

ORIGINAL RESEARCH

STRUCTURAL

Impact of Valve Frame Height on PCI Outcomes After TAVR



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ABSTRACT

BACKGROUND Coronary access after transcatheter aortic valve replacement (TAVR) remains challenging, particularly with tall-framed valves (TFVs), raising concerns about long-term percutaneous coronary intervention (PCI).

OBJECTIVES The aim of this study was to evaluate the impact of bioprosthetic aortic valve type on long-term clinical outcomes in patients undergoing PCI following TAVR.

METHODS Data were derived from the multicenter REVIVAL-PCI registry, which included patients from 21 European centers who underwent PCI after TAVR between 2008 and 2023. Patients were classified according to valve frame height: TFVs or short-framed valves (SFVs). The primary endpoint was the 4-year incidence of major adverse cardiovascular events, defined as the composite of cardiovascular death, myocardial infarction, or stroke. Cumulative event rates were estimated using Kaplan-Meier method, and weighted Cox regression models using an entropy balance approach were used to adjust for imbalances in clinical and procedural confounders.

RESULTS The analysis included 441 patients, with 230 having undergone TAVR with SFVs (30.9% women) and 211 with TFVs (44.1% women). The median follow-up after PCI was 908 days (Q1-Q3: 322-1,728 days). The 4-year incidence of major adverse cardiovascular events was comparable between the SFV and TFV groups (38.1% [95% CI: 24.6%-43.9%] vs 31.9% [95% CI: 24.8%-41.0%]; HR: 1.04; 95% CI: 0.71-1.52; $P = 0.846$). Similar findings were observed after adjustment for potential confounders.

CONCLUSIONS In current practice, long-term outcomes after PCI in TAVR patients do not appear to be significantly different between those receiving SFVs and TFVs. Future investigations with newer generation valves and refined implantation techniques are needed to clarify these associations and optimize management strategies. (JACC Cardiovasc Interv. 2026;19:345-355) © 2026 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/>).

ABBREVIATIONS AND ACRONYMS

AS	= aortic stenosis
CAD	= coronary artery disease
CV	= cardiovascular
MACE	= major adverse cardiovascular event(s)
MI	= myocardial infarction
PCI	= percutaneous coronary intervention
SFV	= short-framed valve
SMD	= standardized mean difference
TAVR	= transcatheter aortic valve replacement
TFV	= tall-framed valve
TVR	= target vessel revascularization

The development of coronary artery disease (CAD) and aortic stenosis (AS) shares common pathogenic mechanisms.¹ Consequently, these conditions frequently coexist, with CAD found in up to 75% of patients with AS and associated with worse clinical outcomes following aortic valve interventions.^{2–4}

Transcatheter aortic valve replacement (TAVR) has become the standard of care for symptomatic severe AS in patients across a broad spectrum of surgical risk. However, as TAVR is increasingly performed in younger individuals with longer life expectancies, there is growing concern regarding the feasibility of subsequent coronary revascularization. Unplanned percutaneous coronary intervention (PCI) following TAVR remains relatively infrequent. However, its incidence is increasing as these patients live longer and remain at risk for progressive CAD.^{2,5–7} This underscores the importance of strategic valve selection at the time of TAVR to optimize future coronary access and ensure long-term procedural success.^{4,8}

Although SFVs are associated with more favorable coronary reaccess, PCI remains feasible with tall-framed valves (TFVs), albeit with potentially greater complexity.^{9–11} A recent study by Zendjebil et al¹² highlighted this distinction, reporting a higher long-

term risk for death or heart failure rehospitalization in patients with TFVs after coronary events. However, this finding, driven only by heart failure hospitalizations, was derived from an unadjusted analysis. This raises the possibility that the finding was due to confounding rather than a true effect of valve type. Furthermore, the impact of valve design on other pivotal endpoints such as myocardial infarction (MI) and stroke remains unknown.

Given that valve selection is influenced by multiple clinical and anatomical factors, a robustly adjusted analysis is essential. Although prior work has focused on procedural feasibility of PCI following TAVR,⁶ data on long-term clinical outcomes remain scarce. This study from the multicenter REVIVAL-PCI registry addresses these critical evidence gaps.

We hypothesized that valve frame height, by influencing coronary access, may affect long-term cardiovascular (CV) outcomes after PCI in TAVR patients. Therefore, we provide the first comprehensive, adjusted comparison of a broad range of CV outcomes in patients undergoing PCI after TAVR with either short-framed valves (SFVs) or TFVs.

METHODS

STUDY POPULATION. The REVIVAL-PCI registry included consecutive patients undergoing PCI after TAVR for significant CAD from 2008 to 2023 at

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors’ institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the [Author Center](#).

21 centers across Europe ([Supplemental Table 1](#)). The study was conducted following the ethical principles of the Declaration of Helsinki and was approved by the Institutional Review Board of each center.

Detailed information on baseline characteristics, PCI and TAVR procedures, antithrombotic regimen after PCI, and clinical outcomes was retrospectively collected by each participating center in a preformatted extraction sheet. For the present analysis, patients were classified according to the implanted valve type according to frame height: SFV vs TFV.

Both TAVR and PCI procedures were performed according to standard techniques, with device choice based on operator preference. Antithrombotic therapy and duration were left to the discretion of the treating physician. Clinical follow-up was conducted via either inpatient or outpatient visits or telephone interviews. All adverse events were site reported.

ENDPOINTS. The primary outcome of interest of this study was major adverse CV events (MACE), defined as the composite of CV death, MI, or stroke at 4-year follow-up. Secondary outcomes included the single components of the primary outcome, CV death, target vessel MI, periprocedural MI, target lesion revascularization, target vessel revascularization (TVR), target vessel failure (defined as a composite of TVR, MI, and CV death), definite or probable stent thrombosis, and CV hospitalization. Outcome definitions can be found in [Supplemental Table 2](#).

