Research and Application of Three-dimensional Quantitative Coronary Angiography

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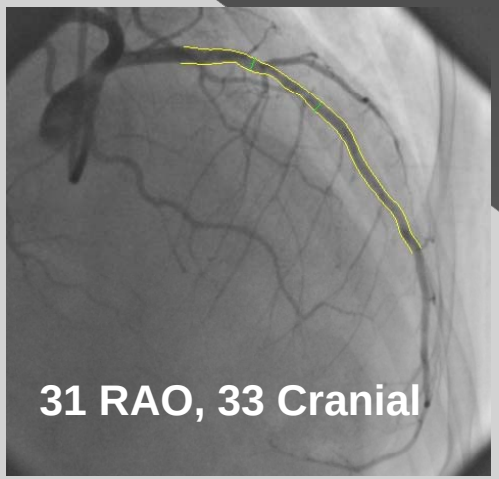
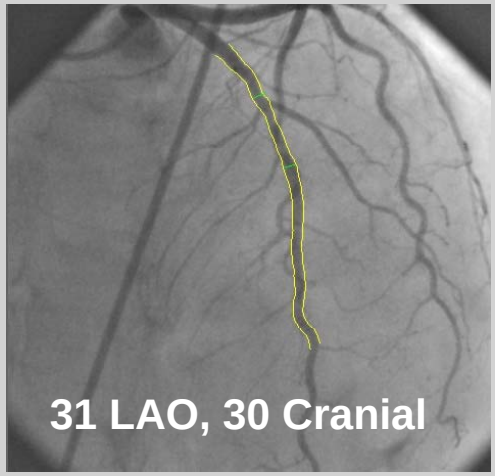
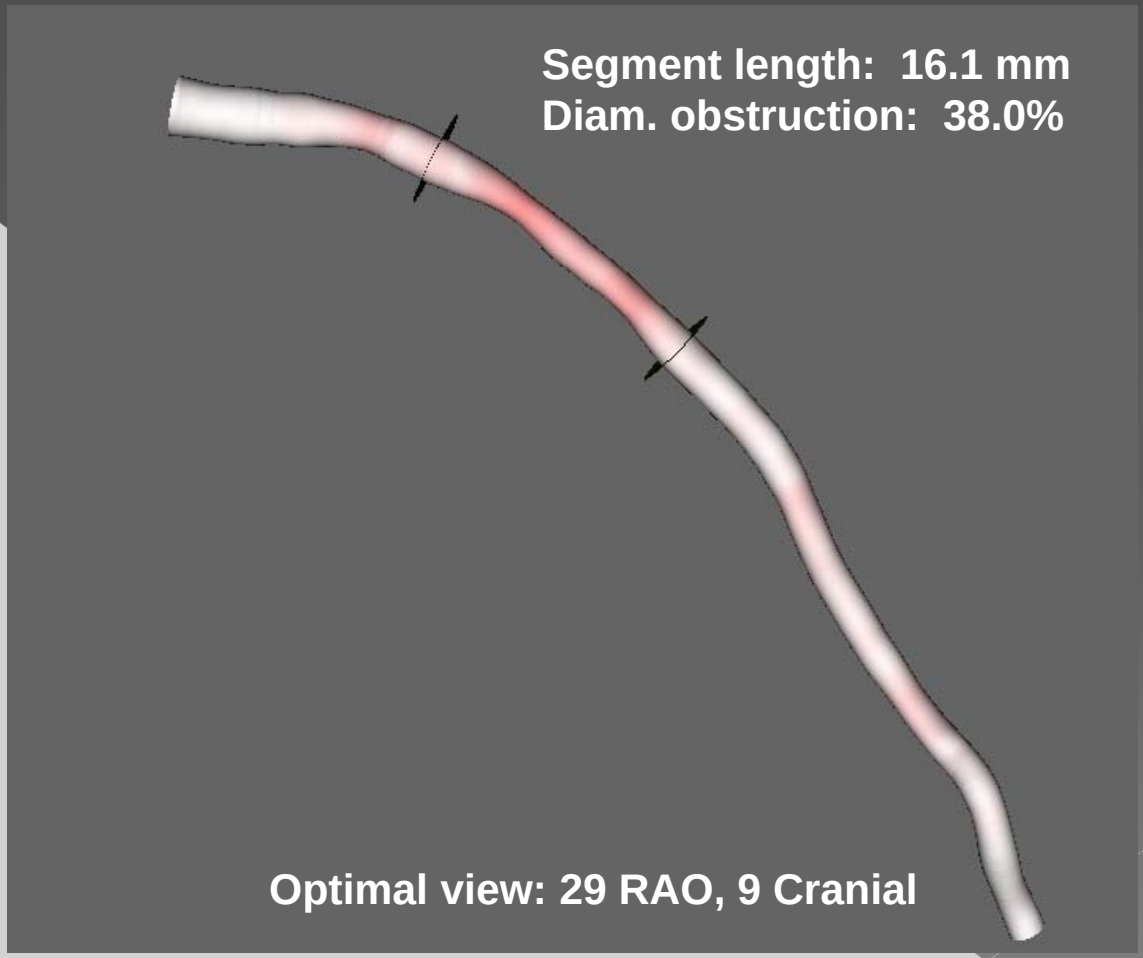
Background

