Normalization of Mitral Valve Anatomy and Annular Motion after Repair of Mitral Valve Prolapse: Geometric Quantification Using Intraoperative 3D TEE

MAYO CLINIC

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Background

Mitral valve repair is the definitive therapy for severe degenerative mitral regurgitation. Despite the effectiveness of repair, post-operative geometry and the effect of annuloplasty on mitral annular dynamics have not been fully delineated in myxomatous mitral valve disease (MVD).

Methods

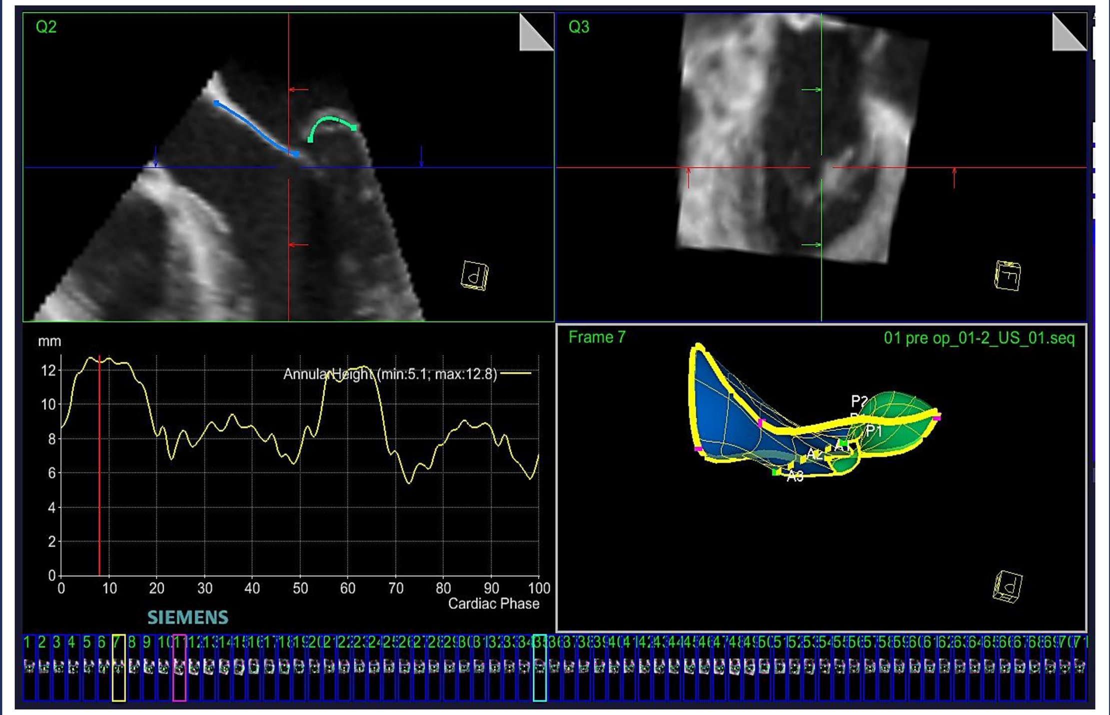
Patients:
Patients undergoing mitral valve repair with annuloplasty for severe degenerative mitral regurgitation (n=9) were evaluated with 3-dimensional (3D) transesophageal echocardiography (TEE) pre-operatively (PRE) and post-operatively (POST). Patients undergoing non-mitral cardiac surgery with normal 2D TEE mitral valve anatomy served as Controls (n=8). Patients with left ventricular (LV) dysfunction (ejection fraction --EF < 50%) or atrial fibrillation were excluded.

Measurement:
Four beats breath-hold 3D full volume images were obtained using real time 3D TEE probe (X7-2t, iE 33, Philips Medical System, Bothell, Wa) and analyzed off-line utilizing novel 3D valve software (eSie Valve, pre-release version Siemens, Mountain View, CA) **[Figure 1]**. Mitral annular and valvular geometric assessments were performed throughout the cardiac cycle including sequential quantification of annular height (AH) to analyze dynamic annular motion. Comparisons were made between PRE, POST, and Controls.

Disclose

No relevant financial relationship(s) for any of the authors.

Figure 1



Sequential analysis of AH in a patient with MVD by using eSie Valve. Two cardiac cycles (71 frames) were acquired in this 3D dataset. After adequately positioning landmarks (Trigones, commissures and tips of valve leaflets), the valvular surface was detected automatically by this novel 3D software. Manual fixation of valvular outlines perfected the result. Measurements were exported in an excel file for further analysis.

