Differences between valve types in anatomic changes of the aortic root after surgical aortic valve replacement

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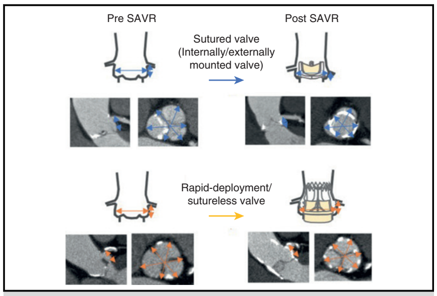
ABSTRACT

Background: When transcatheter aortic valve-in-surgical aortic valve (TAV-in-SAV) is considered as a secondary interventional option, it is desirable to estimate the risk of coronary obstruction during future TAV-in-SAV before the initial surgical aortic valve replacement (SAVR), for which knowledge of the anatomic changes after SAVR is essential. We investigated the changes in the aortic root and evaluated the differences in changes between valve types.

Methods: Pre- and post-SAVR computed tomography scans of 124 patients with aortic stenosis who underwent SAVR with various bioprosthetic valves were analyzed retrospectively. Postoperative aortic root changes and parameters related to future TAV-in-SAV were compared between the sutured valve group and rapid-deployment/sutureless valve group.

Results: After SAVR, the coronary height in the sutured valve group and rapid-deployment/sutureless valve group was shortened by a median of 4.6 to 5.3 mm and 0.5 to 2.2 mm, respectively, and the sinus of Valsalva (SOV) diameter was reduced by a median of 1.6 to 2.7 mm and 0.1 to 1.3 mm, respectively. A significantly higher proportion of patients in the rapid deployment/sutureless valve group had a coronary orifice (especially in the right coronary artery) above the risk plane. The valve-to-coronary distance and valve-to-aorta distance (VTA) were adequate in most patients. The only difference between the groups was in the left VTA.

Conclusions: Decreases in coronary height and SOV diameter were observed after SAVR, especially in the sutured valve group. The aortic root structure was better preserved in the rapid-deployment/sutureless valve group. This may be advantageous for future TAV-in-SAV. These results are important for considering the feasibility of future TAV-in-SAV. (JTCVS Techniques 2024;27:51-9)



Changes in the aortic root after SAVR were examined and compared between valve types.

CENTRAL MESSAGE

Coronary heights and sinus of Valsalva diameters were decreased significantly after surgical aortic valve replacement, especially in the sutured valve group, and were relatively preserved in the rapid-deployment/sutureless valve group.

PERSPECTIVE

Reflecting the fact that coronary height is less likely to decrease in the rapid-deployment/sutureless valve group, the proportion of patients with a coronary orifice above the risk plane was significantly higher in that group compared to the sutured valve group, suggesting a potential advantage for future transcatheter aortic valve implantation in surgical aortic valve (TAV-in-SAV). The results provide important baseline data to assess the feasibility of future TAV-in-SAV.

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Abbreviations and Acronyms

AS	=	aortic stenosis
CT	=	computed tomography
ID	=	internal diameter
LCA	=	left coronary artery
RCA	=	right coronary artery
SAVR	=	surgical aortic valve replacement
SOV	=	sinus of Valsalva
STJ	=	sinotubular junction
TAV-in-SAV	=	transcatheter aortic valve implantation in surgical aortic valve
VTA	=	valve-to-aorta distance
VTC	=	valve-to-coronary distance

▶ Video clip is available online.

In recent years, the importance of lifetime management of aortc valve therapy has been widely discussed. The use of bioprosthetic valves has been increasing, with favorable long-term results achieved, and the patient age is decreasing.[1,2] Reintervention for the management of failed bioprosthetic valves will become increasingly common, and transcatheter aortic valve-in-surgical aortic valve (TAV-in-SAV) is an important treatment option along with redo surgical aortic valve replacement (SAVR). TAV-in-SAV has been reported to have lower early mortality and morbidity rates and a shorter length of hospitalization than redo SAVR[3,4]; however, a high postoperative gradient and coronary obstruction are key problems. In particular, coronary obstruction is associated with a high mortality rate and must be avoided.[5] From the perspective of the lifetime management, an initial SAVR that allows future TAV-in-SAV to be performed safely without coronary obstruction is required to preserve many treatment options for future secondary intervention.

