The Assessment of Immediate Post-operative Scoliosis Correction Using Pedicle Screw System by Utilising the Fulcrum Bending Technique

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SUMMARY

Assessment of the curve flexibility is a crucial step in a surgeon's pre-operative planning for scoliosis surgery. Many techniques have been described. These include traction films, supine side bending films, push prone techniques, traction under general anaesthesia as well as fulcrum bending film. In this study, we studied the pre- and immediate post-operative radiographs of twenty eight adolescent idiopathic scoliosis (AIS) patients who were corrected using pedicle screw systems between January 2004 and August 2006. There were twenty two females and six male patients. The mean age of the patients were 17.5 years with a range of 12 to 38 years. Skeletal maturity of the patients was assessed by Risser's score. The majority was Risser 4 (15 cases, 53.6%). Based on King and Moe's classification, the most common curve was type 3 curve (15 cases, 53.6%). Among the twenty eight patients, twenty three patients underwent only posterior correction, while 5 patients underwent additional anterior release surgery. The mean pre-operative Cobb's angle for the posterior surgery group was 65.5 ± 13.9° and the mean post-operative Cobb's angle was 32.9 ± 12.6°. There was no difference between the mean correction estimated by fulcrum bending films (Fulcrum Flexibility) and the post- operative Correction Rate figures (44.2% vs. 49.9%). The mean Fulcrum Bending Correction Index (FBCI) in this group of patients is 112.8%. In the group of patients who underwent additional anterior release, their curves were noted to be larger and less flexible with the mean pre-operative Cobb's angle and Fulcrum Flexibility of 90.4° ± 9.3° and 23.4% respectively. The Fulcrum Bending Correction Index (FBCI) for this group of patients was significantly higher than the posterior surgery group: i.e. 164.0% vs 112.8%. Thus, anterior release does help to improve the correction significantly. The fulcrum bending films give good pre-operative estimation of the amount of correction to be expected post-operatively. The fulcrum bending films can help to identify the curve types which might require anterior release in order to improve the scoliosis correction. Using the Fulcrum Bending Correction Index (FBCI) will also enable surgeons to quantify more accurately the amount of correction achieved by taking into account the inherent flexibility of the spine.

KEY WORDS:
Scoliosis, Pedicle Screw System and Fulcrum Bending Technique

INTRODUCTION

Before embarking on scoliosis correction surgery, assessment of the curve flexibility is a crucial step in the surgeon's pre-operative planning. Curve flexibility assessment is carried out either by clinical and/or radiological means. Due to the lack of objectivity of clinical methods, radiological means remain the mainstay in this crucial step.

Many techniques have been described. These include traction films, supine side bending films, push prone techniques, traction under general anaesthesia as well as fulcrum bending film[1-5]. Klepps *et al*. suggested that fulcrum bending film is the most accurate test in correlating flexibility of the curve with post-operative correction[2].

Determining the inherent flexibility of the curve will help the surgeon quantify more accurately the success of correction as well as help decide whether additional operative methods such as anterior release needs to be employed to achieve a reasonable post-operative Cobb's angle. Recent advances in study of thoracic anatomy as well as instrumentation has enabled surgeons to apply thoracic pedicle screws in scoliotic spine and it has been shown to result in better correction compared to other methods such as hybrid instrumentation[6].

As the fulcrum bending film was described in an era where hybrid instrumentation was the more common technique used, it is our objective to study the use of the fulcrum bending film in patients undergoing scoliosis correction with pedicle screw systems in the adolescent idiopathic scoliosis (AIS) patients in Malaysia.

MATERIALS AND METHODS

We studied the records and radiographs of twenty eight patients from January 2004 to August 2006 in University Malaya Medical Centre. Patients diagnosed with adolescent idiopathic scoliosis (AIS) with thoracic or thoracolumbar components who were corrected with pedicle screw systems were included in the study. Isolated lumbar curves, revision cases, congenital scoliosis case, incomplete data and cases operated with other techniques, i.e. hybrid or hook systems, were excluded. These patients underwent full pre-operative assessment. The fulcrum bending film was performed as originally described by Cheung and Luk in 1997[7].

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A plastic cylinder (Figure 1) with extra padding was applied at the apex of the convex side of the curve with patient lying on the side. The fulcrum was applied ensuring that both shoulder and pelvis of the patient was lifted from the bed. This is to make sure maximal passive bending force has been applied to the spine. A true antero-posterior radiograph is then obtained and the Cobb's angle measured (Figure 2). In addition to this a standing antero-posterior radiograph and lateral radiograph of the whole spine was done. Post-operatively, the antero-posterior radiograph was again repeated. (Figure 3)

The curves are classified based on King and Moe's classification[8]. The Cobb's angles were measured from the radiographs taken. The following parameters were calculated: the Fulcrum Flexibility, which is the percentage of correction of Cobb's angle by the fulcrum bending film; the Correction Rate, which is the percentage correction of the Cobb's angle post-operatively; and Fulcrum Bending Correction Index (FBCI) which is the percentage of the Correction Rate over the Fulcrum Flexibility.

RESULTS

Twenty eight patients with the diagnosis of adolescent idiopathic scoliosis with structural thoracic and thoraolumbar components were included in the study. There were twenty two females and six males. There were eighteen (64.3%) Chinese patients, nine (32.1%) Malay patients and one (3.5%) Indian patient in our study population. The mean age of the patients were 17.5 years with a range of twelve to thirty eight years. Skeletal maturity of the patients was assessed by Risser's score. Fifteen cases (53.6%) had Risser 4, followed by Risser 3 (5 cases, 17.9%), Risser 2 (4 cases, 14.3%), Risser 5 (3 cases, 10.7%) and Risser 0 (1 case, 3.5 %,). In terms of King and Moe's classification, the most common curve was type 3 curve (15 cases, 53.6%). There were no type 5 curves. Other curve types were Type 1 (4 cases, 14.3%), 2 (6 cases, 21.4%) and type 4 (3 cases, 10.7%) curve.

