

Dynamic Assessment of the Normal Aortic Root Using 4D Computed Tomography

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Introduction

Transcatheter Aortic Valve Replacement (TAVR) and valve-sparing surgeries require precise knowledge of aortic root anatomy.

The aortic root is a dynamic 3D structure that changes throughout the cardiac cycle. 3D echocardiography has limitations (operator dependency, acoustic windows).

4D Multiphase Cardiac CT (MCCT)

provides:

- High spatial resolution
- Full 3D reconstruction
- Dynamic assessment across the cardiac cycle

Objectives

- To characterize normal aortic root and leaflet dimensions using 4D MCCT
- To evaluate conformational and dynamic changes of the aortic root throughout the cardiac cycle
- To establish normalized reference ratios relevant for surgical and transcatheter planning

Methods

Population

140 adults (2019–2022) with normal functioning aortic valves.
Excluded: bicuspid valves, dilation >40mm, prior surgery.

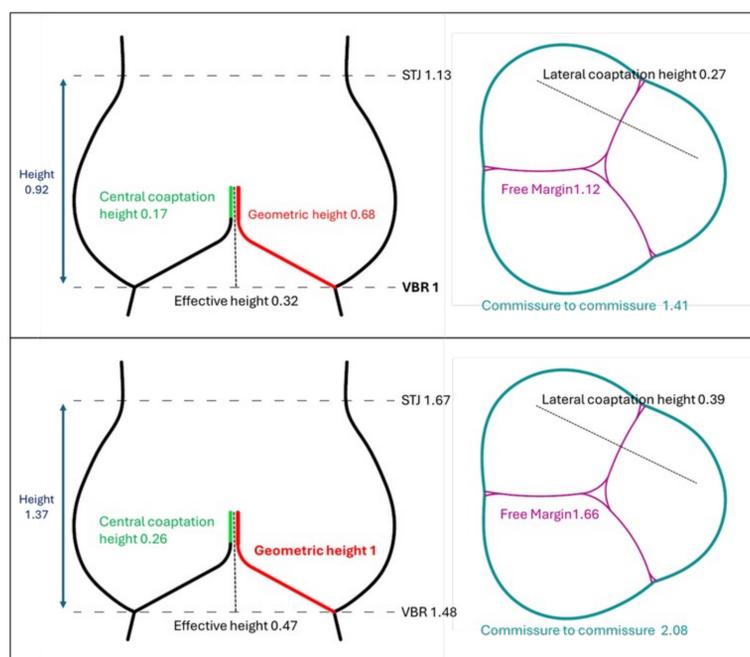
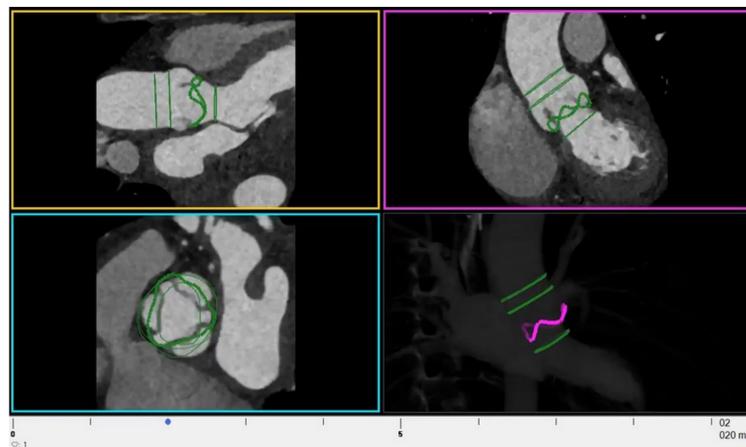
Imaging

- 4D MCCT reconstructed at 10% intervals of cardiac cycle
- Custom in-house software (Lattido®)
- 3D annular reconstruction using cubic spline method

