Pedicle Screws Versus Pedicle Hooks for Correction of Thoracic Scoliosis Using the Universal Spinal System II. A Modification of the Original Technique

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ABSTRACT

Background: *The standard AO technique for posterior correction and instrumentation of thoracic scoliosis, using Universal Spinal System (USS) II, entails the use of pedicle hooks distributed along the upper and middle regions of the thoracic curve and pedicle screws only at the base of the construct.* ***Purpose:*** *To assess thoracic scoliosis correction when pedicle screws are used instead of pedicle hooks and compare the results with the standard technique.* ***Study Design****: Prospective radiographic data review.* ***Patients and Methods:*** *Two patient groups were studied. All patients had structural thoracic scoliosis. Group 1: 14 patients (9 female and 5 male) with mean age of 14.6 years, were treated with posterior correction of scoliosis using the standard USS II technique with pedicle hooks and screws. Group 2: 14 patients (11 female and 3 male) with mean age of 15.3 years were treated using pedicle screws alone to correct the apical deformity, using a variation of the original USS technique. The mean follow up period was 6.7 months (range: 3-18).* ***Outcome Measures:*** *Pre and postoperative Cobb angle, apical vertebral rotation (AVR, Perdriolle method) and apical vertebral translation (AVT) were measured. Unpaired "t" test was used to compare the magnitude of correction in both groups.* ***Results:*** *The mean corrections of Cobb angle, AVR and AVT, in group 1 were 61.1% (range: 48.5-83.9), 33.3% (range: 8.6-100) and 62.9% (range: 43.2-91.4), respectively. In Group 2, the corrections were: 57.4% (range: 21.4-81.7), 57.2% (range: 16.7-100) and 58.7% (range: 34-80.9). There was no statistically significant difference between the correction of Cobb angle or AVT in both groups (P = 0.479 and 0.443 respectively). However, the pedicle screws proved to be more effective at correcting the AVR (P = 0.017). At latest follow up, correction has been well maintained.* ***Conclusion:*** *Pedicle screws can safely and effectively replace the pedicle hooks in the classical USS technique. They are more effective at correcting the rotational deformity, although do not provide a better correction of Cobb angle. These technical results now need to be correlated with relevant clinical outcomes.*

INTRODUCTION

The goals of instrumentation in adolescent idiopathic scoliosis (AIS) include a balanced spine in each of the coronal, sagittal, and axial planes and sufficient fixation to assure fusion and avoid postoperative immobilization[1-4].

Since the introduction of Cotrell-Dubousset instrumentation (CDI) in 1984, the correction techniques in scoliosis surgery have changed from Harrington principles of concave distraction to segmental realignment by a variety of methods including the rod rotation maneuver and segmental approximation via cantilever methods[5-8].

Proven sites of vertebral fixation include the vertebral body, lamina, and pedicle. Hooks have been widely used instrumentation in the treatment of AIS. Hook insertion techniques are standard, familiar, and generally accepted. However, hook displacement or pullout may occur during curve reduction maneuvers. Hooks are effective at distraction and compression, but lateral translation and derotation are difficult to achieve[9]. By

definition all hooks intrude into the spinal canal and may be associated with neurologic complications.

Pedicle screw fixation offers more stable fixation over a shorter segment while remaining completely external to the canal. In addition, it showed improved correction in comparison with hooks[10]. Pedicle screw utilization in lumbar curves enhanced correction and stabilization of various deformities, and various studies have strongly supported the clinical advantages of lumbar pedicle screws versus conventional hook instrumentation[10,11-13].

Some authors have applied similar techniques using thoracic pedicle screws and have reported better correction results and a shorter fusion length in thoracic curves despite the potential risks and the questionable benefits[14-21]. The use of thoracic pedicle screws has become increasingly widespread in the treatment of scoliosis and has led to a significant improvement in deformity correction[16,18,22-24], even in large-magnitude curves[25]. Most authors reported that neurologic risk had not increased with thoracic pedicle screw fixation[15-18, 22, 24].

The standard AO technique for posterior correction and instrumentation of thoracic scoliosis, using the Universal Spinal System (USS) II, entails the use of pedicle hooks distributed in the upper and middle regions of the thoracic curve and pedicle screws only at the base of the construct[26]. To the best of the authors' knowledge, none of the previous reports has compared pedicle screw versus pedicle hook instrumentation on radiographic parameters in patients with thoracic AIS.