Previous studies have shown that the risk of coronary obstruction during TAV-in-SAV can be estimated on a preprocedural cardiac tomography (CT) scan by assessing the location of the coronary orifice and the risk plane of the valve (where the leaflet of the bioprosthesis implanted in the initial SAVR rises and is fixed vertically by the metallic frame of the transcatheter heart valve implanted inside it), along with the valve-to-coronary distance (VTC) and valve-to-aorta distance (VTA) at the risk plane. Specifically, a pre–TAV-in-SAV CT analysis indicates a high risk of coronary obstruction if the VTC is < 4 mm or the coronary orifice below the risk plane and the VTA is < 2 mm.[5,6]

Because these measurements are based on CT evaluation after SAVR, anatomic changes in measurements before and after SAVR needed to be predicted to assess the future risk of TAV-in-SAV before the initial SAVR. However, the changes in anatomic measurements before and after SAVR are not yet been fully understood.

Therefore, we analyzed pre- and post-SAVR cardiac CT images to investigate the changes in the aortic root after SAVR and evaluated the differences in changes between surgical valve types.

METHODS

Patients and Clinical Data Collection

This study was approved by the Institutional Ethics Committee of Osaka University Hospital (approval 16105-4, date: February 11, 2016). We retrospectively evaluated 124 adult patients who underwent isolated or concomitant SAVR with bioprosthetic valves for the treatment of aortic stenosis (AS) of the native aortic valve at the Department of Cardiovascular Surgery at Osaka University Hospital between May 2010 and December 2022 and who underwent both preoperative and postoperative contrast-enhanced cardiac CT. Patients with annular enlargement or patch augmentation of the sinus of Valsalva (SOV)/sinotubular junction (STJ), graft replacement of the ascending aorta, or redo surgery were excluded from this study. Patients whose postoperative CT data were obtained more than 5 years after surgery were also excluded. Patient data were collected from the medical records.

Operative Procedure

Valve type and size selection were dependent on the individual surgeons. Stented valves with internally mounted leaflets included the Carpentier-Edwards Perimount (CEP) Magna/CEP Magna Ease/Inspiris Resilia (Edwards Lifesciences), Mosaic/Mosaic Ultra/Avalus (Medtronic), and Epic/Epic Supra (Abbott Laboratories). Stented valves with externally mounted leaflets included MitroFlow (Corcym) and Trifecta/Trifecta GT (Abbott Laboratories). Rapid-deployment valves (Intuity Elite Valve System; Edwards Lifesciences) and sutureless valves (Perceval; Corcym), also were implanted. All internally and externally mounted valves were sutured in the supra-annular position using noneverting mattress sutures with pledgets through an oblique aortotomy. Rapid-deployment/sutureless valves were implanted after placing 3 simple interrupted guiding sutures were placed at the nadir of each sinus and passed through the sewing ring or suture eyelet; in the sutureless valves, the guiding sutures were eventually removed. Some patients underwent minimally invasive cardiac surgery through a right intercostal thoracotomy.

CT Evaluation

Contrast-enhanced cardiac CT was performed before and after SAVR to assess coronary artery lesions, patency of the coronary artery bypass graft (CABG), leaflet thrombosis, or the feasibility of TAV-in-SAV and redo surgery. If CT was performed several times, the scan done closest to the SAVR was used for analysis.

Perimeter-derived annular diameters, SOV diameters, short diameters of the STJ, and coronary heights were measured using preoperative and postoperative CT. The internal diameter (ID) of the bioprosthetic valve was measured on postoperative CT images and confirmed to be approximately equivalent to the true ID of the valve-in-valve app.[7] The difference in these parameters between preoperative and postoperative measurements were calculated by subtracting the postoperative values. Parameters related to the assessment of future coronary obstruction risk (ie, coronary orifice located above or below the risk plane, VTC, and VTA) were measured on postoperative CT scans as described previously.[8] These results were compared between the sutured bioprosthetic valve (internally/externally mounted valve) and rapid-deployment/sutureless valve groups. The measurement methods are summarized in Figure E1. All measurements were performed with the Aquarius NET medical software module (TeraRecon).

Statistical Analyses

Continuous variables are reported as median (interquartile range [IQR]), and categorical variables are reported as frequencies. Continuous variables were compared using the Student *t* test or one-way analysis of variance with the Tukey honest significant difference test, and categorical variables were compared using the Fisher exact test. Two-sided *P* values < .05 were considered statistically significant. All statistical analyses were performed using JMP Pro version 14.0 (SAS Institute).

RESULTS

Patient Characteristics and Procedural Data

The characteristics of the 124 patients enrolled in the study are summarized in Table 1. The median patient age was 76 years, and 52.4% pf the cohort was male. The median body surface area was 1.56 m^2, and the median body mass index was 22.6.

The operative procedures and details of the valves used are summarized in Table 2. Isolated SAVR accounted for 19.4% of the procedures. Among the other patients, the most common concomitant procedure was CABG surgery (73.4%). Regarding the types of valves used, internally mounted valves were used in 83 patients (66.9%), externally mounted valves in 4 patients (3.2%), and rapid-deployment/sutureless valves in 37 patients (29.8%). The most frequently used valve size was 21 mm (42.7%).

