Influence of spinal rod curvature on scoliosis sagittal correction

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Published in:
Transactions of the Orthopaedic Research Society

Publication date:
2013

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Introduction: Adolescent idiopathic scoliosis is a complex spinal pathology characterized by three-dimensional spine deformation accompanied with vertebral rotation. Correction of severe scoliosis requires surgical fixation of implant rods and screws to deform and fix the spine into desired shape. Until now, optimal scoliosis correction is difficult to attain because surgical treatment is still dependent on the surgeon’s preferences and correction objectives. There is no consensus yet on what possible initial shape of rod could lead to a certain sagittal outcome.

The objective of this study was to analyze the deformation of implant rod using its angle of curvature during surgery and establish its influence on the sagittal correction of scoliosis deformity. Relationship between the degree of rod deformation and preoperative implant rod angle of curvature was sought to establish whether it is possible to predict the postoperative outcome from the initial rod shape.

Methods: Fifteen (n=15) adolescent idiopathic scoliosis patients underwent surgical operation after the approval of the university hospital research ethics committee. A proper informed consent was obtained from all patients. Figure 1(a) shows 6mm rods (USS II Synthes) implanted to the concave and convex side of the deformity. This figure also shows that the rod curvature constitutes the spine sagittal curve within its length. The preoperative implant rod geometry was measured before surgical implantation. The postoperative implant rod geometry a week after surgery was measured by CT scan (Aquilion CT). Implant rod geometry image was fitted using quintic polynomial function [1]. The implant rod angle of curvature was computed as the angle $\theta$ between two tangent vectors of the quintic polynomial function at the rod ends, Fig. 1(b). Degree of rod deformation $\Delta \theta$ was computed as the difference between the preoperative and postoperative implant rod angle of curvature ($\theta_1-\theta_2$).

The average normal spine sagittal curvature $\theta_{FL}$ of healthy adolescents between the vertebral levels obtained by previous studies was used to evaluate scoliosis correction at the sagittal plane of each patient [2,3]. Ideal correction is attained when the normal sagittal angle of curvature $\theta_{FL}$ equals to the postoperative implant rod angle of curvature $\theta_1$ at the corresponding fixation level ends.

Results: The implant rod angles of curvature at the concave side of deformity in all patients tended to reduce indicating that the rods were significantly deformed after scoliosis surgery, average $\Delta \theta$ 15.7 deg. (8.0 to 23.7 deg.), Fig. 2(top). The implant rods at the convex side of all patients did not have significant deformation, average $\Delta \theta$: 1.1 deg. (-4.9 to 7.4 deg.), Fig. 2(bottom). A positive relationship was found between the degree of rod deformation $\Delta \theta$ and preoperative implant rod angle of curvature $\theta_1$ at the concave side ($r = 0.87$, p < 0.001), Fig. 3.

The normal spine sagittal curvature $\theta_{FL}$ used for the concave and convex side was the same for each patient because the extreme fixation levels (most superior and inferior level) were the same for both sides, Fig. 2. Differences between the postoperative implant rod angle of curvature $\theta_1$ and normal spine sagittal curvature $\theta_{FL}$ demonstrates over or under correction of scoliosis deformity at the sagittal plane.

Discussion: The positive relationship obtained indicates that the postoperative sagittal outcome could be predicted from the initial implant rod shape. Implant rod deformation at the concave side suggests that the corrective forces acting on that side are higher than the convex side. Implant rod angle of curvature greatly influenced the clinical outcome and careful preoperative planning of the initial implant rod shape is important because the sagittal curve can be over or under corrected during scoliosis corrective surgery.

Significance: This study revealed that the postoperative sagittal outcome of scoliosis corrective surgery could be predicted from the initial implant rod shape. Results suggest that careful preoperative planning of the rod shape is important to achieve optimal clinical outcome.

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