JACC: CARDIOVASCULAR IMAGING
VOL. 5, NO. 6, 2012

ISSN 1936-878X/$36.00
PUBLISHED BY ELSEVIER INC.
http://dx.doi.org/10.1016/j.jcmg.2012.02.014

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IMAGING VIGNETTE

Side-by-Side Comparison of Fluoroscopy, 2D and 3D TEE During Percutaneous Edge-to-Edge Mitral Valve Repair

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CATHETER-BASED MITRAL VALVE CLIP REPAIR IS AN effective procedure in selected patients with mitral regurgitation. Fluoroscopy and 2-dimensional transesophageal echocardiography (2D TEE) are the primary imaging modalities for guidance mitral-clip procedure. Real-time 3-dimensional transesophageal echocardiography (RT 3D TEE) has been recently suggested as a "complementary" imaging modality. However, whether the use of this mitral-clip technique may offer real benefits over standard imaging techniques is not yet established. The following collage, taken from a series of 22 patients, shows side-by-side images obtained by fluoroscopy, 2D TEE, and RT 3D TEE. While essential data during the procedure are provided by the use of the 2 standard imaging techniques and the most crucial step of the procedure (i.e., the capture of mitral leaflets) is always guided by 2D TEE, our collage demonstrates that in almost every step of the mitral-clip procedure, RT 3D TEE may provide new additional useful data. The more precise anatomic information, the fine details of the devices and the precise relationship of catheters/clip with surrounding anatomic structures, may enhance the confidence of imaging interpretation and eventually improve the efficiency of the procedure.

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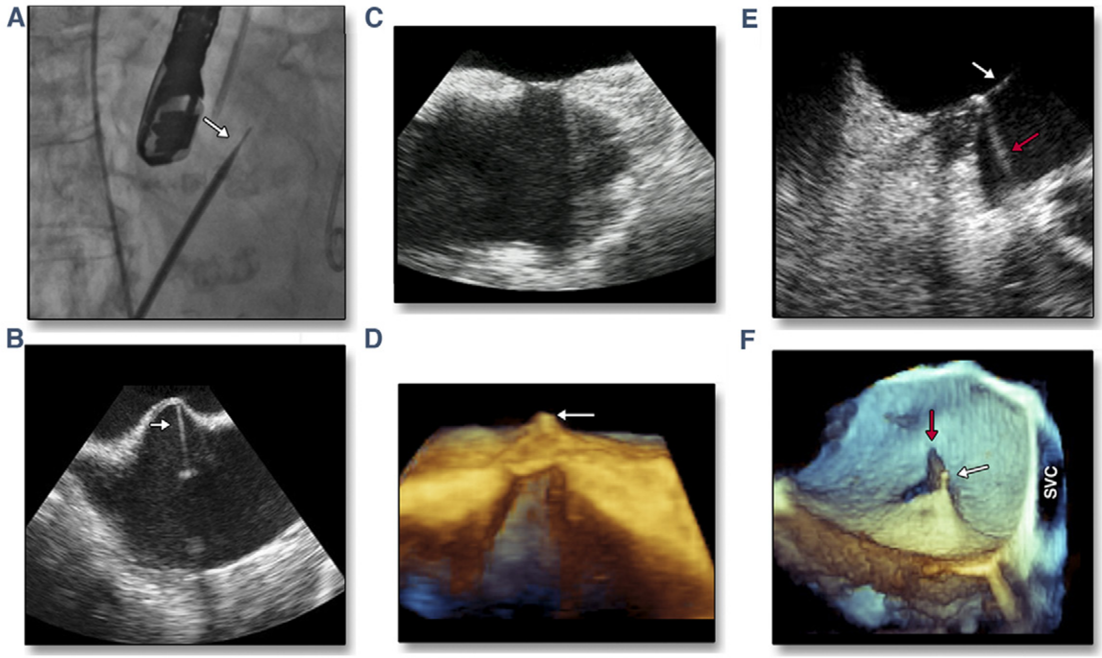

