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Distal junctional kyphosis in patients with Scheuermann´s disease. A retrospective radiographic analysis

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Abstract:	Purpose: To investigate relationship between preoperative and postoperative spinopelvic alignment and occurrence of DJK/DJF Study design: Retrospective observational cohort study. Patient sample: forty patients who underwent posterior correction of SK from January 2006 to December 2014. Outcome measures: Correlation analysis between preoperative and postoperative spinopelvic alignment parameters and development of DJK over the course of the study period. Methods: Whole spine x-rays obtained before surgery, 3 months after surgery and at latest follow-up were analyzed. The following parameters were measured: Maximum of thoracic kyphosis (TK), lumbar lordosis (LL), sagittal vertical axis (SVA), pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), lower instrumented vertebra (LIV) and LIV plumbline. Development of DJK was considered as the primary endpoint of the study. Patient population was split into a control and DJK group; with 34 patients and 6 patients respectively. Statistic analysis was performed using unpaired t-test for normal contribution and Mann-Whitney-test for skew distributed values. The significance level was set to 0.05. Results: DJK occurred in 15% (n=6) over the study period. There was a significantly lower postoperative TK for the DJK group (42.4 ± 5.3 vs 49.8±6.7, p=0.015). LIV plumb

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	line showed higher negative values in DJK group (-43,6±25.1 vs -2.2±17.8, p=0.0435). Postoperative LL changes were lower for DJK group (33,84±13,86 % vs 31,77 ±14.05, p<0.0001). The age of patients who developed DJK was significantly lower than the control group (16.8 ±1,7 vs 19.6±4,9, p=0.0024.) Conclusions: SK patients who developed DJK appeared to have a significantly higher degree of TK correction, and more negative LIV plumbline. Furthermore there may be a higher risk for DJK for patients undergoing corrective surgery at younger age.
Response to Reviewers:	Reviewer 6: I carefully read your paper on "Distal junctional kyphosis in patients with Scheuermann´s disease. A retrospective radiographic analysis". I found it interesting and eligible for publication on ESJ. Since some of your references are quite old, may I suggest the discussion of the following key manuscripts to enrich your already valuable work. Authors: Thank you very much for your review and your insightful comment. As you have kindly advised we have added the three valuable references and highlighted those in gray colour. We appreciate your time and effort.

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Response to reviewers

Reviewer #2: Summary and take home message:
I greatly appreciate the efforts that the authors have made for completion of the study and writing of the article. Despite the fact that it is a retrospective study with a limited number of probands, the message is clear and authors should be congratulated. I personally recommend acceptance of the manuscript for publication in its present form.
Authors: Thank you very much for your review and your interest in our work. We appreciate your time and effort.

Reviewer #3: Summary and take home message:
This paper is a retrospective analyses on the relationship between clinical and radiological preoperative and postoperative spinopelvic alignment and Distal Junctional kyphosis. It's based on a sample of forty patients who underwent posterior correction of SK. The article is well written and the conclusions are helpful. I would recommend publication as it is.
Authors: Thank you very much for your review and your interest in our work. We appreciate your time and effort.

Reviewer #4:
Comment: page 3 line 86 Should that endpoint be DJK not PJK .
Authors: Thank you very much for your review and your interest in our work. We are very grateful for the detail you have put in your comments and we appreciate the opportunity of improving the impact and quality of our work through your insightful comments.
The word PJK (page 3 line 86) has been replaced by DJK.

Comment: In all your figures you have ns for p-values not significant I would enter the actual number.
Authors: We have revised tables accordingly and entered the numbers.

Comment: in the results: Is there any clinical data to show that the patients with DJK did worse?
Authors: We acknowledge the importance of clinical outcome for DJK patients. Due to the objectives of this study we do not have results regarding clinical scores (e.g.. EQ5D, VAS, patients satisfaction). We will strongly consider this for our next study.

Comment: I would also state if there was any revision surgery for DJK.
Authors: We have now stated in the text, that there were no revision surgery due to DJK.

Comment: I would also include the average degree of DJK difference between preop and final postop data in the patients who developed it.
Authors: The suggested values are now included in the results section.

