



How to mirror tricuspid transcatheter edge-to-edge repair (TEER) to mitral TEER in terms of procedural imaging and device workflow: a step-by-step primer

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Transcatheter edge-to-edge repair (TEER) has emerged as a pivotal therapy for mitral and tricuspid regurgitation in patients at high surgical risk. Although anatomical similarities between the mitral and tricuspid valves have allowed the use of the same clip delivery system (CDS) for both procedures, important anatomical differences and imaging challenges necessitate distinct procedural strategies. In this keynote lecture, we compare the technical aspects and imaging guidance of mitral and tricuspid TEER and highlight key maneuvers that optimize procedural success and safety. We focus on the Abbott MitraClip and TriClip systems given both are Food and Drug Administration (FDA) approved in the United States and we have extensive experience with both systems. This stepwise procedural review outlines the nuances of CDS manipulation in both mitral and tricuspid TEER, emphasizing directional response, trajectory optimization, clip alignment, leaflet grasping, and deployment techniques. Differences in imaging requirements and catheter steering are addressed with reference to transesophageal echocardiography (TEE), intracardiac echocardiography (ICE), and fluoroscopic landmarks. CDS flexion and advancement from the atrium to the valve follow similar principles in both TEER procedures; however, CDS rotation produces opposite directional effects relative to the septum. In mitral TEER, the CDS is steered from lateral to medial, whereas in tricuspid TEER, it is directed from septal to lateral. Using the Abbott MitraClip system, trajectory and orientation adjustments rely primarily on the M and + knobs for mitral TEER, and on the F and S/L knobs for tricuspid TEER. ICE serves as a critical adjunct to TEE in tricuspid TEER due to limited acoustic windows. Grasp optimization involves leaflet-specific torque and individual gripper manipulation. Mitral and tricuspid TEER require distinct navigation strategies and imaging approaches, but can be standardized and mirrored in parallel for better understanding between both procedures. Mastery of these valve-specific techniques, along with continued innovation in imaging and CDS design, will be essential to improving the safety and efficacy of tricuspid TEER.

Keywords: Transcatheter edge-to-edge repair (TEER); mitral regurgitation; tricuspid regurgitation; transesophageal echocardiography (TEE); intracardiac echocardiography (ICE)



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Introduction

The mitral and tricuspid valves are both atrioventricular valves, symmetrically positioned on either side of the interatrial septum and in proximity to the aortic valve.

This anatomic symmetry suggests that the imaging strategies and procedural workflows developed for mitral transcatheter edge-to-edge repair (TEER) can, in principle, be adapted for tricuspid TEER. Indeed, early tricuspid

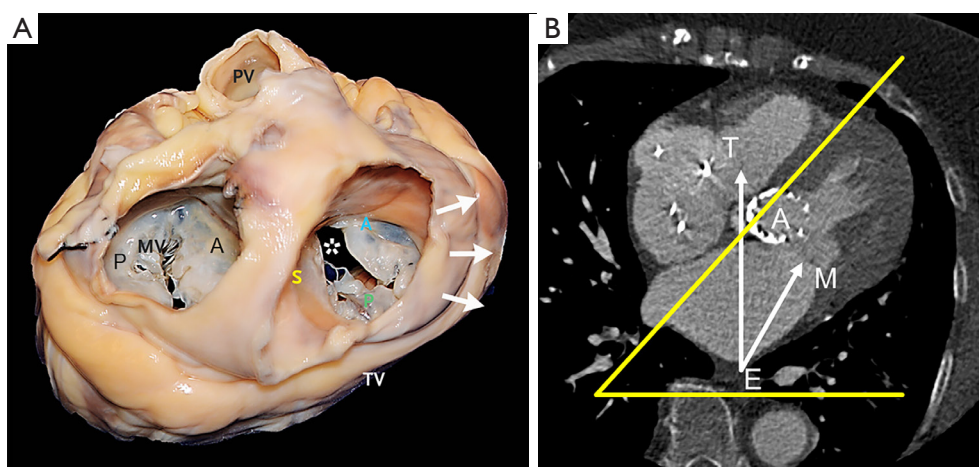


Figure 1 Anatomic relationship between mitral and tricuspid valve. (A) Anatomy of the tricuspid valve (17). As seen from the atrial aspect (A), the valve has a D-shaped annulus, with the septal leaflet adjacent to the interatrial and interventricular septum, the anterior leaflet posterior to the aorta and PV, and the posterior leaflet closest to the diaphragm. In this pathological specimen, the lateral annulus is dilated (arrows), resulting in a large leaflet coaptation gap (asterisk). (B) Spatial relationship between esophagus, mitral valve, and tricuspid valve: reason why asymmetric in vivo. From anterior chest wall side, ventricles, atrioventricular valves, atriums, and esophagus line up in order. Because cardiac axis points to a left at 45° angle (yellow lines), relationships between E and each atrioventricular valve are different from left to right. The esophagus is just behind the left atrium and is close to the M, which makes it easy for the TEE to visualize the mitral valve. On the other hand, the esophagus is far from the T, which decreases the quality of TEE visualization. Furthermore, in cases such as post aortic valve replacement, post mitral valve replacement, and post mitral TEER, the prosthetic shadowing interrupts the tricuspid images. black A, anterior mitral leaflet; blue A, anterior leaflet of the tricuspid valve; white A, aortic valve; CT, computed tomography; E, esophagus; M/MV, mitral valve; P in black, posterior mitral leaflet; P in green, posterior leaflet of the tricuspid valve; PV, pulmonic valve; T/TV, tricuspid valve; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

TEER procedures employed the MitraClip system (Abbott Structural Heart, Santa Clara, CA, USA), originally designed for the mitral valve (1-16).

However, despite their anatomic similarities, the mitral and tricuspid valves differ in their spatial relationship to the esophagus and the orientation of the cardiac axis, which typically tilts leftward at approximately 45°. These differences affect transesophageal echocardiography (TEE) visualization and device navigation.

Understanding these distinctions facilitates the effective translation of mitral TEER techniques to the tricuspid setting. In this lecture, we discuss the anatomic parallels between the valves, the spatial relationships among the esophagus, mitral valve, and tricuspid valve, and present a step-by-step procedural and imaging workflow that mirrors mitral TEER for tricuspid TEER. Of note, this lecture is focused on the MitraClip and TriClip systems (Abbott Structural Heart) because only both are commercially available in the United States and therefore, other devices are beyond the scope of this article.

Anatomic symmetry between the mitral and tricuspid valves

The mitral and tricuspid valves exhibit partial anatomical symmetry in reference to the interatrial septum, particularly with respect to the relationship between the septal-side leaflet and its opposing lateral leaflet complex (*Figure 1A*) (17). Adjacent to the septum are the anterior leaflet of the mitral valve and the septal leaflet of the tricuspid valve. Opposite to the septum are the posterior leaflet of the mitral valve and the lateral leaflet complex of the tricuspid valve.

The lateral leaflets of the tricuspid valve consist of both the anterior and posterior leaflets. Therefore, the mitral anterior leaflet corresponds anatomically to the tricuspid septal leaflet, while the mitral posterior leaflet corresponds to the tricuspid lateral leaflet complex (i.e., the anterior and posterior leaflets).

From the perspective of mirroring mitral and tricuspid TEER procedures, understanding each leaflet's relationship to the interatrial septum is critical, as many device

maneuvers are performed relative to the septal-lateral axis. In the mitral valve, the anatomically defined anterior leaflet lies adjacent to the septum and can be considered the septal-side (medial) leaflet, whereas the posterior leaflet lies opposite the septum and corresponds to the lateral leaflet in procedural terms. Similarly, in the tricuspid valve, the septal leaflet represents the septal-side (medial) leaflet, while the anterior and posterior leaflets together form the lateral leaflet complex. Accordingly, grasping the anterior and posterior mitral leaflets parallels grasping the septal and lateral (anterior or posterior) tricuspid leaflets. Recognizing this functional, septal-based mirroring, rather than strict anatomical symmetry, is essential for adapting mitral TEER techniques to the tricuspid position and for avoiding confusion during device navigation and leaflet grasping.

Annular anatomy and structural differences

Both the mitral and tricuspid annuli are dynamic and generally D-shaped in morphology. One primary difference is that the anterior mitral annulus forms a rigid fibrous continuity with the aortic valve, known as the aortic-mitral curtain, and connects the anterior mitral leaflet to the aortic root. In contrast, the posterior mitral annulus lacks fibrous support, making it susceptible to annular dilation and contributing to leaflet malcoaptation between the anterior and posterior mitral leaflets.

The tricuspid annulus consists of a large, C-shaped segment that corresponds to the free wall of the right atrium and right ventricle, and a short, relatively straight septal segment adjoining the ventricular septum and septal leaflet (18,19). Histological studies have demonstrated that the tricuspid annulus lacks significant fibrous or collagenous architecture (20,21). Instead, it is composed largely of adipose tissue, particularly in the anterosuperior and inferior regions (21). Right ventricular muscle bridges insert directly into the tricuspid annular region (20), further influencing its compliance and mechanical behavior.

Tricuspid annular dilation predominantly occurs along the anteroposterior axis, corresponding to the right ventricular free wall. In contrast, dilation of the septal segment is limited due to its proximity to the fibrous skeleton of the heart (19). Thus, in both valves, annular dilation tends to occur laterally—away from the aortic valve and interatrial septum.

In mitral TEER, the presence of the anterior fibrous skeleton allows for an indirect annuloplasty effect in the anteroposterior direction (22-24). In tricuspid TEER,

data evaluating the annuloplasty effect of tricuspid TEER remain limited (25). Further investigation is warranted.

Leaflet anatomy and implications for TEER

The mitral valve consists of two primary leaflets—anterior and posterior—each further subdivided into three segments from lateral to medial: A1, A2, and A3; P1, P2, and P3, respectively.

Tricuspid valve leaflets are generally thinner and more delicate than mitral valve leaflets, necessitating careful and gentle grasping during TEER procedures. The tricuspid valve typically has three leaflets: anterior, posterior, and septal. However, leaflet number and morphology can vary significantly in the general population (17,26,27). A standardized echocardiographic classification of tricuspid leaflet anatomy has described the following variations (*Figure 2*) (26):

- ❖ Type I (three distinct leaflets): 53.9%.
- ❖ Type II (bicuspid, with fused anterior and posterior leaflets): 4.5%.
- ❖ Type IIIA (four leaflets with two anterior leaflets): 2.6%.
- ❖ Type IIIB (two posterior leaflets): 32.1%.
- ❖ Type IIIC (two septal leaflets): 3.8%.
- ❖ Type IV (more than four leaflets): 2.4%.

During TEER, leaflet grasping is typically performed between a leaflet located medially—toward the aortic valve or interatrial septum—and its lateral counterpart. In mitral TEER, this involves grasping the anterior and posterior mitral leaflets. Similarly, in tricuspid TEER, the septal leaflet is grasped with either the anterior or posterior leaflet.

