Supplementary data

Supplementary Appendix 1. Methods: Leaflet-to-annulus index measurements

The posteroseptal and anteroposeterior coaptation lines were identified in the biplane midoesophageal or transgastric views. Then, the experienced cardiologist retrospectively evaluated leaflet length and annular dimension of each coaptation line. The measurement in the posteroseptal coaptation line was performed in the midoesophageal 4-chamber view at 150-180°, while that in the anteroposterior coaptation line was performed in the transgastric 2-chamber view at 110-140°. We used the images in which the widest vena contract of the TR jet in each coaptation line was observed; however, if the TR jet was not located in the posteroseptal or anteroposterior coaptation lines, images across 5 mm inside of each leaflet edges were used.

Supplementary Table 1. Univariate logistic regression analysis for residual tricuspid regurgitation ≥3+ after transcatheter edge-to-edge repair.

	OR	95% CI	p-value
Echocardiographic findings			
LAI (per 0.1 increase)	0.50	0.33–0.75	<0.001
Annular diameter (mm)	1.05	0.99–1.11	0.07
Anterior leaflet length (mm)	0.98	0.92–1.04	0.47
Septal leaflet length (mm)	0.96	0.89–1.03	0.27
Coaptation gap (mm)	1.24	1.10–1.40	<0.001
Coaptation depth (mm)	1.12	1.02–1.24	0.02
Secondary TR	3.30	0.39–27.7	0.27
TR severity ≥4+	8.13	3.54–18.70	<0.001
Vena contracta (mm)	1.34	1.20–1.50	<0.001
EROA (mm2)	1.02	1.01–1.03	0.005
TR jet location			
Non-central/non-anteroseptal commissure	2.86	1.27–6.43	0.01
LVEF (%)	1.01	0.97–1.05	0.55
LVEDV (ml)	0.99	0.98–1.00	0.05
RA area (cm^2)	1.03	1.00–1.07	0.04
RV diameter (mm)	1.02	0.97–1.06	0.49
SPAP (mmHg)	0.98	0.94–1.01	0.13
TAPSE (mm)	1.00	0.93–1.08	0.99
MR ≥2+	0.68	0.32–1.44	0.31
Procedural findings			
MitraClip/TriClip (vs PASCAL)	0.46	0.20–1.06	0.07
Simultaneous TMVR	0.47	0.10–2.28	0.32
Number of clips	1.28	0.85–1.93	0.24
Post-procedural mean TVPG	1.29	0.96–1.72	0.08

EROA: effective regurgitant orifice area; IVC: inferior vena cava; LAI: leaflet-to-annulus index; LVEDV: left ventricular end-diastolic volume; LVEF: left ventricular ejection fraction; MR: mitral regurgitation; RA: right atrium; RV: right ventricle; SPAP: systolic pulmonary artery pressure; TAPSE: tricuspid annular plane systolic excursion; TMVR: transcatheter mitral valve repair; TR: tricuspid regurgitation; TVPG: tricuspid valvular pressure gradient.

Supplementary Table 2. Incremental effect of adding the leaflet-to-annulus index to conventional factors for residual tricuspid regurgitation ≥3+.

	C-statistics	NRI (95% CI)	p-value	IDI (95% CI)	p-value
Conventional factors*	0.780	NA		NA	
Conventional factors+LAI	0.822	0.65 (0.29–1.01)	0.004	0.04 (0.01–0.08)	0.03

*Conventional factors included: coaptation gap width ≥7.2 mm, non-central/non-anteroseptal TR jet location, and TR ≥4+ at baseline.

CI: confidence interval; IDI: integrated discrimination improvement; LAI: leaflet-to-annulus index; NRI: net reclassification improvement

Supplementary Table 3. Leaflet-to-annulus indexes of posteroseptal and anteroposterior coaptation lines.