The aim of the current study is to assess thoracic scoliosis correction when pedicle screws are used instead of pedicle hooks of the USS II, and compare the results with the standard technique.

PATIENTS & METHODS

A prospective radiographic data review was conducted on 28 patients with structural thoracic AIS, Lenke Type 1. Two patient groups were studied. Group 1: 14 patients (9 female and 5 male) with a mean age of 14.6 (range: 9-20), treated with the standard technique. Group 2: 14 patients (11 female and 3 male) with a mean age of 15.3 years (range: 9-21), treated using pedicle screws alone to correct the deformity. Mean follow up period was 6.7 months (range: 3-18).

The outcome measures consisted of measuring the mean preoperative, postoperative and latest follow up Cobb angle, apical vertebral rotation (AVR, Perdriolle method) and apical vertebral translation (AVT) for both groups, then calculating the percentage of correction for each parameter. Statistical analysis was performed using the SPSS programme version 10. Unpaired "t" test was used to compare the magnitude of correction in both groups.

The standard AO technique [26]:

No distraction or compression is applied to the vertebrae during correction of the deformity. The spine passively finds its own length. Pedicle hooks are distributed along the upper and middle regions of the thoracic curve, including the apex. Apical vertebra is instrumented on both sides. Bottom two vertebrae are instrumented with pedicle screws. On the concave side, the vertebrae intervening between the top and bottom of the curve are instrumented at alternate levels. A supralaminar hook is attached to the top vertebra on the convex side. A screw or supralaminar hook is attached to the concave side just below the apex. An optional supralaminar hook is

attached to the vertebra just cranial to the bottom vertebra on the convex side (fig 1A). Rods are contoured in correct sagittal plane and reduction of the spine to the rods is achieved by segmental manipulation starting at the top and bottom of the concave side, leaving its middle part to be corrected after application of the convex side rod, particularly in large curves (fig. 1B &C). The convex side rod is then connected at the top and apex, then pushed downwards and medially to allow translation of the apex towards the midline (fig. 1D). The remaining middle part of the curve including the apex is then connected to the concave side rod. Derotation of individual vertebrae is performed and finally the rods are cross linked at the top and bottom (fig. 1E).

The modified technique:

Pedicle screws are used instead of hooks except for the upper supra-laminar hook on the convex side (fig. 2). This hook was exempted because the authors believed that a screw in that position may fail in tension owing to the tremendous pull out force applied to this point during the convex side rod manipulation.