TABLE 1. Basic characteristics of the patients enrolled in this study (N = 124)

Characteristic	Value
Age, y, median (IQR)	76 (72-79)
Male sex, n (%)	65 (52.4)
BSA, m^2, median (IQR)	1.56 (1.42-1.65)
BMI, median (IQR)	22.6 (20.8-25.5)
Hypertension, n (%)	83 (66.9)
Diabetes mellitus, n (%)	52 (41.9)
Dyslipidemia, n (%)	65 (52.4)
Hemodialysis, n (%)	17 (13.7)
COPD, n (%)	26 (21.0)
CVD, n (%)	17 (13.7)
IE, n (%)	1 (0.8)
Bicuspid, n (%)	16 (12.9)
NYHA class ≥III, n (%)	30 (24.2)
LVEF <30%, n (%)	5 (4.0)
STS risk score, %, median (IQR)	3.4 (2.3-5.3)

IQR, Interquartile range; *BSA*, body surface area; *BMI*, body mass index; *COPD*, chronic obstructive pulmonary disease; *CVD*, cerebrovascular disease; *IE*, infective endocarditis; *NYHA*, New York Heart Association; *LVEF*, left ventricular ejection fraction; *STS*, Society of Thoracic Surgeons.

Postoperative Changes in the Aortic Root

Preoperative and postoperative measurements of the aortic root are summarized in Table 3. Preoperative and postoperative anatomic parameters of the aortic root were compared between the sutured bioprosthetic valve (internally and externally mounted valves) and rapid-deployment/sutureless valve groups. The preoperative annular diameter, SOV diameter, STJ diameter, and coronary artery height were not significantly different between

TABLE 2. Details of operative procedures and bioprosthetic valves (N = 124)

Procedure	Value
Isolated SAVR, n (%)	24 (19.4)
Concomitant procedure, n (%)	
CABG	91 (73.4)
MVR	5 (4.0)
MVP	8 (6.5)
TAP	4 (3.2)
Maze/PVI	6 (4.8)
LAA closure	15 (12.1)
Myectomy	1 (0.8)
Extirpation of myxoma	1 (0.8)
Coronary-PA fistula closure	1 (0.8)
Median sternotomy, n (%)	132 (97.8)
MICS, n (%)	3 (2.4)
Emergent operation, n (%)	9 (7.3)
Operation time, min, median (IQR)	307 (250-375)
ACC time, min, median (IQR)	83 (68-111)
CPB time, min, median (IQR)	165 (132-196)
Valve, n (%)	
Internally mounted	83 (66.9)
CEP Magna	27 (21.8)
Inspiris	17 (13.7)
Avalus	2 (1.6)
Epic	10 (8.1)
Mosaic	27 (21.8)
Externally mounted	4 (3.2)
Trifecta	3 (2.4)
Mitroflow	1 (0.8)
Rapid-deployment/sutureless valve	37 (29.8)
Intuity	20 (16.1)
Perceval	17 (13.7)
Size, n (%)	
19 mm, S	38 (30.6)
21 mm, M	53 (42.7)
23 mm, L	31 (25.0)
25 mm	2 (1.6)
27 mm	0 (0)

SAVR, Surgical aortic valve replacement; *CABG*, coronary artery bypass grafting; *MVR*, mitral valve replacement; *MVP*, mitral valve plasty; *TAP*, tricuspid annuloplasty; *PVI*, pulmonary vein isolation; *LAA*, left atrium appendage; *PA*, pulmonary artery; *MICS*, minimally invasive cardiac surgery; *IQR*, interquartile range; *ACC*, aortic cross-clamp; *CPB*, cardiopulmonary bypass.

