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Selection of the Distal Fusion Level in Posterior-Only Surgery of Scheuermann Kyphosis: The Concept of the FLV-1

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ABSTRACT

Background Data: Lumber spine mobility is very important clinically and functionally especially in younger patients. Fusion in Scheuermann kyphosis is a long fusion surgery that usually extends into the lumber spine leaving less mobile segments. Debate has focused on the selection of the LIV. Some recommend fusing into the SSV to decrease the incidence of DJK while others use the FLV which is just caudal to the first lordotic disc as the LIV to save more motion segments. Few studies recommend fusion into the vertebra just cephalic to the first lordotic disc (FLV-1).

Study Design: A prospective clinical case study.

Purpose: To evaluate the outcomes of fusing into the FLV-1 in surgical treatment of SK and whether it is associated with increased incidence of distal junctional failure and DJK or not.

Patients and Methods: The study included 25 patients with SK treated by posterior-only surgery using all pedicular screw instrumentation with or without posterior release/Ponte osteotomies using the FLV-1 as the LIV. The study was done in the period between February 2011 and February 2015. Patients were evaluated radiologically by full length standing biplanar X-rays and hyperextension flexibility X-ray. Parameters assessed included KA, TK, LL, and SVA for assessments of sagittal balance together with three pelvic parameters including the PI, PT, and SS angles. Clinical outcome was measured by the ODI and SRS-30 scores. Any complication encountered was documented, especially DJK, PJK, or implant failure.

Results: Mean follow-up period of the patients was 40±14.88 months. The average KA improved from 82.2±9.2° preoperatively to 38.2±5.47° yielding 53.54% correction rate with minimal change at final follow-up of 39.9±5.47° and 2% loss of correction. SVA improved from 6.35 mm (range, 60–40) to 12.25 mm (range, 25–10) at final follow-up. The difference between the FLV and FLV-1 was 1 segment whereas the difference between the SSV and FLV-1 was 1.7±0.47 segments (range, 1-2) and the difference between the SSV and the FLV was 0.7±0.47 segments (range, 0-1). PJK occurred in 2 patients without symptoms and another 2 patients suffered mild radiological DJK and all required no treatment. Only one patient had screw pull-out and required revision. Final SRS-30 score was 125.4±15.71 (range, 95–140) and the average ODI was 7.3±2.56 (range, 4–12) without any disability.

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Conclusion: The outcome parameters in this study suggest that using the vertebra just cephalic to the FLV (FLV-1) as the LIV was associated with good clinical and radiological results. The benefit of saving more mobile segments in the lumber spine might outweigh the risk of DJK especially in the precious lower lumber spine segments (ESJ2018170).

Keywords: Scheuermann kyphosis; distal level of fusion; posterior-only surgery; DJK

INTRODUCTION

Scheuermann's kyphosis (SK) is a round structural sagittal plane deformity of the spine. It is the most common cause of sagittal plane deformity in children and adolescents with an incidence of 0.4 to 8.3 %.[17] Not treating patients may lead to progression of deformity and chronic back pain.

Surgical treatment is indicated in curves more than 70°, progressive curves, persistent back pain, neurologic deficits, and unacceptable cosmetic appearance.[17] The development of safe pedicle screw fixation in the thoracic spine with its strong three-column fixation together with posterior release and posterior shortening Ponte osteotomies, posterior-only surgery currently becomes the preferred method of treatment without the need for additional unnecessary anterior surgery with good clinical and radiological[5,7,10,14,15,21] and fewer complications.[8,15]

Surgery in SK is a long fusion results surgery that usually extends to the lumbar spine leaving less mobile segments. A lot of debate has focused on the selection of the lowest instrumented vertebra (LIV). Some recommended fusing into the sagittal stable vertebra (SSV)[3,12,19] to decrease the incidence of distal junctional failure and distal junctional kyphosis (DJK) but at the expense of saving less mobile segments in the lumber spine in these young patients. The SSV is defined as the most proximal vertebra touched by the posterior sacral vertical line which is the vertical line drawn vertically from the posterior superior corner of S1 vertebra. Others recommended fusing short of the SSV and including the first lordotic disc and fusing into the first lordotic vertebra (FLV) which is just caudal to the first lordotic disc to save at least one mobile segment.[2,4,6,16,25] Few studies used the vertebra just proximal or cephalic to the first lordotic disc.[13]

In this prospective study, we used the vertebra just cephalic to the first lordotic disc (FLV-1) as the LIV to save more motion segments in the lumber spine and show the results and whether this was associated with increased incidence of DJK or revision surgery.

