2019 Joint Meeting of Coronary Revascularization

Visualization of the improvement of myocardial perfusion after coronary intervention using motorized fractional flow reserve pullback curve

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Disclosure of Conflicts of Interest

I have no actual or potential conflict of interest in relation to this presentation.

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FFR Supported by New PCI Guidelines

Title	Recommendations
2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions[25]	• FFR is reasonable to assess angiographic intermediate coronary lesions (50-70% diameter stenosis) and can be useful for guiding revascularization decisions in patients with stable ischemic heart disease (SIHD). (Class lla, Level of Evidence A).

ACCF/AHA/SCAI
2011

2014 ESC/EACTS Guidelines on myocardial revascularization: the Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). Developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI)[28]	• Deferral of PCI or coronary artery bypass graft in patients with FFR >0.80 appears safe. • FFR measurement is indicated for the assessment of the functional consequences of moderate coronary stenosis. • FFR-guided PCI with medical therapy has been shown to decrease the need for urgent revascularization compared with the best available medical therapy alone

ESC/EACTS
2014

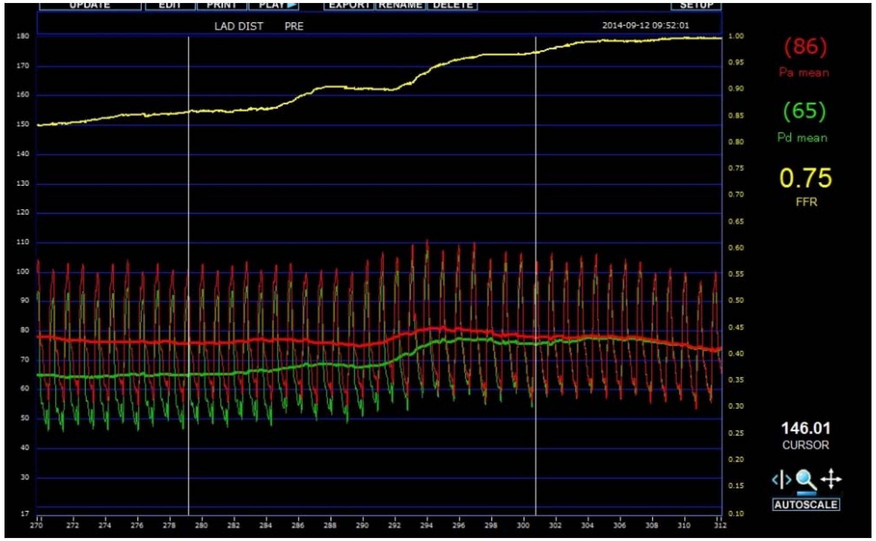
ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS 2016 Appropriate Use Criteria for Coronary Revascularization in Patients With Acute Coronary Syndromes: A Report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, and the Society of Thoracic Surgeons[29]	• In the presence of an asymptomatic intermediate-severity non-culprit artery stenosis, revascularization was rated as "appropriate therapy," provided that the FFR was ≤0.80.

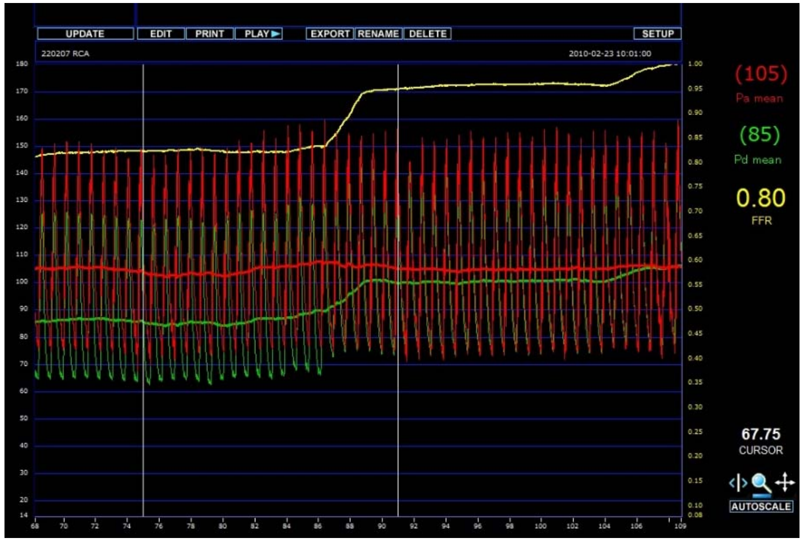
ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS
2016

