

Transcatheter Mitral Valve Edge-to-Edge Repair for Commissure Prolapse Successfully Guided by Stitch Artifact Technique



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INTRODUCTION

Transcatheter mitral valve (MV) edge-to-edge repair (TEER) using the MitraClip System (Abbott, Abbott Park, IL) has been widely used as an alternative treatment for patients with symptomatic severe mitral regurgitation (MR) and high surgical risk.^{1,2} Although the most suitable anatomical lesion for TEER is the central portion of the middle scallops of the anterior and posterior leaflets (A2/P2), TEER has also been widely used for noncentral degenerative MR (DMR) based on clinical necessity. Furthermore, the evidence of the safety and efficacy of TEER for noncentral DMR has been accumulated from real world data.^{3,4}

Among noncentral DMR cases, severe MR may be due to commissure prolapse, although the exact frequency is unknown.⁵ Although TEER can also be performed for noncentral DMR, TEER for commissure lesion is still considered especially challenging due to its complex chordal anatomy or the size of the prolapsed leaflet.⁶ Therefore, accurate intraprocedural echocardiographic guidance is essential for the success of TEER cases for commissure prolapse. However, there have been no established echocardiographic techniques for noncentral DMR, especially for commissural cases.

Stitch artifact is one of the artifacts of three-dimensional (3D) echocardiography that are derived from a misaligned 3D image. Although it is originally an artifact, we found that this artifact can be used to indicate the exact position or angle of a visualized two-dimensional (2D) image as a line on a wide-angle 3D image of the MV. Given that the appropriate grasping strategy is highly variable depending on each case's anatomy in noncentral DMR (especially in commissure cases), we have to thoroughly discuss the grasping strategy by referencing both 2D and 3D echocardiography in each case. Therefore, this new transesophageal echocardiography (TEE) technique to integrate 2D and 3D images might help us to understand the exact anatomy of the target site and enhance the quality of TEER.

Here we report 2 successful TEER cases of isolated anterior commissure (AC) prolapse that were successfully guided by a unique

VIDEO HIGHLIGHTS

Video 1: Two-dimensional TEE, zoomed grasping view, which we planned in the preprocedural TEE of case 1.

Video 2: The stitch artifact technique was used to confirm that the visualized 2D image (Video 1) was the most lateral portion of A1-P1.

Video 3: Final 3D-TEE with color Doppler, atrial perspective, demonstrates that residual MR grade was mild.

Video 4: Final 3D image, obtained from the 3D zoom mode.

Video 5: Intraprocedural 3D zoom image demonstrates that the stitch artifact line was located on the clip line, which indicated that the 2D image was the optimal grasping angle.

Video 6: Final 3D-TEE image, atrial perspective, obtained from the 3D zoom mode.

Video 7: Two-dimensional TEE, zoomed x plane image with color Doppler, demonstrates that the residual MR was mild.

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echocardiographic technique, the “stitch artifact technique,” which enhanced the quality of preprocedural and intraprocedural echocardiographic guidance.

CASE PRESENTATION

Case 1

An 89-year-old woman with a medical history of heart failure, paroxysmal atrial fibrillation, and flutter was transferred to our hospital for TEER for severe MR. Physical examination showed Levine 3/6 pansystolic murmur at apex. Blood testing showed reduced renal function and elevated brain natriuretic peptide level (446 pg/mL). Cardiac catheterization showed no significant coronary artery disease. Transthoracic echocardiography revealed normal left ventricular ejection fraction (76%), normal wall thickness, and severe eccentric MR due to prolapse of the anterior MV leaflet (effective regurgitant orifice area, 0.51 cm²; regurgitant volume, 52 mL; regurgitant fraction, 50%). Transesophageal echocardiography (TEE) was also performed with 3D image acquisition. Three-dimensional TEE revealed severe eccentric MR jet due to a small flail anterior commissural scallop with ruptured chordae (Figure 1A and B). Our heart team decided to perform TEER considering the patient's high age, frailty, and high surgical risk (Society of Thoracic Surgeons risk score 9.8%).

