



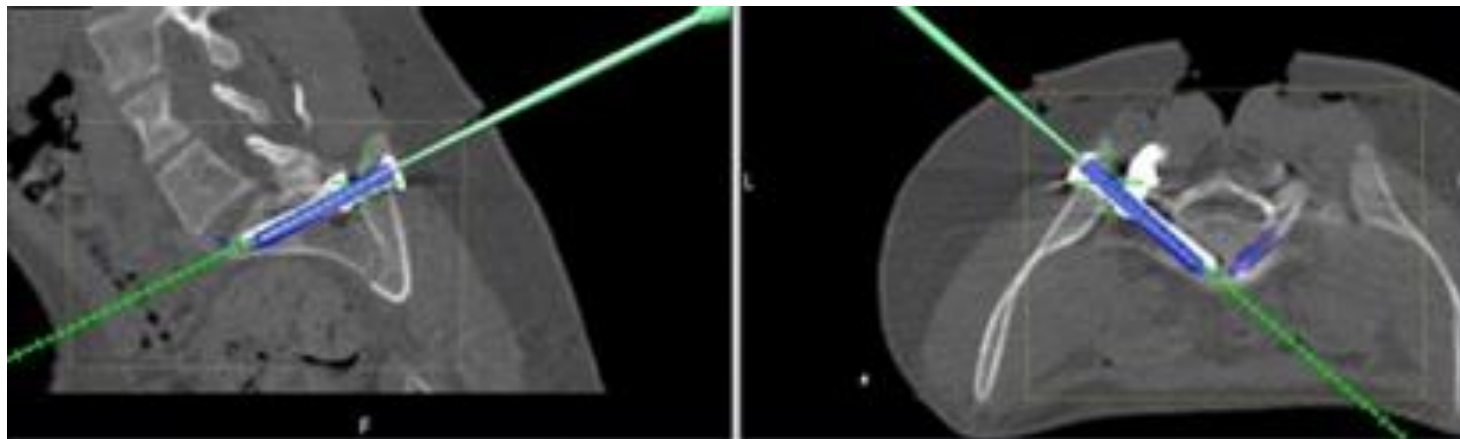
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Advantages of preoperative planning for iliosacral screw placement using intraoperative navigation systems in the treatment of paediatric neuromuscular scoliosis.

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Introduction

- The surgical treatment of neuromuscular scoliosis differs from idiopathic scoliosis, being more complex and with a higher rate of complications.¹⁻⁴
- The main goal of surgery in neuromuscular (NM) scoliosis is to provide a solid spinopelvic unit and firm sitting balance.⁵⁻⁶

Therefore...

- The fusion is often extended to the pelvis, further increasing the technical difficulty and complication rate in these frail patients.⁷



1. Vialle R, Thévenin-Lemoine C, Mary P (2013) Neuromuscular scoliosis. *Orthop. Traumatol. Surg. Res.* 99:S124–S139
2. Reames DL, Smith JS, Fu K-MG, et al (2011) Complications in the Surgical Treatment of 19,360 Cases of Pediatric Scoliosis. *Spine (Phila Pa 1976)* 36:1484–1491.
3. Master DL, Connie P-K, Jochen S-H, et al (2011) Wound Infections After Surgery for Neuromuscular Scoliosis. *Spine (Phila Pa 1976)* 36:E179–E185.
4. Gill I, Eagle M, Mehta JS, et al (2006) Correction of Neuromuscular Scoliosis in Patients With Preexisting Respiratory Failure. *Spine (Phila Pa 1976)* 31:2478–2483.
5. Dayer R, Ouellet JA, Saran N (2012) Pelvic fixation for neuromuscular scoliosis deformity correction. *Curr Rev Musculoskelet Med* 5:91–101.
6. Lubicky JP, McCarthy RE (2004) Sacral pelvic fixation in neuromuscular deformities. *Semin Spine Surg* 16:126–133.
7. McCall RE, Hayes B (2005) Long-term outcome in neuromuscular scoliosis fused only to lumbar 5. *Spine (Phila Pa 1976)* 30:2056–2060.

