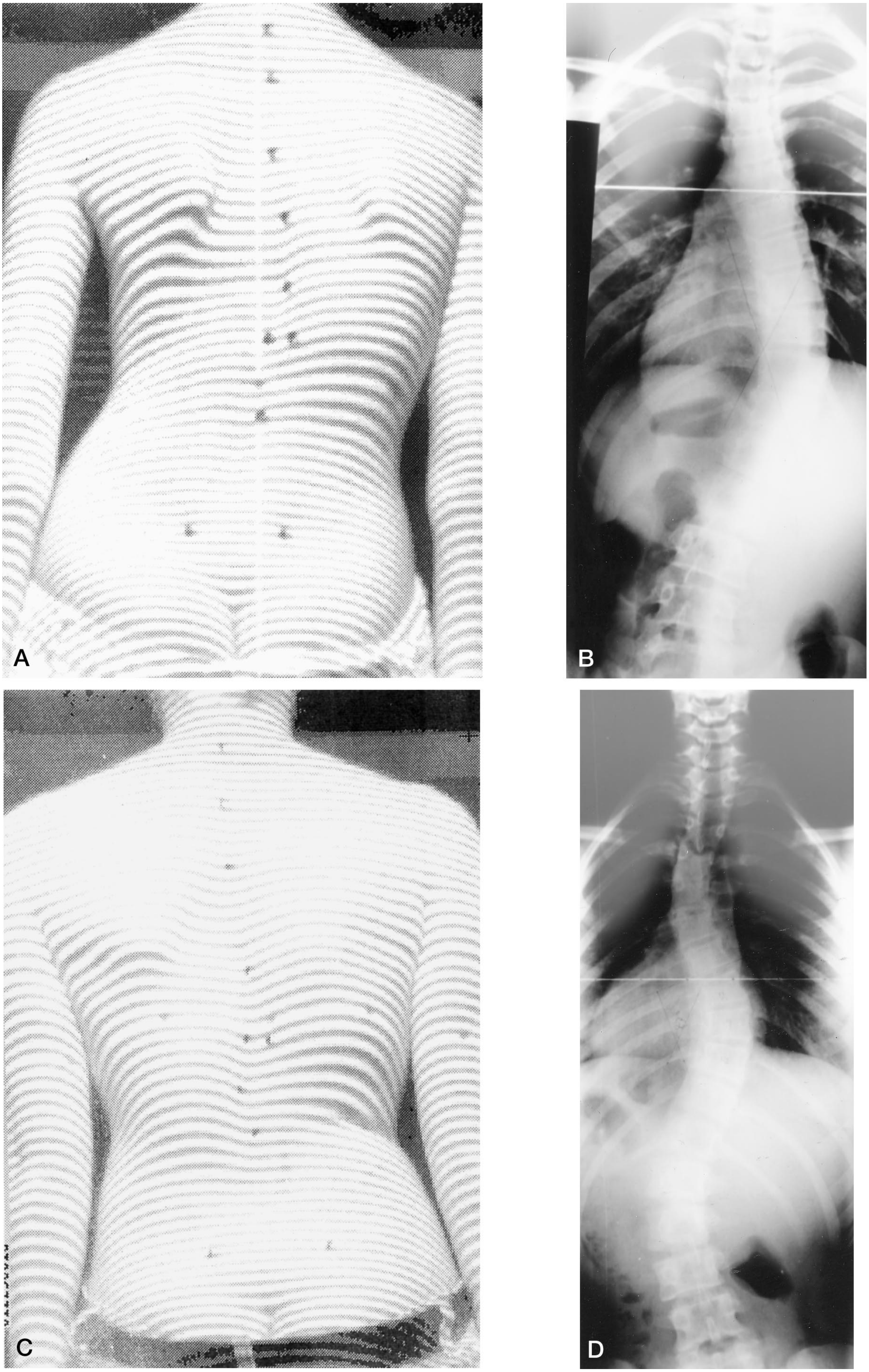
45.58°± 16.07°, and for the second was 55.17°± 18.89°. For first and second matching Quantec angles, the mean was 24.6884°± 10.2841° and 29.1737°± 12.4666°. In 31 patients, the Cobb angle neither decreased nor progressed by 10° or more. In 26 there was at least a 10° progression, and in 2 there was at least a 10° improvement. The matched spinal angle increased in 10 patients but a reduction was not recorded. The mean difference between the first and second Cobb angles was an increase of 9.59° ± 10.76°. Paired t test shows this to be a statistically significant increase ($t = 6.849$, 95% confidence intervals 6.79–12.4, $P < 0.01$) Between the first and second Quantec angles, the mean difference was 4.8453° ± 8.74°, ($t = 3.94$, 95% confidence intervals 2.22–6.76, $P < 0.01$). For these changes, Pearson's coefficient (r) was 0.549, significant at $P = 0.01$. However, r^2 was only 0.301, indicating that only 30% of the change in Quantec angle was associated with the Cobb angle change.