PATIENTS AND METHODS

This prospective study included 25 patients with SK treated surgically by posterior-only approach using all pedicle screw fixation and posterior release with or without posterior shortening Ponte osteotomies between 2011 and 2015. The inclusion criteria included all patients with the radiographic criteria of SK according to Scheuermann and Sorensen[23] and curve magnitude >70°. Exclusion criteria included non-SK patients as congenital and posttraumatic kyphosis and patients with any previous spinal surgery.

Patients were evaluated both clinically and radiologically. Radiological evaluation included full-length standing biplanar X-ray films done preoperatively, postoperatively, and at final follow-up. Preoperative curve flexibility was assessed by the hyperextension film with the patient lying supine over a bolster beneath the apex of kyphosis. Cobb method was used for radiographic measurements which also included the following: kyphosis angle (KA), thoracic kyphosis angle (TK), and lumber lordosis (LL). Sagittal balance was defined by the sagittal vertical axis (SVA). Three pelvic parameters including the pelvic incidence (PI), pelvic tilt (PT), and sacral slop (SS) angles were measured. PI is the angle between the line perpendicular to the midpoint of the sacral endplate and the bicoxofemoral axis (middle axis of the femoral heads). PT angle was measured

as the angle between the line connecting the midpoint of the sacral endplate to bicoxofemoral and the vertical. SS angle is the angle between the sacral endplate and the horizontal. The KA of the sagittal deformity is the angle between the superior endplate of the upper end vertebra and the lower endplate of the lower end vertebra. TK is the angle between the superior end plate of T4 and the inferior endplate of T12. LL angle is the angle between the superior endplates of L1 and S1. SVA is the horizontal distance between C7 plumb line and the posterosuperior corner of S1 with negative values if the plumb line is behind and positive values if it is in front of S1 posterosuperior corner. Preoperative curve flexibility was identified from the preoperative hyperextension film by measuring the flexibility index using the following formula: flexibility index=(preoperative Cobb angle on side-bending-preoperative Cobb angle) / preoperative Cobb angle x 100.

The upper instrumented vertebra (UIV) was selected as the upper end vertebra of the kyphosis. The lowest instrumented vertebra (LIV) was selected as the vertebra just cephalic to the first lordotic disc (FLV-1). Screw density was calculated as the number of pedicle screws used/number of available pedicles in the curve for screw insertion.

Any complications encountered were documented as distal junctional kyphosis (DJK), proximal junctional kyphosis (PJK), screw pull-out or loosening or misplacement, loss of fixation, or implant failure.

Radiological DJK was diagnosed if the angle below the LIV$\geq 10^{\circ}$[22] or if disc space below the LIV becomes kyphotic or neutral.[19] DJK angle is the angle between the upper endplate of the LIV and the inferior endplate of the vertebra distal to the LIV.[6] PJK was defined as proximal sagittal angle $>10^{\circ}$ or at least 10° greater than the preoperative measurements in the two motion segments above the UIV.[6] It is measured as the angle between the lower endplate of the UIV and the upper endplate of the 2nd adjacent vertebrae above the UIV.[4] Clinical outcome was assessed using the Oswestry disability index (ODI) and the scoliosis research society-30 (SRS-30) questionnaire.

Statistical Analysis:

Data was analyzed using SPSS (Statistical Package for Social Sciences) version 15. Qualitative data was presented as number and percent. Qualitative data was presented as mean±SD and range (min-max). Paired t-test was used for comparison within groups. $P<0.05$ was considered to be statistically significant.

Operative Technique:

The operation was done in the prone position under general hypotensive anaesthesia. The spine was exposed subperiosteally up to the tips of the transverse processes on either side. Pedicle screws (6.25 mm) were inserted bilaterally perpendicular to the kyphotic deformity using the free hand technique and confirmed by the C-arm. The spinous processes were excised and the spine decorticated posteriorly together with excision of the inferior facets. The most proximal two and distal one spinous processes were left intact for latter attachment of the paraspinal muscles. Two titanium rods (6.25) were slightly pre-contoured at the upper end into slight kyphosis and into lordosis at the lower end.

