

Adjacent segment degeneration and topping off. Never stop at the apex!

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Abstract

We investigated if applying the Transition system (Globus Medical Inc., Audubon, PA, USA) as topping off can prevent Adjacent Segment Degeneration (ASD) and if rate of ASD is increased if instrumentation stopped at the apex of the Lumbar Lordosis (LL). We enrolled 99 consecutive patients in a retrospective study who have been operated by instrumented fusion of the lumbar spine. Thirty patients were treated by topping of (Group 1), 69 patients received the standard procedure (Group 2). 18 patients of group 1 (60%) and 38 patients of group 2 (55%) developed ASD. The difference was not significant ($P>0.05$). In 17 patients (17%) instrumentation stopped at apex of LL. 14/17 patients (82%) developed an ASD. This influence was significant ($P<0.05$). Instrumented fusion of the lumbar spine should not stop at the apex of the lumbar curve. Topping off by hybrid dynamic fixation does not reduce the rate of ASD.

Introduction

Incidence of Adjacent Segment Degeneration (ASD) after instrumented fusion of lumbar spine (Figure 1) is reported to be between 23% and 43% and to correlate with clinical outcome.¹⁻⁷

Several operative techniques to prevent ASD are applied, among them posterior dynamic stabilization devices (PDS). Khoeir provided a classification system for these devices.⁸ Hybrid instrumentation based on Pedicle Screw/Rod-based devices (PSR) are applied in a "topping off" technique to prevent ASD.⁹⁻¹³ Biomechanical studies showed that PSR reduce mobility and intradiscal pressure of the adjacent segment and may reduce ASD.^{10,12,14} However Mageswaran *et al.*¹² demonstrated that reduction of mobility of the dynamical instrumented adjacent segment was approximately as high as in the rigidly fused segment: The issue of increased mobility in the

adjacent segment was not solved, but shifted to the level above the adjacent segment.

Clinical outcome studies of PSR showed a tendency towards non-superiority without being fully conclusive, most of all studies being conducted by applying the Dynasis System (Zimmer, Warsaw, IN, USA).^{9,11,13} Regarding these conflicting data there still is no definitive answer to the question if there are patients who have a better outcome if treated by topping off.

The Transition system (Globus Medical Inc., Audubon, PA, USA) is a PSR with a different design (semi-rigid spacer between pedicle screws and dampening spacer cranial of cranial screw) (Figure 2). In a biomechanical study it was shown to reduce mobility more equally in all directions than other PSR.¹⁵

Kereochana reported that apical segments may be significantly more mobile than other segments.¹⁶ Segments adjacent to instrumented fusion of the lumbar spine show more mobility than before fusion.^{13,17} Based on these data, choosing lumbar apical vertebra (LAV) as UIV may lead to a significantly higher rate of ASD due to more mobility at this segment and subsequent more strain on the intervertebral disc level adjacent to LAV.

To the best of our knowledge there is no study that investigates the impact of relation of upper instrumented vertebra (UIV) to the apex of the lumbar lordosis (LL) on ASD.

We conducted a study to investigate if applying the Transition system (Globus Medical) as topping off can prevent ASD and if rate of ASD is increased if UIV is LAV.

Materials and Methods

We enrolled 134 consecutive patients treated by dorsal instrumented fusion of the lumbar spine (L1 – S1) from 01.2010 to 02.2013 in a retrospective analysis. The remaining group of patients were routinely examined at 6 weeks, 12 weeks, 12 months and 24 months post-operative by clinical and radiological examination. 35 patients were examined in other institutions close to their domestic location and were excluded from the study. Mean follow up was 20 months (StE 1.1).

Thirty patients were treated with topping off by hybrid instrumentation (Figure 2) (Group 1), 69 patients had the standard procedure without topping off (Group 2).

Clinical and demographic data, radiological data including parameters of sagittal balance and Weiner grade of adjacent segment, number and localization of instru-

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mented levels and complications were assessed.¹⁸

ASD was diagnosed if Weiner grade increased by 1 or more levels during the follow-up period.

Statistical Analysis was performed by SPSS 23 (© IBM).

Descriptive data are presented as mean and standard error (StE). We conducted a one-sided Chi-Square test to analyze if hybrid instrumentation, level of UIV in relation to Apex of LL (LAV) and preoperative degree of degeneration of the adjacent segment were related to rate of ASD. Significance level was set at $P<0.05$, Bonferroni adjustment was applied.