	Total n=140	Residual TR ≥3+ n=43	Residual TR <3+ n=97	p-value
Posteroseptal coaptation line				
LAI	1.08±0.08	1.07±0.07	1.10±0.10	0.05
Annular diameter (mm)	42.5±7.4	43.7±8.1	42.1±7.0	0.26
Septal leaflet length (mm)	18.7±5.3	19.3±0.9	18.6±0.6	0.50
Posterior leaflet length (mm)	27.0±6.7	26.4±0.7	28.5±1.2	0.15
Anteroposterior coaptation line				
LAI	1.13±0.08	1.12±0.08	1.13±0.08	0.92
Annular diameter (mm)	41.4±6.7	44.7±7.0	40.0±6.1	0.0001
Anterior leaflet length (mm)	24.2±5.3	25.7±5.3	23.6±5.1	0.04
Posterior leaflet length (mm)	22.3±5.0	24.4±4.4	21.4±5.0	0.002

Values are mean±SD.

LAI: leaflet-to-annulus index; TR: tricuspid regurgitation

Supplementary Table 4. Univariate Cox-proportional hazard analysis for the one-year composite outcome after transcatheter edge-to-edge repair.

	Univariate analysis		
	HR	95% CI	p value
Male	1.19	0.59 – 2.36	0.62
Age (year)	0.98	0.93 – 1.03	0.32
BMI (kg/mm2)	1.00	0.94 – 1.07	0.91
eGFR (ml/min/1.73m2)	0.99	0.97 – 1.01	0.22
Coronary artery disease	1.83	0.89 – 4.02	0.10
Previous myocardial infarction	1.05	0.48 – 2.15	0.90
Atrial fibrillation	1.64	0.27 – 5.45	0.53
NYHA class III/IV	1.61	0.48 – 4.09	0.40
Lead across tricuspid valve	1.84	0.95 – 3.58	0.07
COPD	1.47	0.67 – 3.00	0.32
Logistic EuroSCORE (%)	1.01	0.99 – 1.03	0.12
NT-pro BNP (pg/ml)	1.00	0.99 – 1.00	0.25
Medication at baseline			
Beta-blocker	1.74	0.68 – 5.87	0.27
RAS inhibitor	0.62	0.31 – 1.25	0.18
MRA	1.11	0.55 – 2.21	0.76
Loop diuretics	1.50	0.32 – 26.6	0.67
Echocardiographic findings			
LAI (per 0.1 increase)	0.90	0.63 – 1.27	0.54
Annular diameter (mm)	0.96	0.91 – 1.01	0.17
Septal leaflet length (mm)	0.99	0.92 – 1.07	0.88
Lateral leaflet length (mm)	0.94	0.87 – 1.01	0.10
Coaptation gap (mm)	1.08	0.99 – 1.16	0.06
Coaptation depth (mm)	1.10	0.98 – 1.21	0.07
Secondary TR	0.15	0.36 – 4.21	0.53
TR severity ≥4+	1.36	0.67 – 2.71	0.39

TR jet location			
Non-central/non-anteroseptal TR jet location	1.12	0.56 – 2.28	0.75
Vena contracta (mm)	1.04	0.96 – 1.13	0.31
EROA (mm2)	0.99	0.98 – 1.01	0.58
LVEF (%)	0.97	0.94 – 0.99	0.04
LVEDV (ml)	1.01	1.00 – 1.02	0.03
RA area (cm2)	1.00	0.97 – 1.03	0.92
RV diameter (mm)	1.03	0.99 – 1.07	0.21
SPAP (mmHg)	0.99	0.95 – 1.02	0.40
TAPSE (mm)	0.93	0.87 – 1.01	0.06
MR ≥moderate	1.83	0.91 – 3.63	0.09
Procedural findings			
MitraClip/TriClip (vs. PASCAL)	1.18	0.49 – 3.51	0.73
Simultaneous TMVR	1.05	0.25 – 3.95	0.93
Number of Clips	0.87	0.53 – 1.40	0.59
Post-procedural mean TVPG (mmHg)	1.22	0.93 – 1.57	0.13
Implant failure	6.72	2.42 – 16.2	0.001
Implantation site of devices			
Posteroseptal coaptation line	1.14	0.53 – 2.30	0.73
Anteroposterior coaptation line	1.44	0.08 – 6.71	0.73
Reduction in vena contracta (mm)	0.85	0.76 – 0.95	0.005
Mean reduction in TR grade	0.53	0.32 – 0.87	0.01
Residual TR ≥3+	2.17	1.08 – 4.32	Male