TABLE 3. Preoperative and postoperative CT measurements of the aortic root

Parameter	Total (N = 124)	Sutured valve group (N = 87)	Rapid-deployment/sutureless valve group (N = 37)	P value
Preoperative CT measurements, median (IQR)				
Annulus diameter, mm	23.8 (22.4-25.4)	23.9 (22.3-25.4)	23.4 (22.5-25.6)	.763
SOV diameter, mm				
Right	29.6 (27.7-31.9)	29.5 (27.8-31.8)	29.7 (27.6-32.8)	.401
Left	31.0 (28.9-32.7)	31.1 (29.0-32.8)	30.3 (28.7-32.3)	.635
Non	31.0 (29.5-33.3)	31.2 (29.4-33.4)	31.0 (29.7-33.0)	.910
Average	30.4 (28.6-32.4)	30.5 (28.6-32.4)	30.0 (28.8-32.1)	.868
STJ diameter, mm	27.2 (25.4-29.6)	27.2 (25.4-29.6)	27.3 (25.8-29.5)	.793
Coronary height, mm				
RCA	17.3 (15.3-19.4)	17.6 (15.6-19.8)	16.8 (14.9-18.9)	.183
LCA	16.0 (14.4-17.6)	16.2 (14.4-17.8)	15.3 (14.0-17.0)	.221
Postoperative CT measurements, median (IQR)				
ID, mm	18.8 (17.2-20.2)	18.4 (17.0-19.1)	20.2 (18.9-20.6)	<.001*
SOV diameter, mm				
Right	28.2 (26.6-30.7)	28.1 (25.8-29.9)	29.5 (27.2-31.3)	.002*
Left	28.5 (26.7-30.5)	28.2 (26.6-30.5)	29.2 (27.7-30.7)	.075
Non	29.1 (27.2-31.6)	28.7 (26.1-31.5)	30.2 (28.3-32.6)	.018*
Average	28.7 (27.0-30.7)	28.1 (26.3-30.5)	29.6 (27.7-31.3)	.011*
STJ, mm	26.0 (23.8-27.5)	25.8 (23.7-27.5)	26.1 (24.3-28.5)	.264
Coronary height, mm				
RCA	13.5 (11.0-15.7)	12.4 (10.5-15.0)	15.8 (13.7-18.1)	<.001*
LCA	12.3 (10.6-14.1)	11.9 (10.2-13.3)	14.0 (12.3-15.5)	.002*

CT, Computed tomography; *IQR*, interquartile range; *SOV*, sinus of Valsalva; *STJ*, sinotubular junction; *RCA*, right coronary artery; *LCA*, left coronary artery; *ID*, inner diameter. *$P < .05$.

the 2 groups; however, the postoperative ID of the prosthetic valve, SOV diameter at the right coronary and noncoronary cusps, average SOV diameter, and both right and left coronary heights were significantly greater in the rapid-deployment/sutureless group compared to the sutured valve group. The analysis of postoperative anatomical changes in coronary height, SOV diameter, and STJ diameter revealed that the coronary height was shortened by a median of 4.6 to 5.3 mm in the sutured bioprosthetic valve group and 0.5 to 2.2 mm in the rapid-deployment/sutureless valve group, a significant difference ($P < .001$). Similarly, the SOV diameter was decreased by a median of 1.6 to 2.7 mm in the sutured valve group and 0.1 to 1.3 mm in the rapid-deployment/sutureless valve group. Thus, there was a significant difference for each sinus ($P < .001$). The STJ diameter was also decreased by a median of 1.4 mm in the sutured valve group and 0.7 mm in the rapid-deployment/sutureless group; however, the difference did not reach statistical significance (Figure 1, Table 4).

Postoperative Anatomic Parameters Related to Risk of Coronary Obstruction During Future TAV-in-SAV

The location of the coronary orifice in relation to the risk plane, the VTC of the right coronary artery (RCA) and left coronary artery (LCA), and the VTA in each cusp were analyzed on postoperative cardiac CT images and compared between the sutured bioprosthetic valve group and the rapid-deployment/sutureless valve group (Table 5). The proportion of patients with an RCA orifice above the risk plane was significantly higher in the rapid-deployment/sutureless group (59.5% vs 12.6%; $P < .001$). The proportion of patients with an LCA orifice above the risk plane also was higher in the rapid-deployment/sutureless group than in the sutured group (18.9% vs 6.9%); however, the difference was not statistically significant ($P = .051$). The VTC of both the RCA and LCA were almost equivalent between these 2 groups, with a median of 4.9 to 6.4 mm. The median VTAs above all sinuses were >2 mm but tended to be smaller in the sutured valve group than in the rapid-deployment/sutureless valve group, with a significant difference in the VTA above the left sinus ($P = .026$).

DISCUSSION

Coronary obstruction is a major problematic issue during the TAV-in-SAV procedure, with a reported frequency of approximately 2.5% to 3.5%, which is 4- to 6-fold higher than TAVR for native AS, and a 30-day mortality rate that jumps to approximately 50%.[4,9] Several studies have been examined the risk factors of coronary obstruction, and the use of stentless and externally mounted valves has been reported to increase the risk of coronary obstruction.[5,10] Externally mounted valves, such as Mitroflow or Trifecta, reportedly carry a high risk of early structural valve deterioration and currently are not commercially