Considering the other topographic parameters, there was significant correlation between the change in major Cobb angle the Suzuki hump sum (mean difference 3.97, SD 7.62, $r = 0.482$, $P < .01$), and POTSI (mean difference 5.27, SD 11.0, $r = 0.423$, $P < 0.01$) but not the remaining parameters. Although these results show statistical significance, they also show that topographic measures are not strongly dependent on Cobb angle, as was shown by Thulbourne and Gillespie[46] in 1976.

Agreement on Significant Radiographic Change and Change on Individual Quantec Parameters

Comparing the two sets of measurements on a change = 1/no change = 0 basis, Cobb angle status (change of at least 10°) was compared with the status (change of more than 10 units) of each parameter individually, to a change of more than 10° in any one of the three spinal angles and to any change of more than 10 units on any parameter (Table 2). Individually, there were statistically significant associations between the fact of significant Cobb angle change (increase or decrease of at least 10°) and change of more than 10° in thoracic kyphosis, and of more than 10 units in Suzuki hump sum and in POTSI. However, the most relevant finding was the highly significant association between Cobb angle change on the one hand and change in at least one of the 11 Quantec parameters on the other.

In this series of 59 cases there was not one false-negative finding. Although the authors are not so sanguine as to expect this situation to continue indefinitely, it indicates that clinically significant change of


A
B
C
D

10° or more in Cobb angle is usually accompanied by a measurable change (*i.e.*, greater than the smallest change that is detectable) in at least one of the parameters that are routinely recorded on Quantec imaging at this center. The reverse is not true; there were a number of false positive results. As a pretest for significant change on radiograph, the system had a sensitivity of 100%, a specificity of 45%, a positive predictive value of 62%, a negative predictive value of 100%, a false positive rate of 37.77% and a false negative rate[12] of 0%.

Discussion

Intrasubject Variation

This particular system was chosen because it offered good photographic images of the patient that are immediately recognizable (Figure 2), and are available within minutes, thus allowing comparison with previous images and quantification of this visual impression. Initially, the wide variation on single scans was disappointing, but repeat imaging with repositioning for each scan has reduced this. Although larger numbers of scans would reduce this still further, the variation can never be brought below that of the positioning itself, and increasing the number of repositioned replicate scans indefinitely would never reduce it to zero. In practice, the authors find that a protocol of four scans, with the child stepping out and back into the apparatus between each, is the maximum that is feasible within a sensible time and provides meaningful and useful results, while keeping the cost in investigator's time to an affordable level.

Recently, Thometz et al[45] reported their results using the Quantec system in 40 normal children, giving standard deviation, standard error, and 95% confidence intervals on the full range of 18 Quantec measures, including the ones discussed in this study. In the present approach the variance of the same measures on a mixed group of patients was examined, but the clinical use only reported on the 11. This method takes the inquiry a stage further, because it gives not only the margin that must be allowed on a single scan, but also can improve precision to whatever level required by increasing numbers of repositioned and replicate scans.

These considerations raise the question of repeatability of radiographs. Studies[3,8,30], have concentrated on inter- and intraobserver variation and, for obvious reasons, have not investigated the variation that might be seen if a radiograph were taken, the child repositioned, and the radiograph repeated (within-subject variation). There are two studies[2,51] in which investigators have examined diurnal variation in Cobb angle and reported quite wide differences, both increase and decrease, but explained their findings within the context of their inquiry by disc shrinkage. It is unlikely that ethical approval or informed consent would be given now for a study that would necessitate obtaining two radiographs in a child when one had previously been considered sufficient. At this center, major treatment decisions are not made purely on the evidence of a 5° increase in Cobb angle, and it is thought that 10°, as Risser[35] stated in 1958, is a more clinically significant change. Consideration of topography parameters, Cobb angle, child's appearance and prognosis, and her or his wishes and those of the parents are taken into account before major decisions are taken.

Correlation of Cobb and Topographic Angles

Sakka and Mehta[37] and Sakka et al[38] reported their findings with Quantec scanning and radiography in the follow-up of all types of scoliosis. They deduced an algorithm (Q angle = 3.834 + 0.753 · Cobb angle, where r = 0.801) to convert topographic to radiographic measures, but state that this fails at the extremes—*i.e.*, for very small and very large curves. This is different from the equivalent figures reported in the current results. Although this may be due to somewhat different techniques, it indicates that, as with personal Cobb angle variation, each topography investigator would do well to calculate his or her own equation.