When anatomic variants are present—such as accessory or multiple leaflet segments—the procedure becomes technically challenging. Complex subvalvular chordal anatomy, limited leaflet grasping surface area, and irregular regurgitant orifice shapes may complicate device positioning and leaflet capture (26).

Additionally, attempts to grasp the anterior and posterior tricuspid leaflets directly (without involving the septal leaflet) have not been shown to be effective in reducing TR, due to the inability to reduce the gap caused by the anterior-posterior canyon, and cannot lead to septal-lateral reduction.

Chordae tendinae and papillary muscle anatomy

In the mitral valve, the primary chordae attach to the free

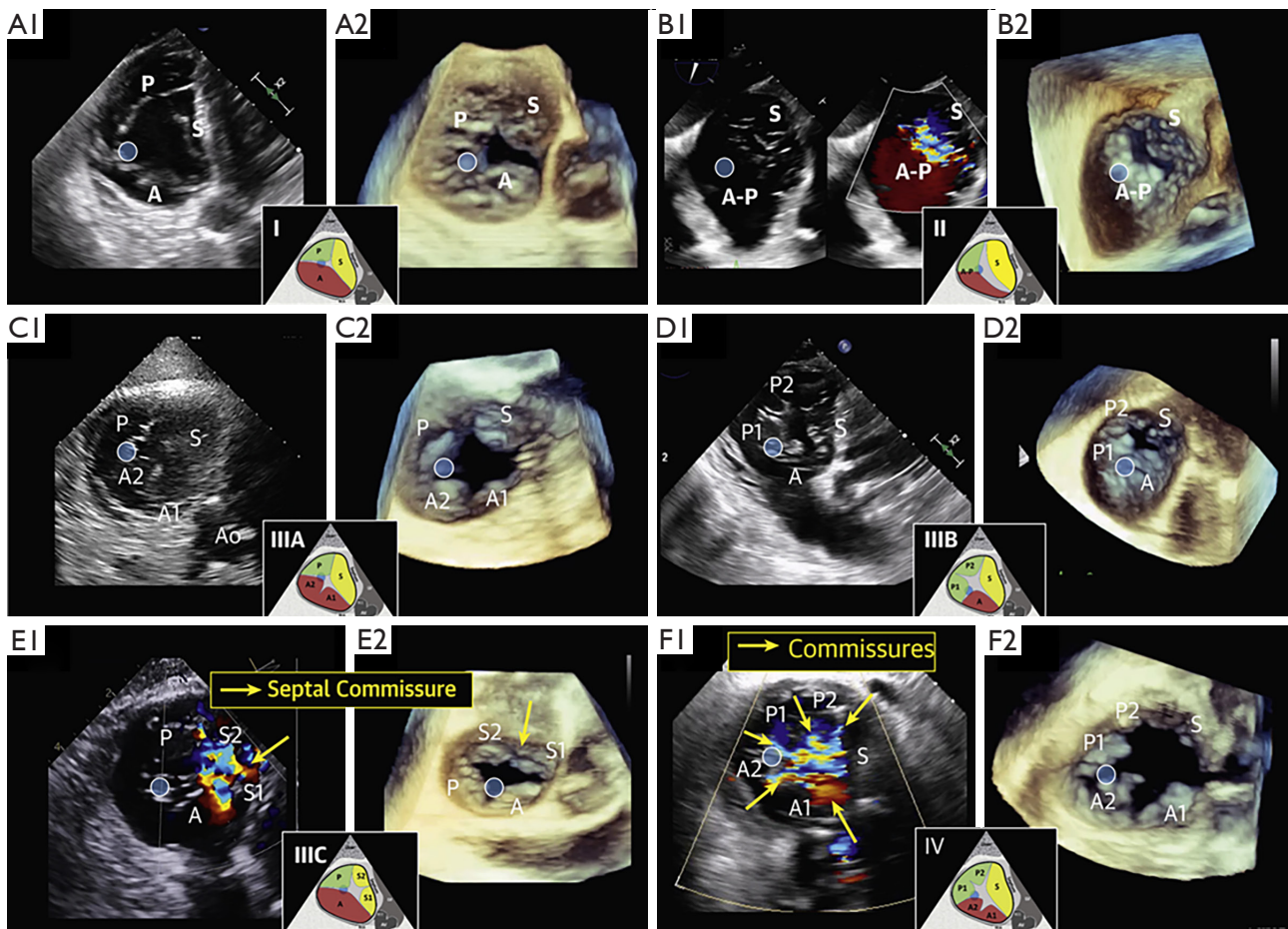


Figure 2 Transesophageal imaging examples of tricuspid valve nomenclature classification scheme (26). In the examples shown in this figure, locating the anterior papillary muscle (blue circle) defines the commissure between the anterior and posterior leaflets. (A1,B1,C1,D1,E1,F1) Transgastric two-dimensional imaging plane; (A2,B2,C2,D2,E2,F2) three-dimensional en-face midesophageal view. (A1,A2) Type I, three-leaflet configuration; (B1,B2) type II, two-leaflet configurations; (C1,C2) type IIIA, quadricuspid valve with two anterior leaflet; (D1,D2) type IIIB, quadricuspid valve with two posterior leaflets; (E1,E2) IIIC, quadricuspid valve with two septal leaflets; (F1,F2) type IV, 5-leaflet configuration. A, anterior leaflet; P, posterior leaflet; S, septal leaflet.

edge of the rough zone of both anterior and posterior leaflets. Secondary chordae insert along the ventricular surface of the leaflet body, while tertiary chordae—found exclusively in the posterior leaflet—anchor directly to the ventricular wall at the basal zone (28). The anterolateral papillary muscle provides chordal support to the lateral halves of both the anterior and posterior leaflets, whereas the posteromedial papillary muscle supports their medial halves (28).

In the tricuspid valve, the anterior papillary muscle is typically the largest and supplies chordae to both the anterior and posterior leaflets. The posterior papillary muscle is frequently bifid or trifid and provides chordal

attachments to the posterior and septal leaflets. Notably, the tricuspid valve also receives chordae from small septal papillary muscles or directly from the interventricular septum, a unique feature not seen in the mitral valve. These septal chordae support the anterior portion of the septal leaflet and adjacent regions of the anterior or posterior leaflet (17,18).

Chordal anatomy plays a critical role in clip orientation during TEER procedures. As the clip delivery system (CDS) advances into the ventricle, rotation to achieve proper alignment risks entanglement with subvalvular chords. A thorough understanding of chordal distribution is essential to prevent and manage such complications.

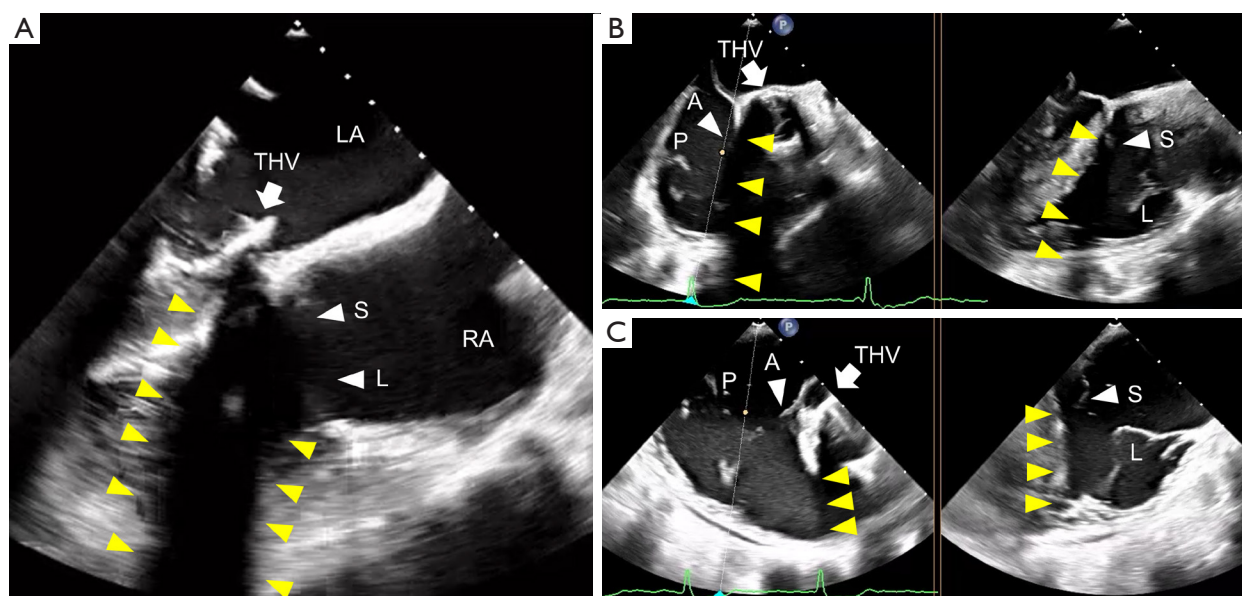


Figure 3 TEE images showing poor visualization of tricuspid valve after transcatheter heart valve replacement with balloon-expandable valve. (A) Mid-esophageal grasping view for tricuspid TEER. Strong acoustic shadow (yellow arrow heads) from the metal frame of the mitral THV (white arrow) significantly limits visualization of the septal and lateral leaflets of the tricuspid valve (white arrowheads). (B) In a patient with the aortic THV (white arrow), mid-esophageal RV inflow view (left) bi-plane imaging to the RV grasping view (right) demonstrates significant acoustic shadowing (yellow arrowheads) from the aortic THV, restricting visualization of the tricuspid anterior and septal leaflets (white arrowheads). (C) In the same patient as in (B), deep esophageal RV inflow (left) bi-plane imaging to the RV grasping view (right) improves visualization of the tricuspid anterior and septal leaflets (white arrowheads) by displacing the aortic THV (white arrow) and its associated acoustic shadow (yellow arrowheads) away from the echocardiographic beam. A, anterior; L, lateral; LA, left atrium; P, posterior; RA, right atrium; RV, right ventricle; S, septal; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair; THV, transcatheter heart valve.

Additionally, tricuspid chordae are generally thinner and more fragile than mitral chordae. Any attempt to resolve entanglement must be performed with deliberate, gentle manipulation to avoid damaging these delicate structures.

Spatial relationship between esophagus, interatrial septum, mitral valve, and tricuspid valve: understanding catheter movement

From the anterior chest wall inward, the anatomic alignment proceeds as follows: ventricles, atrioventricular valves, atria, and finally the esophagus (*Figure 1B*). Due to the cardiac axis angling approximately 45° to the left (*Figure 1B*, yellow lines), the spatial relationship between the esophagus and each atrioventricular valve differs significantly between the left and right sides of the heart (*Figure 1B*, white arrows).

The esophagus lies directly posterior to the left atrium

and in close proximity to the mitral valve, allowing excellent visualization of the mitral apparatus with TEE. In contrast, the tricuspid valve is located farther from the esophagus. This greater distance results in reduced TEE image quality for the tricuspid valve due to attenuation and scattering of the ultrasound signal.

