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Key Role of Preoperative Recumbent Films in the Treatment of Severe Sagittal Malalignment

Isaac O. Karikari, MD[a,*], Lawrence G. Lenke, MD[b], Keith H. Bridwell, MD[c], Ryoji Tauchi, MD[d], Michael P. Kelly, MD[c], Patrick A. Sugrue, MD[e], David B. Bumpass, MD[f], Aladine A. Elsamadicy, BE[a], Owoicho Adogwa, MD, MPH[g], Ramin Lalezari, BS[c], Linda Koester, BS[c], Kathy Blanke, RN[b], Jeffrey Gum, MD[h]

[a]*Department of Neurosurgery, Duke University Spine Center, 200 Trent Dr, Durham, NC 27710, USA*
[b]*The Spine Hospital, Department of Orthopedics, Columbia University Medical Center, 630 W 168th St, New York City, NY 10032, USA*
[c]*Department of Orthopedic Surgery, Washington University School of Medicine, 660 S Euclid Ave, St. Louis, MO 63110, USA*
[d]*Department of Orthopedic Surgery, Nagoya University Graduate School of Medicine, Nagoya, Japan*
[e]*Department of Neurological Surgery, Northwestern University Feinberg School of Medicine, 420 E Superior St, Chicago, IL 60611, USA*
[f]*University of Arkansas for Medical Sciences, 4301 W Markham St, Little Rock, AR 72205, USA*
[g]*Department of Neurosurgery, Rush University Medical Center, 1653 W Congress Pkwy, Chicago, IL 60612, USA*
[h]*Norton Leatherman Spine Center, University of Louisville School of Medicine, 323 E Chestnut St, Louisville, KY 40202, USA*

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Abstract

Study Design: Retrospective cohort study.
Objective: To determine if severe sagittal malalignment (SM) patients without fixed deformities require a three-column osteotomy (3CO) to achieve favorable clinical and radiographic outcomes.
Summary of Background Data: 3CO performed for severe SM has significantly increased in the last 15 years. Not all severe SM patients require a 3CO.
Methods: Severe SM patients (sagittal vertical axis [SVA] > 10 cm) who underwent deformity correction between 2002 and 2011. Patients with <33% change in their lumbar lordosis (LL) on a preoperative supine radiograph were classified as stiff deformities, whereas those with ⩾33% change were categorized as flexible deformities. The clinical/radiographic outcomes were assessed at minimum two years postoperatively.
Results: Seventy patients met the inclusion criteria, 35 patients with flexible and 35 with stiff deformities. Eighteen flexible-deformity patients underwent a 3CO versus 22 stiff-deformity patients. The remaining patients in each group underwent spinal realignment without a 3CO. The flexible-deformity patients not undergoing a 3CO had overall improvement in all sagittal radiographic parameters. Preoperative LL (22°), LL−pelvic incidence (PI) mismatch (43), SVA (17 cm), and pelvic tilt (PT, 34°) improved to 46°, 18, 6 cm, and 26°, respectively, $p < .05$. Flexible-deformity patients who underwent a 3CO also had overall improvement in all radiographic parameters. Preoperative LL (8.5°), LL-PI mismatch (47), SVA (19 cm), and PT (37°) improved to 39°, 15, 7 cm, and 24°, respectively ($p < .05$). Stiff-deformity patients who underwent a 3CO had statistically significant improvement in all radiographic parameters. However, stiff-deformity patients who did not undergo a 3CO had suboptimal improvement in all radiographic parameters, except for SVA (14 cm-9 cm, $p < .05$). Flexible patients who did not undergo a 3CO had statistical improvement in the SRS domains of function and self-mage as well as in their ODI scores ($p < .05$).
Conclusion: Severe SM that is flexible can be corrected without a 3CO without compromising clinical and radiographic outcomes.
Level of Evidence: Level III.

Keywords: Sagittal malalignment; Sagittal imbalance; Flexible deformity; Stiff deformity; Three-column osteotomy

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*Corresponding author. Neurosurgery and Spine Surgery, Duke University Medical Center, Durham, NC 27710, USA. Tel.: (919) 681-6855; fax: (919) 684-7937.

E-mail address: isaac.karikari@duke.edu (I.O. Karikari).