STATISTICAL ANALYSIS. Continuous variables are reported as mean $\pm$ SD or median (Q1–Q3), while categorical variables are expressed as absolute numbers and percentages. Patients undergoing PCI with prior SFVs were compared with those with prior TFVs. Covariate balance between the 2 groups was assessed using the standardized mean difference (SMD), with an SMD <0.1 indicating good balance.

To control for confounding variables, we used entropy balancing, a powerful reweighting method designed to achieve superior covariate balance compared with traditional propensity score methods.¹³ The selection of covariates for adjustment was prespecified on the basis of clinical expertise and a directed acyclic graph model to identify potential confounders while excluding known mediators (eg, procedural success) that lie on the causal pathway between valve type and outcome. We chose entropy balancing more than alternatives like inverse probability of treatment weighting because of its methodological advantages in this setting. Whereas inverse probability of treatment weighting relies on a predictive model for treatment assignment that may still leave residual imbalances, entropy balancing is an

optimization algorithm that computed weights to make the covariate distributions nearly identical across the 2 valve groups. This is achieved by matching not just their means, but also their variance and skewness. This approach is particularly effective in studies with modest sample sizes and significant baseline imbalances, as seen in our cohort. Final weights were truncated at the 1st and 99th percentiles, a standard technique to improve the stability and precision of the estimates by preventing subjects with extreme weights from having undue influence.¹⁴

To assess the impact of both the baseline clinical profile and the PCI procedure itself, we computed 2 distinct weighted models, as outlined in [Supplemental Figure 1](#). Our primary analysis (model 1) adjusted for a comprehensive set of clinical, demographic, and TAVR-related confounders that were present before the index PCI. For sensitivity analysis, we then included all variables from model 1 and additionally adjusted for a detailed set of procedural characteristics from index PCI (model 2). A complete list of the specific covariates included in each of these 2 adjustment models is provided in [Supplemental Table 3](#). The pre- and postweighting balance diagnostics for these models are detailed in [Supplemental Figures 2 and 3](#). The number of missing values for each variable in each model is reported in [Supplemental Table 4](#).

We estimated 95% CIs using a robust variance estimator to account for potential correlations introduced by weighting. The association between valve type and outcomes was estimated using weighted Cox regression models. The Kaplan-Meier method was used to estimate both crude and weighted cumulative incidences, which were compared between groups using the log-rank test for the time-to-first event. The proportional hazards assumption was evaluated for the weighted Cox models using Schoenfeld residuals and corresponding global tests. No relevant violations of the assumption were found.

To explore for potential treatment effect modification, we performed formal tests for interaction within our primary adjusted Cox regression model (model 1). Subgroup analyses were conducted for the primary endpoint on the basis of clinical presentation (acute vs chronic coronary syndrome), sex, and median age.

To ensure the robustness of our findings with respect to country-level differences, we conducted a dedicated sensitivity analysis ([Supplemental Table 5](#)). To reduce statistical instability, we applied a 2-step filtering process: 1) exclusion of small centers contributing fewer than 10 patients; and 2)

TABLE 1 Baseline Clinical Characteristics of the Population With No Adjustment and After Adjustment With Model 1

	Unadjusted			Adjusted		
	SFV (n = 230)	TFV (n = 211)	SMD	SFV (n = 191.8)	TFV (n = 182.0)	SMD
Clinical characteristics						
Age, y	80.7 ± 5.8	81.1 ± 6.4	0.065	80.9 ± 5.4	80.9 ± 6.3	0.001
Women	71 (30.9)	93 (44.1)	0.275	73.0 (38.1)	70.8 (38.9)	0.017
Logistic EuroSCORE	12.6 ± 11.7	14.7 ± 11.6	0.177	14.1 ± 13.8	13.39 ± 11.23	0.058
EuroSCORE II	5.2 ± 6.7	5.8 ± 5.8	0.095	6.2 ± 8.3	5.50 ± 5.39	0.102
BMI, kg/m ²	26.7 ± 4.7	27.5 ± 4.9	0.170	27.30 ± 4.8	27.22 ± 4.45	0.017
Hypertension	202 (87.8)	193 (91.5)	0.120	172.6 (90.0)	163.7 (89.9)	0.002
Diabetes	70 (30.4)	70 (33.2)	0.059	57.3 (29.9)	56.3 (31.0)	0.023
Dyslipidemia	162 (70.4)	154 (73.0)	0.057	138.4 (72.2)	132.4 (72.8)	0.013
Previous PCI	85 (37.0)	105 (49.8)	0.261	80.0 (41.7)	75.6 (41.5)	0.004
Previous CABG	25 (10.9)	39 (18.5)	0.216	28.0 (14.6)	26.0 (14.3)	0.009
Previous PCI or CABG	95 (41.3)	118 (55.9)	0.296	90.6 (47.2)	82.5 (45.3)	0.038
Peripheral arterial disease	42 (18.3)	42 (19.9)	0.040	35.7 (18.6)	34.7 (19.0)	0.011
eGFR, mL/min/1.73 m ²	63.5 ± 22.3	60.2 ± 20.8	0.152	62.0 ± 22.5	62.1 ± 20.9	0.005
LVEF, %	53.6 ± 12.7	55.6 ± 11.0	0.165	54.8 ± 11.6	54.9 ± 11.0	0.014
TAVR characteristics						
Year of TAVR procedure			0.263			0.022
2008-2012	33 (14.3)	33 (15.7)		25.9 (13.5)	24.1 (13.2)	
2012-2017	102 (44.3)	116 (55.2)		93.2 (48.6)	90.5 (49.7)	
2018-2023	95 (41.3)	61 (29.0)		72.6 (37.9)	67.4 (37.0)	
Transapical approach	24 (10.4)	12 (5.7)	0.175	15.0 (7.8)	14.0 (7.7)	0.006
Valve size, mm	25.90 ± 2.11	27.19 ± 2.39	0.571	26.40 ± 2.00	26.39 ± 2.22	0.004
Valve-in-valve	2 (0.9)	3 (1.4)	0.052	1.0 (0.5)	1.9 (1.0)	0.056
Postdilatation	35 (15.2)	90 (42.7)	0.635	55.4 (28.9)	55.4 (30.4)	0.034