Moreover, the longer acoustic pathway increases susceptibility to ultrasound interference. In particular, artifacts are common in patients with prior structural interventions—such as aortic valve replacement, mitral valve replacement, or mitral TEER—where prosthetic materials or implanted devices may create acoustic shadowing or reverberation that obscures tricuspid leaflet visualization (*Figure 3A,3B*). The TEE deep esophageal view may help mitigate prosthetic valve–related acoustic shadowing and should be considered when available (*Figure 3C*).

In such cases, three-dimensional intracardiac echocardiography (ICE), positioned within the right atrium, offers a direct and

Table 1 Principles of mirroring relationship between mitral and tricuspid TEER

Maneuvers	Mitral	Tricuspid
After entering atrium	Advance CDS posteriorly and laterally to straddle against SGC (<i>Figure 4A</i> , white arrow 1); retracts system towards septum to make room to steer CDS to mitral valve	Remains within right atrium and retracts SGC towards IVC to make room to steer CDS to tricuspid valve
Steering down to valve using CDS	M knob: flex medially away from lateral annulus toward the mitral valve (<i>Figure 4A</i> , white arrow 2)	F knob: flex centrally away from septum toward the tricuspid valve (<i>Figure 4A</i> , white arrow 3)
Advancing the system with stabilizer	Moves the clip along the coaptation line between the septal-side (mitral anterior) leaflet and the lateral (mitral posterior) leaflet toward the lateral commissure (<i>Figure 4A</i> , yellow arrow a)	Moves the clip along the coaptation line between the septal-side (tricuspid septal) leaflet and the lateral [tricuspid lateral (anterior or posterior)] leaflet toward the anterior-septal commissure (<i>Figure 4A</i> , green arrow a)
Retracting the system with stabilizer	Moves the clip along coaptation line between the septal-side (mitral anterior) leaflet and the lateral (mitral posterior) leaflet toward the medial commissure (<i>Figure 4A</i> , yellow arrow b)	Moves the clip along coaptation line between the septal-side (tricuspid septal) leaflet and the lateral [tricuspid lateral (anterior or posterior)] leaflet toward the posterior-septal commissure (<i>Figure 4A</i> , green arrow b)
Clockwise rotation of SGC	Directs the clip posteriorly toward the posterior leaflet (<i>Figure 4B</i> , yellow arrow c)	Directs the clip toward the septal leaflet (<i>Figure 4C</i> , green arrow c)
Counterclockwise rotation of SGC	Directs the clip anteriorly, toward the anterior leaflet (<i>Figure 4B</i> , yellow arrow d)	Directs the clip away from the septum, laterally toward the anterior or posterior leaflet (<i>Figure 4C</i> , green arrow d)

CDS, clip delivery system; IVC, inferior vena cava; SGC, steerable guide catheter; TEER, transcatheter edge-to-edge repair.

unobstructed view of the tricuspid valve leaflets. ICE serves as a valuable adjunct to TEE, especially when image quality is compromised by anatomical factors (e.g., multiple TV leaflets, large malcoaptation gaps, multiple regurgitant jets, and so on) and/or imaging limitations (horizontal heart, hiatal hernia, acoustic shadowing from prosthetic material or device leads) (29).

General principals of mirroring relationship between mitral and tricuspid TEER

In both mitral and tricuspid TEER procedures, the steerable guide catheter (SGC) and CDS enter the heart via the inferior vena cava (IVC) to reach the right atrium. Afterwards, according to the abovementioned anatomic relationship, most of the procedures are mirrored to the septum. The general principles of the procedural maneuvers are summarized in *Table 1* and *Figure 4*.

Understanding these mirrored relationships—using

the M knob for mitral and F knob for tricuspid, advancing and retracting the system for lateral/medial position for mitral and anterior/posterior for tricuspid respectively, +/- knob on mitral and S/L knob on the SGC to optimize clip trajectory for ventricular entry and grasping, clockwise/counterclockwise rotation of the SGC to go posterior/anterior for mitral and septal/lateral for tricuspid—facilitate intuitive adaptation of mitral TEER procedural skills to tricuspid TEER.

Imaging and procedural step-by-step flow by mirroring mitral technique to tricuspid TEER

Complete step-by-step sequences of both mitral and tricuspid TEER procedures (*Figures 5-10*) are summarized in *Table 2* to help readers visualize the parallels between the two procedures. In addition, step-by-step imaging-focused workflow for mitral and tricuspid TEER are summarized in *Table 3*.

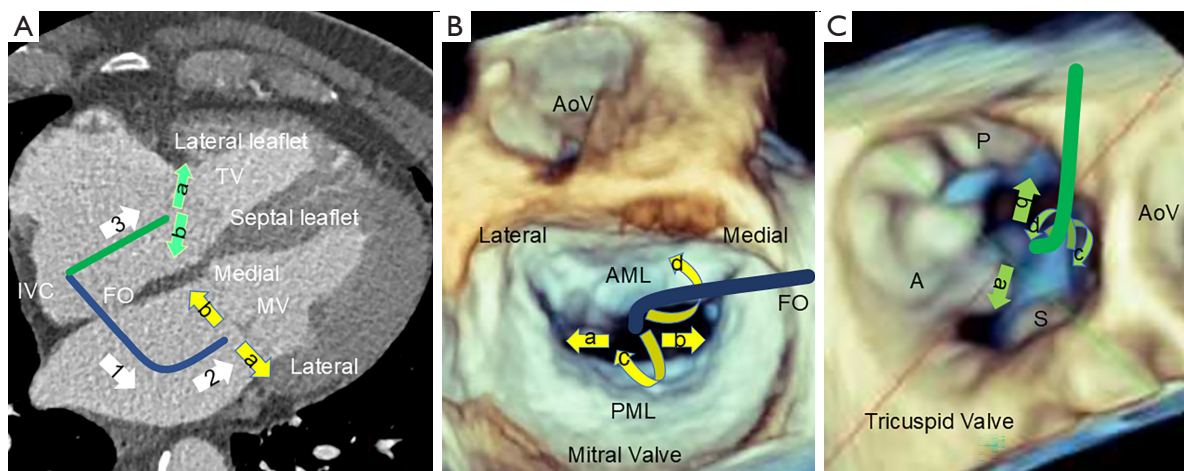


Figure 4 CT and 3D TEE images showing movement of the clip delivery system. Mitral TEER: Advance CDS posteriorly and laterally to straddle against SGC (A, white arrow 1). M knob: flexed anteriorly and medially away from lateral annulus toward the mitral valve (A, white arrow 2). Advancing the system with stabilizer moves toward lateral commissure (A,B, yellow arrow a). Retracting the system with stabilizer moves toward medial commissure (A,B, yellow arrow b). Clockwise rotation of SGC directs the clip posteriorly, away from the aorta which is along the same plane as the septum, toward the posterior leaflet (B, yellow arrow c). Counterclockwise rotation of SGC directs the clip anteriorly, toward the anterior leaflet (B, yellow arrow d). Tricuspid TEER: F knob: flex centrally away from septum toward the tricuspid valve (A, white arrow 3). Advancing the system with stabilizer moves toward anterior-septal commissure (A,C, green arrow a). Retracting the system with stabilizer moves toward posterior-septal commissure (A,C, green arrow b). Clockwise rotation of SGC directs the clip to move medially, toward the septal leaflet (C, green arrow c). Counterclockwise rotation of SGC directs the clip laterally, away from the septum, toward the anterior or posterior leaflet (C, green arrow d). A, anterior leaflet; AML, anterior mitral leaflet; AoV, aortic valve; CDS, clip delivery system; CT, computed tomography; FO, fossa ovalis; IVC, inferior vena cava; MV, mitral valve; P, posterior leaflet; PML, posterior mitral leaflet; S, septal leaflet; SGC, steerable guide catheter; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair; TV, tricuspid valve.

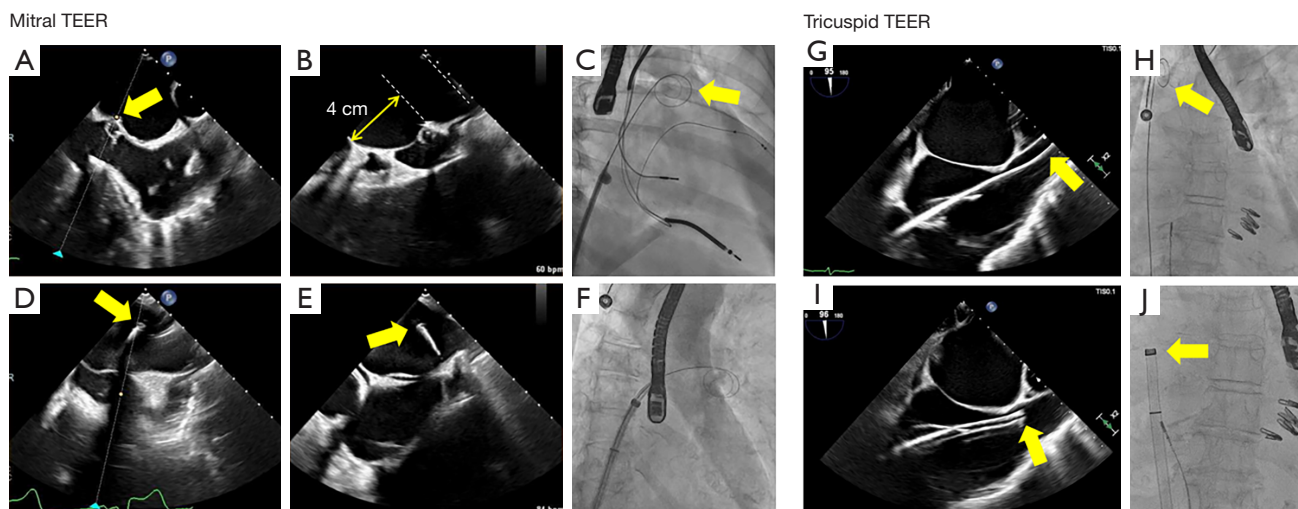


Figure 5 Guidewire and SGC placement in atrium. Mitral TEER: (A) TEE bicaval view showing SafeCross at inferior interatrial septum (yellow arrow). (B) TEE reverse four-chamber view showing distance from puncture site to mitral leaflet coaptation zone more than 4 cm (bidirectional yellow arrow). (C) Fluoroscopic RAO view showing Safari guidewire in left upper pulmonary vein (yellow arrow). (D) TEE bicaval view showing SGC across interatrial septum (yellow arrow). At least 1 cm of the SGC should be advanced into the left atrium. (E)

TEE reverse short axis aortic valve view showing SGC across interatrial septum (yellow arrow: tip of the SGC). At least 1 cm of the SGC should be advanced into the left atrium. (F) Fluoroscopic RAO view showing SGC across interatrial septum. Tricuspid TEER: (G) TEE bicaval view showing Safari guidewire in SVC (yellow arrow). (H) Fluoroscopic AP view showing Safari guidewire in SVC (yellow arrow). (J) Fluoroscopic AP view showing SGC in RA (yellow arrow). The negative deflection is maintained. AP, anterior-posterior; RA, right atrium; RAO, right anterior oblique; SGC, steerable guide catheter; SVC, superior vena cava; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