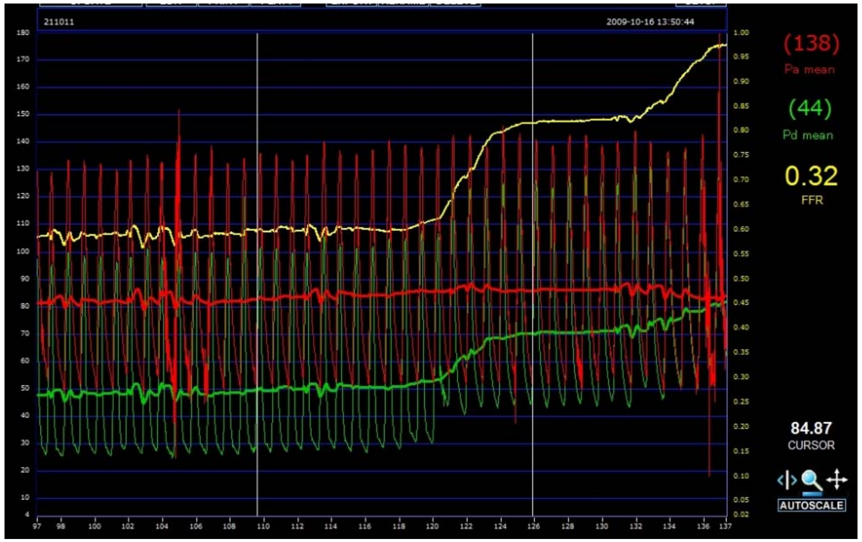
ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS 2017 Appropriate Use Criteria for Coronary Revascularization in Patients With Stable Ischemic Heart Disease: A Report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, and Society of Thoracic Surgeons[27]	• Invasive measurements (such as FFR) may be very helpful in further defining the need for revascularization and may substitute for stress test findings. • FFR ≤0.80 is abnormal and is consistent with downstream inducible ischemia. • Appropriate use criteria advocate for expanded use of intracoronary physiological testing.

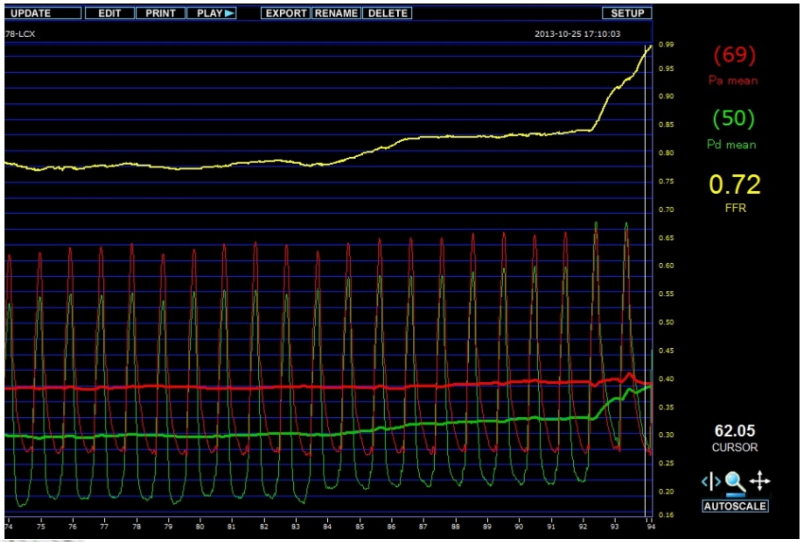
ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS
2017

Importance of pullback pressure tracing for localization









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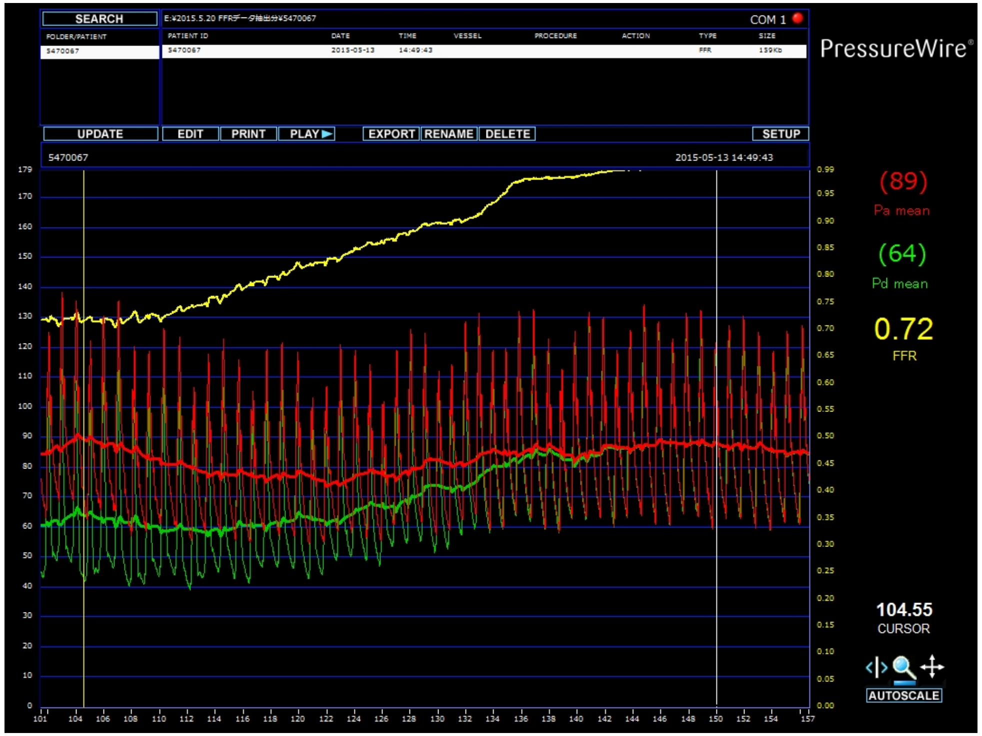
Manual pullback pressure tracing in the LAD with intermediate stenosis