Introduction(2)

- A promising minimally invasive (MI) fusionless technique using iliosacral (IS) screws has been shown to reduce the complication rate and improve the patient's comfort and quality of life. ⁸
- **Nevertheless, placement of IS screws remains challenging as malpositioning is still associated with high rates of revisions, neurological damage and instability.**

We know that...

- The use of computed tomography (CT) navigation has a significant lower rate of screw malposition compared to 2D image-based navigation techniques. ⁹

But...

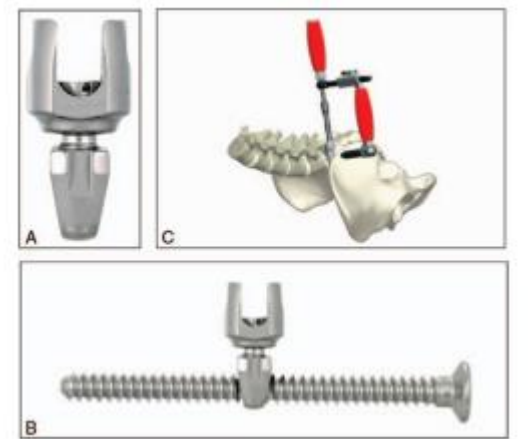
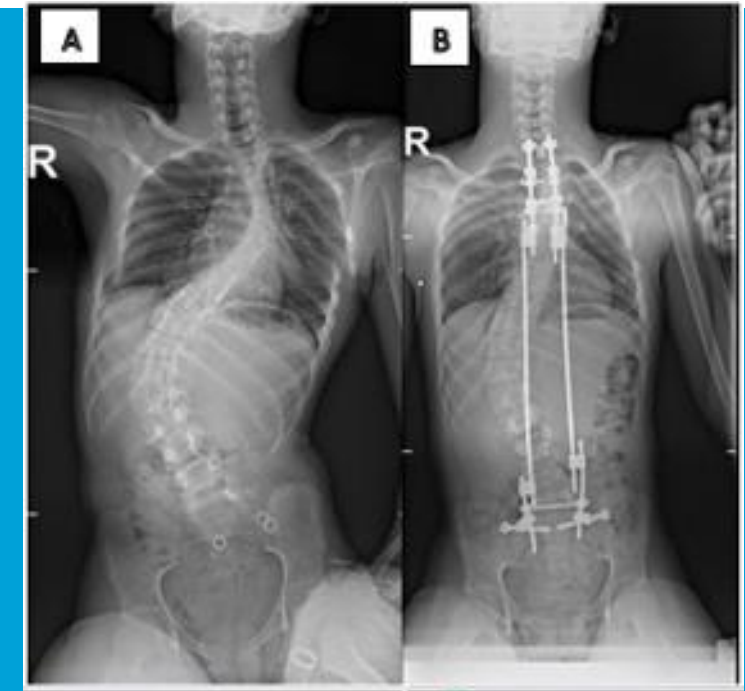
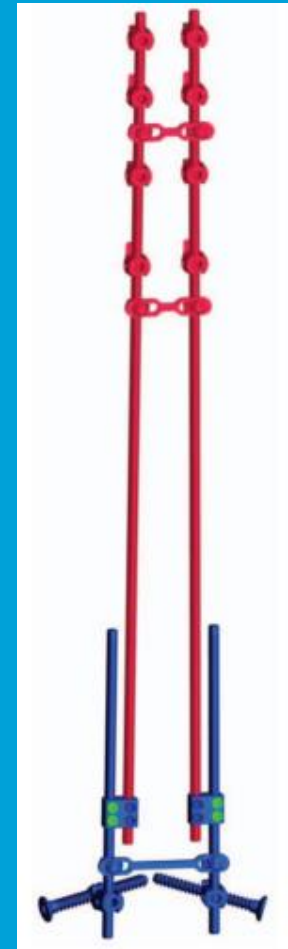
- **Preoperative planning and templating technology for placement of these screws with CT navigation is still debated in literature.**

8. Miladi L, Gaume M, Khouri N, et al (2018) Minimally Invasive Surgery for Neuromuscular Scoliosis. Spine (Phila Pa 1976) 43:E968–E975.

