FFR_{angio} Accuracy vs. STandard FFR:
Results from the *FAST-FFR Trial*

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On Behalf of the FAST-FFR Study Investigators

Disclosure Statement of Financial Interest

Within the past 12 months, I or my spouse/partner have had a financial interest /arrangement or affiliation with the organization(s) listed below

Affiliation/Financial Relationship	Company
Institutional Grant/Research Support:	Abbott, Medtronic, CathWorks,
Consulting Fees/Honoraria:	Boston Scientific
Major Stock Shareholder/Equity Interest:	
Royalty Income:	
Ownership/Founder:	
Salary:	
Intellectual Property Rights:	
Other Financial Benefit:	Stock Options HeartFlow

Background

- **Measuring fractional flow reserve (FFR) with a coronary pressure wire to guide revascularization decisions in the catheterization laboratory has been shown to improve outcomes in a variety of clinical settings and is now included in multiple guideline statements.**

Background

- **FFR utilization, however, remains lower than expected because of a number of potential issues including the extra time it takes, wire handling characteristics, pressure wire drift, the need for hyperemia, and the expense.**
- **For all of these reasons, a technique for deriving FFR without the need of a pressure wire or hyperemic agent would be advantageous and could increase the adoption of physiology-guided revascularization.**

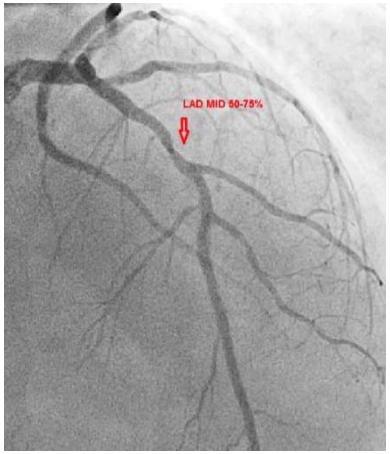
Background

- Coronary angiography-derived FFR (FFR_{angio}) is a new method for measuring FFR without a coronary pressure wire or hyperemic agent.

- FFR_{angio} relies on creating a three-dimensional (3D) reconstruction of the coronary arterial system and estimating the resistance and flow at each point along the entire coronary tree.

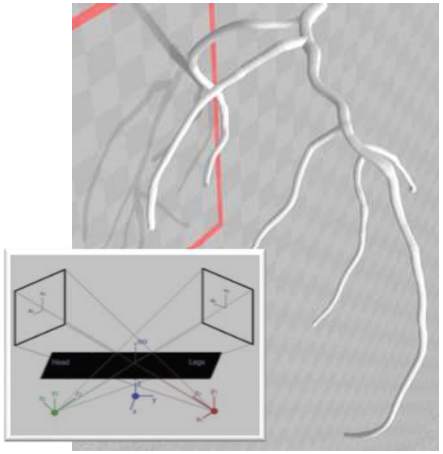
Background

1 Optimal 2D angiography



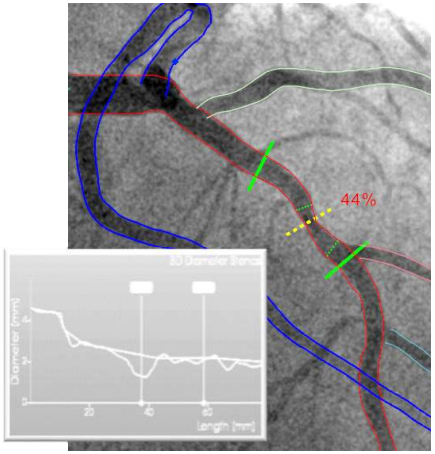
Optimal projections
Optimal frame
Motion compensation