At the preprocedural heart team conference, we decided that the commissure leaflet of this case was too small to grasp directly.

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Keywords: Stitch artifact technique, Transcatheter mitral valve edge-to-edge repair, MitraClip, Mitral regurgitation, Commissure prolapse

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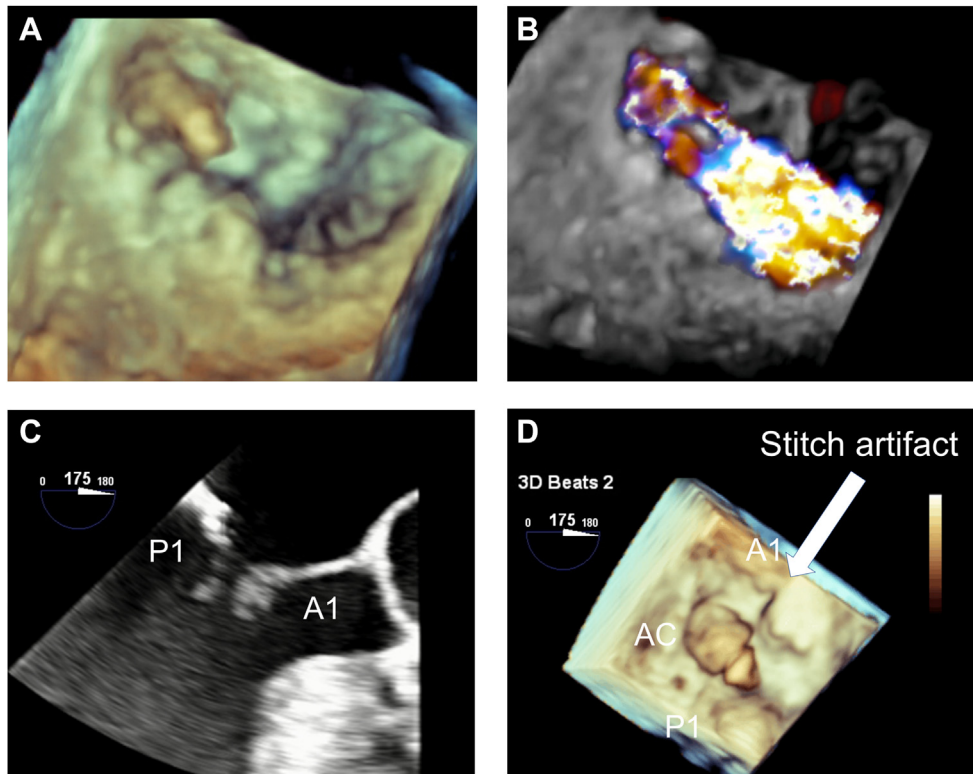


Figure 1 Preprocedural TEE showed an isolated AC prolapse and a severe eccentric MR jet on 3D image (**A** and **B**). For preprocedural determination of the grasping view (**C**), the stitch artifact technique was used (**D**).

