Development of 3D Models to Represent Thoracic Morphology Variation and Assist in Surgical Rib Fixation for Chest Trauma Patients

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INTRODUCTION

- Up to 85% of trauma cases have rib fracture [1]
- Past treatments revolved around conservative efforts such as skeletal traction and ventilation
- Prolonged ventilation is correlated with poor patient outcomes and surgical intervention may be preferred for improved outcomes [2]
- Significant barriers in traumatic rib surgeries:
  - Diversity of thoracic morphology [3]
  - Limitations in pre-operative planning
  - Time- and cost-efficiency of subject-specific models

Objective: Analyze computed tomography (CT) scans to investigate thoracic dimensional variability with age and sex and develop representative 3D rib cage models for use in surgical planning and intervention (Fig 1).

Fig 1. Implementation of surgical rib fixation [4]

METHODS

- Rib cage was segmented from normal patient CT scans and used to create 3D point clouds
- Custom MATLAB code used to rotate point clouds to ensure uniform orientation (Fig 2)

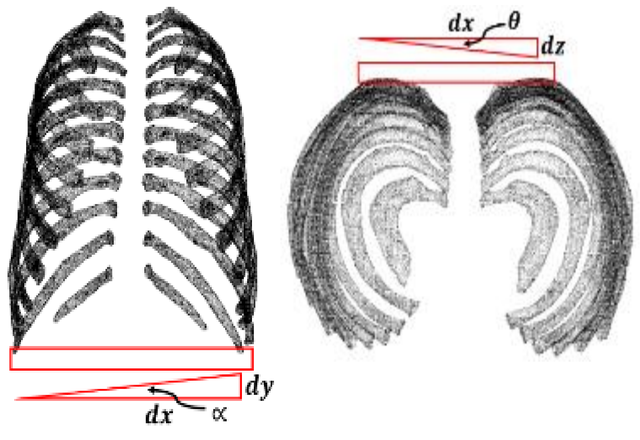

Fig 2. Angles of rotation about y- and z- axes

METHODS CONT.

- Bounding box used to measure individual chest dimensions
- Subjects classified as small, medium, or large based on their percentile rank in all dimensions
- 6 morphological subgroups generated focusing on small and large measures only
- Representative subject from each group used to develop full 3D thorax models (Fig 3a/b)
- Thoracic database used to develop a patient fit calculator

RESULTS

- 141 subjects (~52% female; ages 10-80; ~20 subjects/age decade)
- Mean chest volume tended to increase with age and was ~37% smaller in females (Fig 4)
- Within each age decade, chest volume varied substantially (SD: ± 5,988 cm^3)