2 3D model reconstruction



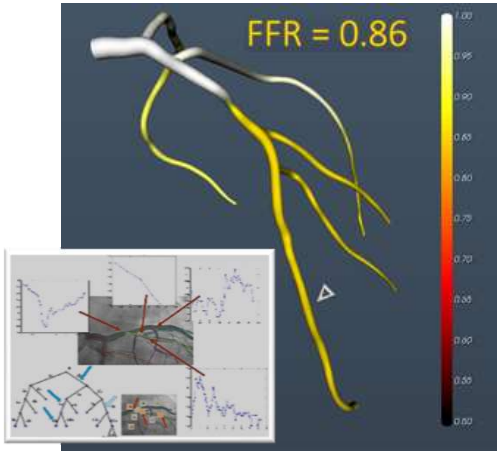
Extracting centerlines
Tree topology

3 Stenosis assessment



Bifurcation analysis
2D-QCA analysis
Estimating diameters

4 Hemodynamic evaluation



Resistance mapping
Maximum blood flow
Flow rate ratio

Background

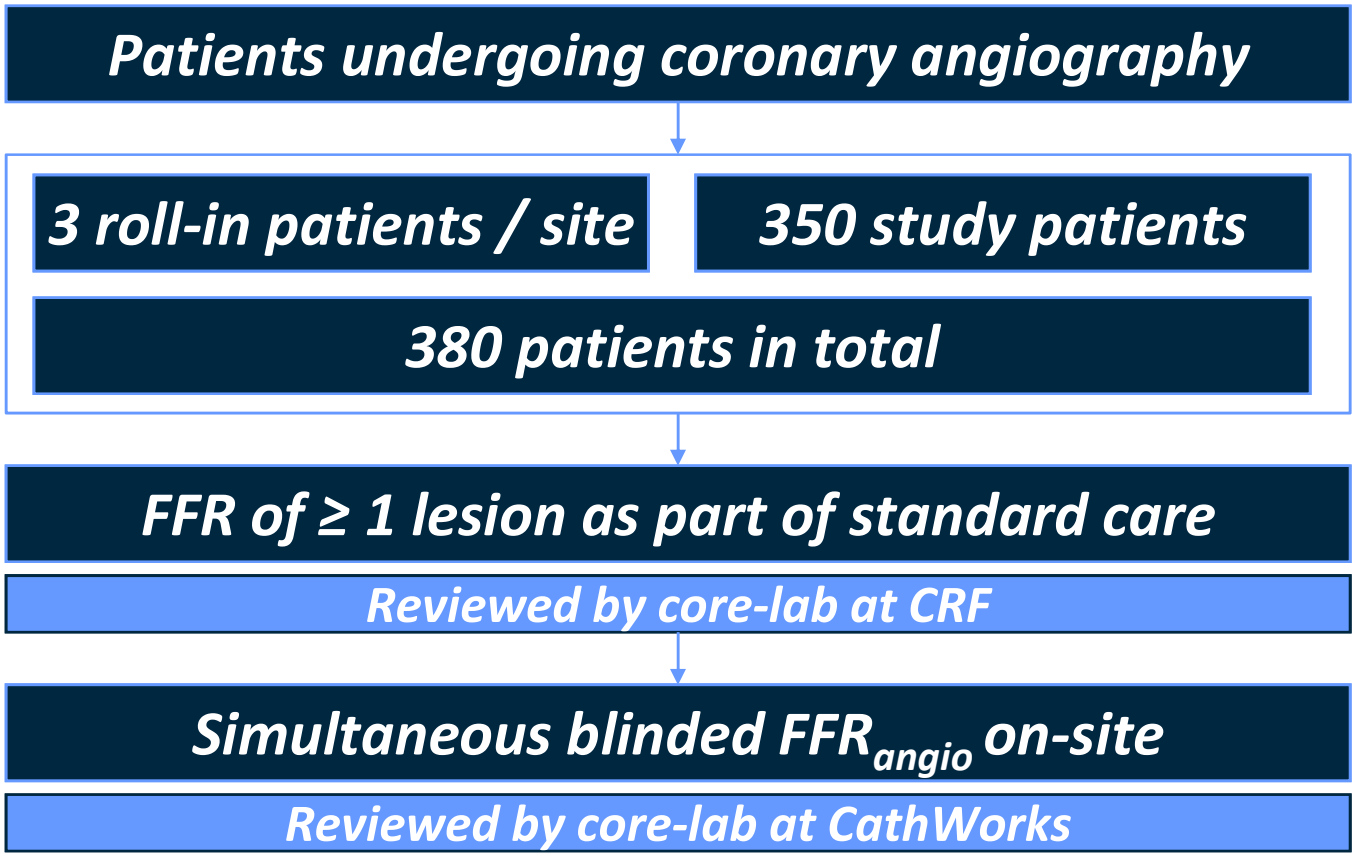
- Preliminary studies have found that FFR_{angio} when measured off-site by experienced operators correlates well with pressure wire-derived FFR.