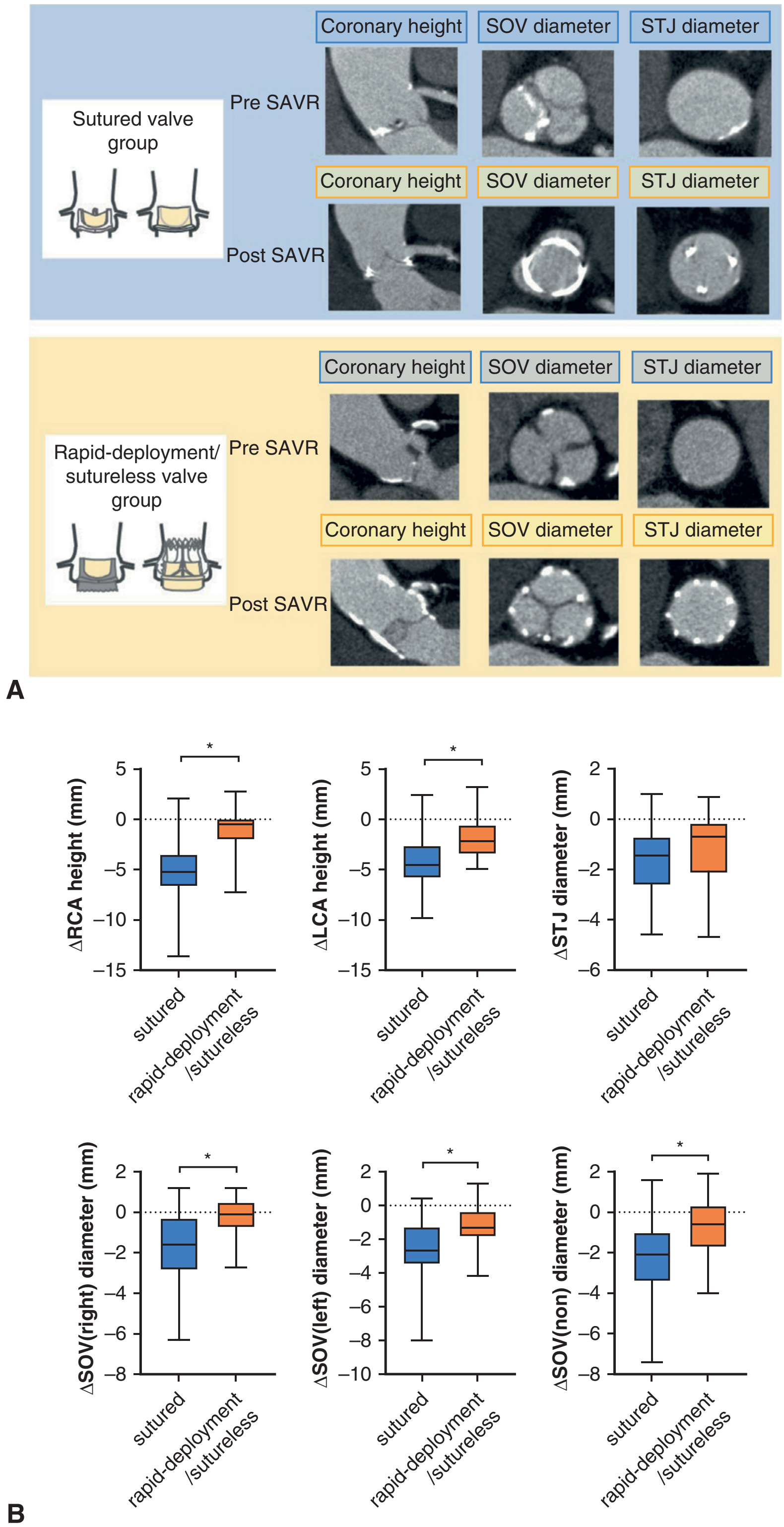

FIGURE 1. Anatomic changes in the aortic root after surgical aortic valve replacement (*SAVR*) using sutured valves and rapid-deployment/sutureless valves. A, Representative preoperative and postoperative computed tomography images of the aortic root in patients with sutured bioprosthetic valves (*upper*) and patients with rapid-deployment/sutureless valves (*lower*). B, Box chart showing postoperative changes in the aortic root in the sutured valve and rapid-deployment/sutureless groups. The coronary height and sinus of Valsalva (*SOV*) diameter of each sinus were significantly decreased in the sutured valve group, while the STJ diameter did not differ to a statistically significant extent between the 2 groups. **P* < .05. *STJ*, Sinotubular junction; *RCA*, right coronary artery; *LCA*, left coronary artery.

