CLINICAL ARTICLE

Comparison of pre-operative correction X-rays with post-operative correction achieved in adolescent idiopathic scoliosis

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Abstract

Aim:

To determine how accurately pre-operative stress radiographs predict the final outcome in adolescent idiopathic scoliosis surgery.

Methods:

Records of 20 patients were reviewed retrospectively. Pre-operative correction was measured by comparing the initial Cobb angle of the main structural curves on plain standing radiographs to values measured at corresponding levels after correction on traction and fulcrum bending radiographs. Post-operative correction was obtained by measurements at corresponding levels of the instrumented and uninstrumented curves.

Results:

Mean correction of the main instrumented curve by traction was 24.2° (40.9%), and by fulcrum bending 32.3° (56.0%). Post-operative correction yielded a mean value of 41.1° (68.2%). Expressing pre-operative values as a percentage of final correction, traction views predicted 60%, and fulcrum bending radiographs 82% of the final correction. If agreement within 10° of pre- and post-operative values is regarded as clinically significant, only 18% of traction and 45% of fulcrum bending views came within that range.

Discussion:

We concluded that fulcrum bending views are of superior predictive value in terms of surgical correction to be expected, but still correlate poorly with final surgical correction achieved.

Introduction

Pre-operative assessment of the flexibility of scoliotic curves provides the surgeon with some information regarding the levels to be included in arthrodesis, the amount of correction that can be achieved safely if an anterior release is required, and whether a secondary curve should be treated with arthrodesis or not. Unfortunately the results of these stress views often bear little relation to the final surgical correction achieved.

Methods employed to determine the flexibility of the curves include Cobb angle comparisons between standing and supine radiographs, traction radiographs, push prone radiographs, lateral bending radiographs with the patient supine or standing, and fulcrum bending radiographs.

Most commonly performed are the traction, lateral fulcrum bending and lateral side bending pre-operative stress views. Cheung *et al*.[1] have previously demonstrated the superior predictive value of fulcrum bending radiographs compared to supine lateral bending radiographs, in posterior segmental spinal instrumentation for correction of idiopathic scoliosis.

We performed a retrospective analysis to determine the predictive value of pre-operative correction radiographs by comparing correction measured either by traction or fulcrum bending radiographs, to the final correction achieved by posterior spinal arthrodesis.

Methods and materials

The study population consisted of 20 patients treated by posterior correction and fusion for adolescent idiopathic scoliosis. Pre-operative correction was measured by determining the initial Lippmann-Cobb[2] angle of the thoracic and lumbar curves on plain standing radiographs. Results were compared to values measured on stress views either by traction or fulcrum bending methods.

Traction radiographs were performed in 11 cases with the patient placed supine, cervical traction being applied by the observer, and countertraction to the lower extremities by a second person. A maximum effort was applied at the time of exposure.

Fulcrum bending radiographs were obtained in all 20 cases. The patient was placed in a lateral decubitus position, and a standardised 25 cm diameter foam cylinder was positioned either under the rib corresponding to the apex of the curve for the thoracic spine, or directly under the apex of the lumbar curve (four cases). To be certain that the fulcrum provided a maximum passive bending force, it was ensured that the patient's lower shoulder was lifted off the table after placement of the fulcrum as described by Cheung[1] in his initial study, if necessary by placing a sand bag under the foam cylinder *(Figure 1).*

Figure 1: Positioning of patient for fulcrum bending view

The senior author (JAS) personally positioned all cases in the series.

All patients were managed with posterior spinal instrumentation for correction of the main structural curve using a minimum of eight thoracic and lumbar pedicle screws. Screws were not placed in every fused level. Pedicle hooks were used in four patients where a pedicle screw could not be inserted. The levels of fusion and amount of corrective force applied intra-operatively were based on the experience and clinical judgement of the operating surgeon, and not solely on the pre-operative correction views. The stable vertebra, and whether it was changed due to the pre-operative views, influencing levels to be fused as suggested by Vaughan,[3] was not taken into consideration.

Post-operative correction achieved was evaluated by standing radiographs, with measurements of the Lippmann-Cobb angles at corresponding levels used in the pre-operative evaluation.

Both pre- and post-operative measurements and traction views of the uninstrumented secondary lumbar curves were performed in 13 cases; unfortunately only four cases included fulcrum bending radiographs.

All measurements were performed by the authors, and reviewed and remeasured prior to final analysis of the results.

Results

Correction achieved on both pre-operative stress views and post-operative radiographs were compared to the initial measured curves on standing radiographs, and expressed as correction achieved, measured in degrees (as measured with the Cobb method) or as a percentage for both the instrumented (*Table I*) and the uninstrumented (*Table II*) . To illustrate the predictive value of the pre-operative stress radiographs, both traction and fulcrum bending values were calculated as a percentage of final correction achieved post-operatively.

In the instrumented thoracic curves the mean correction achieved with traction radiographs *(Figure 2)* pre-operatively was 24.2° (40.9%).

Lateral fulcrum bending radiographs *(Figure 3)* showed a mean 32.3° (56.0%) correction. Final post-operative correction had a mean value of 41.1° (68.2%).

