Predict TAVI BAV Re-Access: Patient-specific computer modelling to predict anatomical risk factors preventing post transcatheter aortic valve implantation coronary re-access in bicuspid aortic valve

St George's University of London

St George's University Hospitals NHS Foundation Trust

Dargan J.[a], Rocatello G.[b], Weng Y.[b], Khan F[c], Firoozi S.[c], Dowling C.[d], Brecker S.[a]

[a] Cardiovascular clinical academic group, St. George's, University of London and St. George's University Hospitals NHS Foundation Trust, London, UK, [b] FEops nv, Gent, Belgium, [c] St. George's University Hospitals NHS Foundation Trust, London, UK, [d] Division of Cardiovascular Medicine, Stanford University School of Medicine, Stanford, CA

Background

Post Transcatheter aortic valve implantation (TAVI) coronary re-access is predicted to become more common as TAVI expands into lower risk cohorts. The use of a self-expanding valve (SEV) has been recognised as an independent predictor for unsuccessful coronary cannulation in addition to implantation depth.[1] Other predictors include reduced transcatheter heart valve (THV) to coronary distance and sinus of Valsalva relation.[2]

Despite this however a patient cohort remains in which the use of a SEV is preferable due to anatomical complexity or extensive calcification.

In addition to increased procedural complexity and calcification, bicuspid aortic valve (BAV) is also associated with increased ostial eccentricity and cusp asymmetry.[3]

Purpose

Using patient-specific computer modelling, we aimed to assess how the deployment of different sized THVs and at different depths affected the distance from valve to coronary and valve to sino-tubular junction in complex anatomy

Methods

In this modelling study we have used pre-procedural, CT-derived, patient-specific finite element analysis computer models using the FEops (Ghent, Belgium) HEARTguide platform to predict the eventual valve result for patients with bicuspid aortic valve who underwent TAVI with a SEV.

We studied two anatomical measures for both right and left coronary sinuses. The distance from coronary ostium to nearest structure, either THV or displaced native leaflet – Sinus of Valsalva (SoV) free space. The second distance was from the STJ to THV – STJ free space.

THVs were modelled at both high and medium implant positions. THV size was based upon annular dimensions. Where the annular dimensions fell near an anatomical grey-zone, a second size THV was modelled.

For each patient and measure, a mean of all distances was calculated, in addition to both minimum and maximum distances.

BASELINE CHARACTERISTICS	N = 15
Age, years	80.6±7.4
male	8/15 (53.3)
BMI, kg/m^2	25.9±7.0
NYHA class III or IV	10/15 (66.7)
Diabetes Mellitus	4/15 (26.7)
Known atrial fibrillation	7/15 (46.7)
Left ventricular ejection fraction, %	49±18.4
EuroSCORE II, %	4.72±4.74
STS mortality, %	3.1±1.4
Presence of coronary artery disease	3/15 (20)
Prior PCI	3/15 (20)
Prior CABG	0/15 (0)
prior PPM	1/15 (6.7)
Values are mean±standard deviation or n/N (%)	