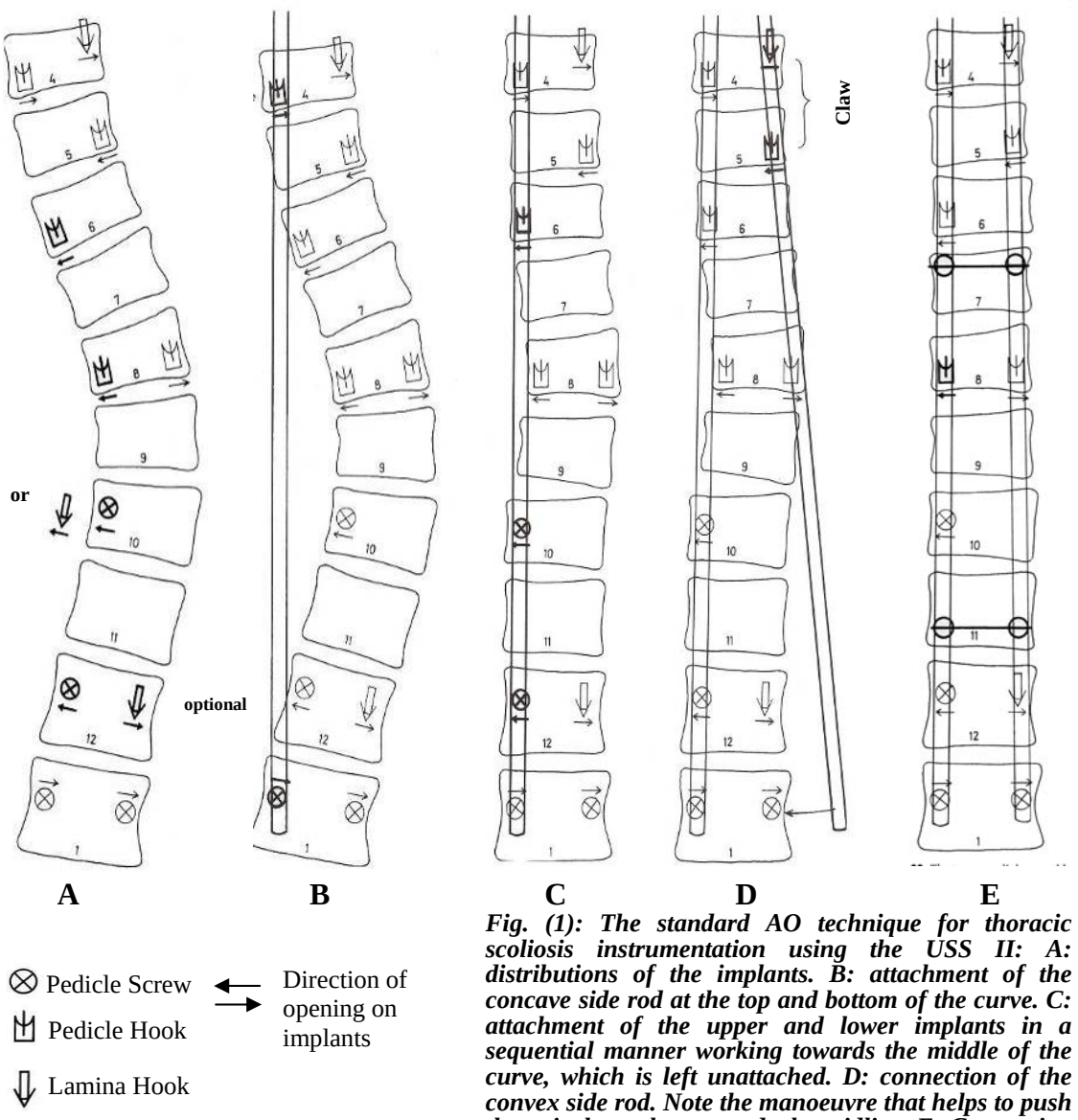


Fig. (1): The standard AO technique for thoracic scoliosis instrumentation using the USS II: A: distributions of the implants. B: attachment of the concave side rod at the top and bottom of the curve. C: attachment of the upper and lower implants in a sequential manner working towards the middle of the curve, which is left unattached. D: connection of the convex side rod. Note the manoeuvre that helps to push the apical vertebra towards the midline. E: Connecting the concave side rod to the apex and insertion of two cross links [26].

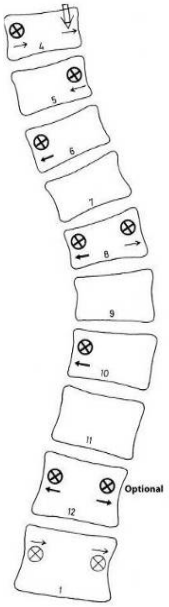


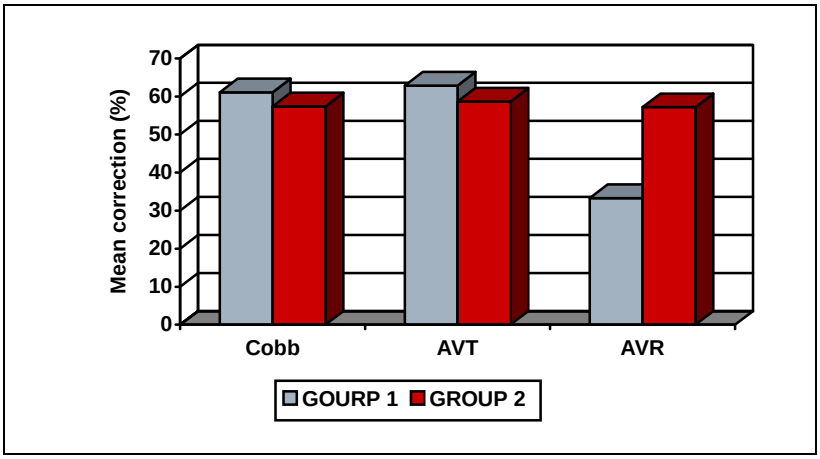
Fig. (2): The modified technique. All the pedicle hooks and the two optional supralaminar hooks of the standard technique are replaced by pedicle screws. The convex side upper supralaminar hook is still used