BMI: body mass index; CI: confidence interval; COPD: chronic obstructive pulmonary disease; eGFR: estimated glomerular filtration rate; EROA: effective regurgitant orifice area; EuroSCORE: European System for Cardiac Operative Risk Evaluation; HR: hazard ratio; IVC: inferior vena cava; LVEDV: left ventricular end-diastolic volume; LVEF: left ventricular ejection fraction; MR: mitral regurgitation; MRA: mineralocorticoid receptor antagonist; NT-pro BNP: N-terminal pro-brain natriuretic peptide; NYHA: New York Heart Association; RA: right atrium; RAS: renin angiotensin system; ROA: effective regurgitant

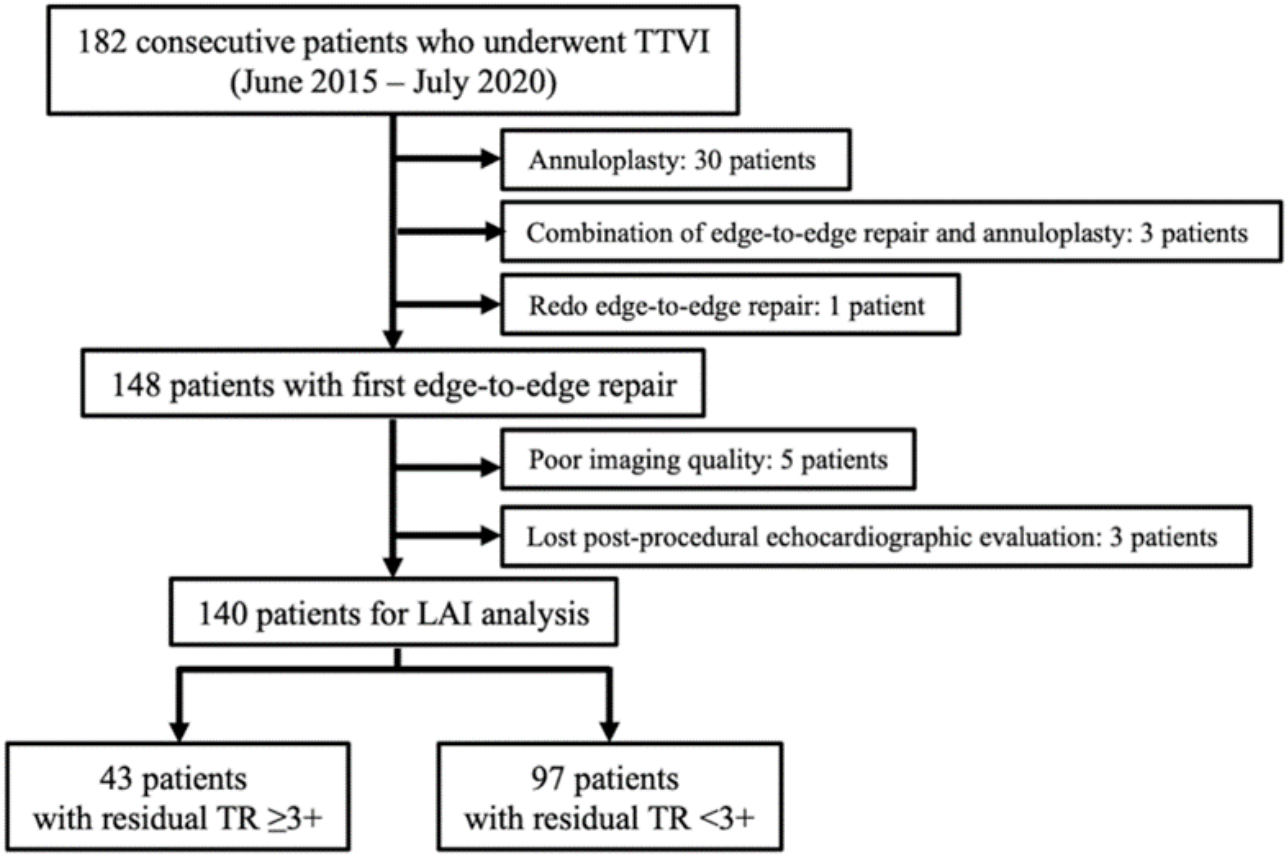
orifice area; RV: right ventricle; SPAP: systolic pulmonary artery pressure; TAPSE: tricuspid annular plane systolic excursion; TMVR: transcatheter mitral valve repair; TR: tricuspid regurgitation; TVPG: tricuspid valvular pressure gradient.

