Case Report

Use of navigation for anterior and posterior instrumentation in the surgical management of pediatric pathologic lumbosacral deformity

ABSTRACT

We report the use of computerized tomography (CT)-guided navigation for complex spinal deformity correction (anterior and posterior) in an 8-year-old patient with neurofibromatosis complicated by dystrophic pedicles, dural ectasia, and extensive vertebral scalloping. A retrospective review was conducted of the patient's medical records for the past 3 years, including the patient's office visit notes, operative reports, pre- and 2-year postoperative imaging studies. The patient successfully underwent anterior lumbar interbody fusion from L3–S1 using CT-guided navigation to negotiate the challenges posed by dural ectasia and vertebral body scalloping. One week after the anterior procedure, she underwent navigation-guided T10-to-pelvis posterior instrumented fusion. There were no perioperative or postoperative complications at 2 years. In patients with complex deformities of the spine, including dural ectasia, scalloped vertebral bodies, and decreased pedicle integrity, the use of intraoperative CT-guided navigation can benefit surgeons by facilitating the safe placement of interbody spacers and pedicle screws.

Keywords: Anterior instrumentation, complex, navigation, neurofibromatosis, spine deformity

INTRODUCTION

The use of navigation in assisting with pedicle screw placement has been described in the literature as early as 1995.[1] In comparing computerized tomography (CT) navigation to conventional fluoroscopy or freehand technique, investigators have focused on operating times and accuracy.[2-8] The investigations and operative case reports have been mainly focused on the utility of this technology on posterior instrumentation. In this report, the authors present a case report utilizing intraoperative CT-based navigation for both anterior and posterior instrumentation in a pediatric patient with Type 1 neurofibromatosis (NF1), neuromuscular scoliosis, and dural ectasia. Skeletal anatomy limited our ability to instrument posteriorly and necessitated the use of anterior instrumentation. Anterior exposure and instrumentation was particularly challenging in this 10-year-old child due to extensive anterior vertebral scalloping due to dural ectasia, presence of significant scoliosis and the relatively small size of the vertebral bodies of the lower lumbar spine.

Sassan Keshavarzi, Jeffrey Spardy[1], Subaraman Ramchandran[2], Stephen George[2]

Department of Neurosurgery, Tulane University School of Medicine, New Orleans, LA, [1]Herbert Wertheim College of Medicine, Florida International University, [2]Department of Orthopedic Surgery, Nicklaus Children' s Hospital, Miami, FL, USA

Address for correspondence: Dr. Subaraman Ramchandran, Department of Orthopedic Surgery, Center for Spinal Disorders, Nicklaus Children's Hospital, 3100 SW 62nd Ave, Miami, FL 33155, USA.
E-mail: subaraman.ramchandran@nicklaushealth.org

Submitted: 25-Oct-23 **Accepted:** 31-Dec-23
Published: 13-Mar-24

Access this article online	
Website: www.jcvjs.com	**Quick Response Code**
DOI: 10.4103/jcvjs.jcvjs_144_23	

How to cite this article: Keshavarzi S, Spardy J, Ramchandran S, George S. Use of navigation for anterior and posterior instrumentation in the surgical management of pediatric pathologic lumbosacral deformity. J Craniovert Jun Spine 2024;15:114-7.

CASE REPORT

An 8-year-old female with NF1 and bilateral optic gliomas presented in our clinic for right thoracic scoliosis of 16°. On follow-up at 1 year, she developed an antalgic gait and the curve progressed to the 24° right thoracic and 40° left lumbar curves, respectively [Figure 1a and b]. A CT scan and magnetic resonance imaging revealed dural ectasia with marked posterior lumbar vertebral scalloping. In addition, she had recurrent stress fractures in her L2–L4 pedicles bilaterally, which were elongated and dysplastic [Figure 2]. At 10 years of age, due to the progression of her curve and symptoms, it was decided to perform a surgical stabilization [Figure 1c and d].

