

Screw view model of navigation in posterior corrective surgery for adolescent idiopathic scoliosis

A case report and technique note

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Abstract

Rationale: The purpose of this study is to introduce the application of screw view model of navigation (SVMN) for adolescent idiopathic scoliosis (AIS). It is a challenge to insert pedicle screw into the vertebral body of scoliosis, and the misplaced screw may lead to neurovascular injury. In order to minimize surgical complications, we used a novel method of SVMN technology to facilitate pedicle screw insertion.

Patient concerns: Her mother brought her to our outpatient department upon noticing the girl's different heights of shoulders and unbalance of the trunk.

Diagnoses: She was diagnosed with AIS and syringomyelia.

Interventions: We used an SVMN technology to assist pedicle screw insertion and correction surgery in this 20-year-old patient.

Outcomes: This study indicates that the SVMN could obtain a satisfactory surgical effect for AIS. The Cobb angle of segmental scoliosis (T7-L2) was 55° before surgery, and 3.5° after surgery, and the rate of correction was 93.6%. The segmental kyphosis (T7-L1) was 56.8° preoperatively and 32° postoperatively with the rate of correction of 43.6%. The distance between the center sacral vertical line (CSVL) and the C7 plumb line (CPL) was reduced from 56.2 mm to 0.2 mm, and the sagittal imbalance of 35.8 mm was improved to 3.5 mm. In addition, the misplacement of pedicle screws, the volume of blood loss, the operation time, and surgical complications were also recorded. The follow-up duration was 33 months.

Lessons: The utilization of SVMN in AIS might reduce the incidence of screw misplacement and avoid neurovascular damage, as well as a satisfactory correction. The application of SVMN for AIS is an efficacious and safe method.

Abbreviations: 3D = three dimensional, AIS = adolescent idiopathic scoliosis, CPL = C7 plumb line, CSVL = center sacral vertical line, CT = computer tomography, EMG = electromyography, L = lumbar, T = thoracic.

Keywords: corrective surgery, navigation, scoliosis, screw view model

1. Introduction

Adolescent Idiopathic Scoliosis (AIS) is a three dimensional (3D) anatomical deformity of the vertebral column, mainly including variations in alignment of the sagittal plane, deviations in coronal plane and vertebral rotation in axial plane.^[1-4] At present, screw-rod system fixation in posterior approach has become the

primary measure for AIS.^[5,6] On the one hand, a satisfactory orthopedic effect should be achieved, on the other hand, complications should be avoided during operation.

More accurate pedicle screw implantation could decrease the probability of neurovascular structures injury. Over the last 2 decades, pedicle screw placement with free-hand for scoliosis has obtained acceptable outcomes. However, with the increasing angle of scoliosis and degree of vertebra rotation, the difficulty of screw implantation increased gradually,^[7,8] and the incidence of screw misplacement is 1.7% to 15.7% by free-hand.^[9,10] Numerous methods have been applied to facilitate scoliosis correction and promote pedicle screw insertion, involving computer-assisted surgery,^[11] pedicle screw insertion guiding devices,^[12] 3D rapid prototyping technique^{5.6%},^[7] and robot-assisted surgery,^[13] but the effect was not satisfactory. The application of these measures still has 5.6% to 11.4% screw malposition rate.^[7,12-14] In order to minimize surgical complications, we used a novel method of SVMN technology, which could facilitate pedicle screw insertion. To our knowledge, the use of this SVMN technology for AIS has rarely been reported.

2. Ethics

The patient signed written informed consent and her information was hidden. This study has been approved by the Ethics

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TY and LY contributed equally to this work.

The authors have no conflicts of interest to disclose.

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Table 1

Patient characteristics.

Sex	Age (years)	UEV	AV	LEV	Complications	FU (months)
F	20	T7	T11	L2	None	33

AV = apex vertebra, F = female, FU = Follow up, L = lumbar, LEV = lower end vertebra, T = thoracic, UEV = upper end vertebra.

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3. Case report

3.1. Patient characteristics

This is a healthy female patient at 20 years old (Table 1). Her mother brought her to our outpatient department upon noticing the girl’s unbalance of the trunk. The girl had no obvious uncomfartableness.