The present authors have chosen not to follow the route of numerical conversion from topographic spinal angle to Cobb angle but to treat topographic and radiographic measures as associated but not arithmetically related in a simple manner. Certainly, large numbers in one discipline correlate with large numbers in the other, but as Figure 3 shows, although correlation is statistically significant, the Cobb angle alone cannot explain the whole of the surface deformity. The authors prefer to consider each child individually and as her or his own control, so that change with time is the issue and not numbers on a particular day.

As Thulbourne and Gillespie[46] reported in 1976, Cobb angle and rib hump do not correlate well, so it is unsurprising that individual topographic measures are not good indicators of Cobb angle. Anyone with a view of scoliosis in which all deformity is mechanical and secondary to the spinal curve will not find topography a useful addition, because it will seem superfluous to needs and irritating in its failure to yield a radiation-free Cobb angle. However, the child with scoliosis is dissatisfied with the deformity and not the Cobb angle. Figure 4, A–D, shows how different two children's problems may be, with similar major curves having identical Cobb angles but totally different appearance, prospects, and expectations. It is thought at this center that surface topography has not merely given a noninvasive indication of

Figure 4. **A**, Quantec image. Adolescent idiopathic scoliosis, right thoracic curve; age, 12.4 years; age at menarche; 12.3 years. **B,** Radiograph. Cobb angle 47°. **C,** Quantec image. Adolescent idiopathic scoliosis, right thoracic curve; age, 12.6 years, age at menarche 12.2 years. **D,** Radiograph. Cobb angle 47°.

Cobb angle status but also has broadened the view of scoliosis and provided more information for decision-making.

Clinical Considerations

A surface topography system was introduced with the intention of reducing exposure to radiation and the expense of investigations while maintaining adequate documentation and patient care. This is achievable, as indicated by the very few (59/155, 38%) children who had second pairs of measurements and so could be included in both the first and second comparative studies. The validity[12] of the test is acceptable: sensitivity, the proportion of true positives (*i.e.*, change of 10° or more correctly identified) was 100%. Specificity, the proportion of true negatives correctly identified, at 45%, is low. This can be tolerated, because topography was not used herein as a diagnostic tool or the only basis on which clinical decisions were made and is a lesser problem than the missing of significant progression would be. The positive predictive value, the proportion of those with positive test results that are truly positive, at 62%, represents what the clinician actually sees. This is lower than ideal but is markedly better than, for example, the Adams forward-bending test to detect at screening scoliosis that does or will pass 40°, where the positive predictive value is 8%.[18] The false-positive rate for detecting Cobb angle change by topography, at 37.7%, is high, but the 0% false-negative rate is encouraging.

However, it must be remembered that these figures were calculated in a clinical situation, in which all subjects were known to have scoliosis and to be at risk for progression. Only within-person change was being sought. It would not be safe to transfer these findings to a scoliosis screening session, in which the incidence of true positives would be much lower.[12] Neither is it anticipated that radiography may become entirely redundant. Radiographs are still needed for primary diagnosis and making major treatment changes, where only a Cobb angle will do, and when planning surgery.

At this center, surface topography was an instant success with patients and parents, in that they prefer not to be exposed to radiation and can believe that their complaint, (deformity) is being taken into account as well as the (to them) less easily accessible radiographic parameters. Topography was not found to be a quick fix but required considerable effort to bring it to a useful point, both in the initial gaining of expertise in the simple operation and in the interpretation of results. In fact, early results were discouraging with wide error margins and no apparent association between radiologic and topographic change. Yet surface topography is fundamentally an attempt to quantify what the clinician and the patient are seeing, the cosmetic appearance. If, as these findings show, each patient has an individual association between internal anatomy and external appearance, this is no more than has been already observed in clinical practice. To determine whether there are different spinal configurations that correspond with different topography patterns and the extent to which the latter can be used more usefully to monitor and perhaps to predict progress requires larger numbers studied repeatedly for a longer time.

■ Conclusions

The purpose of this study was to investigate the extent to which surface topography can be used in clinical management and follow-up of patients with pediatric spinal deformity. Although it is generally acknowledged that the Cobb angle does not adequately describe the visual impression of a child with scoliosis, all the principles of treatment and expertise are related to this measure. Therefore, it was necessary to show, as has been done, that there is a correlation between Cobb angle and topography. That this is not perfect emphasizes the point that what the observer sees is still far more subtle than what the clinician can measure but that topography reduces this gap.

■ Key Points

- This is the report of an analysis of surface topography in a pediatric scoliosis clinic to evaluate its usefulness as an adjunct to radiography.
- Error margins were established from 105 consecutive unselected patients from the spinal clinic and reduction of these by the averaging of multiple scans was calculated.
- Correlation of Cobb with spinal angles (n = 155) and of Cobb angle with topographic parameters (n = 59) was statistically significant and permitted identification of significant Cobb angle change from topographic change.
- Surface topography is a valid measure of spinal deformity and can be used in place of radiography for monitoring patients, particularly in minor cases and in young children.

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