RESULTS

The results are summarized in table (1) and graph (1). The mean percentages of Cobb angle and AVT correction compared favorably in the two groups with no statistically significant difference (*P* = 0.479 and 0.443 respectively). However, the mean percentage of AVR correction was significantly higher in group 2, where the pedicle screws were used (*P* = 0.017). At latest follow up, correction of all the three parameters was well maintained in both groups.

Table (1): Comparison of the magnitudes of correction of the deformity in the two groups

	Group 1		Group 2		
	Mean %	**Range %**	**Mean %**	**Range %**	***"P"* value**
Cobb	61.1	48.5- 83.9	57.4	21.4- 81.7	0.479
AVT	62.9	43.2- 91.4	58.7	34- 80.9	0.443
AVR	33.3	8.6- 100	57.2	16.7- 100	0.017



Graph (1): Correction of AVR was significantly higher in group 2. Other parameters were comparable.

DISCUSSION

When Cotrell-Dubousset instrumentation (CDI) was introduced as the third generation spinal instrumentation for AIS in 1984, only hooks were used for correction of the both lumbar and thoracic curves. Later on, when pedicle screws received widespread acceptance for treatment of fractures and degenerative diseases, several investigators started using them for lumbar scoliosis[10,11-13,27,28]. Nowadays, pedicle screws have become the standard treatment for lumbar scoliosis because they have been proven to achieve better three dimensional correction of the deformity, including the adjacent distal un-instumented segment, and maintain the correction better than the conventional hooks, without increase in complication rates.

Following their great success in correction of lumbar scoliosis, several authors reported on using pedicle screws for the thoracic curves as well, even those with large magnitude[16-18,22-25]. However, there is a debate over whether pedicle screws are safe in thoracic scoliosis surgery and whether their usage might enable a better curve correction[18, 20, 23].

The authors of the current study are aware of four previous studies that compared pedicle screws with hooks for correction of thoracic AIS[23,29-31]. Liljenqvist et al[23] in 2002 compared Cotrel-Dubousset system, using hooks exclusively (hook group), with Münster Posterior Double Rod System, using either screws exclusively or screws in the lumbar and lower thoracic regions (screw group). They showed that Pedicle screw instrumentation alone or in combination with proximal hook instrumentation offered a significantly better primary and secondary curve correction in idiopathic thoracic scoliosis and enabled a significantly shorter fusion length. However, correction of the AVR according to Perdriolle was minimal in both groups.

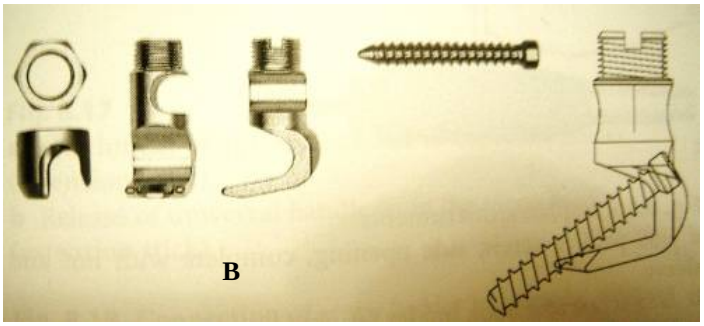
Kim et al[29] in 2004 published a comprehensive comparative analysis of pedicle screw versus hook instrumentation in posterior spinal fusion of AIS, in groups matched for age, fusion levels, Lenke curve type, and operative methods. They showed that pedicle screw instrumentation, although more expensive, offered a significantly better major and minor curve correction without neurologic problems, improved pulmonary function values and enabled a slightly shorter fusion length than segmental hook instrumentation.

Storer et al[30] in 2005 found no significant differences between the two patient groups in terms of the magnitude of curve correction, AVT, end vertebral tilt angle, coronal balance, operative time or quality of life. However, screw constructs were significantly more expensive than hook constructs. They concluded that correction obtained from thoracic pedicle screw fixation is comparable to traditional hook constructs in AIS.