Results

Descriptive data are given in Table 1. Sixteen of 99 patients (16%) have been previously operated on the lumbar spine and 84 of 99 patients (84%) were classified as being multimorbid according to van den Bussche *et al.*¹⁹ A mean of 2.9 levels (StE 0.14) were fused. Fifty-six of 99 patients (56%) developed ASD, 18 patients of group 1 (60%) and 38 patients of group 2 (55%). The difference was not significant ($P<0.05$).

In 73 patients (73%) preoperative degeneration of the adjacent segment was

noted (at least Weiner Grade 1). Thirty-four of the 73 patients (47%) developed an ASD.

Of the 26 patients without preoperative degeneration of the adjacent segment 22 (85%) developed an ASD (progression of Weiner Grade). The difference was significant ($P < 0.05$). In 14 of the 22 patients (64%) UIV was LAV.

Twenty-four of 73 patients presented with a preoperative Weiner Grade of 2 or more of the adjacent segments 0/24 patients (0%) showed progression of Weiner Grade.

In 17 patients (17%) UIV was at the level of LAV (instrumentation stopped at apex of LL). 14/17 patients (82%) developed an ASD. The difference was significant ($P < 0.05$).

In another subgroup analysis of patients with UIV one level above LAV we compared group 1a (rigid instrumentation ends at LAV with an additional level in topping off dynamic fixation technique) and group 2a (rigid fixation with UIV one level above LAV). 50% of group 1a (2/4 patients) and 65% of group 2a (13/20 patients) developed ASD. The difference was not significant ($P > 0.05$).

Parameters of sagittal balance are given in Table 2.

Complications

7 patients underwent revision surgery for ASD 1 patient in group 1 and 6 patients in group 2. See list of complications in Table 3 The rate of complications did not show a significant difference between groups 1 and 2.

Discussion

Adjacent Segments of patients with instrumented fusion of the lumbar spine show more mobility than before fusion,^{13,17} and may degenerate more rapidly due to that increased mechanical strain. Kereochana reported in a study on non-operated lumbar spines that apical segments are significantly more mobile than other segments.¹⁶ In the light of these data, choosing LAV as UIV may lead to a higher rate of ASD due to increased strain on the inter-

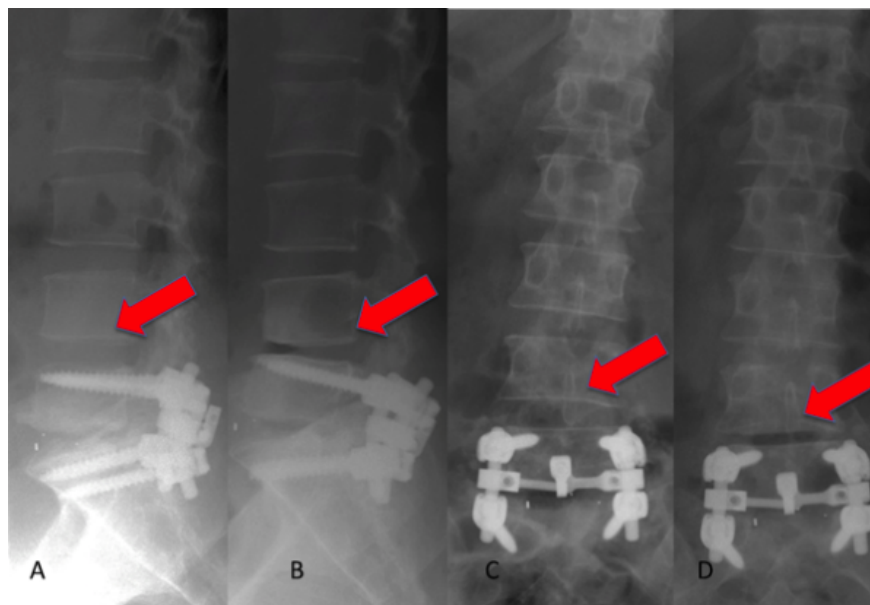


Figure 1. 55 years old female patient, treated by dorsal instrumented decompression and fusion (L5-S1 + TLIF) because of spinal canal stenosis. 1.5 years POP an ASD was diagnosed. A and C: AP (C) and lateral (A) view 1 week after the operative procedure. Red arrow points at adjacent segment. No signs of degeneration. B and D: AP (D) and lateral (B) view 1.5 years POP. Red arrow points at adjacent segment: Degeneration of the segment with loss of lordosis.

