

CRURAL THICKNESS MEASUREMENTS BETWEEN INTRAOPERATIVE AND 3D PRINTED ANATOMICAL MODELS

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Introduction

- This project aims to evaluate the three-dimensional (3D) accuracy of 3D printed (3DP) anatomical models of diaphragmatic crura for pre-surgical planning.

Methods and Procedures

- For this project, all images were acquired using axial contrast and non-contrast CT (Computed Tomography).
- The images were manually segmented with the use of Hounsfield unit-based thresholding to improve accuracy. Each segmentation file was saved and exported as a separate STL (Stereolithography) file for printing.
- We printed nine models for this project using an Ultimaker 3 and an Ultimaker S5 using PLA (polylactic acid) filament. Three measurements were taken of the diaphragmatic crura at the esophageal hiatus.
- Two thickness measurements were taken in the middle of the left and right crura.
- The width of the hiatal opening was also measured. Each measurement was taken intraoperatively by surgeon (IO), digitally on the STL model by radiology, and on a corresponding 3DP anatomical model and then compared.



Image 1. A 3D printed anatomical model of a diaphragmatic hernia.

Measurement	IO average	3DP model average	STL average
Right Thickness	9.40 mm	7.73 mm	8.15 mm
Left Thickness	10.20 mm	11.00 mm	11.40 mm
Hiatal Width	31.00 mm	32.29 mm	35.15 mm

Table 1. A comparison of the average measurements taken intraoperatively (IO), on the 3DP models, and on the digital STL files.

Measurement	IO vs 3DP model	IO vs STL	3DP model vs STL
Right Thickness	2.52 mm	1.57 mm	0.96 mm
Left Thickness	2.00 mm	0.58 mm	1.06 mm
Hiatal Width	7.00 mm	7.83 mm	3.55 mm

Table 2. A comparison of the average differences of each measurement type for each patient

Results

- The average differences between IO measurement and 3DP model measurement of the right crura, left crura, and hiatus were 2.52 mm, 2 mm, and 7 mm respectively.
- The average differences between IO measurement and STL measurement of the right crura, left crura, and hiatus were 1.57 mm, 0.85 mm, and 7.83 mm respectively.

Conclusions

- 3D printed anatomical models can be used to provide a tangible, close approximation of human anatomy prior to complex hiatal hernia repair.
- Depending on the desired accuracy, they can be used for volumetric measurements as well.
- However, there are some sources of error that should be considered.
- oft structures such as the diaphragmatic crura can change in thickness depending on factors such as inspiratory status. Another cause of these differences can be attributed to slice thickness.
- Volumetric accuracy is likely to improve with more solid anatomical structures, but further investigation is warranted.