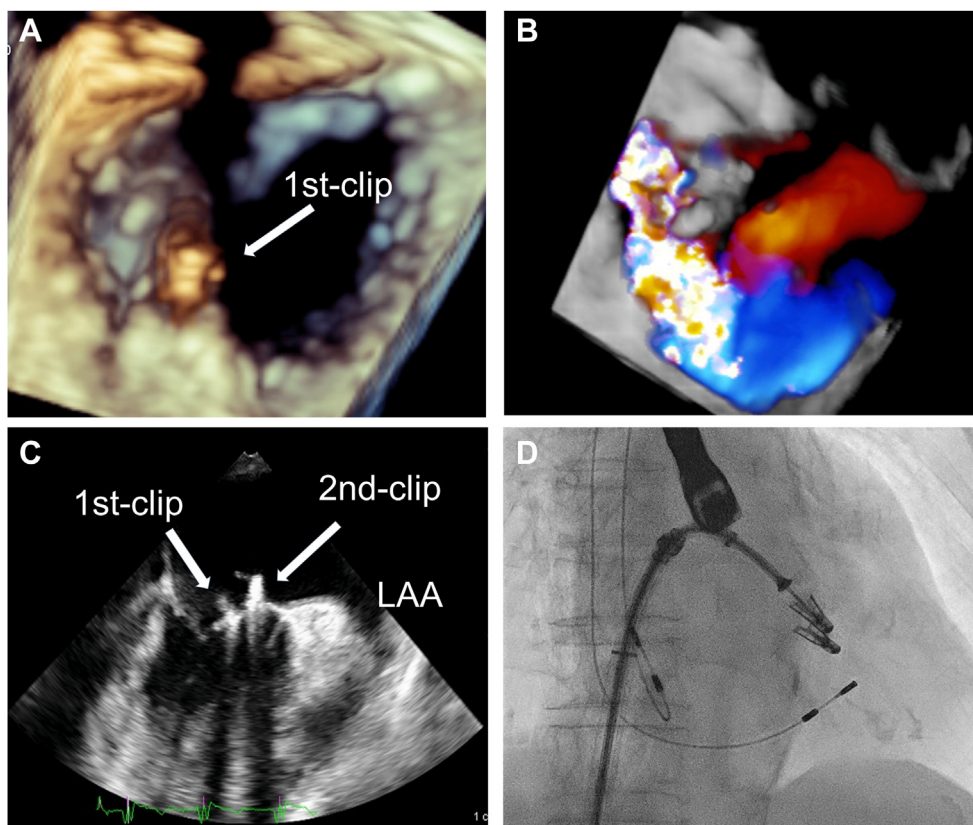


Figure 2 Intraprocedural TEE showed a first clip deployment at the A1-P1 scallop (**A**) and residual MR originating from AC (**B**). The second clip was inserted at the more lateral portion at A1-P1 on 2D image and fluoroscopic image (**C** and **D**). LAA, left atrial appendage.