Traction views achieved a mean **60.1%** ($p<0.0001$) of the surgical correction. Fulcrum bending values showed a better correlation with a mean **82.2%** ($p<0.0042$) of the final surgical correction.

Uninstrumented lumbar curves displayed a mean correction of 17.7° (45.9%) by traction, and 23° (57.8%) with use of the fulcrum bending technique.

The levels of fusion and amount of corrective force applied intra-operatively were based on the experience and clinical judgement of the operating surgeon

Table I: Thoracic and thoraco-lumbar (instrumented) curves

Variable	n	Mean	Std Dev	Minimum	Maximum
Traction (°)	11	24.2	9.3	10.0	39.0
Traction (%)	11	**40.9**	16.0	13.0	70.0
Fulcrum (°)	20	32.3	7.7	22.0	50.0
Fulcrum (%)	20	**56.0**	16.7	28.0	97.0
Surgery (°)	20	41.1	10.4	22.0	56.0
Surgery (%)	20	**68.3**	14.3	45.0	95.0
Tracsurg (%)	11	60.1	19.6	29.0	89.0
Fulcrsurg (%)	20	82.2	26.6	52.0	155.0

Table II: Lumbar (uninstrumented) curves

Variable	n	Mean	Std Dev	Minimum	Maximum
Traction (°)	13	17.7	8.1	8.0	29.0
Traction (%)	13	**45.9**	17.7	18.0	71.0
Fulcrum (°)	4	23.0	11.7	7.0	34.0
Fulcrum (%)	4	**57.8**	35.9	16.0	92.0
Surgery (°)	13	23.9	5.8	16.0	34.0
Surgery (%)	13	**65.2**	20.1	36.0	92.0
Tracsurg (%)	13	72.9	38.8	22.0	152.0
Fulcrsurg (%	)4	73.8	33.9	33.0	106.0

traction (°):	traction correction in **degrees**
traction (%):	traction correction as a **percentage of initial curve**
fulcrum (°):	fulcrum bending correction in **degrees**
fulcrum (%):	fulcrum bending as a **percentage of initial curve**
surgery (°):	surgical correction in **degrees**
surgery (%):	surgical correction as a **percentage of initial curve**
tracsurg (%):	traction as a **percentage of final surgical correction achieved**
fulcrsurg (%):	fulcrum bending as a **percentage of final surgical correction**

Final correction after surgery was a mean of 23.9° (65.2%). Both traction and fulcrum bending radiographs correlated closely with the final corrective results; expressed as a percentage thereof, they produced values of **70.5%** and **82.2%** respectively.

Discussion

Literature review

Pre-operative assessment of scoliotic curve flexibility with stress views can have variable results due to measurement errors, variability in flexibility of different individual's deformities, and the method of application of corrective forces. Other problems include the need for the presence of a physician to apply the force for correction, standardisation of such a force, exposure of the physician to radiation, and active co-operation and effort by the patient. Reproducibility and accuracy of these measurements are questionable due to these variables.

Traction views are limited by the question as to what constitutes an adequate or optimal traction film; the amount of force necessary to maximally correct the curve is unclear and unmeasurable. What should be regarded as an adequate endpoint for applying longitudinal force is also debatable; tolerable pain is cited as one such an endpoint, but could originate from a spinal location, or from the sites of application of the traction and countertraction. Whether the strength of the personnel applying the traction plays a role has been questioned in previous studies.[4]

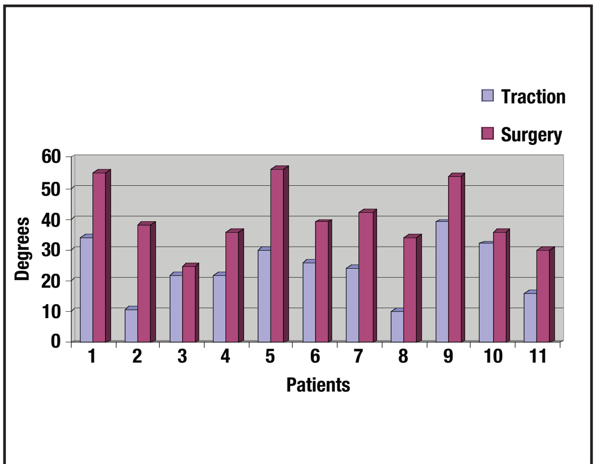

Figure 2: Thoracic traction corrective values compared to surgical correction

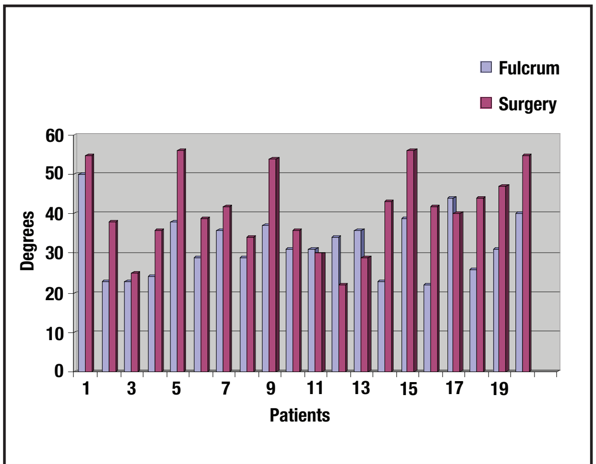

Figure 3: Thoracic fulcrum bending corrective values compared to surgical correction