Gradual pattern

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Background

<u>Motorized</u> pullback pressure tracing in the same LAD

Abrupt pattern

Objective

This study aimed to assess the feasibility of motorized pressure-wire pullback in visualizing and quantifying the improvement in FFR following PCI.

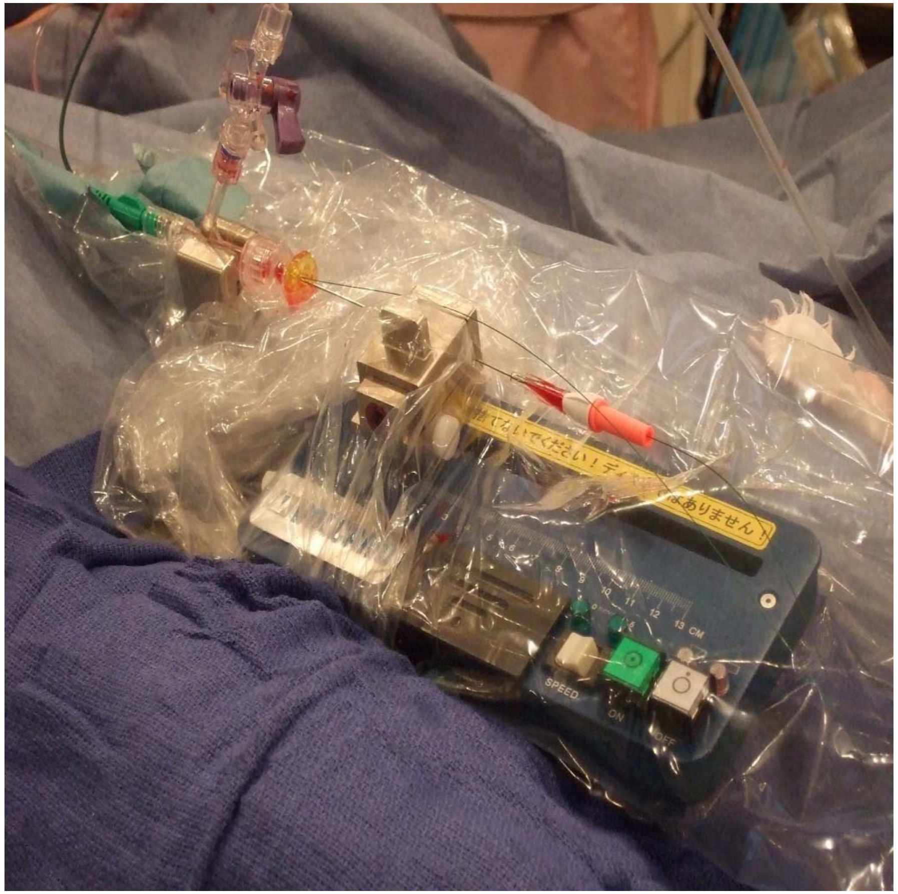
Study population

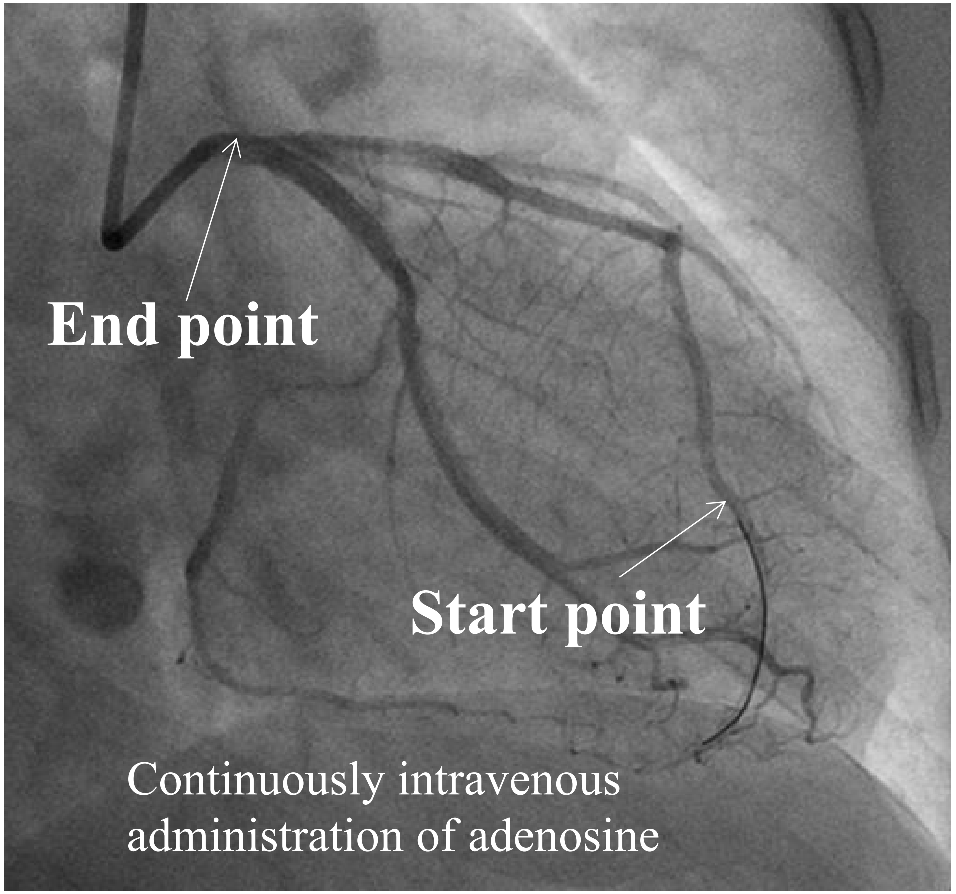
The study included 20 patients with intermediate coronary lesions in the left anterior descending (LAD), who presented with chest pain and had evidence of ischemic