BiomedicalEngineering
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Manual Realignment of Short Axis 2DE Images Provides Stable Reference Point for Wall Motion Analysis

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Introduction

- Two Dimensional Echocardiography (2DE) is used for detecting wall motion abnormalities (WMAs) during cardiac stress testing reflecting underlying ischemia
- Current diagnosis of relies on cardiologist's qualitative interpretation of 2DE images
- Quantitative measures have been limited by inability to define a coordinate system for analysis [1]
- We previously developed method that solves coordinate system problem using 3DE images [2]
- Using our findings from 3DE we developed a quantitative approach with 2DE images that relies on user-defined landmarks and manual realignment (Fig 1)
- **Objective: To determine how potential errors in manual realignment will affect subsequent quantitative wall motion analysis.**

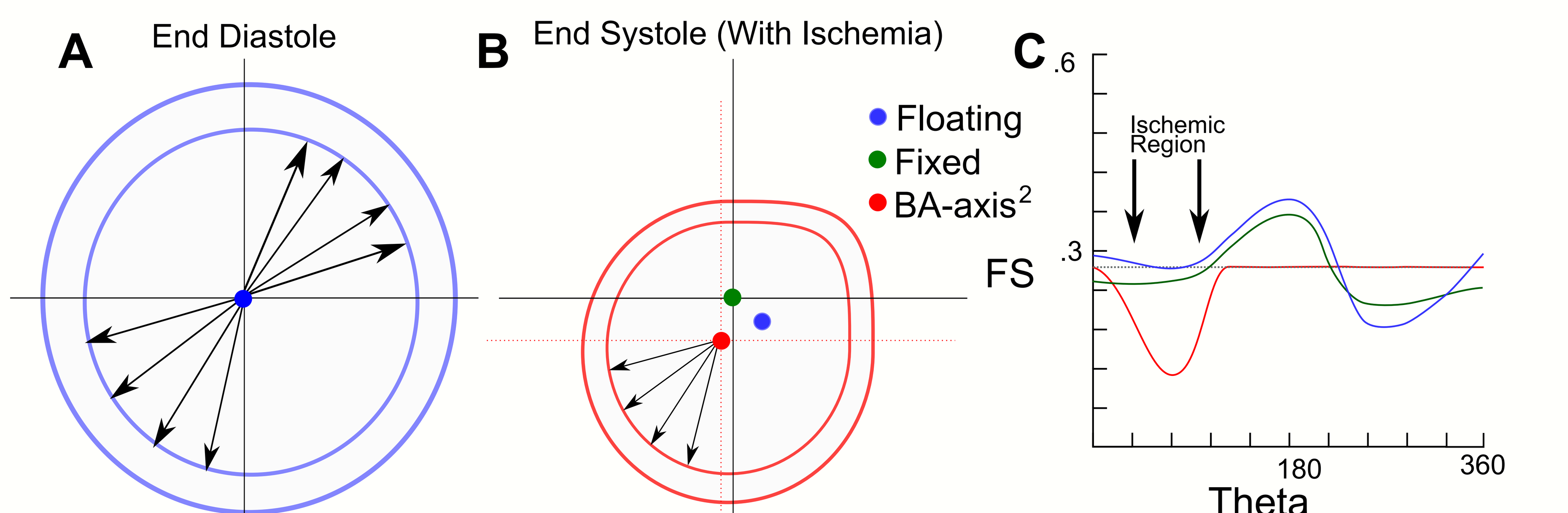


Figure 1: The short axis of the LV at end diastole (a) and end systole (b) when a WMA is present. The floating centroid is the center of mass (COM) of the short axis view and is calculated at ED and ES. The COM shifts causing overestimation of FS in the AWM region (b,c). The fixed centroid is the center of mass calculated at ED and is assumed to stay in the same place from ED to ES, resulting in issues when the heart translates during contraction (b,c). The BA-axis point is defined by distant user-defined landmarks at both end diastole and end systole.