- FFR_{angio} has not been well validated when performed on-site by independent, local operators blinded to pressure wire-derived FFR and compared with core laboratory analyzed FFR values in a large, prospective, multicenter fashion.

Methods

Objective

- **The FAST-FFR study is a prospective, multicenter, international trial comparing the accuracy of on-site FFR_{angio} with pressure wire-derived FFR.**


Patients undergoing coronary angiography
3 roll-in patients / site
350 study patients
380 patients in total
FFR of ≥ 1 lesion as part of standard care
Reviewed by core-lab at CRF
Simultaneous blinded FFR angio on-site
Reviewed by core-lab at CathWorks

Methods

Inclusion Criteria

- **Adult patients with stable angina, unstable angina, or non-ST elevation acute coronary syndromes undergoing coronary angiography with coronary pressure wire-derived FFR measurement of a coronary stenosis**

Methods

Clinical Exclusion Criteria

- **STEMI within the past 12 months**
- **Prior CABG, valve surgery, or heart transplantation**
- **Severe aortic stenosis**
- **LV Ejection Fraction ≤ 45%**

Methods

Angiographic Exclusion Criteria

- Left main stenosis > 50%
- Chronic total occlusion in target vessel
- < TIMI 3 flow in target vessel
- In-stent restenosis or recent stent placement in target vessel
- Severe diffuse disease
- Target vessel receiving collaterals

Methods

Coronary Angiography

- **Performed at each site per standard of care at a cine frame rate of at least 10 frames/second.**

- **Obtained at different projections (the exact inclination of the C-arm was left to the operator's discretion), with the entire vessel visualized, with adequate contrast opacification, avoiding vessel overlap, and without panning the table or moving the image intensifier.**

Methods

Pressure Wire-Derived FFR

- Any commercially available pressure wire system
- FFR measured in standard fashion with intravenous or intracoronary adenosine or intracoronary papaverine
- Pressure drift checked on pullback. If > ±0.03, the pressure wire was to be re-equalized and FFR was to be remeasured
- FFR tracings were sent to FFR core laboratory for review, blinded to FFR_{angio} values

Methods

FFR_{angio}

- At least 3 DICOM videos of the vessel of interest were transferred immediately to the FFR_{angio} console
- A hospital operator then calculated the FFR_{angio} blinded to the pressure wire-derived FFR
- The FFR_{angio} result was then sent to the core laboratory for review

Methods

Co-Primary Endpoints

- **Sensitivity & Specificity of FFR_{angio} as compared with pressure wire-derived FFR using a cutoff value ≤ 0.80.**

- **Powered to meet the lower bound of the 95% CI for pre-defined performance goals set at:**
  - **Sensitivity = 0.70**
  - **Specificity = 0.75**

Methods

Secondary Endpoints

- **Diagnostic accuracy of FFR_{angio}**
- **Correlation between FFR_{angio} and FFR**
- **FFR_{angio} device success**

