

FFR_{CT} et planification de procédure interventionnelle

Le cath-lab du futur frappe à votre porte

Jeroen Sonck, MD

Cardiovascular Center, OLV Clinic Aalst

Belgium

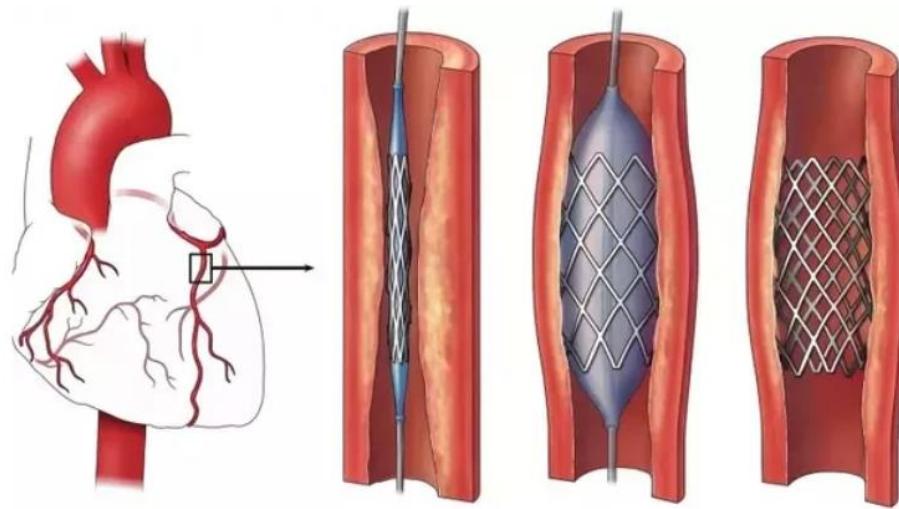
DÉCLARATION DE LIENS D'INTÉRÊT AVEC LA PRÉSENTATION

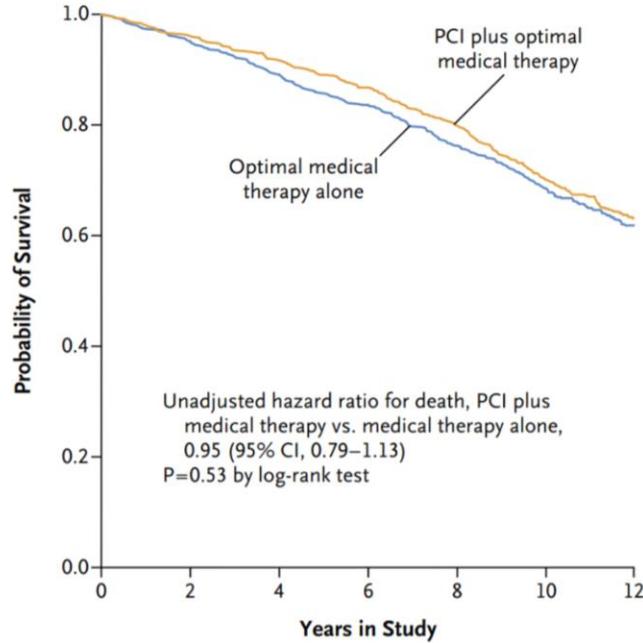
Intervenant : Jeroen SONCK, Aalst

- Je n'ai pas de lien d'intérêt à déclarer



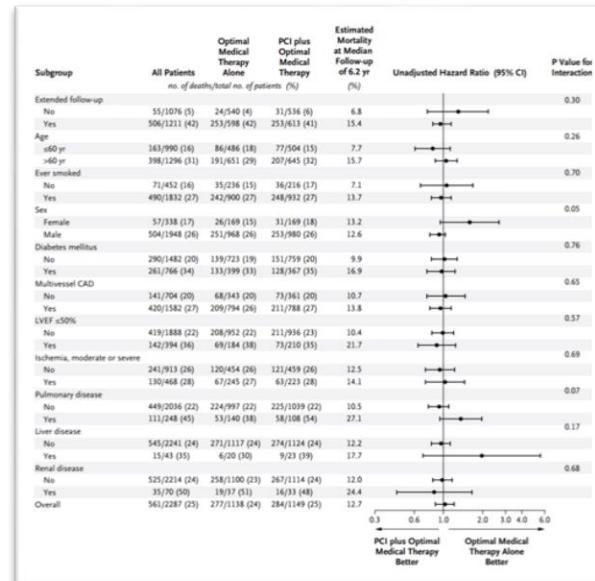
Cardiovascular
Center
Aalst



B Extended Follow-up Study Cohort


Effect of PCI on Long-Term Survival in Patients with Stable Ischemic Heart Disease

Steven P. Sedlis, M.D., Pamela M. Hartigan, Ph.D., Koon K. Teo, M.B., B.Ch., Ph.D., David J. Maron, M.D., John A. Spertus, M.D., M.P.H., G.B. John Mancini, M.D., William Kostuk, M.D., Bernard R. Chaitman, M.D., Daniel Berman, M.D., Jeffrey D. Lorin, M.D., Marcin Dada, M.D., William S. Weintraub, M.D., and William E. Boden, M.D., for the COURAGE Trial Investigators*



FAME

Defer PCI for lesions with $FFR > 0.8$

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812

JANUARY 15, 2009

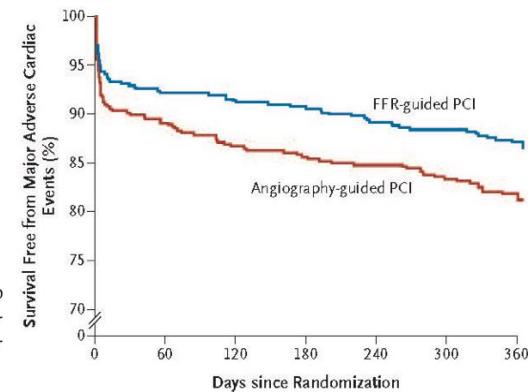
VOL. 360 NO. 3

Fractional Flow Reserve versus Angiography for Guiding Percutaneous Coronary Intervention

CONCLUSIONS

Routine measurement of FFR in patients with multivessel coronary artery disease who are undergoing PCI with drug-eluting stents significantly reduces the rate of the composite end point of death, nonfatal myocardial infarction, and repeat revascularization at 1 year. (ClinicalTrials.gov number, NCT00267774.)

Tonino et al. NEJM 2009, 360: 213



FAME-2

Perform PCI for lesions with $FFR \leq 0.8$

THE NEW ENGLAND JOURNAL OF MEDICINE

ORIGINAL ARTICLE

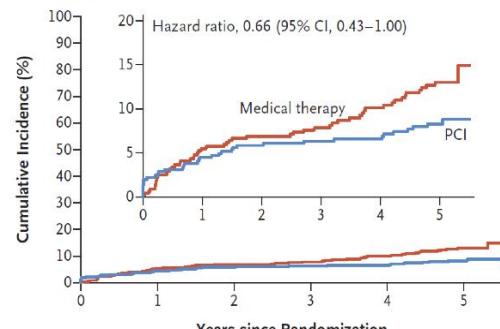
Five-Year Outcomes with PCI Guided by Fractional Flow Reserve

CONCLUSIONS

In patients with stable coronary artery disease, an initial FFR-guided PCI strategy was associated with a significantly lower rate of the primary composite end point of death, myocardial infarction, or urgent revascularization at 5 years than medical therapy alone. Patients without hemodynamically significant stenoses had a favorable long-term outcome with medical therapy alone. (Funded by St. Jude Medical and others; FAME 2 ClinicalTrials.gov number, NCT01132495.)

Xaplanteris et al. NEJM 2018

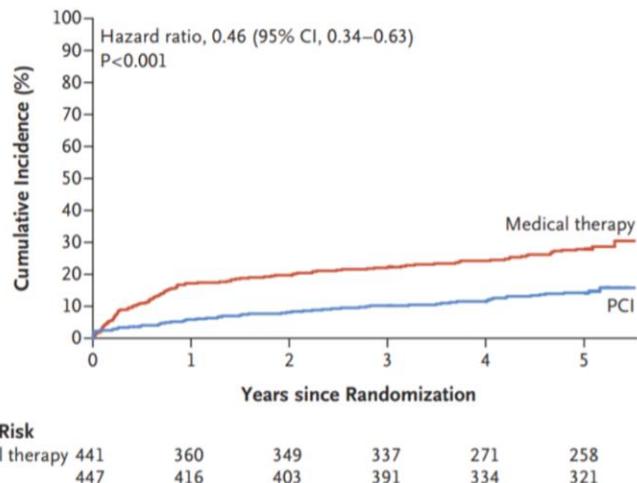
B Myocardial Infarction



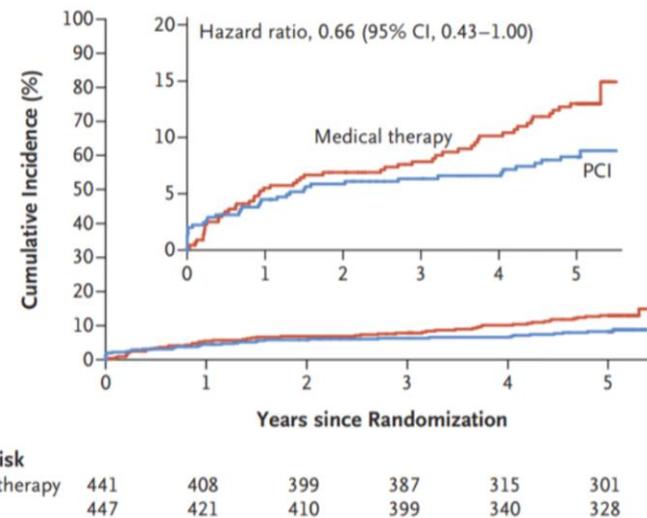
No. at Risk	Medical therapy	PCI	Medical therapy	PCI	Medical therapy	PCI
441	408	399	387	315	301	328
447	421	410	399	340	328	

Patient selection using *physiology* at the *vessel level* is associated with improved clinical outcomes.

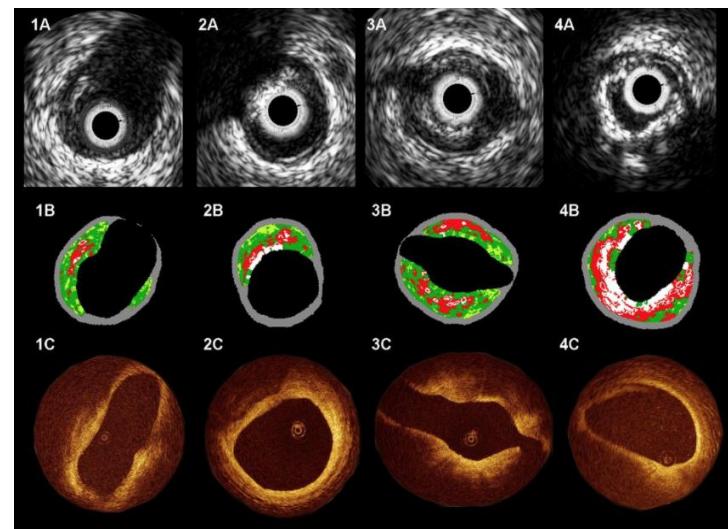
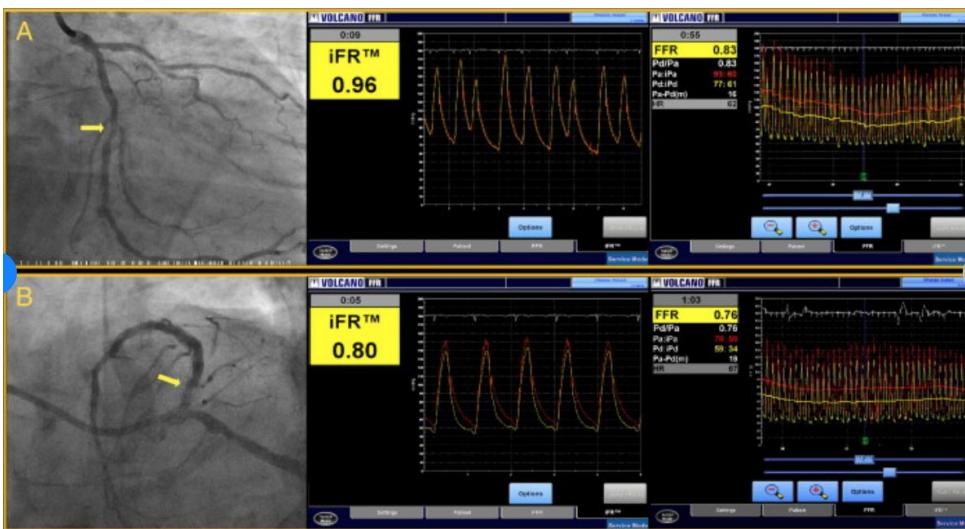
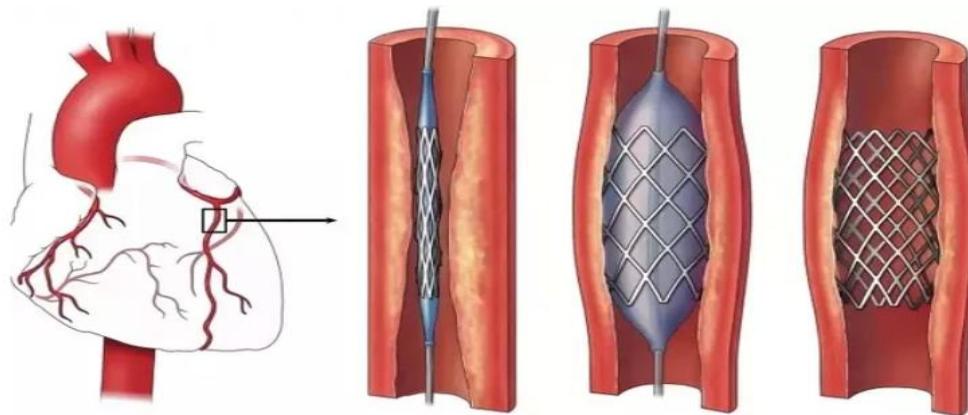
MACE