Supplementary Table 5. Association of clinical parameters with leaflet-to-annulus index.

	Standardised β	95% CI	p-value
Male	-0.14	-0.30–0.02	0.11
Age (year)	-0.17	-0.33 to -0.01	0.04
BMI (kg/mm2)	0.04	-0.13–0.21	0.68
eGFR (ml/min/1.73m2)	-0.14	-0.30–0.02	0.09
Coronary artery disease	-0.02	-0.19–0.15	0.79
Previous myocardial infarction	-0.02	-0.19–0.15	0.85
Atrial fibrillation	-0.08	-0.25–0.09	0.35
NYHA class III/IV	-0.01	-1.68–1.66	0.92
Lead across tricuspid valve	-0.11	-0.28–0.06	0.36
COPD	0.04	-0.13–0.21	0.64
Logistic EuroSCORE (%)	-0.16	-0.32–0.01	0.06
NT-pro BNP (pg/ml)	0.18	0.01–0.35	0.04
Coaptation gap (mm)	-0.30	-0.46 to -0.14	0.004
Coaptation depth (mm)	0.03	-0.14–0.20	0.70
TR severity grade	-0.24	-0.40 to -0.08	0.004
TR jet location			
Non-central/non-anteroseptal TR jet location	-0.22	-0.38 to -0.06	0.008
Posteroseptal commissure	-0.18	-0.34 to -0.02	0.04
Anteroposterior commissure	-0.28	-0.44 to -0.12	0.002
Vena contracta (mm)	-0.26	-0.42 to -0.10	0.002
EROA (mm2)	-0.14	-0.31–0.03	0.10
LVEF (%)	-0.19	-0.35 to -0.03	0.02
LVEDV (ml)	0.21	0.04–0.38	0.02
RA area (mm2)	-0.11	-0.29–0.07	0.22
RV diameter (mm)	-0.03	-0.21–0.15	0.75
SPAP (mmHg)	0.11	-0.07–0.29	0.22
TAPSE (mm)	-0.03	-0.20–0.14	0.72

