

MOIRÉ TOPOGRAPHY IN SCOLIOSIS

ITS ACCURACY IN DETECTING THE SITE AND SIZE OF THE CURVE

J. S. DARUWALLA, P. BALASUBRAMANIAM

From Singapore General Hospital, Singapore

Moiré topography was added to school scoliosis screening in Singapore in 1982. The results from 1342 topographs, assessed in isolation, were used to study the accuracy of the method in predicting the radiographic location and magnitude of scoliotic curves.

Accuracy in identifying the site of the curve was 68% in the thoracic spine, 54% in the thoracolumbar spine, and 15% in the lumbar region. There were 12.7% false-positive results and 4.3% false negatives. Of patients with a deviation of one moiré fringe, 76.5% had a curve of 15° or less; of those with a deviation of four moiré fringes, 69% had a curve greater than 26°. The prediction of the Cobb angle was less accurate when there was a deviation of two or three fringes. It is suggested that moiré topography as a screening device should be reserved for use in the second tier of screening, since the forward-bending test is an effective and cheap method for the first tier of a mass school-screening programme.

Many methods have been described for the early detection of scoliosis (Lonstein 1977; Cooke, Carter and Pilcher 1980; Ashworth and Ersil 1981). Takasaki (1970) demonstrated the clinical application of moiré topography to measure deformity of the body surface and this has been used for scoliosis screening in Japan (Harada, Takemitsu and Imai 1981; Ohtsuka, Shinoto and Inoue 1981) and in Canada (Adair, Van Wijk and Armstrong 1977; Suzuki, Armstrong and Armstrong 1981).

A moiré topograph, or contourgraph, of a normal back is shown in Figure 1. Its value, as a non-invasive screening technique which reduces radiation exposure, depends on its accuracy in showing the location and the magnitude of a curve. This paper studies this accuracy using the criteria of Moreland, Barce and Pope (1981) for location, and of Willner (1981) for size of curve.

MATERIAL AND METHODS

Moiré topography was introduced in 1982 at the second tier of our school screening programme as described on pages 182 to 184 in this journal (Daruwalla *et al.* 1985). We used the Otal contourgraph model SS-1 which was developed by the National Research Council of Canada. A total of 1342 contourgraphs were available for this study. All were measured by both authors together with-

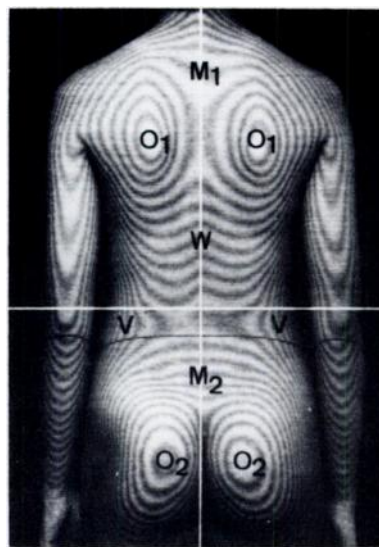


Fig. 1
Moiré fringe topograph of a normal subject.

out prior knowledge of the clinical or radiological findings.

RESULTS

In 1093 children, 1464 curves were confirmed radiologically, with a double curve in 355 children and a triple curve in eight. Of these curves 696 were thoracic, 518 thoracolumbar and 250 lumbar.

Site of the curve. The location could be diagnosed accurately on moiré topography in only 790 (54%) of the 1464 curves. The accuracy varied with the region, being best in the thoracic spine (Table I). Both curves were identified in only 121 (34%) of 355 double curves and

J. S. Daruwalla, MS, FRCS Ed, MCh Orth, Associate Professor
P. Balasubramaniam, FRCS, Professor
University Department of Orthopaedic Surgery, Singapore General Hospital, Singapore 0316.

Requests for reprints should be addressed to Mr J. S. Daruwalla.