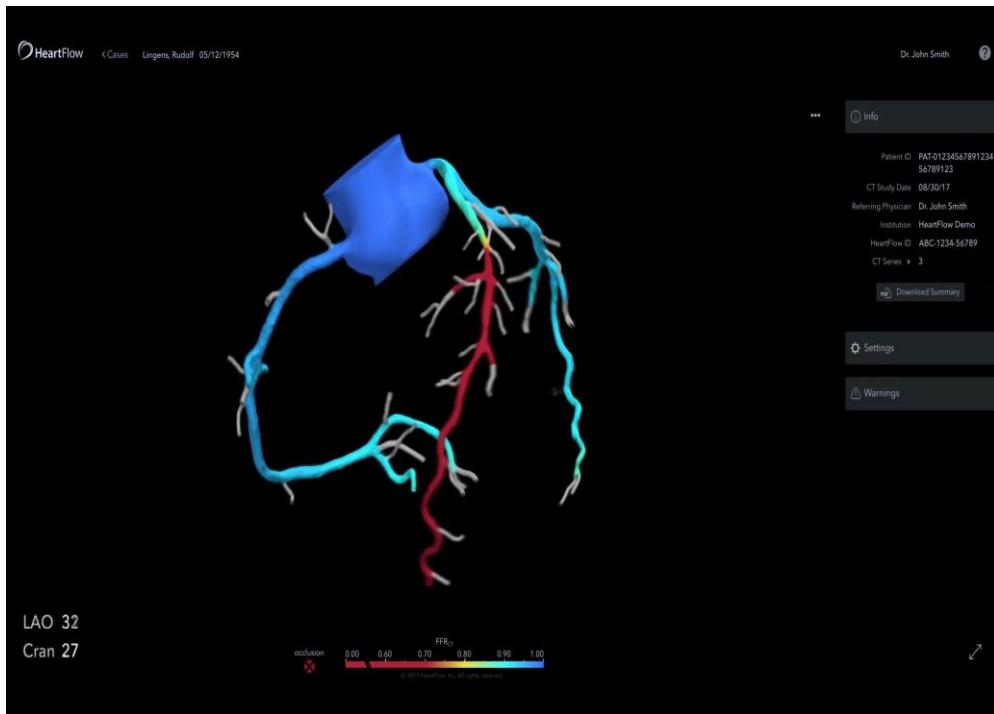
Myocardial infarction



Xaplanteris P et al. NEJM 2018

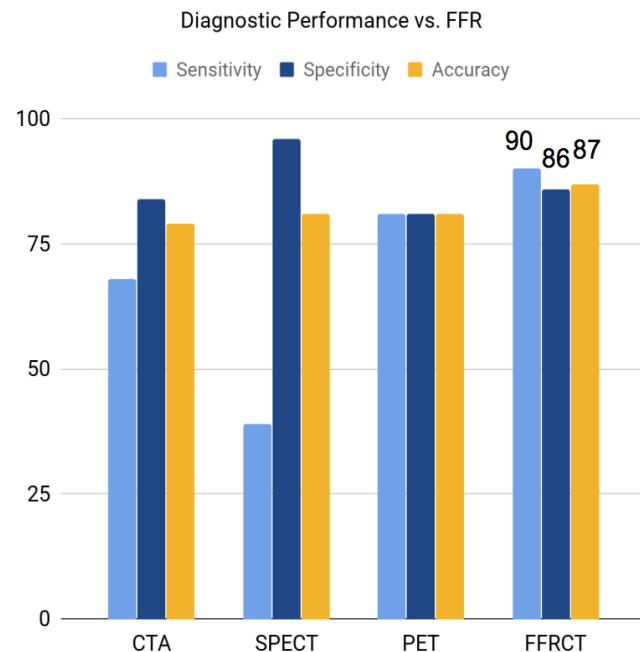


The incremental value of CT-derived FFR on top of CCTA

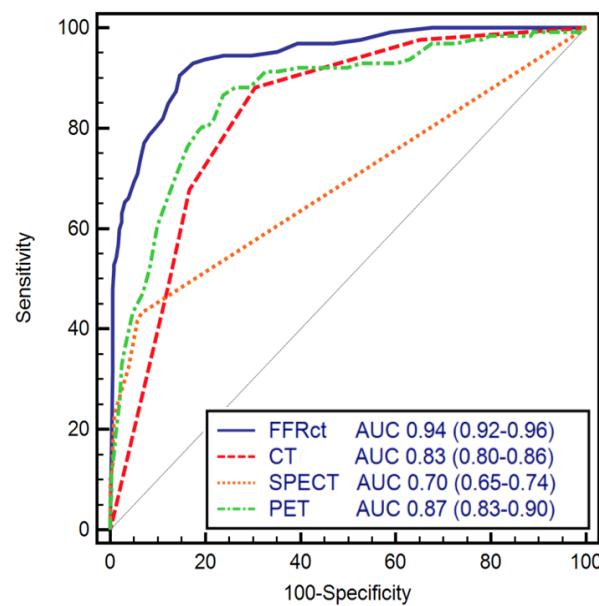


- 1/ Optimize patient selection for the lab
 - Vessel and lesion-specific physiology
 - Pre-lab MVD classification
- 2/ Plaque assessment \approx IVUS/OCT
- 3/ Plan the percutaneous approach

Diagnostic performance of FFR_{CT}: PACIFIC trial



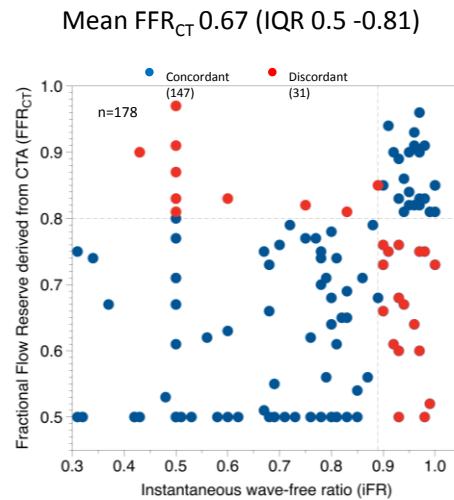
Presented Euro PCR 2018, Driessen RS et al.



Highest discrimination of ischaemia causing lesions for FFR_{CT} compared to:

- CT stenosis: Δ AUC 0.11, $p < 0.001$
- SPECT: Δ AUC 0.24, $p < 0.001$
- PET: Δ AUC 0.07, $p < 0.001$

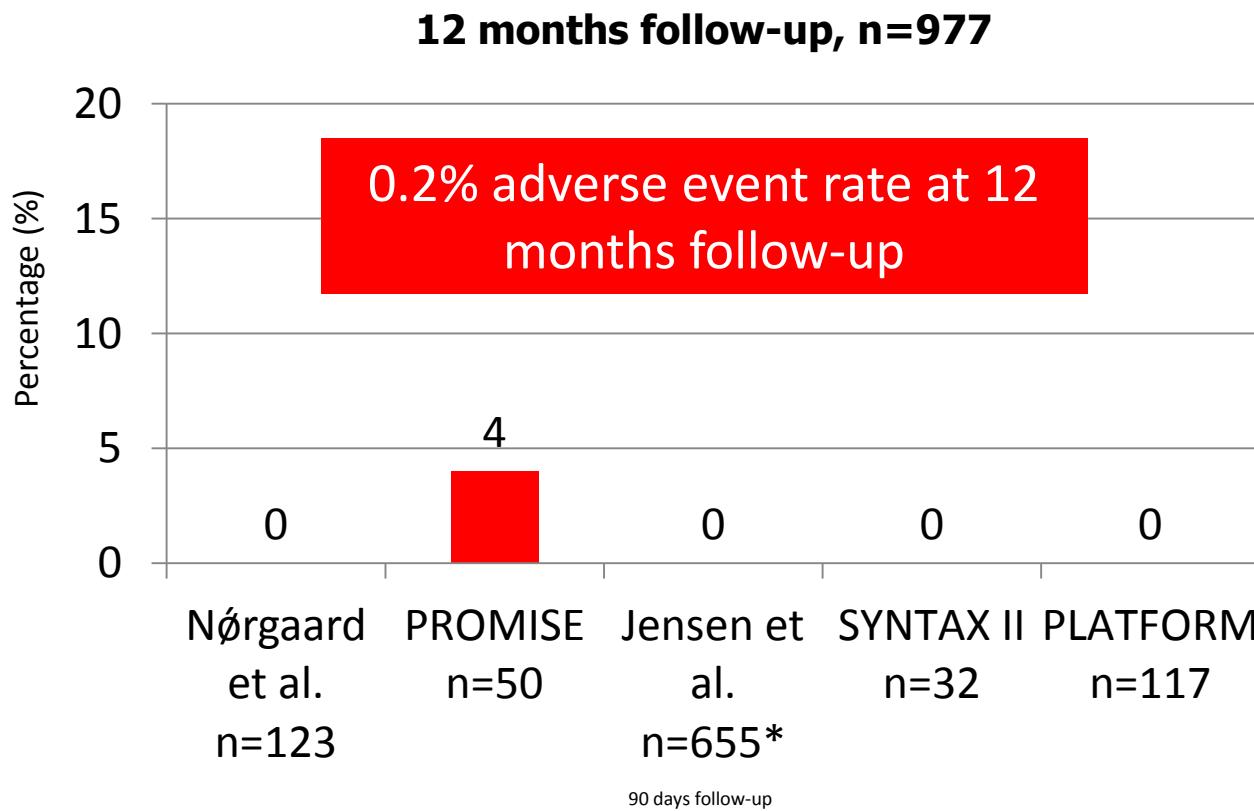
SYNTAX II sub-study: Performance of FFR_{CT} in patients with multivessel disease



Sensitivity 95% (95% CI: 89% to 98%); specificity 61% (95% CI: 48% to 73%); positive predictive value 81% (95% CI: 76% to 86%) and negative predictive value 87% (95% CI: 74% to 94%).

Collet, Sonck and Serruys, JACC 2018

Major Adverse Cardiac Events in patients with deferred lesions based on FFR_{CT}



Jensen et al. EHJCI. 2017

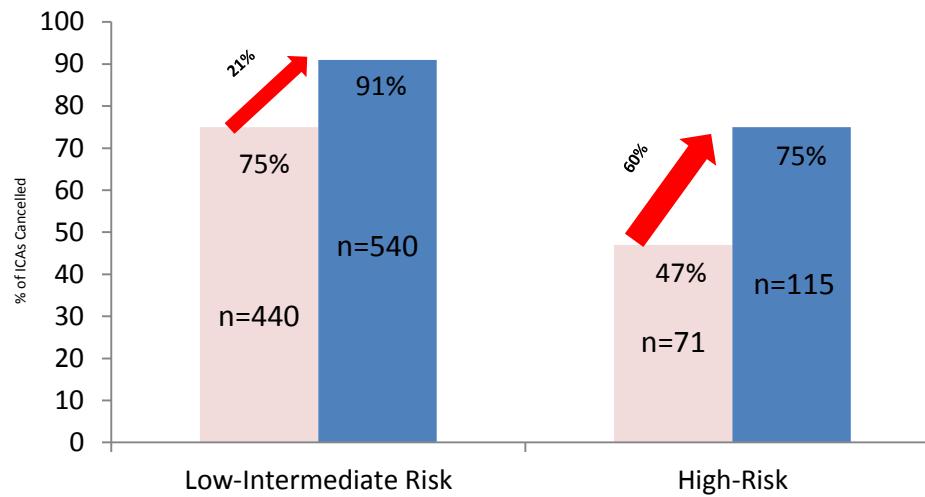
Lu, M. e.a. TCT 2015

PLATFORM. JACC 2016

Collet et al. JACC 2018

Norgaard et al. JACC Imag. 2017

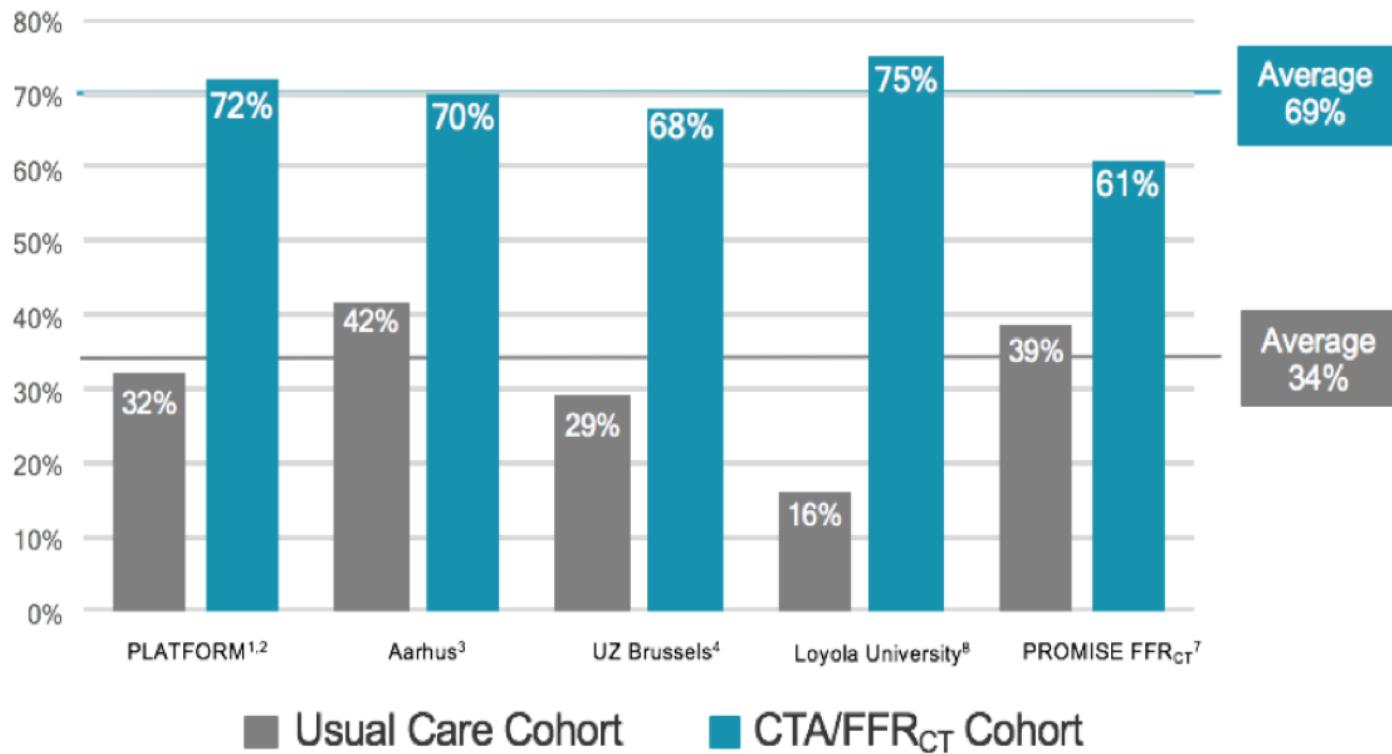
Combined cCTA and FFR_{CT}: ICA cancellations in high-risk patients