Values are mean ± SD or n (%). Variables included in the adjusted model are reported in Supplemental Table 3.
 BMI = body mass index; CABG = coronary artery bypass grafting; eGFR = estimated glomerular filtration rate; EuroSCORE = European System for Cardiac Operative Risk Evaluation; LVEF = left ventricular ejection fraction; PCI = percutaneous coronary intervention; SFV = short-framed valve; SMD = standardized mean difference; TAVR = transcatheter aortic valve replacement; TFV = tall-framed valve.

exclusion of countries where, after this step, one valve type was no longer represented. In the resulting restricted cohort, we re-estimated the weighted Cox regression using the same covariates as in model 1, while additionally including country as a balancing variable in the entropy weighting procedure.

Moreover, to assess the potential for overestimation of risk by the Kaplan-Meier method, we performed 2 sensitivity analyses on model 1. First, we evaluated the adjusted outcomes at 1 year. Second, as an alternative to the primary Cox model, we used an adjusted Fine-Gray subdistribution hazard model to re-estimate the subdistribution HRs while accounting for competing risks. To account for the nature of the different endpoints, the competing risks were defined as follows: for the composite endpoint of MACE and the individual endpoint of CV death, non-CV death was treated as the competing risk; for all other nonfatal endpoints, all-cause death was treated as the competing risk.

P values <0.05 were considered to indicate statistical significance. All analyses were performed using R version 4.3.1 (R Foundation for Statistical Computing).

RESULTS

BASELINE CLINICAL AND PROCEDURAL CHARACTERISTICS.

Of the 464 patients in the REVIVAL-PCI registry, 441 patients were included in this analysis after excluding 23 recipients of mechanically expandable or transapical valves. A total of 230 patients received SFVs and 211 received TFVs across 21 centers. SFVs were almost entirely balloon expandable SAPIEN valves (226 [98.3%]; Edwards Lifesciences). Conversely, all TFVs were self-expanding, predominantly CoreValve or Evolut (141 [66.8%]; Medtronic), Symetis or ACURATE (54 [25.6%]; Boston Scientific), and Portico or Navitor devices (13 [6.2%]; Abbott Laboratories).

Tables 1 and 2 report clinical and procedural characteristics according to valve type before weighting and after weighting for clinical confounders.

Before weighting, SFV patients were less likely to be female (30.9% vs 44.1%, SMD = 0.275) and had lower rates of hypertension (87.8% vs 91.5%, SMD = 0.120) and prior PCI (37.0% vs 49.8%, SMD = 0.261) or CABG (10.9% vs 18.5%, SMD = 0.216) compared with TFV patients. Age was

TABLE 2 PCI Characteristics of the Population With No Adjustment and After Adjustment With Model 1

	Unadjusted			Adjusted		
	SFV (n = 230)	TFV (n = 211)	SMD	SFV (n = 191.8)	TFV (n = 182.0)	SMD
PCI characteristics						
Days from TAVR to PCI	89.5 (40.0-613.5)	143.0 (40.0-396.2)	0.088	87.6 (41.0-536.7)	140.7 (39.1-402.6)	0.011
PCI planned at time of TAVR	59 (25.7)	57 (27.0)	0.031	51.6 (26.9)	50.1 (27.5)	0.014
Indication for PCI			0.397			0.006
CCS	164 (72.6)	113 (54.1)		127.3 (66.4)	120.9 (66.4)	
Unstable angina	13 (5.8)	21 (10.0)		16.8 (8.8)	15.9 (8.7)	
NSTEMI	38 (16.8)	54 (25.8)		36.3 (18.9)	34.7 (19.0)	
STEMI	9 (4.0)	17 (8.1)		8.8 (4.6)	8.2 (4.5)	
AHF or cardiac arrest	2 (0.9)	4 (1.9)		2.6 (1.4)	2.4 (1.3)	
Radial access	114 (52.3)	84 (42.0)	0.207	84.3 (45.7)	69.6 (39.2)	0.132
Number of diseased vessels	1.0 (1.0-2.0)	1.0 (1.0-1.0)	0.176	1.0 (1.0-1.0)	1.0 (1.0-1.0)	0.036
ACC/AHA type 2B or C	172 (90.1)	130 (86.1)	0.122	155.1 (89.8)	121.5 (89.5)	0.010
Severe calcifications	58 (25.2)	51 (24.2)	0.024	49.7 (25.9)	44.0 (24.2)	0.040
CTO	8 (3.5)	3 (1.4)	0.133	9.6 (5.0)	3.3 (1.8)	0.176
Evidence of thrombus	8 (3.7)	9 (4.7)	0.052	9.3 (5.0)	7.7 (4.6)	0.016
Intravascular imaging	14 (6.1)	18 (8.5)	0.094	6.6 (3.4)	14.1 (7.7)	0.189
Bifurcation	66 (28.7)	43 (20.4)	0.194	54.3 (28.3)	43.0 (23.6)	0.107
ISR	26 (11.3)	30 (14.2)	0.087	21.1 (11.0)	26.9 (14.8)	0.113
Thrombus aspiration	1 (0.5)	1 (0.5)	0.007	0.4 (0.2)	1.0 (0.6)	0.057
Use of plaque modification device	14 (6.6)	5 (2.7)	0.189	10.7 (5.9)	2.4 (1.5)	0.234
Predilatation	183 (86.7)	154 (82.8)	0.110	159.9 (87.1)	143.3 (86.7)	0.012
PCI on LM	33 (15.1)	37 (18.6)	0.094	25.1 (13.5)	27.2 (15.5)	0.058
PCI on LAD	105 (47.9)	83 (41.7)	0.126	87.0 (46.6)	88.0 (50.1)	0.070
PCI with DES	202 (93.5)	180 (92.3)	0.047	173.4 (93.7)	156.1 (90.3)	0.126
Number of lesions per patients	1.0 (1.0-2.0)	1.0 (1.0-2.0)	0.128	1.0 (1.0-2.0)	1.0 (1.0-2.0)	0.067
Number of stents per lesion	1.0 (1.0-2.0)	1.0 (1.0-2.0)	0.118	1.0 (1.0-2.0)	1.0 (1.0-2.0)	0.006
Total stent length per lesion, mm	40.4 ± 27.8	35.1 ± 24.4	0.203	38.5 ± 26.1	38.5 ± 26.6	0.001
Minimum stent diameter, mm	2.9 ± 0.5	3.0 ± 0.6	0.217	3.0 ± 0.6	3.0 ± 0.6	0.035
Total number of stents per patient	1.0 (1.0-2.0)	1.0 (1.0-2.0)	0.186	1.0 (1.0-2.0)	1.0 (1.0-2.0)	0.094
Total stent length per patient, mm	35.2 ± 29.6	27.9 ± 25.3	0.264	36.6 ± 29.9	30.7 ± 24.5	0.217
Complex PCI	76 (36.2)	57 (30.0)	0.132	67.0 (36.5)	51.3 (31.2)	0.113
Successful PCI	221 (98.2)	197 (95.2)	0.171	187.0 (97.6)	171.2 (94.7)	0.152
Angiographic success	215 (98.6)	192 (99.0)	0.032	185.0 (99.1)	168.2 (99.0)	0.013
Complete revascularization	158 (71.2)	137 (67.8)	0.073	130.6 (68.2)	121.7 (67.4)	0.018
Coronary occlusion	3 (1.3)	1 (0.5)	0.089	1.0 (0.5)	0.7 (0.4)	0.022
Post-PCI antiplatelet therapy						
OAC	59 (26.7)	47 (23.2)	0.082	50.0 (26.1)	46.7 (25.7)	0.010
Short DAPT (≤3 mo)	59 (28.9)	39 (20.3)	0.201	48.3 (27.6)	43.2 (25.7)	0.044