Surgical technique

The patient was positioned in a supine position with the left side slightly up using a beanbag underneath due to the left-sided convex thoracolumbar curve. A retroperitoneal exposure from L4 to S1 was performed, and the L4–L5 and L5–S1 discs were approached between the bifurcation. Localizing fiducials were placed on the vertebral bodies of L4, L5, and S1, and an intraoperative CT scan was performed. Following registration of the fiducials, discectomies were performed from L4 to S1 under navigation, given the narrow anteroposterior window secondary to dural ectasia and extensive vertebral scalloping [Figure 3]. Interbody cages were placed at L4–5 and L5–S1 levels and were packed with bone grafts consisting of demineralized cortical mineralized cortical and cancellous bone. One week after the anterior procedure, posterior instrumented fusion was performed from T10 to pelvis assisted by navigation. Two iliac screws were placed on each side because of poor bone quality and to aid distal fixation since no instrumentation could be placed in the lower lumbar and sacral spine [Figure 4]. No neuromonitoring changes were detected during the correction. At 1 year following the procedure, the patient is doing well and has returned to full activities. There were no hardware-related complications.

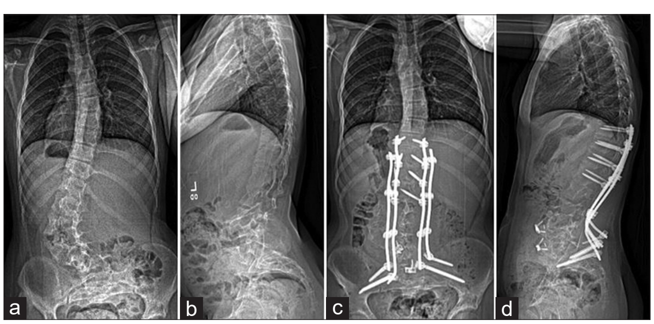

Figure 1: Preoperative (a and b) and 2 years postoperative (c and d) standing radiographs of the spine of our patient with dystrophic Type 1 neurofibromatosis

DISCUSSION

NF1 dystrophic scoliosis classically has an early onset and aggressive behavior. Surgical intervention is challenging on account of dural ectasia, dysplastic pedicles, poor bone quality, and sharp angular deformities. Dural ectasia is an abnormal expansion of the thecal sac with increased cerebrospinal fluid (CSF) space and associated dysmorphic findings such as vertebral scalloping and wedging. Dural ectasia can result in intraoperative challenges and postoperative complications, particularly when decompressions or osteotomies are performed, due to the increased risk of CSF leaks. Existing literature on spinal deformity correction in patients with dystrophic NF1 has been limited to case series and reports