Results

Baseline Characteristics: 14 men and 4 women were enrolled (mean age of 63.0 ± 8.9years). Nine patients with severe MR underwent mitral repair and 9 patients with normal mitral valve underwent non-mitral surgery. Pre-operative 2 -dimensional (2D) transthoracic echocardiography (TTE) showed similar LVEF in MVD vs. Control (65.4±4.8% vs. 64.7± 6.5%), and larger LV chamber in MVD vs. Control (LVEDD: 58.1± 3.6 vs. 49.0±4.1 mm, p<0.001; LVESD: 35.7±4.0 vs. 41.7 ± 15.9 mm, p=0.032). Post-OP 2D TTE showed decreased LVEF in MVD vs. Control (53.8±5.4 vs. 64.8± 8.3, p=0.014). There were 7 patients who underwent robotic mitral repair and 2 for sternotomy mitral repair. In the Control group, 4 received coronary artery bypass graft surgery (CABG), 3 aortic valve replacement (AVR) and 2 septal myectomy.**[Table 1]**

Table 1: Baseline Characteristics

	MVD (n=9)	Control (n =9)	P value
Age (year old)	61 ± 4.9	65.1 ± 12.7	0.358
Male (%)	8(57.14)	6(42.86)	0.069
SBP (mmHg)	131.8 ± 16.2	133.4 ± 12.8	0.854
DBP(mmHg)	73.4 ± 8.7	76.6 ± 16.6	0.665
HR (bpm)	62.6 ± 2.6	62.3 ± 6.6	0.939
Pre- OP 2D TTE			
LVEF (%)	65.4 ± 4.8	64.7 ± 6.5	0.834
LVEDD (mm)	58.1 ± 3.6	49.0 ± 4.1	<0.001
LVESD (mm)	35 7± 4.0	29.5 ± 4.20	0.032
LAVI	55.6 ± 10.2	41.7 ± 15.9	0.093
Post –OP 2D TEE			
LVEF (%)	53.8 ± 5.4	64.8 ± 8.3	0.014
LVEDD (mm)	51.5 ± 6.6	-	
LVESD (mm)	36.7 ± 6.7	-	
Cardiac Surgery			
Robotic mitral repair	7		
Sternotomy mitral repair	2		
CABG		4	
AVR		3	
Myectomy		2	

Results

3D measures :
Measures of 8 different phases of a cardiac cycle including MV close (MVC), early systole (ES), middle systole (MS), late systole (LS), MV open (MVO), early diastole (ED), middle diastole (MD) and late diastole (LD) were taken into average and compared between groups. Averaged annular anteroposterior (AP) diameter and lateral diameter, annular area and maximal (Max) mitral valve (MV) area were greater in PRE vs. Controls. (Averaged annular AP diameter in PRE vs. Control: 38.9±3.8 mm vs. 29.5 ±3.7mm, p<0.001; averaged annular lateral diameter in PRE vs. Control: 42.4 ± 7.3 mm vs. 32.3 ± 3.7mm, p=0.002; averaged annular area in PRE vs. Control: 13.8 ±3.6 cm^2 vs. 8.3 ± 1.5cm^2, p<0.001; averaged Max MV area in PRE vs. Control: 6.4 ± 1.4 mm2 vs. 4.2 ± 1.0 cm2) **[Table 2]**. These parameters became smaller in POST vs. Control (averaged annular AP diameter in POST vs. Control: 24.1±2.6 mm vs. 29.5 ±3.7mm, P=0.002; averaged annular lateral diameter in POST vs. Control: 28.1 ± 2.8 mm vs. 32.3 ± 3.7, p=0.015; averaged annular area in POST vs. Control: 5.7±1.0 cm^2 vs. 8.3 ± 1.5 cm^2, p<0.001 averaged Max MV area in POST vs. Control: 2.8 ± 0.6 cm^2 vs. 4.2 ± 1.0 cm^2, P=0.004) see **[Table 3]**.