TABLE 4. Postoperative anatomic changes in the aortic root after sutured and rapid-deployment/sutureless SAVR

Change	Total (N = 124), median (IQR)	Sutured valve group (N = 87), median (IQR)	Rapid-deployment/sutureless valve group (N = 37), median (IQR)	*P* value
⊿RCA height, mm	−4.0 (−6.2 to −1.5)	−5.3 (−6.7 to −3.5)	−0.5 (−2.0 to 0.1)	<.001*
⊿LCA height, mm	−3.8 (−5.2 to −2.1)	−4.6 (−5.9 to −2.7)	−2.2 (−3.4 to −0.6)	<.001*
⊿SOV diameter, mm				
Right	−1.0 (−2.5 to −0.1)	−1.6 (−2.8 to 0.3)	−0.1 (−0.8 to 0.5)	<.001*
Left	−1.9 (−3.2 to −0.8)	−2.7 (−3.5 to −1.3)	−1.3 (−1.9 to −0.4)	<.001*
Non	−1.6 (−2.9 to −0.4)	−2.1 (−3.4 to −1.0)	−0.6 (−1.7 to 0.3)	<.001*
Average	−1.5 (−2.6 to −0.7)	−2.1 (−3.3 to −1.2)	−0.6 (−1.1 to −0.2)	<.001*
⊿STJ diameter, mm	−1.2 (−2.5 to −0.4)	−1.4 (−2.6 to −0.7)	−0.7 (−2.2 to 0.2)	.062

SAVR, Surgical aortic valve replacement; *IQR*, interquartile range; *RCA*, right coronary artery; *LCA*, left coronary artery; *SOV*, sinus of Valsalva; *STJ*, sinotubular junction. $^*P<.05$.

available.[11,12] With regard to the anatomy of the aortic root, low take-off coronary arteries and a small SOV were identified as risk factors for coronary obstruction.[5,13] However, no attempt has been made to predict future coronary obstruction risk during TAV-in-SAV based on the anatomy before initial SAVR. In addition, although understanding the structural changes in the aortic root after SAVR is essential, there have been few studies on this topic.

To our knowledge, only 1 study to date has reported changes in the aortic root anatomy after SAVR.[14] The previous study comparing the effect of SAVR on coronary height in patients with sutured bioprosthetic valves and rapid-deployment valves reported a significant reduction in coronary height of 5.4 to 6.3 mm in the sutured group, compared to only 1.9 to 3.8 mm in the rapid-deployment group, with a particularly small reduction in RCA height,[14] consistent with the results of the present study.

In addition, a detailed analysis of the changes in SOV and STJ diameters revealed a significant decrease in SOV diameter in the sutured valve group, likely due to the oblique incision. In contrast, the SOV diameter was relatively preserved in the rapid-deployment/sutureless valve group.

The present study also analyzed the factors associated with coronary obstruction during future TAV-in-SAV using postoperative CT. Consistent with the significantly reduced shortening of the coronary height in the rapid-deployment/sutureless group, the proportion of patients with a coronary orifice above the risk plane who were able to safely undergo the future TAV-in-SAV procedure without the risk of coronary obstruction was significantly higher in this group compared to the sutured group. However, the reduced shortening of the SOV diameter in the rapid-deployment/sutureless group was not reflected in the difference in the VTC or VTA values of the 2 groups, which might be related to the larger ID of the implanted prosthetic valve in the rapid-deployment/sutureless group. Although most patients in the present cohort had a VTC of ≥4 mm and a VTA of ≥2 mm, some patients did not have a sufficient VTC or VTA and thus might have been considered at high risk for coronary obsturction. Therefore, the preoperative aortic root anatomy and valve size should be considered in each individual case.

Although rapid-reployment/sutureless valves may have advantages in terms of feasibility for future TAV-in-SAV

TABLE 5. Postoperative anatomic parameters related to risk of coronary obstruction risk during future TAV-in-SAV

Parameter	Total (N = 124)	Sutured valve group (N = 87)	Rapid-deployment/sutureless valve group (N = 37)	*P* value
Coronary orifice above risk plane, n (%)				
RCA	33 (26.6)	11 (12.6)	22 (59.5)	<.001*
LCA	13 (10.5)	6 (6.9)	7 (18.9)	.051
VTC, mm, median (IQR)				
RCA	6.3 (4.6-7.7)	6.4 (4.8-7.7)	5.7 (4.0-7.7)	.757
LCA	4.9 (3.8-6.4)	4.9 (3.6-6.4)	4.9 (4.1-6.5)	.564
VTA, mm, median (IQR)				
Above right sinus	5.4 (3.7-7.0)	5.1 (3.7-6.6)	5.6 (3.7-7.9)	.282
Above left sinus	3.9 (2.7-5.2)	3.5 (2.3-4.6)	4.6 (3.4-5.8)	.026*
Above noncoronary sinus	2.9 (1.9-4.2)	2.8 (1.9-3.9)	3.3 (2.2-5.5)	.135

TAV-SAV, Transcatheter aortic valve implantation in surgical aortic valve; *RCA*, right coronary artery; *LCA*, left coronary artery; *VTC*, valve-to-coronary distance; *IQR*, interquartile range; *VTA*, valve-to-aorta distance. $^*P<.05$.