On either side, the rod was connected to the screws starting from proximal towards the apex and then distally towards the distal end using gentle cantilever force. Further correction was achieved using compression across the screws towards the apex. The apical screws were sunken into the cortex helping in correction of the deformity while 2 threads of the uppermost screws were left out of the posterior cortex (Figures 1 and 2). This, together with avoiding over-compression across these screws and adequate soft tissue attachment into the spinous processes, decreases the incidence of PJK. Fusion was done by good decortication of the posterior spine and using local bone graft. Adequate soft tissue closure was done to avoid development of painful bursitis over prominent spinous processes and to avoid junctional problems.

Postoperatively, patients were mobilized on the first postoperative day without orthosis. Patients were followed up every 3 months during the first year and then at 6 monthly intervals till the end of follow-up. Return to unrestricted activities

and bending were allowed after 2-3 months postoperatively.

RESULTS

Table (1) summarizes our patients' demographics and surgical related parameters. The study included 25 patients, 17 males and 8 females. Their mean age was 17.5±1.97 years (range, 15–20) and the mean follow-up period was 40±14.88 months (range, 30–65). Thoracic kyphosis (TSK) was the most common curve pattern in our study group, 20 patients (80 %) TSK and 5 patients (20 %) TLSK. The mean number of fused levels was 11.5±1.70 (range, 9–14) levels and screw density was 87.90±7.89% (range, 78–100). The mean operative time was 165±20.60 minutes (range, 150–200) and the mean amount of blood loss was 800±157.2 ml (range, 600–1250).

The mean preoperative KA was 82.21±9.21° (range, 64–100°) and this was significantly (P=0.000) improved postoperatively to 38.20±5.4° (range, 30–47°) showing 44±4.89° (range, 33–50°) correction (Table 2). The rate of correction was 53.54±2.42 % (range, 43–95°). The mean radiological follow-up period in our group of patients was 4o±14.88 months (range, 30–65). The last follow-up KA was 39.90±5.47° (range, 31.5–50°), showing minimal change at final follow-up. Loss of correction was 1.7±0.64° (2%). Correlation of % of correction with the screw density was statistically insignificant (P=0.415). TK and LL significantly improved from 78±11.09° (range, 60–95°) and 63.80±4.67°, respectively, preoperatively to 36.55±4.68° and 43.35±3.46°, respectively, at final follow-up. The SVA improved from -6.35±2 8.85 mm (range, -60–40) preoperatively to -12.25±7.43 mm (range, -25–10) at final follow-up although this was statistically insignificant.

The difference in the LIV between the FLV and the FLV-1 was 1±00 segment and the difference between the SSV and the FLV-1 was 1.70±0.47 segments (range, 1-2), whereas the difference between the SSV and the FLV was 0.70±0.47 SD segments (range, 0-1) (Table 3). SS and PT angles show significant postoperative changes as compared to preoperative values while PI showed no significant changes (Table 2). PJK was observed in 2 patients and was not symptomatizing and did not require revision surgery. Two patients developed radiologic DJK in the form of mild change of the lordotic disc angle from -5° to a slightly kyphotic angle of +3-5° but no patient required revision surgery because it was not symptomatizing. Pull-out of the distal screw occurred in one patient whose LIV was D12 and the patient was revised and the instrumentation was extended to L2. There were no neurologic complications, deep infection, or pseudoarthrosis. The mean SRS-30 score at final follow-up was 125.4±15.71 (range, 95–140) and the mean ODI score at final follow-up was 7.30±2.56 (range, 4–12).

Table 1. Patients demographics and surgery related parameters.

Parameters		Value
Total number		25 (100%)
Age (years)		17.5±1.97 (15-20)
Sex	Male	17 (68%)
	Female	8 (32%)
	Total	25 (100%)
Follow-up (months)		40.15±14.88(30–65)
Type of curve	Th	20 (80%)
	TL	5 (20%)
	Total	25 (100%)
Flexibility index (%)		42.80±6.17(30–50)
Screw density (%)		87.90±7.89 (78-100)
Number of fused levels		11.50±1.70 (9-14)
Operative time (min)		180.0±24.60 (150-200)
Blood loss (ml)		800.0±157.20 (600-1250)

Th: thoracic; TL: thoracolumbar.

