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Original Article

Efficacy of three-dimensional guide plate technique guided sacral 2 alar iliac screws fixation in patients with degenerative kyphoscoliosis

Liqiang Cui[1*], Shuangquan Gong[1*], Shiming Xie[2], Lei Zhang[1], Wusi Peng[1]

[1]Department of Spinal Surgery, Mianyang Orthopaedic Hospital, Mianyang, Sichuan Province, China; [2]Department of Orthopaedics, Mianyang Tumor Hospital, Mianyang, Sichuan Province, China. [*]Equal contributors and co-first authors.

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Abstract: Objective: To investigate the efficacy of three-dimensional (3D) guide plate technique guided sacral 2 alar iliac (S2AI) screws fixation in patients with degenerative kyphoscoliosis. Methods: Eighty-four patients with degenerative kyphoscoliosis who were admitted to our hospital were selected as the subjects. They were divided into control group and observation group by the random number table method, with 42 patients in each group. S2AI free-hand screw implantation technique was adopted for screws fixation in control group; 3D guide plate technique guided S2AI screw implantation was used for screws fixation in observation group. A 2-year routine follow-up was carried out after the surgery. The followings were compared: screw parameters of preoperative pre-set screw trajectory and postoperative actual screw trajectory: sagittal angle (SA), transverse angle (TA), horizon distance from the entry point to the median sacral crest (HD), vertical distance from the entry point to the superior margin of the second posterior sacral foramina (VD), and the incidence rate of complications; scoliosis Cobb angle, sagittal vertical axis, C7 plumb line-center sacral vertical line (C7PL-CSVL), regional kyphosis Cobb angle (RK), pelvic incidence (PI), and pelvic tilt (PT) before, after and 2 years after surgery; Oswestry disability index (ODI) and shot form 36 health survey questionnaire (SF-36) before and 2 years after surgery. Results: The difference between preoperative simulation and postoperative actual values of SA, TA, HD and VD was significantly lower in observation group than in control group ($P<0.001$). Scoliosis Cobb angle, lumbar lordosis, C7PL-CSVL, RK, PI and PT after and 2 years after surgery were significantly improved than those before surgery in the two groups ($P<0.001$), and there was no significant difference between those after surgery and 2 years after surgery ($P>0.05$). Patients in the two groups had significantly lower ODI scores and higher SF-36 scores at 2 years after surgery than those before surgery (both $P<0.001$), and there was no significant difference at 2 years after surgery between the two groups ($P>0.05$). The incidence rate of complications in observation group was significantly smaller than that in control group ($P<0.05$). Conclusion: 3D guide plate technique guided S2AI fixation can significantly increase the accuracy of screw implantation, effectively correct degenerative kyphoscoliosis, achieve rigid internal fixation, improve patient's spinal function and quality of life, and greatly enhance surgical safety, which is worthy of clinical popularization.

Keywords: Three-dimensional guide plate technique, sacral 2 alar iliac screws, degenerative kyphoscoliosis, efficacy

Introduction

Degenerative kyphoscoliosis is a common lumbar degenerative disease in the elderly, which not only affects spinal aesthetics, but also leads to ache of lower limb and lower back, intermittent claudication and even cardiopulmonary impairment [1]. A study indicated that conservative treatment was hard to work on degenerative kyphoscoliosis, and a surgery, by which it could enlarge spinal canal volume and correct spinal curvature and height malformation to reconstruct spinal stability, was the most effective treatment means [2]. Sacropelvic fixation is currently a major surgical method for treating degenerative kyphoscoliosis, including Galveston technique, iliac screw fixation, sacral 2 alar iliac (S2AI) screws fixation and others, with good biomechanical property. The first two surgical methods are commonly used in the past and have been proved to have significant limitations. For Galveston technique iliac internal loosening easily occurs; during iliac screw fixation there are many dissected soft tissues and high screw tail incisura which easily protrudes under the skin and induces cutaneous complications, pseudoarticulation formation, infection and other complications, and single transverse connector can affect fixation stability [3]. S2AI fixation, with the advantages of few dissected soft tissues, long distance from screw tail to the skin surface, high anti-pulling strength and low incidence rate of complications, has become a new surgical selection for lumbosacral pelvic reconstruction since its successful implementation was first reported in 2009. However, due to the complex anatomical structure and adjacent relationship near the sacroiliac region, S2AI free-hand screw implantation within this range requires the surgeon to have precision technique, anatomical knowledge and three-dimensional (3D) spatial orientation ability; screw implantation direction deviation can cause damages to the sacroiliac region, cauda equine, and pelvic vessels and organs, so it is vital to grasp the entry point, trajectory and angle of screw implantation [4]. S2AI screw implantation guidance technique has always been the focus of clinical attention, and it has also been found that C-arm fluoroscopy, cone-beam computed tomography (CT) and other technologies significantly improve the accuracy of screw implantation, but with significant radiation risks. 3D navigation technology emerges recently, having good navigation accuracy and the ability of reducing radiation exposure risk [5]. However, there are few reports on its application in S2AI screw implantation at home and abroad, and its effectiveness and safety are not yet clear. Therefore, this study was performed based on this topic, aiming to provide guidance for clinical S2AI screw implantation navigation selection.