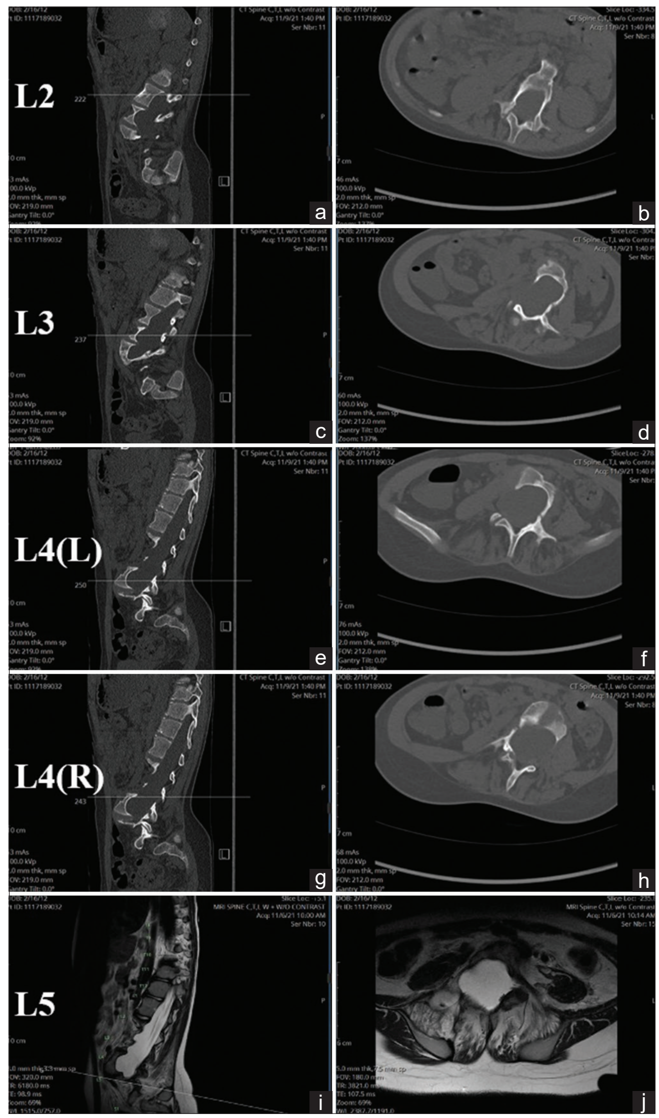

Figure 2: Preoperative computerized tomography images of the patient in the sagittal views at the levels of L2 (a), L3 (c), left side of L4 (g), and right side of L4 (g) alongside computerized tomography images in the transverse views at the levels of the patient alongside the L2 (b), L3 (d), sagittal views at the level of left side of L4 (e), left side of L4 (f), and right side of L4 (h). Preoperative sagittal (i) and transverse (j) magnetic resonance imaging views of the curve at the level of L5

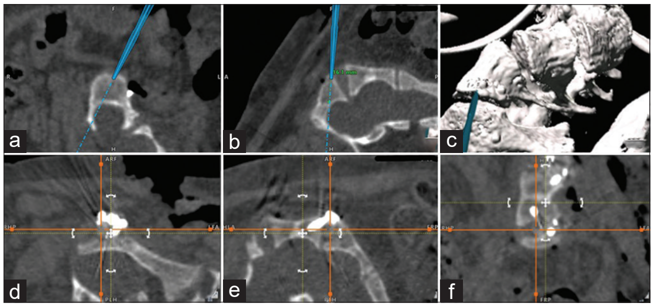

Figure 3: (a-f) Utilization of intraoperative computerized tomography navigation for anterior instrumentation allowing optimal trajectory for placement of the interbody spacer

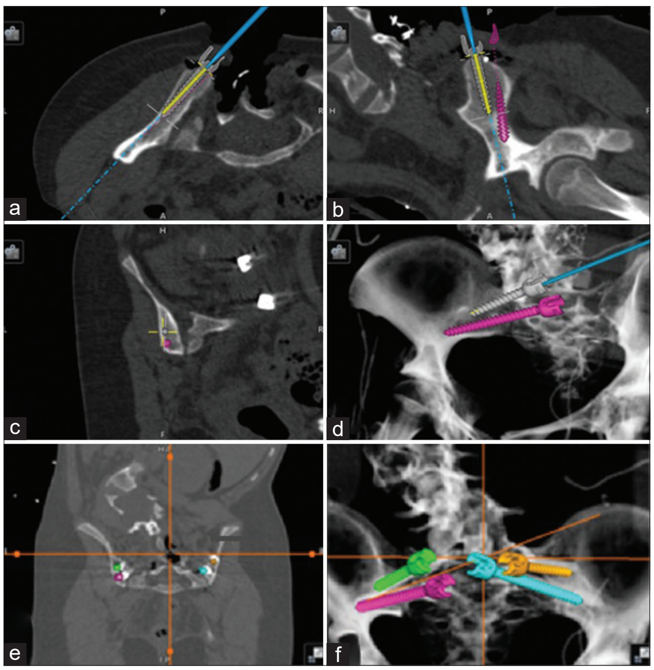

Figure 4: (a-f) Utilization of posterior intraoperative computerized tomography navigation placement of four pelvic screws, critical in a patient who has a small corridor for pelvic instrumentation, with no possibility of sacral or distal lumbar instrumentation

evaluating the approaches to the repair, with an emphasis on posterior-only instrumentation.[9-12] As expected, pedicle dysplasia results in high rates of malpositioned screws, with one study reporting an incidence of 30.5% (9.9% medial and 20.6% lateral) with the freehand insertion technique.[13,14] Navigation allows surgeons to circumvent some of the challenges, but the true problem is the lack of osseous volume to simply place a screw. Jia *et al*. showed that navigation can decrease the misplaced screw rates, but even with navigation guidance, more than 20% of screws were still malpositioned.[15] With a high rate of pseudoarthrosis in this high-risk population, anterior instrumentation and bone grafting should be considered whenever possible, especially when posterior anatomy obviates high implant density. In a systematic review by jia *et al*., the authors report similar efficacy, long-term stability, and safety of both combined anteroposterior versus only posterior instrumentation in dystrophic neurofibromatosis.