Values are median (Q1-Q3), n (%), or mean ± SD. Variables included in the adjusted model are reported in Supplemental Table 3. CCS was defined as stable angina, silent ischemia, or left ventricular ejection fraction deterioration.

ACC = American College of Cardiology; AHA = American Heart Association; AHF = acute heart failure; CCS = chronic coronary syndrome; CTO = chronic total occlusion; DAPT = dual antiplatelet therapy; DES = drug-eluting stent(s); ISR = in-stent restenosis; LAD = left anterior descending coronary artery; LM = left main coronary artery; NSTEMI = non-ST-segment elevation myocardial infarction; OAC = oral anticoagulation; STEMI = ST-segment elevation myocardial infarction; other abbreviations as in Table 1.

similar in the 2 groups (81.1 ± 6.4 years vs 80.7 ± 5.8 years, SMD = 0.065), as well as the prevalence of diabetes (33.2% vs 30.4%, SMD = 0.059). In the SFV group, mean valve size was smaller (25.9 ± 2.1 mm vs 27.2 ± 2.4 mm, SMD = 0.571), and a transapical approach was more frequently used (10.4% vs 5.7%, SMD = 0.175) than in the TFV group.

PCI was performed 89.5 days (Q1-Q3: 40.0-613.5 days) after TAVR implantation in the SFV group

and 143.0 days (Q1-Q3: 40.0-396.25 days) in the TFV group. Radial access was more commonly used in the SFV group than in the TFV group (52.3% vs 42.0%, SMD = 0.207). An acute coronary syndrome as index presentation was more common in the TFV cohort (43.9% vs 26.6% in the SFV cohort, SMD = 0.397). PCI was more frequently successful in the SFV group than in the TFV group (98.2% vs 95.2%, SMD = 0.171) despite the higher rate of complex lesions treated (36.2% vs 30.0%, SMD = 0.132).

TABLE 3 4-Year Clinical Outcomes in the Unadjusted Population and After Adjustment With Model 1