© 1985 British Editorial Society of Bone and Joint Surgery
0301-620X/85/2055 \$2.00

Table I. The accuracy of diagnosis of the location of 1464 scoliotic curves by moiré topography

Level of curve	Radiography Number	Moiré topography	
		Number	%
Thoracic	696	472	67.8
Thoracolumbar	518	280	54.1
Lumbar	250	38	15.2
TOTAL	1464	790	54.0

only one of the two curves was identified correctly in 180 cases (50.7%). Kyphosis was accurately diagnosed in all six cases.

Magnitude of the curve. Asymmetry of the moiré pattern equal to or greater than one fringe interval was considered to be significant, as proposed by Willner (1981). With a deviation of one moiré fringe we were able to diagnose a curve of 15° or less in 76.5% of cases. A curve with a Cobb angle between 16° and 25° was diagnosed in 39.3% of cases with a deviation of two fringes. A curve of 26° to 35° was diagnosed in only 25.5% of those with a deviation of three fringes; but with a deviation of four moiré fringes 46% of curves were greater than 35°. Details are given in Table II.

same degree of accuracy. Moreland *et al.* were able to identify correctly a thoracic curve in 83% of cases, a thoracolumbar curve in 70%, and a lumbar curve in 58%. In our study the figures were 67.8%, 54%, and 15.2% respectively.

Cases in our series with a deviation of one and two moiré fringes had mean ranges of Cobb angle of 12° and 16° respectively, a result similar to the means of 12° and 21° reported by Willner (1981). There was a wider variation in the Cobb angle in our series, possibly because we analysed a greater number of cases. Of children showing a deviation of two moiré fringes, 52% had a lateral curve of more than 16°, a result similar to that reported by Willner (1981). With a deviation of three moiré fringes a wide distribution of the Cobb angle from 6° to 42° was noted. In 33 (70%) of 47 cases in this group the curve was more than 16°, whereas of those with a deviation of four moiré fringes, 92% had a curve of more than 16°, while a majority (69%) had a curve of over 26°.

The correlation between the Cobb angle and the asymmetry of the moiré fringes is, in our opinion, fairly accurate only at the extremes of the range of results when there is a deviation of either one or four fringes.

Table II. Correlation of the Cobb angle and the degree of deviation of moiré asymmetry

Asymmetry of moiré topograph	Cobb angle (degrees)								Total
	15 or under		16-25		26-35		Over 35		
	Number	%	Number	%	Number	%	Number	%	
Deviation of 1 fringe	362	76.5	90	19	19	4	2	0.4	473
Deviation of 2 fringes	123	47.8	101	39.3	27	10.5	6	2.3	257
Deviation of 3 fringes	14	29.7	15	32	12	25.5	6	12.8	47
Deviation of 4 fringes	1	8	3	23	3	23	6	46	13
TOTAL	500		209		61		20		790

DISCUSSION

The moiré method is a photostereometric system which measures asymmetry of the body surface resulting mainly from deformity of the ribs and muscles. Since the deformity of the rib cage bears no direct relationship to the degree of vertebral rotation or to the Cobb angle (Thulbourne and Gillespie 1976) moiré topography cannot accurately reflect the spinal deformity. But it does have two advantages over the bending test: it provides a permanent record of the contours for longitudinal review, and data can be stored in a computer for future analysis.

We were able to identify the presence of a curve in 95.7% of cases, a result comparable with the accuracy of 93% to 100% reported by Moreland *et al.* (1983b). But the location of the curve could not be predicted with the

Adair *et al.* (1977) reported a 25% incidence of false-positive results whereas Moreland *et al.* (1983a) reported only 2.7% false positives and 1.8% false-negative results. In our series there were 171 false-positive results from moiré topography (12.7% of the total). These were due to rotational asymmetry without scoliosis in 126 children, to an error of positioning in 37, and to leg-length discrepancy in the remaining eight.

The moiré topograph was normal in 130 children. In 40 of these it accurately reflected the absence of scoliosis both on clinical and on radiological examination. In 32 children the topograph was normal in spite of some asymmetry of body surface with no true scoliosis. The remaining 58 children had radiological scoliosis and provided an incidence of 4.3% false negatives. The use of positioning devices during topography may decrease the

number of false positives to some extent; but a rotational deformity without true scoliosis, which was responsible for most of the false-positive results, can only be excluded by radiography. A positioning device would be useful especially in a longitudinal review, since a reproducible position is important in allowing comparison of topographs and so detecting progression of a curve.