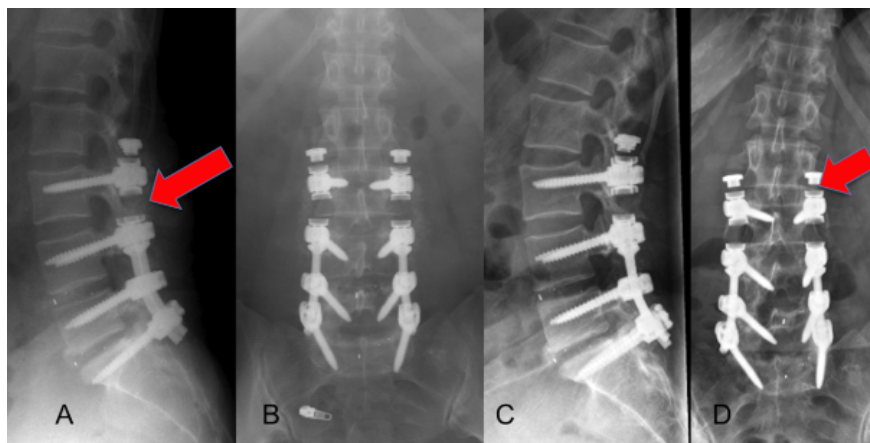


Figure 2. 37 years old female patient, treated by dorsal instrumented fusion (L4-S1 + TLIF L4/5 and L5/S1) and topping off by hybrid dynamic fixation L3/4 by Transition (Globus Medical). No signs of ASD 2 years after the operation. A and B: AP (C) and lateral (A) view 1 week after the operative procedure. Arrow Points at semi-rigid spacer between pedicle screws. C and D: AP (C) and lateral (A) view 2 years after the operative procedure. No signs of ASD. Arrow Points at dampening spacer cranial of cranial screw.

Table 1. Clinical data of patients.

	Age, years	Intraoperative blood loss, mL	OP time, min	Length of stay in hospital, days	Follow up, months
N.	99	37	93	96	99
Mean	62,68	1432,432	195,656	18,896	19,96
Standard error of mean	1,285	164,1773	5,8970	1,2035	1,122

Table 2. Parameters of sagittal balance.

	PI	LL Pre OP	LL POP	LL POP – LL Pre OP	LL POP - PI POP
Mean	57,458	36,46	31,868	-5,006	-27,498
Standard error of mean	1,4617	1,573	1,4681	1,1566	1,6280

Table 3. Complications.

Complication	Number of complications	%
Others	3	3,0
Dural leak	4	4,0
Infection	10	10,1
Mechanical complication	17	17,2
No complication	65	65,7
Sum	99	100,0

tebral discs as consequence of the combined effects (apical segment of LL and adjacent segment to rigid fixation).

We found a radiological impact of the increased biomechanical strain on the segment adjacent to LAV in our group of patients: If instrumentation ended at the apex (UIV = LAV) the rate of ASD was significantly increased compared to patients in whom UIV was at least one level above LAV.

In our group of patients, we did not see any beneficial effect of the Topping off technique: Rate of ASD was not reduced by hybrid instrumentation in our group of patients. These data support results of studies on other non-fusion implant systems.^{11,12,20}

Limitations of our study

The patients in our study were 63 years old (mean) and 84% were multimorbid: The conclusions may not be as important to younger patients than to aged and multimorbid patients.

Since ASD is known to correlate with age and Boden reported about age related natural degeneration of intervertebral discs the overall rate of 57% of ASD in our group of patients can be explained.^{13,21,22}

Interestingly we found a higher grade of ASD (progression of Weiner Grade) in patients who preoperatively did not have any signs of degeneration in the adjacent segment than in those patients who already presented degeneration in the adjacent segment at the time of operation. Of the 26 patients without preoperative degeneration of the adjacent segment 22 (85%) developed an ASD (progression of Weiner Grade). However, in 14 of the 22 patients (64%) LAV was chosen as UIV.

Since Li *et al.*⁴ and Liang *et al.*¹⁴ reported about a higher rate of ASD in patients with preoperative detected signs of degeneration in adjacent segments, the high rate of ASD in these 22 patients is most probable due to the fact that UIV was LAV.

Topping off systems have not proven to prevent ASD. Adding one dynamically fixed level to a posterior instrumentation of the lumbar spine cannot be advocated according to the existing data. Instrumentation to the lowest possible level is indicated in order to reduce severity of the operation and preserve motion segments, instrumented levels have to be planned according to the underlying degeneration and deformity of the lumbar spine, balance needs to be restored and UIV should not be LAV.

Conclusions

Instrumented fusion of the lumbar spine should not stop at the apex of the lumbar curve. Topping off by hybrid dynamic fixation does not reduce the rate of ASD.

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