Physical examination displayed different heights of shoulders and “razor back” deformity. There was no obvious hypoaesthesia. The muscle strengths of bilateral iliocsoas muscle, quadriceps femoris muscle, anterior tibial muscle, peroneal longus, and soleus muscle are all V grade. Both Achilles tendon reflex and knee reflex were normal. Bilateral Chaddock signs, Babiskin signs, and Patellar clonus were negative. The Bragard sign and Lasegue test were negative.

Imaging examination demonstrated that the segmental scoliosis (T7-L2) was 55° (Fig. 1A) and the segmental kyphosis (T7-L1) was 56.8° (Fig. 1B). The distance between the CPL and the CSVL was improved from 56.2mm to 0.2mm, and the sagittal imbalance of 35.8mm was reduced to 3.5mm. The upper end vertebra, apex vertebra, and the lower end vertebra were T7, T11, and L2 respectively (Table 1). The total spine magnetic



Figure 1. Anterior-posterior and lateral standing full-length spinal X-rays were obtained preoperatively (A–B).

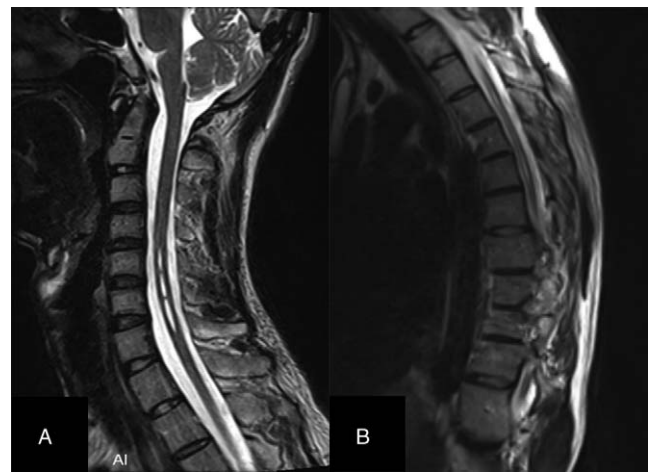


Figure 2. Magnetic resonance imaging displayed formation of syringomyelia in C5–7 and T3–6 segments.

resonance imaging displayed the formation of syringomyelia in C5–7 and T3–6 segments (Fig. 2). Ultrasonic cardiography was examined to estimate whether heart disease was existent. The



Figure 3. Preoperative 3D CT scan revealed spinal deformity (A–B).

result of pulmonary function tests showed that the percentage of residual gas and total lung increased slightly, and the diffusion function of lung was normal. Results of electromyography showed that there was no neurogenic lesion in the muscles of the lower extremities and motor and sensory nerve conduction velocity and the double tibial nerve's H reflex were normal. The Risser grade of this patient was V grade. The primary diagnosis was AIS and syringomyelia.

3.2. Surgical technique

Preoperative CT scans of the whole spine was performed (Fig. 3), and the image data was burned on a CD that could be recognized by the computer-navigation workstation so as to facilitate preoperative design, including the length, diameter, and trajectory of pedicle screws.

The patient was placed in prone position after general anesthesia took effect. The posterior structures of T5-L3 were exposed. A patient tracker for locating the patient's spatial location was installed on the spinous process of T5 vertebra. The SpineMap 3D 2.0 (Stryker Navigation, Kalamazoo, MI, USA) software was selected in Navigation System workstation. The C-arm tracker, the

patient tracker and the surgical instrument tracker (Stryker Leibinger GmbH & Co., Freiburg, Germany) were activated in turn. We finished image acquisition after 190° scanning at the segmental lesion and made automatic fusion of scanned image intraoperative and CT image preoperative. We chose SVMN in the workstation and moved the position of the surgical instrument until the direction of surgical instrument was completely consistent with the planned trajectory preoperatively. The surgical instrument was not inserted until the lower right corner of the screen turned green (Fig. 4). Then scoliosis was corrected. Anteroposterior position and lateral X-rays were performed intraoperatively to examine the position of inserted screw. A multimodal intraoperative monitoring system was applied throughout the operation, mainly monitoring motor evoked potentials and somatosensory evoked potentials.^[15] Brace was used for 3 months after operation to ensure the stability of the spine.

The surgical complications, the operation time, and the bleeding volume were collected from the medical records. The frontal and lateral of total spine X-rays were taken (Fig. 5A–B) and CT image was scanned postoperatively. We estimated the position of pedicle screw reported by Ughwanogho et al.^[16] The clinical pictures were also collected postoperatively (Fig. 6A–B).