	Unadjusted				Adjusted for Clinical Variables			
	KM Incidence at 4 Years (95% CI)				KM Incidence at 4 Years (95% CI)			
	SFV (n = 230)	TFV (n = 211)	HR (95% CI)	P Value	SFV (n = 191.8)	TFV (n = 182.0)	HR (95% CI)	P Value
MACE	38.1 (24.6-43.9)	31.9 (24.8-41.0)	1.04 (0.71-1.52)	0.846	40.4 (25.8-51.9)	34.1 (22.6-44.0)	1.13 (0.64-2.00)	0.674
Death	39.3 (30.3-49.2)	35.8 (28.8-45.4)	1.09 (0.76-1.57)	0.632	46.3 (31.5-57.9)	38.5 (26.2-49.1)	1.28 (0.78-2.01)	0.336
MI	10.7 (1.9-11.8)	13.7 (7.4-19.3)	0.62 (0.32-1.20)	0.156	6.1 (0.1-11.8)	15.1 (6.2-23.3)	0.43 (0.12-1.56)	0.201
Stroke	11.4 (3.8-16.7)	4.2 (1.1-8.5)	2.03 (0.81-5.10)	0.133	12.6 (2.9-21.5)	6.1 (0.0-12.2)	1.65 (0.41-6.75)	0.482
CV death	26.5 (17.1-35.3)	21.6 (15.8-30.8)	1.22 (0.76-1.96)	0.412	28.4 (15.5-39.4)	19.5 (11.0-27.4)	1.45 (0.76-2.78)	0.258
Stent thrombosis	1.0 (0.0-2.7)	2.1 (0.0-4.7)	0.46 (0.08-2.50)	0.366	2.8 (0.0-7.6)	0.8 (0.0-1.6)	3.62 (0.46-28.4)	0.221
Periprocedural MI	7.7 (0.8-13.2)	9.8 (4.1-16.8)	0.80 (0.32-2.00)	0.636	8.4 (0.4-15.8)	11.2 (2.8-19.1)	0.95 (0.27-3.28)	0.936
Target vessel MI	4.8 (0.0-6.8)	8.7 (3.9-14.5)	0.55 (0.22-1.38)	0.204	5.0 (0.0-10.6)	8.5 (1.2-15.2)	0.74 (0.16-3.39)	0.699
TLR	8.0 (2.8-13.6)	13.2 (8.2-20.6)	0.56 (0.27-1.15)	0.114	13.1 (3.9-21.4)	13.9 (5.1-22.0)	1.00 (0.39-2.55)	0.997
TVR	12.0 (4.8-18.5)	19.6 (14.1-28.9)	0.54 (0.29-0.99)	0.046	14.1 (4.9-22.5)	18.7 (9.4-27.1)	0.78 (0.33-1.84)	0.577
TVF	35.1 (25.4-44.8)	36.6 (31.0-48.0)	0.90 (0.61-1.31)	0.567	40.4 (26.2-52.0)	34.8 (23.8-44.4)	1.15 (0.67-1.95)	0.607
CV rehospitalization	36.6 (22.0-42.0)	31.9 (25.0-42.2)	0.98 (0.66-1.47)	0.931	37.0 (22.2-49.1)	31.2 (19.6-41.5)	1.05 (0.58-1.89)	0.875

Variables included in the adjusted model are reported in [Supplemental Table 3](#).CV = cardiovascular; KM = Kaplan-Meier; MACE = major adverse cardiovascular event(s); MI = myocardial infarction; TLR = target lesion revascularization; TVF = target vessel failure; TVR = target vessel revascularization; other abbreviations as in [Table 1](#).

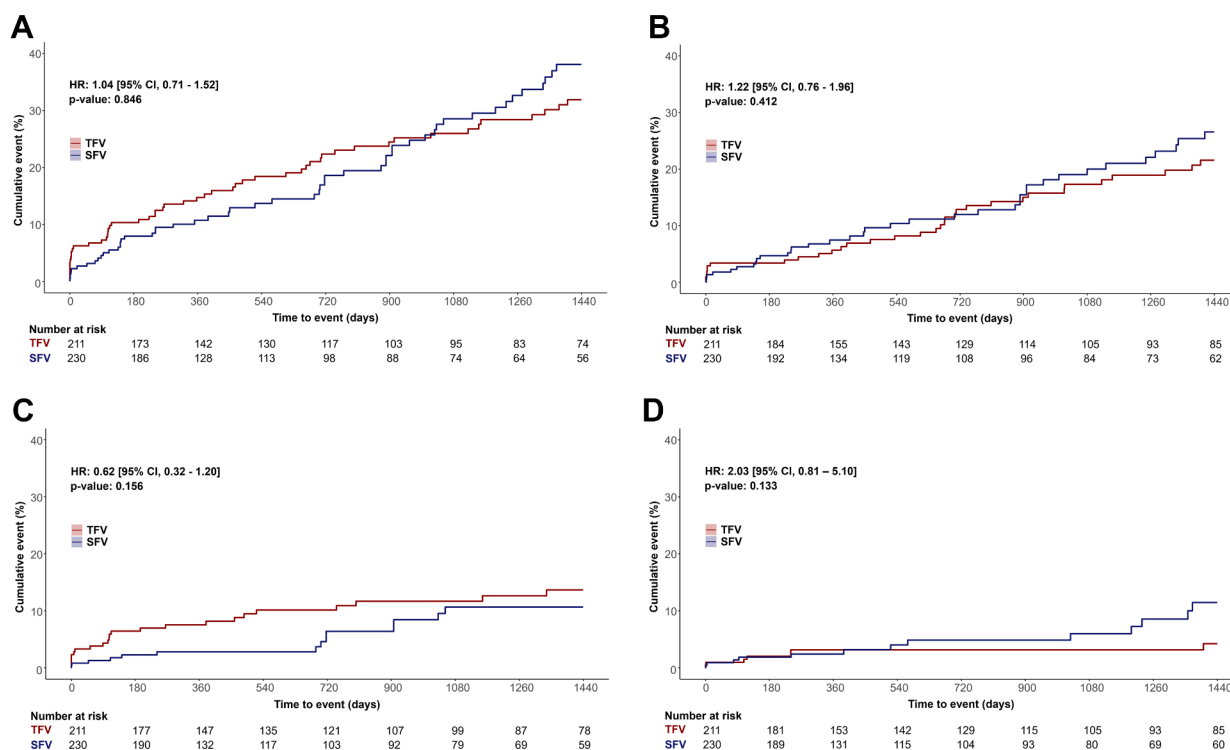
After adjustment for a comprehensive set of clinical, demographic, and TAVR-related confounders (model 1), balance was achieved for all included variables ([Table 1](#), [Supplemental Figure 2](#)), though some procedural differences remained ([Table 2](#)).