Kim et al[31] in 2006 published another matched comprehensive comparative analysis of pedicle screw versus hybrid instrumentation (pedicle screws in lumbar spine and hooks in thoracic spine) in posterior spinal fusion of AIS. They showed that pedicle screw instrumentation offered a significantly better major curve correction and postoperative pulmonary function values without neurologic problems compared with hybrid constructs. Both instrumentation methods offered similar lowest instrumented vertebra, operative time, and postoperative SRS-24 outcome scores.

To the best of the authors' knowledge, none of the previous reports has compared USS II pedicle screw versus pedicle hook instrumentation on radiographic parameters in patients with thoracic AIS. The USS has unique mechanical characteristics. Being a side loading system (fig. 3), it depends on bringing the deformed spine, in a segmental fashion, towards the anatomically contoured sagittaly adjusted concave side rod. In other words, this system does not apply the derotation principle used for CDI and other top loading systems. Furthermore, unlike the top loading systems, the convex side rod in USS II plays an important role in correction of the apical translation (fig. 1D). Lastly and most importantly, the pedicle hook of USS II is fixed to the pedicle with a 3.2 mm screw (fig. 3B). This allows it to provide a stronger anchor and makes it more stable than the other conventional laminar, facet or pedicle hooks. However, until the time of this study, no one had known whether or not this type of hooks can be equal to pedicle screws in correction of thoracic AIS.

A



B

Fig. (3): Side loading USS II implants. A: Pedicle screw with its cap and nut. B: Front and side views of the pedicle hook with its cap, nut and fixation screw [(26)].

Among the above mentioned four previous studies, only Storer et al[(30)] found no statistically significant difference between thoracic pedicle screws and hooks regarding correction of thoracic curves. Although the results of curve correction (Cobb angle and AVT) in the current study compares well with the work of Storer et al, we feel that their results were not accurate because they compared pedicle screws with two different types of hooks (laminar and unfixed pedicle hooks). This can explain the contradiction between their results and the results in the other three studies[(23,29,31)] where only laminar hooks were compared to screws. On the other hand, the fact that pedicle hooks were comparable to pedicle screws regarding correction of Cobb angle and AVT in the current study, confirms that the USS II fixed pedicle hooks are more stable than the other types of hooks.

As regard to correction of AVR, it was only measured by Liljenqvist et al [(23)] who found it to be minimal in both groups. However, in their study, they included cases with hooks in the upper and middle thoracic region among the "screw group", which might have negatively affected the result in that

group. The other three previous studies did not comment on AVR. In the current study, AVR correction with pedicle screws was significantly better than with pedicle hooks. This seems logical as, unlike pedicle screw, hook is fixed close the spine axis of rotation and does not reach the anterior column, thus making its torque moment arm short. Correction of the rotational deformity improves the cosmetic results, by reducing the rib hump, and decreases the possibility of postoperative curve progression.

As far as the cost is concerned, in the USS II, pedicle screw is marginally cheaper than pedicle hook. Thus, unlike the previous studies, cost was not increased by using pedicle screws in the current study.

CONCLUSION

Pedicle screws can safely and effectively replace the pedicle hooks in the classical USS technique. They are more effective at correcting the rotational deformity, although do not provide a better correction of Cobb angle. The improvement in results is not associated with an increase in the cost. A possible follow up of this study would be to correlate these technical results with relevant clinical outcomes

Case presentations:

Case (1): The standard technique. Fig. (4)

20 years old female patient with lenke type 1BN AIS. She presented with a right thoracic curve (T4-T11), measuring 55°; left lumbar curve (T12-L4), measuring 50°; AVT 17mm and AVR 25°. On bending views, the thoracic curve reduced to 35° and the lumbar curve reduced to 10°. She was treated with posterior correction and instrumentation with USS II using the standard technique. Postoperatively, the thoracic Cobb angle reduced to 22°, AVT reduced to 6mm and AVR reduced to 15°. The percentages of correction of Cobb angle, AVT and AVR were 60%, 65%, and 40%, respectively. Correction was well maintained at latest follow up.