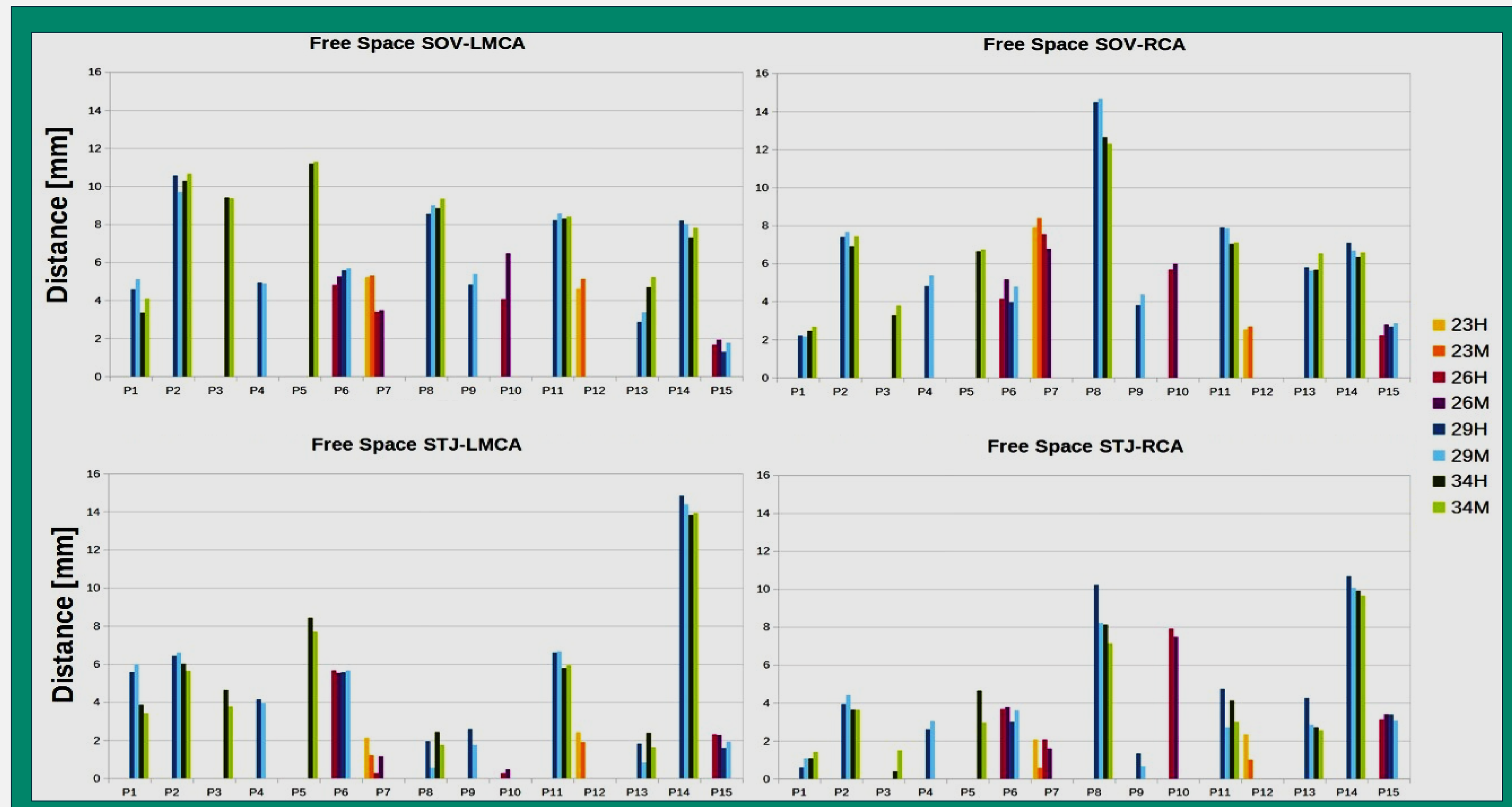


Figure 1: Results table by anatomical measure, showing patient ID number across the x-axis against distance measured. Colours represent different transcatheter heart valve size and depth deployed. H – high, M – medium.

Results

The free space SOV left main coronary artery (LMCA) mean was 6.39 mm (4.87-7.91 mm). The difference between maximum and minimum was 0.9461 mm (0.54–1.36 mm), p<0.01. The largest patient-specific difference between minimum and maximum was 2.41 mm, using the same THV size but at different depths.

The free space SOV right coronary artery (RCA) mean was 5.73 mm (4.17-7.30 mm). The difference between maximum and minimum was 0.789 mm (0.49-1.09 mm), p<0.01.

The STJ free space LMCA mean was 4.3 mm (2.35–6.27 mm), The difference between maximum and minimum was 0.99 mm (0.63-1.35 mm), p<0.01.

The STJ free space RCA mean was 3.76 mm (2.2-5.32 mm).The difference between maximum and minimum was 1.18 mm (0.9-1.56 mm), p<0.01. The largest patient-specific difference between minimum and maximum was 2.02 mm, using the same valve size but at different depths.

Data presented as mean (95% confidence intervals), n=15 patients/48 models.

Measure	Mean	Minimum	Maximum	Difference	P value
SOV LMCA	6.39 (4.87-7.91)	5.90 (4.27-7.52)	6.84 (5.4-8.28)	0.95 (0.54-1.36)	<0.01*
SOV RCA	5.73 (4.17-7.30)	5.34 (3.89-6.78)	6.13 (4.45-7.81)	0.789 (0.49-1.09)	<0.01*
STJ LMCA	4.3 (2.35-6.27)	3.79 (1.78-5.79)	4.78 (2.81-6.75)	0.99 (0.63-1.35)	<0.01*
STJ RCA	3.76 (2.2-5.32)	3.2 (1.65-4.75)	4.38 (2.72-6.01)	1.18 (0.9-1.56)	<0.01*

Figure 2: Results table. SOV – free space sinus of Valsalva, STJ – free space sino-tubular junction, LMCA – left main coronary artery, RCA – right coronary artery. Results expressed as mean in mm (95% confidence intervals). N=15 patients/48 models.