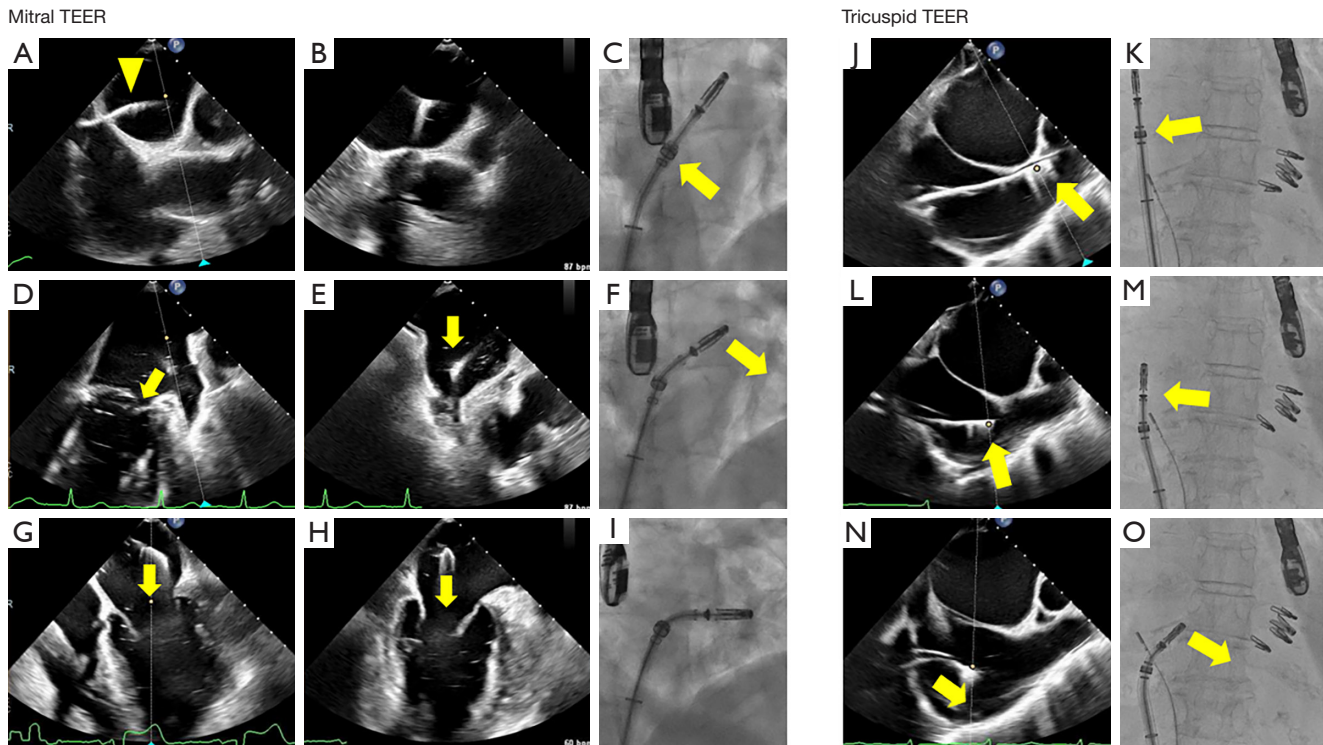


Figure 6 CDS steering towards valve. Mitral TEER: (A) TEE bicaval view and (B) biplane to short axis view. The SGC tip remains at least 2 cm within the left atrium to avoid accidental withdrawal from the left to right atrium (yellow arrowhead). (C) Fluoroscopic AP view. Stabilizer may need to be retracted towards the septum to facilitate CDS advancement and straddle against SGC (yellow arrow). (D,E) CDS is steered down from the lateral side towards the mitral valve. This is achieved by flexing the CDS medially using the M-knob, while simultaneously clockwise rotation of the SGC by applying posterior guide torque (yellow arrows). (F) Fluoroscopic RAO view. CDS is steered down from the lateral side towards the mitral valve. This is achieved by flexing the CDS medially using the M-knob, while simultaneously clockwise rotating the SGC by applying posterior guide torque (yellow arrows). (G) TEE bicaval view and (H) biplane to LVOT view. CDS is steered down from the lateral side towards the mitral valve. This is achieved by flexing the CDS medially using the M-knob, while simultaneously clockwise rotating the SGC by applying posterior guide torque (yellow arrows). (I) Fluoroscopic RAO view. CDS is steered down from the lateral side towards the mitral valve. This is achieved by flexing the CDS medially using the M-knob, while simultaneously clockwise rotating the SGC by applying posterior guide torque. Tricuspid TEER: (J) TEE bicaval view showing clip at SVC-RA junction (yellow arrow). (K) Fluoroscopic AP view. Stabilizer may need to be partially retracted towards the IVC to facilitate CDS advancement and straddle against the SGC (yellow arrow). (L) TEE bicaval view. The negative deflection is neutralized while maneuvering the clip away from septum (yellow arrow). (M) Fluoroscopic RAO view. The negative deflection is neutralized while maneuvering the clip away from septum (yellow arrow). (N) TEE bicaval view. CDS is steered down from the septal side towards the tricuspid valve. This is achieved by flexing the CDS using the F-knob, while simultaneously counterclockwise rotating the SGC, which shifts the CDS away from the septum (yellow arrow). (O) Fluoroscopic RAO view. CDS is steered down from the septal side towards the tricuspid valve. This is achieved by flexing the CDS using the F-knob, while simultaneously counterclockwise rotating the SGC, which shifts the CDS away from the septum (yellow arrow). AP, anterior-posterior; CDS, clip delivery system; LVOT, left ventricular outflow tract; RA, right atrium; RAO, right anterior oblique; SGC, steerable guide catheter; SVC, superior vena cava; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

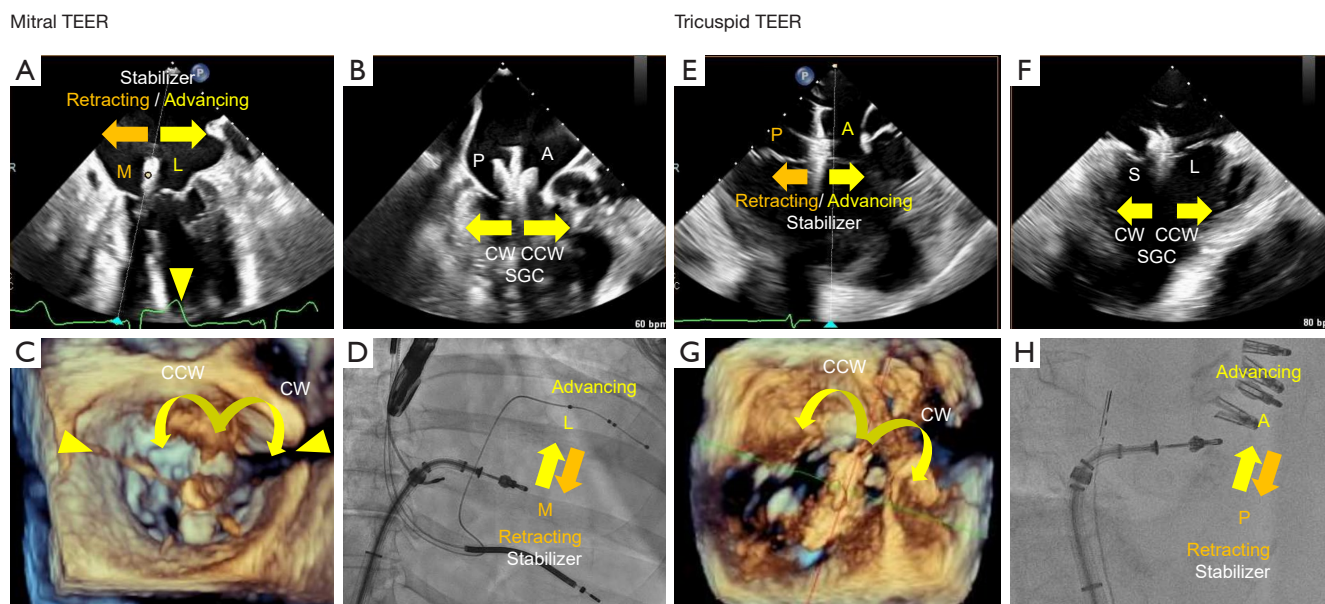


Figure 7 Adjusting clip position and orientation. Mitral TEER: (A) TEE bicommissural view with the apex oriented at 6 o'clock (yellow arrowhead). Advancing stabilizer moves the clip from medial to lateral commissure (yellow arrow). Retracting stabilizer moves the clip from lateral to medial commissure (orange arrow). (B) TEE LVOT view. Clockwise rotating SGC brings the clip towards posterior leaflet. Counterclockwise rotating SGC brings the clip towards anterior leaflet (yellow arrows). (C) TEE 3D en-face view with medial and lateral commissures at 2° and 10°, respectively (yellow arrowheads). The clip arm orientation is adjusted perpendicular to the coaptation line of the target lesion by rotating the DC fastener handle (yellow arrows). (D) Fluoroscopic RAO view. Advancing stabilizer moves the clip from medial to lateral commissure (yellow arrow). Retracting stabilizer moves the clip from lateral to medial commissure (orange arrow). Tricuspid TEER: (E) ICE RV inflow view. Advancing stabilizer moves the clip from posterior-septal to anterior-septal commissure (yellow arrow). Retracting stabilizer moves the clip from anterior-septal to posterior-septal commissure (orange arrow). (F) ICE reverse 4-chamber grasping view. Clockwise rotating SGC brings the clip towards septal leaflet. Counterclockwise rotating SGC brings the clip towards lateral (anterior/posterior) leaflet (yellow arrows). (G) ICE 3D en-face view. The clip arm orientation is adjusted perpendicular to the coaptation line of the target lesion by rotating the DC fastener handle (yellow arrows). (H) Fluoroscopic RAO view. Advancing stabilizer moves the clip from posterior-septal to anterior-septal commissure (yellow arrow). Retracting stabilizer moves the clip from anterior-septal to posterior-septal commissure (orange arrow). A, anterior leaflet; CCW, counterclockwise; CDS, clip delivery system; CW, clockwise; ICE, intracardiac echocardiography; L, lateral commissure for Mitral TEER, lateral leaflet for Tricuspid TEER; LVOT, left ventricular outflow tract; M, medial commissure; P, posterior leaflet; RAO, right anterior oblique; RV, right ventricular; S, septal leaflet; SGC, steerable guide catheter; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

Future directions

Ongoing innovation and enhancement of imaging modalities, particularly three-dimensional ICE to complement TEE, are essential to improve procedural guidance and outcomes.