Figure 1. Trans-Septal Crossing

(A) Fluoroscopy of trans-septal crossing. The limited resolution for soft tissue differentiation makes a precise localization of the fossa ovalis difficult (the **arrow** points at the tip of the needle). **(B)** Two-dimensional transesophageal echocardiography (2D TEE) identification of "tenting"; the **arrow** points at the catheter in right atrium. **(C, D)** Occasionally, 2D TEE may not show any tenting. Real-time 3-dimensional transesophageal echocardiography (RT 3D TEE) imaging shows that the tenting was deeper in relation to the 2D plane **(arrow)**; **(E, F)** 2D TEE and RT 3D TEE imaging of a deep tenting due to an elastic fossa ovalis. The **white arrows** point to the needle, the **red arrows** point to the reverberations due to the metal. The RT 3D TEE imaging depicts the real anatomic aspect of tenting ("tent-shaped" configuration), which may facilitate understanding of septal morphology and increase the confidence for interventionalists. SVC = superior vena cava.

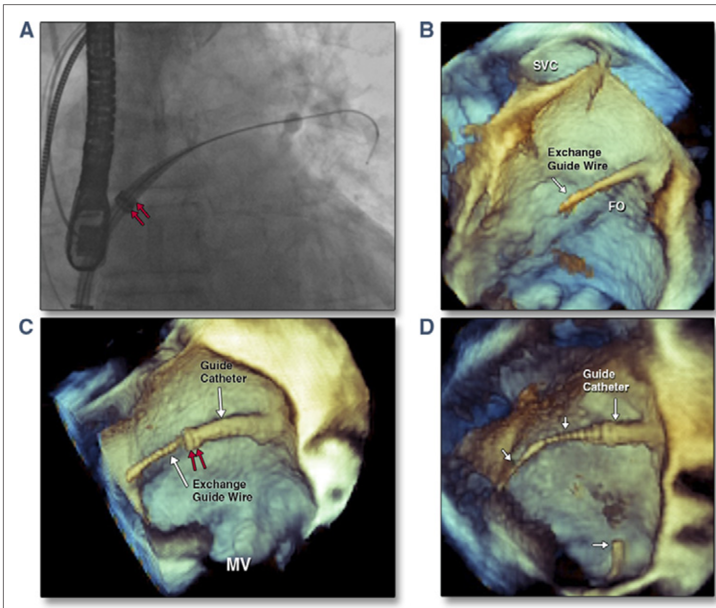

Figure 2. Left Atrial Positioning of Exchange Guide Wire and Guide Catheter

(A) Fluoroscopy imaging of exchange guide wire. The **red arrows** point to the radio-opaque rings used for fluoroscopic identification of the outer catheter guide tip. **(B)** Exchange guide wire and **(C)** guide catheter into the left atrium. The radio-opaque rings are easily recognizable **(red arrows)**. **(D)** A long segment of guide wire **(white arrows)** visualized by RT 3D TEE. Online Video 1 shows withdrawal of the guide wire. FO = fossa ovalis; MV = mitral valve; other abbreviations as in Figure 1.

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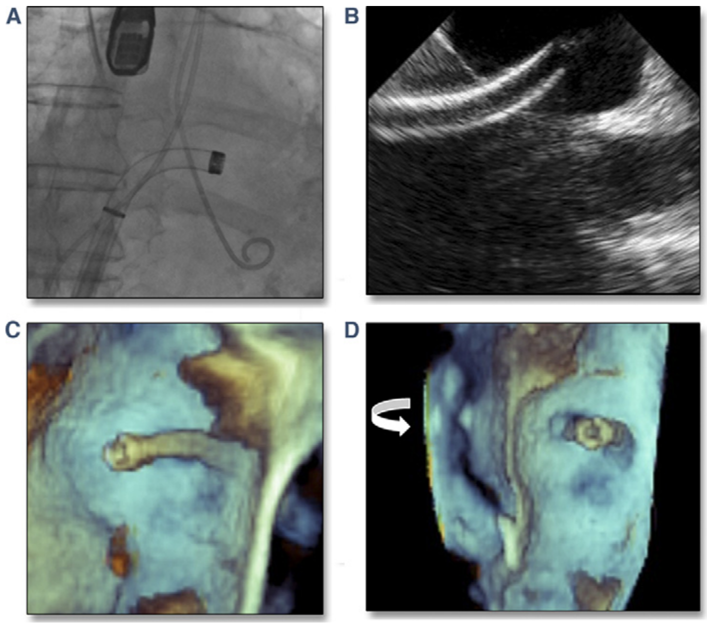