Materials and methods

General data

Eighty-four patients with degenerative kyphoscoliosis who were admitted to our hospital from October 2015 to February 2018 were selected as the subjects. They were divided into control group and observation group by the random number table method, with 42 patients in each group. Inclusion criteria: Patients met the diagnostic criteria for degenerative kyphoscoliosis [6]; patients received posterior S2AI screw implantation and met relevant surgical indications; patients did not have severe diseases of heart, brain, vessels, liver, kidney, lung, and other vital organs and tissues; patients had complete data of follow-up time and clinical and image data before and after surgery; patients voluntarily participated in this study and signed the informed consent. Exclusion criteria: Patients with congenital or clear cause of spine malformation; patients previously received thoracolumbar vertebral or sacroiliac joint surgery; patients were accompanied by severe infectious disease or blood, immune or other system diseases; patients had a length difference of lower limbs of >2 cm; patients had poor follow-up compliance and quality due to various reasons. This study was reviewed and approved by the Ethics Committee of Mianyang Orthopaedic Hospital.

Methods

All patients received general anesthesia and took prone position after routine disinfection and draping. S2AI screws were implanted and fixed by the posterior middle longitudinal incision approach. The retention range for internal fixation was determined before surgery, and then corresponding decompression and fusion segments were exposed. In the convex and concave sides of fixation segments above sacral 1, pedicle screws were implanted manually. S2AI screws implantation and fixation: S2AI free-hand screw implantation technique was adopted for screws fixation in control group. 3D guide plate technique guided S2AI screw implantation was used for screws fixation in observation group. The entry point was selected at the intersection point of the horizontal line 1 cm under the inferior margin of the sacral 1 (S1) foramina and the vertical line at 0.1 cm outside the outer margin. The lumbosacral pelvis was scanned by 3D CT before surgery, and according to the results, patient-specific navigational templates were prepared by 3D printing. 3D printing technology and Mimics 3D reconstruction software were used to build 3D simulation models, and Geomagic software was used to design the best screw trajectory of internal fixation. Then the best patient-specific navigational template was designed according to the screw trajectory. S2AI screws with the diameter of 7.5 mm and the length of 85 mm were implanted bilaterally under the guidance of the navigational template. Then the site of screw implantation was confirmed by C-arm fluoroscopy. After screw implantation, decompression, orthopedic and fusion treatments were performed on the responsible vertebrae, and one rod was implanted respectively on both sides for fixation. Then the decompression morselized bone and allograft bone were used for lateral bone graft fusion. Patients were monitored by motor evoked potential and somatosensory evoked potential throughout the surgery.

Outcome measures

Main outcome measures

(1) Screw parameters of preoperative pre-set screw trajectory and postoperative actual screw trajectory: sagittal angle (SA), transverse angle (TA), horizon distance from the entry point to the median sacral crest (HD), and vertical distance from the entry point to the superior margin of the second posterior sacral foramina (VD) were compared between the two groups and analyzed by using a computer software, and the difference between preoperative simulation and postoperative actual values was compared. SA: an included angle between the sagittal projection and the horizontal line; TA: an included angle between the transverse projection and the sagittal median line. (2) The incidence rate of complications, such as incision infection, screw exposure, screw loosening and dropping, pseudoarticulation formation and rod breaking, was compared between the two groups. Incidence rate of complications = Number of patients with complications/total number of patients × 100.0%.

