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Automated Quantitative 3-D Echocardiography of The Surgical Mitral Valve Anatomy in Functional Mitral Regurgitation to Guide Mitral Valve Repair

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Abstract:
Background: The contributions of mitral annular (MA) and leaflet (ML) remodeling to functional mitral regurgitation (FMR) is a key factor in the consideration of mitral valve repair. Also, selection of the ring size and type is based on quantification of MA and ML remodeling. We tested the feasibility of a novel *automated*, 3-D modeling algorithm using real-time volumetric TEE (3-D TEE) to quantify MA and ML remodeling in FMR.
Methods: The MV was *automatically* modeled from clinical 3-D TEE data in 15 normals and 27 patients (12 with normal annulus size- Group 1,15 with dilated annulus- Group 2) with ≥ moderate FMR. The following parameters were *automatically* quantified using a previously described algorithm (IEEE Trans Medical Img 2010;29: 1636-50): Antero-posterior (AP) and anterolateral-posteromedial (AL-PM) annuluar diameters, intercommissural distance (ICD), trigone length (TL),anterior leaflet height (ALH), total annular circumference (AC), and anterior and posterior annular circumference (AAC and PAC). The dynamic change in AP diameter was computed as the difference in early systole (ES) vs. early diastole.
Results: The only significant difference between normals and Group 1 FMR was in the reduction in the change AP annular diameter in ES (Table 1). The latter indicates reduction in the dynamic annular remodeling in ES so that there is reduced accentuation of the saddle shape with consequent reduction in leaflet coaptation. In Group 2 FMR, the ALH was markedly increased (= significant ML remodeling) in addition to a dilated, adynamic annulus. The choice of ring size and type can be made based on the automated measurements of the TL, AC, AAC, APC, ALH. Figure shows representative example.
Conclusion: *Automated 3-D quantitative surgical anatomy* in FMR 1) shows that an adynamic annulus is an early basis for MR, followed by annular dilatation and anterior leaflet lengthening, and 2) that these mechanistic insights and the quantitative characterization of the pathologic anatomy can aid surgical decision-making.

Mitral Annulus and Leaflet Measurements			
	Normal n = 15 (mm)	**FMR Group 1** n = 12 (mm)	**FMR Group 2** n =15 (mm)
Annulus AP diameter	29.2±3	33.1±1	34.4±4*
Annulus ALPM diameter	35.6±3	33.7±2†	40.6±4*
Trigone length	24.9+2.9	22.9+2.1†	28.3+2.4*
Inter-commissural distance	25.7±4	23.9±3†	31.0±4*
Anterior leaflet height	20.9±3	23.9±4	26.9±5*
Total Annular circumference	112.1±9	114.4+5†	129.0+12*
Anterior AC Posterior AC	51.4±4 60.6±6	50.4±4† 63.9±3	57.3±6* 71.6±7*
Dynamic AP diameter change			
Early diastole Early systole Mean diameter change	30.6±4 26.1±3 4.4±0.8(~14%)	33.3±2 32.9±3* 0.4±0.9*(~4%)	33.9±4 32.5±4* 0.9±0.4*(~4%)
*p≤0.02 Normal Vs. FMR Group 2; †p≤0.03 FMR Group 1 Vs. FMR Group 2			

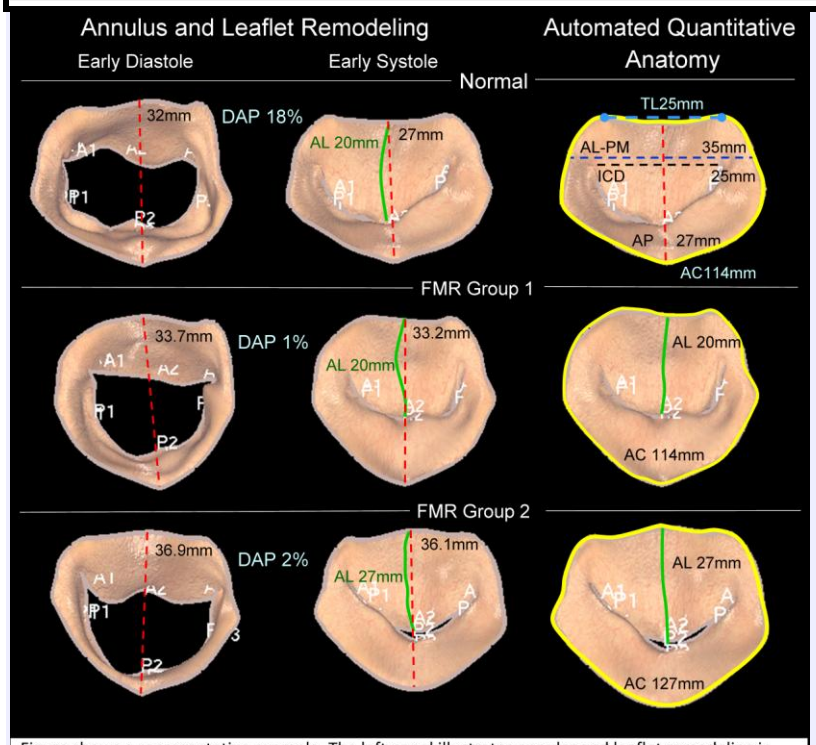

Figure shows a representative example. The left panel illustrates annular and leaflet remodeling in FMR Group 1 (normal annulus size) and Group 2 (dilated annulus) compared to normal. The dynamic change in AP diameter (DAP) in early systole is ~18% in the normal and is reduced in both the FMR groups (1% and 2%). This indicates reduction in accentuation of the saddle shape in ES leading to leafletlet mal-coaptation and MR. This abnormality in dynamic annular remodeling is the only signficant abnormality in Group 1 (AL height is normal, thus there is predominant annular remodeling), whereas in Group 2 FMR the AL height is also significantly increased, in addition to an adynamic, dilated annulus. Thus, there is both leaflet and annular remodeling. The panel on the right shows automated quantification of mitral valve anatomy which can be used to plan MV repair (all parameters are shown in the normal, and AC and AL height shown in the abnormals). AL= anterior leaflet; AC=total annular circumference; TL=trigone length and ICD=inter-commissural distance.

Additional Consideration: YIA Competition:

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