- The efficacy of coronary interventions with DES depends on complete lesion coverage, stent apposition, stent positioning, etc.
- Despite that dedicated QCA techniques has significantly evolved over the past years, at present, the assessment of absolute lumen dimensions by conventional 2D analysis is still limited by the well-known errors due to vessel foreshortening and out-of-plane magnification.
- IVUS or OCT is often used to identify the position and extent of plaque burden and composition; however, the interventional cardiologist must mentally make the connection between the IVUS/OCT abnormalities and the X-ray based coronary anatomy.
- 3D QCA aims to overcome the limitations of 2D QCA/IVUS/OCT in supporting coronary interventions.

3D angiographic reconstruction

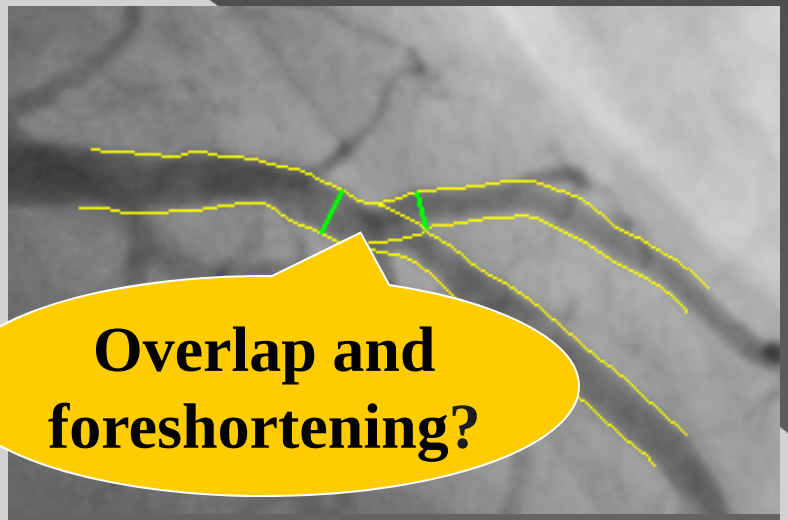


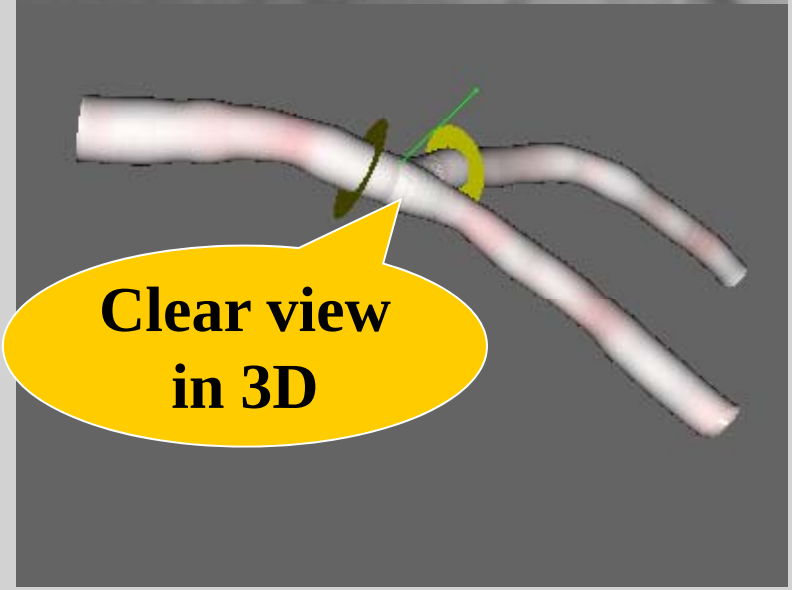




* 2D lumen contour detection uses Medis' QCA algorithms.
* 3D reconstruction system was developed by Medis.

