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CASE REPORT

INTERMEDIATE

CLINICAL CASE

Transcatheter Edge-to-Edge Repair for a Patient With Severe Mitral Regurgitation of Carpentier IIIa Classification

Huan-Fu Liu, MD,[a] Hui-Chin Lai, MD, PhD,[a,b,c] Chia-Ning Liu, MD,[a] Chih-Yen Wang, MD,[a,b] Yen-Hsu Chen, MD,[a] Hao-Ji Wei, MD,[a] Wen-Lieng Lee, MD, PhD,[a,b,c] Wei-Wen Lin, MD, PhD,[a] Tsun-Jui Liu, MD, PhD[a,b,c,d]

ABSTRACT

Whether patients diagnosed with mitral regurgitation of Carpentier class IIIa (rheumatic origin) can possibly be treated with balloon mitral commissurotomy followed by transcatheter edge-to-edge repair remains unclear. Here, we report on such a case who was successfully treated with balloon mitral commissurotomy and then transcatheter edge-to-edge repair without aggravating mitral stenosis. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2023;18:101911) © 2023 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Treating severe mitral regurgitation (MR) of Carpentier class IIIa (rheumatic origin) through transcatheter edge-to-edge repair (TEER) is currently regarded as a red light form of treatment owing to its technical complexity and high risk of postprocedural mitral valvular stenosis.[1] Here, we report on a patient with just such a type of mitral disease in terms of severe MR with lateral commissural fusion, for whom mitral TEER was successfully accomplished after a preceding balloon mitral commissurotomy (BMC), with the results providing good hemodynamic and clinical benefits. Thus, when indicated, mitral TEER can still be considered as both an efficient and safe form of therapy for patients with severe MR of the Carpentier IIIa classification who have specific anatomic characteristics.

LEARNING OBJECTIVES

- To describe one specified subset of Carpentier class IIIa mitral regurgitation presenting commissural fusion but adequate leaflet length.
- To appreciate the role of precedent percutaneous balloon mitral commissurotomy in such situation to facilitate subsequent transcatheter therapy.
- To recognize the potential of transcatheter mitral edge-to-edge repair for such balloon mitral commissurotomy-pretreated Carpentier class IIIa MR patients.

HISTORY OF PRESENTATION

An 80-year-old male patient was presented to the outpatient clinic experiencing progressively aggravated orthopnea and paroxysmal nocturnal dyspnea, with recent development of leg edema and abdominal fullness.

From the [a]Department of Anesthesiology and Cardiovascular Center, Taichung Veterans General Hospital, Taichung, Taiwan; [b]Chung-Hsing University School of Medicine, Taichung, Taiwan; [c]National Yang-Ming-Chiao-Tung University School of Medicine, Taipei, Taiwan; and the [d]Cardiovascular Research Center, National Chung Hsing University School of Medicine, Taichung, Taiwan.
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ABBREVIATIONS AND ACRONYMS

BMC = balloon mitral commissurotomy

LV = left ventricular

MR = mitral regurgitation

MV = mitral valve

NT-proBNP = N-terminal pro-B-type natriuretic peptide

TEE = transesophageal echocardiography

TEER = transcatheter edge-to-edge repair

PAST MEDICAL HISTORY

The patient had previously undergone a permanent pacemaker implantation (VVI mode) 1 year previously for chronic atrial fibrillation with slow ventricular conduction. He also had been experiencing congestive hepatopathy and cirrhosis of the liver, Child B, for years. There was no history of rheumatic fever in the past.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis included coronary artery disease, heart failure, and pacemaker dysfunction.