Secondary outcome measures

A 2-year follow-up was carried out after the surgery. (1) Scoliosis Cobb angle, regional kyphosis Cobb angle (RK), and C7 plumb line-center sacral vertical line (C7PL-CSVL) before, after and 2 years after surgery were compared between the two groups. Scoliosis Cobb angle referred to the scoliosis angle between upper and lower vertebral bodies of the main bending that was measured on anteroposterior and lateral films of full spine in erect position. RK referred to the included angle between tangent lines of the superior and lower endplates of the most inclined lumbar vertebra on the lateral film of full spine in erect position. C7PL-CSVL was used to evaluate the coronal balance of vertebral bodies. (2) Sagittal vertical axis, pelvic incidence (PI), and pelvic tilt (PT) before, after and 2 years after surgery were compared between the two groups. Sagittal vertical axis referred to the horizontal distance between the C7 plumb line and the posterior superior angle of the sacrum on the lateral film of full spine in erect position. Two straight lines through the midpoint of S1 endplate were perpendicular to S1 endplate and the midpoint of the line connecting centers of bilateral femoral heads, respectively, and the intersection angle between the two straight lines was PI. A straight line was made through the midpoint of superior endplate of S1 and the midpoint of the line connecting centers of bilateral femoral heads, and the intersection angle between the straight line and the plumb line was PT. (3) Oswestry disability index (ODI) and shot form 36 health survey questionnaire (SF-36) before and 2 years after surgery were compared between the two groups. Lumbar function before and after surgery was evaluated by ODI, which included 10 items, each with 6 answer choices on a scale from 0 to 5 [7]. Scores ranged from 0-50. The higher scores indicated poorer lumbar function. ODI = Practical score/50 (the highest possible score) × 100.0%. The quality of life before and after surgery was evaluated by SF-36, which included 8 dimensions and a total of 36 items in 10 sections [8]. The first four dimensions were physical health, while the last four were mental health. The higher scores indicated better quality of life.

All patients received anteroposterior and lateral X-rays of full spine in erect position, pelvic CT and other imageological examinations before and after surgery for evaluating indicators such as screw trajectory parameters, bone graft fusion and imaging parameters. Examination results were obtained by the same veteran radiologist and orthopedist.

Statistical analysis

All data were analyzed by using SPSS 21.0 professional statistical software. The measurement data were expressed as mean ± standard deviation ($\bar{x}$ ± sd); comparison between groups was carried out by independent sample t test and comparison before and after surgery was performed by paired t test. The enumeration data were shown as number of patients (per-

Table 1. Comparison of general data (n)

General data	Control group (n=42)	Observation group (n=42)	t/χ^2	P
Gender (male/female)	19/23	20/22	χ^2=0.783	>0.05
Age (years)	62.1±8.9	62.3±8.7	t=1.077	>0.05
Course of disease (years)	5.23±2.01	5.16±1.95	t=0.549	>0.05
Fusion segment	6.13±2.54	6.07±2.39	t=0.910	>0.05
Fusion segment range			χ^2=0.639	>0.05
Short segment	25	24		
Long segment	17	18		

Table 2. Comparison of differences of preoperative simulation and postoperative actual screw trajectory parameters

Group	Differences of preoperative simulation and postoperative actual screw trajectory parameters			
	SA (°)	TA (°)	HD (mm)	VD (mm)
Control (n=42)	0.19±0.05	0.13±0.04	0.20±0.07	0.15±0.03
Observation (n=42)	0.04±0.02	0.06±0.02	0.07±0.04	0.02±0.01
t	10.472	6.731	8.589	13.043
P	<0.001	<0.001	<0.001	<0.001

Note: SA: sagittal angle; TA: transverse angle; HD: horizon distance from the entry point to the median sacral crest; VD: vertical distance from the entry point to the superior margin of the second posterior sacral foramina.

centage), and comparison between groups was implemented by chi-square test. P<0.05 suggested a significant difference.

Results

Comparison of general data

There were no significant differences in gender, age, course of disease, fusion segment, and fusion segment range between the two groups (P>0.05, **Table 1**).

Comparison of differences of preoperative simulation and postoperative actual screw trajectory parameters

By comparing the differences between preoperative simulation and postoperative actual screw trajectory parameters, SA, TA, HD and VD differences in observation group were significantly lower than those in control group (P<0.001, **Table 2** and **Figure 1**).

Comparison of scoliosis Cobb angle and RK before, after and 2 years after surgery

Scoliosis Cobb angle and RK before, after and 2 years after surgery between two groups showed no significant differences (P>0.05). Scoliosis Cobb angle and RK after and 2 years after surgery in two groups were significantly improved compared with those before surgery (P<0.001, **Table 3**).