Optimal Viewing Angle can be predicted from 3D anatomy





In vivo assessment of bifurcation optimal viewing angles and bifurcation angles by 3D QCA[1]

[Background] Bifurcation lesions are frequent. The treatment remains challenging with a tendency towards increased restenosis and stent thrombosis. Correct assessment of bifurcation lesion anatomy, especially the ostia of branches, is essential in the choice of treatment strategy. Currently, the operators will Continually adjust the C-arm angle to minimize the foreshortening and overlap .In order to obtain optimal viewing angle. This "trial-and-error" approach could significantly increase the volume of contrast medium used and the radiation exposure to the patient and staff.

So Evaluation and stenting of coronary bifurcation lesions may benefit from optimal angiographic views. The anatomy-defined bifurcation optimal viewing angle (ABOVA) is characterized by having an orthogonal view of the bifurcation, such that overlap and foreshortening at the ostium are minimized. However, due to the mechanical constraints of the X-ray systems, certain deep angles cannot be reached by the C-arm. Therefore, second best or, socalled obtainable bifurcation optimal viewing angle (OBOVA) has to be used as an alternative.

1.Tu S& Jing Jing, et. al. In vivo assessment of bifurcation optimal viewing angles and bifurcation angles by 3D QCA.Int J Cardiovasc Imaging 2011. Epub Ahead of Print.DOI 10.1007/s10554-011-9996-x

In vivo assessment of bifurcation optimal viewing angles and bifurcation angles by 3D QCA[1]

Patient	n = 181
Age	61 (39–88)
Male/female	145/36
Bifurcation	n = 194
LM/LAD/LCx	49 (25.3%)
LAD/Diagonal	51 (26.3%)
LCx/OM	51 (26.3%)
PDA/PLA	43 (22.2%)
Lesion classifications[a]	
(1,0, 0)	14 (7.2%)
(0, 1, 0)	35 (18.0%)
(0, 0, 1)	14 (7.2%)
(1,1,0)	33 (17.0%)
(1,0, 1)	19 (9.8%)
(0, 1, 1)	23 (11.9%)
(1, 1, 1)	56 (28.9%)

[Study Population]
A total of 194 bifurcations from 181 patients with obstructive coronary bifurcation disease in four main coronary bifurcations were assessed.

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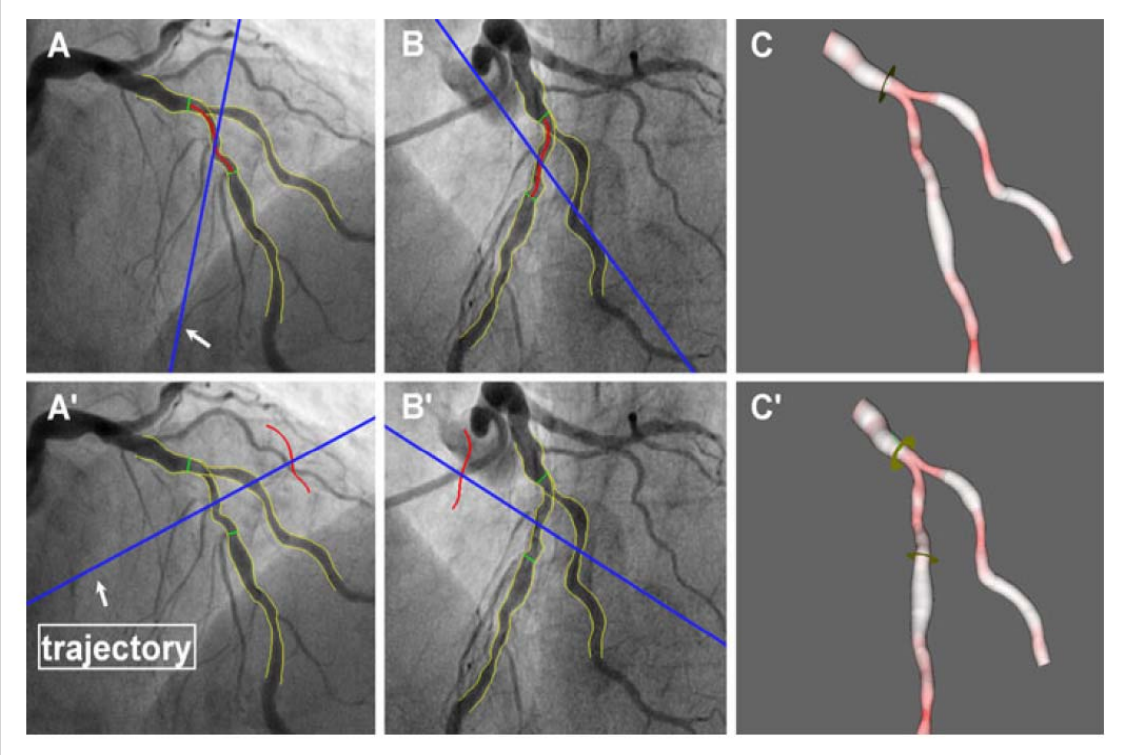
In vivo assessment of bifurcation optimal viewing angles and bifurcation angles by 3D QCA[1]