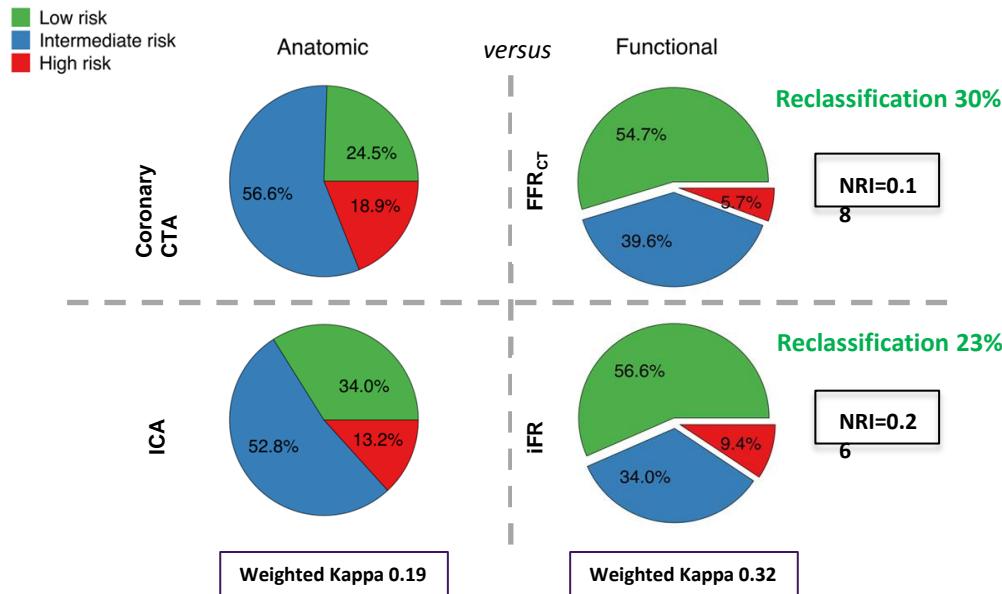
- A frontline cCTA and FFR_{CT} testing strategy cancelled 75% of ICAs in the high-risk group
- The incremental impact of FFR_{CT} was greater in high-risk as compared with the low-intermediate risk group
 - 60% in high-risk versus 21% in low-intermediate risk

Jensen et al, European Heart Journal – Cardiovascular Imaging 2017

Ratio of cath/PCI: Cath-lab efficiency

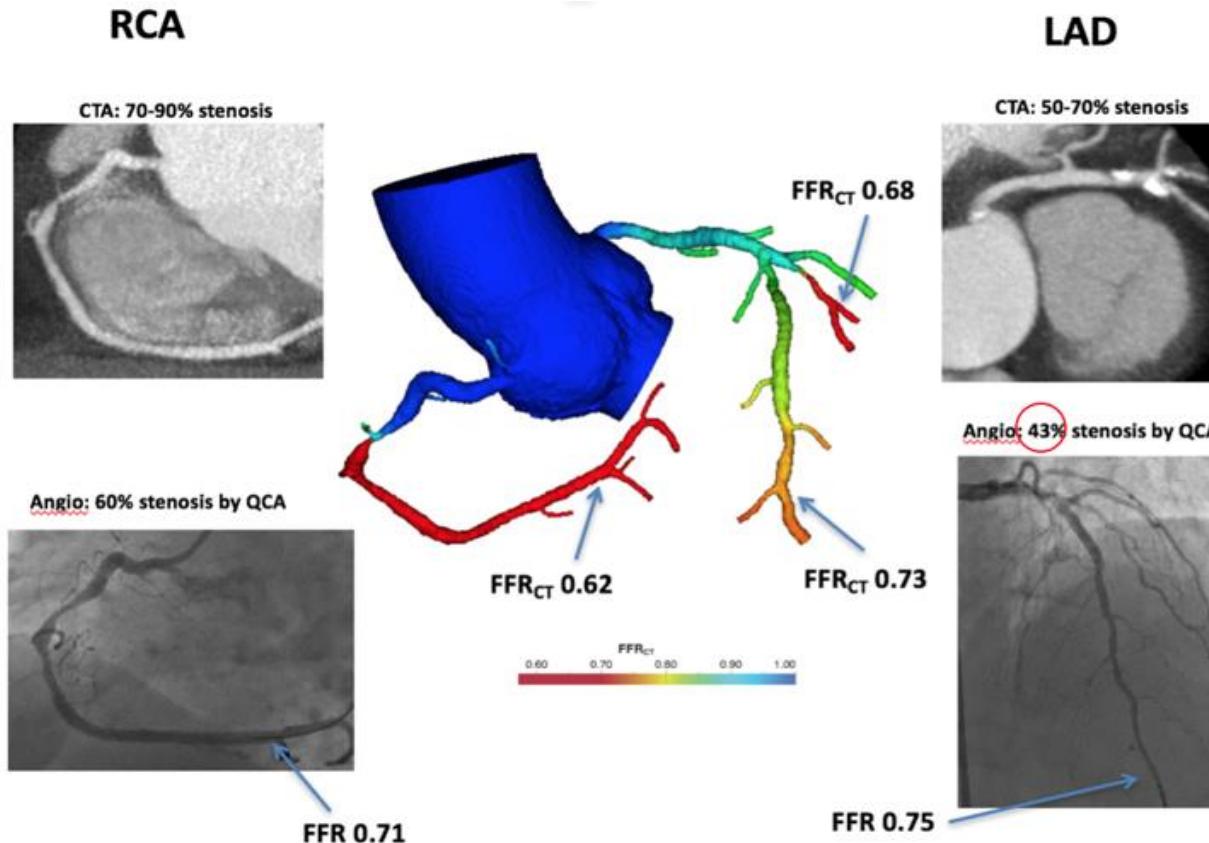


Reclassification of the SYNTAX-score tertiles



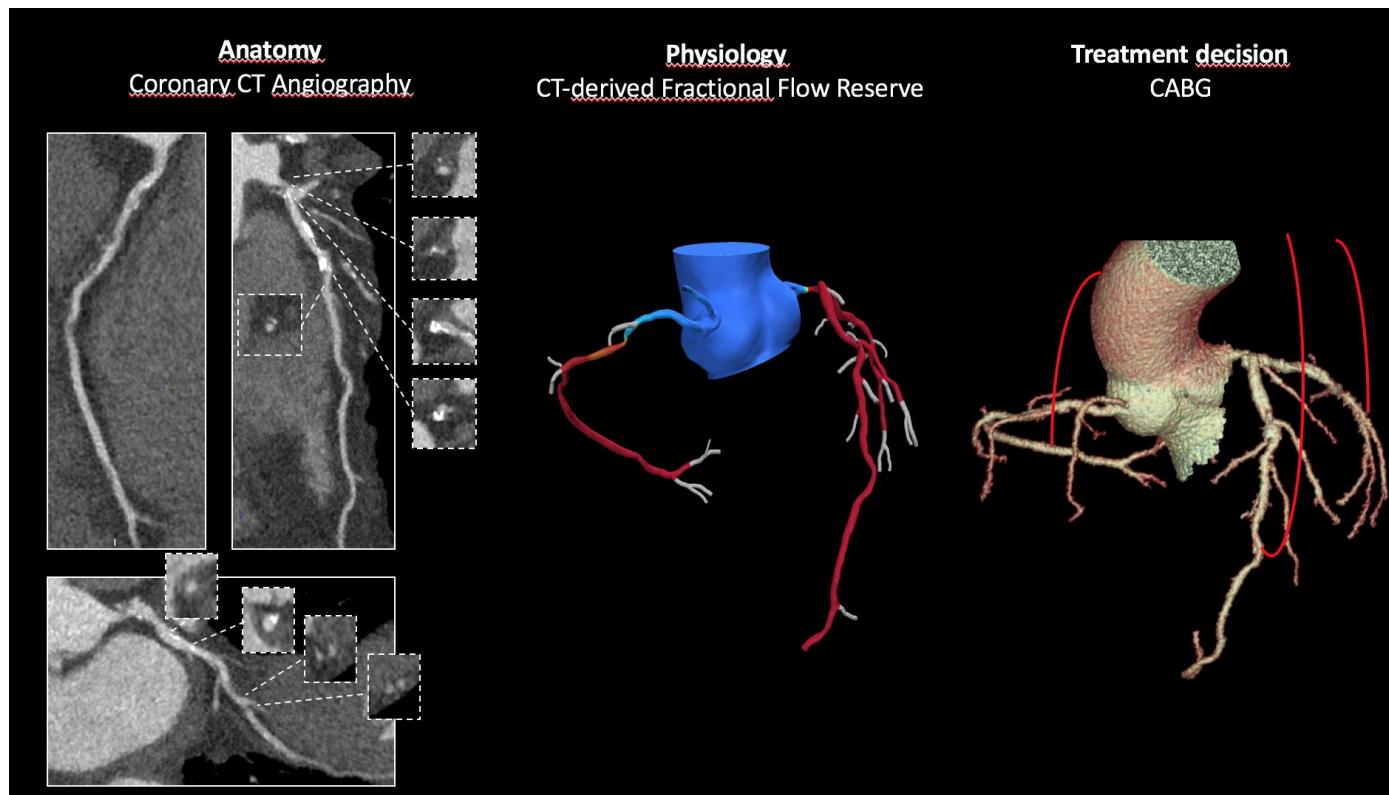
Collet, Sonck, Serruys et al. JACC 2018

MVD classification before we enter the lab



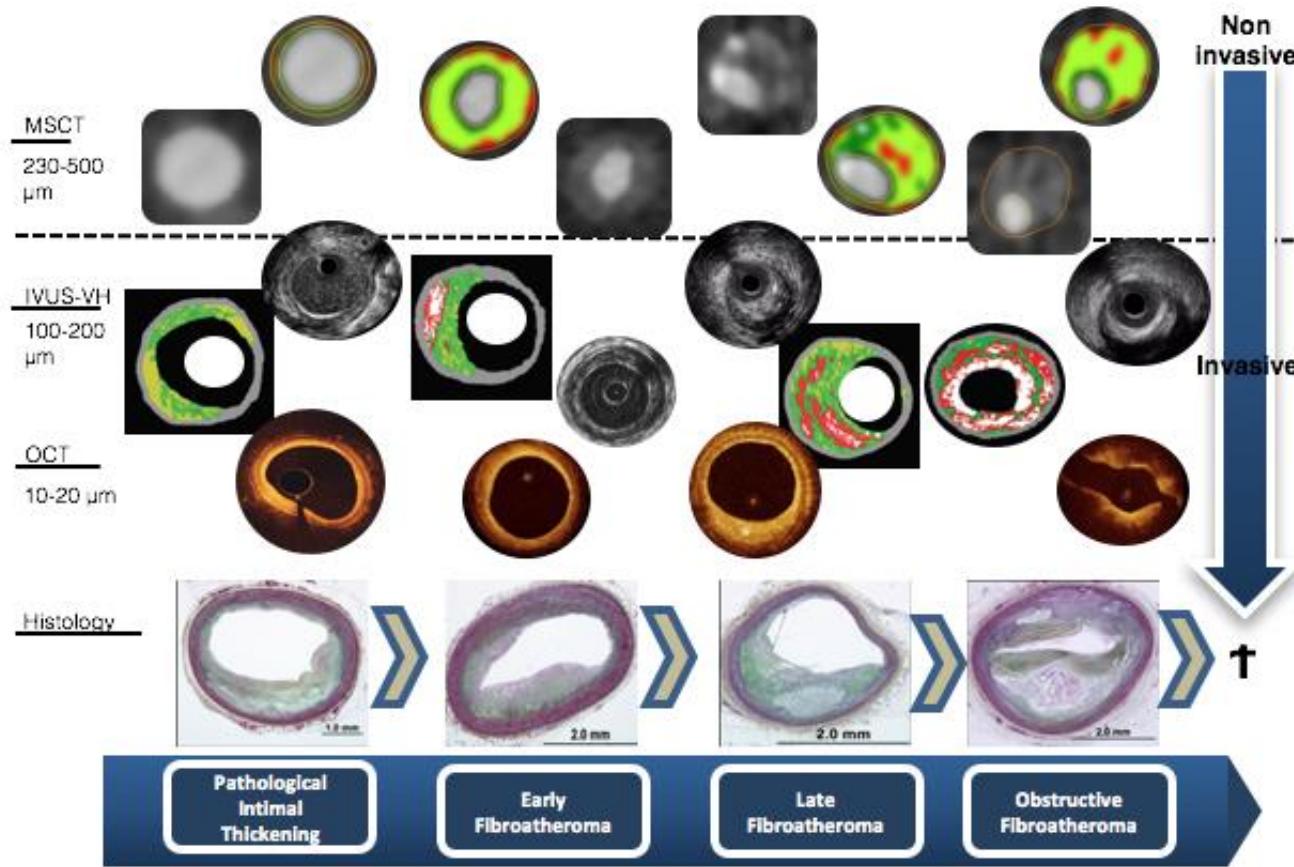
Ongoing trial: CABG Revolution

CABG without ICA



In patients with left main or three-vessel coronary artery disease, a heart team treatment decision-making based on coronary CTA showed an almost perfect agreement with the decision derived from conventional coronary angiography suggesting the potential feasibility of a treatment decision-making and planning based solely on this non-invasive imaging modality.