Comment: Are we just showing a radiographic problem in this paper or is there any clinical data in this paper to support that there is problem clinical with DJK here?
Authors: Thank you for your comment. As you mentioned we are analysing the correlation between radiographic measurements and the occurrence of DJK. We acknowledge the importance of clinical outcome for DJK patients and will take this into account for our future studies.

Comment: I would have a paragraph explaining the revision rate for DJK in SK patients and how this paper adds to the literature (meaning what parameters were seen for a revision surgery to occur or there was no revision surgery in these 6 patients.
Authors: Thank you very much for your helpful comment. We have now added to the text that none of the DJK patients has received revision surgery.

Comment: If there was no revision patients then I would revise your conclusion to show that even though DJK occurred in these patients this is a radiographic finding with no evidence of revision surgery do to this.
Author: we have now added this comment to our conclusion.

Distal junctional kyphosis in patients with Scheuermann´s disease. A restrospective radiographic analysis

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Distal junctional kyphosis in patients with Scheuermann´s disease. A restrospective radiographic analysis

Abstract

Purpose: To investigate relationship between preoperative and postoperative spinopelvic alignment and occurrence of DJK/DJF.

Study design / setting: Retrospective observational cohort study.

Patient sample: forty patients who underwent posterior correction of SK from January 2006 to December 2014.

Outcome measures: Correlation analysis between preoperative and postoperative spinopelvic alignment parameters and development of DJK over the course of the study period.

Methods: Whole spine x-rays obtained before surgery, 3 months after surgery and at latest follow-up were analyzed.

The following parameters were measured: Maximum of thoracic kyphosis (TK), lumbar lordosis (LL), sagittal vertical axis (SVA), pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), lower instrumented vertebra (LIV) and LIV plumbline. Development of DJK was considered as the primary endpoint of the study. Patient population was split into a control and DJK group; with 34 patients and 6 patients respectively. Statistic analysis was performed using unpaired t-test for normal contribution and Mann-Whitney-test for skew distributed values. The significance level was set to 0.05.

Results: DJK occurred in 15% (n=6) over the study period. There was a significantly lower postoperative TK for the group with DJK (42.4 ± 5.3 vs 49.8±6.7, p=0.015). LIV plumb line showed higher negative values in the DJK group (-43,6±25.1 vs -2.2±17.8, p=0.0435). Furthermore postoperative LL changes was lower for DJK group (33,84±13,86 % vs 31,77 ±14.05, p<0.0001.) The age of patients who developed DJK was also significantly lower than the control group (16.8 ±1,7 vs 19.6±4,9, p=0.0024.)

Conclusions: SK patients who developed DJK appeared to have a significantly higher degree of TK correction, and more negative LIV plumbline. In addition there may be a higher risk for DJK for patients undergoing corrective surgery at younger age.

Keywords:

Scheuermann's kyphosis; distal junctional kyphosis (DJK); sagittal balance; spinopelvic parameters; junctional failure.

Introduction:

Scheuermann's disease is an idiopathic structural hyperkyphotic deformity of unknown etiology that occurs during childhood and adolescence [1, 2]. Surgical correction is indicated for adolescents with progressive kyphosis with failed conservative measures and for patients with persistent back pain, neurologic deficits and individually inacceptable cosmetic appearance [2, 3]. Currently, posterior segmental Ponte osteotomies and pedicle screw fixation is the preferred method of treatment for Scheuermann´s kyphosis. [4, 5]

An overall reported complication rate for Scheuermann´s kyphosis surgery is as high as 14%. [6]In addition to proximal junctional Kyphosis (PJK) distal junctional kyphosis (DJK), is one of the main instrumentation-related complications after instrumented correction of Scheuermann kyphosis (SK) and is seen in up to 28% of the cases after SK surgery. Despite lower incidence of DJK, comparing to PJK, the rate of necessary additional surgical procedure is higher than PJK [7-9]. It is therefore of essential importance to identify criteria to avoid this complication. In literature, debate has focused especially on criteria for selection of the lowest instrumented level (LIV) [10].
The other factors correlating with occurrence of DJK after surgical correction of SK have not been clearly defined in literature.

The aim of this study was to evaluate and investigate the risk factors for development of distal junctional kyphosis in corrective surgery, in particular the influence of spinopelvic parameters.