Comparison of C7PL-CSVL and sagittal vertical axis before, after and 2 years after surgery

C7PL-CSVL and sagittal vertical axis before, after and 2 years after surgery between the two groups showed no significant differences (P>0.05). C7PL-CSVL and sagittal vertical axis after and 2 years after surgery in the two groups were significantly improved compared with those before surgery (P<0.001, **Table 4**).

Comparison of PI and PT before, after and 2 years after surgery

PI and PT before, after and 2 years after surgery between the two groups showed no significant differences (P>0.05). PI and PT after and 2 years after surgery in the two groups were significantly improved compared with those before surgery (P<0.001, **Table 5**).

Comparison of ODI scores and SF-36 total scores before and 2 years after surgery

There were no significant differences in ODI scores and SF-36 total scores before and 2 years after surgery between the two groups (P>0.05). ODI scores and SF-36 total scores at 2 years after surgery in the two groups were significantly improved compared with those before surgery (P<0.001, **Table 6**).

Comparison of complication incidence

Total incidence rate of incision infection, screw exposure, screw loosening and dropping, pseudoarticulation formation and rod breaking was 11.90% in observation group, which was significantly lower than 26.18% in control group (P<0.05, **Table 7**).

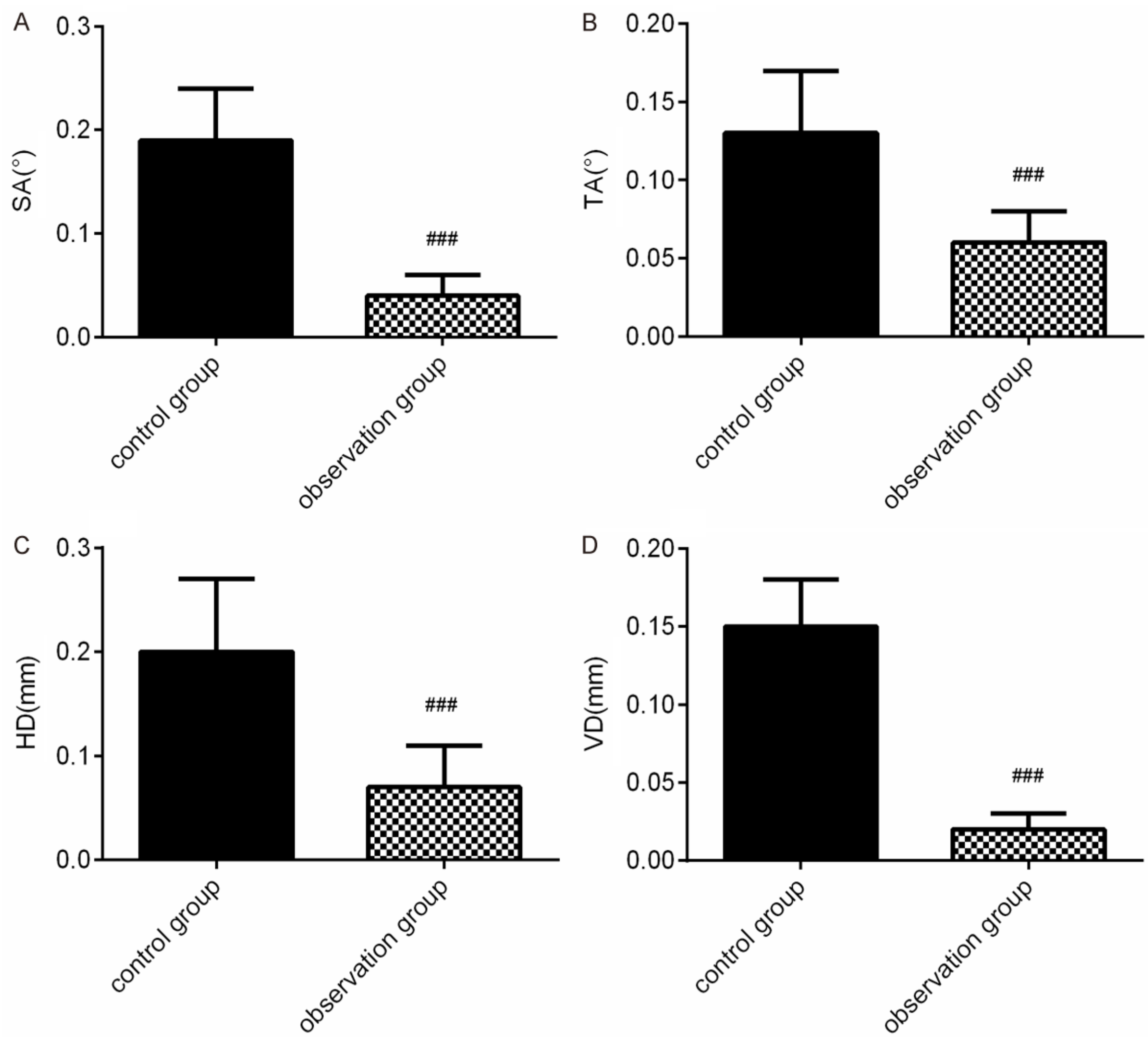

Figure 1. Comparison of differences of preoperative simulation and postoperative actual screw trajectory parameters. A: Differences of SA (°); B: Differences of TA (°); C: Differences of HD (mm); D: Differences of VD (mm). Compared with control group, ###P<0.001. SA: sagittal angle; TA: transverse angle; HD: horizon distance from the entry point to the median sacral crest; VD: vertical distance from the entry point to the superior margin of the second posterior sacral foramina.

Table 3. Comparison of scoliosis Cobb angle and RK before, after and 2 years after surgery

Time	Control group (n=42)	Observation group (n=42)	t	P
Scoliosis Cobb angle (°)				