9. Preoperative (preop) planning and templating technology for placement of these screws with CT navigation is still debated in literature.

“Distal bilateral fixation is achieved using ilio-sacral screws which transfix a multi-axial connector. The multi-axial connector is inserted in a trough created between the articular process of L5-S1 and the first posterior sacral foramen.”⁸

Nevertheless, placement of these IS screws remains challenging as malpositioning is still associated with high rates of revisions, neurological damage and instability.



Purpose

The purpose of this study was to retrospectively compare the trajectory of IS screws placed with and without preoperative planning in neuromuscular scoliosis with the minimal technique⁸

Methods

32 patients treated for NM scoliosis
by the minimally invasive technique
(between 01/2020 – 02/2021)

PLANNED GROUP (P group):

- N=19 patients, 38 screws (59%).
- With preop planning of the trajectory of the iliosacral screw
- 9 females, 10 males
- Mean age 15.5 ± 4.8 years

NONPLANNED GROUP (NP group):

- N=13 patients, 26 screws (41%).
- Without preop planning of the trajectory of the iliosacral screw (but with navigation)
- 7 females, 6 males
- Mean age 13.5 ± 3.6 years

Each trajectory (n=64) was evaluated retrospectively by a radiographical score composed by our author group based on the elemental properties described by Miladi et al. (*Spine*, 2018).

➤ CT based score with a total score of max 22 points.

➤ Determined by following criteria:

- **Embedding of the screw in the iliac wing (more embedded = better stability)**
 - Yes: 1point, No: 0points
- **Position of the screw with regard to the sacro-iliac joint.**
 - >2mm above the SI joint: 2pts, <2mm above the SI joint 1pts, intra-articular position 0pts.
- **Position of the screw with regard to the S1 foramen (risk for S1 injury).**
 - No: 2pts, <1mm: 1pt, >1mm: 0pts.
- **Perpendicular distance between the screw and the promontorium (closer = better stability).**
 - <2mm: 4pts, >2mm: 3pts, >4mm: 2pts, >6mm: 1pt, >8mm: 0pts.
- **Perpendicular distance between the screw and de sacral chondral plate (closer = better stability).**
 - <2mm: 4pts, >2mm: 3pts, >4mm: 2pts, >6mm: 1pt, >8mm: 0pts.
- **Presence of perforation of the anterior cortex of the sacral bone (risk for NV damage).**
 - No: 2pts, <1mm: 1pt, >1mm: 0pts.
- **Presence of crossing of the IS screws (crossing gives a better stability)**
 - Yes: 0pts, No: 1pt.
- **Position of the screw with regard to the medullary canal.**
 - No: 2pts, <1mm: 1pt, >1mm: 0pts.
- **Position of the screw with regard to the L5 notch described by Goetzen et al. ¹⁰**
 - No: 2pts, <1mm: 1pt, >1mm: 0pts.
- **Position of the swrew with regard to the lateral recess. (risk of neurological damage).**
 - No: 2pts, <1mm: 1pt, >1mm: 0pts.

For the planned group

Preoperatively, a CT scan (<6 months preop) from L4 till pelvis was performed on which we planned the optimal trajectory and corresponding dimensions of each iliosacral screw using 'cranial trajectory planning software Brainlab AG' (Munich, Germany).

Intraoperatively, the reference frame for navigation is fixed to the pelvis with pins placed under fluoroscopy just above the acetabulum on the convex side of the curve. A low-dose CT scan is then performed. These intraoperative CT images are then fused with the preoperative CT images on which the trajectories were planned. Next, the iliosacral screws were placed with the navigated probe. At last, a control scan was performed to evaluate the trajectory of the placed screw.