Material and Methods:

Following institutional board review approval (as part of service evaluation and adhering to Helsinki declaration) the records of 40 patients treated in our institution from January 2006 to December 2014 were retrieved from our database and included in the study.

The study population was divided into two groups: a group of patients who developed distal junctional kyphosis (DJK) and a control group. Development of DJK at any time during the follow-up period was considered the primary endpoint of our study.

Scheuermann´s Kyphosis was diagnosed, based on radiological criteria reported by Sørensen [11] and Bradford [12] with having a thoracic kyphosis of more than 40° or thoracolumbar kyphosis of more than 30°, at least 3 consecutive vertebral bodies with a minimum of 5° wedging, irregularities of the vertebral endplates, disc material herniation through the endplates (Schmorl nodes), narrowing of the disc spaces, and lengthening of the vertebral bodies.

Patients with any other spinal deformities in addition to SK with influences in the sagittal (e.g. spondylolysis, spondylolisthesis, previous trauma or infections) or coronal plane (e.g. scoliosis) were excluded from the study [13].

Indication for surgery was a persistent or increasing thoracic or thoracolumbar kyphosis with a sagittal curve greater than 65° with persistent back pain, with no satisfactory response to conservative management [13].
For clinical data the age as well as the age at time of surgery, Risser grade, sex, Follow up duration and levels of instrumentation were recorded.
All received a posterior only correction procedure with segmental Ponte osteotomies [14] and pedicle screw fixation. UIV was chosen as the proximal end Cobb vertebra [13, 15] whilst the lower instrumented vertebra (LIV) was chosen as the sagittal stable vertebra as previously described [7, 13]. During surgery generally, care was taken to preserve superspinous and interspinous ligaments and the spinous processes of the UIV and LIV and the level above it and below. No patient received immobilization by brace. Postoperative physiotherapy was initiated in hospital und furthermore extended with local sessions and a home exercise protocol for 5 to 6 months after surgery.

Radiographic measurements were performed using our institutional software (IMPAX v 6.5.2, AGFA) on digital standing, full weight bearing whole spine x-ray images (See example in Figure 1). The radiographic measurements were made independently by three of the authors, the noted value was the mean of the repeated measurements.

X-rays were obtained at least before surgery (preoperative), postoperative 3 months after surgery, and at the latest follow-up.

For each patients, the following parameters were measured [13]:

- Highest thoracic kyphosis (TK), the angle between the upper endplate of the most tilted vertebra cranially and the lower endplate of the most tilted vertebra caudally (greatest Cobb kyphosis [15])
- lumbar lordosis (LL), the angle between the upper endplate of L1 and the upper endplate of S1
- sagittal vertical axis (SVA), the distance between the C7 plumb line and the posterosuperior corner of S1
- pelvic incidence (PI), the angle between the line perpendicular to the sacral endplate at its midpoint and the line
  connecting the point to the middle axis of the femoral heads
- pelvic tilt (PT), the angle between the line connecting the midpoint of the sacral endplate to the middle axis
  of the femoral heads and the vertical
- sacral slope (SS), the angle between the sacral endplate and the horizontal plane.
- apex of the sagittal curve
- extension of the kyphosis with upper kyphotic and lower lordotic level as well as apex of deformity
- lower instrumented vertebrae plumb line.

Distal junctional kyphosis (DJK) was defined as an abnormal distal junctional angle ≥ 10° and at least 10º greater than preoperative value according to values

in the literature [16]. The presence of both criteria was necessary to be considered abnormal.

The distal junctional angle was defined as the Cobb angle between the superior endplate of the lower instrumented vertebra (LIV) and the inferior endplate of the segment distal to the LIV.

Statistical analysis

For statistical analysis, utilizing GraphPad Prism (GraphPad Software, San Diego, California, USA) und Microsoft Excel (Microsoft, Redmond, USA), student's t-test was performed in case of normal distribution, in skew distributed data the Mann-Whitney-U-test was used. The significance level was set to 0.05.

Results:

Overall, 40 patients were included in the study, 6 females and 34 males. The average age at final follow up examination was 25.2 ± 5.9 years. Overall 6 patients developed DJK over the study period and were included in the DJK group, whereas 34 patients, who did not develop DJK and were grouped in the control group. None of the patients from DJK group has received a revision surgery during the follow up period. There are significant differences of age at surgery of 19,6 ±4,9 years for control group and 16.8 ±1,7 years for DJK group. Detailed values for demographic factors and group distribution can be found in Table 1. The minimum follow up was two years with a range from two to 10 years.