Figure 3. The Catheter Guide

(A) Fluoroscopic imaging of the guide catheter. **(B)** 2D TEE imaging: the guide catheter usually appears as two parallel lines. **(C)** RT 3D TEE imaging: the guide catheter appears very similar to the real structure. **(D)** The lumen of the catheter can be seen "en face" when the image is properly rotated **(curved arrow)**. Abbreviations as in Figure 1.

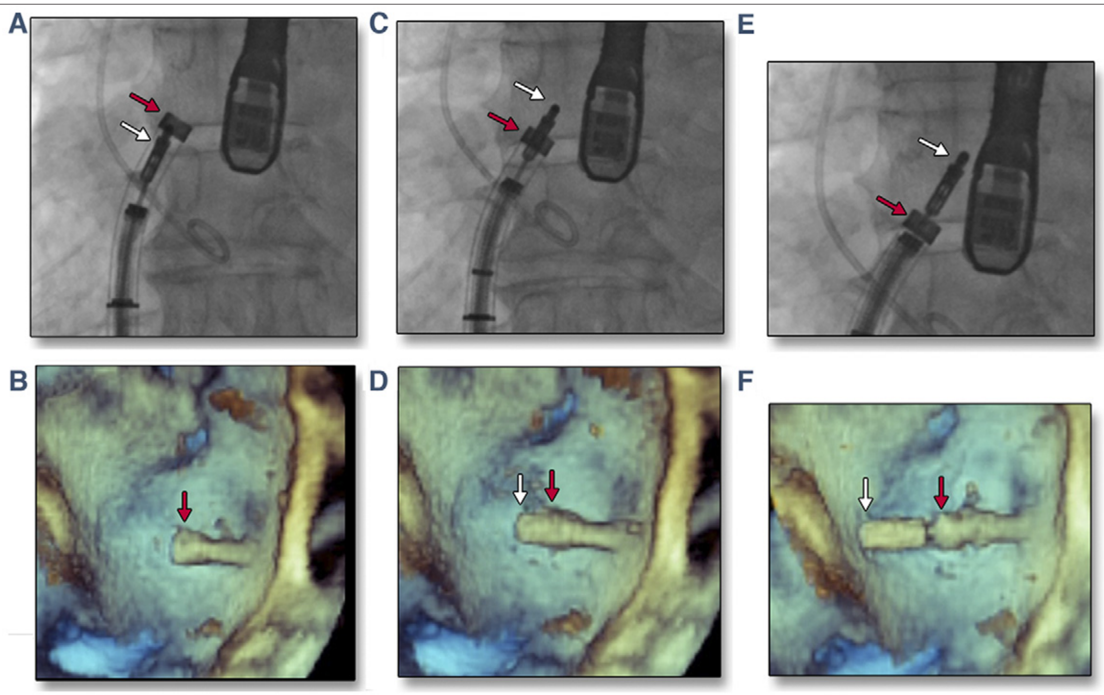

Figure 4. Advancement of Mitral-Clip Delivery System Into Left Atrium

(A, C, E) Fluoroscopic and **(B, D, F)** RT 3D TEE images showing the advancement of mitral-clip delivery system into the left atrium. The **red arrows** point to the tip of the guide catheter, the **white arrows** point at the tip of the mitral-clip delivery system. Because 3-dimensional imaging includes catheters and left atrial walls in one volumetric dataset, interventionalists can easily monitor that the clip is not in contact with the atrial walls and the tip of guide catheter remains across the interatrial septum. This maneuver can be also followed with 2D TEE but it requires, once again, multiple adjustments. Abbreviations as in Figure 1.