Table 2. Reported radiographic parameters in our series.

Parameters	Preoperative	Postoperative	Last follow-up (40±14.88 months)	Pre versus post	Post versus last
KA	82.15±9.21	38.20±5.14	39.57±5.47	<0.001*	<0.001*
THK	78.00±8.20	35.80±4.50	36.55±4.68	<0.001*	<0.001*
LL	63.80±4.67	41.20±3.49	43.35±3.62	<0.001*	<0.001*
SVA	-6.35±28.85	-12.25±7.43		<0.001*	
PI	39.00±3.13	39.42±3.27		0.181	
PT	9.50±5.85		12.58±2.71		
SS	38.30±8.90	33.55±2.98		0.006*	

KA: kyphosis angle, THK: thoracic kyphosis, LL: lumbar lordosis, SVA: sagittal vertical axis, PI: pelvic incidence, PT: pelvic tilt, and SS: sacral slope.

Table3. Difference between the levels in the LIV.

Parameters	Value
FLVFLV1	1.0±0.0(1–1)
SSVFLV1	1.70±0.47(1–2)
SSVFLV	0.70±0.47(0–1)

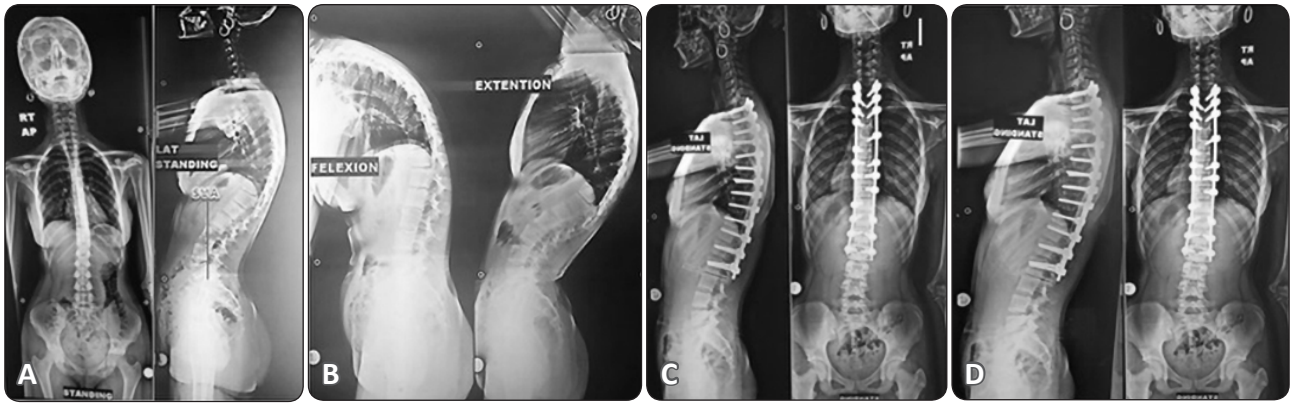

Figure 1. Images of a 15-year-old female patient with thoracic Scheuermann kyphosis are shown. (A) Biplanar X-rays with (TSK) of 80°. (B) Preoperative flexion and hyperextension flexibility views showing 35 % flexibility index. The SSV and the FLV were 13 and the FLV-1 was 12. The patient was operated on posteriorly only using all pedicle high density screws of nearly 81% with screws in the apical and periapical region and using the FLV-1 as the LIV which was L2. This saved one motion segment. (C) One-month postoperative X-ray showing that the kyphosis angle was corrected to 35° achieving 56 % correction rate and a well-balanced spine with a slightly negative SVA of -10 mm and a neutral disc space below the LIV. (D) 36-month postoperative last follow-up X-rays showing maintenance of correction without significant change in the Cobb angle and no change in the disc space angulation below the LIV. There was no DJK.