Coronary Imaging: from vessel to plaque



Otsuka et al. Atherosclerosis 2015

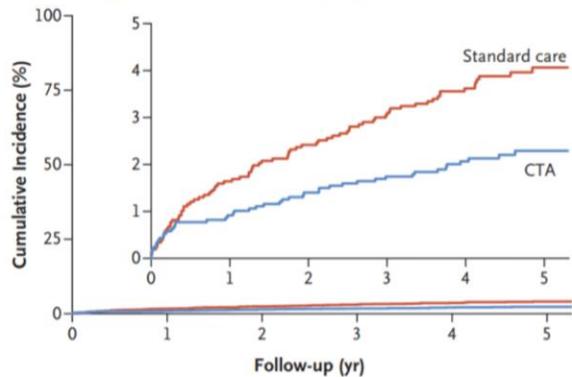
Cheng et al ATHEROREMO-IVUS EHJ 2014

Serruys et al. JACC 2015

Coronary CT Angiography and 5-Year Risk of Myocardial Infarction

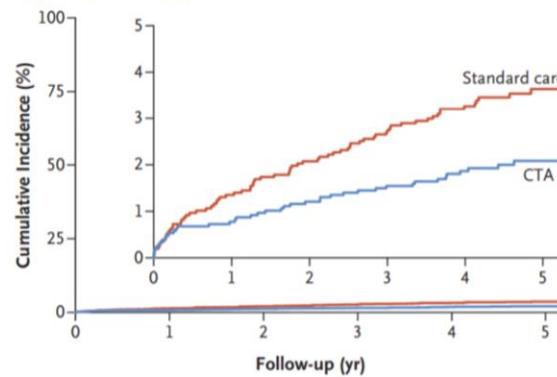
The SCOT-HEART Investigators*

A Death from Coronary Heart Disease or Nonfatal Myocardial Infarction



	No. at Risk					
Standard care	2073	2033	2008	1994	1572	856
CTA	2073	2051	2029	2015	1588	872

B Nonfatal Myocardial Infarction



	No. at Risk					
Standard care	2073	2045	2030	2017	1597	881
CTA	2073	2057	2048	2041	1618	891

Newby et al. NEJM 2018

High Risk Plaques and Clinical Outcomes

Low attenuation plaque. Positive remodeling. Spotty calcification

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**Computed Tomographic Angiography
Characteristics of Atherosclerotic Plaques
Subsequently Resulting in Acute Coronary Syd**

Sakae Miyamoto, MD, PhD; Masatoshi Saito, MD, PhD; Hiroshi Ito, MD, PhD; Kazuji Itoya, MD; Toshiyuki Hata, MD; Junichi Ito, MD; Toshiaki Yamada, MD; Toshiaki Nishida, MD, PhD; Toshiro Honda, MD; Toshiaki Yano, MD; PGSY Japan, Nagoya, M
Tosako and Takasaki, Japan; Kyoto, Kyoto, Japan; and Gifu University, Gifu, Japan

Objectives To compare angiographic CT angiography results, we identified the characteristics of coronary plaques in patients who developed acute coronary syndrome (ACS) and those who did not.

Background The 10-year incidence of repeat events in ACS patients is higher than in patients without ACS. These 10-year rates have been observed in the series in previous reports. In ACS, it has been reported that ACS is associated with more extensive lesions and more complex lesions.

Methods A total of 1000 consecutive patients were examined by coronary angiography. We analyzed the characteristics of coronary plaques in patients who developed ACS and those who did not.

Results Of the 1000 patients, 27 patients developed ACS during the follow-up period (2.7%). Compared with 2.3% of the 27 patients who developed ACS, there was no difference in the rate of the 973 patients who did not develop ACS. The mean age of the ACS group was 61.6 ± 10.0 years, and the mean age of the non-ACS group was 61.0 ± 9.9 years ($p = 0.05$). The mean number of plaques per segment was 2.6 ± 0.6 in the ACS group and 2.5 ± 0.6 in the non-ACS group ($p = 0.80$). The mean size of the largest plaque was 3.0 ± 1.6 mm² in the ACS group and 2.8 ± 1.6 mm² in the non-ACS group ($p = 0.44$). The mean size of the largest plaque was 3.0 ± 1.6 mm² in the ACS group and 2.8 ± 1.6 mm² in the non-ACS group ($p = 0.44$).

Conclusions The patients demonstrating positive remodeling, irregular surface, and spotty calcification had a higher risk of future ACS events.

J Am Coll Cardiol 2009;53:646-53.e1-2. doi:10.1016/j.jacc.2009.01.030

Napkin-Ring Sign on Coronary CT Angiography for the Prediction of Acute Coronary Syndrome

Kunihiro Matsuzaki, MD,¹ Shiro Fukuda, MD,¹ Atsushi Tanaka, MD,² Hayao Taguchi, MD,² Junichi Yokoyama, MD,² Kuniaki Shimada, MD,² Mizuo Yoshizawa, MD,² Gozo Tsuboi, and Nishimura, Japan

ORIGINAL INVESTIGATIONS

Plaque Characterization by Coronary Computed Tomography Angiography and the Likelihood of Acute Coronary Events in Mid-Term Follow-Up

Tadamitsu Matsunaga, MD, PhD;¹ Naoto Ito, MD, PhD;¹ Makoto Kondo, MD, PhD;² Yutaka Nagata, MD,² Shinji Kita, MD,² Masaharu Arai, MD, PhD;² Hisashi Takahashi, MD,² Jun-ichi Hosono, MD, PhD;² Atsushi Matsu, MD, PhD

ABSTRACT

BACKGROUND Coronary computed tomography angiography (CTA)-verified positive remodeling and low attenuation plaques are considered independent characteristics of high-risk plaques (HRP) and predict short-term risk of acute myocardial infarction (AMI).

OBJECTIVES The aim of this study was to determine the predictive value of coronary computed tomography angiography (CTA) for future acute coronary events in patients with coronary artery disease.

BACKGROUND Recent studies have reported a close association between coronary CTA and this captherosclerosis.

METHODS The subjects of this prospective study were 895 consecutive coronary CTA examinations and followed for >1 year. The primary event (cardiac death, nonfatal myocardial infarction, or unstable angina presenting with a new or worsened symptom) was defined as a composite of the presence of obstructive plaque, positive remodeling (PR), and the napkin-ring sign. This study examined the relationship between the presence of a ring of high attenuation around certain coronary arteries and the presence of a ring of high attenuation around certain coronary arteries.

RESULTS Of the 12,727 segments, 1,774 plaques were observed, including 130 segments (1.0%), LAF in 107 segments (0.8%), and napkin-ring sign (NRS) in 11 segments (0.1%). The presence of PR was associated with PR or NRS. Thirty-six of the 45 plaques with napkin-ring signs (80%) overlapped with LAF. During the follow-up period, 108 events (12.1%) occurred, including 24 AMI, 28 unstable angina, and 56 cardiac deaths. The hazard ratio (HR) for the presence of PR was 1.41 with a 95% confidence interval (CI) of 1.18–1.64 ($p = 0.001$), and the HR for the presence of a ring of high attenuation around certain coronary arteries was 1.31 with a 95% CI of 1.08–1.54 ($p = 0.001$).

CONCLUSIONS CTA-verified HRP was an independent predictor of ACS. However, the number of HRP was small. We are unable to draw any conclusions from this study.

J Am Coll Cardiol 2009;53:646-53.e1-2. doi:10.1016/j.jacc.2009.01.030

Computed tomographic (CT) angiography is a useful tool for assessing not only coronary artery stenosis (>50%), but also the presence of high-risk coronary plaques (HRP) that are causally related to acute coronary syndromes (ACS). ACS is usually caused by luminal narrowing but are also associated with positive remodeling and/or spotty calcification (PR/SC). The culprit lesions characteristically

denote low attenuation, positive remodeling, and spotty calcification on CT angiography. We identified the characteristics of coronary plaques in patients who developed ACS and those who did not.

From the Department of Radiology and Molecular Diagnoses, University Hospital of Witten/Herdecke, Witten, Germany; the Division of Cardiovascular Medicine, Department of Internal Medicine, University of Wisconsin School of Medicine, Madison, WI, USA; and the Department of Radiology, University of California, San Francisco, San Francisco, CA, USA. This work was funded by grants from the Ministry of Education, Science, Sports and Culture of Japan. Presented at the 61st Annual Meeting of the Japanese Society of Radiology, Tokyo, Japan, October 2008. Presented at the 53rd Annual Meeting of the American College of Cardiology, New Orleans, LA, USA, April 2009.

2009

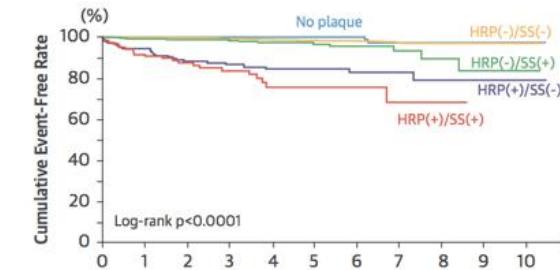
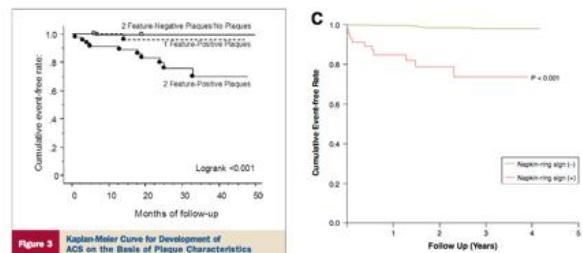
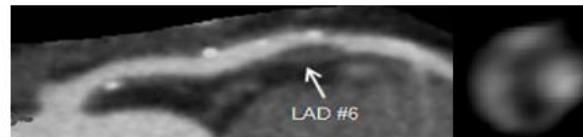
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With the support of the American College of Cardiology Foundation, the National Heart, Lung, and Blood Institute of the National Institutes of Health, the National Institute of Diabetes and Digestive and Kidney Diseases, the National Institute of Child Health and Human Development, the National Institute of Neurological Disorders and Stroke, the National Institute of Allergy and Infectious Diseases, the National Institute of General Medical Sciences, the National Institute of Environmental Health Sciences, the National Institute of Occupational Safety and Health, the National Institute of Biomedical Imaging and Bioengineering, the National Institute of Standards and Technology, and the National Institute of Justice. This work was supported by grants from the Ministry of Education, Science, Sports and Culture of Japan. Presented at the 61st Annual Meeting of the Japanese Society of Radiology, Tokyo, Japan, October 2008. Presented at the 53rd Annual Meeting of the American College of Cardiology, New Orleans, LA, USA, April 2009.