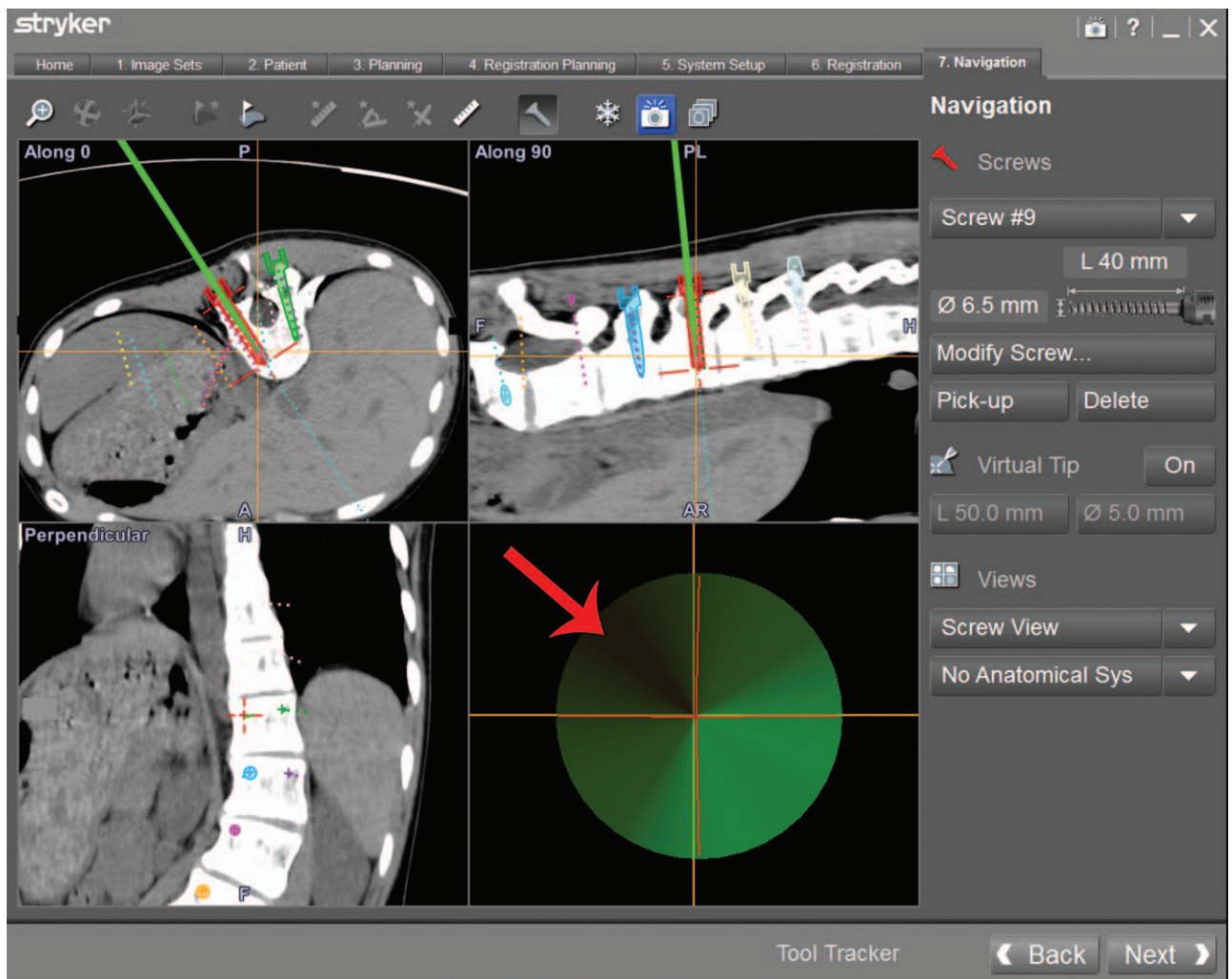


Figure 4. The screw view model of navigation displays the trajectory of surgical instrument during screw implantation, and the guide wire is not inserted until the area indicated by the yellow arrow turns green.



Figure 5. Clinical pictures of the patient postoperatively (A–B).