OUTCOMES BEFORE WEIGHTING. The median follow-up duration after PCI was 908 days (Q1-Q3: 322-1,728 days), and 274 patients (62.1%) completed 4-year follow-up. [Table 3](#) reports clinical outcomes according to valve type in the crude population and after weighting for clinical confounders. The 4-year crude incidence of MACE was 38.1% (95% CI: 24.6%-43.9%) in the SFV group vs 31.9% (95% CI: 24.8%-41.0%) in the TFV group (HR: 1.04; 95% CI: 0.71-1.52; $P = 0.846$) ([Figure 1A](#)). Similarly, we did not find significant differences in terms of all-cause mortality (39.3% [95% CI: 30.3%-49.2%] in the SFV group vs 35.8% [95% CI: 28.8%-45.4%] in the TFV group; HR: 1.09; 95% CI: 0.76-1.57; $P = 0.632$), CV death (26.5% [95% CI: 17.1%-35.3%] vs 21.6% [95% CI: 15.8%-30.8%]; HR: 1.22; 95% CI: 0.76-1.96; $P = 0.412$) ([Figure 1B](#)), MI (10.7% [95% CI: 1.9%-11.8%] vs 13.7% [95% CI: 7.4%-19.3%]; HR: 0.62; 95% CI: 0.32-1.20; $P = 0.156$) ([Figure 1C](#)), stroke (11.4% [95% CI: 3.8%-16.8%] vs 4.2% [95% CI: 1.1%-8.5%]; HR: 2.03; 95% CI: 0.81-5.10; $P = 0.133$) ([Figure 1D](#)), or any other secondary endpoint, except for TVR, whose incidence was lower in the SFV group than in the TFV group (12.0% [95% CI: 4.8%-18.5%] vs 19.6% [95% CI: 14.1%-28.9%]; HR: 0.54; 95% CI: 0.29-0.99; $P = 0.046$).

OUTCOMES AFTER WEIGHTING (MODEL 1). After weighting for clinical confounders, the 4-year adjusted incidence of MACE was 40.3% (95% CI: 25.8%-51.9%) in the SFV group vs 34.1% (95% CI: 22.6%-44.0%) in the TFV group (HR: 1.13; 95% CI: 0.64-2.00; $P = 0.674$) ([Table 3](#), [Figure 2A](#)). Similarly, there were no statistically significant differences in the rates of all-cause mortality (46.3% [95% CI: 31.5%-57.9%] in the SFV group vs 38.5% [95% CI: 26.2%-49.1%] in the TFV group; HR: 1.28; 95% CI: 0.78-2.01; $P = 0.336$), CV death (28.4% [95% CI: 15.5%-39.4%] vs 19.5% [95% CI: 11.0%-27.4%]; HR: 1.45; 95% CI: 0.76-2.78; $P = 0.258$) ([Figure 2B](#)), MI (6.1% [95% CI: 0.1%-11.8%] vs 15.1% [95% CI: 6.2%-23.3%]; HR: 0.43; 95% CI: 0.12-1.56; $P = 0.201$) ([Figure 2C](#)), stroke (12.6% [95% CI: 2.9%-21.5%] vs 6.1% [95% CI: 0.0%-12.2%]; HR: 1.65; 95% CI: 0.41-6.75; $P = 0.482$) ([Figure 2D](#)), or any other secondary endpoint.

SENSITIVITY ANALYSES. The robustness of our primary findings from model 1 was confirmed across several sensitivity analyses. A country-level analysis, which excluded centers and countries with statistical instability, yielded an adjusted HR for MACE consistent with the main analysis ([Supplemental Table 5](#)). To address potential overestimation by the Kaplan-Meier method, both an analysis of adjusted outcomes at 1 year and a formal competing risk analysis confirmed the lack of significant differences between groups ([Supplemental Tables 6 and 7](#)). Formal tests for interaction showed that the effect of valve type

FIGURE 1 Kaplan-Meier Estimates of 4-Year Clinical Outcomes in the Unadjusted Population



(A) Major adverse cardiovascular events. (B) Cardiovascular death. (C) Myocardial infarction. (D) Stroke. SFV = short-framed valve; TFV = tall-framed valve.

on 4-year MACE was consistent across prespecified subgroups of clinical presentation, sex, and age (P for interaction > 0.10 for all) (Supplemental Figure 4).

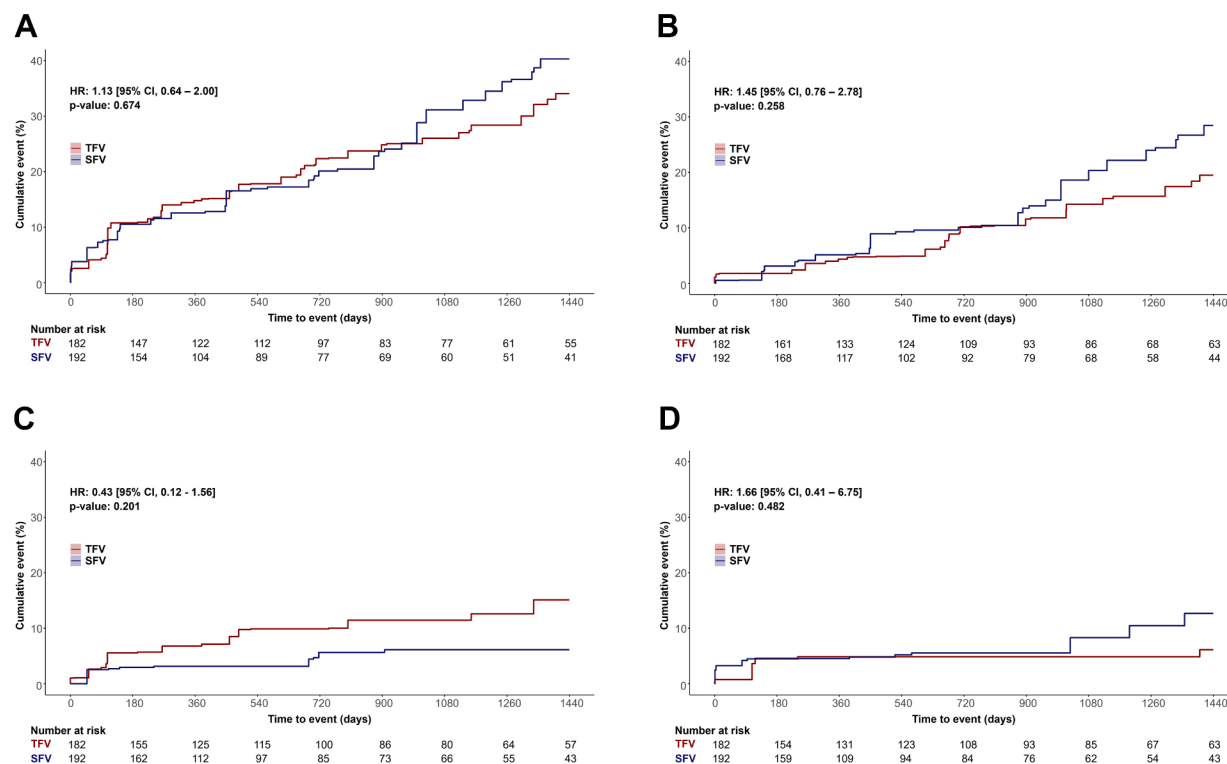
In the sensitivity analysis that additionally adjusted for procedural characteristics of the index PCI (model 2), all included baseline and procedural variables were well balanced between the 2 groups (Supplemental Tables 8 and 9, Supplemental Figure 3). Consistent with the findings from model 1, there were no significant differences in the rates of MACE or any other adverse events between the SFV and TFV groups (Supplemental Table 10, Supplemental Figure 5).