Pre-operative spinopelvic alignment

The preoperative values showed no differences for the measured and calculated values despite significant differences in the sagittal vertical axis. See detailed information in Table 2.

Postoperative data and last follow up:

Figure 2 shows the location of the upper and lower kyphotic vertebrae for both groups. While there was a distribution from T1 to T4 in control group, all patients in DJK group had an upper kyphotic level at T2, nevertheless, there is no significant difference in the distribution of the upper levels. The median kyphotic angle was 18.9° ± 2.9° for the DJK group and 6.5° ± 8.4 ° for the control group. The lower kyphotic level was mainly in T12 (72%) in group II and 28% at L2, there was a more general distribution between T12, L1 und L2 in group I.

The difference for the lower kyphotic level to the lower instrumented level was 1.6 ± 0.9 levels for the group without and 1.1 ± 0.9 levels in the patient group with DJK and the difference of the LIV to the first lordotic level was 1.3 ± 1.3 vertebrae in the control groups and 1.0 ± 1.0 vertebrae in the DJK group, the statistical analysis showed no statistic differences. In 85,7% or the control group the first lordotic disc was included and in 83,3% of the patients in the DJK group.

The data for the sagittal balance in both study groups shows significant differences for various parameters as for lower overall thoracic kyphosis and bigger correction in DJK group, significantly higher values for the difference of pre- and postoperative lumbar lordosis, but no difference of LL and PI (lumbopelvic difference) and TK and LL (thoracolumbar difference). Furthermore the lowest instrumented vertebrae plump line showed significant differences in comparison between the two patient groups. Detailed values can be found in Table 3.

The final angular values (in the latest follow-up examination) of lumbar lordosis and thoracic kyphosis were significant different between the two groups, also the LIV plumb line showed significant differences. However, the difference between TK and LL showed no difference, while we found significant lower values in the lumbopelvic difference (LL-PI) with lower values in the DJK group. Exact values are summarized in Table 4.

Discussion

We conducted a retrospective cohort analysis from 2006 to 2014, which included 40 patients in two groups (control group and DJK group). The main findings are, that patients, who developed a distal junction kyphosis had a higher degree of TK correction, resulting in a lower lordosis and more negative postoperative LIV plumbline. Furthermore there may be a higher risk for DJK for patients undergoing corrective surgery at younger ages.

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The incidence of DJK has been reported variable. Sturm et al have not found any case of DJK after reviewing 30 patients treated with Harrington rod instrumentation [17]. In contrast Lowe et al found DJK in 28% of patients after surgical correction of SK [9]. In our study 15 % of the patients developed DJK.

For further demographics and preoperative data, in our study, patients in the DJK group were significant younger at the time of surgery. Denis et al had a cohort consisting of 67 patients with a mean age of 39 years (range: 16–51) [8]. In another Study from Yanik et al 54 patients have been included with a mean age of 21.2 years (range: 12–43) [10]. Nevertheless the age for groups developed DJK and groups without DJK hasn't been compared in both studies. Comparing to these studies we have overall a significantly younger patients sample (19.3 ± 4.8 years).

The significant age difference between two groups could be suggestive that younger Patients who had a correction surgery in form of posterior instrumented fusion for SK are more likely to develop DJK. The reason for this may be a residual growth potential for these patients. However, the Risser grade did not differ between the two patients groups.

The median follow up was 4.3 years with a minimum follow up of 2 years. There was no significant difference between the groups. Nevertheless, as some patients developed DJK several years after surgery maybe patients reaching the

minimum limit for follow up with 2 years and which are sorted in the control group, may develop DJK over time at later follow up examinations.
In the preoperative comparison, we also found a significant more negative SVA in the DJK group. Other authors also describe, that pre- or postoperative sagittal dysbalances in patients play a role in pathogenesis of junctional problems [18, 19]. Nevertheless, the PI is seen as the primary parameters for sagittal dysbalances [18], with is not different in our patient population. The role of the SVA as a risk factor remains unclear. In the postoperative comparison, there are no differences between the control group and DJK group.