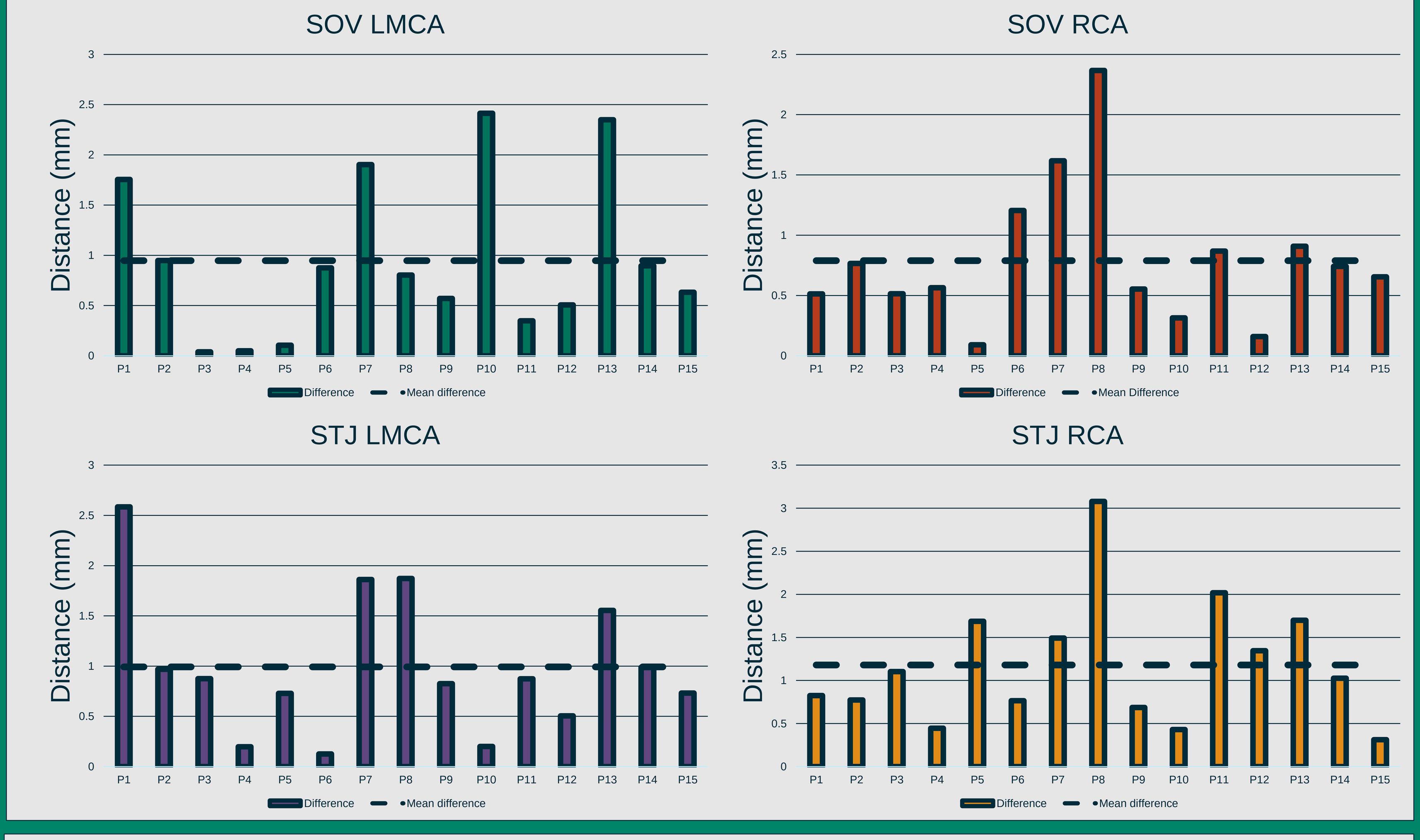
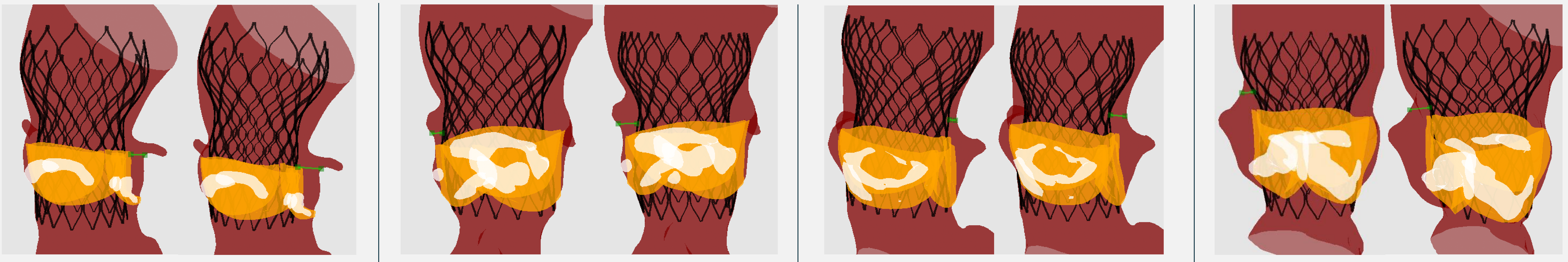