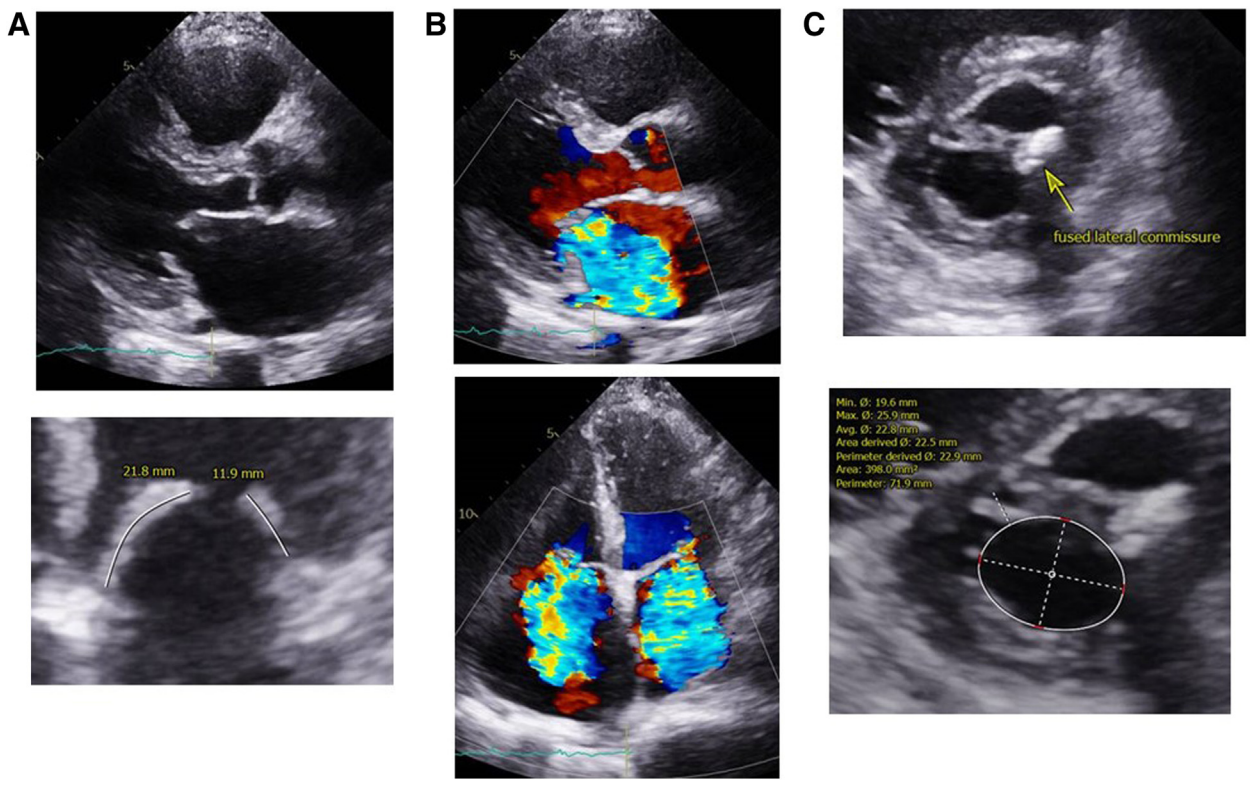
INVESTIGATIONS

An electrocardiograph showed atrial fibrillation with an adequate ventricular pacing rhythm, and a chest radiograph showed pulmonary edema and pleural effusions. Transthoracic echocardiography revealed severe MR with restricted leaflet motion and lateral commissural fusion (Carpentier class IIIa) (**Figure 1**, Video 1), massive functional tricuspid regurgitation, and an impaired left ventricular ejection fraction of 46%. Mitral area by planimetry was 3.6 cm^2 and serum N-terminal pro-B-type natriuretic peptide (NT-proBNP) was 2,464 pg/mL. Transesophageal echocardiography (TEE) demonstrated fusion of the lateral mitral commissures (A1P1) with focal leaflet calcification, severe MR of the central origin (A2P2) (**Figure 2A**), a systolic reversal wave on the pulmonary vein waveform (**Figure 2B**), and a mean transmitral pressure gradient of 3.6 mm Hg (**Figure 3C**).