[Methods] A recently developed 3D QCA software package was used to reconstruct 194 bifurcations in patients with coronary artery disease undergoing elective coronary angiography. The ABOVA and a list of OBOVA was automatically proposed by the software. In a next step, the operator selected the best OBOVA, while applying a novel overlap prediction approach to assure that there was no overlap between the target bifurcation and other major coronary segments.

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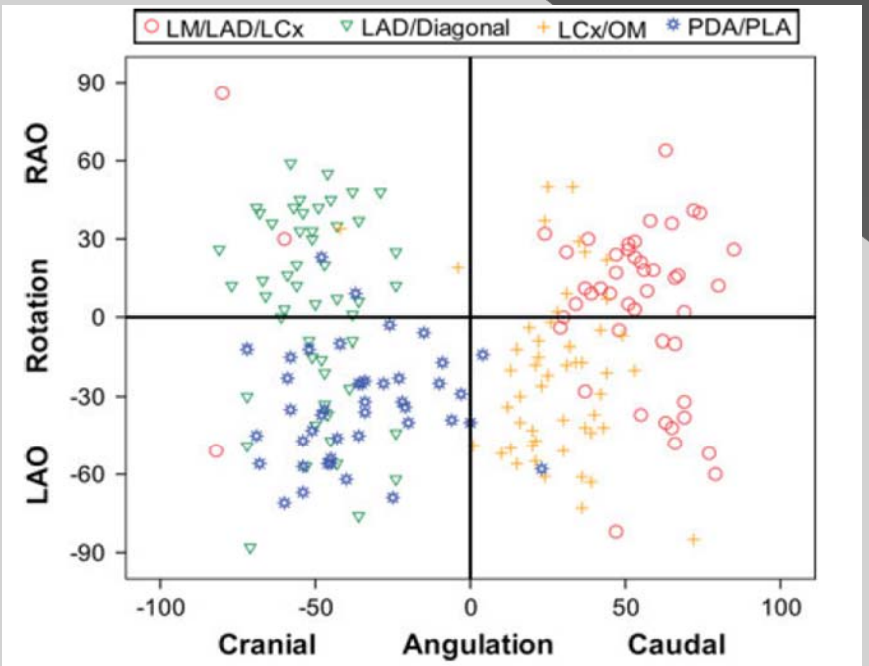
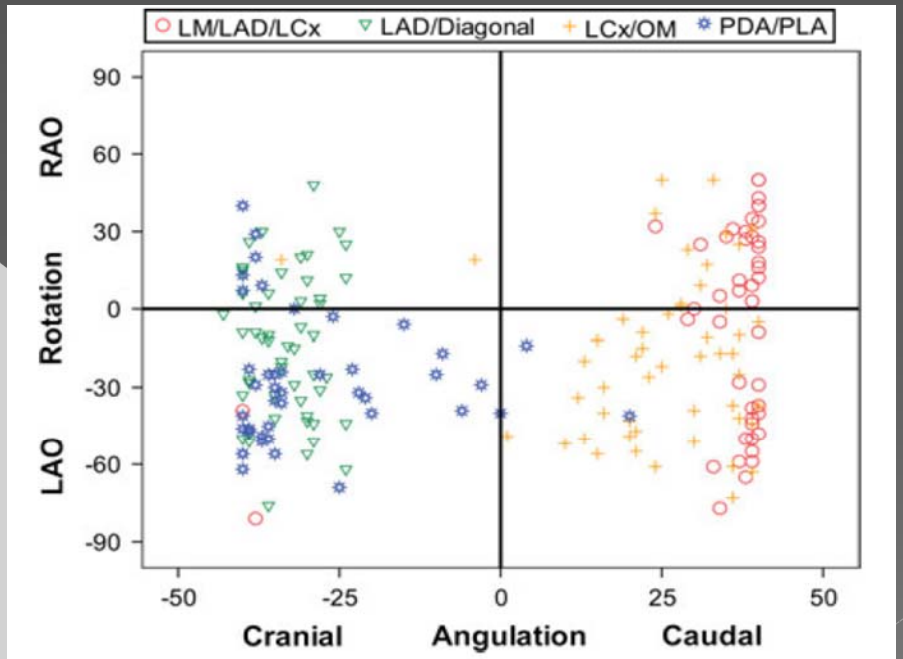
In vivo assessment of bifurcation optimal viewing angles and bifurcation angles by 3D QCA[1]