MR ≥moderate	-0.09	-0.26–0.08	0.27

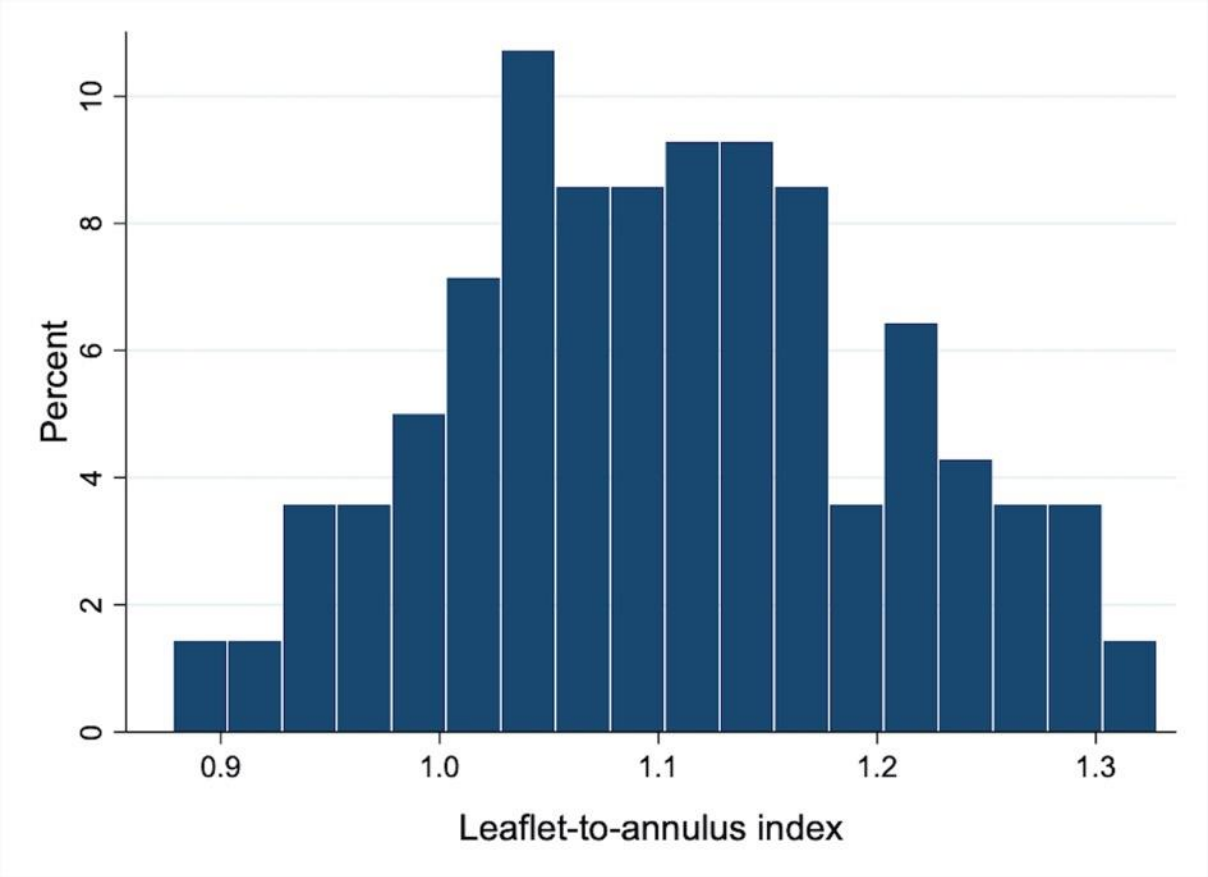
BMI: body mass index; CI: confidence interval; COPD: chronic obstructive pulmonary disease eGFR: estimated glomerular filtration rate; EROA: effective regurgitant orifice area; EuroSCORE: European System for Cardiac Operative Risk Evaluation; IVC: inferior vena cava; LVEDV: left ventricular end-diastolic volume; LVEF: left ventricular ejection fraction; MR: mitral regurgitation; MRA: mineralocorticoid receptor antagonist; NT-pro BNP: N-terminal pro-brain natriuretic peptide; NYHA: New York Heart Association; RA: right atrium; RAS: renin angiotensin system; ROA: effective regurgitant orifice area; RV: right ventricle; SPAP: systolic pulmonary artery pressure; TAPSE: tricuspid annular plane systolic excursion; TMVR: transcatheter mitral valve repair; TR: tricuspid regurgitation; TVPG: tricuspid valvular pressure gradient.



Supplementary Figure 1. Study flowchart.