MANAGEMENT

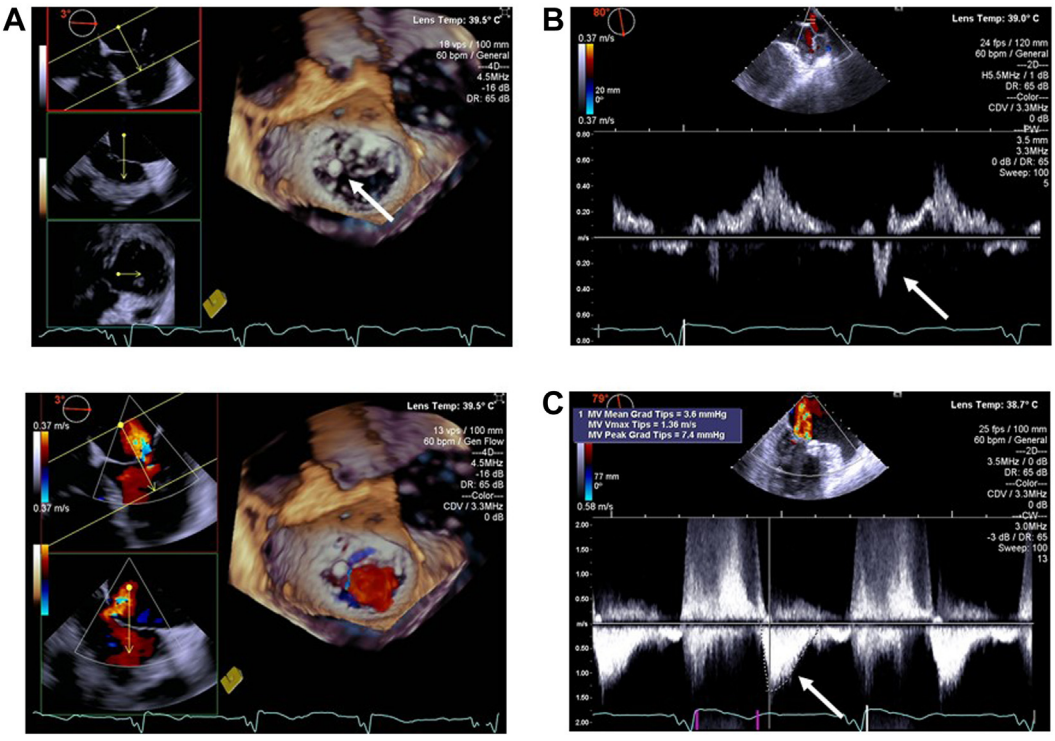
Severe degenerative MR of the Carpentier IIIa class as well as massive tricuspid regurgitation were diagnosed. The European System for Cardiac Operative Risk Evaluation (EuroSCORE) II for mitral valve (MV)

FIGURE 1 Baseline Transthoracic Echocardiography



(A, top) Hockey-Stick sign of the mitral leaflets. **(Bottom)** Lengths of the anterior (21.8 mm) and posterior (11.9 mm) leaflets. **(B)** Severe concentric mitral regurgitation and tricuspid regurgitation. **(C)** Lateral commissure calcification and fusion with a mitral valve area of 3.6 cm^2.

FIGURE 2 **Baseline Transthoracic Echocardiography**



(A) Three-dimensional en face view, confirming lateral commissure fusion **(arrow)** and reduced mitral valve area **(red color)**. **(B, left top)** pulmonary venous pulse Doppler, showing systolic reversal waveform **(arrow)**. **(C)** Mitral inflow pulse Doppler, showing a mean transmitral pressure gradient of 3.6 mm Hg **(arrow)**.