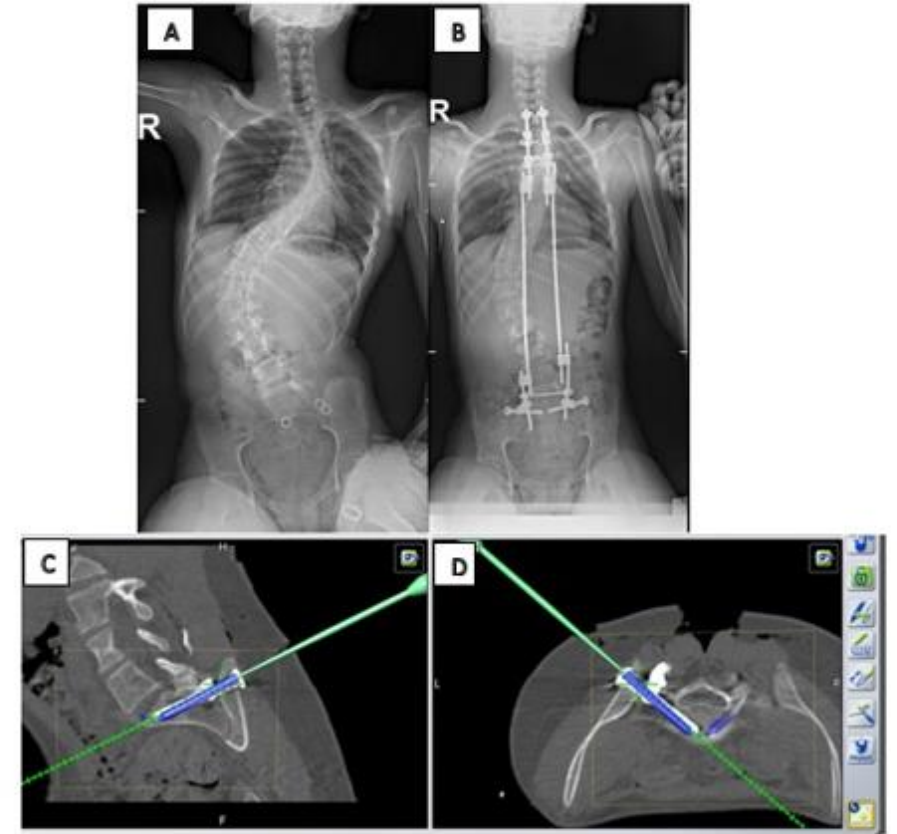


Figure 1: Minimally invasive fusionless technique for neuromuscular scoliosis using iliosacral screws with preoperative trajectory planning and intraoperative CT based navigation. A: preoperatively, B: Postoperatively, C and D Intraoperative fusion of the preoperative CT images with the screw planning (blue lines) and the CT navigation images. The green line present the probe with whom we make the trajectory of the planned screws.

Results

Table 1. Mean (\pm Standard deviation) of the individual criteria (based on the elemental properties described by Miladi et al. (Spine, 2018)) that were used by the author group to compose a radiographical score.

	iliac wing	SI joint	S1 foramen	Promontorium	Sacral plate	Anterior sacrum	Crossing	lat recess	Medullary canal	L5 notch
Planned group (P)	0.9 \pm 0.3	1.8 \pm 0.5	1.9 \pm 0.3	1.5 \pm 1.4	2.6 \pm 1.6	1.9 \pm 0.4	0.9 \pm 0.2	1.8 \pm 0.5	2.0 \pm 0.0	2.0 \pm 0.2
Non-planned group (NP)	0.7 \pm 0.5	1.2 \pm 0.7	1.5 \pm 0.6	0.8 \pm 1.4	1.5 \pm 1.4	1.8 \pm 0.7	0.6 \pm 0.5	1.7 \pm 0.6	1.8 \pm 0.6	1.8 \pm 0.6

Table 2. Mean (\pm Standard deviation) of the screw length and the radiographical score.