changes on an exercise test, single-photon emission computed tomography (SPECT), or ambulatory electrocardiography.

Exclusion.
Patients with shock, totally occlusive lesions, severe tortuous lesions, tandem lesions, multivessel disease, old myocardial infarction (OMI), congestive heart failure, acute coronary syndrome, or those receiving hemodialysis

Methods

Motorized pressure-wire pullback system





Pullback device:R100
(Volcano)

Pressure guidewire: Aeris
(St.Jude Medical)

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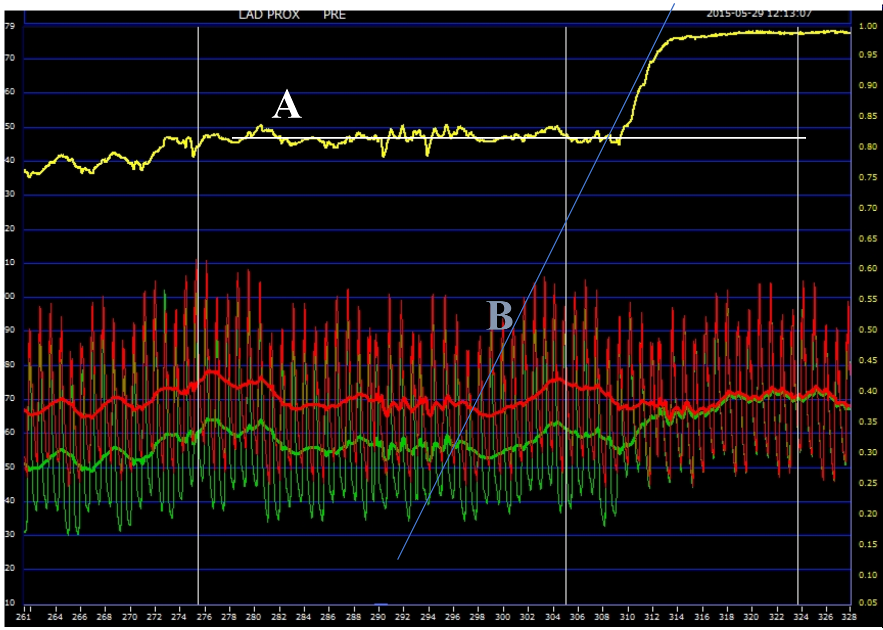
Methods