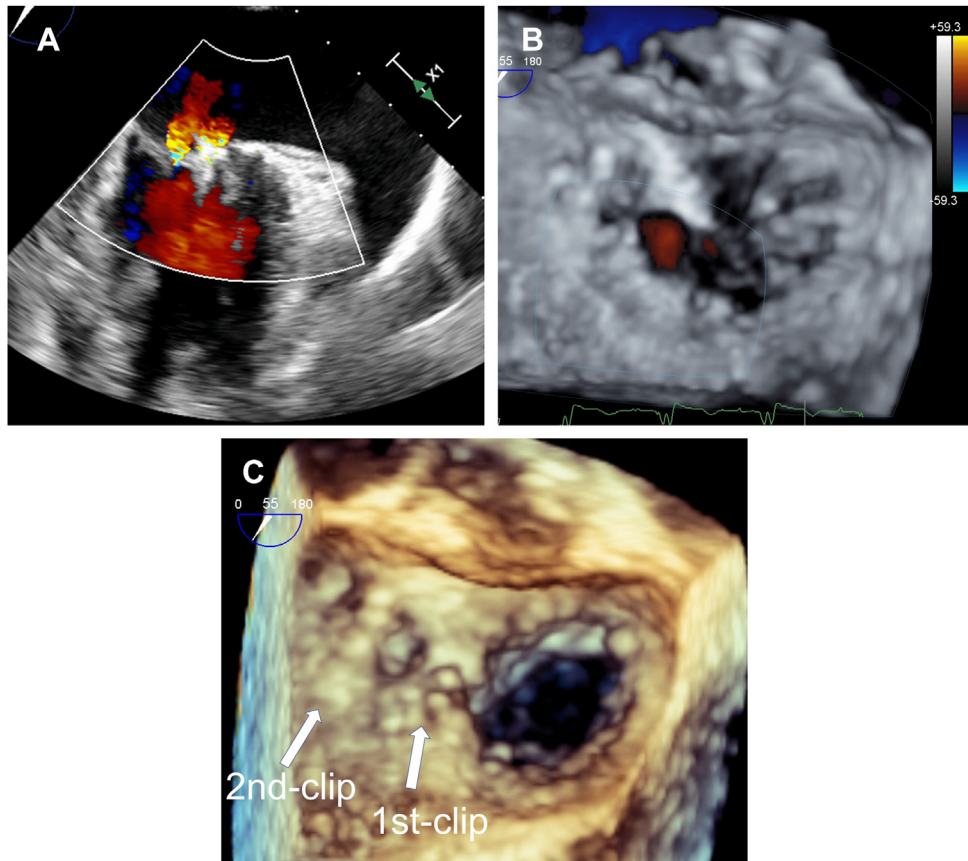


Figure 3 Intraoperative TEE 2-chamber view showed a significant reduction of MR after second clip deployment on 2D and 3D images (**A** and **B**). Three-dimensional TEE showed the final image of the procedure (**C**).

However, preprocedural TEE showed that there was a sufficient length of A1-P1 scallop to grasp (**Figure 1C**, **Video 1**). Then the stitch artifact technique was used to confirm that the visualized 2D image (**Video 1**) was the most lateral portion of A1-P1 (**Figure 1D**, **Video 2**) by creating the stitch artifact intentionally (constructing a 3D image from 2-beat acquisition without stopping ventilation). Therefore, we concluded that effective TEER would be possible by grasping the most lateral portion of the A1-P1 scallop adjacent to the AC, imitating the surgical edge-to-edge repair technique for commissure prolapse.

The patient underwent the TEER procedure under general anesthesia with TEE and fluoroscopy guidance. We used the MitraClip G2 NT system. Intraoperative TEE was conducted using EPIQ 7 and X8-2t (Royal Philips Electronics, Amsterdam, The Netherlands). At first, we attempted to grasp the most lateral portion of A1-P1 with AC, but it was difficult to stabilize the leaflet on the clip arm adequately. Therefore, we decided to deploy the first clip at the medial portion of A1-P1 to stabilize the A1-P1 scallop motion (**Figure 2A**). After the first clip deployment, there was still a severe residual MR from the AC portion as we expected (**Figure 2B**). The second clip was inserted into the lateral portion of A1-P1 (**Figure 2C** and **D**), and we could grasp the initially targeted lesion easily because of the restricted A1-P1 motion. After the second clip deployment, severe eccentric MR was almost completely erased (**Figure 3A** and **B**, **Video 3**). At the end of the procedure, a tightly bridged A1-P1 scallop was observed by 3D-TEE (**Figure 3C**, **Video 4**). Pulmonary vein flow was improved from blunt type to forward flow type. On the follow-up

echocardiography 1 year later there was no relapse of significant MR (MR grade was mild).

Case 2

An 86-year-old man was referred to our hospital for severe symptomatic MR due to AC prolapse. Physical examination showed Levine 3/6 pansystolic murmur at apex. Blood test showed mildly elevated brain natriuretic peptide level (132 pg/mL). A transthoracic echocardiogram revealed normal left ventricular ejection fraction (68%) with normal wall thickness and severe eccentric MR due to prolapse of the anterior MV leaflet (effective regurgitant orifice area, 0.61 cm²; regurgitant volume, 95 mL; regurgitant fraction, 59%). Three-dimensional TEE revealed that the prolapse of the anterior commissural scallop was observed and severe eccentric MR jet was originating from the same area (**Figure 4A** and **B**). Based on the patients' high age and wishes, our heart team selected TEER rather than surgery. Our preprocedural strategy was to grasp the most lateral portion of A1-P1 with AC simultaneously to plicate lateral commissure, based on the experience of case 1.

The patient underwent the TEER procedure under general anesthesia with TEE and fluoroscopy guidance. In this case, we used the MitraClip G4 NT system. At first, we inserted the clip into the left ventricle, targeting the most lateral portion of the A1-P1 leaflet, with the clip angle aligned in the 1 to 7 o'clock position (**Figure 4C**). However, this procedure was difficult because of the entanglement