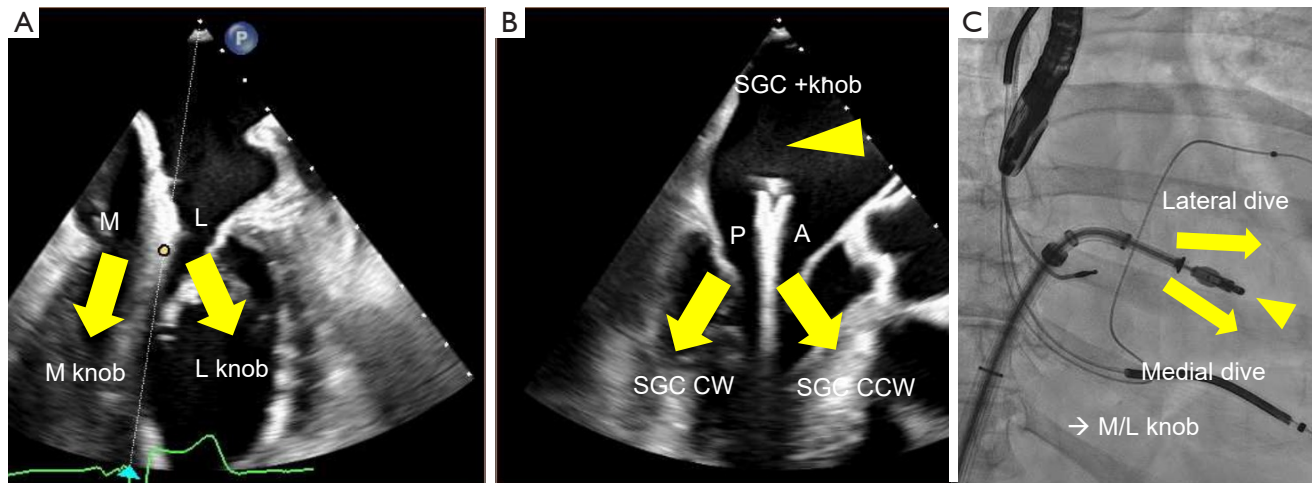
Recent advancements in the latest-generation MitraClip and TriClip G5 systems have improved ease of use for both procedures. Further device innovations are needed to

address anatomic challenges which currently complicate device navigation and positioning, such as the aorta hugger trajectory in mitral TEER, and the offset between the IVC and the tricuspid annulus causing septal hugger trajectory in tricuspid TEER.

Conclusions

The spatial relationship between the esophagus and

Mitral TEER



Tricuspid TEER

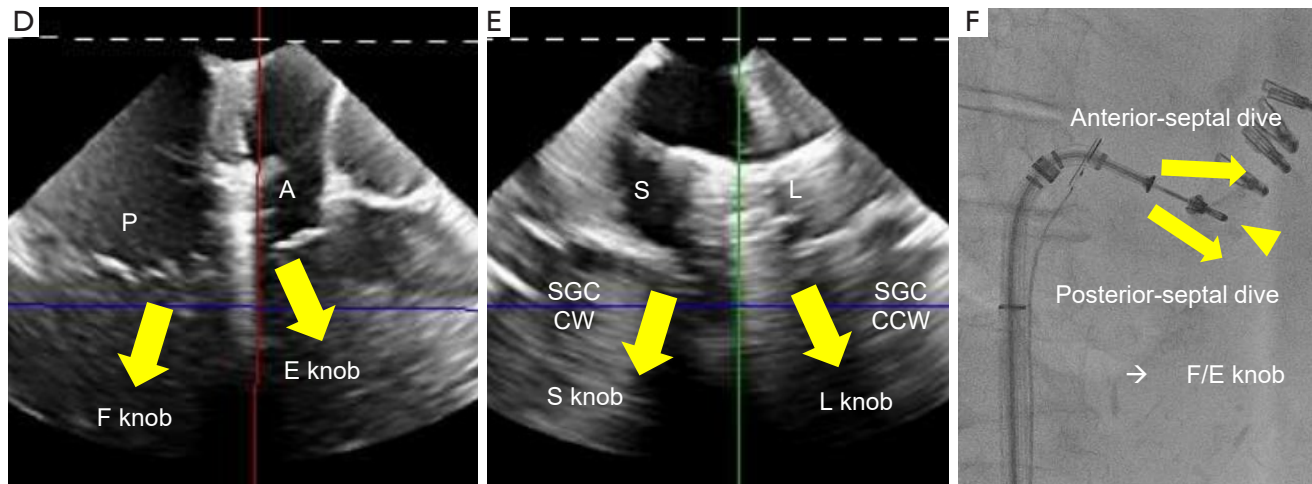


Figure 8 Checking clip trajectory. Mitral TEER: (A) TEE bicommissural view. M-knob towards medial trajectory. L-knob toward lateral trajectory (yellow arrows). (B) TEE LVOT grasping view. Clockwise SGC to posterior leaflet. Counterclockwise SGC to anterior leaflet (yellow arrows). The “+” (plus) knob is used to move the clip away from aorta. For anterior transseptal puncture, aorta hugger trajectory, to correct, add (+) knob to deflect the CDS more medially in bicommissural view, then counterclockwise the SGC to bring the CDS from posterior to more centrally on LVOT grasping view (yellow arrowhead). (C) Fluoroscopic RAO view. M-knob towards medial trajectory. L-knob toward lateral trajectory (yellow arrows). Parallax is eliminated from the clip arms to optimize orientation by rotating the DC fastener handle on 3D en-face view on TEE (yellow arrowhead). Tricuspid TEER: (D) ICE RV inflow view. F-knob towards posterior trajectory. E-knob toward anterior trajectory (yellow arrows). (E) Grasping view. Clockwise SGC to septal leaflet. Counterclockwise SGC to lateral (anterior/posterior) leaflet (yellow arrows). S knob on SGC is used to move the clip towards septum. L knob on SGC is used to move the clip away from septum toward lateral annulus (yellow arrows). For septal hugger trajectory, to correct, add L knob then clock the SGC to optimize clip trajectory before entering into right ventricle. (F) Fluoroscopic RAO view. F-knob towards posterior-septal trajectory. E-knob toward anterior-septal trajectory (yellow arrows). Parallax is eliminated from the clip arms to optimize orientation by rotating the DC fastener handle under the transgastric short-axis view on TEE/3D MPR in ICE (yellow arrowhead). A, anterior leaflet; CCW, counterclockwise; CDS, clip delivery system; CW, clockwise; ICE, intracardiac echocardiography; L, lateral commissure for Mitral TEER; LVOT, left ventricular outflow tract; M, medial commissure; P, posterior leaflet; RAO, right anterior oblique; RV, right ventricular; S, septal leaflet; SGC, steerable guide catheter; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

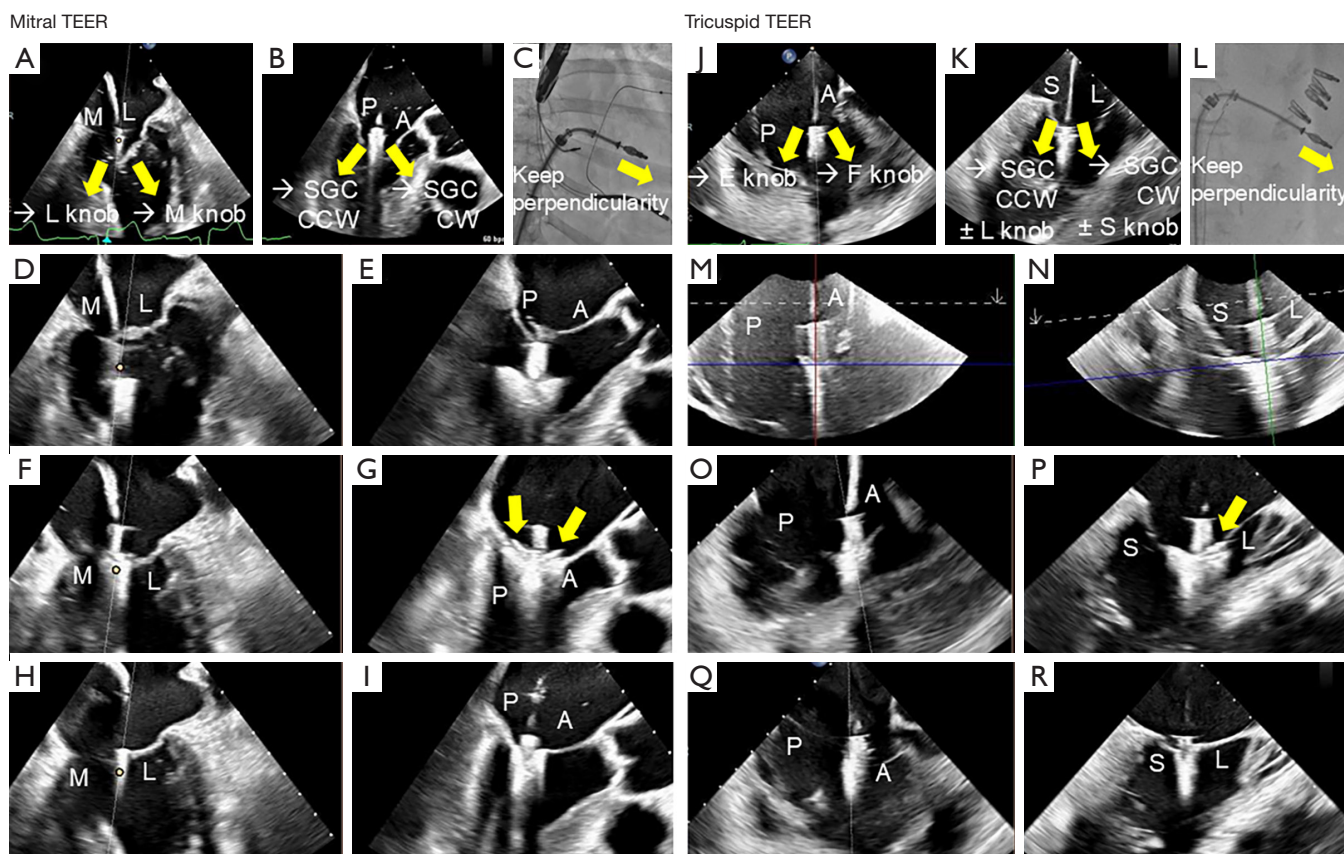


Figure 9 Advancing clip into ventricle and grasping leaflets. Mitral TEER: (A) TEE bicommissural view. Medial dive → L knob to shift more lateral. Lateral dive → M knob to shift more medial (yellow arrows). (B) TEE LVOT view. Anterior dive → SGC clockwise to posterior. Posterior dive → SGC counterclockwise to anterior (yellow arrows). (C) Fluoroscopic RAO view. Adjust clip perpendicularity by maintaining no parallax on the clip to maintain its optimal orientation, while watching for medial or lateral dive (yellow arrow). (D) TEE bicommissural view with biplane imaging showing LVOT view (E). Recheck clip orientation. (F) TEE bicommissural view with biplane imaging showing LVOT view (G). Grippers are slowly lowered during diastole to grasp the leaflets. A gripper “bounce” is a useful echocardiographic sign confirming leaflet capture (yellow arrows). (H) TEE bicommissural view biplane imaging to LVOT view (I). Further clip closure is performed while slowly advance the DC fastener handle to below the annulus to remove system tension. Tricuspid TEER: (J) ICE RV inflow view. Anterior dive → F knob to shift more posterior. Posterior dive → E knob to shift more anterior (yellow arrows). (K) ICE grasping view. Septal dive → SGC counterclockwise ± L knob. Lateral dive → SGC clockwise ± S knob (yellow arrows). (L) Fluoroscopic RAO view. Adjust clip perpendicularity by maintaining no parallax on the clip to maintain its optimal orientation, while watching for anterior or posterior dive (yellow arrow). (M) ICE RV inflow view biplane imaging to grasping view (N). Recheck clip orientation. (O) ICE RV inflow view biplane imaging to grasping view (P). Grippers are slowly lowered during diastole to grasp the leaflets. A gripper “bounce” is a useful echocardiographic sign confirming leaflet capture (yellow arrow). (Q) ICE RV inflow view with biplane imaging to grasping view (R). Further clip closure is performed while slowly advance the DC fastener handle to below the annulus to remove system tension. A, anterior leaflet; CCW, counterclockwise; CDS, clip delivery system; CW, clockwise; ICE, intracardiac echocardiography; L, lateral commissure for Mitral TEER, lateral leaflet for Tricuspid TEER; LVOT, left ventricular outflow tract; M, medial commissure; P, posterior leaflet; RAO, right anterior oblique; RV, right ventricle; S, septal leaflet; SGC, steerable guide catheter; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