The distribution of lowest kyphotic level doesn't show any significant difference between two groups. However we found that in both groups the LIV was lower than the lower kyphotic level (1.6±0.9 for group I and 1.1±0.9 for group II) and not significant different. In both groups, the lowest kyphotic level was included in the instrumentation. Lonner et al. [20] found that the number of levels fused is an independent risk factor for major complications. It is important to avoid unnecessary extension of fusion to reduce the complication rate and spare a mobile level. Denis et al. [8] suggested that the first lordotic disc as well as all vertebrae involved in the true kyphosis including the lower kyphotic vertebrae need to be included in the instrumentation, which was done in 85% of the control and 83% of the DJK group. This was no predictor for DJK in our study group. Yanik et al. found that fusion to FLV is sufficient and it is not necessary to extend the instrumentation to SSV [10]. This is in accordance with our results. In contrast Lundine et al. [21] suggest the fusion of SSV to reduce DJF.
Denis et al also suggest, that a ligamentous complex disruption at the end of fusion should be avoided to minimize the risk of junctional kyphosis [8]. However, the rate of ligamentous preservation was not recorded in our study.

While some authors did not find an association between preoperative curve magnitude or amount of curve correction and the onset of junctional kyphosis, Papagelopoulos et al believe an overcorrection greater than 50% or failure to

incorporate the proximal end vertebrae or the first lordotic disc may contribute to junctional kyphosis [8, 22]. This is supported by our findings, with the correction amount of thoracic kyphosis of 41% in the control and 49 % in the DJK group with for distal junctional kyphosis with higher corrections. We also found that there was even a significantly higher pre- and post-operative lordosis difference for the DJK group comparing to control group with a lumbar lordosis difference of 45% in the DJK group, while there was and 32% in the control group. This might be as a result of compensation mechanisms secondary to overcorrection of thoracic kyphosis as well as a general iatrogenic kyphosis due to the instrumentation over the thoracolumbar junction and in the lumbar spine in both groups.

Our data shows significant differences for various parameters with regards to sagittal balance. Higher correction of kyphosis resulting in overall lower thoracic kyphosis in DJK group has been noticed. Consequently lower lumbar lordosis was achieved for patients in the DJK group. These results are consistent with the above-mentioned conclusion from Papagelopoulos in regards to risk of junctional failure and higher correction of kyphotic deformity [22].

In follow up examination, we found statistic differences for the lumbopelvic parameters, especially meaning the difference between lumbar lordosis and PI. Schwab et al [23] and other authors [23-30], argue, that the LL should be about 10 higher than the PI overall generally, while Lafage et al, described values for age related groups for PI [31]. While the values for the control group meet the estimated criteria from these authors, patients in the DJK group in the follow up examination actually has almost the same values for LL and PI. This means lack of lordosis, which then may facilitate local overall kyphosis in the lumbar area.

Furthermore, the LIV plumbline for both groups is significantly different and more negative for DJK group in the postoperative as well as in the follow up radiographs. This finding may indicate, that early postoperative high negative values may have an impact for further DJK development and that these patients should receive more attention and be scheduled for continuous follow up

examinations in the first years. In addition, while selecting LIV, a plumbline with a high value should be avoided to reduce the risk of DJK.

Despite lower incidence of distal junctional problems the rate of additional surgical procedures is higher than PJK [7-9]. In our study none of the patients from DJK group received revision surgery within the follow up period. It is however important to consider the fact that none of our patients has developed a distal junctional failure, which would eventually cause more symptoms.

Although there are significant outcomes in our study, there is a general limitation due to relatively small sample group as well as small number of patients in DJK group. In order to investigate these correlations a randomized prospective study is needed. Furthermore, due to the limited patient load of corrective surgery of scheuermann´s disease, a multicentre study might be ideal to include higher patient numbers.

Conclusion:

In our findings, we could conclude, that lower patient's age and higher kyphosis correction are predictors for distal junctional kyphosis. We also found that a greater value for LIV plumbline is associated with higher risk of developing DJK. The occurrence of DJK was a radiographic finding with no evidence of revision surgery for these patients.

All authors declared, that there is no conflict of interest.