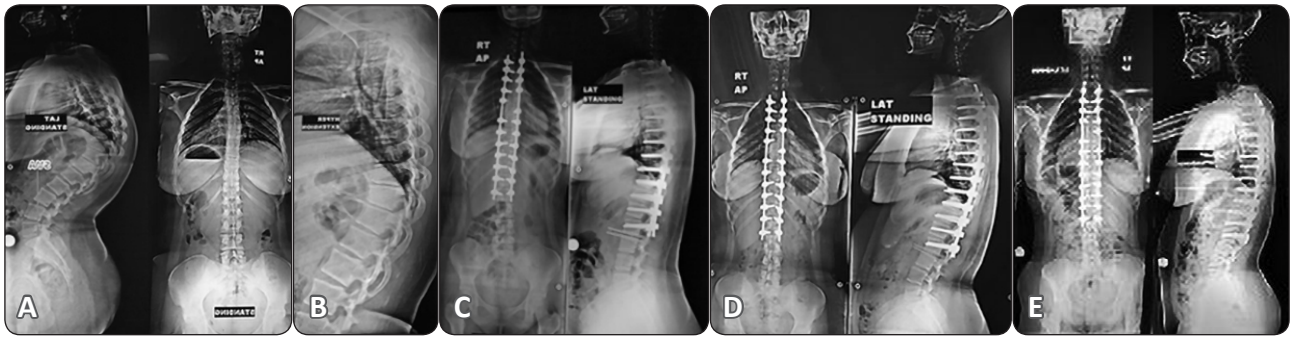

Figure 2. Images of 16-year-old female patient are depicted. (A) Preoperative biplanar X-ray showing lower thoracic Scheuermann kyphosis (TSK) of 90°. (B) Preoperative hyperextension film showing correction to 50° with 44.4 % flexibility index. The SSV and the FLV were the same which is L3. (C) X-ray one month after the patient was treated by posterior release and all pedicle screws of 92.3 % screw density. The LIV was L2 which is the FLV-1 with correction of the kyphosis angle to 30° and a neutral disc space below the LIV. (D) Six-month follow-up X-rays revealed slight kyphotic angulation of the disc space of< 5° but the patient was asymptomatic. This patient was diagnosed as asymptomatic DJK. (E) Last follow-up (36 months) postoperative X-rays showing no change in the disc space angulation.

DISCUSSION

In this study, fusing to the vertebra just cephalic to the first lordotic disc (FLV-1) achieved good results clinically and radiologically and was not associated with increased incidence of distal junctional failure and DJK. This policy avoids unnecessary longer fusion and saves at least one mobile segment which is important functionally and for avoiding or delaying later development of earlier degenerative changes in the unfused adjacent motion segments of the lumber spine. This is especially important in the lumber spine between L2 and L5 in this highly active younger age group. It saves an average of 1.7 mobile segments when compared to the concept of fusing into the SSV and 1 mobile segment when compared to the FLV concept.

The incidence of DJK in this study after a follow-up period of 40±14.88 SD months was 8%. Two patients developed radiological DJK within the first postoperative 6-month period without clinical symptoms and did not require revision. Only one patient with implant failure required revision because the LIV was wrongly chosen at D12 which is a junctional area. This was not higher than the incidence of DJK in other studies using the SSV or the FLV as the LIV which is up to 28%.[3,24]

Selection of the distal fusion level in SK surgery is a debatable issue among studies. Some recommended fusion into the SSV which is usually lower than the FLV to avoid DJK and failure but at the expense of saving less mobile segments. Cho et al.[3] examined 31 patients treated by anterior release and posterior hybrid instrumentation including all hooks instrumentation in some patients. DJK developed in three patients and fusion was stopped at the FLV in two patients and at the SSV in one patient and they concluded from these findings that fusion should include the SSV although they used hooks which are less stable and can cause more junctional problems related to more soft tissue dissection.[4,16] Lundline et al.[19] in a study assessing the incidence of DJK in 22 nonhomogenous patients (not all SK) treated by anterior release and pedicular screws in the distal levels of fusion reported DJK in 11 patients (50 %). Five patents were fused proximal to the FLV and five were instrumented to the FLV and one patient to the SSV and they concluded that fusion should include the SSV to avoid DJK. However, in Lundline et al. study the surgical technique was not uniform, the instrumentation was pedicular screws in the distal levels and hooks in the proximal levels, and not all patients had SK. Also, the primary aim of Lundline et al.[19] was the incidence of DJK radiologically according to their definition which they defined as any change in the disc distal to the instrumentation that was lordotic before surgery and became kyphotic or neutral after surgery although 7 of them were clinically asymptomatic and did not require revision. Recently, Kim et al.[12] found that fusing at or below the SSV, rather than fusing to the FLV, results in lower incidence of DJK and a significantly lower incidence of revision surgery for distal junctional failure.