Manuscript received February 20, 2009; revised March 20, 2009; accepted March 20, 2009. © 2009 by the American College of Cardiology Foundation. 0898-2683/\$36.00. doi:10.1016/j.jacc.2009.01.030

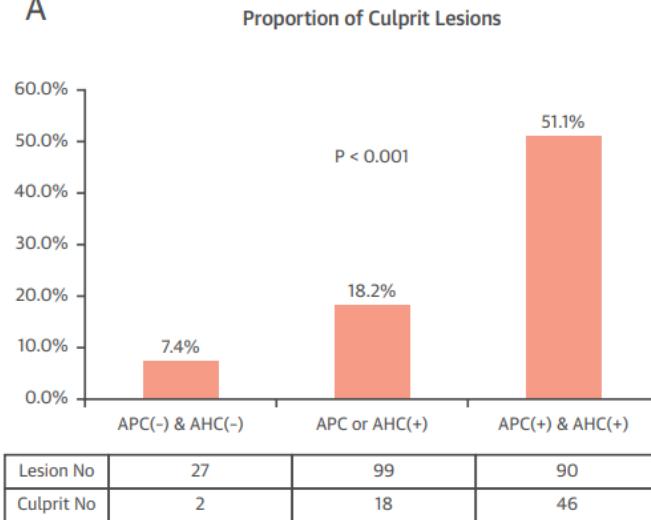
2013

2015

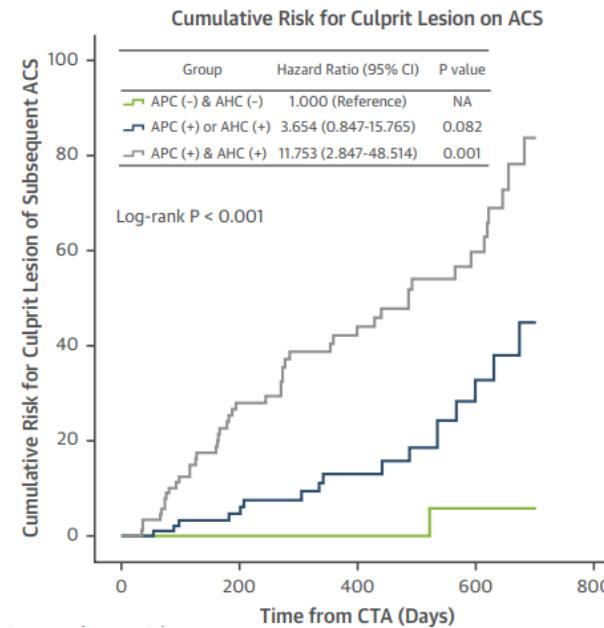


Identification of High Risk Plaques

A



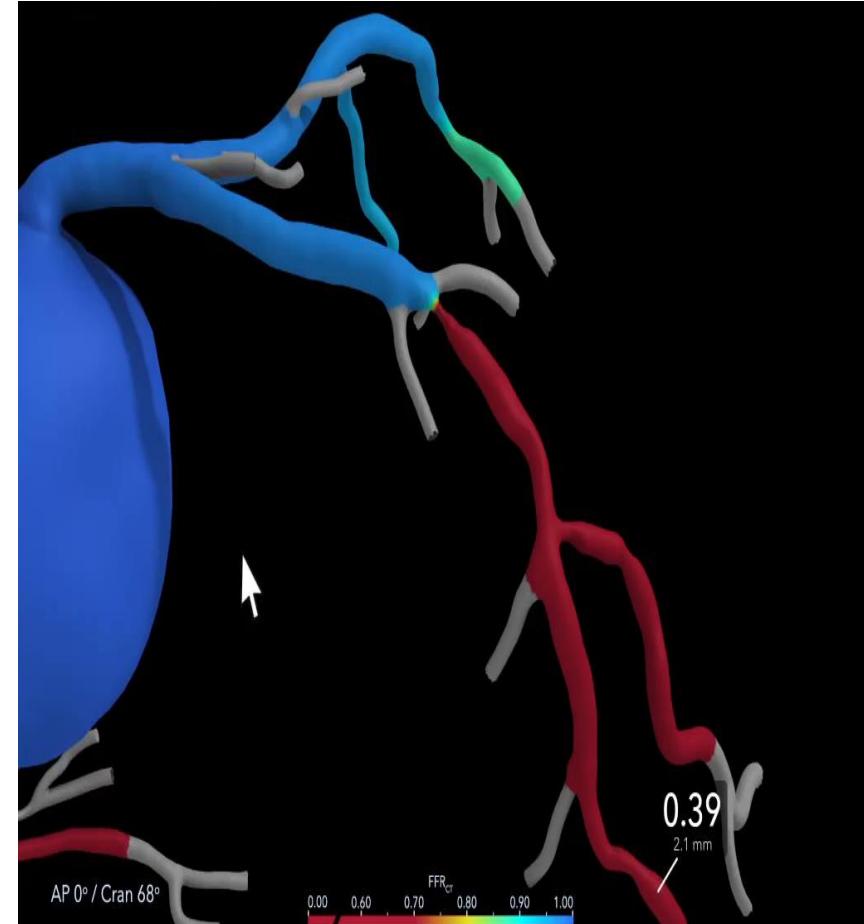
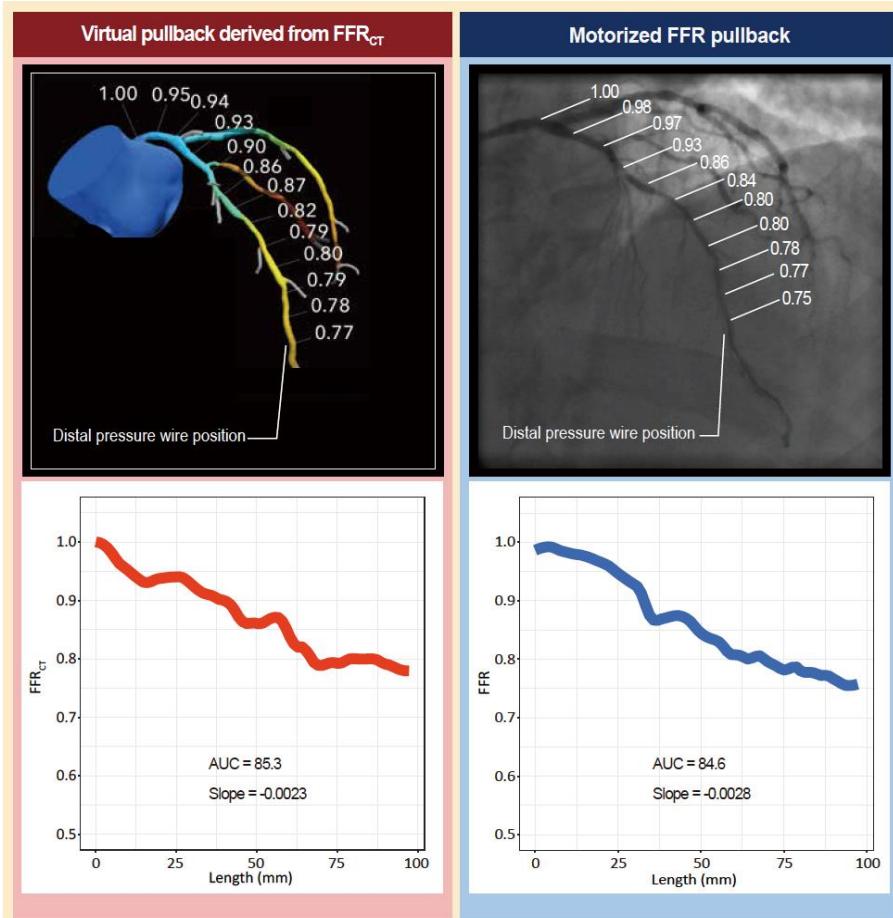
B



Adverse Hemodynamic characteristics (AHC) defined as lesions that have **low FFR_{CT}** (<0.80), high **ΔFFR_{CT} (>0.06)**, high **WSS** (≥ 154.7 dyn/cm 2), or **high axial plaque stress** ($\geq 1,606.6$ dyn/cm 2).

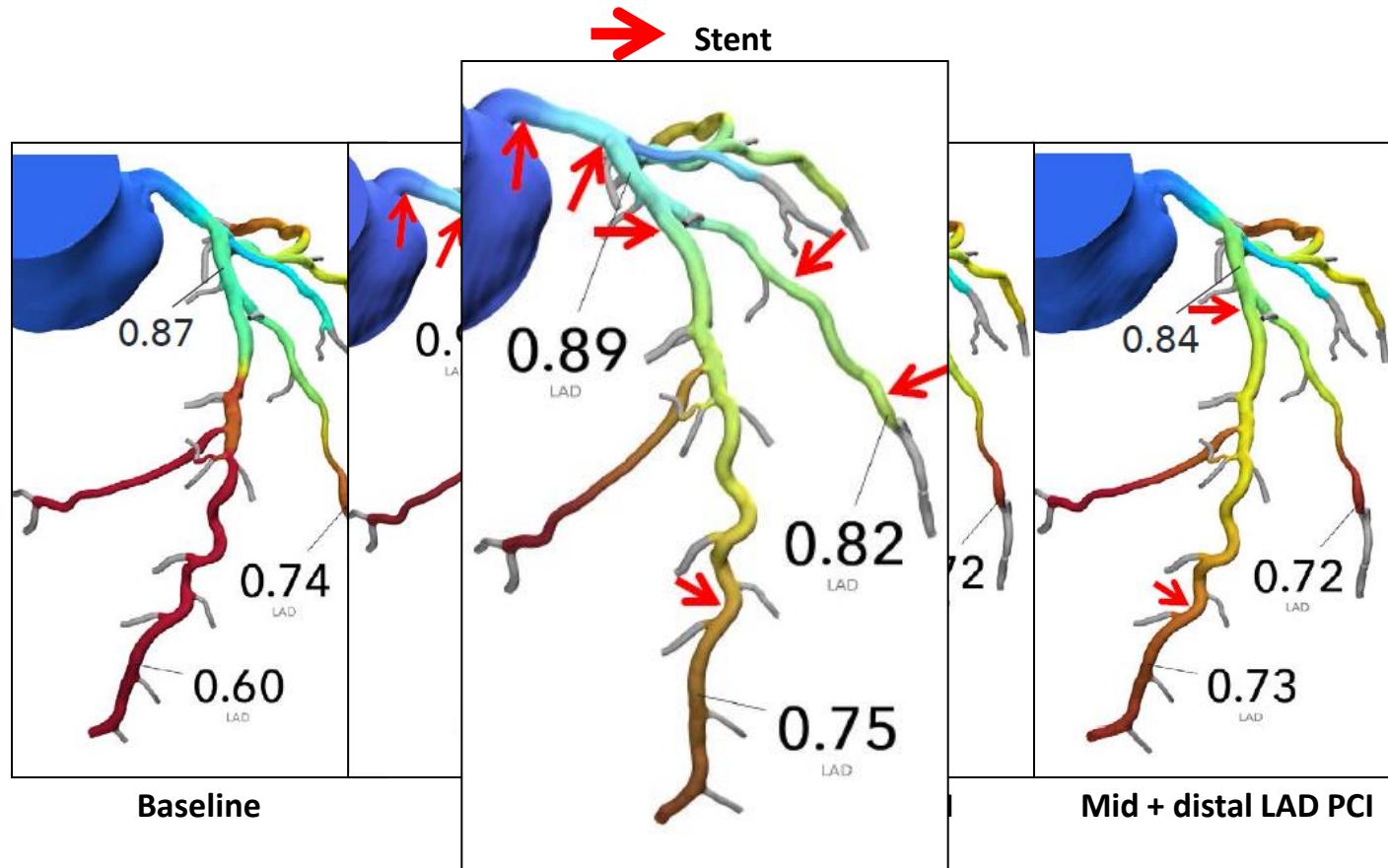
Lee et al. EMERALD trial. JACC Imaging 2018

Treatment planning based on FFR_{CT}



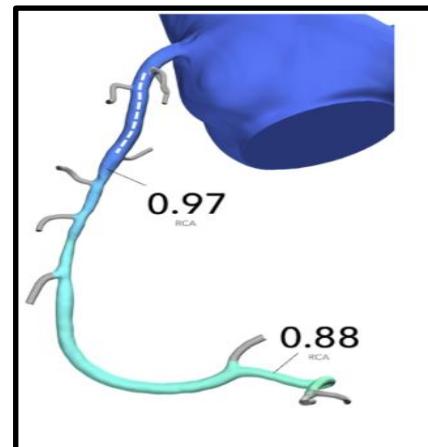
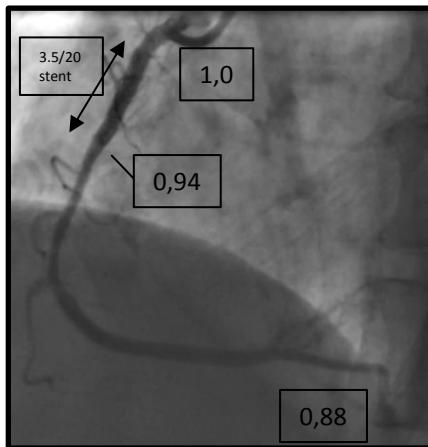
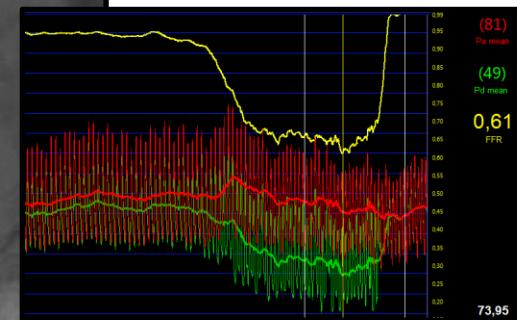
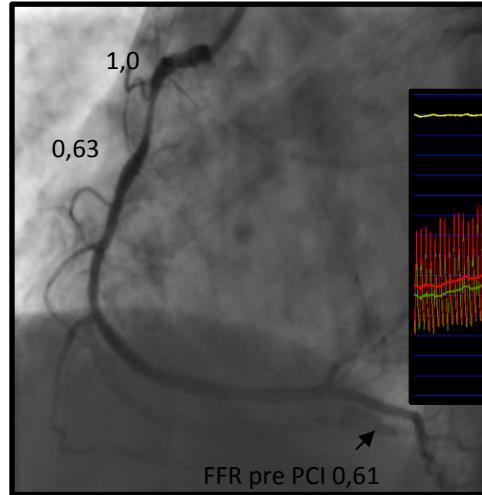
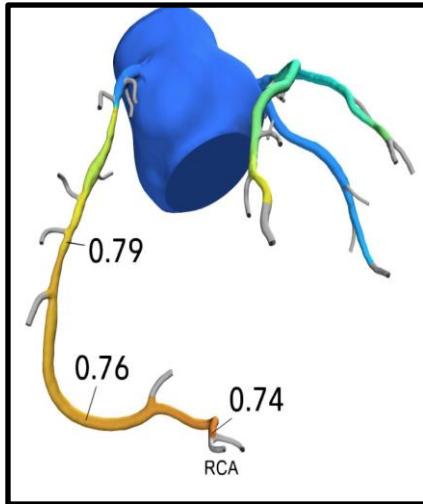
Collet et al. Circulation 2018. Sonck et al. Circ Interv submitted.

