PS-13

The Efficacy of 3D-Printed TLSO for Patient with Spastic Quadriplegia : A Case Report

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Introduction

In the medical field, three-dimensional (3D) printing has been extensively utilized. The advantages of 3D-printed orthoses over conventional ones include faster fabrication and the capability to produce easily modifiable objects. This technology enables the creation of customized orthotic devices for disabled patients. We present a case of a custom 3D-printed spinal brace designed for an adult patient with rigid spinal deformities.

Case report

A 19-year-old female with spastic quadriplegia visited our clinic for scoliosis management. She was diagnosed with bilateral basal ganglia hemorrhage at age 8 and has underlying X chromosome mosaicism. The conventional spinal brace failed to effectively address her condition, especially the right-side coronal deviation and a prominent sacrum. Given her fully developed spine, we designed a custom 3D-printed thoraco-lumbosacral orthosis (3DP-TLSO) primarily for comfort over scoliosis correction.

The patient's spine from C7 to the sacrum was scanned using a 3D scanner from RealDimension, rotating in 3D space to model the skeleton. She maintained a sitting position with support and held a bar for 7 seconds during the scan. After three revisions, based on serial X-ray follow-ups, caregiver feedback, and specialist supervision, the orthosis was customized.

To assess spinal convexity, we used the Cobb's angle. Coronal balance was evaluated by the distance between the C7 plumb line (C7PL) and the central sacral vertical line (CSVL), defined as the coronal distance. The sagittal balance was assessed by the distance between the C7PL and the posterior superior angle of the first sacral vertebrae, known as the sagittal distance or sagittal vertical axis (SVA). Values closer to 0 indicate optimal correction.

The efficacy of the orthosis, evaluated across scenarios with no brace, a conventional TLSO, and the 3DP-TLSO, showed the following improvements: Cobb angles improved from 33.2° to 30.6° and then to 28.6°; coronal distances from 69.46mm to 65.10mm and then to 16.66mm; sagittal distances from 108.34mm to 90.28mm and finally to 87.9mm. When surveyed, the caregiver reported the 3DP-TLSO was comfortable and expressed satisfaction with the ease of the modification process.

Fig. 1. (a) 3D scanner, (b) Photo of 3DP-TLSO

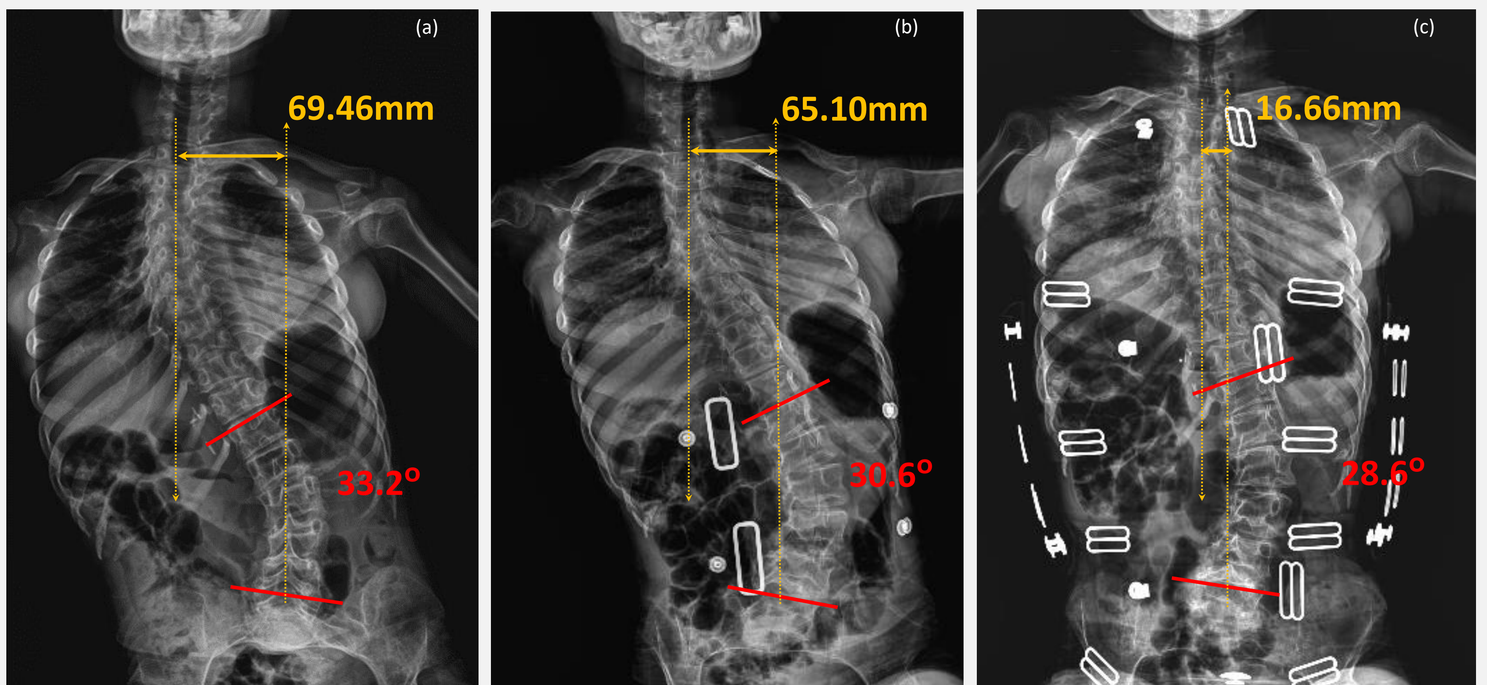

Fig. 2. AP view (a) without brace, (b) with conventional TLSO, (c) with 3DP-TLSO; The angle between the two red lines represents Cobb's angle, the horizontal yellow line represents coronal distance.