DISCUSSION

This study represents the largest and most comprehensive analysis to date evaluating the impact of transcatheter heart valve frame height on long-term clinical outcomes in patients undergoing PCI after TAVR (Central Illustration). We leveraged a large, multicenter registry and applied robust statistical methods to account for confounding bias. Using this approach, we found no significant differences in 4-

year MACE risk between the 2 cohorts. Rates of MI were higher in the TFV group, while strokes occurred more frequently in the SFV group. However, these differences did not reach statistical significance.

Valve selection in TAVR remains a matter of debate, particularly given its implications for future coronary access.¹² Suboptimal coronary engagement in patients with a TFV may increase procedural complexity and duration, necessitate greater contrast volume, and hinder equipment delivery.^{6,9-12,15-18} This is reflected in our findings, as patients with TFVs demonstrated lower rates of drug-eluting stent implantation (90.3% vs 93.7%), overall PCI success (94.7% vs 97.6%), and radial access (39.2% vs 45.7%) compared with those with SFV, even after weighting for clinical confounders. These procedural hurdles may partially explain why prior studies revealed that patients with balloon-expandable SFVs were more likely to undergo PCI compared with self-expanding TFVs, despite similar rates of unplanned coronary angiography between the 2 groups.^{12,15} Beyond procedural challenges, TFVs have also been associated with an elevated risk for delayed coronary obstruction, which may contribute to the numerically higher

FIGURE 2 Kaplan-Meier Estimates of 4-Year Clinical Outcomes After Adjustment With Model 1

(A) Major adverse cardiovascular events. (B) Cardiovascular death. (C) Myocardial infarction. (D) Stroke. Variables included in the adjusted model are reported in Supplemental Table 3. Abbreviations as in Figure 1.

MI rates observed in this study.^{19,20} This heightened risk is multifactorial, but the challenges in coronary reaccess with target vessel failure likely play a significant role.²¹⁻²³ Nevertheless, given the lack of statistical significance, these results should be regarded as hypothesis generating only.

Recent retrospective data have suggested that patients undergoing PCI after TAVR with balloon-expandable SFVs experience fewer rehospitalizations for heart failure compared with those with self-expanding TFVs, although no significant difference in all-cause death was detected.¹² Notably, that study also reported a numerically higher incidence of stroke in the SFV group compared with the TFV group (9.3% vs 8.4%), which aligns with our findings. However, the absence of adjustment for confounding variables in that analysis raises concerns about residual bias, underscoring the need for more rigorous evaluation of these associations.

A key strength of our registry is the availability of granular details, allowing a comprehensive adjustment for both baseline (ie, before PCI) and procedural (ie, at the time of PCI) confounding factors. Notably,

the initially significant difference in unadjusted TVR rates (favoring SFVs with an HR of 0.54) became nonsignificant after adjustment for confounding variables. This change appears to be driven by 2 distinct mechanisms. First, the effect size was substantially attenuated after accounting for baseline clinical characteristics alone (HR increased to 0.78), indicating that much of the initial disparity was likely due to confounding by indication; that is, the TFV cohort presented with a higher intrinsic risk for repeat revascularization. Second, the adjustment process reduced statistical precision, widening the 95% CI (from 0.29-0.99 to 0.33-1.84). The effect was further nullified when procedural variables were included in model 2.

The issue of prosthesis-related coronary access limitations is expected to diminish with the development of new-generation TFVs featuring dedicated ostium-sparing designs. Additionally, advanced implantation techniques, including commissural and coronary alignment, leaflet modification strategies, and computed tomography-guided PCI, may further mitigate these challenges.²⁴⁻³¹

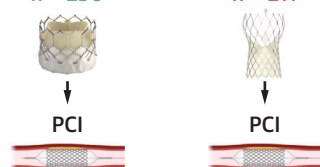
CENTRAL ILLUSTRATION Study Population and Main Finding

Impact of Valve Frame Height on Outcomes of PCI After TAVR: Data From the REVIVAL-PCI Registry