Methods

2DE Realignment Program

- Bring in four standard 2DE views - 3 long axis (LA) views and 1 short axis (SA) view
- User selects mitral valve hinge points (MVHPs) and the apex at end diastole (ED) and end systole (ES)
- User adjusts slices in 3D until satisfied with alignment (Fig 2C)
- From alignment and MVHP selection an ellipse is fit to simulate mitral valve position in 3D (Fig 2C)
- Line between center of mitral valve and apex in 3D is the base-apex (BA) axis
- BA axis intersection with the short axis provides the fractional shortening reference point (FSRP) at ES and ED

Effect of SA Alignment on FSRP Error

- Four standard views were selected from ten clinical 3DE datasets
- 1,000 SA views taken from each dataset to simulate variations in transducer position (Fig 2A, red)
- SA slices were automatically realigned, correcting for slice height, but not tilt or rotation (Fig 2A, blue)
- Error in the FSRP was determined (Est FSRP)

Cardiologist Realignment

- Cardiologist performed three realignments on four of the clinical datasets with SA view estimated FSRP error < 1mm
- Allowed to fully correct LA views, but limited to correcting only the height of the SA view
- Error of FSRP (Fig 2B, Card FSRP - Ideal FSRP)

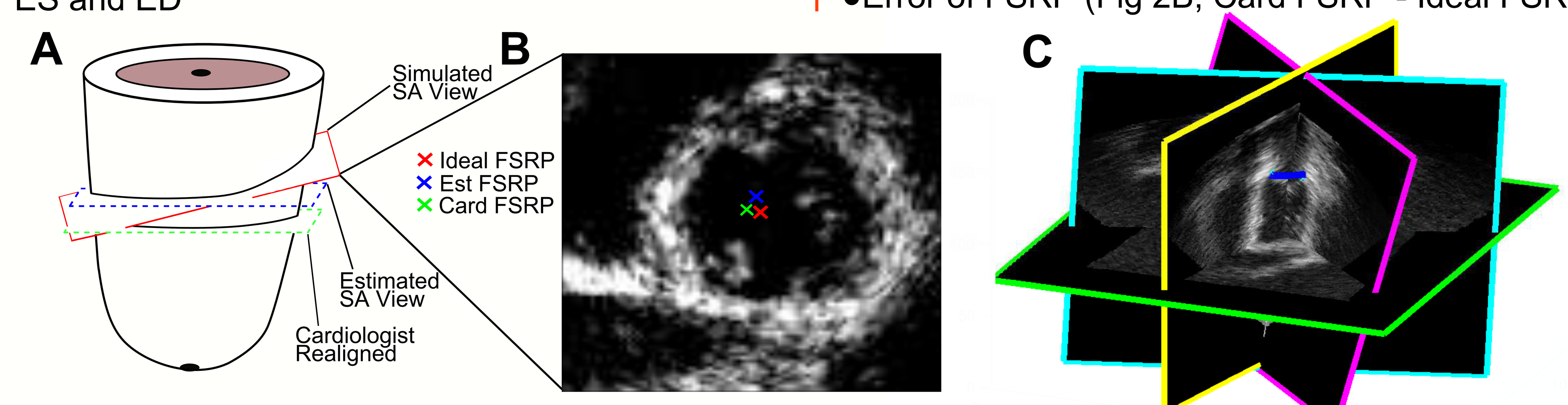
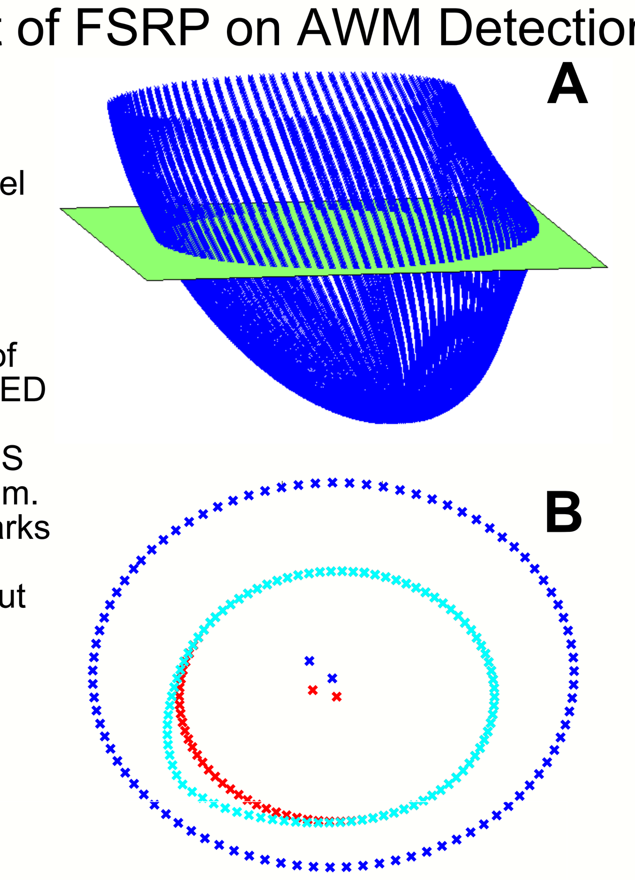
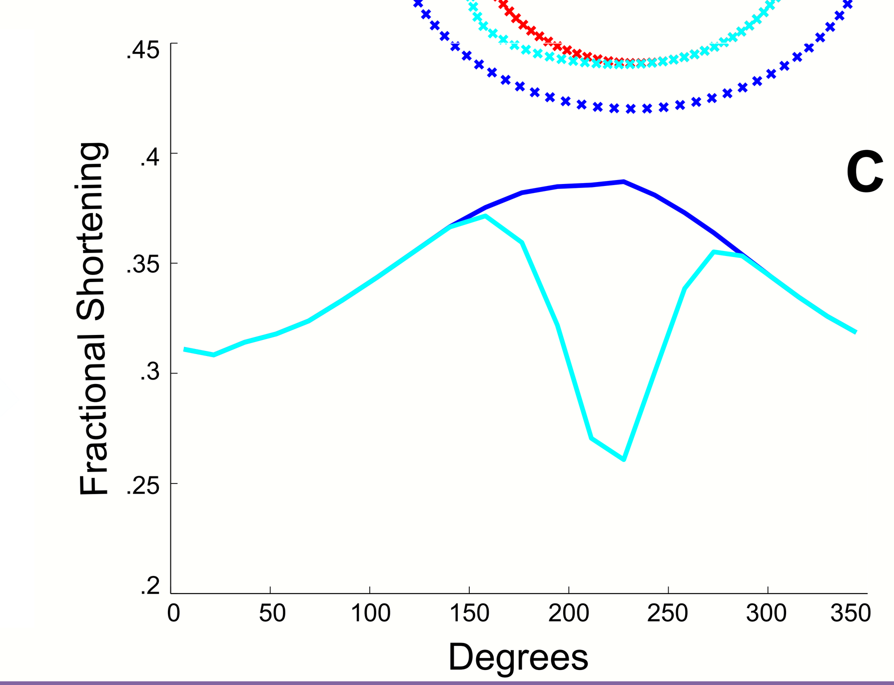