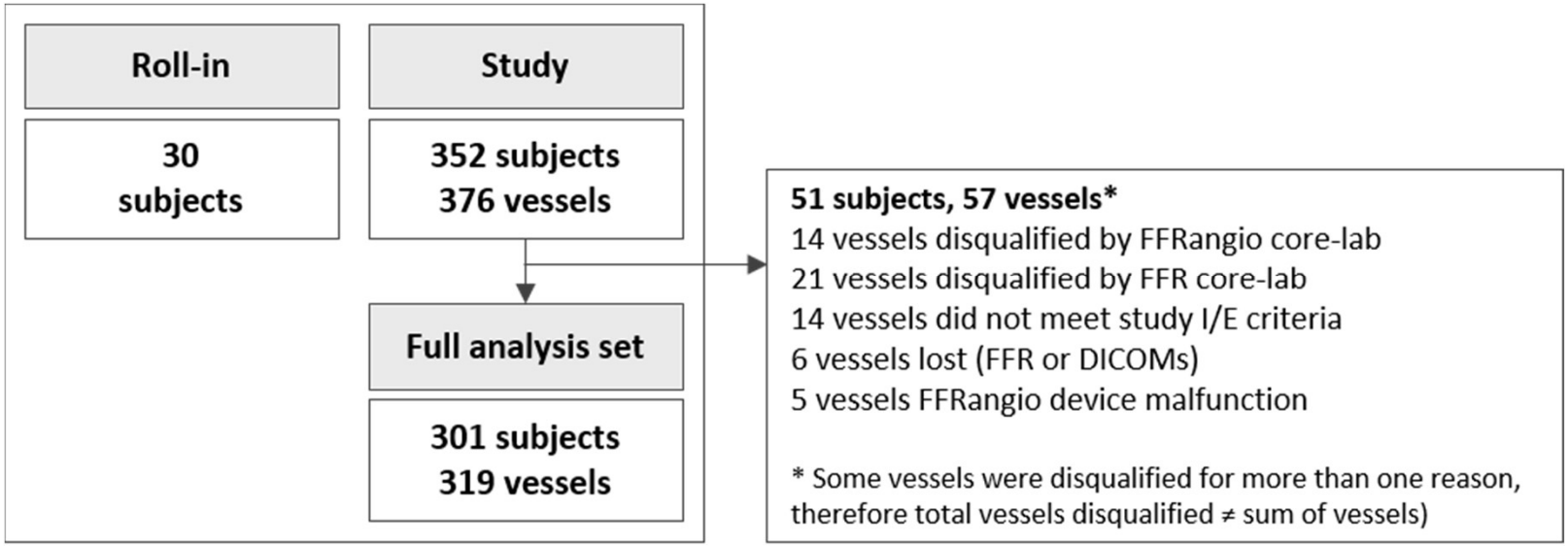
Results

Enrollment by Site

PI	Site	Country	Enrollment
Stephane Achenbach	University of Erlangen	Germany	67
Thomas Engstrom	Rigshospitalet	Denmark	64
Abid Assali	Rabin Medical Center	Israel	59
Allen Jeremias	St. Francis Hospital	United States	56
Stephane Fournier	OLV Aalst	Belgium	33
William Fearon	Stanford University	United States	32
Ajay Kirtane	Columbia University	United States	25
Gabriel Greenberg	HaSharon Medical Center	Israel	19
Rami Jubeh	Shaare Zedek Medical Center	Israel	16
Daniel Kolansky	University of Pennsylvania	United States	11