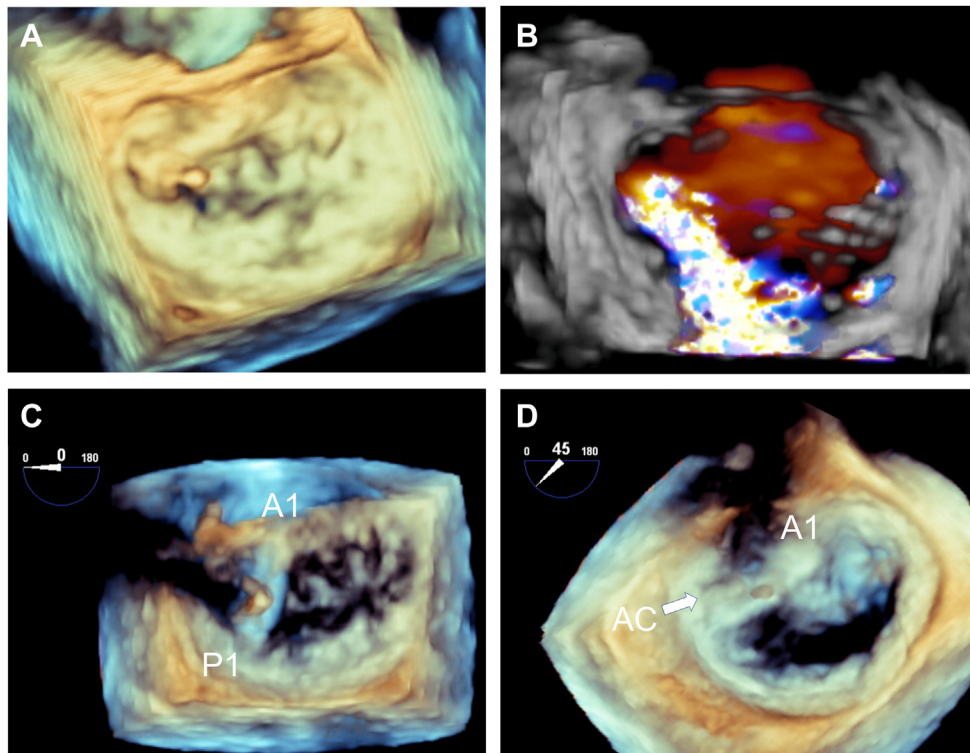


Figure 4 Preprocedural TEE showed an isolated AC prolapse and a severe eccentric MR jet on 3D image (**A** and **B**). Intraoperative TEE showed the clip in the left ventricle to grasp the A1-P1 scallop on the 3D image (**C**). (**D**) Modified grasping strategy to grasp A1-AC on 3D image.

between the clip arm and subvalvular apparatus. Therefore, we changed the clip arm angle to be aligned in the 2 to 8 o'clock position to grasp between AC and A1, which was better aligned with the commissure flail (Figures 4D and 5A). We constructed an optimal grasping view (Figure 5B), which was confirmed using a 3D-TEE stitch artifact technique (Figure 5A, Video 5). After visually recognizing a good leaflet insertion by the optimal grasping view (Figure 5B), we deployed the clip. At the end of the procedure, the bridged A1-AC scallop was observed by 3D-TEE (Figure 5C, Video 6). The residual MR was mild (Figure 5D, Video 7). Pulmonary vein flow was improved from blunt type to forward flow type.

DISCUSSION

In the present case report, we successfully treated 2 cases of severe MR due to prolapse of AC. The main messages of the present study are as follows: (1) the stitch artifact technique for this kind of anatomically complex case is useful, and (2) 2 different grasping strategies are available for commissure prolapse.

The Usefulness of Stitch Artifact Technique

The importance of 3D-TEE guidance in TEER procedure is well established.^{3,7} We recognize the general image of the whole MV from the 3D image and obtain the precise anatomical information of the target site, such as the leaflet length, width, and tissue characteristics, from the 2D image. However, it is difficult to objectively show the exact position and angle of the visualized 2D image on a wide-angle 3D image of the MV, except for with the latest 3D systems (live multiplanar reconstruction [MPR] mode). Based on the necessity of

understanding the precise anatomical information of the grasping site, we established a new TEE technique to integrate the 2D and 3D images, the stitch artifact technique.