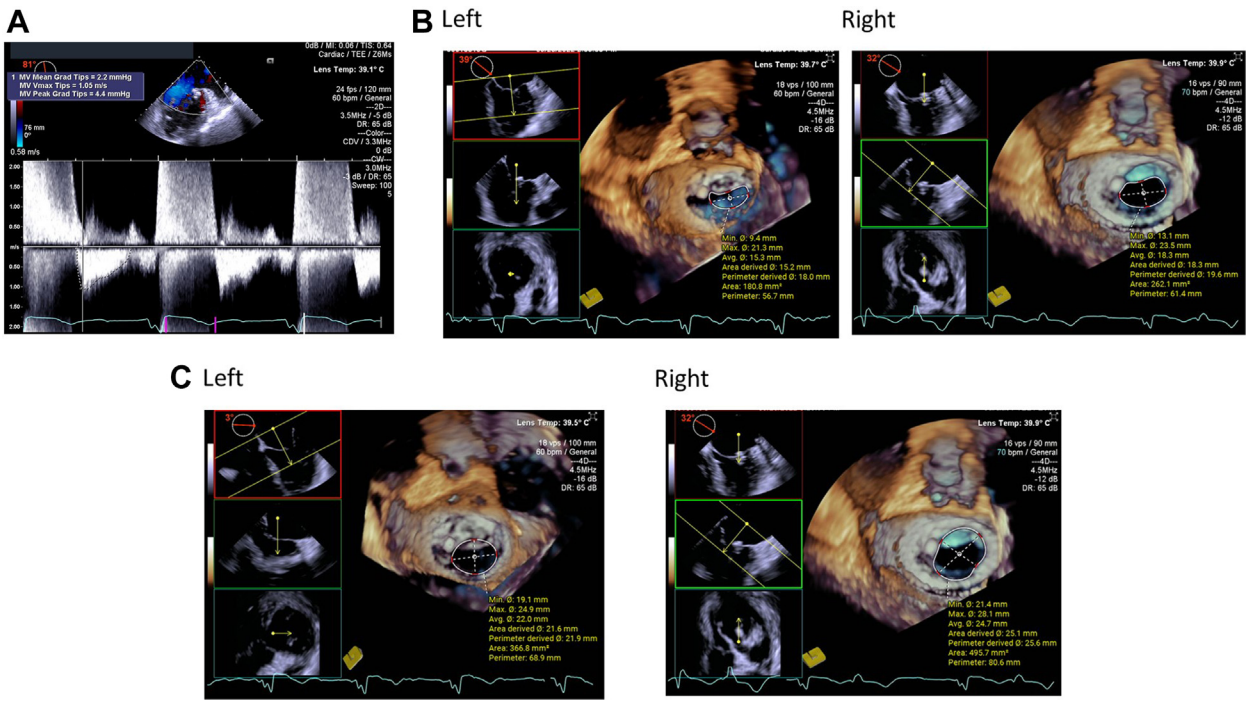
surgery was 2.46%. Surgical MV replacement with or without tricuspid replacement has been a standard treatment, but was declined by the patient and the surgeons owing to the patient's preference and his advanced liver disease. Because transcatheter MV replacement was still unavailable, the heart team decided to perform TEER facilitated by a preceding BMC for this specific patient who had mitral commissural fusion and a relatively small MV area, but adequate leaflet length.

Under general anesthesia, a coronary angiography showed no significant stenosis. Hemodynamic and TEE assessments revealed a low cardiac index (1.8 L/min/m^2), low systolic LV pressure (80 mm Hg), high mean left atrial pressure of 15 mm Hg, and a trans-MV mean pressure gradient of 3.6 mm Hg. An ordinary BMC was performed using a 26-mm Inoue balloon catheter (Toray Industries) for twice (Video 2A, fluoroscopy; Video 2B, TEE images) to split apart the fused lateral commissure (**Figure 3A**), resulting in a reduction of the mean transmitral pressure gradient to 2.2 mm Hg (**Figure 3B**) and enlargement of MV area (**Figures 3C and 3D**, Videos 3A and 3B). Afterward, TEER was completed using a G4 NTW Mitraclip device (Abbott) placed at the A2P2 region (**Figure 4A**), which effectively ameliorated MR to grade I without creating significant mitral stenosis (effective MV area of 1.57 cm^2 by the pressure half-time method). Postoperative hemodynamic and TEE assessments showed vanishment of the pulmonary vein systolic reversal (**Figure 4B**), an increase of systolic LV pressure to 128 mm Hg, and improvement in the cardiac index to 2.6 L/min/m^2 despite elevation in the trans-MV mean pressure gradient to 8 mm Hg (**Figure 4C**). The patient was immediately extubated at the completion of anesthesia and discharged uneventfully 3 days after the procedures.