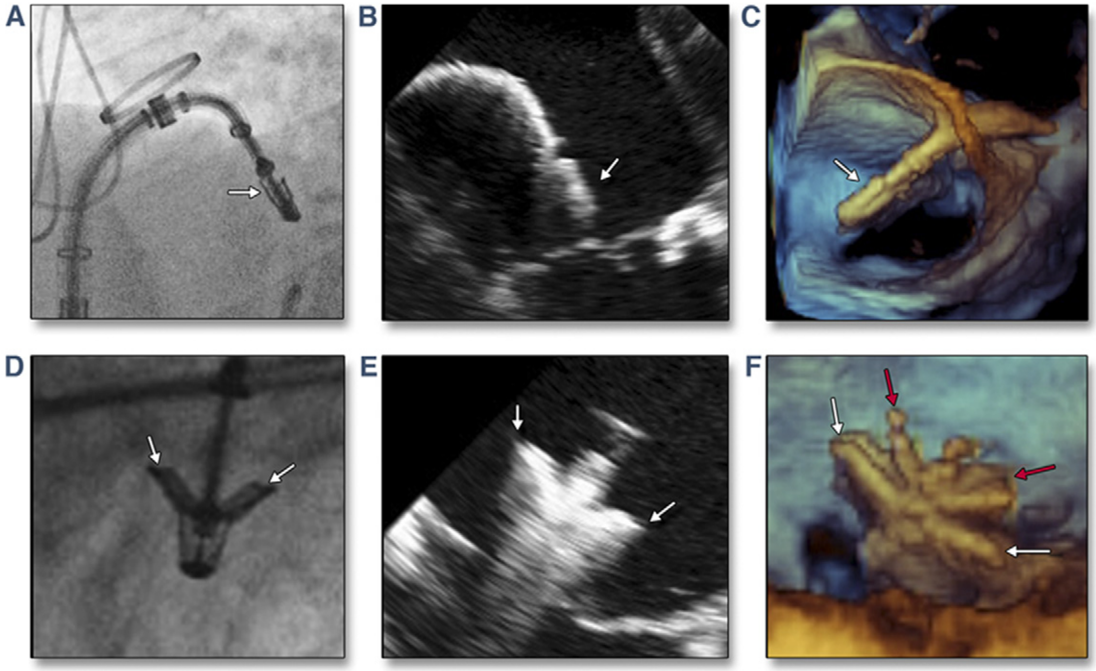

Figure 5. Arms

Arms in closed **(A, B, C)** and in open **(D, E, F)** position visualized with **(A, D)** fluoroscopy, **(B, E)** 2D TEE, and **(C, F)** RT 3D TEE imaging. The **arrows** point at the arms in **(A, B)** closed and **(D, E)** opened position. RT 3D TEE shows the fine details of arms closed and opened **(white arrows in C and F)** and of grippers **(red arrows in F)**. Abbreviations as in Figure 1.