HeartFlow Interactive Revascularization Planner



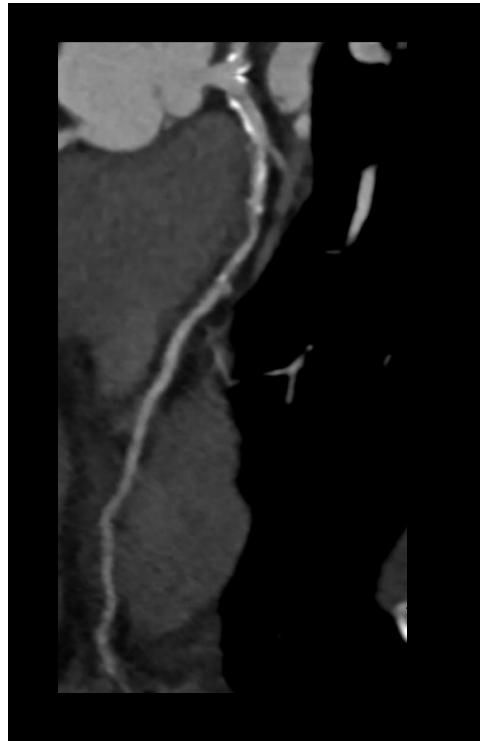
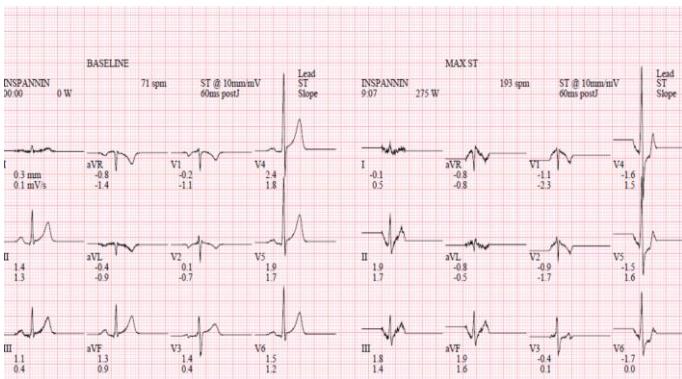
Collet et al. Nature Reviews 2018.

Case 1 Precise PCI Plan Study

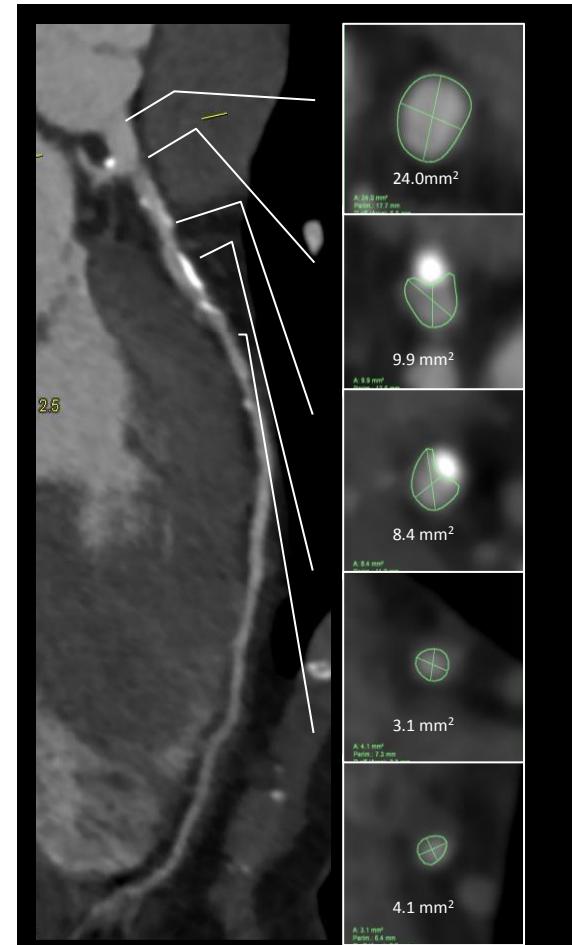


Case 2 Precise PCI Plan Study

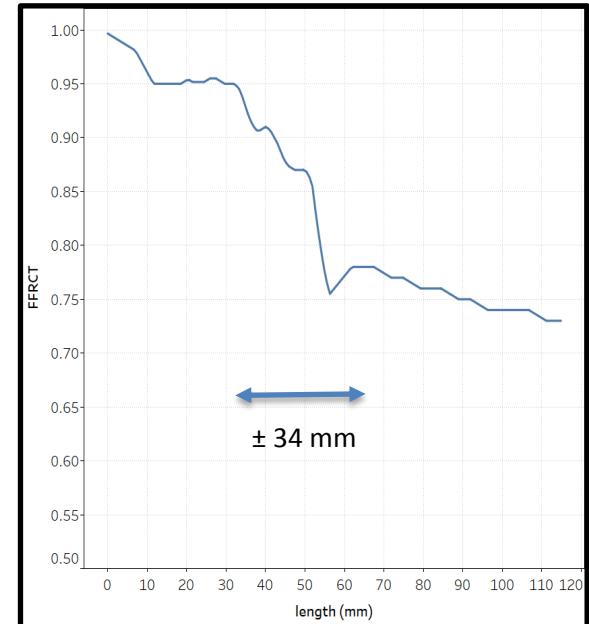
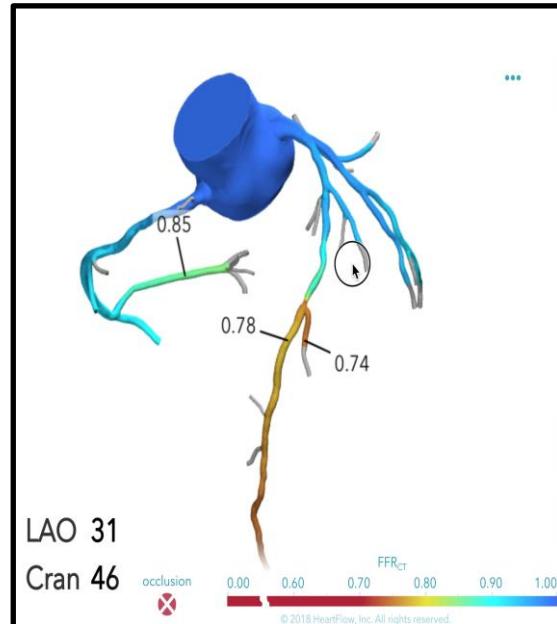
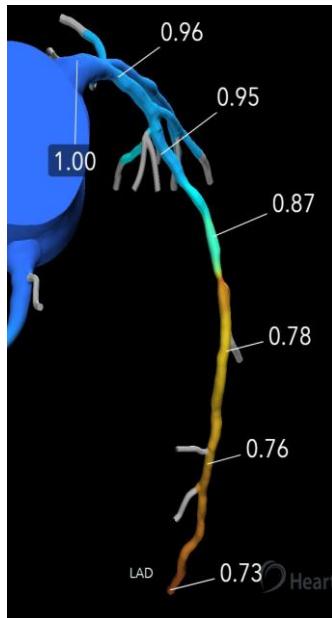
- 40 year old sportive male
- Asymptomatic



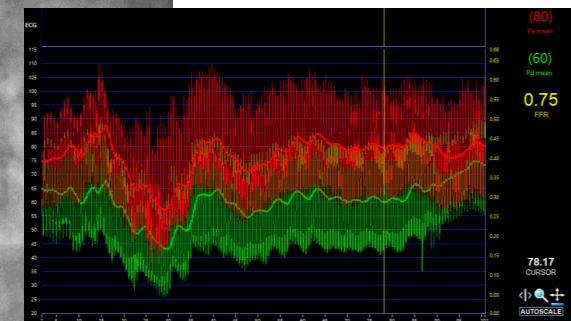
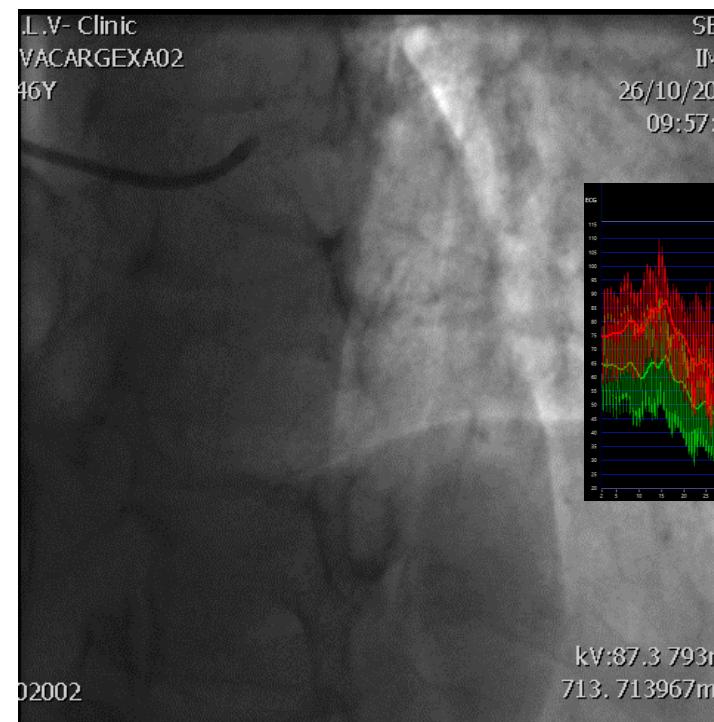
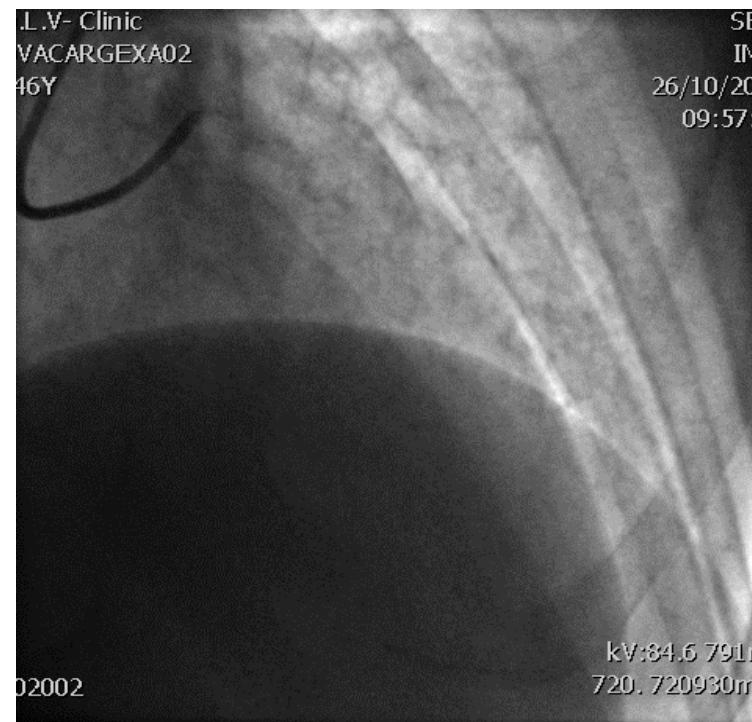
Multiplanar reconstruction (MPR)