Stitch artifact, which is a misaligned 3D image usually caused by patient's respiratory motion or irregular heart rhythm during multibeam 3D image acquisition, should be avoided when constructing a high-quality image (Figure 6A).⁸ Therefore, we usually conduct breath holding or stop ventilation under general anesthesia during multibeam 3D image acquisition. However, the steps to conduct the stitch artifact technique require the opposite: when sonographers need to identify the exact position, angle, and leaflets of the visualized 2D image (Figure 6B(i)), constructing a 3D image from 2-beat acquisition without stopping the ventilation intentionally creates the stitch artifact line, which emerges on the 3D image (Figure 6B(ii)). In this way, they know the exact position, angle, and leaflets of the visualized 2D image (Figure 6B(iii)). This stitch artifact on the 3D image indicated the exact position and angle of the 2D cut-plane image, which we visualized just before showing the 3D image.

The merits of using this stitch artifact technique when compared with conventional MPR mode or live MPR mode are (1) higher spatial and temporal resolution and (2) wider availability in any 3D echo machines. Because images obtained from MPR modes have a limitation of dropped spatial and temporal resolution,⁹ images are sometimes not clear enough to observe the tissue character or length of target site. Thus, we consider leaflet grasping should be conducted using conventional 2D echocardiography as much as possible, even in a situation where live MPR is available. In that context, leaflet grasping using a conventional 2D image that was confirmed by the stitch artifact technique can provide a higher spatial and temporal resolution.

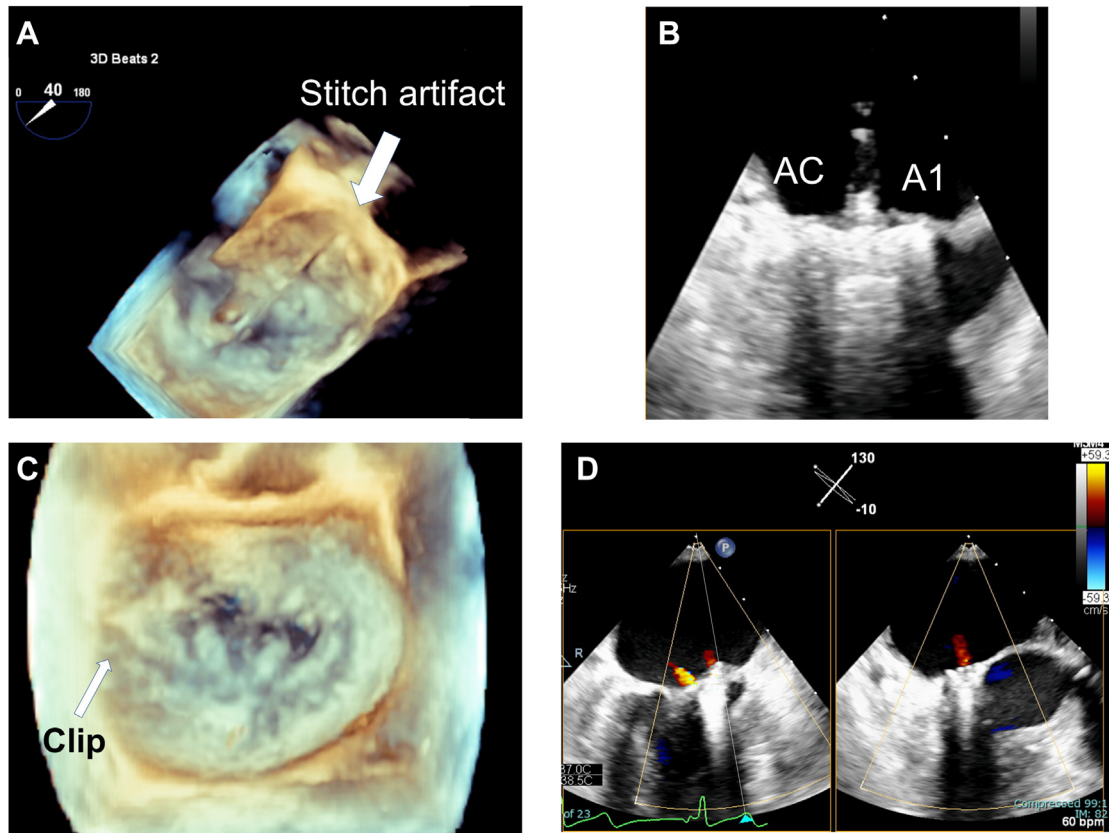


Figure 5 The stitch artifact technique was used to determine the optimal grasping angle (A). Clear visualization of the stabilized commissure leaflet on the clip arm was obtained on 2D image (B). Three-dimensional TEE showed the final image of the procedure (C). Residual MR was mild on the 2D image (D).

