CURRENT TOPIC

Assessing the child with scoliosis: the role of surface topography

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Scoliosis is a very common problem and many children show some evidence of trunk asymmetry. Clinical significant scoliosis is less common, with one study showing the UK prevalence of curves greater than 20 degrees to be less than 1 in 1000 among children aged 6-14 years.¹ Children with spinal deformity attend for outpatient assessment regularly and often undergo repeated radiographic examination. While this is an imaging modality that most doctors are comfortable with there are some problems in its application to spinal deformity.

Curves are described by their appearance on plain films and quantified by the magnitude of the Cobb angle derived from the radiograph. This is the angle subtended between lines drawn along the upper border of the most tilted vertebrae above the curve's apex and the lower border of the most tilted vertebrae below the apex.² Interpretation of these results is difficult as radiographs represent oblique projections of the twisting spine and the Cobb angle can be seen to vary widely depending on the angle of the beam to the patient.³ In addition significant positioning, and intraobserver and interobserver errors have been observed in calculation of the Cobb angle.⁴

The child and parents involved are also less concerned with size of the radiographic curve than the magnitude of the perceived deformity, which is very difficult to quantify using radiographs. A large component of the deformity is a result of vertebral rotation causing one side of the trunk to become prominent, producing a rib or loin prominence. While vertebral rotation may be assessed from radiographs, the size of this prominence is less easily defined and as computed tomography (CT) and magnetic resonance imaging (MRI) are performed supine, at present, their exact relation to the erect clinical picture is unclear. All these factors combine, and a clinician can have no clear picture of what the deformity of a patient with an observed Cobb angle of 30 degrees will actually be. A curve of 60 degrees will not be twice as bad as a curve of 30 degrees and a surgical correction of 50% according to the Cobb angle may not halve the deformity.³

Even when using low dose postero-anterior and lateral radiographs, concern exists about the repeated exposure of children to ionising radiation. Recent work has suggested significant excess in breast cancer deaths, with a standardised mortality ratio of 4.1 for a woman

receiving 50 or more radiographs, with a lag time of 30 years.^{5,6}

Clearly a safe, reliable, truly three dimensional investigation would be highly useful in the assessment of the child with scoliosis.

Surface topography

Surface topography is the study of the three dimensional shape of the surface of the back; measurement systems do not involve exposure to ionising radiation and are therefore completely safe. Many devices have been used in the past, with varying results, and can be considered in two broad groups: those that require direct measurement off the patient's back; and those utilising reconstruction of surface shape from scanned light or photographic techniques.⁷⁻¹²

The first group can provide simple measures of trunk asymmetry and spine shape and have been used as part of screening programmes and longitudinal studies of spinal growth in large numbers of normal schoolchildren. While providing useful results they are not widely used as they are limited in their application and their direct relation to radiographic measures is uncertain.¹³

The second group, including Moiré and ISIS topography, contains systems providing greater detail of surface shape that have been used successfully both in the detection of deformity and their subsequent follow up.^{10,14} This group also includes the Quantec imaging system, which is the system most in use in the UK.¹²

The Quantec system

This system produces a true three dimensional surface representation of a single video photographic image of a fringe pattern projected onto the subject's back. Marker dots are placed over T1, T12, dimples of Venus, and occasional additional spinous processes in between. The subject then stands, or sits if necessary, in a relaxed upright position, undressed from the waist up with remaining clothes pushed down to reveal the dimples of Venus and top of the natal cleft. The image is captured in 1/50th of a second. Children of all ages may be assessed although we have found useful images from toddlers difficult to acquire.

Computer software reconstructs the surface representation using some 250 000 points and indicates a line along the posterior spinal elements (fig 1). This image can be manipu-

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Figure 1 Quantec reconstruction of surface shape with posterior spine line highlighted. The image may be rotated to give sagittal profiles and transverse sections at any level.

lated to provide images in any plane desired, including transverse sections at any level.

The whole system, if required, may be modular and easily disassembled for transport, fitting into a small van. A Quantec system has been taken to many Yorkshire schools and has even been set up in a tent. Large numbers of children, upwards of 150, may be scanned easily within normal school hours. Quantec examination, on the whole seems acceptable to most children, although older girls may feel a little uncomfortable standing uncovered from the waist up in a school setting.