Fulcrum bending methods provide a passive force, eliminating the need for a physician to apply the force required. Recently the reproducibility of this method has been questioned by Ibrahim *et al*[5] due to muscle spasm, patient discomfort, and difficulty in positioning the bolster at the apex of the curve – suggesting forced traction under general anaesthesia to be better at predicting curve flexibility for curves exceeding 60°. We found the fulcrum bending method reproducible and easy to perform, but co-operation from the patient is still required and smaller children may require a person to assist in maintaining their position. It is now recommended by Luk and Cheung[6] that positioning and size of the bolster should allow the patients' shoulder **and** pelvis to be lifted off the table for thoracic curves.

From this study we were able to determine that fulcrum bending views predict final surgical correction more accurately than traction radiographs, and found this correlation to be 82%, as compared to the 60% of traction views. It is important to note that in the fulcrum bending group the predicted correction varied widely (52%-155% of final correction) with a standard deviation of 10.5; and in four patients from the group of 20 the fulcrum bending values exceeded the post-operative values by a mean of 10.7° (21.5%).

The authors feel that a clinically significant correlation exists when the pre- and post-operative values agree within a 10° range. The traction stress views *(Figure 4)* produced two such cases from 11 patients (**18%**), and the fulcrum bending views nine from 20 cases (**45%**) *(Figure 5)*.

We found the fulcrum bending method reproducible and easy to perform, but co-operation from the patient is required

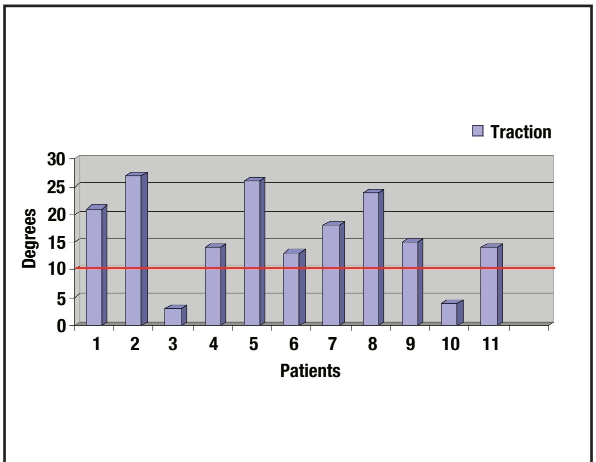

Figure 4: Difference in thoracic surgical correction compared to pre-operative traction correction

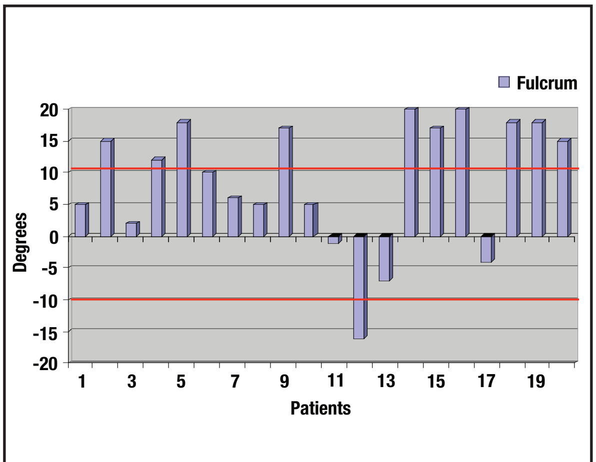

Figure 5: Difference in thoracic surgical correction compared to pre-operative fulcrum bending correction

The uninstrumented lumbar curve revealed similar correction on fulcrum bending (82%) and traction views (70%) compared to post-operative curves. However, only four cases were measured with fulcrum bending views of the lumbar curve, and the significance of this small number is uncertain. Further comparison of these values in a larger study population is necessary to elicit any statistical and clinical difference.

We conclude that even with fulcrum bending radiographs, instrumented correction of scoliotic curves cannot be accurately predicted within 10°.

Passive correction of uninstrumented curves is more predictable by fulcrum bending views. This disparity between predicted and final correction complicates the decision whether to extend instrumentation to a minor curve to avoid decompensation of the trunk. It is possible that the configuration of the instrumentation influenced the final surgical result, but the corrections achieved are in line with published results, and in most cases increased surgical correction would have further increased the difference between predicted and final correction.

Application of a maximum corrective force by the foam cylinder was ensured by the patient's shoulder being lifted off the X-ray table at the time of exposure, however it is possible that the patient's body weight cephalad to the fulcrum is inadequate to achieve full correction of the curve in many cases. In such instances an external corrective force applied by the examiner may yield more accurate prediction of surgical correction to be expected.

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