In the case of an ideal target site determined by conventional MPR mode, sonographers might struggle to visualize the target site on a conventional 2D image at the time of leaflet grasping during the procedure, given the complex anatomy of the commissure site. The stitch artifact technique can serve as a confirmation method via visualizing the stitch line on a wide-angle 3D image. Although live MPR mode can also provide the same line as the stitch artifact technique, our technique has an advantage in terms of wider availability in any 3D echo machine, given that the live MPR mode is only available in the latest 3D systems.

In case 1, this technique enabled us to confirm that the most lateral portion of the A1-P1 leaflet had enough length to grasp (Figure 1C and 1D, Videos 1 and 2). Without this technique, it was difficult to know the visualized 2D image was adjacent to the AC portion. Because A1 and P1 have a certain width, it is important to know whether the visualized 2D image is the medial portion, center or lateral portion, of the leaflet for the optimization of the procedure.

In case 2, the optimal grasping angle on 2D image was obviously different depending on the grasping leaflet: either the A1-P1 grasping (Figure 4C) or A1/AC grasping strategy was used (Figure 4D). According to the change of the grasping strategy during the operation, sonographers had to modify the optimal grasping view as appropriate. Without this technique, it was difficult to know, objectively whether the visualized 2D image was A1-P1 or A1/AC. Furthermore, the optimal grasping angle is highly variable depending on each case especially in noncentral DMR cases. Furthermore, even in the same case, the optimal grasping angle changes from moment to moment

depending on the posture of the patient and depth or up/down of the TEE probe. This technique helps us to confirm the relationship between the clip and grasping view in real time (Figure 5A). By using this technique, we could always visualize the true long axis of the clip (Figure 5B), leading to optimal grasping and reducing the risk of single-leaflet device attachment.

Grasping Strategies

MitraClip is currently widely used for noncentral DMR in daily practice.⁴ However, the decision-making for the operative strategy is difficult especially in commissure lesions among noncentral DMR.¹⁰ In a previous study, there was a case series successfully treated by a hybrid technique using MitraClip and the Amplatzer Duct Occluder II.⁶ However, this strategy cannot be applied in daily clinical practice due to its off-label use.

When conducting surgical mitral repair for commissure prolapse, the commissural edge-to-edge technique is a simple and effective technique.¹¹⁻¹³ Therefore, we mimicked this surgical technique using the MitraClip system in case 1. The key points for the success of this plication methodology are as follows: (1) the length of the targeted A1-P1 scallop adjacent to the commissure must be sufficient and (2) the prolapsed commissure lesion must not be too big to plicate. On the other hand, in case 2, we had a procedural success by grasping the commissure leaflet directly. Considering that the basic idea is to grasp the prolapsed leaflet directly for the treatment of DMR, the strategy of case 2 was natural. Because of the risk of single-leaflet device