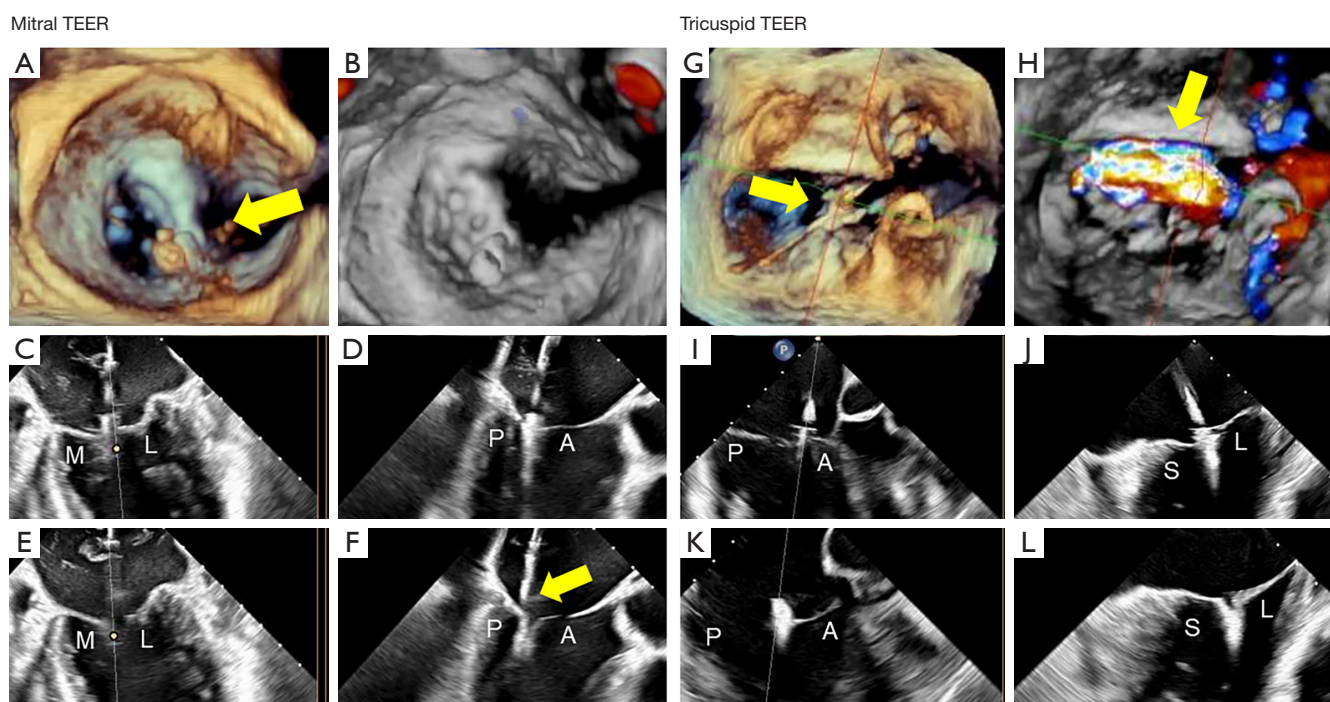


Figure 10 Assessment of grasping and releasing the clip. Mitral TEER: (A) TEE 3D en-face view showing tissue bridge between anterior and posterior leaflet (yellow arrow). (B) TEE 3D en-face color view. Assess reduction in mitral regurgitation. (C) TEE bicommissural view with biplane imaging to LVOT view (D). Final clip arm angle is established by rotating the arm opener counterclockwise to the neutral position, then an additional 270° to ensure that the clip arms are fully secured and cannot reopen. (E) TEE bicommissural view biplane imaging to LVOT view (F) showing that the DC fastener is slowly withdrawn to disengage the needle from the deployed clip (yellow arrow). Tricuspid TEER: (G) ICE 3D en-face view showing tissue bridge between anterior and septal leaflets (yellow arrow). (H) ICE 3D en-face color view. Assess reduction in tricuspid regurgitation (yellow arrow). (I) ICE RV inflow view with biplane imaging to grasping view (J). Final clip arm angle is established by rotating the arm opener counterclockwise to the neutral position, then an additional 270° to ensure that the clip arms are fully secured and cannot reopen. (K) ICE RV inflow view biplane imaging to grasping view (L) showing that the DC fastener is slowly withdrawn to disengage the needle from the deployed clip. A, anterior leaflet; CDS, clip delivery system; ICE, intracardiac echocardiography; L, lateral commissure for Mitral TEER, lateral leaflet for Tricuspid TEER; LVOT, left ventricular outflow tract; M, medial commissure; P, posterior leaflet; RV, right ventricular; S, septal leaflet; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

cardiac structures, as well as the orientation of the cardiac axis, significantly influence both TEE visualization and device navigation in mitral versus tricuspid TEER procedures.

While certain maneuvers—such as steering the CDS toward the valve using the M knob or F knob to “flex” the CDS and advancing the clip along the coaptation line with the stabilizer—are similar in both procedures, clockwise/

counterclockwise rotation of the CDS results in opposite directional movement relative to the septum between mitral and tricuspid TEER.

To enhance procedural safety and success, continued innovation in ICE to complement TEE, together with refinements in SGC and CDS designs, will be valuable—particularly for overcoming anatomic challenges in tricuspid TEER.

Table 2 Step-by-step flow by mirroring mitral technique to tricuspid TEER		
Steps	Mitral	Tricuspid
Preparation	General anesthesia. Tidal volume around 300 mL to minimize respiratory-related cardiac motion. Heart rate below 80 beats per minute facilitates more effective leaflet grasping	
Approach	<ul style="list-style-type: none"> • Right femoral vein • A pressure bag may be placed behind the right scapula to improve TEE image quality if needed 	<ul style="list-style-type: none"> • Right femoral vein standard, but left femoral vein can achieve greater height above the tricuspid leaflets and to better optimize device trajectory to reduce septal hugger • A pressure bag may be placed behind the right scapula to improve TEE image quality if needed • ICE catheter is inserted via the contralateral femoral vein
Guidewire placement	<ul style="list-style-type: none"> • Transseptal puncture is performed at the posterior and mid portion of the fossa to create an optimal trajectory (“runway”) for the SGC (<i>Figure 5A</i>) • The ideal distance from the puncture site to the mitral leaflet coaptation zone is ≥ 4 cm (<i>Figure 5B</i>) • A stiff guidewire, such as a Safari wire, is advanced into the LUPV (<i>Figure 5C</i>) • TEE in bicaval biplane views is used to guide the transseptal puncture, ensuring both the optimal puncture location and successful placement of the stiff wire in the LUPV on both TEE and fluoroscopy 	<ul style="list-style-type: none"> • A stiff guidewire is positioned in the SVC via a multipurpose catheter (<i>Figure 5G,5H</i>) • The TEE bicaval view and fluoroscopy are used to confirm secure wire placement in the SVC
SGC insertion into the atrium	<ul style="list-style-type: none"> • SGC is initially inserted into the femoral vein with negative deflection to keep it aligned in a straight configuration during advancement into the atrium • The negative deflection is then neutralized, allowing the SGC to enter the left atrium with a gentle corkscrew • If resistance is encountered, reapplying negative deflection on SGC can help straighten the tip and enhance advancement • Approximately 2 cm of the SGC should be advanced into the left atrium (<i>Figure 5D-5F</i>) 	<ul style="list-style-type: none"> • The negative deflection is maintained (<i>Figure 5I,5J</i>)
CDS insertion into SGC and steering down toward valve	<ul style="list-style-type: none"> • CDS—comprising the steerable sleeve catheter and the DC fastener—is inserted into the SGC using a “waterfall” technique from above • Blue alignment line on the CDS must be matched to the corresponding line on the SGC (“blue to blue”) to ensure 1:1 torque transmission between the two systems • Advance beyond the SGC until its two radiopaque marker lines straddle the radiopaque tip marker of the SGC • Stabilizer may need to be retracted towards the septum to facilitate CDS advancement and straddle against SGC (<i>Figure 6A-6C</i>, yellow arrow) • During this maneuver, TEE confirms that the SGC tip remains at 2 cm within the left atrium to avoid accidental withdrawal from the left to right atrium (<i>Figure 6A</i>, yellow arrowhead) • CDS is steered down from the lateral side towards the mitral valve (<i>Figure 6D-6F</i>) • This is achieved by flexing the CDS medially using the M-knob, while simultaneously clockwise rotating the SGC by applying posterior guide torque (<i>Figure 6G-6I</i>) 	<ul style="list-style-type: none"> • Stabilizer may need to be retracted towards the IVC to facilitate CDS advancement and straddle against the SGC (<i>Figure 6J,6K</i>) • The negative deflection is neutralized while maneuvering away from septum under TEE (<i>Figure 6L</i>) and fluoroscopy (<i>Figure 6M</i>) • CDS is steered down from the septal side towards the tricuspid valve • This is achieved by flexing the CDS using the F-knob, while simultaneously counterclockwise rotating the SGC (upside down), which shifts the CDS away from the septum (<i>Figure 6N,6O</i>)
Adjusting clip position above the valve		
Echo view	<ul style="list-style-type: none"> • TEE • Bicommisural view with the apex oriented at 6 o’clock (<i>Figure 7A</i> yellow arrowhead) biplane to LVOT grasping view (<i>Figure 7B</i>) • 3D (<i>Figure 7C</i>) and 3D color view • MPR 	<ul style="list-style-type: none"> • TEE/ICE • RV inflow view (<i>Figure 7E</i>) biplane to grasping view (<i>Figure 7F</i>) • Transgastric view • MPR (<i>Figure 7G</i>)
Advancing stabilizer	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • 3D en-face and 3D en-face color view • MPR • From medial to lateral commissure (<i>Figure 7A</i>, yellow arrows) • Fluoroscopic RAO view (<i>Figure 7D</i>, yellow arrow) 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • Transgastric view • MPR • From posterior-septal to anterior-septal commissure (<i>Figure 7E</i>, yellow arrow) • Fluoroscopic RAO view (<i>Figure 7H</i>, yellow arrow)
Retracting stabilizer	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • 3D en-face and 3D en-face color view • MPR • From lateral to medial commissure (<i>Figure 7A</i>, yellow arrows) • Fluoroscopic RAO view (<i>Figure 7D</i>, yellow arrow) 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • Transgastric view • MPR • From anterior-septal to posterior-septal commissure (<i>Figure 7E</i>, yellow arrow) • Fluoroscopic RAO view (<i>Figure 7H</i>, yellow arrow)