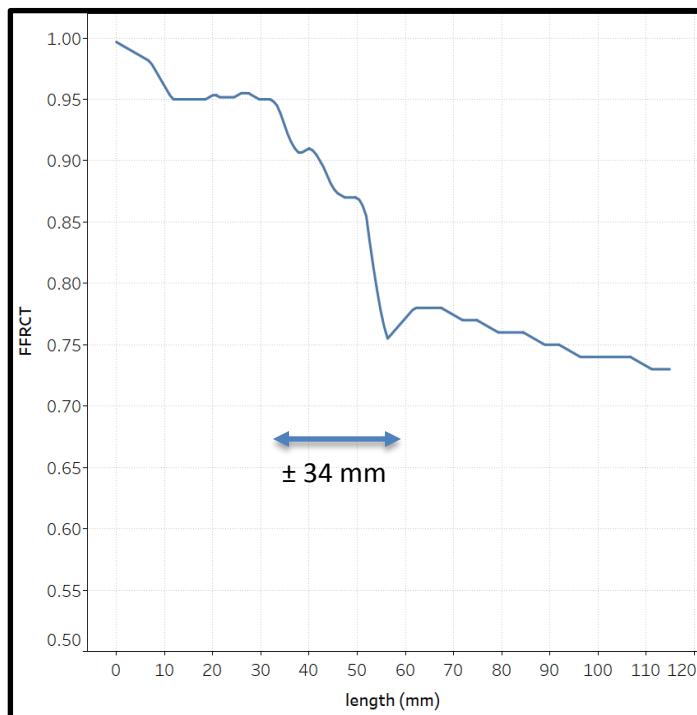
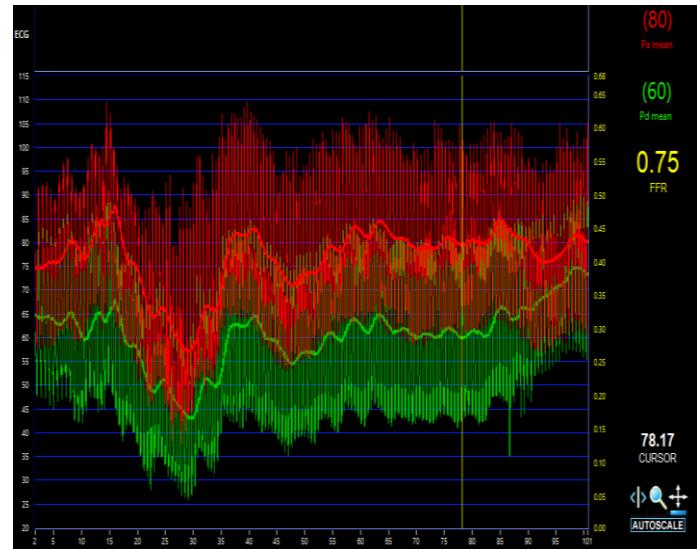
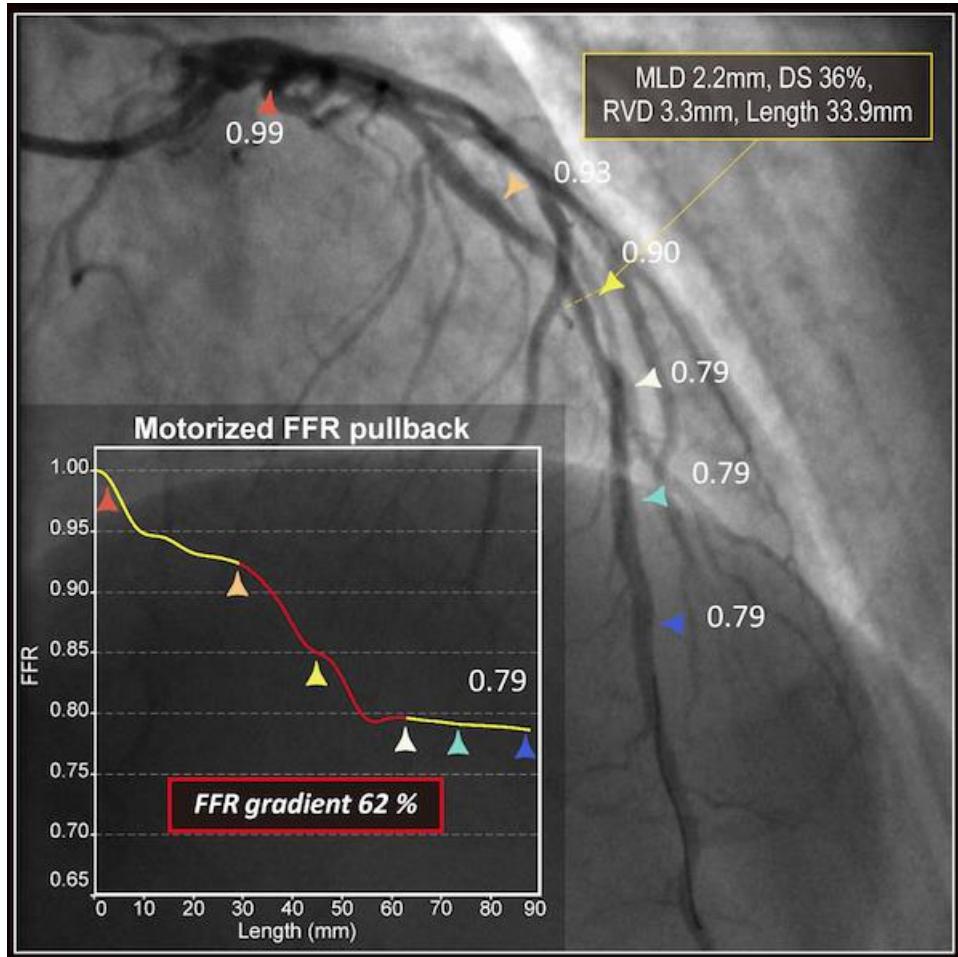
Case 2 Precise PCI Plan Study

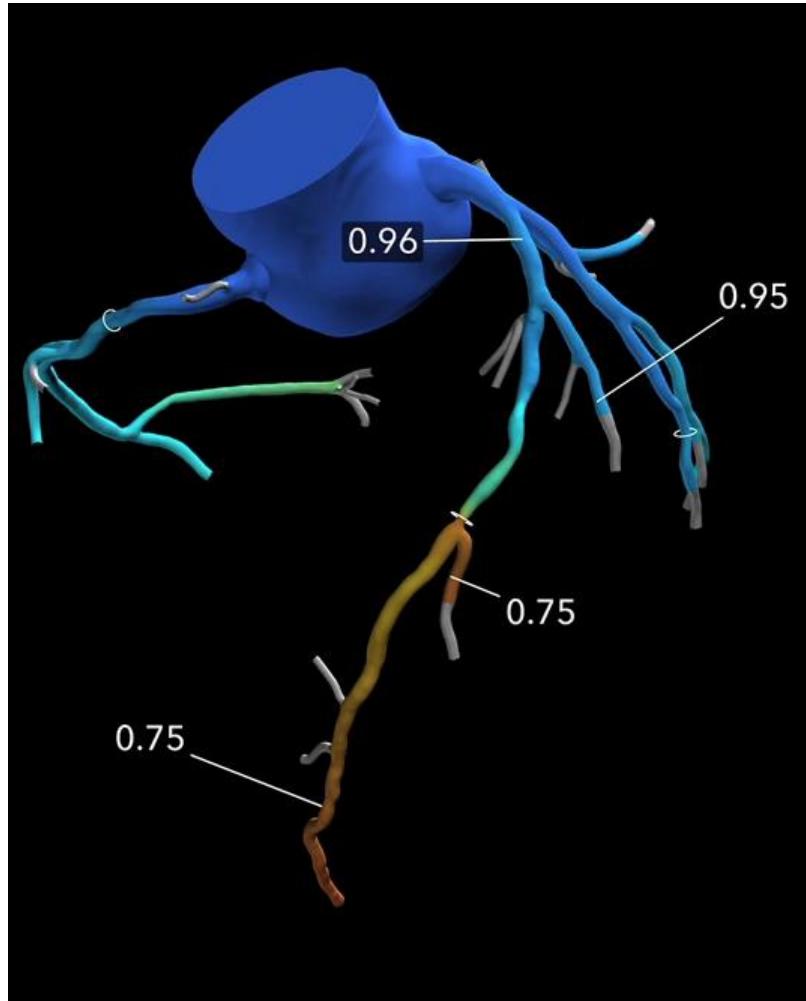


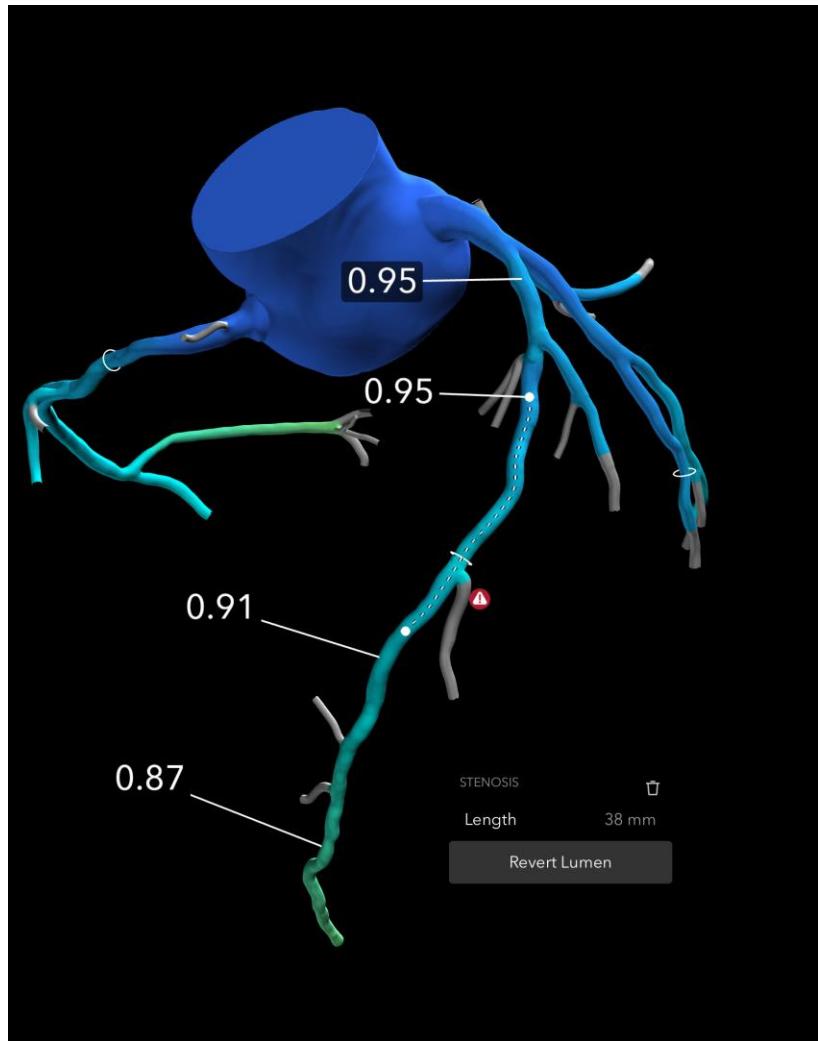
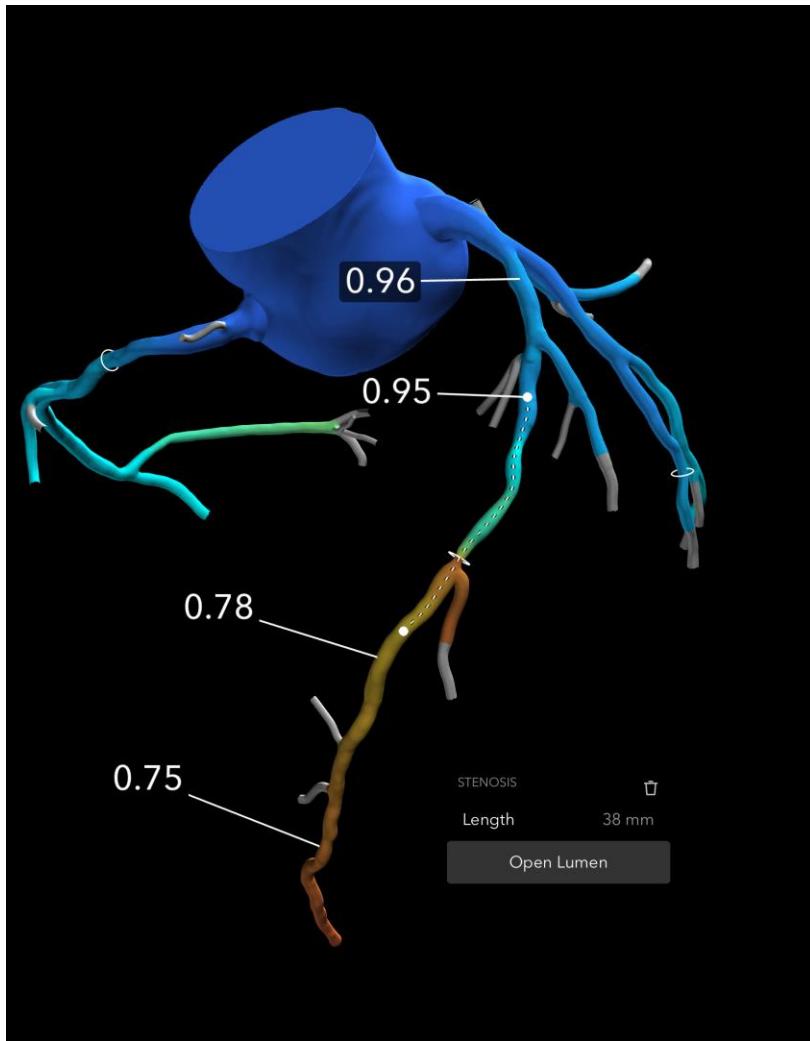
Case 2 Precise PCI Plan Study