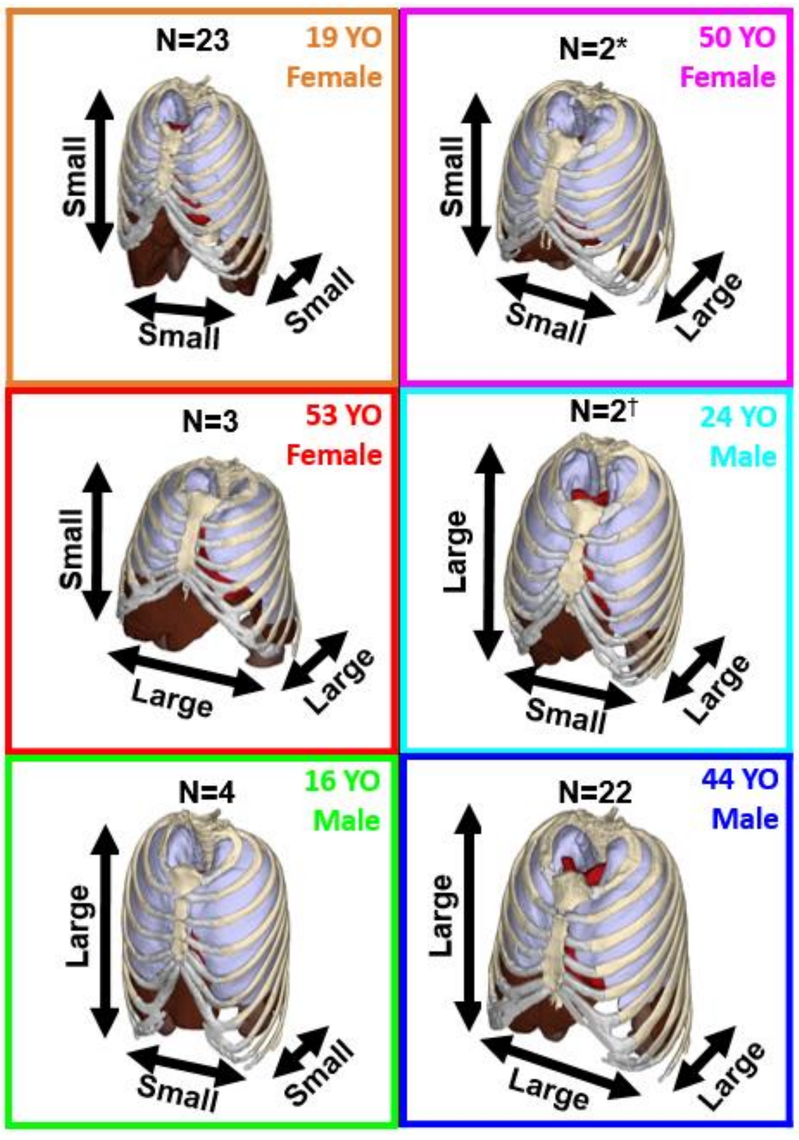

Fig 3. a) Full thoracic models of representative subjects chosen from each of the 6 morphology subgroups b) Chest height, width, and depth for all 141 subjects aged 10-80 years old with subjects selected for 3D model development

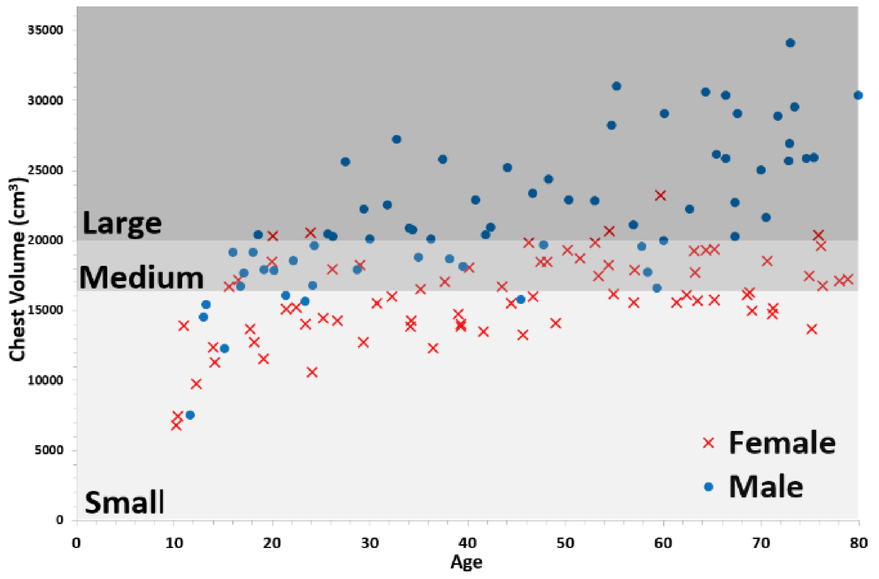

Fig 4. Chest volume for all subjects grouped by gender and classified as small, medium, or large

CONCLUSION

- 6 models developed cover a broad range of thoracic morphologies and can serve as a basis for:
  - Device design testing
  - Computational modeling applications
  - Pre-operative planning
- Compared to subject-specific models, these representative models are a cost- and time-efficient alternative

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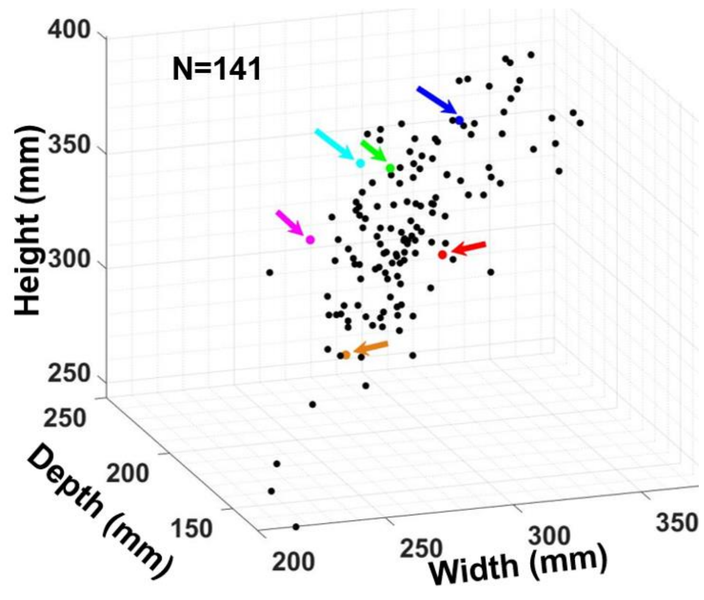

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