Acknowledgements: None

Table 1
Demographic and group distribution for the patient population

Table 2

Preoperative parameters for the whole study population as well as for both study groups

Table 3

Postoperative values for the patient population as well as for both groups in the early postoperative follow up

Table 4

Sagittal balance parameters for both study groups with mean values, standard deviation and significance values

Figure 1

Illustration of a patient with Scheuermann´s disease. On the left, a sagittal whole spine x-rays showing a significant kyphosis. The x-ray in the middle shows the early postoperative x-ray after instrumentation and osteotomies with corrected thoracic kyphosis and lumbar lordosis and LIV plumbline, while the x-ray on the right demonstrates a negative LIV plumbline as well as a distal junctional kyphotic angle.

Figure 2

Percentage distribution of upper kyphotic and lower lordotic levels in both study groups

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Figure 1

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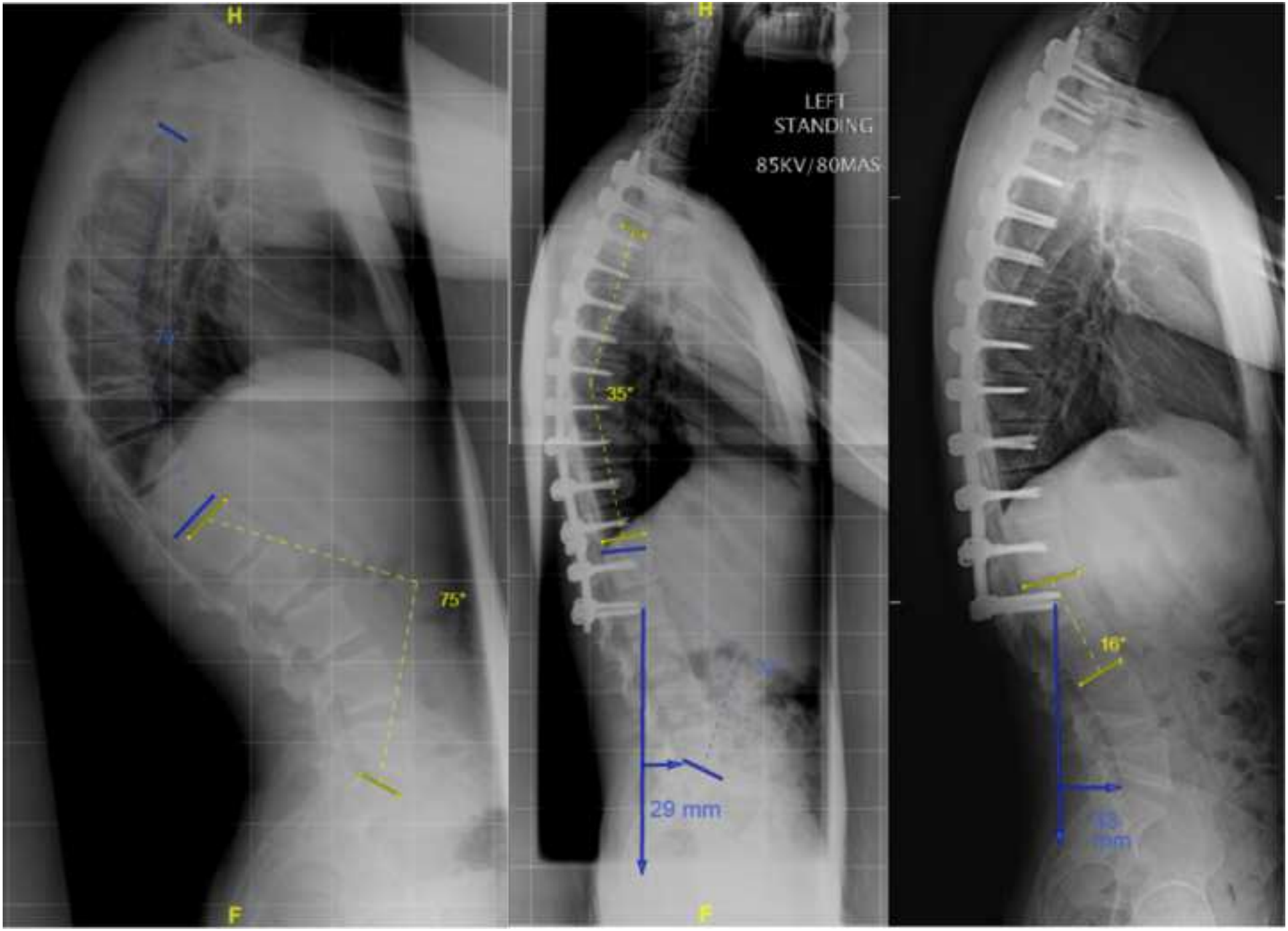