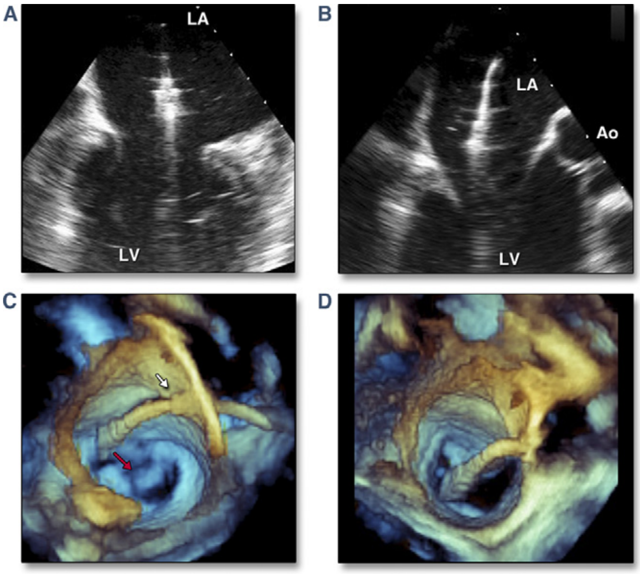

Figure 6. Axial Alignment of the Clip Delivery System

(A, B) 2D TEE guiding axial alignment of the clip. For this maneuver, repetitive cross-checking of two 2-dimensional orthogonal planes (i.e., long axis and intercommissural planes for anterior/posterior and medial/lateral positioning) are required. **(C)** RT 3D TEE imaging of the mitral-clip system positioned near the lateral commissure. The **white arrow** points to the position of the tip of the guide catheter across the interatrial septum. **(D)** The mitral-clip system is repositioned **(red arrow in C)** in the center of mitral valve. Ao = aorta; LA = left atrium; LV = left ventricle; other abbreviations as in Figure 1.

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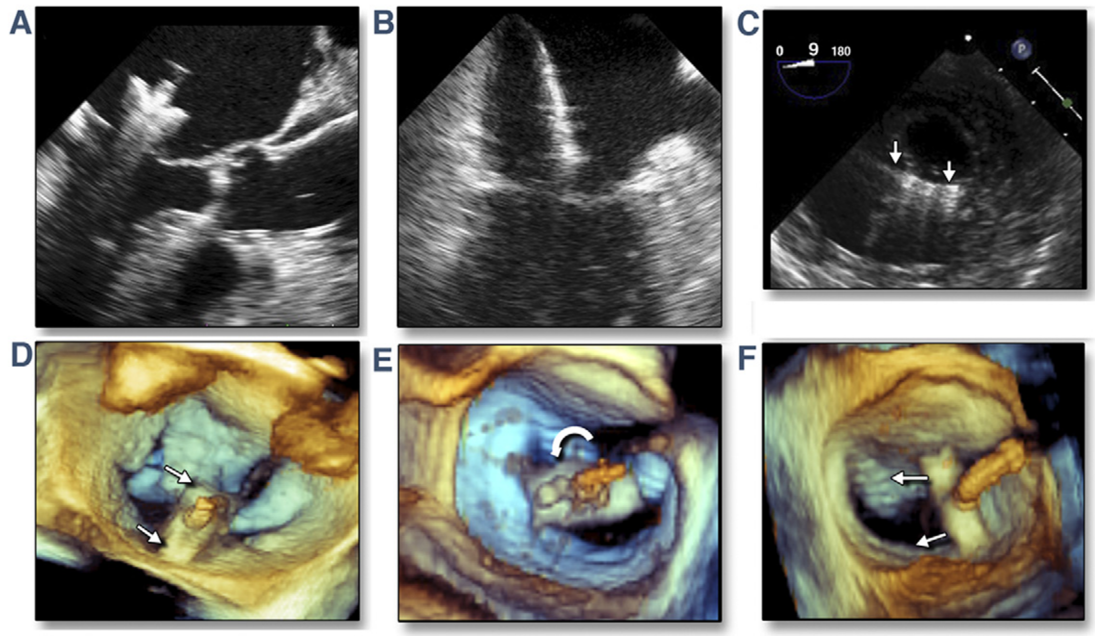

Figure 7. Alignment of the Clip Arms Perpendicular to the Line of Coaptation

(A, B) 2D TEE orthogonal planes must be used for arms alignment. Repetitive cross-checking of these 2 orthogonal planes are usually required. **(C)** Supplemental transgastric short-axis with the arms perpendicular to the line of coaptation. **(D)** RT 3D TEE imaging allows an immediate perception of the position of the arms relative to a coaptation line **(arrows)**. **(E)** Clip arms are not perpendicular to the line of leaflet coaptation. Adjustment requires a counter clock wise rotation **(curved arrow)**; **(F)** clip arms are oriented perpendicular to the line of leaflet coaptation but positioned near the medial commissure. Repositioning requires a movement toward the center **(arrows)**. Abbreviations as in Figure 1.