Results

Subject Flowchart



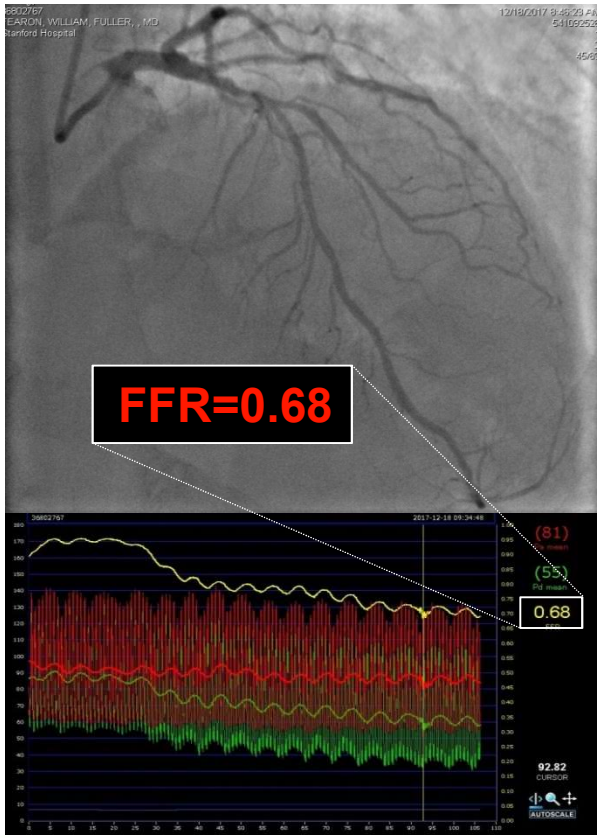
Results

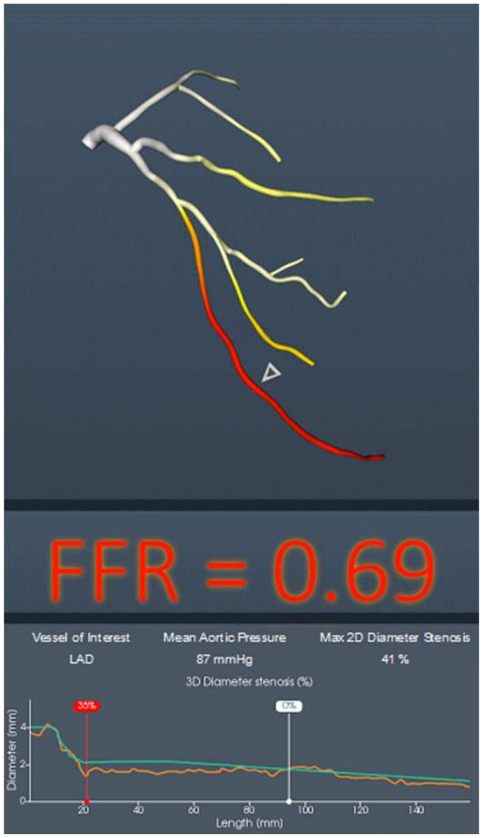
Baseline Characteristic	n=301 patients
Age	64.7 ± (9.7)
Male	74.1%
Body Mass Index (kg/m^2)	28.9 ± (4.8)
Hypertension	69.1%
Hypercholesterolemia	76.4%
Diabetes Mellitus	31.9%
Smoking (current or former)	52.8%
Left Ventricular Ejection Fraction (LVEF)	58 ± (6)%
Family history of coronary artery disease	39.3%
Prior STEMI	3.3%
Prior PCI with stent	29.2%
Presentation	
Acute coronary syndrome (UA or NSTEMI)	41.9%
Stable patients	57.2%

Results

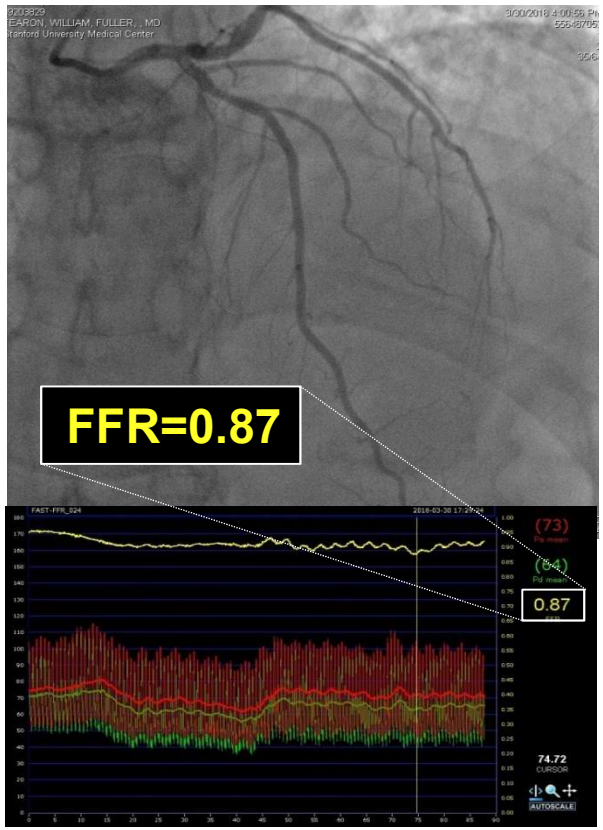
Angiographic Result	n=319 vessels
Lesions per patient	1.1 ±0.3
Target Vessel	
LAD	54.2%
RCA	24.1%
LCX	19.1%
Ramus	2.5%
% Diameter Stenosis (Visual)	63 ±17%
% Diameter Stenosis (QCA)	51 ±10%
Lesion and Vessel Characteristics	
Bifurcation	17.3%
Moderate/Severe Tortuosity	5.5%
Moderate/Severe Calcification	19.9%
Lesion Class B or C	88.8%