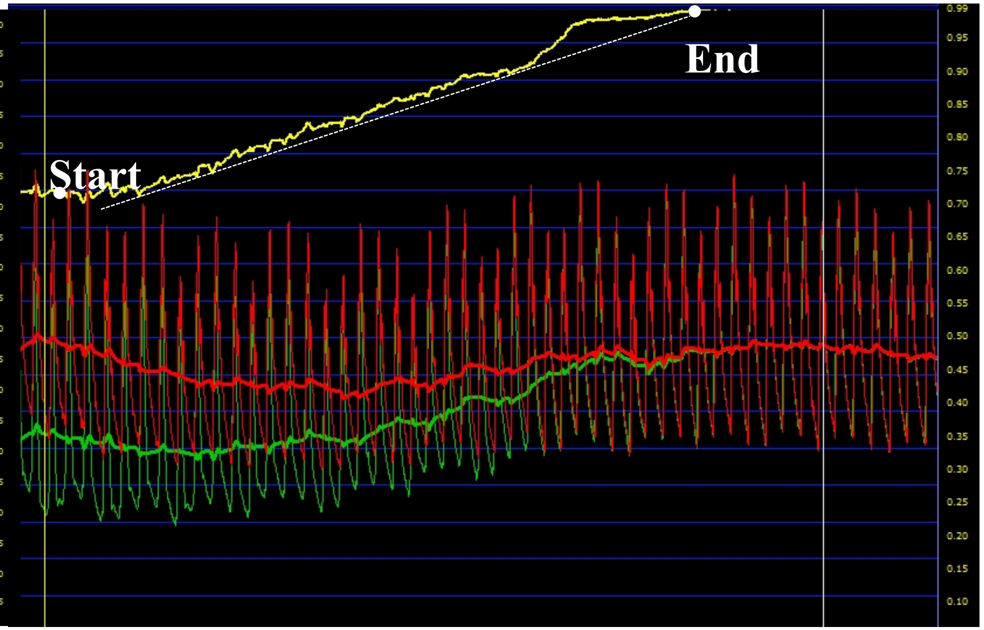
Patterns of pullback pressure tracing

Abrupt pattern



Two different tangential lines:
Line A and line B

Gradual pattern

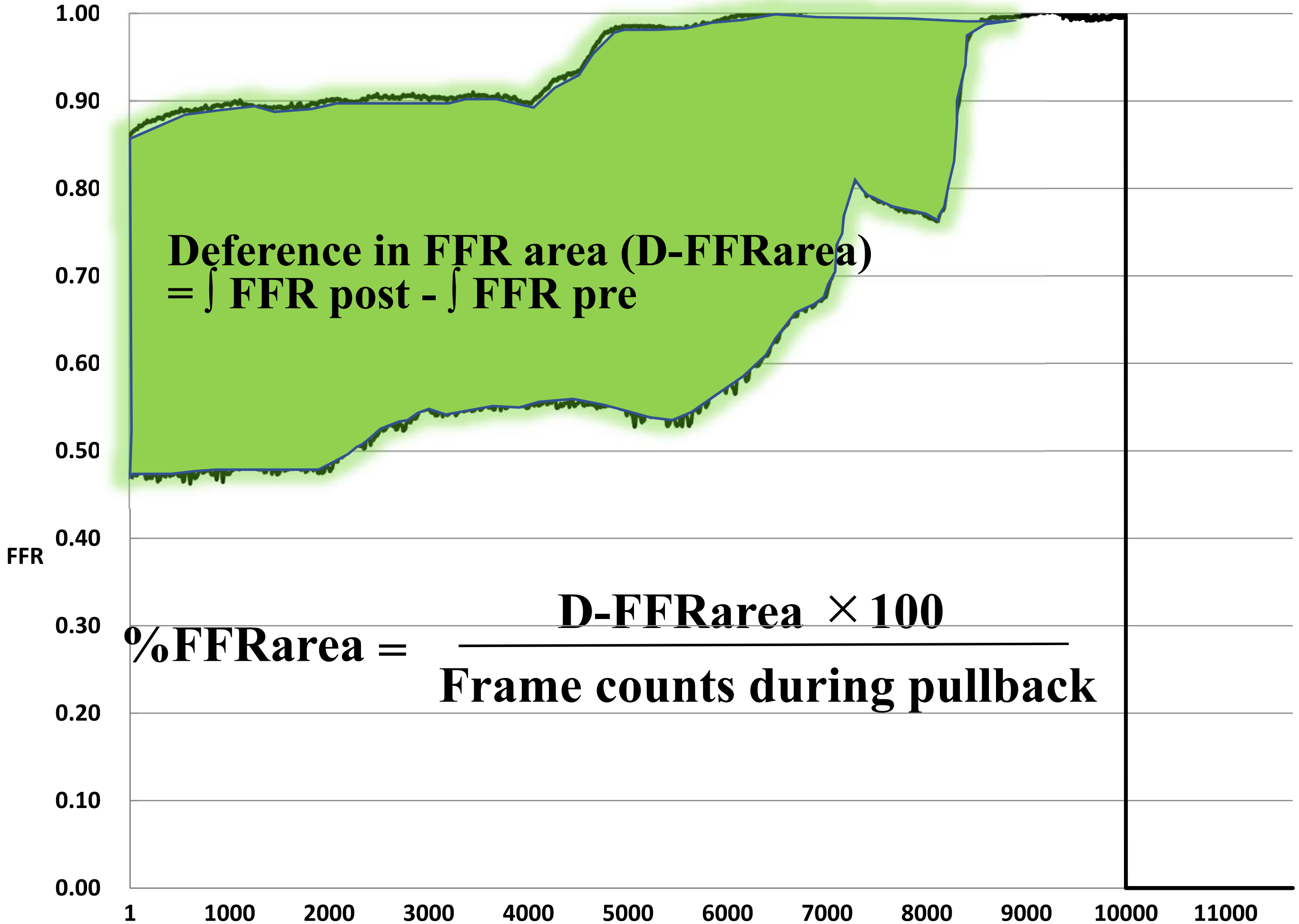


Close to the line passing through the start point and the end point

Methods

Pressure tracing analysis

Definition of the percentage increase in FFR area (%FFRarea)



Results

Baseline characteristics

	Abrupt	Gradual	p
n	13	7	
Age	71.3 ± 12.2	71.9 ± 19.0	0.92
Prior MI, n(%)	5 (38.4)	6(85.7)	0.66
Male	11(84.6)	2(28.6)	0.95
Diabetic mellitus	4 (30.8)	4(57.1)	0.25
Family history	3 (23.0)	2(28.6)	0.79
Dyslipidemia	12(92.3)	3(42.8)	0.95
Hypertension	10(76.9)	4(57.1)	0.36
Smoking	7 (53.8)	7(100.0)	0.10
CKD	5 (38.5)	3(42.8)	1.00

Myocardial infarction, MI; Chronic kidney disease, CKD

Matsuo A.Cardiovasc Interv and Ther 2018

Lesion characteristics

	Abrupt	Gradual	p
proximal lesion n,(%)	12(92.3)	6(85.7)	1.00
Type B2/C	10(76.9)	6(85.7)	1.00
Calcified lesion	4(30.8)	2(28.6)	1.00
RD, mm	2.65 ± 0.41	2.82 ± 0.59	0.43
%DS, (%)	60.15 ± 16.89	53.81 ± 13.32	0.40
MLD, mm	1.07 ± 0.52	1.27 ± 0.32	0.38
Lesion Length	19.02 ± 8.63	25.04 ± 12.59	0.22
Post MLD	2.89 ± 2.48	2.74 ± 0.44	0.85
Post %DS, (%)	14.39 ± 16.75	-2.73 ± 8.43	0.02
Stent diameter, mm	2.93 ± 0.30	2.93 ± 0.34	0.98
Stent length	26.92 ± 13.33	28.57 ± 15.72	0.81