Table 2 (continued)

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Steps	Mitral	Tricuspid
Clockwise rotating SGC	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • 3D en-face and 3D en-face color view • MPR • Towards posterior mitral leaflet (<i>Figure 7B</i>, yellow arrows) 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • Transgastric view • MPR • Towards septal leaflet (<i>Figure 7F</i>, yellow arrows)
Counterclockwise rotating SGC	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • 3D en-face and 3D en-face color view • MPR • Towards anterior leaflet (<i>Figure 7B</i>, yellow arrows) 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • Transgastric view • MPR • Towards lateral (anterior/posterior) leaflet (<i>Figure 7F</i>, yellow arrows)
Positioning clip arms for gripper check	<ul style="list-style-type: none"> • In an RAO fluoroscopic view, CDS DC fastener is gently jiggled clockwise and counterclockwise to release tension within the system and orient the clip without parallax to approximately perpendicular to the coaptation line • Grippers are raised and lock handle in G4 is raised (or lock knob in G5 is turned clockwise) to unlock the clip • Clip arms are opened to 60 degrees by rotating arm opener counterclockwise 	
Gripper check	<ul style="list-style-type: none"> • Tactile gripper is lowered first to identify the corresponding leaflet • Then, non-tactile gripper is lowered to confirm • Once confirmed, both grippers are raised with their latches engaged 	
Check clip trajectory	<ul style="list-style-type: none"> • Carefully advancing CDS toward annulus without crossing the valve 	
Flexing CDS	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • MPR • M-knob towards medial trajectory (<i>Figure 8A</i>, yellow arrow) • Fluoroscopic RAO view (<i>Figure 8C</i>, yellow arrow) 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • MPR • F-knob towards posterior-septal trajectory (<i>Figure 8D</i>, yellow arrow) • Fluoroscopic RAO view (<i>Figure 8F</i>, yellow arrow)
Extending CDS	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • MPR • L-knob toward lateral trajectory (<i>Figure 8A</i>, yellow arrow) • Fluoroscopic RAO view (<i>Figure 8C</i>, yellow arrow) 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • MPR • E-knob toward anterior-septal trajectory (<i>Figure 8D</i>, yellow arrow) • Fluoroscopic RAO view (<i>Figure 8F</i>, yellow arrow)
Clockwise SGC	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • MPR • To posterior leaflet (<i>Figure 8B</i>, yellow arrow) 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • MPR • To septal leaflet (<i>Figure 8E</i>, yellow arrow)
Counterclockwise SGC	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • MPR • To anterior leaflet (<i>Figure 8B</i>, yellow arrow) 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • MPR • To lateral (anterior/posterior) leaflet (<i>Figure 8E</i>, yellow arrow)
S knob on SGC		<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • MPR • Towards septum to optimize trajectory (<i>Figure 8E</i>, yellow arrow)
L knob on SGC		<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • MPR • Away from septum toward lateral annulus • For septal hugger trajectory. To correct, add L knob then clock the SGC to optimize clip trajectory before entering into right ventricle (<i>Figure 8E</i>)

Table 2 (continued)

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Steps	Mitral	Tricuspid
+ knob on SGC	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • MPR • Away from aorta • For anterior transeptal puncture, aorta hugger trajectory. To correct, add (+) knob to deflect the CDS more medially in bicommisural view, then counterclockwise the SGC to bring the CDS from posterior to more centrally on LVOT grasping view (Figure 8B, yellow arrowhead) 	
Fluoroscopy	<ul style="list-style-type: none"> • RAO (Figure 8C,8F) • Document clip orientation • Confirm perpendicularity (Figure 8C,8F) • Serve as a fluoroscopic reference 	
Orient clip to perpendicular to coaptation line for optimal orientation for grasping	<ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • 3D en-face view • 3D MPR • Rotating the DC fastener handle to optimize clip orientation (Figures 7C,8C) 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • Transgastric short-axis view • 3D MPR • Rotating the DC fastener handle to optimize orientation (Figures 7C,8C)
Clip entering ventricle	<ul style="list-style-type: none"> • ALWAYS close the clip before advancement into ventricle to prevent leaflet entanglement with the grippers • Bicommisural view with biplane to LVOT grasping view (Figure 9A,9B, yellow arrows) • MPR • Medial dive → L knob to shift more lateral • Lateral dive → M knob to shift more medial • Anterior dive → SGC clockwise to posterior • Posterior dive → SGC counterclockwise to anterior • Fluoroscopic RAO (Figure 9C,9L, yellow arrow) • Adjust clip perpendicularity 	<ul style="list-style-type: none"> • RV inflow view with biplane to grasping view (Figure 9J,9K, yellow arrows) • MPR • Anterior dive → F knob to shift more posterior • Posterior dive → E knob to shift more anterior • Septal dive → SGC counterclockwise ± L knob • Lateral dive → SGC clockwise ± S knob
Preparing for leaflet grasping	<ul style="list-style-type: none"> • Once the clip is positioned below the target leaflets, the clip arms are opened to 120–150 degrees 	
Recheck clip orientation	<ul style="list-style-type: none"> • Bicommisural view biplane imaging to LVOT view (Figure 9D,9E) • 3D en-face view • MPR • RAO fluoroscopic view 	<ul style="list-style-type: none"> • RV inflow view biplane imaging to grasping view (Figure 9M,9N) • Transgastric short-axis view • MPR
Leaflet grasping	<ul style="list-style-type: none"> • Bicommisural view biplane imaging to LVOT grasping view • 3D en-face view • MPR • Retract DC fastener to engage the leaflets for grasping • Grippers are slowly lowered during diastole to engage the leaflets (Figure 9F,9G,9O,9P) • A gripper “bounce” is a useful echocardiographic sign confirming leaflet capture (Figure 9G,9P, yellow arrows) • G4 system: lower the lock handle to lock • G5 system: turn the lock knob counterclockwise to lock • Clip arms are partially closed to 60 degrees, while the DC fastener handle is advanced to reduce leaflet tension and maintain insertion 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • Transgastric short-axis view • MPR

Table 2 (continued)

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Steps	Mitral	Tricuspid
Optimizing leaflet insertion	<ul style="list-style-type: none"> • Bicommisural view biplane imaging to LVOT grasping view • Grasping is optimized by applying posterior (clockwise) or anterior (counterclockwise) torque on the SGC, while maintaining clip orientation by micro-rotation of the DC fastener under fluoroscopy 	<ul style="list-style-type: none"> • RV inflow view biplane to reverse 4-chamber grasping view • Transgastric short-axis view • MPR • Grasping is optimized by applying septal (clockwise) or lateral (counterclockwise) torque on the SGC, while maintaining orientation by micro-rotation of the DC fastener on fluoroscopy
Closing the clip	<ul style="list-style-type: none"> • Further clip closure is performed while continuing to advance the DC fastener handle (<i>Figure 9H,9I,9Q,9R</i>) • Slight posterior torque is applied to prevent posterior leaflet slippage 	<ul style="list-style-type: none"> • Slight septal torque is applied to prevent septal leaflet slippage
Evaluation of leaflet insertion after grasping	<ul style="list-style-type: none"> • Bicommisural biplane to LVOT grasping view • 3D en-face • MPR • Residual leaflet length is measured and compared to the baseline leaflet length to confirm successful capture 	<ul style="list-style-type: none"> • RV inflow biplane to grasping view • Transgastric short-axis view • 3D MPR • Measurement of residual leaflet length may be less reliable due to increased leaflet stretchability, which can affect visual estimation
Echo visualization of leaflet insertion	<ul style="list-style-type: none"> • 3D en-face or MPR view showing tissue bridge (<i>Figure 10A</i>, yellow arrow) • Evaluate for side-biting of the leaflets, when the leaflets are not inserting into the center of the clip 	<ul style="list-style-type: none"> • Transgastric short-axis or 3D MPR view showing tissue bridge (<i>Figure 10G</i>, yellow arrow)
Echo assessment of reduction in regurgitation, leaflet insertion	<ul style="list-style-type: none"> • Bicommisural biplane to LVOT grasping view • Assess reduction in mitral regurgitation (<i>Figure 10B</i>) • Systematic sweep for both sides of the clip for potential location for subsequent clipping • Assess for jet through the clip, suggesting inadequate leaflet insertion • Assess the proximity of the clip to the annulus, particularly for the posterior mitral leaflet or the tricuspid septal leaflet, to determine whether further optimization is required 	<ul style="list-style-type: none"> • RV inflow biplane to grasping view • Assess reduction in tricuspid regurgitation reduction (<i>Figure 10H</i>) • Systematic sweep from anterior-septal commissure to posterior-septal commissure for potential location for subsequent clipping
Hemodynamic assessment	<ul style="list-style-type: none"> • Trans-mitral gradient • Pulmonary venous flow pattern • LA pressure and v wave • Echocardiographic and invasive hemodynamic assessments are important determinants of therapeutic effectiveness in addition to anatomical findings 	<ul style="list-style-type: none"> • Trans-tricuspid gradient • RA pressure and v wave
Optimizing grasping	<ul style="list-style-type: none"> • Unlatch the gripper lever to independently raise the appropriate gripper • G4 system: after raising the lock handle to unlock, the clip arms are reopened to 120–150° • G5 system: after turning the lock knob to unlock, the clip arms are reopened to 120–150° • To optimize anterior leaflet: rotate SGC counterclockwise • To optimize posterior leaflet: rotate SGC clockwise • Raise the respective gripper • Lower gripper • Lock the clip • Slowly close the clip • Reassessment of leaflet insertion and coaptation quality 	<ul style="list-style-type: none"> • To optimize lateral (anterior/posterior) leaflet: rotate SGC counterclockwise • To optimize septal leaflet: rotate SGC clockwise
Reassessment of leaflet insertion, reduction of regurgitation, transvalvular gradient	<ul style="list-style-type: none"> • Repeat assessment is performed using the above echo views, to confirm adequate and secure leaflet insertion before clip deployment 	