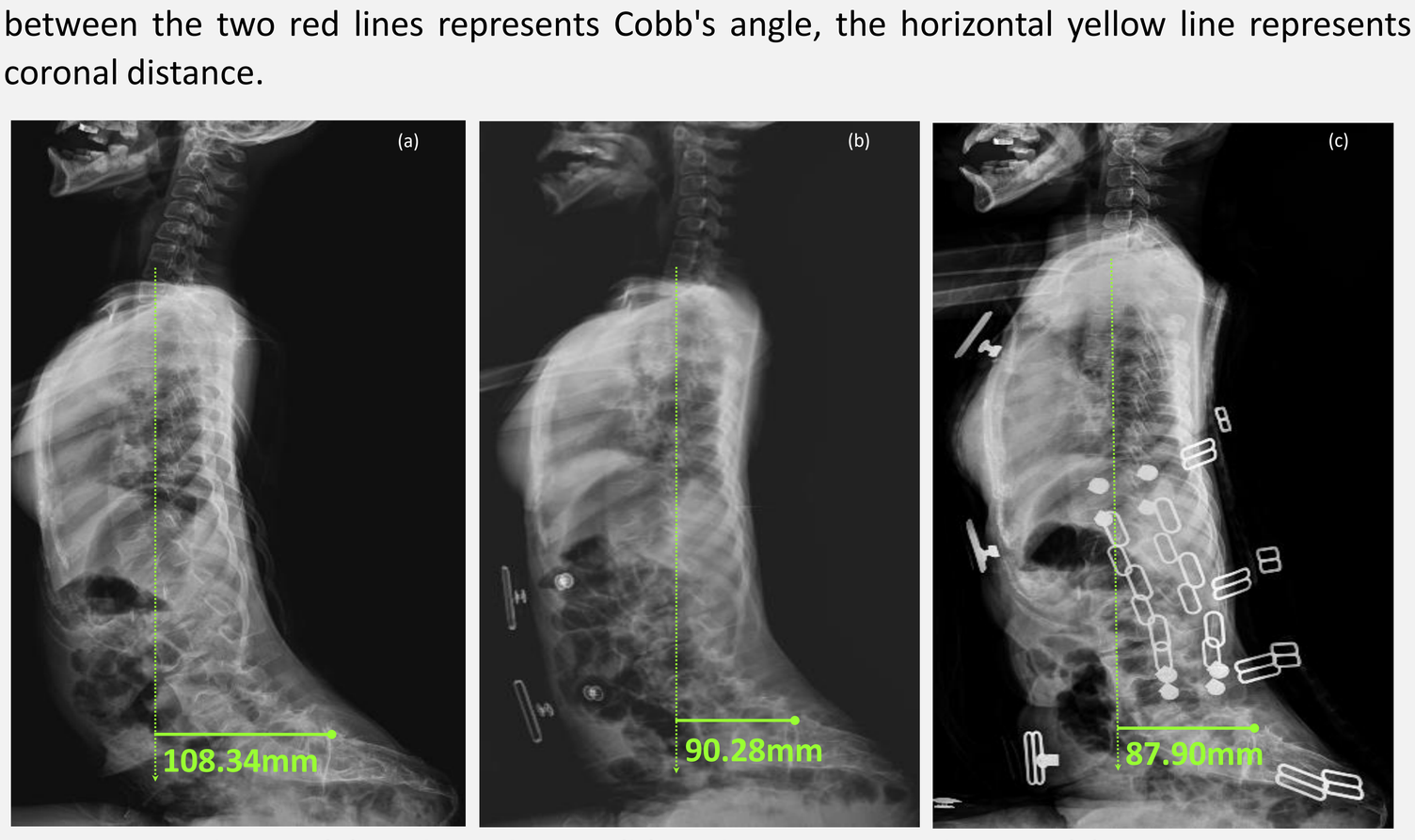

Fig. 3. Lateral view (a) without brace, (b) with conventional TLSO, (c) with 3DP-TLSO; The downward green arrow indicates C7PL, the horizontal green line represents sagittal distance.

Conclusion

In this case, the 3DP-TLSO outperforms traditional TLSO by offering enhanced comfort, correction of spinal deformities, and easy modification capabilities. Future applications aim to include scoliosis patients with hypotonia or severe deformities, indicating broad rehabilitation potential. Developing additional measurement methods for patients with severe disabilities is essential.