Figure 2

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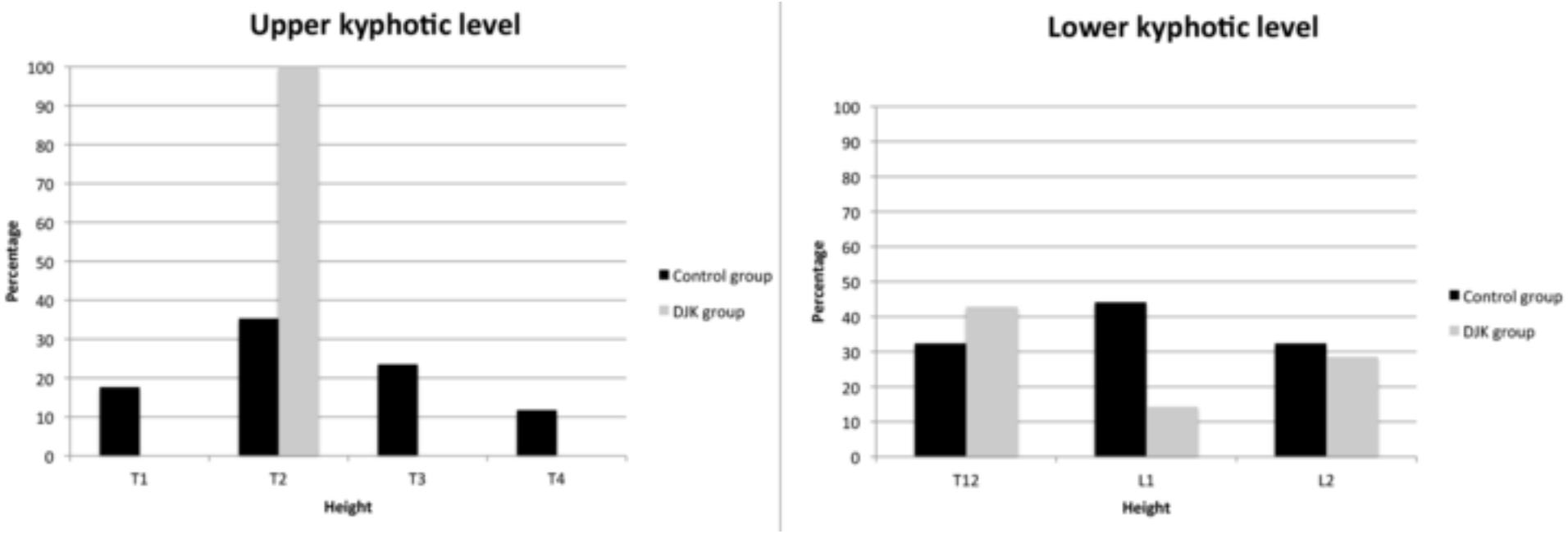

Table 1

Type	Total (40)		Control group (34)		DJK group (6)		Significance
	Mean	Std deviation	Mean	Std deviation	Mean	Std dev	p values
Age	25,2	5,9	25,5	6,1	24,8	5,1	0.79
Age at surgery	19,3	4,8	19,6	4,9	16,8	1,7	**0.024**
Risser at surgery	4,7	0,6	4,7	0,6	4,3	1,0	0.39
Sex F;M (%)	6;34 (17,65%;82,35%)	-	6;28 (17,7%; 82,3%)	-	0;6 (0%;100%)		0.12
Follow up (years)	4,33	2,15	4,13	1,97	6,05	3,18	ns