Before surgery	44.57±15.36	44.92±15.67	0.433	>0.05
After surgery	21.39±8.49$^{###}$	20.51±8.03$^{###}$	1.052	>0.05
2 years after surgery	16.50±5.83$^{###}$	15.66±5.41$^{###}$	0.849	>0.05
RK (°)				
Before surgery	32.49±10.53	33.02±10.39	0.308	>0.05
After surgery	-10.84±24.72$^{###}$	-12.63±22.90$^{###}$	1.735	>0.05
2 years after surgery	-9.77±18.45$^{###}$	-11.34±19.62$^{###}$	2.213	>0.05

Note: Compared with before surgery, $^{###}$P<0.001. RK: regional kyphosis Cobb angle.

Typical case

A female patient of 53 years old was diagnosed with degenerative kyphoscoliosis and lumbar spinal stenosis. Treatment method: Fixation from thoracic 10 to sacral 1, decompression at lumbar 3rd, 4th and 5th segments, Ponte osteotomy, posterolateral fusion, and 3D guide plate technique guided S2AI screw fixation.

Table 4. Comparison of C7PL-CSVL and sagittal vertical axis before, after and 2 years after surgery

Time	Control group (n=42)	Observation group (n=42)	t	P
C7PL-CSVL (mm)				
Before surgery	25.38±13.47	26.12±13.63	0.471	>0.05
After surgery	15.41±6.55###	14.26±5.07###	1.283	>0.05
2 years after surgery	11.69±3.70###	10.08±2.95###	1.035	>0.05
Sagittal vertical axis (mm)				
Before surgery	29.47±10.30	29.60±10.46	0.296	>0.05
After surgery	13.84±5.67###	12.44±5.19###	1.374	>0.05
2 years after surgery	11.21±3.40###	9.83±3.13###	1.536	>0.05

Note: Compared with before surgery, ###P<0.001. C7PL-CSVL: C7 plumb line-center sacral vertical line.

Table 5. Comparison of PI and PT before, after and 2 years after surgery

Time	Control group (n=42)	Observation group (n=42)	t	P
PI (°)				
Before surgery	50.73±13.88	51.09±13.65	0.824	>0.05
After surgery	38.41±10.34###	37.72±9.63###	0.961	>0.05
2 years after surgery	35.96±11.62###	34.78±10.26###	1.373	>0.05
PT (°)				
Before surgery	29.45±9.87	29.81±10.03	0.506	>0.05
After surgery	16.96±6.82###	16.02±7.15###	1.145	>0.05
2 years after surgery	17.09±7.20###	15.76±6.77###	2.023	>0.05

Note: Compared with before surgery, ###P<0.001. PI: pelvic incidence; PT: pelvic tilt.

See **Figure 2** for details of images before and after surgery.