The blood loss volume was 768 ml, and the operation time was 186 minutes. The distance between the CPL and the CSVL was improved from 56.2 mm to 0.2 mm, and the sagittal imbalance of 35.8 mm was reduced to 3.5 mm. The main curve was 3.5° postoperative with 93.6% correction rate. The segmental kyphosis (T5-T12) was 32° after surgery with 43.6% correction rate (Table 2). No screw misplacement and neurological impairment were found postoperatively. No curve progression,

pseudarthrosis formation, or loosening of pedicle screw was discovered during 33 months of follow-up duration.

4. Discussion

At present, the major approach for AIS is the posterior screw-rod system fixation.^[1,3,5,8] Screw misplacement is a primary factor that leads to disastrous neurovascular compromise.^[2–4] Literature^[1,17] reported that navigation system allows the surgeon to implant pedicle screw more accurately than free hand technique, whereas the pedicle violation was still observed 11.4% with navigation. Research reported that computer navigation system could improve the accuracy of screw implantation in scoliosis patients, while the malposition rate was as high as 16.9%.^[6] To minimize surgical risk, we used a novel SVMN technology to promote the success of the operation.

In this study, there was no pedicle screws misplacement, and the neurologic function was intact postoperatively. The major Cobb angle correction was 93.6%, which is slightly better than Quan GM (69.9% correction).^[18] We attribute the excellent correction rate and the precise pedicle screw insertion to SVMN technique. To our way of thinking, this SVMN technology could help surgeons prevent neurovascular injury and pedicle invasion as well as increase the stability of the spine.

Postoperative screw loosening is a very familiar surgical complication of spinal surgery.^[19,20] Morr et al.^[19] and Ohtori et al.^[20] stated that the incidence of pedicle screw loosening was in the range of 7% to 19.6%. The main reasons for screw loosening include insufficient length of the selected screw, poor angle of screw placement, repeated screw placement, and excessive postoperative spinal load. Pedicle screw loosening was also associated with many other surgical complications, such as pseudarthrosis, screw breakage, and even loose correction.^[21] In this study, no screw loosening was detected during 33 months of follow up. In our opinion, we attribute these positive outcomes to screw insertion with SVMN technology so that all screws were



Figure 6. Postoperative total spine X-rays revealed good correction of segmental scoliosis (A) and segmental kyphosis (B).

Table 2
Scoliosis correction pre- and postoperatively.

SC (°)		SK (°)		SI (mm)		TS (mm)	
Pre	Post	Pre	Post	Pre	Post	Pre	Post
55	3.5	56.8	32	35.8	3.5	56.2	0.2

Post = postoperative, Pre = preoperative, SC = segmental curve, SI = sagittal imbalance, SK = segmental kyphosis, TS = trunkshift.

successfully implanted at the best trajectory at one time and we applied a brace to maintain stability of spine postoperatively.

The operation time was 186 minutes with SVMN technology. This outcome was similar to a literature reported by Yang et al.^[12] This positive outcome was most likely to be attributed to the full understanding of the deformity spinal anatomical structures via 3D models in navigation workstation, so we could quickly identify the entry point and trajectory intraoperatively. Besides, the duration of surgery was associated with the total intraoperative bleeding volume, and there usually is a large volume of blood loss in deformity correction surgery.^[22] Effective measures to reduce intraoperative bleeding are crucial for doctors, as blood transfusion can result in infection, hemodynamic changes, fever, acute lung injury, and even death.^[23–25] In this study, the blood loss was 768 ml with SVMN technology. We attribute this good result to much shorter operation time with the SVMN technology.

Our study obtained satisfactory outcomes, however, it also has many limitations. Firstly, the case report was a small sample size and there were no randomized controlled trials. Secondly, the patient may have suffered more X-ray radiation because the whole operation was carried out 3 times of image acquisition. Therefore, a multicenter and randomized controlled trial should be conducted and radiographic exposure duration should be reduced to assess the effectiveness of SVMN technology for the patients with AIS.

5. Conclusion

This study demonstrates that the SVMN could achieve a better therapeutic effect for AIS. The application of SVMN in AIS might decrease operation time, screw loosening rate, and the risk of screw malposition. Besides, we obtained a successful correction. Therefore, SVMN for AIS is a safe and efficacious method.

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Author contributions

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