Population: Patients Undergoing PCI After TAVR

REVIVAL-PCI registry, 2008-2023

Short-framed valve n = 230 Tall-framed valve n = 211



30.9% 44.1%

Women

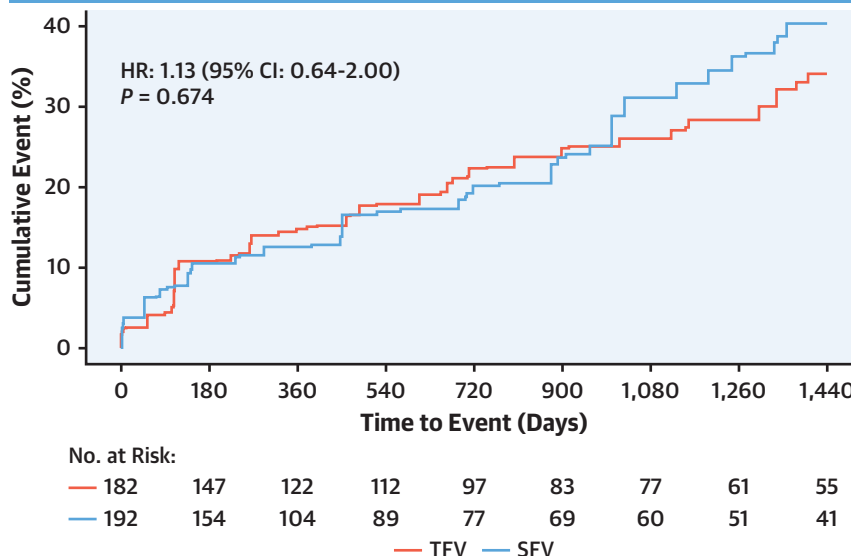
52.3% 42.0%

Radial access

98.2% 95.2%

Successful PCI

Primary Endpoint: Adjusted 4-Year Cumulative Incidence of MACE



- The 4-year MACE rate was comparable between the SFV and TFV groups (38.1% vs 31.9%; $P = 0.846$)
- Future investigations with newer-generation valves and refined implantation techniques are needed to further improve outcomes for this growing patient population.

Pivato CA, et al. JACC Cardiovasc Interv. 2026;19(3):345-355.

On the left, the study population of 441 patients undergoing percutaneous coronary intervention (PCI) after transcatheter aortic valve replacement (TAVR), stratified by valve frame height (short-framed valves [SFVs] vs tall-framed valves [TFVs]); on the right, the main result showing no significant difference in long-term major adverse cardiovascular event (MACE) risk between the 2 groups. HRs and Kaplan-Meier estimates are adjusted (model 1).

STUDY LIMITATIONS. To our knowledge, this is the first study to report a comprehensive set of clinical outcomes in patients undergoing PCI after TAVR according to valve frame height. Our analytical approach incorporated 2 separate adjustments: one accounting for baseline clinical confounders before PCI and another incorporating procedural characteristics of PCI itself, yielding consistent findings. Additionally, sensitivity analyses stratified by country demonstrated similar results, reducing the potential impact of regional practice variations on our conclusions.

Nevertheless, several limitations must be acknowledged. First, as an observational study, our ability to reduce potential bias from unmeasured confounders is inherently limited. Although a randomized trial is necessary to provide definitive evidence, conducting such a study would be highly challenging because of the relatively low incidence of PCI after TAVR.

Second, although participating centers were instructed to report all consecutive cases to minimize selection bias, the retrospective nature of the registry introduces the risk for information and reporting biases. However, the high procedural success rates observed in our cohort are highly consistent with those reported in large national and single center registries, which are less susceptible to selection bias. Reported success rates in these registries range from 92.5% to 99%, suggesting that a major reporting bias is unlikely in our study.^{17,32}

Third, despite being the largest study to date, the relatively low incidence of PCI after TAVR limited our overall sample size.⁶ This is directly reflected in the wide CIs observed for our adjusted HRs, indicating a lack of statistical precision. Consequently, our study had limited power to detect modest but potentially clinically relevant differences between the groups, and the risk for a type II error cannot be dismissed.

This limitation is particularly pronounced for our secondary endpoints, where the number of events was even smaller. Therefore, although our primary analysis revealed no statistically significant difference in MACE, our results should be interpreted with caution. They do not definitively rule out a benefit for one valve type over another but rather suggest that any difference, if one exists, is unlikely to be large.

Last, the prolonged data collection period, required by the low event rate, introduces potential temporal biases. However, adjustment for time-related factors mitigated concerns regarding evolving practice patterns.

CONCLUSIONS

In this large, multicenter registry, we found that PCI following TAVR was highly feasible for recipients of both SFV and TFV, and critically, there were no significant differences in 4-year MACE risk. These findings provide reassurance that the potential PCI complexities associated with TFV do not translate into adverse long-term outcomes. Future investigations are warranted to determine if newer generation valves with access-preserving designs and refined implantation techniques can further improve outcomes for this growing patient population.

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PERSPECTIVES

WHAT IS KNOWN? As TAVR expands to patients with longer life expectancies, the incidence of PCI following TAVR is increasing. Preserving coronary reaccess is pivotal in the lifetime management of these patients, but data on the impact of valve design on clinical outcomes following PCI are lacking.

WHAT IS NEW? At 4-year follow-up, major clinical outcomes after PCI did not differ significantly between patients receiving SFVs and TFVs. This offers important reassurance on long-term outcomes in patients with TFVs, even though PCI in this setting may be more challenging. Accordingly, operators should anticipate procedural complexity and prioritize access-preserving techniques, such as commissural alignment, at the time of initial TAVR.

WHAT IS NEXT? Future studies should evaluate if newer generation TFVs with dedicated coronary access features can reduce procedural complexity. Furthermore, prospective data are needed to confirm if systematic strategies such as computed tomography-guided PCI planning and commissural alignment translates into improved procedural efficiency and long-term clinical outcomes for this growing patient population.

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KEY WORDS PCI, short-framed valve, tall-framed valve, TAVR

APPENDIX For supplemental tables and figures, please see the online version of this paper.