Discussion

Patients with degenerative kyphoscoliosis having the scoliosis Cobb angle of more than 10° on the coronal plane of the spine could be accompanied by changes such as osteoproliferation, spinal stenosis and intervertebral space narrowing and suffer from neuropathic pain in the lower limbs, intractable low back pain and other symptoms, which seriously affect their health and quality of life [9]. Sacral pelvic fixation is currently a commonly used surgical method for treating degenerative kyphoscoliosis. Galveston technique and iliac screw fixation were mainly used in the past. Although by these two surgical methods good fixation effect can be achieved, there are risks of lumbosacral pseudoarticulation formation, iliac internal loosening, infection and other complications, thus affecting the long-term overall internal fixation effect [10]. S2AI fixation is a new type of sacral pelvic fixation, in which the screw trajectory passes the sacroiliac joint, lateral sacral mass of S2 and the ilium [11]. The screw trajectory passing three-layers cortical bones significantly increases the fixation strength. There are stable biomechanics of screw, few dissected surrounding soft tissues during screw implantation, and long distance from screw tail to the skin surface, avoiding damages to the peripheral nerves. The operation is relatively simple, and no connector is applied separately. Bidirectional distraction, pressurizing and restoring can significantly increase the screw fixation strength. No sacral foramina is exposed at screw implantation, and the screw incisura is low to avoid screw tail exposure, which significantly reduces neurovascular injury, hip pain, incision infection and other complications [12]. At present, S2AI fixation has become a new surgical selection for degenerative kyphoscoliosis. Moreover, clinical study has indicated that the correction rate of pelvic tilt by S2AI fixation can reach up to 70.0% or more, while for conventional iliac screw fixation the correction rate is only about 30.0-60.0% [13]. The study by Sponseller et al. showed that the correction rate of Cobb angle by S2AI fixation in patients with spine malformation reached 67.0%, while for iliac screw fixation the correction rate was only 55.0%, confirming that S2AI fixation could achieve better spine orthopedic results [14]. The incidence rate of complications by iliac screw fixation generally ranged from 18.5% to 37.0% [15]. The study by Hassanzadeh et al. showed screw loosening rate of only 6.1%, rod breaking rate of 6.5% and hip pain rate of 5.4% by S2AI fixation, all of which were significantly lower than those by iliac screw fixation, suggesting that S2AI fixation had higher safety [16].

Table 6. Comparison of ODI scores and SF-36 total scores before and 2 years after surgery

Group	ODI (scores)		SF-36 total scores (scores)	
	Before surgery	2 years after surgery	Before surgery	2 years after surgery
Control group (n=42)	44.39±10.26	20.46±8.61###	82.61±20.47	133.86±30.12###
Observation group (n=42)	44.70±10.51	19.15±7.92###	83.05±19.89	135.78±32.51###
t	0.642	0.865	0.408	1.337
P	>0.05	>0.05	>0.05	>0.05

Note: Compared with before surgery, ###$P<0.001$. ODI: Oswestry disability index; SF-36: shot form 36 health survey questionnaire.

Table 7. Comparison of complication incidence (n, %)

Complication	Control group (n=42)	Observation group (n=42)	χ^2	P
Incision infection	3 (7.14)	1 (2.38)		
Screw exposure	1 (2.38)	0 (0.00)		
Screw loosening and dropping	4 (9.52)	2 (4.76)		
Pseudoarticulation formation	2 (4.76)	1 (2.38)		
Rod breaking	1 (2.38)	1 (2.38)		
Total incidence (%)	26.18	11.90	5.883	0.012

S2AI screw implantation consists of three processes: entry point determination, screw trajectory preparation and screw implantation. Due to the lack of accurate and objective measurement instruments in freehand screw implantation, the entry point and trajectory control can only rely on the 3D spatial orientation ability and experience of the surgeon. The entry point location is overly dependent on clear sacral structure. Changes of iliac structure due to lesions significantly increase the difficulty of entry point determination. When the screw dip angle and inside and outside abduction angles cannot be determined, multiple or even continuous fluoroscopy-assisted screw implantation is required, which increases radiation to the surgeon and patients [17]. Sutterlin et al. found that the failure rate of S2AI freehand screw implantation was up to 22.0%, mainly due to poor entry point and screw trajectory position through fluoroscopy and false channel formation caused by repeated screw implantation [18]. Therefore, the method to improve the accuracy of S2AI screw implantation has always been the focus of clinical attention. In previous clinical practice, C-arm fluoroscopy and cone-beam CT were used for screw implantation guidance. However, due to the risk of a large number of fluoroscopy radiations, they are difficult to be widely popularized.