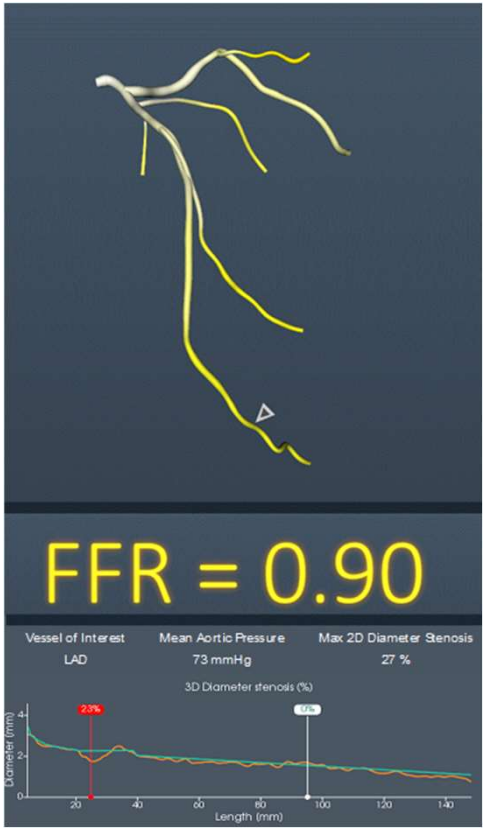
FFR and FFR_{angio} Case Example





FFR and FFR_{angio} Case Example





Results

FFR and FFR_{angio} Results

Physiologic Result	FFR	FFR_{angio}
Mean	0.81 ± (0.13)	0.80 ± (0.12)
Median	0.83 (0.74, 0.90)	0.82 (0.73, 0.89)
% of positive lesions (≤ 0.80)	43.3%	45.5%
% within 0.70-0.90	58.9%	63.6%
% within 0.75-0.85	31.3%	31.0%

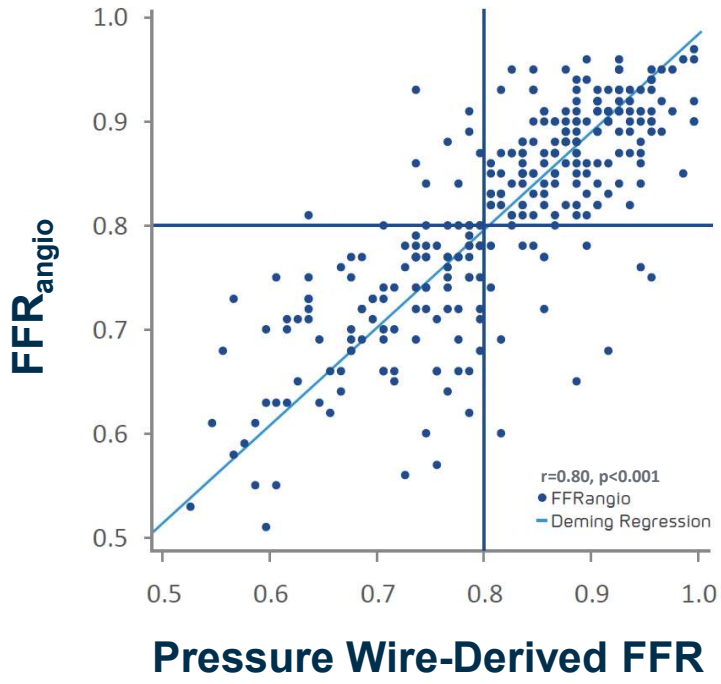
FFR_{angio} was successfully measured in 98.7% of cases