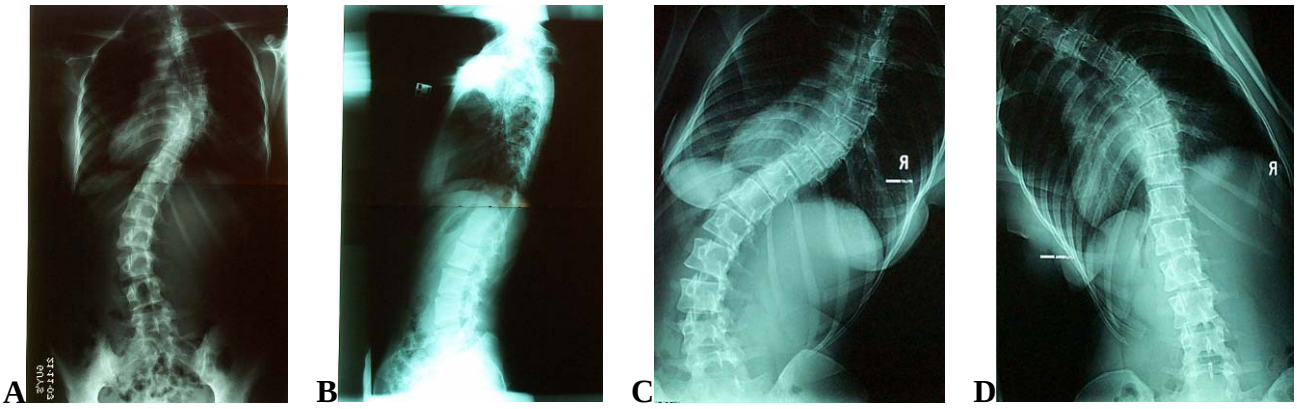


Fig. (4): A & B: AP and lateral radiographs of Lenke type 1BN AIS. C & D: Right and left bending radiographs showing a structural thoracic curve and secondary compensatory lumbar curve.

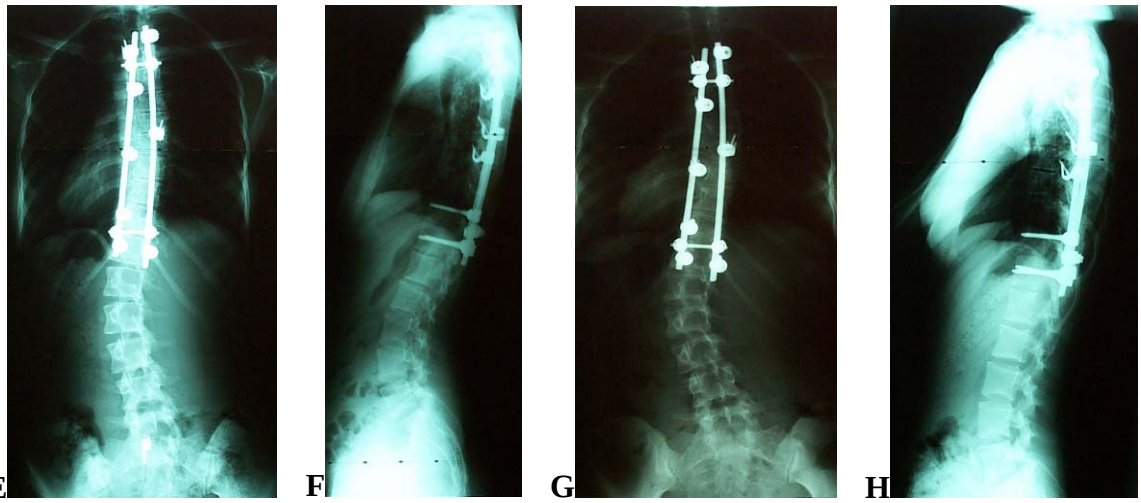


Fig. 4 (Cont.): E & F: AP and lateral postoperative radiographs following correction and instrumentation with the USS II, using the standard technique. G & H: 1 year follow-up AP and lateral radiographs. Correction maintained.

Case (2): The modified technique. Fig. (5)

15 years old female patient with lenke type 1CN AIS. She presented with a right thoracic curve (T5-T12), measuring 65°; left lumbar curve (T12-L4), measuring 48°; AVT 37mm and AVR 25 °. On bending views, the thoracic curve reduced to 50° and the lumbar curve reduced to 23°. She was treated with posterior correction and instrumentation with USS II using pedicle screws instead of pedicle hooks. Postoperatively, the thoracic Cobb angle reduced to 32°, AVT reduced to 13mm and AVR reduced to 10°. The percentages of correction of Cobb angle, AVT and AVR were 51%, 65%, and 60%, respectively.