Table 2

Preoperative Values	Total (40)		Control group (34)		DJK group (6)		Significance Group I and II
	Mean	Std deviation	Mean	Std deviation	Mean	Std dev	p
Thoracic kyphosis (TK)	81,1	8,6	81,1	8,8	80,4	7,0	0.87
Lumbar lordosis (LL)	70,7	9,0	70,4	9,3	72,6	7,4	0.54
Difference TK and LL= LL-TK	-6,9	12,8	-6,5	13,4	-9,5	8,2	0.59
Difference LL and PI= LL-PI	27,0	12,8	26,4	13,4	30,5	5,6	0.47
Sagittal vertical axis (SVA)	-13,1	36,0	-6,7	34,3	-49,1	22,6	**0.006**
PI	43,7	9,4	44,0	9,7	42,1	7,9	0.65
Pelvis Tilt	16,9	18,0	17,1	18,1	16,2	15,7	0.91
Sacral Slope	32,8	7,6	33,3	7,6	29,7	8,7	0.31
Lower instrumented Vertebrae (LIV) Plumpline	-9,3	20,5	-8,5	21,5	-7,1	8,1	0.92

Table 3

Postoperative Values	Total (40)		Control group (34)		DJK group (6)		Significance Group I and II
	Mean	Std dev	Mean	Std dev	Mean	Std dev	p
Thoracic kyphosis (TK)	47,0	7,2	48,1	6,8	40,8	4,3	**0.006**
Difference pre/postop grade	34,0	9,8	33,0	9,8	39,9	5,0	**0.02**
Difference pre/postop %	41,6	9,9	40,2	9,7	49,4	4,6	**0.03**
Lumbar lordosis (LL)	46,4	9,0	47,5	9,2	40,1	6,7	**0.04**
Difference pre/postop grade	24,4	11,9	23,0	12,1	32,5	6,1	**0.01**
Difference pre/postop %	33,7	13,9	31,8	14,0	44,8	7,1	**0.004**
Difference TK and LL= LL-TK	-0,7	10,6	-0,7	11,0	-0,7	9,3	0.99
Difference LL and PI= LL-PI	2,6	9,2	3,5	9,5	-2,0	3,3	0.37
Sagittal vertical axis (SVA)	1,5	33,6	2,5	34,6	-3,7	26,4	0.68
Difference pre/postop grade	-14,6	42,8	-9,2	41,3	-45,4	44,6	0.06
Difference pre/postop %	86,9	265,2	92,4	280,6	56,1	48,8	0.76
PI	43,7	9,4	44,0	9,7	44,0	9,7	0.65
Pelvis Tilt	12,5	10,5	12,0	10,8	15,4	7,1	0,48
Difference pre/postop grade	4,4	15,2	5,0	15,6	0,8	10,6	0,53
Difference pre/postop %	-90,1	399,8	-97,0	420,2	-51,2	137,9	0,80
Sacral Slope	31,2	7,5	31,9	7,7	26,7	6,4	0,13
Difference pre/postop grade	1,6	8,9	1,3	9,3	3,0	4,5	0,67
Difference pre/postop %	2,0	27,0	0,8	28,2	8,8	11,6	0,50
Lower instrumented Vertebrae (LIV) Plumpline	-4,0	23,9	-1,4	24,1	-22,7	10,8	**0.04**

Table 4

Follow up	Total (40)		Control group (34)		DJK group (6)		Significance Group I and II
	Mean	Std deviation	Mean	Std deviation	Mean	Std dev	p
Thoracic kyphosis (TK)	48,7	7,2	49,8	6,7	42,4	5,3	**0.015**
Lumbar lordosis (LL)	52,3	9,5	54,0	9,0	42,6	8,2	**0.006**
Difference TK and LL= LL-TK	3,6	9,8	4,2	10,0	0,2	9,6	0.37
Difference LL and PI= LL-PI	8,4	11,1	10,0	10,4	-0,6	11,6	**0.049**
Sagittal vertical axis (SVA)	32,0	7,1	-8,0	24,3	29,1	6,3	0.92
PI	43,7	9,4	44,0	9,7	44,0	9,7	0.65
Pelvis Tilt	11,5	10,2	11,2	10,1	13,0	10,7	0.70
Sacral Slope	32,0	7,1	32,5	7,0	29,1	6,3	0.27
Lower instrumented Vertebrae (LIV) Plumpline	-4,8	25,0	2,2	17,8	-43,6	25,1	**<0.0001**

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