	Mean length of the implanted screws	<u>Mean score</u>
Planned group (P)	61.2 \pm 9.2 mm	17.3 \pm 3.1 pts
Non-planned group (NP)	60.8 \pm 9.5 mm	13.2 \pm 2.9 pts

Results(2)

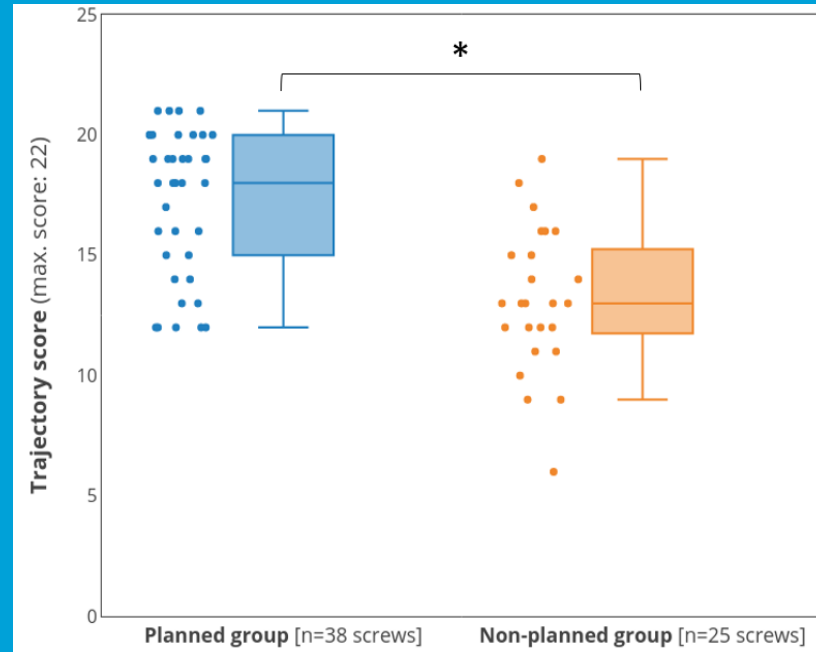


Figure 1. The radiographical score plotted for the planned and non-planned group. * *significant difference* ($p < 0.05$)

The mean trajectory score of the screws was significantly ($p < 0.05$) higher in the Planned group compared to the Non-planned group.

Conclusion

Preop planning optimized the placement of IS screws using the minimally invasive correction technique⁸ in neuromuscular scoliosis.



Therefore, the use of preop planning and navigated placement of IS screw on fusion images with intraoperative CT, may further reduce the complication rate in neuromuscular scoliosis.

1. Vialle R, Thévenin-Lemoine C, Mary P (2013) Neuromuscular scoliosis. *Orthop. Traumatol. Surg. Res.* 99:S124–S139
2. Reames DL, Smith JS, Fu K-MG, et al (2011) Complications in the Surgical Treatment of 19,360 Cases of Pediatric Scoliosis. *Spine (Phila Pa 1976)* 36:1484–1491.
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8. Miladi L, Gaume M, Khouri N, et al (2018) Minimally Invasive Surgery for Neuromuscular Scoliosis. *Spine (Phila Pa 1976)* 43:E968–E975
9. Preoperative (preop) planning and templating technology for placement of these screws with CT navigation is still debated in literature.
10. Goetzen et al. A simple approach for the preoperative assessment of sacral morphology for percutaneous SI screw fixation. *Arch Orthop Trauma Surg* 2016 Sep;136(9):1251-1257.

Disclosures

- Dr. De Geyter Jasper, MD, University Hospitals Leuven, Belgium.
 - I have no financial conflicts to disclosure
- Dr. Schelfaut Sebastiaan, MD, University Hospitals Leuven/KU Leuven IORT, Belgium.
 - I have no financial conflicts to disclosure in relation to this topic
- Dr. Ackermans Thijs, PhD, KU Leuven IORT, Belgium.
 - I have no financial conflicts to disclosure
- Moustie Simon, MS, Department of Development and Regeneration KU Leuven, Belgium.
 - I have no financial conflicts to disclosure
- Prof. Dr. Moke Lieven, MD, University Hospitals Leuven/KU Leuven IORT, Belgium.
 - I have no financial conflicts to disclosure in relation to this topic
- Dr. Moens Pierre, MD, University Hospitals Leuven, Belgium.
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