Figure 2:(a) A translation (tilt, rotation and base-apex shift) was applied to produce a view that simulated error in transducer position (red). The obtained view was placed horizontally at the correct base-apex axis position (dotted blue). The calculated FSRP error (b) is the difference between the intersection of the base-apex axis with the red plane (×) and the blue plane (×). (c) 2D slices realigned in 3D by cardiologist.

Model Effect of FSRP on AWM Detection

Figure 3: (a) model of left ventricle in 3D with SA slice through midwall (green plane). (b) cross section of midwall slice with ED (blue), normal ES (red) and infarct ES (cyan) endocardium. Blue and red x marks represent FSRP positions. (c) output radial position in degrees vs. FS.





Results

Estimated FSRP Error Distribution

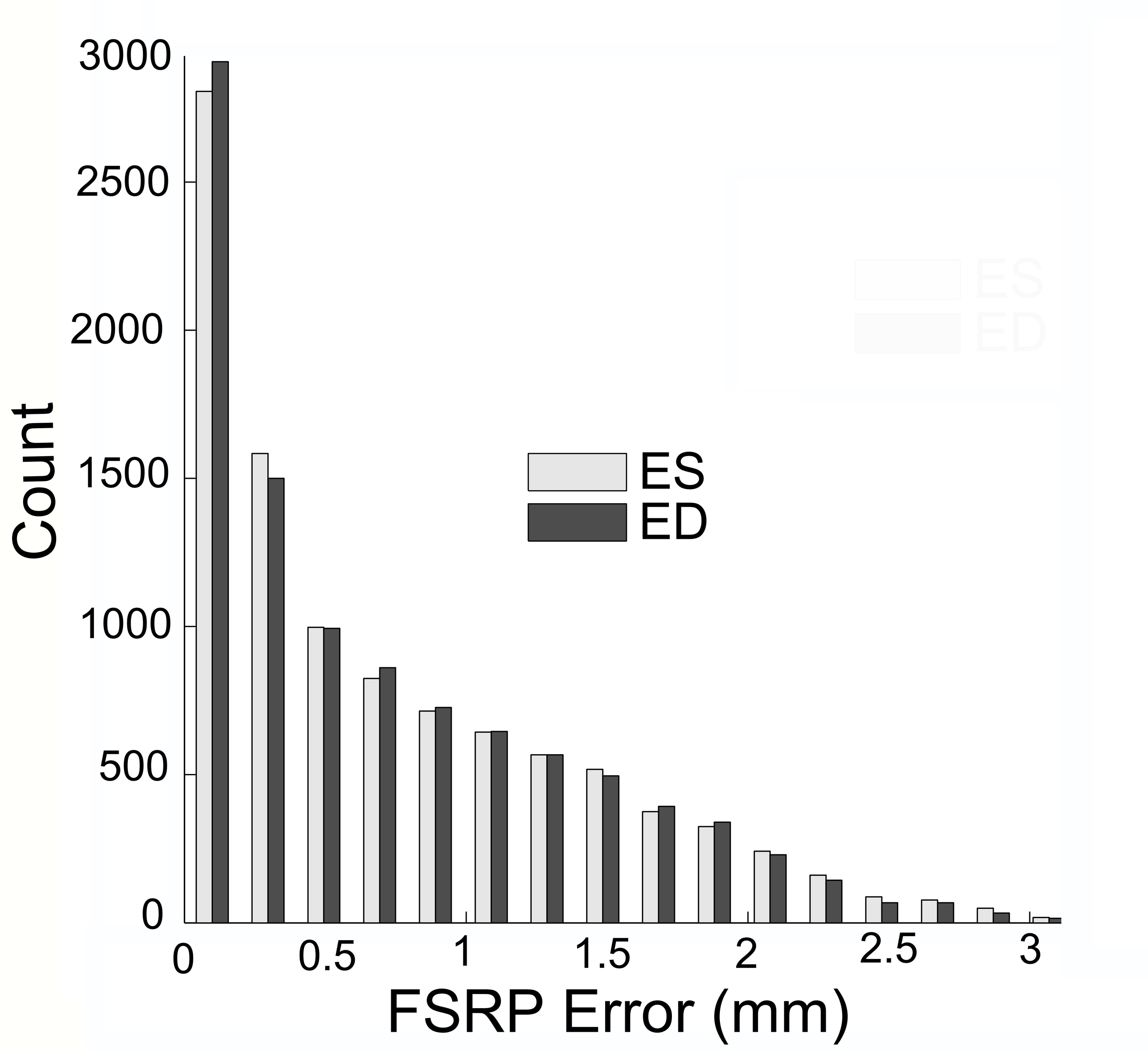


Figure 4: Distribution of the error in the FSRP after z-position correction of 10,000 randomly generated slices through the 3D datasets. The slices were used to simulate variations in the acquisition of an ultrasound technician. These translations included rotation about the ultrasound viewing axis (±15°), tilting of the transducer (±15°) and base-apex directional shifts (±15mm). The resulting histogram shows small FSRP errors (ED average = .73 ± .64 mm; ES average = .70 ± .63 mm).

Cardiologist Realignment and Corrections

		none	LA2&3&4	SA
Average ED Error	FSRP (mm)	2.919	0.709	3.198
	Base (mm)	7.241	0	7.241
	Apex (mm)	8.844	0	8.844
Average ES Error	FSRP (mm)	2.957	0.436	2.993
	Base (mm)	7.466	0	7.466
	Apex (mm)	8.844	0	8.844

Table 1: The errors in the FSRP, base and apex of the cardiologist realignments. Following user realignment, corrections to slice placement were made to determine where most of the error was from during user realignment.

- Cardiologist realignment results in ED and ES FSRP errors of 2.919 ± 1.91 mm and 2.957 ± 1.67 mm respectively
- Correcting for long axis aligment places base and apex in correct position and causes FSRP error decrease to .709 ± .42 mm for ED and ..436 ± .59 mm for ES
- Correcting for SA alignment does not significantly change the FSRP error
- This indicates most of the error arises from realignment of the LA views and supports the findings from figure 4

Discussion

- The tilt and rotation variation that occurs during SA image acquisition does not have much effect on the position of the FSRP
- A program was developed allowing a user to fully align standard 2DE LA views while constrained to making only base-apex adjustments of the SA view
- The FSRP error found as a result of manual realignment can be contributed mostly to misalignment of the LA views

Conclusion

- Manual realignment of 2DE images in a 3D coordinate system offers potential for quantitative detection of abnormal wall motion in the short axis view.

References

1. Wiske et al., J Am Coll Cardiol, 16(4): 993-999

2. Herz et al., Ann Biomed Eng, 38 (4): 1367-1376

Acknowledgements

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