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The Advantages of Using a 3D Printed Spine Biomodel during Perioperative Care for Congenital Scoliosis

Ahmed Hiue*

Department of Orthopedic Surgery, Okayama Rosai Hospital, 1-10-25 Chikkomidorimachi, Okayama 702-8055, Japan

Introduction

Congenital scoliosis, a complex spinal deformity that results from vertebral malformations during fetal development, poses significant challenges for both diagnosis and surgical management. Treatment options often involve spinal fusion or correction surgeries to prevent the progression of the curvature, especially in severe cases. However, due to the structural complexities of congenital scoliosis, these surgeries can be risky and technically demanding. The three-dimensional nature of the deformity is often difficult to appreciate fully through conventional imaging techniques such as X-rays, computed tomography, or magnetic resonance imaging. Surgeons are therefore tasked with planning and executing complex procedures with limited tactile and spatial feedback. The advent of 3D printing technology has revolutionized various aspects of surgical practice, particularly in the realm of orthopedics and spinal surgery. A significant innovation in this field is the use of patient-specific 3D printed biomodels, which can replicate the unique anatomical features of a patient's spine based on preoperative imaging data. These models are increasingly being used for preoperative planning, intraoperative navigation, and postoperative care in patients with congenital scoliosis.

By offering a tangible and detailed representation of the spinal deformity, 3D printed spine biomodels provide numerous advantages throughout the perioperative process. This article aims to explore the various advantages of using a 3D printed spine biomodel during perioperative care for congenital scoliosis. It will delve into the benefits for surgical planning, intraoperative assistance, patient and family communication, and postoperative care. We will also address the potential challenges and future directions of this technology in congenital scoliosis management [1-3].

Description

3D printing, also known as additive manufacturing, involves creating three-dimensional objects layer by layer using a digital model. In the medical field, 3D printing has been employed to fabricate anatomical models, surgical guides, implants, and even tissue scaffolds for regenerative medicine. The process begins with imaging data, typically obtained from CT or MRI scans, which are converted into a digital 3D model using specialized software. This digital model is then used to create a physical replica of the anatomical structure using materials such as plastic, resin, or metal. In the context of spinal surgery, 3D printed models allow for precise replication of the patient's unique spinal anatomy, including vertebral malformations, curvature angles, and surrounding structures.

***Address for Correspondence:** Ahmed Hiue, Department of Orthopedic Surgery, Okayama Rosai Hospital, 1-10-25 Chikkomidorimachi, Okayama 702-8055, Japan, E-mail: hiuea@gmail.com*

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These models provide an invaluable tool for surgeons, enabling them to visualize and manipulate the complex anatomy of congenital scoliosis in a way that is not possible with traditional imaging techniques. Congenital scoliosis arises due to abnormalities in the formation or segmentation of vertebrae during fetal development. Because congenital scoliosis is present at birth and tends to progress during growth, early diagnosis and surgical intervention are often required to prevent significant deformity and complications such as respiratory impairment. However, the surgical correction of congenital scoliosis is challenging due to the highly individualized nature of the deformities and the presence of other anatomical anomalies, including rib malformations and spinal cord tethering. Traditional imaging modalities, while effective for diagnosis, can be limited in their ability to convey the full extent of the three-dimensional deformity. This is where 3D printed spine biomodels come into play, offering a more intuitive and accurate representation of the patient's anatomy [4,5].

Conclusion

One of the often-overlooked benefits of 3D printed biomodels is their ability to enhance communication between surgeons, patients, and their families. Congenital scoliosis is a condition that can be difficult to explain to non-medical individuals, and traditional imaging methods may not convey the severity of the deformity in a way that is easily understood. A 3D printed model provides a tangible and easy-to-understand representation of the patient's spine, allowing the surgeon to explain the nature of the deformity and the planned surgical procedure in a more visual and engaging manner. This can help alleviate anxiety for both the patient and their family, as they gain a better understanding of the condition and the rationale behind the surgical approach. The use of a 3D model can facilitate more informed discussions about the risks and benefits of surgery, helping patients and their families make more educated decisions about their care.

By showing them a physical representation of the spine and the areas that will be addressed during surgery, the surgeon can provide a clearer picture of what to expect in terms of outcomes and potential complications. After the surgery, the 3D model can be used to explain the results of the procedure, including how the spinal alignment was corrected and what the next steps in the patient's recovery will be. This visual tool helps patients and families understand the significance of the surgical outcome and the importance of adhering to postoperative care protocols. The advantages of 3D printed spine biomodels extend beyond the operating room and into the postoperative phase of care. Following spinal surgery for congenital scoliosis, patients typically require a period of rehabilitation to restore function and mobility. In the early postoperative period, maintaining proper spinal alignment is crucial for ensuring the long-term success of the surgery. A 3D model can be used to assess the initial alignment achieved during surgery and provide a baseline for comparison during follow-up appointments.

Physical therapists can use the 3D model to better understand the patient's spinal anatomy and tailor rehabilitation exercises to the specific needs of the individual. This can help improve the effectiveness of the rehabilitation program and promote a faster recovery. For patients with congenital scoliosis, long-term monitoring is essential to ensure that the spinal correction remains stable as the patient grows. The 3D model can serve as a reference point for assessing changes in spinal alignment over time, allowing for early detection of any issues that may require further intervention.

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Conflict of Interest

None.

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