[Result]



1. The distribution of the anatomy-defined bifurcation optimal viewing angle (ABOVA): The ABOVA distributed sparsely with large ranges of variation for all main coronary bifurcations. $n = 194$



2. The distribution of the obtainable bifurcation optimal viewing angle (OBOVA): The OBOVA distributed sparsely with large ranges of variation for all main coronary bifurcations. $n = 194$

1.Tu S& Jing Jing, et. al. In vivo assessment of bifurcation optimal viewing angles and bifurcation angles by 3D QCA.Int J Cardiovasc Imaging 2011. Epub Ahead of Print.DOI 10.1007/s10554-011-9996-x

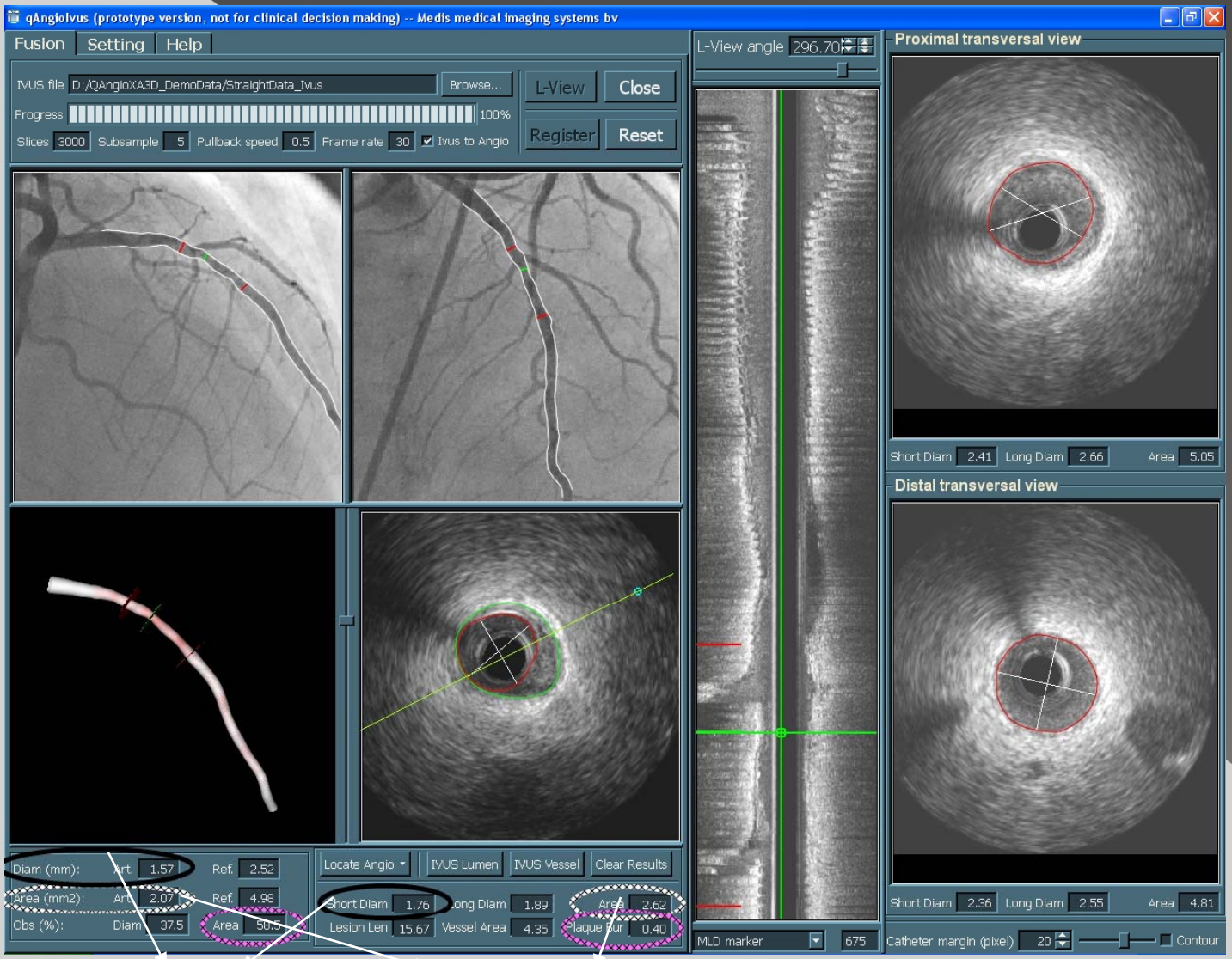
In vivo assessment of bifurcation optimal viewing angles and bifurcation angles by 3D QCA[1]