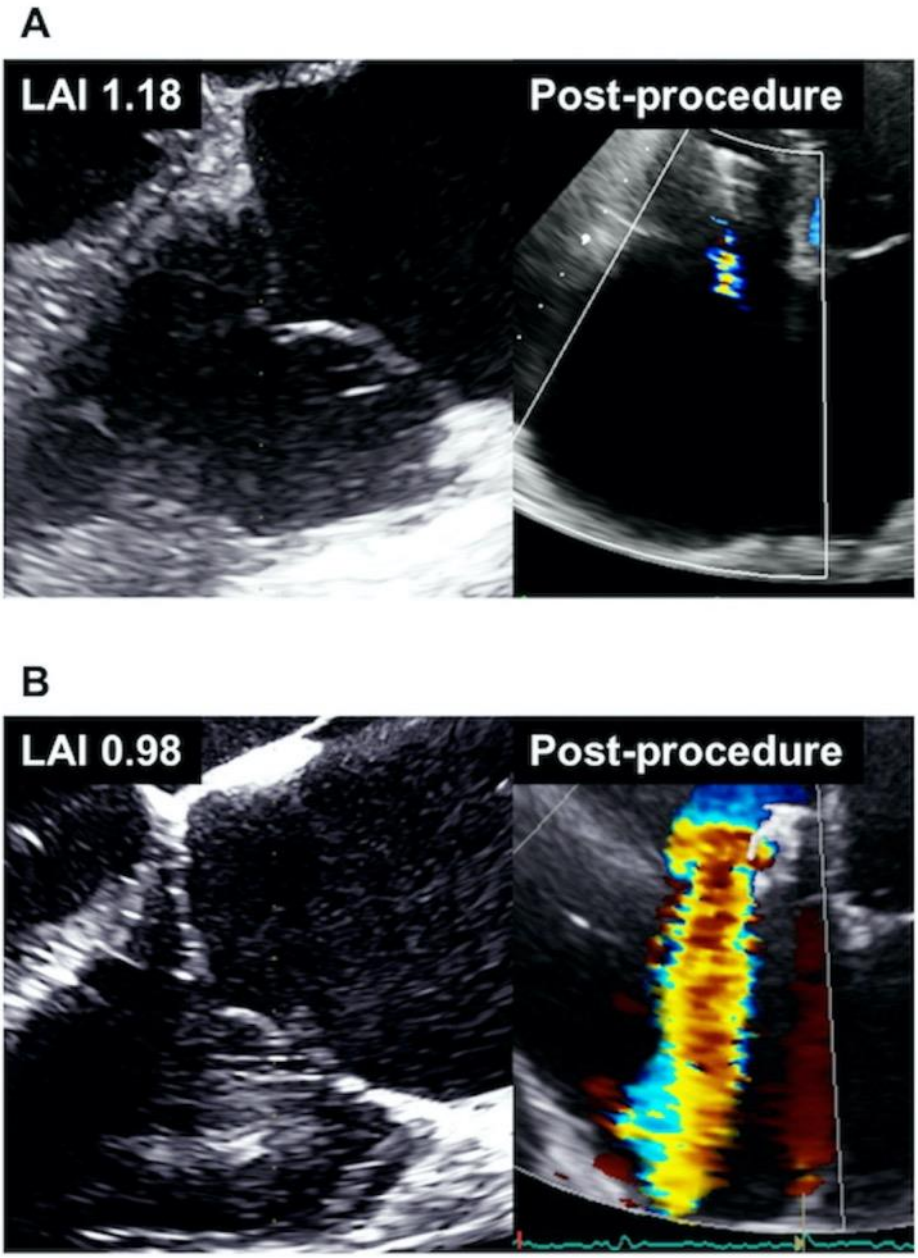
A study flowchart of this study.

LAI: leaflet-to-annulus index; TR: tricuspid regurgitation; TTVI: transcatheter tricuspid valve intervention.