With the emerging of 3D printing technology and its application in the medical field, 3D guide plate technology-assisted screw implantation has been used in orthopedic surgery, and it has also been used in S2AI screw implantation to some extent. 3D guide plate technology-guided S2AI screw implantation has many advantages, including: (1) No continuous fluoroscopy-assisted screw implantation during surgery which significantly reduces the radiation exposure risk for the surgeon and patients; (2) Data processing software can be used before surgery to simulate screw implantation, and the entry point location does not depend on the anatomical structure of the iliac surface, avoiding the entry point deviation caused by the lack of pelvic anatomical structure knowledge of the surgeon and the fuzzy anatomical structure of the patient, reducing the difficulty of screw implantation and improving the accuracy; (3) Screw implantation can be accomplished by simply fitting the guide plate to partial laminar bony surface, thus decreasing the exposure range and operation time, and reducing trauma and bleeding volume; (4) The location hole and guide rod device are adopted to replace the traditional bilateral base channels, and the two-side separation structure is adopted to replace the connected structure. During the operation, the direction of the guide rod can be actively adjusted to ensure the accuracy of screw trajectory. The interaction of position change of bilateral guide plates can be avoided. The influence of bit micromotion on the positions of guide plate and entry point can be reduced; (5) The tail position of the guide rod is greatly affected by the navigational template [19]. The slight movement of the navigational template during the