[conclusion]

Large variabilities in optimal viewing angles existed for all main coronary bifurcations. The anatomy-defined bifurcation optimal viewing angle could not be reached in vivo in roughly half of the cases due to the mechanical constraints of the current X-ray systems. Obtainable bifurcation optimal viewing angle should be provided as an alternative or second best. The bifurcation angles in the left main bifurcation demonstrated the largest variabilities.

1.Tu S& Jing Jing, et. al. In vivo assessment of bifurcation optimal viewing angles and bifurcation angles by 3D QCA.Int J Cardiovasc Imaging 2011. Epub Ahead of Print.DOI 10.1007/s10554-011-9996-x

XA-IVUS co-registration



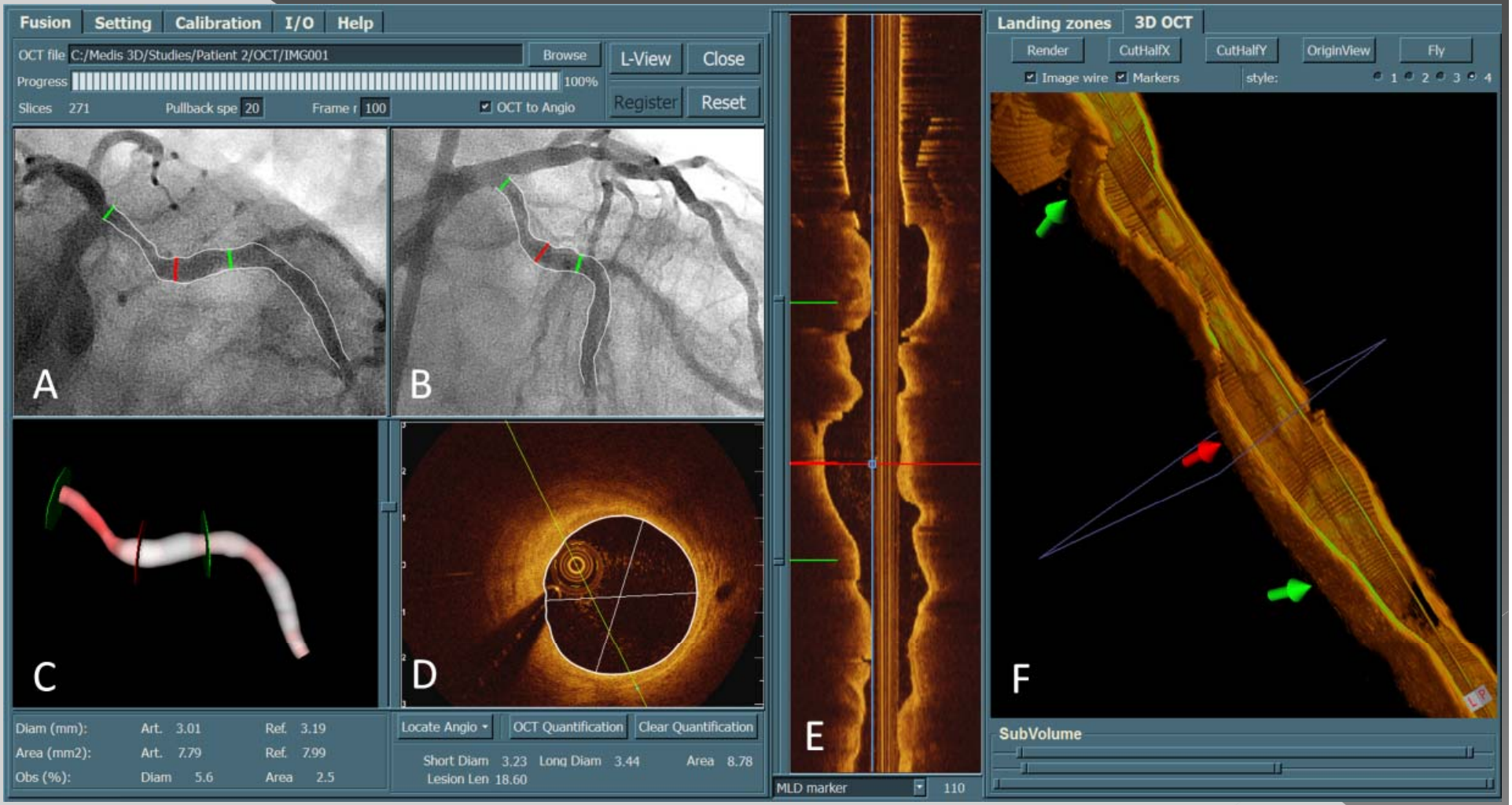
Registration: identify marker (sidebranch, stent border, etc) in both imaging modalities;