Multiple stenting, n(%)	4(30.8)	4(57.1)	0.50

Post, polst-interventional; RD, reference diameter; MLD, minimal lesion diameter

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Intravascular images parameters

	Abrupt	Gradual	p
Lipid-rich plaque n(%)	8(61.5)	6(85.7)	0.95
Calcified plaque	5(38.5)	1(14.8)	0.39
Plaque rupture	4(30.8)	0(0.0)	0.22
Lesion length, mm	28.34±14.64	27.31±14.97	0.89
Proximal RA, mm^2	6.78±1.81	7.98±14.97	0.32
Distal RA	5.42±1.62	7.98±14.97	0.11
Minimal lumen area	**1.75±0.72**	**2.37±0.49**	**0.06**
Minimal stent area	4.94±1.55	5.61±3.18	0.12

RA, reference lumen area

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Intracoronary pressure parameters

	Abrupt	Gradual	p
Pre- FFR	0.59 ± 0.11	0.74 ± 0.03	< 0.01
Distal Pd/Pa	0.66 ± 0.12	0.78 ± 0.03	0.02
Proximal Pd/Pa	0.94 ± 0.05	0.93 ± 0.07	0.31
Trans lesion FFR gradient	0.29 ± 0.15	0.15 ± 0.05	0.01
Post-FFR	0.81 ± 0.05	0.84 ± 0.02	0.19
ΔFFR in-stent	0.07 ± 0.05	0.05 ± 0.03	0.37
Pd/Pa at the proximal stent edge	0.92 ± 0.0	0.95 ± 0.0	0.46
Pd/Pa at the distal stent edge	0.88 ± 0.05	0.89 ± 0.05	0.91
Frame count	8837.8 ± 1934.2	11234.0 ± 764.5	< 0.01
pre- FFRarea	6554.7 ± 1576.0	9634.0 ± 687.0	< 0.01
post-FFRarea	7987.3 ± 1747.4	10275.5 ± 735.8	< 0.01
%FFRarea	**16.21 ± 8.86**	**5.78 ± 3.90**	**< 0.01**
D-FFR	**0.22 ± 0.10**	**0.10 ± 0.03**	**< 0.01**