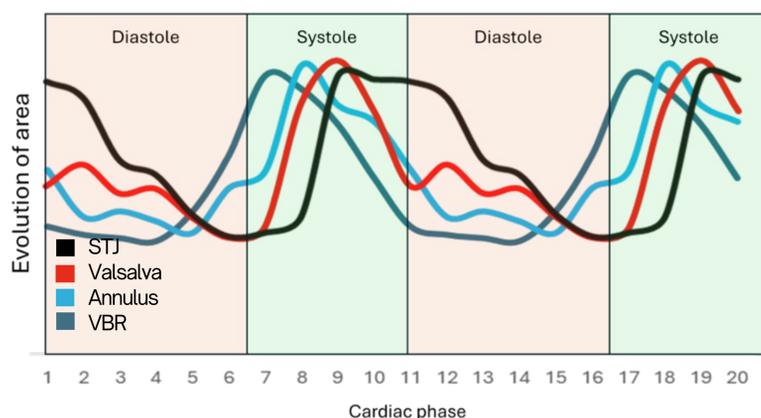
Measurements

- Dynamic study of the aortic annulus and other planes of the aortic root across all 10 temporal phases of the cardiac cycle
- Leaflet dimensions calculated in mid-diastole
 - 3D area, perimeter, diameter
 - VBR, Valsalva sinuses, STJ

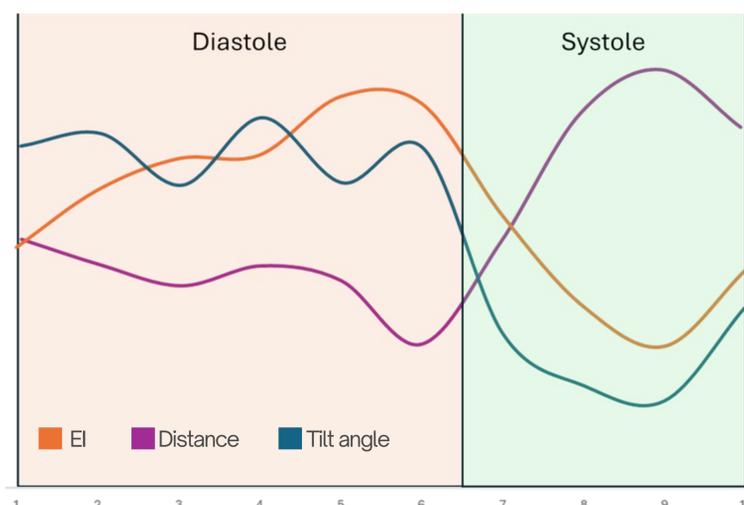
Results



Normalization of leaflet dimensions to VBR (A) and geometric height (B)



Evolution of area of virtual basal ring, annulus, Valsalva, and sinotubular junction during cardiac cycle.



Evolution of eccentricity index, commissural height, tilt angle during cardiac cycle.

Root Morphometrics

- Mean 3D area: $15.5 \pm 3.6 \text{ cm}^2$
- Mean diameter: $2.38 \pm 0.5 \text{ cm}$
- Mean perimeter: $17.8 \pm 2.6 \text{ cm}$

Leaflets

- Mean geometric height: 17.48 mm
- Mean effective height: 8.3 mm
- Right coronary leaflet:
 - Lowest gH
 - Longest free margin ($p < 0.001$)

Correlations

Conformational Changes

- Annulus becomes more circular in systole
 - EI: 0.45 systole vs 0.52 diastole
- VBR & STJ:
 - Become more parallel in systole
 - Increased alignment of outflow tract

Conclusions

This study provides a detailed description of the normal size, shape, and motion of the aortic root using advanced 4D CT imaging.

The results show that the aortic root is a dynamic structure that changes shape during every heartbeat, helping the valve function properly and maintain efficient blood flow. These measurements can serve as reference values for normal aortic valve anatomy and may help improve valve repair surgery and transcatheter valve replacement procedures.

Overall, these findings suggest that doctors should consider how the aortic root moves over time rather than relying on a single static measurement when planning treatments.