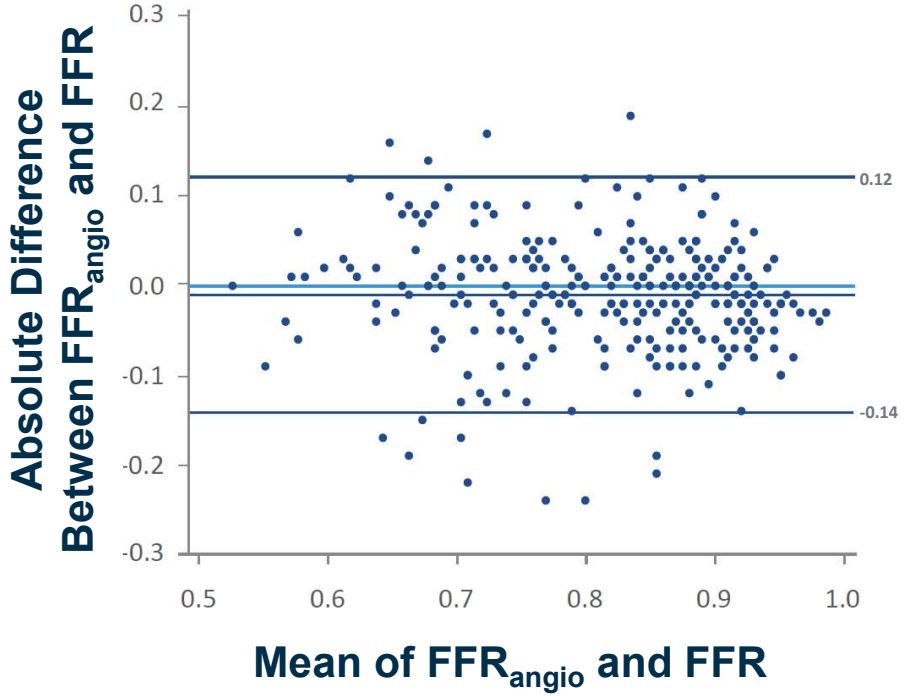
Results

Primary and Secondary Endpoints

Results

Correlation and Bland Altman Plot





Results

Characteristic	Concordant (N = 277)	Discordant (N = 24)	P value
Age	64.7 ± (9.7)	64.6 ± (9.8)	0.52
Male	74.1%	73.3%	0.28
Body Mass Index (kg/m^2)	28.9 ± (4.8)	28.8 ± (4.9)	0.07
Hypertension	69.1%	69.0%	0.85
Hypercholesterolemia	76.4%	76.5%	0.87
Diabetes Mellitus	31.9%	32.1%	0.77
Smoking (current or former)	52.8%	53.4%	0.48
Left Ventricular Ejection Fraction (LVEF)	58 ± (6)%	58 ± (6)%	0.99
Family history of coronary artery disease	39.3%	39.9%	0.53
Presentation			
Acute coronary syndrome (UA or NSTEMI)	41.5%	45.8%	0.68
Stable patients	44.8%	33.3%	0.28

Results

Characteristic	Concordant (N = 297)	Discordant (N = 25)	P value
Target vessel			
LAD	55.9%	32.0%	0.03
RCA	22.6%	40.0%	0.04
LCX	19.5%	20.0%	0.14
Ramus	2.0%	8.0%	0.09
% Diameter Stenosis (Visual estimation)	63 ± (17)	63 ± (9.8)	0.88
Mean FFR	0.80 ± (0.13)	0.83 ± (0.07)	0.16
FFR ≤ 0.80	43.9%	36.0%	0.42
Mean FFRangio	0.80 ± (0.12)	0.79 ± (0.08)	0.52
FFRangio ≤ 0.80	43.9%	64.0%	0.05

Limitations

- We did not specifically assess the time it takes to calculate FFR_{angio} in comparison to pressure wire-derived FFR.

- Some important patient subsets including left main disease, low ejection fraction and in-stent restenosis were not included and will require further study.

Summary

- FFR derived from routine coronary angiography (FFR_{angio}) had very high sensitivity, specificity and diagnostic accuracy, all of which were greater than 90% for predicting the reference standard, coronary pressure wire-derived FFR.
- FFR_{angio} and FFR remained highly correlated over the entire range of FFR values.
- FFR_{angio} was successfully measured in almost all cases included.

Conclusion

- **FFR_{angio} may provide an easier and potentially faster method for performing physiology guided assessment of the overall coronary angiogram with similar accuracy to the reference standard, coronary pressure wire-based FFR.**
- **This may translate into a greater percentage of patients undergoing physiologic guidance for revascularization decisions and ultimately improve long-term outcomes.**

Circulation

Accuracy of Fractional Flow Reserve Derived From Coronary Angiography

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