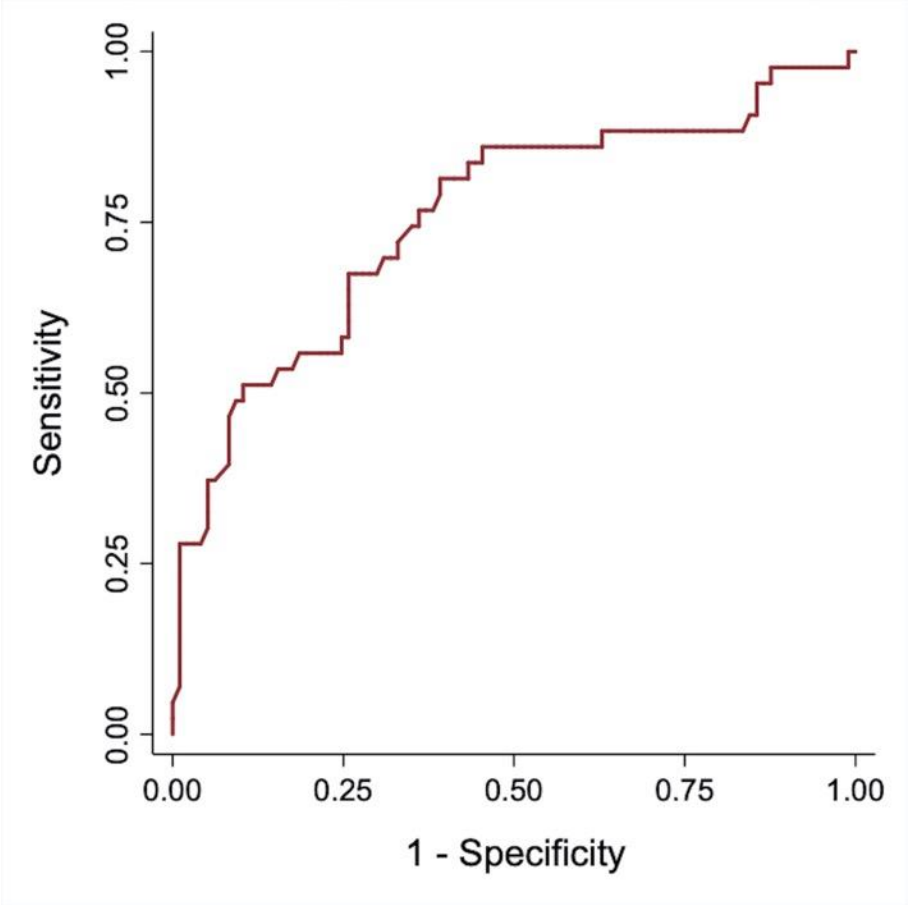
Supplementary Figure 2. Distribution of the leaflet-to-annulus index.

A histogram showing the distribution of leaflet-to-annulus index.



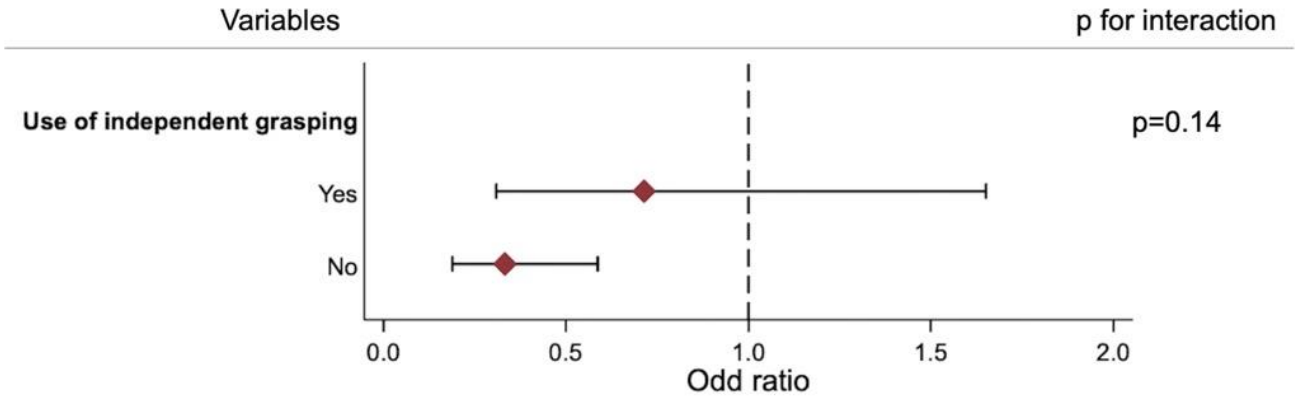
Supplementary Figure 3. Representative echocardiographic images of patients with a high and low leaflet-to-annulus index.