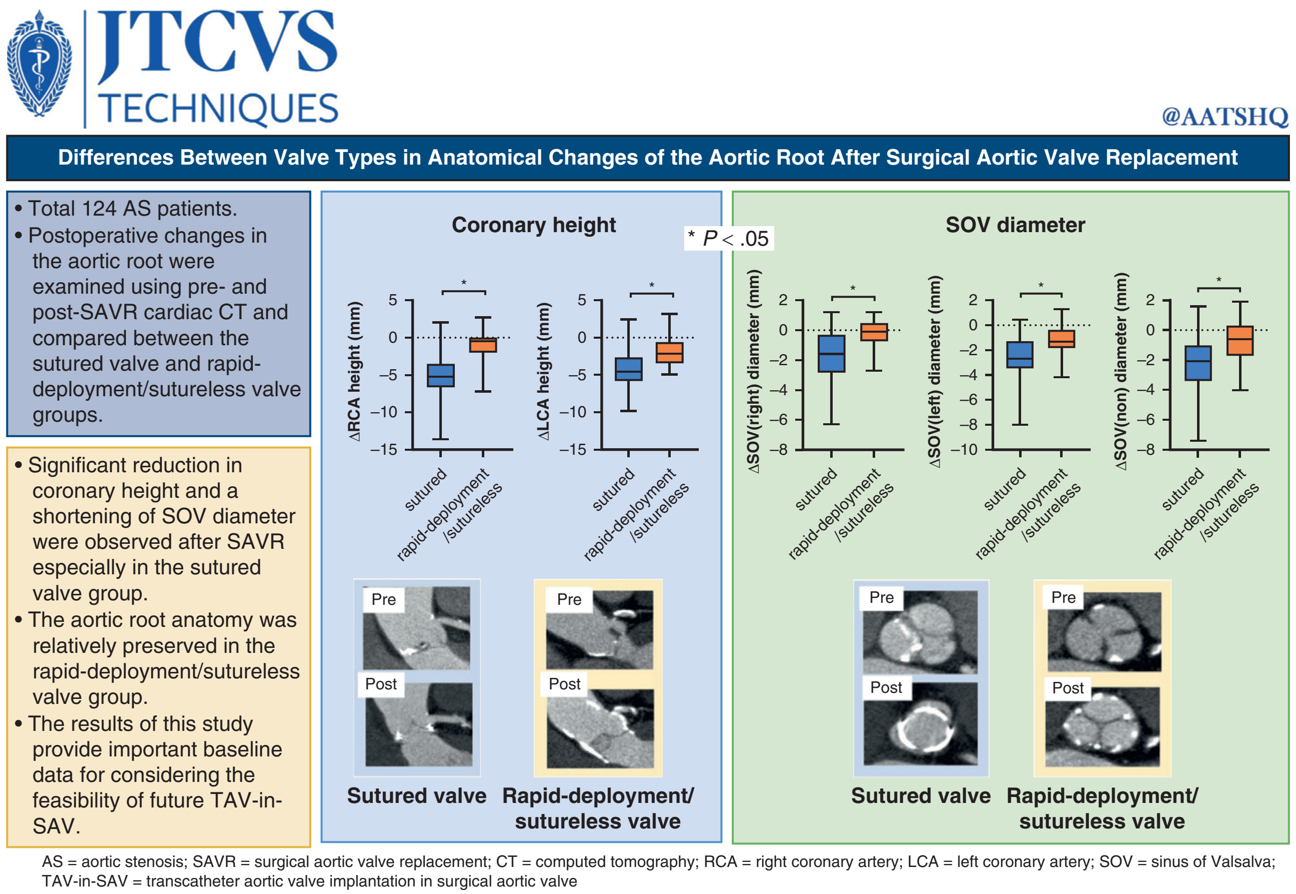

FIGURE 2. Graphical summary of the study. We retrospectively analyzed pre- and post-surgical aortic valve replacement (*SAVR*) computed tomography scans of 124 patients with aortic stenosis to investigate the anatomic changes in the aortic root after SAVR. Postoperative aortic root changes were compared between the sutured valve and rapid-deployment/sutureless valve groups, indicating that a significant shortening in coronary heights and sinus of Valsalva diameters occured after SAVR, especially in the sutured bioprosthesis (internally and externally mounted valves). The aortic root anatomy was relatively preserved in the rapid-deployment/sutureless valves group. The results are important for considering the feasibility of future transcatheter aortic valve implantation in surgical aortic valve. *$P < .05$.

in that they allow for greater preservation of the aortic root anatomy after SAVR, these valves have the problem of a higher rate of postoperative perivalvular leakage and permanent pacemaker implantation compared to conventional sutured valves.[15-17] The TAV-in-SAV procedure has been reported less frequently,[18,19] so the indication for using these valves should be carefully determined.