On the other hand, other studies found that fusion into the FLV was sufficient and did not increase the incidence of DJK. Denis et al.[4] in their study on 67 patients of SK found DJK in 8 patients (12%); 7 of them were fused short of the FLV and they suggested including the first lordotic disc and all the kyphotic vertebrae in the fusion to avoid DJK. Lonner et al.[16] found no significant difference for development of DJK between patients fused to SSV and those fused to the FLV. Yanik et al.[25] found that extension of instrumentation and fusion into the SSV are unnecessary and fusion to the FLV was sufficient and results in comparable rates of DJK and saves more mobile levels.

In surgical correction of deformity in adolescents, lumber mobility and function decrease and disability and morbidity increase with the number of fused lumber levels.[20,24] Koller et al.[13] using the FLV-1 as the LIV on 111 patients treated by anterior release and posterior spinal fusion (AR/PSF) using all pedicle screws found that extension of fixation into the FLV-1 saves one to two mobile levels and was not associated with increased incidence of DJK and extension

to the SSV or the FLV was unnecessary. Only one patient required revision surgery for DJK.

In this study fusion into the vertebra just above the FLD (FLV-1) was sufficient. It saved one to two mobile levels in the lumber spine which is especially important in the lower lumber spine when compared to fusing into the FLV or the SSV without increase in the risk of symptomatizing DJK. This leads to improvement of function and patient satisfaction as indicated by the improvement of the SRS-30 score and ODI score. The only patient that had revision surgery with extension of instrumentation for two additional levels was a patient with instrumentation failure in the form of distal screw pull-out because we stopped wrongly at D12. Concerns of increased biomechanical stresses at the thoracolumbar junctional area should be addressed to avoid junctional problems as recommended by Koller et al.[13] Thus, if there were concerns regarding fusion stopping at D12 or L1, L1 should be selected. Again, the benefit of saving one or two mobile segments outweighs the risk of revision surgery. Koller et al.[13] used the FLV-1 as the LIV in their study and found similar results using AR/PSF.

In our study, we used only the posterior technique together with posterior release and posterior Ponte osteotomies which achieved adequate correction and the required release for eliminating the stresses at the ends of the implant decreasing the incidence of junctional problems. Thus, adequate release whether anterior or posterior to increase the flexibility of the curve decreases the incidence of DJK. DJK has been attributed to junctional ligamentous disruption during exposure, overcorrection of deformity, and improper selection of the LIV.[1] The proximal and distal two spinous processes should be left intact with their attached ligaments and the paraspinal muscles should be attached to the spinous processes.

Our correction rate was 53.54% because our patients were young, because of the use of high density pedicular screws (87 %) which are lordosing in nature, and also because of the use of adequate posterior release and Ponte osteotomies in some patients. Although the correction rate of kyphosis was slightly over 50 %, DJK risk was not increased. Yanik et al.[25] found no significant difference between those with over 50% and those with less than 50% correction.

In this study, the ability to restore a normal physiologic sagittal contour with a balanced spine with the C7 plumb line slightly shifted behind the sacrum within the balanced range (slightly negative SVA) as reported in other studies [4,9,15,18] decreased the incidence of DJK. It has been stated that decreased lumber lordosis may lead to DJK.[9] In this study, restoration of a normal lumber lordosis through contouring the distal end of the rod into slight lordosis was achieved and this helped in decreasing the incidence of DJK by shifting the gravity line posteriorly behind the unfused lumber segments.[1]

In this study, the average screw density was 87.9 % (range, 78-100%) with no statistically significant correlation with the rate of correction. Screw fixation into each level including the apical and periapical areas decreases the risk of junctional problems through different mechanisms. It increases the correction rate by pushing anteriorly on the apex, makes the correction more segmental distributing the correction over many segments, and increases the anchorage fixation points eliminating the stresses at the ends of the instrumentation decreasing the risk of major junctional problems.