Procedural and post-procedural echocardiographic images in patients with high leaflet-to-annulus index (LAI) (A) and those with low LAI (B).



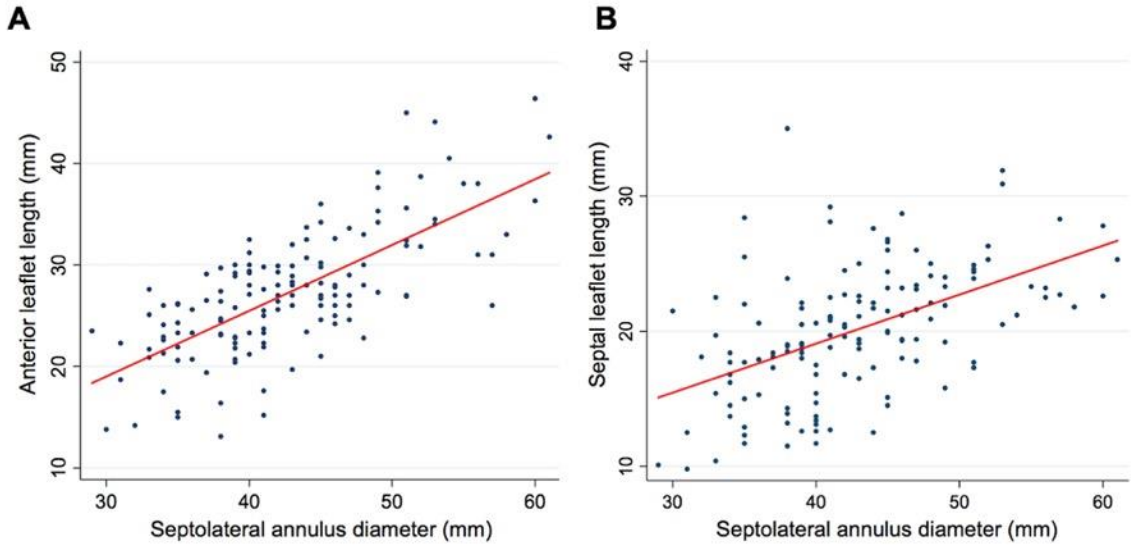
Supplementary Figure 4. Receiver operating characteristics curve of the leaflet-to-annulus index for residual tricuspid regurgitation (≥3+) after transcatheter edge-to-edge repair**.**

The receiver operating characteristics analysis showed that the value of leaflet-to-annulus index needed to discern residual tricuspid regurgitation ≥3+ was 1.06 (sensitivity: 56%; specificity: 75%; C-statistic: 0.757; p=0.001).



Supplementary Figure 5. Interaction between leaflet-to-annulus index and use of independent grasping on the risk of residual tricuspid regurgitation ≥3+.

A forest plot illustrating the interaction between the leaflet-to-annulus index (continuous) and use of independent grasping on the risk of residual tricuspid regurgitation ≥3+.



C

	Univariate analysis			Multivariable analysis		
	Standardized β	95%CI	p value	Standardized β	95%CI	p value
Anterior leaflet length (mm)	0.71	0.59 - 0.83	<0.0001	0.67	0.55 - 0.80	<0.0001
Septal leaflet length (mm)	0.51	0.37 - 0.66	<0.0001	0.46	0.32 - 0.61	<0.0001

Multivariable analysis was adjusted by body surface area.

Supplementary Figure 6. Association between leaflet length and annulus dimension of tricuspid valve.

A. Correlation between septolateral annulus diameter and anterior leaflet length (R=0.71; p<0.0001).

B. Correlation between septolateral annulus diameter and septal leaflet length (R=0.51; p<0.0001).

C. Univariate and multivariable linear regression analyses for Correlation of anterior and septal leaflet lengths with septolateral annulus diameter. Multivariable model was adjusted by body surface area.