Several limitations of the present study warrant mention. First is its retrospective nature with a single-center design. Second is the limited number of patients enrolled. Third, a selection bias might exist in patients with postoperative cardiac CT. Finally, the results regarding the anatomic changes after SAVR may be largely influenced by the valve suturing method used at our institution. In this study cohort, all internally/externally mounted valves were sutured with non-everting mattress sutures using surgical thread with pledgets. Although this method has the advantages of simplicity, versatility, and relative ease of implanting prosthetic valves in a small aortic annulus, it is likely to significantly shorten the height of the coronary artery. Changing the suturing technique from noneverting mattress sutures to everting mattress sutures or simple interrupted sutures and implanting a valve in an intra-annular position may yield different results.

CONCLUSIONS

After SAVR, the aortic root anatomy changed drastically, with significant reductions in coronary height and SOV diameter, especially in the sutured bioprosthetic valve group. The aortic root anatomy was relatively preserved in the rapid-deployment/sutureless valves group, with a significantly higher proportion of patients having an RCA orifice above the risk plane. Although future studies are needed, the results of this study provide important baseline data for considering the feasibility of future TAV-in-SAV (Figure 2 and Video Abstract).

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: changes in the aortic root anatomy after surgical aortic valve replacement, TAV-in-SAV feasibility, coronary obstruction

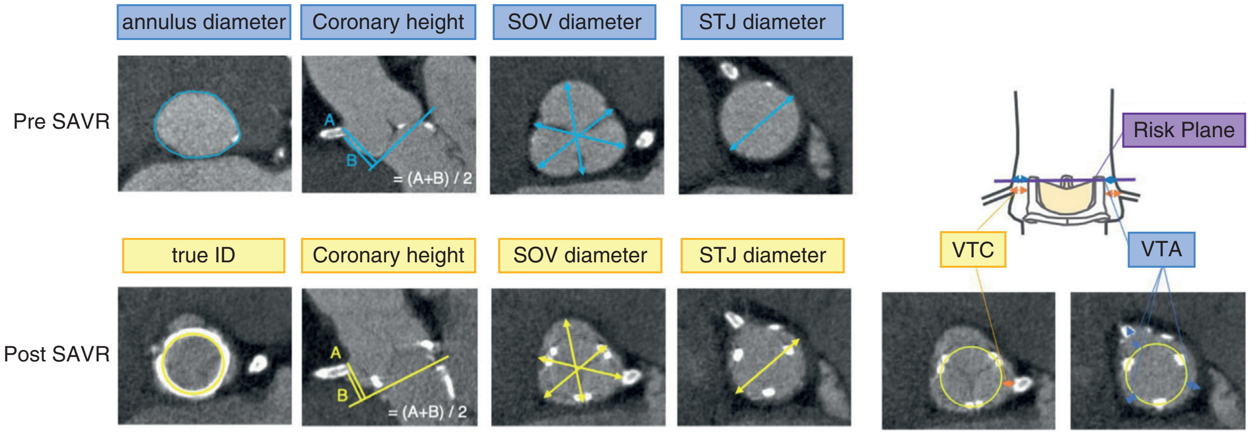

FIGURE E1. Schematic illustrations and computed tomography images of the anatomic parameters of the aortic root before and after surgical aortic valve replacement (*SAVR*). The perimeter-derived annular diameter was measured on systolic short-axis images. The sinus of Valsalva (*SOV*) diameter and short diameter of the sinotubular junction (*STJ*) were measured on a diastolic short-axis image. The height of the coronary artery was defined as the height of the middle position from the annulus by measuring the distance of the *upper* (A) and *lower* (B) edges of the coronary artery from the annulus on diastolic long-axis image, adding them, and then dividing by 2. The risk plane was set as the level at which the stent frame of the transcatheter heart valve would be covered by vertically displaced leaflets of the surgical valves during future transcatheter aortic valve implantation in surgical aortic valve procedures. The inner diameter (*ID*) of the bioprosthetic valve was measured, then a virtual ring of the same diameter as the measured ID was placed at the center of the bioprosthetic valve. The valve-to-coronary distance (*VTC*) was defined as the distance from the virtual ring to the orifice of the coronary artery, and the valve-to-aorta (*VTA*) distance was defined as the distance from the virtual ring to the aortic wall under the risk plane, which was measured on short-axis images.