DISCUSSION

MR is the most prevalent valvular heart disease and results in poor outcomes if left untreated.[2,3] Although surgical intervention remains the standard treatment for degenerative MR,[4] TEER remains an efficient and

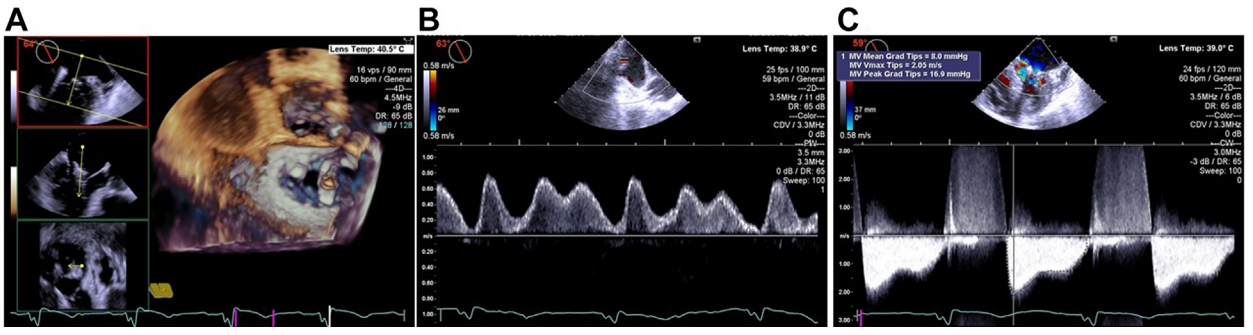
FIGURE 3 **Post-BMC Transesophageal Echocardiography**



(A) Mitral inflow pulse Doppler, showing a decrease in the mean transmitral pressure gradient to 2.2 mm Hg. **(B)** Effective orifice area of the mitral valve (MV) before (**left**, 1.81 cm^2) and after (**right**, 2.62 cm^2) balloon mitral commissurotomy (BMC). **(C)** Annular area of the MV before (**left**, 3.67 cm^2) and after (**right**, 4.96 cm^2) BMC.

safe therapeutic option for patients who carry a high surgical risk.[5,6] However, severe MR of Carpentier class IIIa is still regarded as a contraindication for TEER owing to its technical complexity and increasing risk of mitral stenosis.[1] For our case involving Carpentier IIIa degenerative MR, the initial trans-MV mean pressure gradient was 3.6 mm Hg, the MV area was 3.6 cm^2, the lateral mitral commissure was fused, and the cardiac index was depressed to 1.8 L/min/m^2, all of which predicted post TEER mitral stenosis.[1] Hopefully, neoadjuvant BMC, which split apart the fused lateral commissure and enlarged the

FIGURE 4 **Post-Transcatheter Edge-to-Edge Repair Transesophageal Echocardiography**



(A) A2P2 position of the implanted G4 NTW Mitraclip device and the split-apart lateral commissure. **(B, top left)** Pulmonary venous pulse Doppler, showing vanishment of the systolic reversal waveform. **(C)** Mitral inflow pulse Doppler showing a mean transmitral pressure gradient of 8.0 mm Hg.

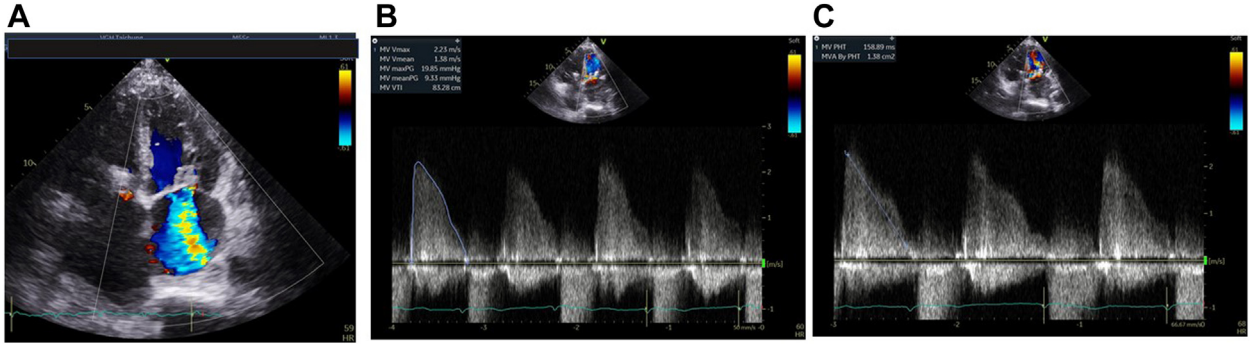
TABLE 1 Echocardiographic and Hemodynamic Parameters at Baseline, Immediately After Mitral Commissurotomy, and After Edge-to-Edge Repair