Figure 3: Demonstrating the difference in minimum and maximum difference by case and anatomical measure. The dotted line represents the mean difference for each measure.

Figure 4: demonstrating worked examples of how modelling different valves and different heights affects these anatomical measures.



26M – 3.7mm 29H – 6.1mm
LMCA

34H – 2.62mm 29M – 4.9mm
RCA

34H – 1.59mm 29M – 3.87mm
STJ-LMCA

29M – 3.1mm 34H – 5.2mm
STJ-RCA

Results table 2

CT ANALYSIS	N = 15
Morphology	
Sievers 0	3/15 (20%)
Sievers 1 – R-L	11/15 (73.3%)
R-N	1/15 (6.7%)
Aortic annular area, mm^2	491.0±127.3
Aortic annular perimeter, mm	79.5±10.7
aortic annular perimeter derived diameter, mm	25.3±3.4
Inter-commisural distance, mm	27.5±3.0
calcium quantification, mm^3 (850HU)	869±954
raphe length, mm	11.1±2.2
LIRA plane perimeter derived diameter, mm	23.3±3.22
Implanted Valve sizes	
Evolut 23mm	1/15 (6.7%)
Evolut 26mm	2/15 (13.3%)
Evolut 29mm	10/15 (66.7%)
Evolut 34mm	2/15 (13.3%)
Values are mean±standard deviation or n/N (%)	

Conclusions

This modelling study has indicated a significant difference in all four measured parameters when different THVs are modelled at different depths in patients with BAV. Note some of the largest differences are seen with the same size THV but at a different depth. We should highlight the fairly small effect size seen across the results, however in cases where the difference is >2mm, this could have an effect on coronary re-access and warrants further investigation.

References

1) Barbanti M, Costa G, Picci A, et al. Coronary Cannulation After Transcatheter Aortic Valve Replacement: The RE-ACCESS Study. *JACC Cardiovasc Interv*. 2020;13(21):2542-2555. doi:10.1016/j.jcin.2020.07.006
2) Khan JM, Kamioka N, Lisko JC, et al. Coronary Obstruction From TAVR in Native Aortic Stenosis: Development and Validation of Multivariate Prediction Model. *JACC Cardiovasc Interv*. 2023;16(4):415-425. doi:10.1016/j.jcin.2022.11.018
3) Wang X, De Backer O, Bieliauskas G, et al. Cusp Symmetry and Coronary Ostial Eccentricity and its Impact on Coronary Access Following TAVR. *JACC Cardiovasc Interv*. 2022;15(2):123-134. doi:10.1016/j.jcin.2021.11.010

Disclosures

St George's University Hospitals NHS Foundation Trust is in receipt of an unrestricted research grant from Medtronic, Minneapolis, Minnesota, USA
Professor Brecker has received grant support, consultant and speaker fees from Medtronic.
Dr Rocatello and Mr Weng are employees of FEops, NV Ghent, Belgium.

Outstanding care every time