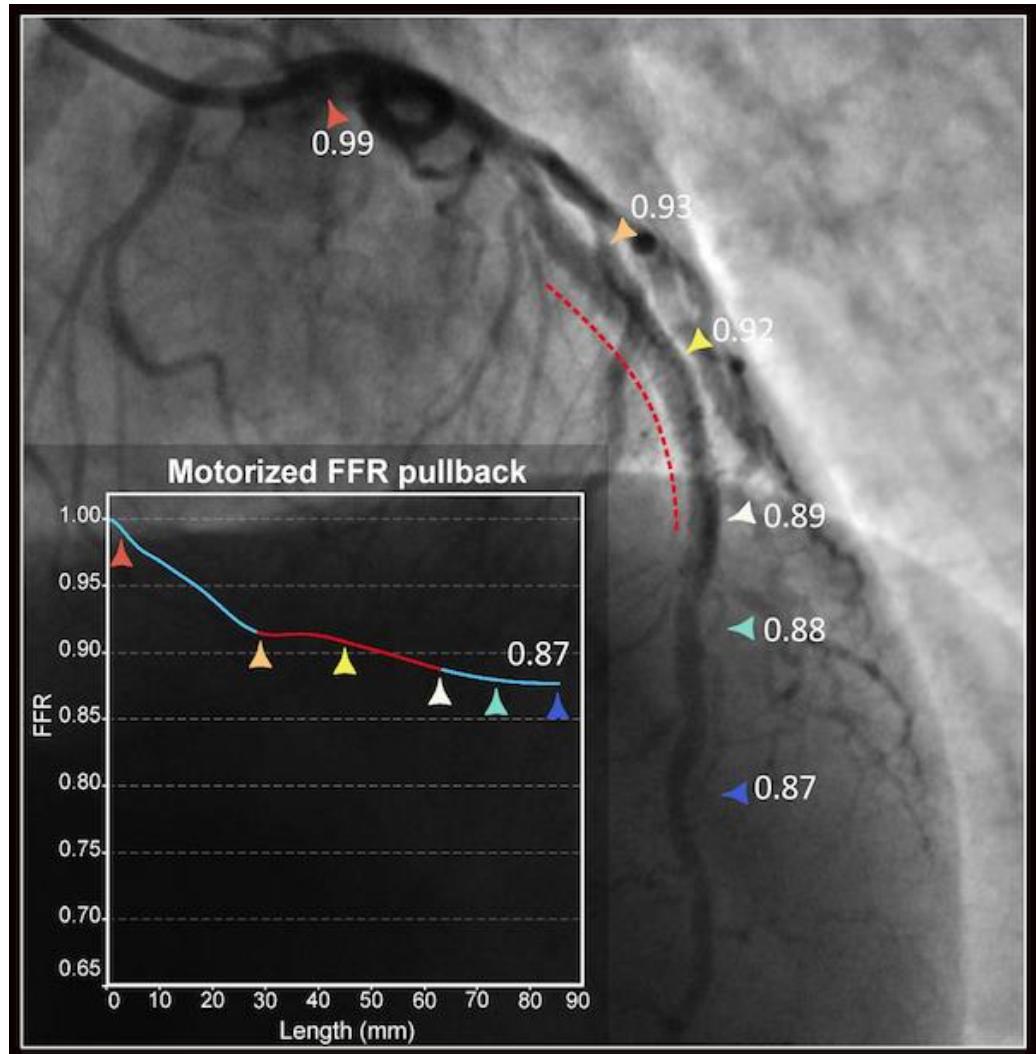
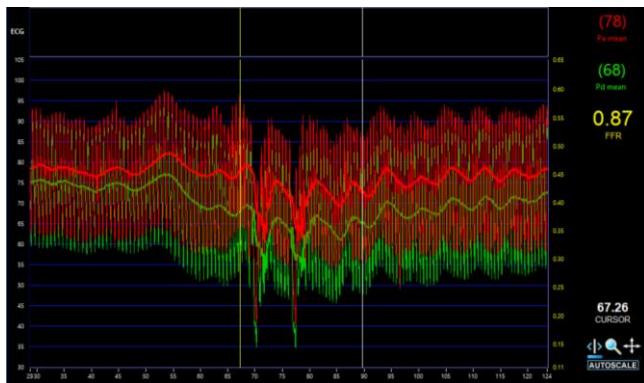
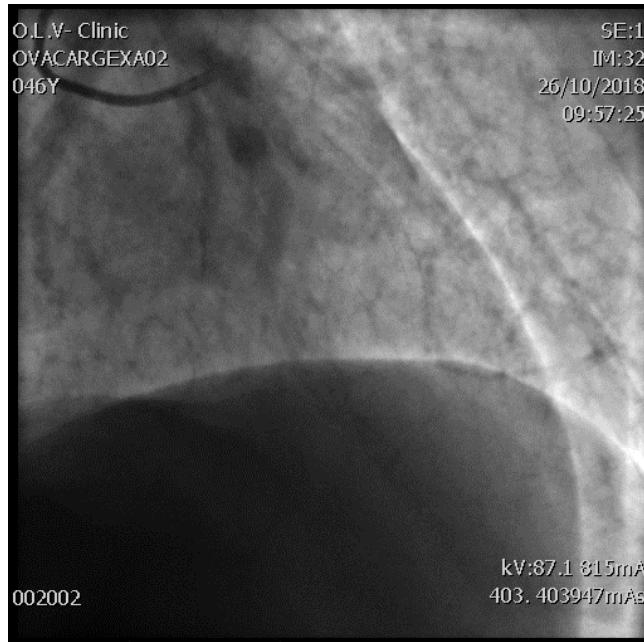


FFR - One distal value

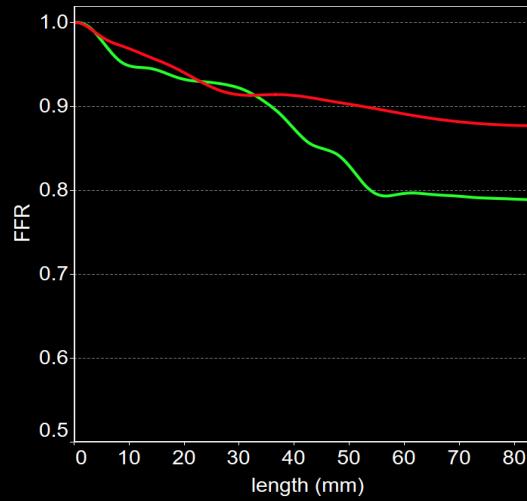




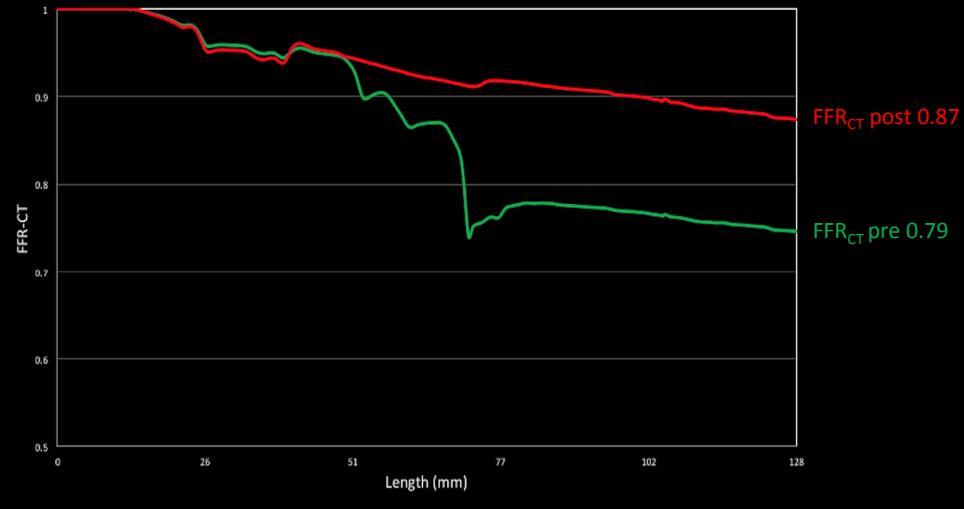




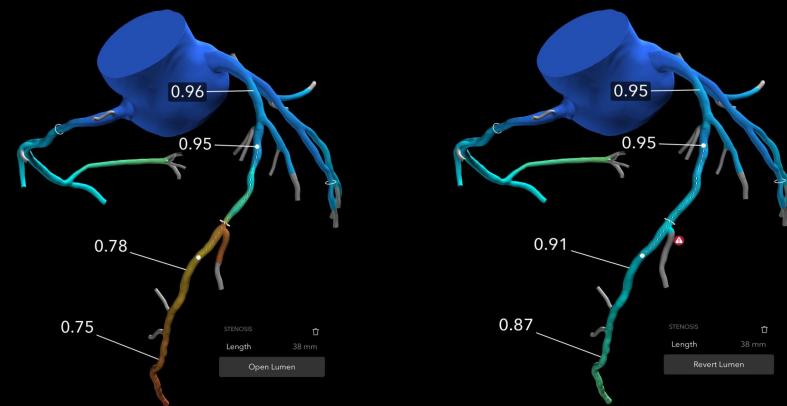
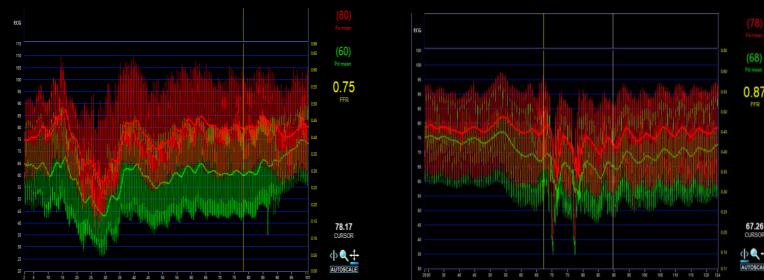
Invasive vs. non-invasive treatment planning



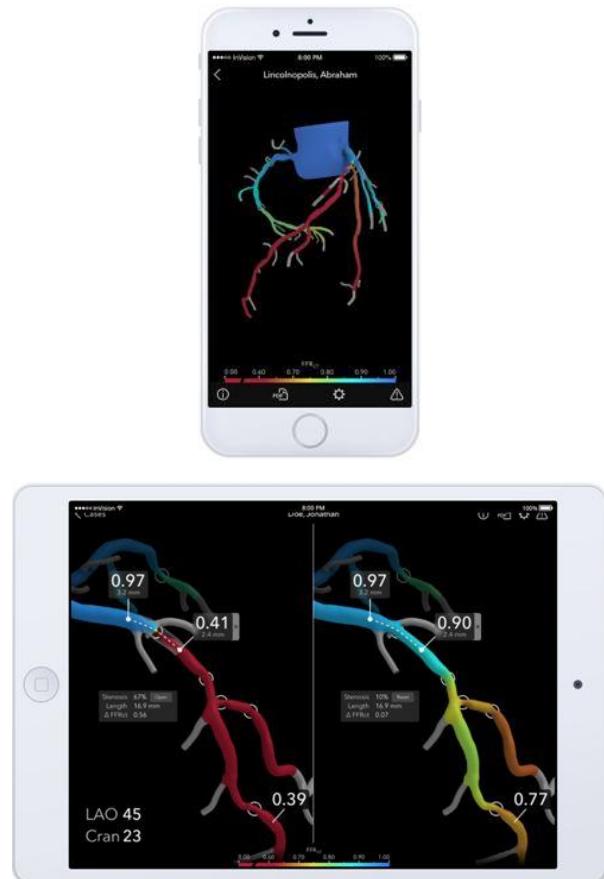
FFR post 0.87
FFR pre 0.79



FFR_{CT} post 0.87
FFR_{CT} pre 0.79



The future of FFR_{CT}: Mobile, On-Demand, Integrated & Interactive





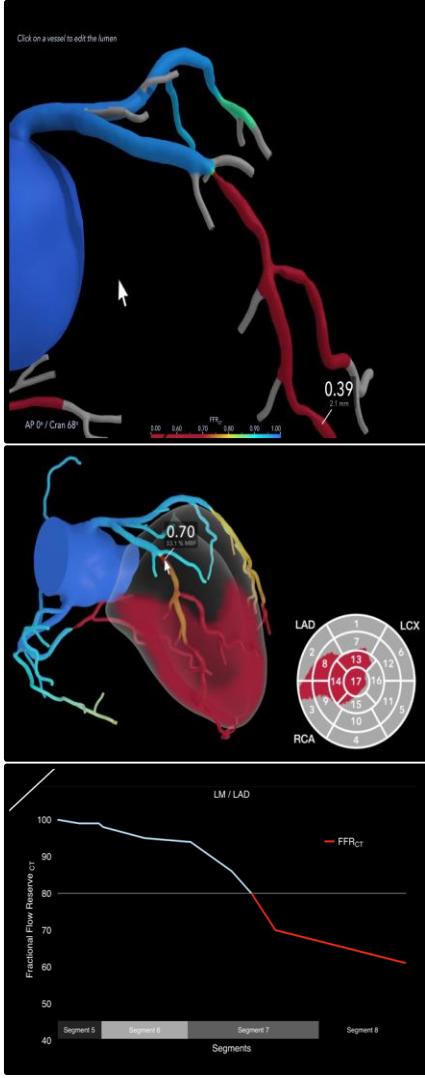
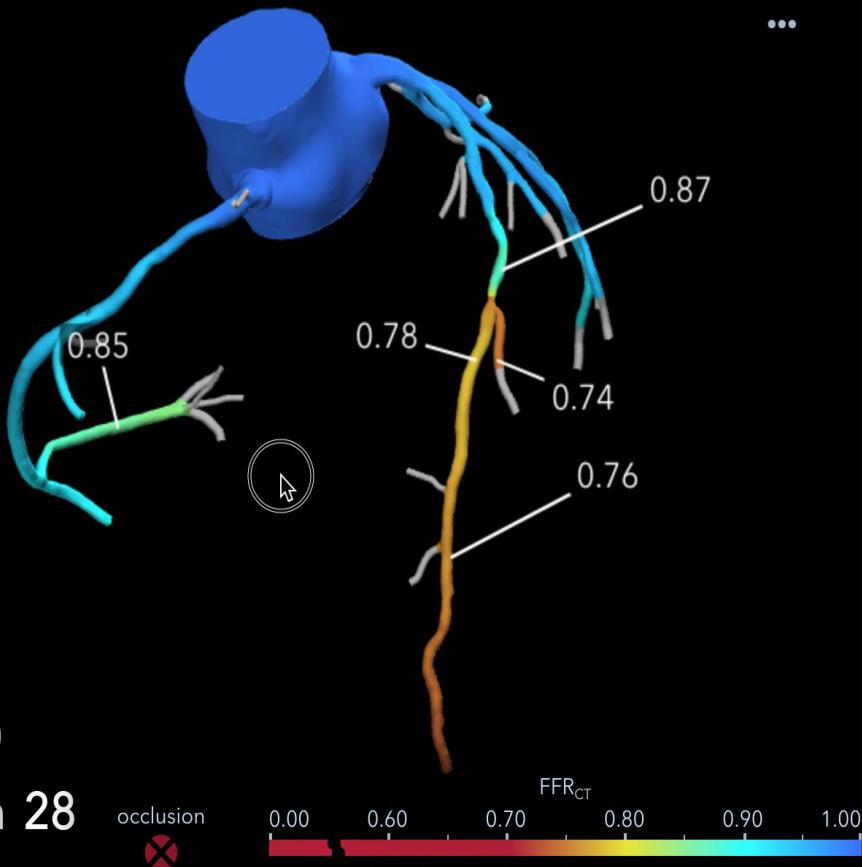
< Cases

Name not provided

AP 0
Cran 28



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Conclusion: FFR_{CT} in the lab of tomorrow

- FFR_{CT} enhances the non-invasive assessment of myocardial ischemia.
- Refine risk stratification with coronary physiology parameters on top of anatomy and known adverse plaque characteristics.
- May allow for decision-making between CABG and PCI and treatment planning in the non-invasive setting.
- Guide which lesions require an invasive assessment in the lab.
- Select the optimal revascularization strategy.
- Improve cathlab efficiency