Stent-positions can be mapped from IVUS/OCT to XA fluoroscopy to plan stent deployment;

Vessel dimensions and plaque information can be assessed at every corresponding position along the vessel segment.

	QCA	IVUS
MLD	1.57	1.76
Area	2.07	2.62
Plaque	58%	40%

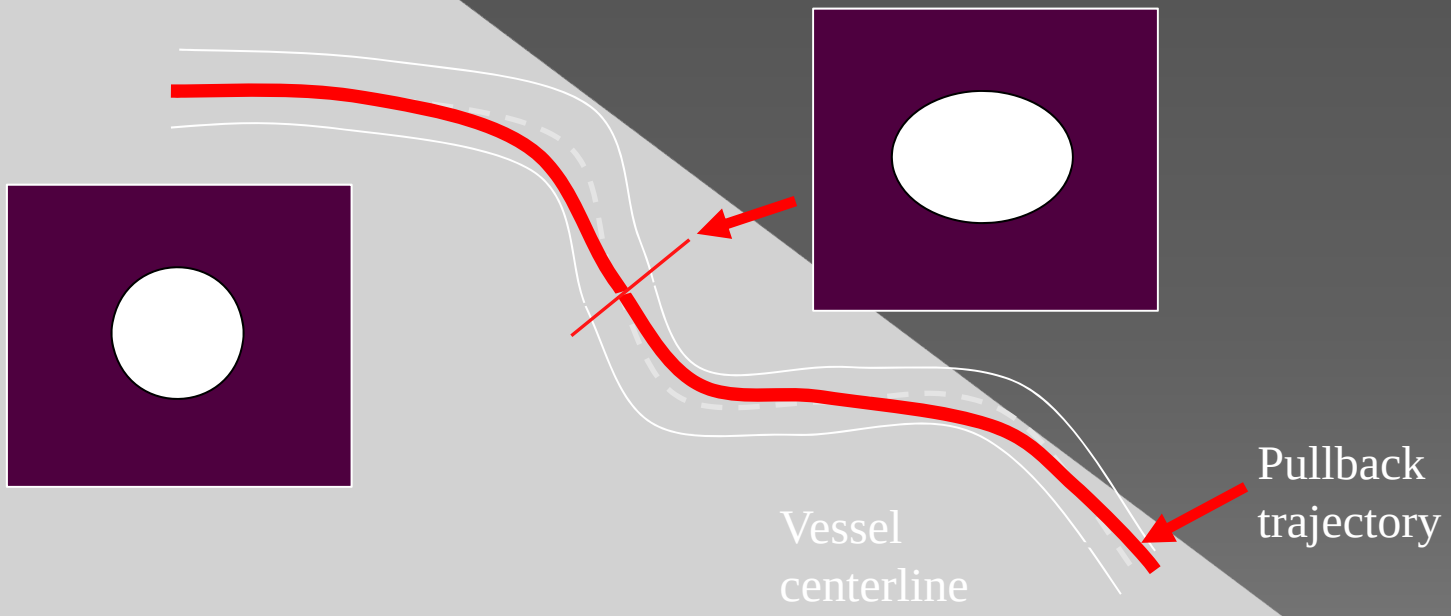
XA-OCT co-registration



Validation – Comparison of Lumen Dimension[2]

To compare lumen size as assessed in-vivo by co-registered 3D QCA and by IVUS or OCT;