Among the twenty eight patients, twenty three patients underwent posterior correction only while five patients underwent additional anterior release surgery. These two groups are dissimilar statistically in terms of pre-operative Cobb's angle and the degree of Fulcrum Flexibility obtained by fulcrum bending films. The twenty three patients who underwent posterior surgery only had a mean pre-operative Cobb's angle of 65.5° ± 13.9°. The mean post-operative Cobb's angle was 32.9° ± 12.6°. This difference was statistically significant ($p < 0.05$). The mean amount of correction estimated by fulcrum bending film (Fulcrum Flexibility) and those obtained post-operatively (Correction Rate) did not yield statistically significant figures (44.2% vs. 49.9%, $p>0.2$). The mean Fulcrum Bending Correction Index (FBCI) in this group of patients was 112.8% (Table I).

In the group of patients who underwent anterior release besides posterior instrumentation fusion, their curve was significantly larger and less flexible with a mean pre-operative Cobb's angle of 90.4° and the fulcrum bending Cobb's angle of 69.4° respectively. The fulcrum bending correction (Fulcrum Flexibility) was only 23.4%. Therefore an anterior release was performed in this group. The post operative Correction Rate was 38.4% with the Fulcrum Bending Correction Index (FBCI) of 164.0%, which was statistically significant more than the Fulcrum Bending Correction Index (FBCI) of the posterior surgery group, 112.8%. (Table I)

DISCUSSION

Thoracic pedicle anatomy has been studied extensively and was described to be very complex[9]. However, Suk *et al*. in a computed tomographic analysis of pedicle screw placement in deformed spine found that thoracic pedicle screws are safe to use even in scoliotic spines[10].

Due to the better control of spinal columns, surgeons are moving towards scoliosis correction using only thoracic pedicle screw systems. It has been shown that compared to hook and hybrid systems, pedicle screw systems offered better post-operative correction[6, 11]. The fulcrum bending film was described at a time when hybrid instrumentation was more commonly used. Therefore, we focused on the application of fulcrum bending films in pedicle screw system correction of scoliosis.

Other studies have described different techniques of flexibility assessment of the scoliotic curve. Polly and Sturm compared traction films with side bending films and discovered that in thoracic curves of more than 60 degrees, traction films demonstrated greater correction[3]. However, this finding is refuted by Vaughan et al. who noted poor results when selecting fusion levels using traction films[4].

Fulcrum bending film was first described by Cheung and Luk in 1997[7]. A recent prospective comparison of these techniques showed that fulcrum bending film correlates the best with post-operative radiological outcome[2]. Luk *et al.* further elaborated on assessing success of the scoliosis correction through the introduction of the Fulcrum Bending Correction Index (FBCI). He described that the inherent flexibility of the spine has to be taken into consideration when assessing the amount of correction achieved post-operatively[12].

Table I : The radiographic parameters between the posterior surgery group and the anterior release followed by the posterior surgery group

	Posterior Instrumentation Fusion	Anterior Release + Posterior Instrumentation Fusion
Pre Operative Cobb's angle	65.5 ± 13.9°	90.4 ± 9.3°
Fulcrum Bending Cobb's angle	37.0 ± 16.3°	69.4 ± 11.6°
Post Operative Cobb's angle	32.9 ± 12.6°	55.6 ± 14.1°
Fulcrum Flexibility	44.2%	23.4%.
Correction Rate	49.9%	38.4%
Fulcrum Bending Correction Index (FBCI)	112.8%	164.0%

Fig. 1: Padded Cylindrical Bolster which is used when performing the fulcrum bending film

In our study, the amount of correction obtained by the fulcrum bending film (Fulcrum Flexibility) correlated well with post-operative Correction Rate. We discovered that our Correction Rate in the posterior surgery group was 49.9%. This was lower than the figures quoted in other papers[6,11,13,14]. However, the Fulcrum Bending Correction Index (FBCI) was not used in those studies when describing the correction achieved. This could result in a seemingly higher amount of correction if the study population's curves were more flexible. The importance of the use of the Fulcrum Bending Correction Index (FBCI) in defining the amount of correction achieved, instead of Correction Rate, has been well emphasized by Luk *et al* in 1998[12].

In the anterior surgery group, using the fulcrum bending film, we were able to identify a group of patients with larger curve magnitude and whose curve was more rigid. The mean fulcrum bending correction (Fulcrum Flexibility) in this group of patients was 23.2%. From this study, the anterior release seemed to be able to provide better correction as shown by the significant improvement of the Fulcrum Bending Correction Index (FBCI): 164.0% compared to 112.8% for the posterior surgery group.

Despite these findings, there were certain limitations in our study. Firstly, several cases had to be excluded from this study due to incomplete information. Ideally, to compare the anterior release group and the posterior surgery only group, it would be best if the number of patients in the two groups is almost equal. In future studies, these shortcomings should be addressed.

CONCLUSION

We believe that fulcrum bending films (Fulcrum Flexibility) provide a good pre-operative estimation of the amount of Correction Rate that can be achieved post-operatively. Using the Fulcrum Bending Correction Index (FBCI) will enable surgeons to quantify more accurately the amount of correction achieved. The fulcrum bending films can also help identify the curve types which might require anterior release to improve post-operative Cobb's angle to an acceptable degree.

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