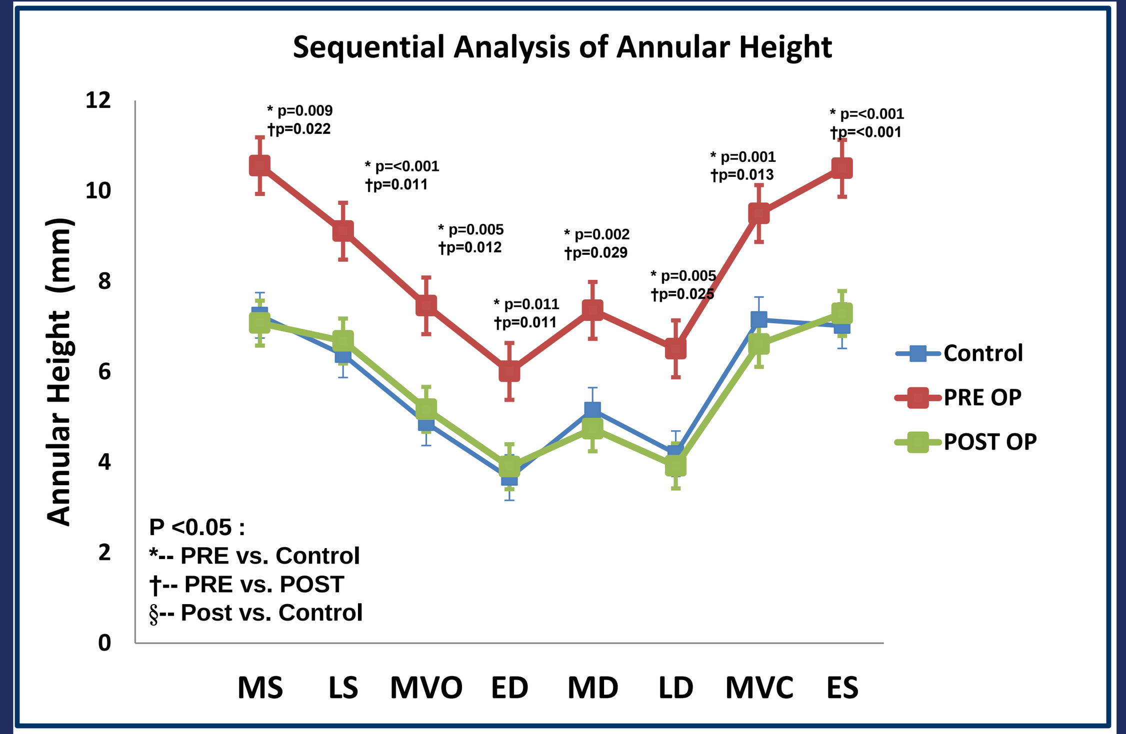
Table 2: 3D Measures (1)

	PRE (n=9)	Control (n=9)	P value
Averaged Annular AP Diameter, mm	38.2±3.8	29.5±3.7	<0.001
Averaged Annular Lateral Diameter, mm	42.4±7.3	32.3±3.7	0.002
Averaged Annular Area, cm^2	13.8±3.6	8.3±1.5	<0.001
Max MV Area, cm^2	6.4±1.4	4.2±1.0	0.003
Averaged ICW, mm	29.8±4.6	22.8±3.2	0.002
Max AH, mm	11.2±2.1	7.4±1.5	<0.001
Min AH, mm	5.7±1.5	3.6±0.5	0.001
Dispersion of AH (Max-Min AH), mm	5.5±1.1	3.9 ±1.4	0.001

Table 3: 3D Measures (2)