Limitations of this study are the small patient sample size, the small number of DJK available for comparison, and absence of a control group for comparison; however, this can be done in the future by a multicentre study. The average follow-up period of 40 months was mostly enough as most studies[3,16,25] indicate that DJK usually occur early in the postoperative period during the first 6 months and this was supported by our results. However, the fate of the radiological mild change in the disc space orientation in the DJK patients may require longer follow-up. Despite these limitations, our study is strengthened by the fact that the material is homogenous, all patients had SK and were younger in age, and all were treated by the same surgical technique which is the modern all-pedicle-screws posterior-only technique using

the FLV-1 as the LIV by the same surgeon and the study was a prospective one.

CONCLUSION

The outcome parameters in this study suggest that using the vertebra just cephalic to the FLV (FLV-1) as the LIV was associated with good clinical and radiological results. The benefit of saving more mobile segments in the lumber spine might outweigh the risk of DJK especially in the precious lower lumber spine segments.

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الملخص العربي

اختيار الحد السفلى لعملية دمج الفقرات فى حالات تحدب شورمان

البيانات الخلفيه: تعتبر حركة الفقرات القطنيه مهمه جدا وظيفيا و اكلينيكيا خصوصا فى السن الاصغر. عملية دمج الفقرات فى حالات تحدب شورمان هى عمليه طويلة الدمج و التى قد تمتد الى الفقرات القطنيه تاركة عددا اقل من الفقرات المتحركه.

تصميم الدراسه: دراسة حاله سريريه مستقبليه

الغرض: تقييم نتائج تثبيت الفقرات الى الفقرة FLV-1 فى علاج تحدب شورمان و معرفة ما ازاكان هزا سييؤيدى الى زياده فى نسبة حدوث اعوجاج او تحدب اسفل التثبيت ام لا .

المرضى و الطرق: اشتملت الدراسه على 25 مريضا من مرضى تحدب شورمان تم علاجهم باستخدام جراحه واحدة من الخلف لتصليح التحدب بالعمود الفقرى باستخدام مسامير عنق الفقرات و تم تثبيت الجزء الاسفل من التحدب حتى الفقرة FLV-1 فى الفترة ما بين فبراير 2011 الى فبراير 2015 0و قد تم تقييم المرضى شعاعيا بواسطة الاشعة السينية مع قياس زوايا الاعوجاج و اتزان العمود الفقرى و الحوض . كما تم تقييم النتائج الاكلينيكية و الوظيفية عن طريق استخدام ال SRS-30 و ODI مع توثيق اية مضاعفات للجراحة خصوصا حدوث فشل قى ناية التثبيت مع حدوث تحدب فى نهاية التثبيت.

النتائج: بلغ متوسط متابعة المرضى 40 شهرا. اظهرت النتائج حدوث تحسن فى زاوية التحدب من متوسط 82° قبل الجراحة الى 38° بعد الجراحة مع تغير طفيف فى نهاية فترة المتابعة بنسبة 2% . كما حدث تحسن فى اتزان العمود الفقرى . و قد اثبتت النتائج ان اتثبيت حتى الفقرة FLV-1 يوفر عدد متوسط1,7فقرة متحركة بدلا من استخدام الفقرة SSV و يوفر عدد 1فقرة لكل حالة ازا ما قورنت باستخدام FLV . حدث تحدب خفيف فى اسفل التثبيت فى حالتين لدرجة 3 و 5 ° دون حدوث اعراض او اى تدخل جراحى اخر . كما حدث خروج لاخر مسمار من اسفل فى مريض واحد و تم عمل اعاده للجراحة مع مد التثبيت لفقرتين اخريين.

الاستنتاج: استعمال الفقرة FLV-1 كاخر فقرة للتثبيت فى حالات تحدب شورمان ادى الى نتائج جيده . حيث ان القيمه من توفير عدد اكبر من الفقرات المتحركة اكبر من المخاطرة بزيادة نسبة التحدب اسفل التثبيت او زيادة فى نسبة اعادة الجراحة.