Table 2 (continued)

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Steps	Mitral	Tricuspid
Deploying the clip: check clip final arm angle round 1	<ul style="list-style-type: none"> • Bicommisural biplane to LVOT grasping view • Fluoroscopy in LAO • Final clip arm angle is established by rotating the arm opener counterclockwise to the neutral position, then an additional 270° to ensure that the clip arms are fully secured and cannot reopen (<i>Figure 10C, 10D, 10I, 10J</i>), then tightly close the clip 	<ul style="list-style-type: none"> • RV inflow biplane to grasping view
Removing the lock line	<ul style="list-style-type: none"> • G4 system: after increasing the infusion drip rate through the lock line, slowly remove lock line by first unscrewing the lock handle cap, then removing the lock line after confirming no knotting on the line • G5 system: after increasing the infusion drip rate through the lock line, slowly remove lock line by first raising the white lock lever, then disengage the lock knob 	
Check clip final arm angle round 2	<ul style="list-style-type: none"> • Fluoroscopy in LAO • Final clip arm angle is established by rotating the clip arm opener counterclockwise to the neutral position, then an additional 270° to ensure that the clip arms are fully secured and cannot reopen then go back to neutral position 	
Releasing the clip	<ul style="list-style-type: none"> • Bicommisural biplane to LVOT grasping view (mitral) or RV inflow biplane to grasping view (tricuspid) • Fluoroscopy RAO with clip parallax removed • Remove the safety pin to enable full rotation of the arm opener • Rotate the arm opener counterclockwise until the groove on the actuator knob pin becomes visible (G4), or until a hard stop (G5) • Rotate the actuator knob counterclockwise for ≥8 full turns, then pull it back to initiate clip release • Retract the gripper levers • Finally, withdraw the DC fastener SLOWLY to disengage the needle from the deployed clip (<i>Figure 10E, 10F, 10K, 10L</i>, yellow arrow) 	
Removing the CDS and SGC	<ul style="list-style-type: none"> • Tip of the DC fastener is retracted to the end of CDS, and CDS is directed anteriorly or posteriorly as needed to keep it centered • ‘+’ knob is neutralized, and the ‘M’ knob is disengaged as the CDS is withdrawn into the SGC • TEE continuously monitors the metal tip of the CDS throughout retraction to ensure it does not injure adjacent structures • Gentle negative suction is applied at the SGC side-port during CDS retraction to prevent air embolism • TEE also evaluates for any air bubbles in the atrium during this process 	<ul style="list-style-type: none"> • Tip of the DC fastener is retracted to the end of CDS, and CDS is directed septally or laterally as needed to keep it centered • ‘L’ knob is neutralized, and the ‘F’ knob is disengaged as the CDS is withdrawn into the SGC
Final step	<ul style="list-style-type: none"> • SGC removal • Access site closure 	

CDS, clip delivery system; DC, delivery catheter; ICE, intracardiac echocardiography; LAO, left anterior oblique; LUPV, left upper pulmonary vein; LVOT, left ventricular outflow tract; MPR, multi planar reconstruction; RAO, right anterior oblique; RV, right ventricle; SGC, steerable guide catheter; SVC, superior vena cava; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

Table 3 Step-by-step imaging workflow for mitral and tricuspid TEER		
Steps	Mitral	Tricuspid
Preprocedure on the table	<p>TEE</p> <ul style="list-style-type: none"> • Check imaging quality • A pressure bag may be placed behind the right scapula to improve TEE image quality if needed 	<p>ICE</p> <ul style="list-style-type: none"> • ICE catheter is inserted via the contralateral femoral vein • ICE is used as complementary to TEE
Transseptal puncture	<p>TEE</p> <ul style="list-style-type: none"> • Bicaval view bi-plane to Short-axis Aortic valve view for puncture position • Bicaval view bi-plane to Reverse four-chamber view for height measurement <p>Fluoroscopy</p> <ul style="list-style-type: none"> • RAO 	
Guidewire placement	<p>TEE</p> <ul style="list-style-type: none"> • LUPV view for Safari placement in LUPV <p>Fluoroscopy</p> <ul style="list-style-type: none"> • AP 	<p>TEE</p> <ul style="list-style-type: none"> • Bicaval view for Safari placement in SVC
SGC insertion into the atrium	<p>TEE</p> <ul style="list-style-type: none"> • Short axis aortic valve view bi-plane to Reverse four chamber view for confirming SGC entry into LA, and the tip of the SGC in the LA at least 2 cm <p>Fluoroscopy</p> <ul style="list-style-type: none"> • AP 	<p>TEE</p> <ul style="list-style-type: none"> • Bicaval view
CDS insertion into SGC	<p>TEE</p> <ul style="list-style-type: none"> • Short axis aortic valve view bi-plane to Reverse four chamber view for advancement and the SGC retraction to make sure the SGC tip remains in LA at least 2 cm <p>Fluoroscopy</p> <ul style="list-style-type: none"> • AP 	<p>TEE</p> <ul style="list-style-type: none"> • Bicaval view for clip advancement and the SGC retraction
Steering down toward valve	<p>TEE</p> <ul style="list-style-type: none"> • Short axis aortic valve view bi-plane to reverse four chamber view, transitioning to Bicommisural view bi-plane to LVOT grasping view for tracking clip movement toward MV <p>Fluoroscopy</p> <ul style="list-style-type: none"> • AP transitioning to RAO while steering down 	<p>TEE</p> <ul style="list-style-type: none"> • Bicaval view bi-plane to four chamber view, transitioning to RV inflow view bi-plane to grasping view for tracking clip movement toward TV

Table 3 (continued)

Table 3 (continued)

Steps	Mitral	Tricuspid
Adjusting clip position above the valve	<p>TEE</p> <ul style="list-style-type: none"> • Bicommisural view with the apex oriented at 6 o'clock biplane to LVOT grasping view • 3D en-face and 3D en-face color view • MPR <p>Fluoroscopy</p> <ul style="list-style-type: none"> • RAO 	<p>TEE/ICE</p> <ul style="list-style-type: none"> • RV inflow view biplane to Reverse 4-chamber grasping view • Transgastric view • MPR
Gripper check	<p>TEE</p> <ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • MPR 	<p>TEE/ICE</p> <ul style="list-style-type: none"> • RV inflow view biplane to Reverse 4-chamber grasping view • MPR
Check clip trajectory	<p>TEE</p> <ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • MPR <p>Fluoroscopy</p> <ul style="list-style-type: none"> • RAO 	<p>TEE/ICE</p> <ul style="list-style-type: none"> • RV inflow view biplane to Reverse 4-chamber grasping view • MPR
Orient clip to perpendicular to coaptation line for optimal orientation for grasping	<p>TEE</p> <ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • 3D en-face view • 3D MPR <p>Fluoroscopy</p> <ul style="list-style-type: none"> • RAO 	<p>TEE/ICE</p> <ul style="list-style-type: none"> • RV inflow view biplane to Reverse 4-chamber grasping view • Transgastric short-axis view • 3D MPR
Clip entering ventricle	<p>TEE</p> <ul style="list-style-type: none"> • Bicommisural view biplane to LVOT grasping view • MPR <p>Fluoroscopy</p> <ul style="list-style-type: none"> • RAO 	<p>TEE/ICE</p> <ul style="list-style-type: none"> • RV inflow view biplane to Reverse 4-chamber grasping view • MPR
Leaflet grasping	<p>TEE</p> <ul style="list-style-type: none"> • Bicommisural view biplane imaging to LVOT grasping view • 3D en-face view • MPR • RAO fluoroscopic view <p>Fluoroscopy</p> <ul style="list-style-type: none"> • RAO 	<p>TEE/ICE</p> <ul style="list-style-type: none"> • RV inflow view biplane to Reverse 4-chamber grasping view • Transgastric short-axis view • MPR • RAO fluoroscopic view

Table 3 (continued)

Table 3 (continued)

Steps	Mitral	Tricuspid
Echo assessment of reduction in regurgitation, leaflet insertion	TEE <ul style="list-style-type: none"> • Bicommisural biplane to LVOT grasping view • 3D en-face • MPR 	TEE/ICE <ul style="list-style-type: none"> • RV inflow biplane to grasping view • Transgastric short-axis view • 3D MPR
Optimizing grasping	TEE <ul style="list-style-type: none"> • Bicommisural view biplane imaging to LVOT grasping view Fluoroscopy <ul style="list-style-type: none"> • RAO 	TEE/ICE <ul style="list-style-type: none"> • RV inflow view biplane to Reverse 4-chamber grasping view • Transgastric short-axis view • 3D MPR
Check clip final arm angle	TEE <ul style="list-style-type: none"> • Bicommisural biplane to LVOT grasping view Fluoroscopy <ul style="list-style-type: none"> • LAO 	TEE/ICE <ul style="list-style-type: none"> • RV inflow biplane to grasping view
Releasing the clip	TEE <ul style="list-style-type: none"> • Bicommisural biplane to LVOT grasping view Fluoroscopy <ul style="list-style-type: none"> • RAO 	TEE/ICE <ul style="list-style-type: none"> • RV inflow biplane to grasping view
Removing the CDS and SGC	TEE <ul style="list-style-type: none"> • Bicommisural bi-plane to LVOT grasping view, transitioning to Bicaval view bi-plane to short-axis aortic valve view Fluoroscopy <ul style="list-style-type: none"> • RAO 	TEE/ICE <ul style="list-style-type: none"> • RV inflow biplane to grasping view, transitioning to bicaval view

AP, anterior-posterior; CDS, clip delivery system; ICE, intracardiac echocardiography; LAO, left anterior oblique; LUPV, left upper pulmonary vein; LVOT, left ventricular outflow tract; MPR, multi planar reconstruction; RAO, right anterior oblique; RV, right ventricle; SGC, steerable guide catheter; SVC, superior vena cava; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

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Footnote

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Conflicts of Interest: L.M.S. has received speaker honoraria for Abbott Structural Heart and served on advisory board

for TriClip and physician proctor, she also received speaker honoraria from Medtronic. G.H.L.T. has received speaker's honoraria and served as a physician proctor, consultant, advisory board member, TAVR publications committee member, RESTORE study steering committee member, APOLLO trial screening committee member and IMPACT MR steering committee member for Medtronic, has received speaker's honoraria and served as a physician proctor, consultant, advisory board member, ENVISION trial screening committee member and

TRILUMINATE trial anatomic eligibility and publications committee member for Abbott Structural Heart, has served as an advisory board member for Boston Scientific, a consultant and physician screening committee member for Shockwave Medical, a consultant for Anteris, Philips and Edwards Lifesciences, Peija Medical and Shenqi Medical Technology, and has received speaker's honoraria from Siemens Healthineers. S.K. is a consultant and proctor for Medtronic, consultant and proctor for Abbott Structural Heart, consultant and proctor for W. L. Gore & Associates, consultant for Terumo, consultant and advisory board member of EastEnd Medical, and serves on the speaker's bureau for Zoll Medical and Edwards Lifesciences. The other authors have no conflicts of interest to declare.

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