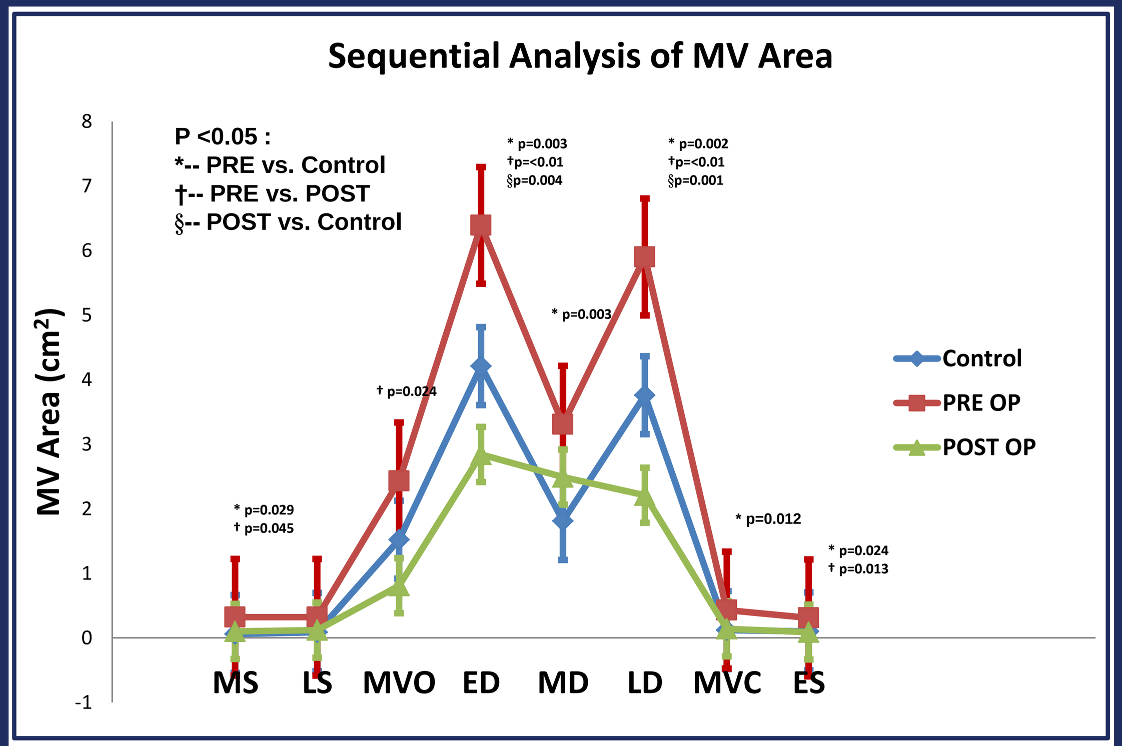
	POST (n=9)	Control (n=9)	P value
Averaged Annular AP Diameter, mm	24.1±2.6	29.5±3.7	0.002
Averaged Annular Lateral Diameter, mm	28.1±2.8	32.3±3.7	0.015
Averaged Annular Area, cm^2	5.7±1.0	8.3±1.5	<0.001
Max MV Area, cm^2	2.8±0.6	4.2±1.0	0.004
Averaged ICW, mm	21.3±2.8	22.8±3.2	0.289
Max AH, mm	7.6±0.9	7.4±1.5	0.696
Min AH, mm	3.6±0.9	3.6±0.5	0.926
Dispersion of AH (Max-Min AH), mm	4.0±0.7	3.9±1.4	0.709

Figure 1



In this sequential measure, the AH increased from the baseline at LD to highest level rapidly at ES, in PRE, POST and Control, Greater AH were noted in MVD throughout the cardiac cycle, returned to normal range post-operatively.

Figure 2



MV area were greater in PRE vs. Control and Pre vs. Post. Leaflet repair surgery reduced mitral regurgitation in systolic phase but reduced the maximal opening of mitral valve in ED and LD.

Results

The dispersion of AH (Max AH-min AH) was greater in PRE vs. Control. (5.5±1.1 mm vs. 3.9±1.4mm, p=0.001). Following mitral leaflet repair plus annuloplasty, the dispersion of AH decreased and became similar to Control (4.0±0.7 mm vs. 3.9 ± 1.4 mm in POST vs. Control, p=0.709), reflecting the normalization of dynamic motion of AH. **[Table 1-2]**

Results

Sequential Analysis:
Dynamic changes between different phases of cardiac cycler were showed in sequential analysis of AH and MV area. **[Figure 1-2]**. The AH was greater in PRE vs. Control throughout the cardiac cycle and became similar in POST vs. Control post-operatively. The AH was low in diastole and was lowest at ED, then slightly increased at MD, decreased to baseline at LD, and rapidly elevated in systolic phase and reached the highest level in ES or MS. The trend of AH change was contrary to the trend of MV area change **[Figure 1]**. The MV area was greater for the most part throughout cardiac cycle in PRE vs. Control. Mitral valve repair successfully restored mitral geometry (The MV area was similar in POST vs. Control in systolic phase) but did slightly reduce the maximal MV opening during diastole (smaller MV area in POST vs. Control in ED and LD) **[Figure 2]**.

Conclusions

Sequential geometric analysis of mitral valve dynamics demonstrates distorted mitral valve geometry and abnormal annular dynamic motion in MVD. Mitral leaflet repair with annuloplasty effectively restores normal mitral annular geometry and annular motion which may explain the long term effectiveness of this procedure.