(Difference in FFR between pre and postintevention)

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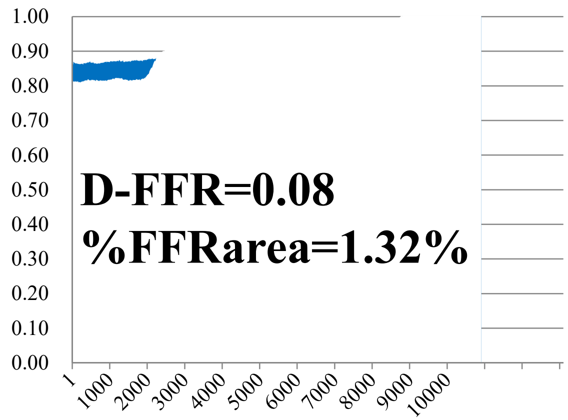
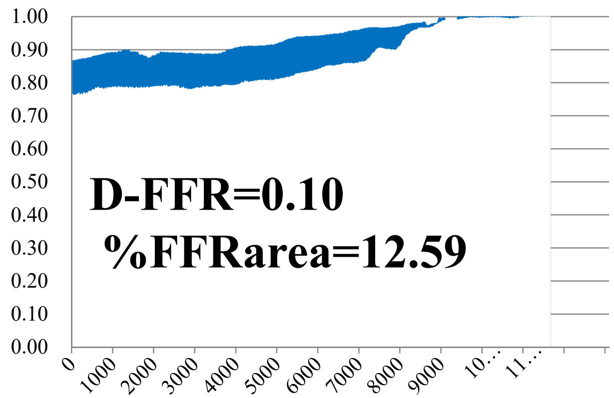
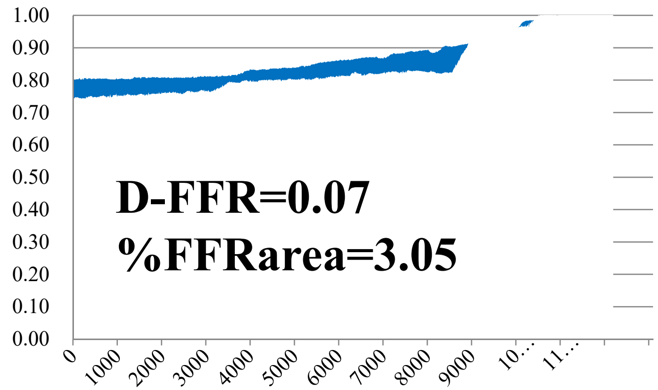
Representative composite graphs of pullback tracing in patients with diffuse and abrupt patterns