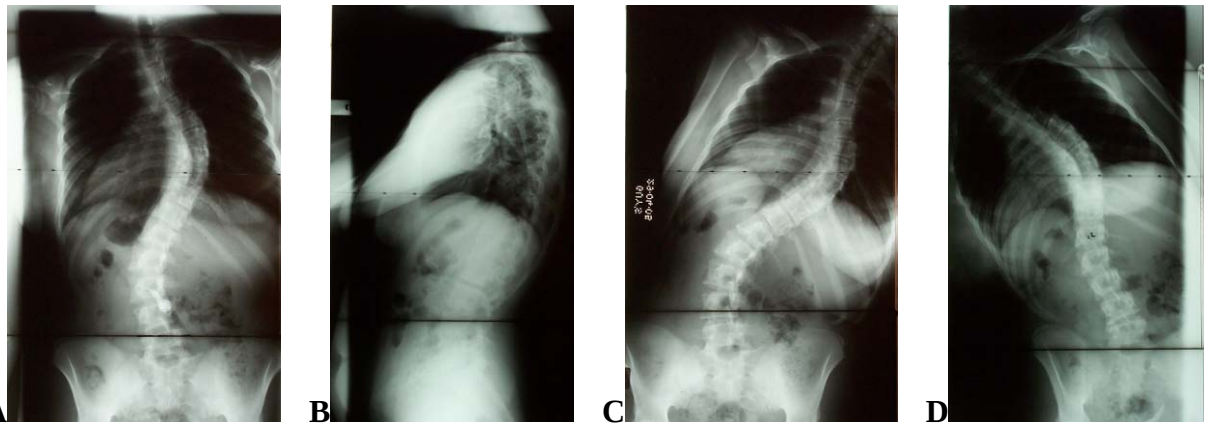


Fig. (5): A & B: AP and lateral radiographs of Lenke type 1CN AIS. C & D: Right and left bending radiographs showing a structural thoracic curve and secondary compensatory lumbar curve

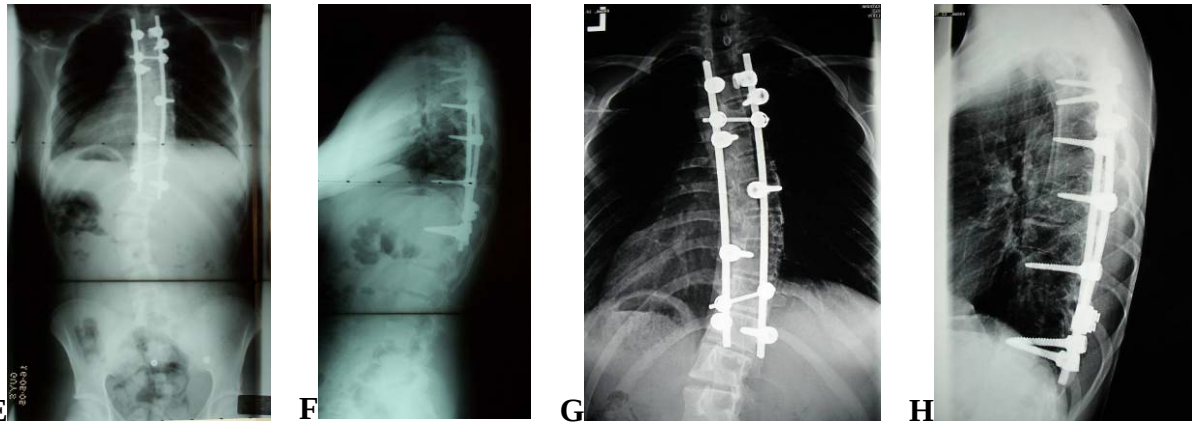


Fig. 5 (Cont.): E & F: AP and lateral postoperative radiographs following correction and instrumentation with the USS II, using the modified technique. G & H: 6 months follow-up AP and lateral radiographs. Correction maintained.

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