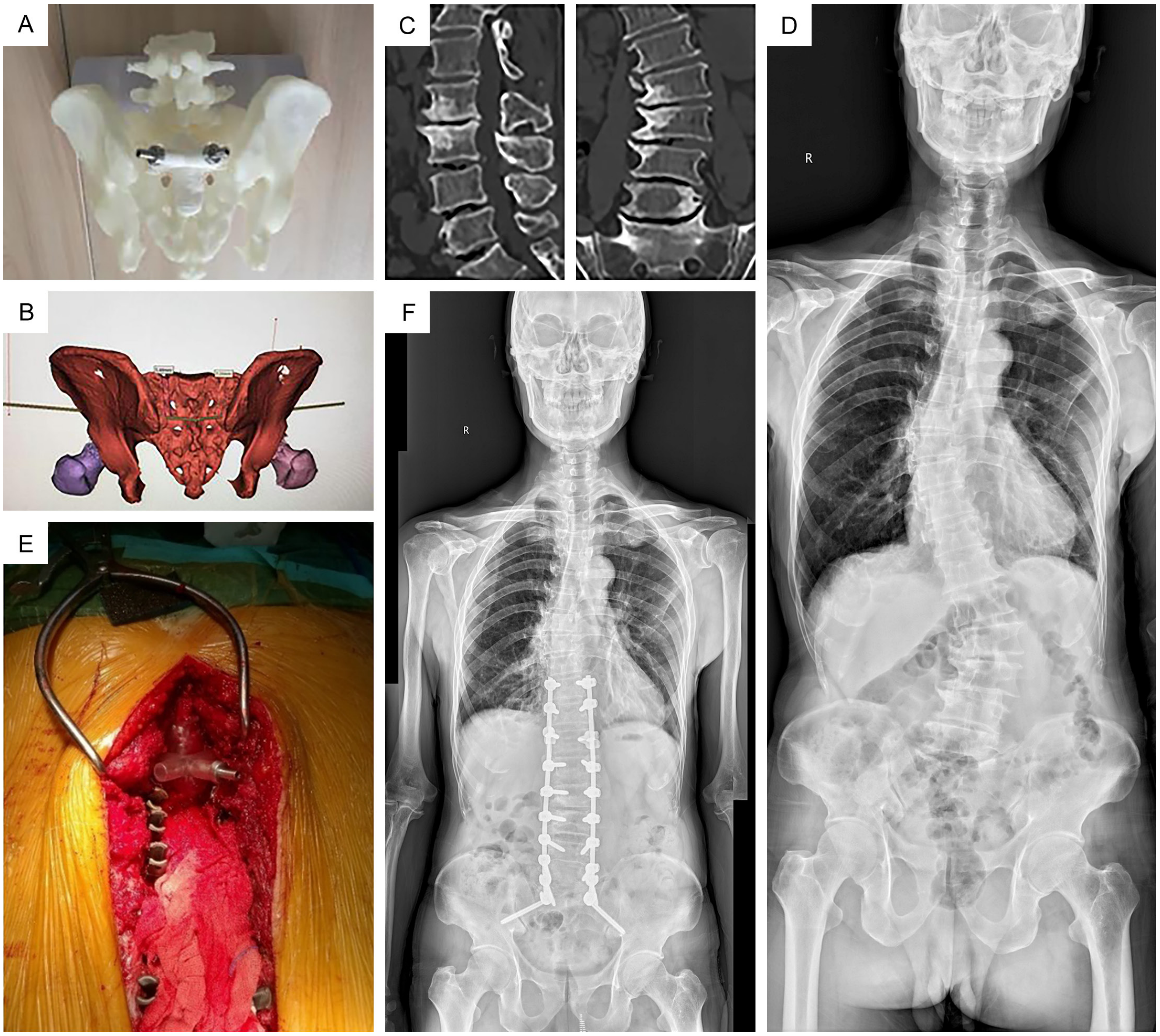

Figure 2. Clinical data of representative cases before and after surgery. A: Designed 3D patient-specific navigational template; B: Designed screw trajectory on 3D navigational template before surgery; C: 3D CT before surgery; D: Scoliosis Cobb angle of 45° shown in preoperative anteroposterior X film; E: Intraoperative screw implantation by 3D navigational template; F: Scoliosis Cobb angle of 10° shown in postoperative anteroposterior X film. 3D: three-dimensional; CT: computed tomography.

operation can cause the tail of the guide rod to swing greatly, which is convenient for the surgeon to observe implantation and correct screw implantation error. Meanwhile, the paralleling of the guide rod with the orientation of the location hole also helps to reduce screw implantation error. However, due to high accuracy requirement for entry point location in 3D guide plate technology, once deviation occurs, the screw trajectory will be deviated significantly, which may lead to severe complications after screw implantation. Meanwhile, for some emergency patients, materials and templates cannot be prepared in a short time, but by freehand screw implantation the surgery can be completed in time [20].

At present, 3D guide plate technology guided S2AI fixation has achieved initial results in the surgery for degenerative kyphoscoliosis. Bederman et al. revealed that 3D printing guide plate assistance could significantly improve the accuracy of S2AI screw implantation technology; there was no statistical difference between preoperative simulation and postoperative actual values of screw implantation parameters: SA, TA, HD and VD, and no obvious complications occurred [21]. Previous studies have also confirmed the rigid internal fixation strength and coronal and sagittal orthopedic effect of 3D printing guide plate assistance. However, there is still a lack of comparison of internal fixation effect, screw implantation accuracy and safety between S2AI freehand fixation and 3D guide plate technology guided screw implantation. In this study, the internal fixation effect, screw implantation accuracy and safety were compared. Results of internal fixation showed that scoliosis Cobb angle, RK, PI, PT, C7PL-CSVL and sagittal vertical axis after and 2 years after surgery in two groups were significantly improved compared with those before surgery, and ODI scores and SF-36 total scores at 2 years after surgery were significantly improved compared with those before surgery, with no significant difference between the two groups. It suggested that the short-term and long-term effects of S2AI fixation in the two groups were similar, and 3D guide plate technology guidance did not significantly improve the internal fixation effect. Results of screw implantation accuracy showed that differences between preoperative simulation and postoperative actual values of screw trajectory parameters SA, TA, HD and VD in observation group were significantly lower than those in control group, suggesting that 3D guide plate technology guidance could improve the accuracy of S2AI screw implantation, which was related to preoperative simulation of surgical operation by data processing software. Results of safety showed that the incidence rates of incision infection, screw exposure, screw loosening and dropping, pseudoarticulation formation and other complications in observation group were significantly lower than those in control group, revealing that 3D guide plate technology guidance could reduce the complication risk of S2AI fixation and improve the safety of screw implantation.

There were some shortcomings in this study. The limited number of patients increased the bias of results, and a further study with larger sample size is required. 3D guide plate technology has been rarely applied in S2AI screw implantation, so its effectiveness and safety remain to be confirmed. Meanwhile, the follow-up time in this study was limited, and the long-term effect and risk of complications could not be determined. Follow-up data should be increased in future study. Although the operation was performed by the same physician, the repeatability of this technique could not be guaranteed. Therefore, it needs to be confirmed in clinic.

In conclusion, 3D guide plate technique guided S2AI fixation can significantly increase the accuracy of screw implantation, effectively correct degenerative kyphoscoliosis, achieve rigid internal fixation, improve patient's spinal function and quality of life, and greatly enhance surgical safety, which is worthy of clinical popularization.

Disclosure of conflict of interest

None.

Address correspondence to: Liqiang Cui, Department of Spinal Surgery, Mianyang Orthopaedic Hospital, No.158 South Section of Changhong Avenue, Mianyang 621000, Sichuan Province, China. Tel: +86-0816-2342043; E-mail: cuiliqiangq3r4@163.com

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