CONCLUSION

Our case demonstrates the efficacy and safety of intraoperative navigation in aiding anterior and posterior instrumentation in dystrophic neurofibromatosis, especially in the setting of complex anatomy, dysplastic pedicles, osteoporotic bone, and dural ectasia.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Nolte LP, Visarius H, Arm E, Langlotz F, Schwarzenbach O, Zamorano L. Computer-aided fixation of spinal implants. J Image Guid Surg 1995;1:88-93.
2. Luther N, Iorgulescu JB, Geannette C, Gebhard H, Saleh T, Tsiouris AJ, *et al.* Comparison of navigated versus non-navigated pedicle screw placement in 260 patients and 1434 screws: Screw accuracy, screw size, and the complexity of surgery. J Spinal Disord Tech 2015;28:E298-303.
3. Yu X, Xu L, Bi LY. Spinal navigation with intra-operative 3D-imaging modality in lumbar pedicle screw fixation. Zhonghua Yi Xue Za Zhi 2008;88:1905-8.
4. Shin BJ, James AR, Njoku IU, Härtl R. Pedicle screw navigation: A systematic review and meta-analysis of perforation risk for computer-navigated versus freehand insertion. J Neurosurg Spine 2012;17:113-22.
5. Ishikawa Y, Kanemura T, Yoshida G, Ito Z, Muramoto A, Ohno S. Clinical accuracy of three-dimensional fluoroscopy-based computer-assisted cervical pedicle screw placement: A retrospective comparative study of conventional versus computer-assisted cervical pedicle screw placement. J Neurosurg Spine 2010;13:606-11.
6. Rajasekaran S, Vidyadhara S, Ramesh P, Shetty AP. Randomized clinical study to compare the accuracy of navigated and non-navigated thoracic pedicle screws in deformity correction surgeries. Spine (Phila Pa 1976) 2007;32:E56-64.
7. Kotani Y, Abumi K, Ito M, Takahata M, Sudo H, Ohshima S, *et al.* Accuracy analysis of pedicle screw placement in posterior scoliosis surgery: Comparison between conventional fluoroscopic and computer-assisted technique. Spine (Phila Pa 1976) 2007;32:1543-50.
8. Ughwanogho E, Patel NM, Baldwin KD, Sampson NR, Flynn JM. Computed tomography-guided navigation of thoracic pedicle screws for adolescent idiopathic scoliosis results in more accurate placement and less screw removal. Spine (Phila Pa 1976) 2012;37:E473-8.
9. Holt RT, Johnson JR. Cotrel-Dubousset Instrumentation in Neurofibromatosis Spine Curves: A Preliminary Report. Clin Orthop Relat Res 1989. 245:19-23.
10. Betz RR, Iorio R, Lombardi AV, Clancy M, Steel HH. Scoliosis surgery in neurofibromatosis. Clin Orthop Relat Res 1989;245:53-6.
11. Koptan W, ElMiligui Y. Surgical correction of severe dystrophic neurofibromatosis scoliosis: An experience of 32 cases. Eur Spine J 2010;19:1569-75.
12. Neifert SN, Khan HA, Kurland DB, Kim NC, Yohay K, Segal D, *et al.* Management and surgical outcomes of dystrophic scoliosis

in neurofibromatosis type 1: A systematic review. Neurosurg Focus 2022;52:E7.

13. Li S, Mao S, Du C, Zhu Z, Shi B, Liu Z, *et al.* Assessing the unique characteristics associated with surgical treatment of dystrophic lumbar scoliosis secondary to neurofibromatosis type 1: A single-center experience of more than 10 years. J Neurosurg Spine 2020;34:413-23.
14. Jin M, Liu Z, Liu X, Yan H, Han X, Qiu Y, *et al.* Does intraoperative navigation improve the accuracy of pedicle screw placement in the apical region of dystrophic scoliosis secondary to neurofibromatosis type I: Comparison between O-arm navigation and free-hand technique. Eur Spine J 2016;25:1729-37.
15. Jia F, Wang G, Sun J, Liu X. Combined anterior-posterior versus posterior-only spinal fusion in treating dystrophic neurofibromatosis scoliosis with modern instrumentation: A systematic review and meta-analysis. Clin Spine Surg 2021;34:132-42.