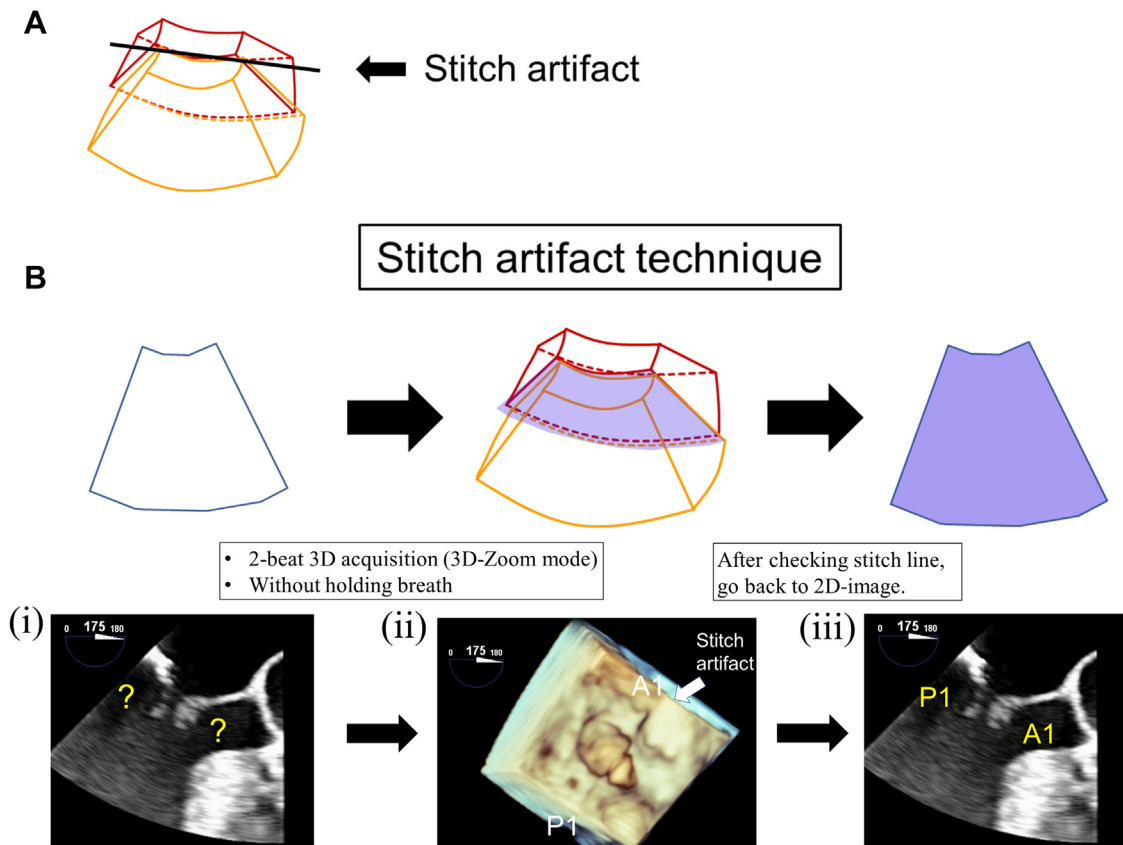


Figure 6 Illustration of the stitch artifact technique. **(A)** By conducting 2-beat image acquisition without stopping the ventilation **(B)** This stitch artifact on 3D image indicates the exact position and angle of 2D cut-plane image which we visualized just before showing 3D-image.

attachment, we believe it is essential to carefully observe the sufficient length and width of the commissure leaflet, especially in this method. In this case, we can make a decision to grasp the AC directly because we can visualize the sufficient length of the commissure leaflet on the clip arm with good stabilization (Figure 5B). In addition, the direct grasping of the commissure leaflet is superior to the strategy of case 1 in terms of the preservation of the valvular area.

In summary, we believe both strategies can be used for commissure prolapse as long as the clip stabilization is available. Especially in challenging cases, such as commissure prolapse, the clip stabilization and absolute grasping are important. Thus, more detailed TEE evaluation is necessary for commissure cases. The stitch artifact technique was helpful to understand the accurate anatomy of the target site.

CONCLUSION

We reported 2 successful TEER cases of isolated AC prolapse. The stitch artifact technique was useful to enhance the quality of echocardiographic guidance for TEER for commissure prolapse.

ETHICS STATEMENT

The authors declare that the work described has been carried out in accordance with The Code of Ethics of the World Medical

Association (Declaration of Helsinki) for experiments involving humans.

CONSENT STATEMENT

Complete written informed consent was obtained from the patient (or appropriate parent, guardian, or power of attorney) for the publication of this study and accompanying images.

FUNDING STATEMENT

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DISCLOSURE STATEMENT

The authors report no conflict of interest.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.case.2022.09.004>.

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