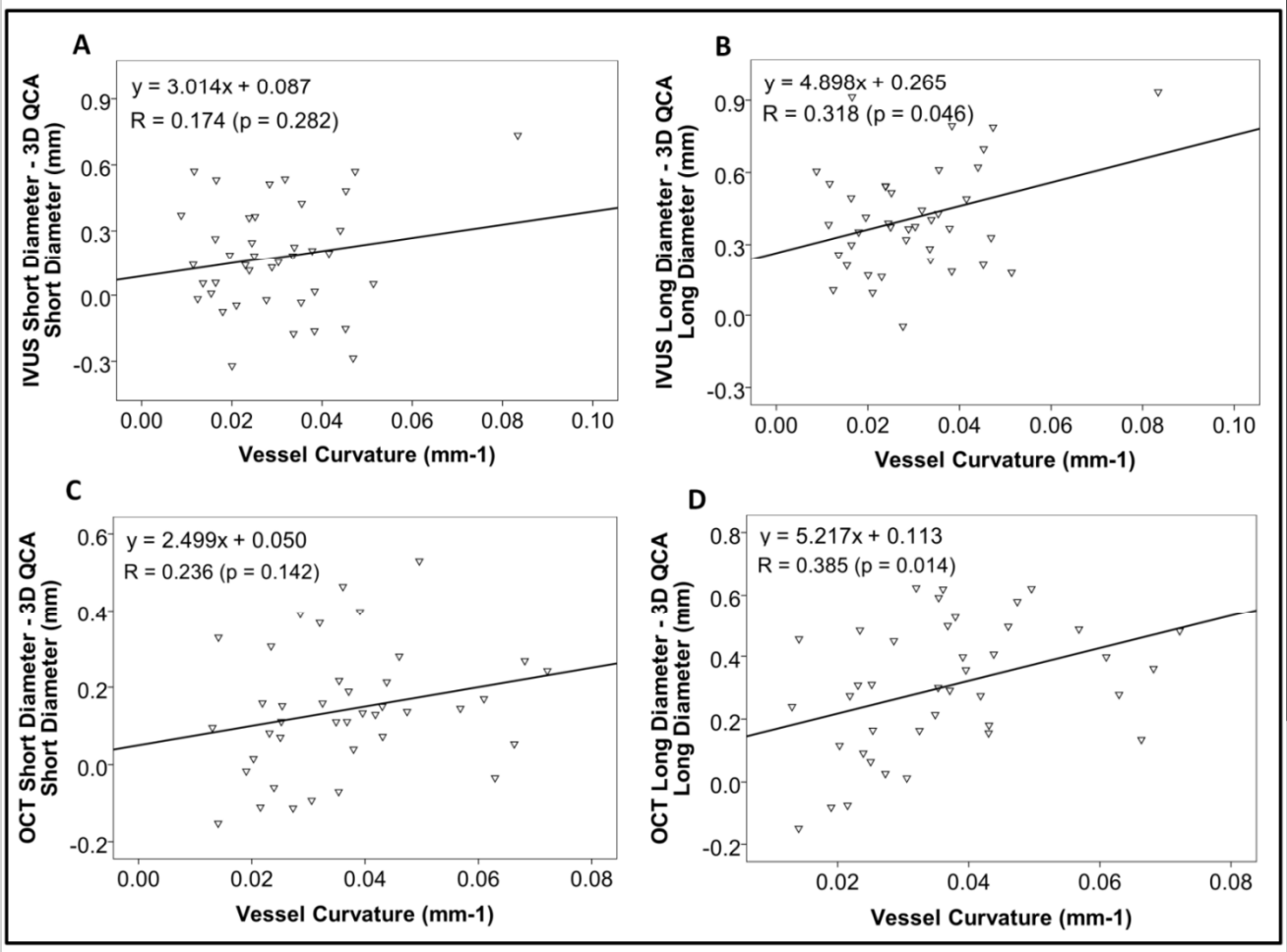
To investigate the impact of vessel curvature on the discrepancy.



Confounder: Catheter Looseness = lumen diameter – catheter diameter

2. Tu S, et. al. In-vivo Comparison of Arterial Lumen Dimensions Assessed by Co-registered Three-dimensional (3D) Quantitative Coronary Angiography, Intravascular Ultrasound and Optical Coherence Tomography. Int J Cardiovasc Imaging 2012. Epub Ahead of Print.

Validation – Comparison of Lumen Dimension



Our comparison of co-registered 3D QCA and invasive imaging data suggested a bias towards larger lumen dimensions by IVUS and by OCT, which was more pronounced in larger and tortuous vessels.

Conclusions

- 3D QCA can accurately assess actual vessel dimensions without foreshortening errors, and allows the assessment of the optimal viewing angles for stent selection and stent positioning;
- The new XA-IVUS/OCT co-registration approach is a straightforward and robust solution to combine X-ray angiography and IVUS/OCT imaging;
- It provides the interventional cardiologist with detailed information about vessel size and plaque burden at every position along the vessel of interest, making this a suitable tool for on-line guiding of PCI.

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