	Baseline	After BMC	MV TEER
MV area, cm^2	3.6 (planimetry)	N/A	1.70 (by PHT)
PV systolic reversal	Present	Present	Absent
RV systolic pressure, mm Hg	32	N/A	29
MR grade	4	4	1
LVEF %	46	N/A	45
CI, L/min/m^2	1.8	2.3	2.6
SVI, ml/m^2	30	38	37
SVV %	10	11	10
SVRI, dyne/s/cm^5/m^2	2,731	1,677	2,137
Brain SpO_2, L/R, %/%	52/52	45/49	60/62
LV pressure (S/D), mm Hg	80/12	78/12	128/8
LA pressure (A/V/M), mm Hg	17/31/15	16/32/20	23/39/23
Trans-MV mean PG, mm Hg	3.6	2.4	8
NT-proBNP	2,464	n/a	1,734 (at 1 month)

BMC = balloon mitral commissurotomy; CI = cardiac index; LA = left atrial; LV = left ventricular; LVEF = left ventricular ejection fraction; MR = mitral regurgitation; MV = mitral valve; N/A = not applicable; NT-proBNP = N-terminal pro-B-type natriuretic peptide; PG = pressure gradient; PHT = pressure half-time; PV = pulmonary venous; RV = right ventricular; SVI = stroke volume index; SVRI = systemic vascular resistance index; SVV = stroke volume variation; TEER = transcatheter edge-to-edge repair.

MV area, created the possibility for the ensuing TEER to be completed. Importantly, we used a shorter but wider version of the Mitraclip device (NTW) so that leaflet shortening and tension from clipping could be minimized, whereas the wide MR jet could be adequately ameliorated by single wide clip rather than ≥2 narrow NT devices, which could render the MV area lost greatly. Finally, despite the elevation in both mean left atrial pressure and trans-MV pressure immediately after TEER, the surrogate of severe MR, that is, the pulmonary vein systolic reversal waveform, vanished completely and the cardiac index increased significantly. Additionally, improvement in clinical symptoms and a decrease in the NT-proBNP level were seen, indicating the success of these procedures for this otherwise TEER-contraindicated patient. Thus, for selected patients of Carpentier class IIIa MR whose fused mitral commissures could be corrected by a preceding BMC, mitral TEER may still be considered

FIGURE 5 Follow-Up Transthoracic Echocardiography at 7 Months



(A) Residual moderate mitral regurgitation (MR). **(B)** Mean transmitral pressure gradient of 9.33 mm Hg. **(C)** Mitral valve (MV) area of 1.38 cm^2 by the pressure half-time method.

as an effective and safe therapeutic alternative to surgical MVR.

FOLLOW-UP

At 1 month after discharge the patient's NYHA functional class improved to class II and serum NT-proBNP level decreased. The preoperative, post-BMC, and post-TEER hemodynamic data are listed in **Table 1**. The patient subsequently underwent tricuspid TEER at 3 months using 2 miskeyed G4 XTW Mitraclip devices to help relieve tricuspid regurgitation-related right heart failure and has maintained a stable condition at 9 months. Follow-up transthoracic echocardiography at 7 months revealed moderate MR, a mean transmitral pressure gradient of 9 mm Hg, and a MV area of 1.36 cm^2 by the pressure half-time method (**Figure 5**, Videos 4A to 4C).

CONCLUSIONS

When indicated, patients with severe MR, commissural fusion and a MV area of <4 cm^2 (Carpentier class IIIa, rheumatic origin) but adequate leaflet length can still be safely and efficiently treated with precedent BAC followed by TEER.

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ADDRESS FOR CORRESPONDENCE: Dr Tsun-Jui Liu, Cardiovascular Center, Taichung Veterans General Hospital, 1650, Sect. 4, Taiwan Boulevard, Taichung 40705, Taiwan. E-mail: trliu@vghtc.gov.tw.

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KEY WORDS balloon commissurotomy, Carpentier classification, mitral regurgitation, transcatheter edge-to-edge repair

APPENDIX For supplemental videos, please see the online version of this paper.