The moiré topographical method requires expensive equipment and has a high rate of false-positive results. It also gives some false-negative results which are not seen in the forward-bending test. In our opinion the forward-

bending test provides an efficient cheap system which is most suitable for a mass screening programme, and allows moiré topography to be reserved for second-tier screening. At this stage it would assist in the detection of minor curves and would also be capable of recording the presence or absence of progression of a curve, possibly reducing the number of referrals for third-tier specialist opinion.

The authors would like to thank Dr S. O. Chay and Dr U. Rajan for their co-operation, Mr S. H. Tow for assistance with the contourgraphy, Nurse Jane Tay and Miss Janet Soh for compilation of results and Miss Joyce Tan for secretarial assistance.

REFERENCES

- Adair IV, Van Wijk MC, Armstrong GWD.** Moiré topography in scoliosis screening. *Clin Orthop* 1977;129:165-71.
- Ashworth MA, Ersil AK.** The management of rib hump inclination: a potential aid in scoliosis screening. *Orthop Trans* 1981;5:334.
- Cooke, ED, Carter LM, Pilcher MF.** Identifying scoliosis in the adolescent with thermography: a preliminary study. *Clin Orthop* 1980;148:172-6.
- Daruwalla JS, Balasubramaniam P, Chay SO, Rajan U, Lee HP.** Idiopathic scoliosis: prevalence and ethnic distribution in Singapore schoolchildren. *J Bone Joint Surg [Br]* 1985;67-B:182-4.
- Harada Y, Takemitsu Y, Imai M.** The role of contour line photography using the light cutting method and moiré topography in school screening for scoliosis. In: Moreland MS, Pope MH, Armstrong GWD, eds. *Moiré fringe topography and spinal deformity*. New York, Oxford, Toronto: Pergamon Press, 1981:113-21.
- Lonstein JE.** Screening for spinal deformities in Minnesota schools. *Clin Orthop* 1977;126:33-42.
- Moreland MS, Barce C, Pope MH.** Moiré topography in scoliosis: pattern recognition and analysis. In: Moreland MS, Pope MH, Armstrong GWD, eds. *Moiré fringe topography and spinal deformity*. New York, Oxford, Toronto: Pergamon Press, 1981:171-85.
- Moreland MS, Cobb LC, Pope MH, Stokes AF.** Pattern recognition in moiré topograms. *J Pediatr Orthop* 1983a;3:120.
- Moreland MS, Pope MH, Stokes IAF, Weierman R.** The clinical use of moiré topography for spinal deformity: a perspective challenge. In: Drerup B, Frobin W, Hierholzer E, eds. *Moiré fringe topography*. New York, Stuttgart: Gustav Fischer, 1983b:129-40.
- Ohtsuka Y, Shinoto A, Inoue S-I.** Application of moiré topography and low dose x-ray imaging to school screening program of scoliosis. In: Moreland MS, Pope MH, Armstrong GWD, eds. *Moiré fringe topography and spinal deformity*. New York, Oxford, Toronto: Pergamon Press, 1981:102-12.
- Suzuki N, Armstrong GWD, Armstrong J.** Application of moiré topography to spinal deformity. In: Moreland MS, Pope MH, Armstrong GWD, eds. *Moiré fringe topography and spinal deformity*. New York, Oxford, Toronto: Pergamon Press, 1981:225-40.
- Takasaki H.** Moiré topography. *Appl Optics* 1970;9:1467-72.
- Thulbourne T, Gillespie R.** The rib hump in idiopathic scoliosis: measurement, analysis and response to treatment. *J Bone Joint Surg [Br]* 1976;58-B:64-71.
- Willner S.** Comparison between moiré and x-ray findings in structural scoliosis. In: Moreland MS, Pope MH, Armstrong GWD, eds. *Moiré fringe topography and spinal deformity*. New York, Oxford, Toronto: Pergamon Press, 1981:157-65.