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Introduction

Symptomatic sagittal malalignment (SM) is commonly encountered by surgeons who treat spinal deformity [1]. Optimal sagittal alignment in patients with spinal deformity has been shown to correlate with improved health-related quality of life scores [2,3]. Thus, in recent years, with an improved understanding of pelvic parameters and their interaction with sagittal alignment, there has been an impetus to promote optimal sagittal alignment in in those patients undergoing deformity surgery. This understanding has led to an increase in the number of three-column osteotomies (3COs), that is, pedicle subtraction osteotomy (PSO) and vertebral column resection (VCR) performed in the United States [4]. These 3COs are complex procedures associated with an increased rate of complications [5-9]. Fortunately, not all patients with severe SM require a 3CO for optimal correction. The relative flexibility of a given deformity dictates if one can achieve optimal correction without an osteotomy [10].

In this study, we sought to determine if patients with severe preoperative SM (sagittal vertical axis [SVA] >10 cm) but without fixed deformities can be successfully treated without a 3CO. We hypothesized that a 3CO is not needed for patients with flexible deformities and such patients can achieve favorable clinical and radiographic outcomes comparable to patients who undergo a 3CO.

Methods

Patient selection

From January 2002 to December 2011, we queried a prospectively maintained institutional data registry. Institutional review board approval was obtained prior to study initiation. Consecutive adult patients at one institution with a primary diagnosis of SM treated by one of two fellowship-trained surgeons were enrolled. The inclusion criteria were age >18 years, spinal fusion >5 levels, SVA >10 cm, preoperative and minimum-two-year postoperative outcomes data (SRS-22 and ODI) and radiographs, including a preoperative recumbent film. The surgical decision-making process was not uniform between the two surgeons and was made on a case-by-case basis preoperatively. Differences between groups were analyzed using the Student *t* test. A p value $<.05$ was considered statistically significant.

Determination of flexibility

To determine the relative flexibility of the deformity in the sagittal plane, a comparison of the change in lumbar lordosis (LL) between the erect and recumbent (supine or prone) sagittal images was performed. The angle measurements were performed by two reviewers (both co-authors and fellowship-trained spine surgeons) at the same time. If there was a discrepancy of $>5^\circ$ between the two authors, the images were remeasured until the best estimated measure was obtained. The percentage change was calculated as [(erect LL − recumbent LL) / erect LL] × 100. The median % change was then used to establish a cut-off for defining whether a patient's deformity was flexible or not. The median value in this study was 33%; thus, patients with $<33\%$ change in flexibility were denoted as "stiff" and those with $\geqslant 33\%$ change were defined as having a "flexible" deformity.

Results

A total of 137 patients with severe SM were treated during the study period. Sixty-seven patients were excluded because of either lack of adequate follow-up or lack of visible radiographs. Seventy patients (flexible deformities: 35 patients, stiff deformities: 35 patients) therefore met the inclusion criteria (Table 1). The mean age was 61 years

Table 1
Clinical summary of patients with flexible and stiff deformities.

	No 3CO	3CO	p value
Flexible (n = 35)	n = 18	n = 17	
Patient age, years	64	59	.20
Primary	8	3	.06
Revision	9	15	.06
Charlson Index	2	2	.60
EBL, mL	1566	1747	.60
Length of surgery, hours	7.7	8.8	.20
LOS, days	9	10	.50
Complication rate, %	18	44	.09
PCO	5	12	.20
TLIF	4	5	1.00
ALIF	6	0	**.02**
Stiff (n = 35)	n = 13	n = 22	
Patient age, years	54	55	.90
Primary	5	2	**.03**
Revision	8	20	**.03**
Charlson Index	2	2	.80
EBL, mL	1012	2495	**.003**
Length of surgery, hours	7.2	10	**.01**
LOS, days	7	11	.10
Complication rate, %	31	41	.60
PCO	4	16	.20
TLIF	0	5	.15
ALIF	5	1	.07

ALIF, anterior lumbar interbody fusion; EBL, estimated blood loss; LOS, length of hospital stay; PCO, posterior column osteotomy; 3CO, three-column osteotomy; TLIF, transforaminal lumbar interbody fusion.
Values significant at the p < .05 level are in bold.

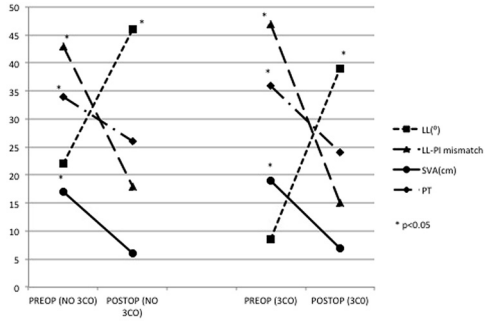

Fig. 1. Radiographic results in the flexible deformity group.