Conventional measures

Surgeons are familiar with radiographs and are used to measuring Cobb angle and kyphosis; it is difficult to introduce new surface shape measures whose meaning may not be immediately apparent. Most systems, including Quantec, have therefore got little further than producing their own estimation of 'Cobb angle', 'kyphosis', and other radiographic measures including vertebral rotation. Topographical measures are obviously made off the subject's back and any measure inferred about the bony spine is therefore indirect. Despite this, the correlation of Quantec derived Cobb, kyphosis, and vertebral rotation with radiographs has generally been found to be favourable.¹⁵⁻¹⁸ Studies looking at repeatability of these measures compared to radiographic estimates have not, in the past, compared like with like. Estimated Cobb angles from multiple Quantec image acquisitions have been compared to multiple measurements of Cobb and kyphosis from the same radiographic image. This has led some workers to state larger variability with surface topography, possibly

caused by postural sway, and suggest that at least three Quantec images be taken and averaged to yield reproducibility similar to radiographs.^{15 19 20} The variability of radiographic estimation of Cobb and kyphosis caused by positioning and sway is not known, as it would be unethical to subject individuals to repeated radiographic examination. Pruijjs *et al* examined a longitudinal series of radiographs from patients who had previously undergone spinal fusion, and found differences of up to 7 degrees in Cobb angle caused by the production of the radiograph.⁴ A figure higher than this may be likely in the mobile, swaying, spine. With an imaging time of 0.02 seconds, Quantec is unlikely to be more susceptible than radiography to postural sway, and variability caused by positioning is likely to be common to both techniques. The ability to take multiple images in quick succession and average them is a clear advantage of surface topography for those concerned about postural sway.

Three dimensional and surface measures

Quantec derived Cobb and kyphosis angles, though widely used to monitor children with scoliosis, are still two dimensional measures and do not adequately quantify a child's deformity. Surface images acquired by topography can be manipulated to produce truly three dimensional representations of spine and surface shape. Work is in progress to develop surface measures that will adequately describe surface deformity as it is hoped that this will allow better quantification of surgical outcome and correlate more closely with the patient's perception of deformity.

In the search to quantify surface deformity two factors are thought important at present. The first is the degree of right-left asymmetry and the second is the size of the rotational prominence produced by the rib cage or loins as the scoliotic spine twists at its apex. A significant rotational prominence may exist with only small degrees of lateral curvature, and therefore a small Cobb angle.²¹ The size of this rotational prominence can be quantified using the Suzuki Hump Sum (SHS),¹⁰ a measure initially designed for the Moiré system, and this may be a better measure of deformity and operative results in these cases. Cobb angle may be corrected by surgery with less effect on the rib hump, leaving an unhappy patient.

Using the Moiré system the SHS on its own has been used to follow up the progression of curves and reduce the number of radiographs taken of patients.¹⁰ It has been found however, that in some patients, in whom apical rotation was not a major factor, the SHS was less accurate at detecting progression. This has led to the development of the Posterior Trunk Symmetry Index (POTSI), a surface measure of coronal plane asymmetry, calculated by looking at the relative positions of landmarks such as axillae, shoulders, and waist creases. Work is underway to produce normal ranges for these measures and it is hoped that the two combined will give a good measure of surface deformity.^{22 23}

The Quantec system is also a valuable research tool. Its portability and safe nature make large scale studies of the normal population possible; many schools in Yorkshire have participated in studies looking at spinal growth and physiognomy. In addition to the clinically relevant surface measures, detailed above, the system can also produce three dimensional coordinates representing the position of the posterior spinal elements. This has been studied using complex mathematics showing a possible familial relationship to normal spine shape.²⁴ A similar analysis has also proved able to detect even quite minor curves when combined with the SHS.²⁵

Conclusion

Conventional imaging techniques are essential in the evaluation of children with scoliosis. Plain radiographs are required to confirm the diagnosis and may show a cause for the scoliosis such as hemivertebrae or rarely tumours. MRI is becoming more widely available and is used in the assessment of any patient or curve that does not fit into the normal clinical pattern to exclude sinister pathologies. Some feel that all patients in whom surgery is planned should have an MRI scan. Surface topography will not replace these investigations; however, it proves a useful adjunct to conventional assessment. The use of surface topography can reduce the number of radiographs required in the monitoring of patients with scoliosis and so reduce radiation exposure. Its versatility and true three dimensional nature can provide greater insight into the nature of the individual's deformity, and when combined with conventional imaging this may allow more informed planning of surgical strategies and accurate assessment of the surgical results.²³ All images and measures produced by the system can be printed rapidly and stored within the patient's notes, providing a permanent pictorial history of deformity.

Clinicians are familiar with radiographs and like the simple measures that they yield. Surface topography produces unfamiliar, abstract measures whose meaning is not immediately apparent and hence the technique is not yet used to its full potential. The advent of open coil MRI scanning may allow topographical and truly three dimensional measures to be derived from a more familiar source, although as yet scanning times are too long. At present, if you wish to know a Cobb angle, take an x ray; if you wish to quantify deformity, surface topography may be a better option.

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