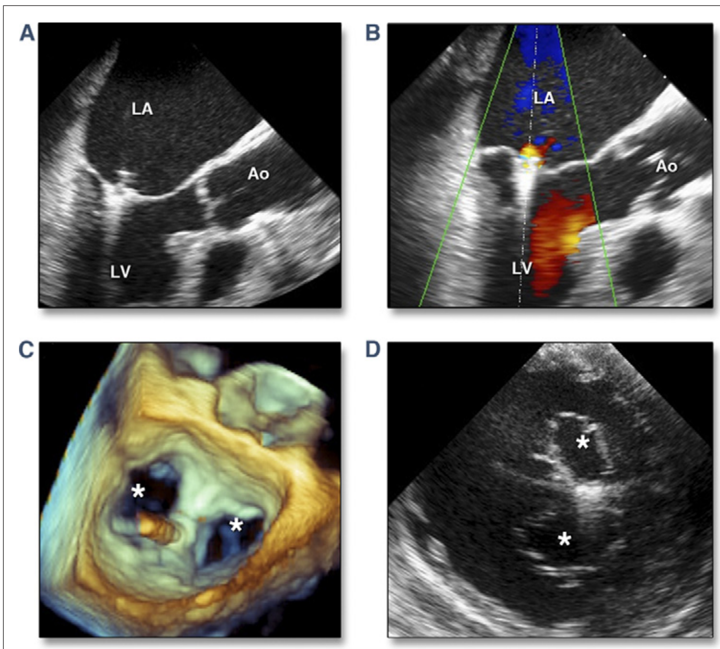

Figure 8. Leaflet Grasping

(A, B) The leaflet capture is guided by 2D TEE. This is because of the higher frame rate and axial resolution in comparison with RT 3D TEE. Moreover, 2D TEE allows the immediate assessment of the residual mitral regurgitation. Although, at present, 2D TEE appears superior to RT 3D TEE, minimizing the pyramidal angle may increase the frame rate up to 30 Hz (Online Video 2). **(C)** The "double orifice" (*) by RT 3D TEE from the above perspective. **(D)** The corresponding 2D TEE imaging obtained in short axis transgastric view. Abbreviations as in Figures 1 and 6.

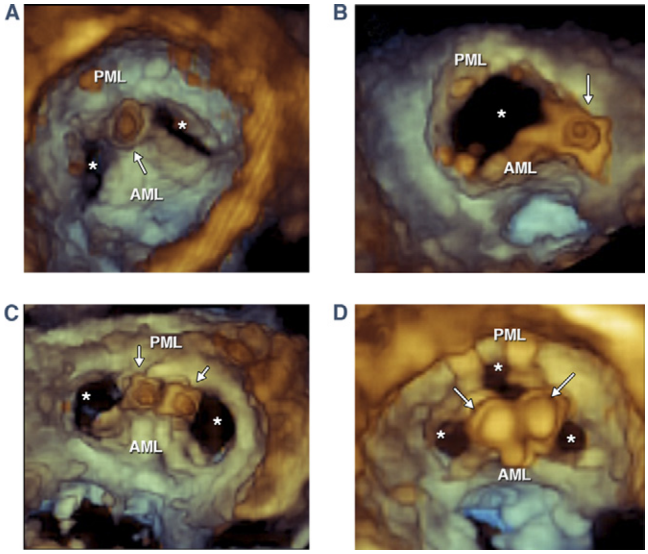

Figure 9. Single, Double, and Triple Orifices

(A, B, C, D) Shows the morphology of the mitral valve after the procedure. The **asterisks** point to the orifices, **arrows** point to the clips. **(A)** One central clip with 2 orifices; **(B)** 1 medial paracommissural clip with 1 orifice; **(C)** 2 adjacent central clips with 2 orifices; **(D)** 2 central separate clips with 3 orifices. AML = anterior mitral leaflet; PML = posterior mitral leaflet.

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APPENDIX

For supplementary videos and their legends, please see the online version of this article.