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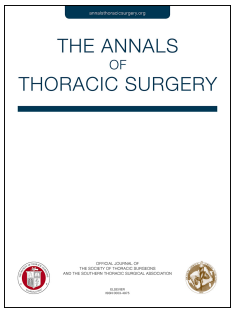

Finite-Element Analysis Aided Design of Customized Nuss Bar in Pectus Excavatum Surgery

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To the Editor:

With great interest, we read the article from Lin et al. [1] in a recent issue of Annals of Thoracic Surgery. Lin et al.[1] applied three-dimensional (3D) printing technique to assist the Nuss procedure. This novel technique reduced the surgical duration and facilitated an optimal morphological outcome. There were three key innovation points. First, the bar curvature was generated by computer-aided design, with higher precision and less error compared with manual methods. Second, the Nuss bar was not designed based on the skin surface but the bony chest wall. Third, the designed bar model was materialized to facilitate execution of operations, rather than the improvisation under the traditional mode. In short, the design of customized Nuss bar played a key role in the 3D printed model-assisted Nuss procedure.

Besides the sternal elevation due to the rotation of Nuss bar, the anterior chest wall was simultaneously transformed by a combined rotational, tensile, and elevation interaction force in the Nuss procedure [2]. Since the 3D printing related design only traced the point-to-point shift of sternum, the physiological morphology of anterior chest wall could not be truly simulated, especially in complicated cases. Thus, the design of customized Nuss bar remained unsolved.

Finite-element analysis (FEA) is an important method of modern engineering refined design and has been applied in orthopedics widely [4]. We recently applied the FEA method to design the customized Nuss bar as described by Xie and colleagues [5]. After 3D model reconstruction, material characteristic definition, meshing and setting up load of bony chest wall, the FEA could repeatedly simulate the Nuss procedure according to different displacement variable set. In this way, both point-to-point shift of stermun and biomechanical change of anterior chest wall could be simulated. Furthermore, the design of customized Nuss bar will match the post-operative curvature of bony chest wall well.

Finally, in view of the biomechanical characteristics, FEA may be used as an ideal tool to design customized bar for the Nuss procedure and provide data support for manufacturing next-generation pectus bar with new bio-absorbable materials [3].