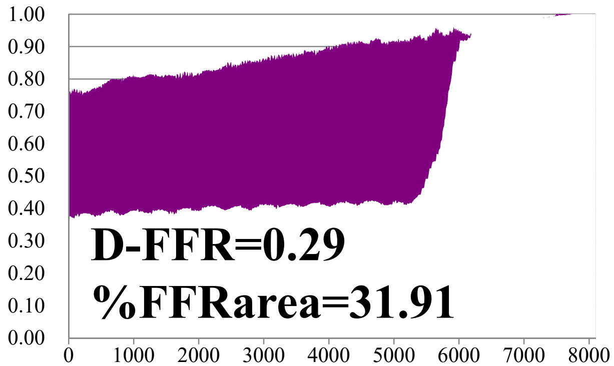
Gradual pattern

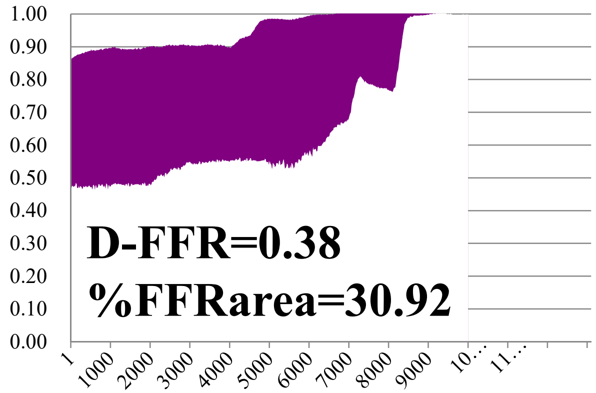


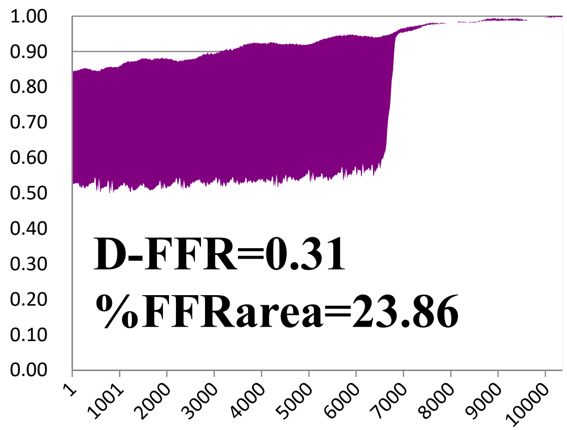




Abrupt pattern







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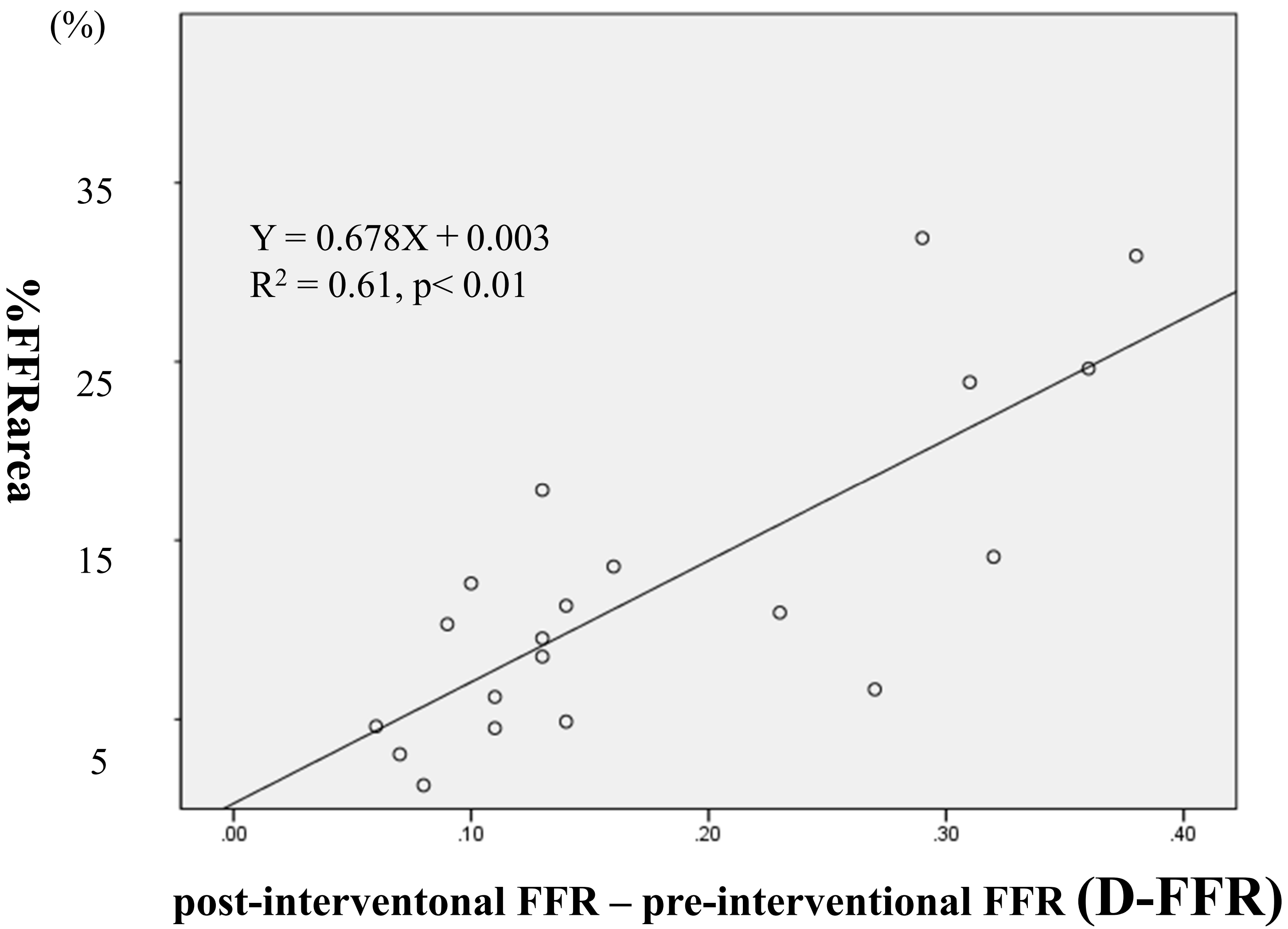
Relationship between the percentage increase in FFR area and pre- and post-interventional FFR difference



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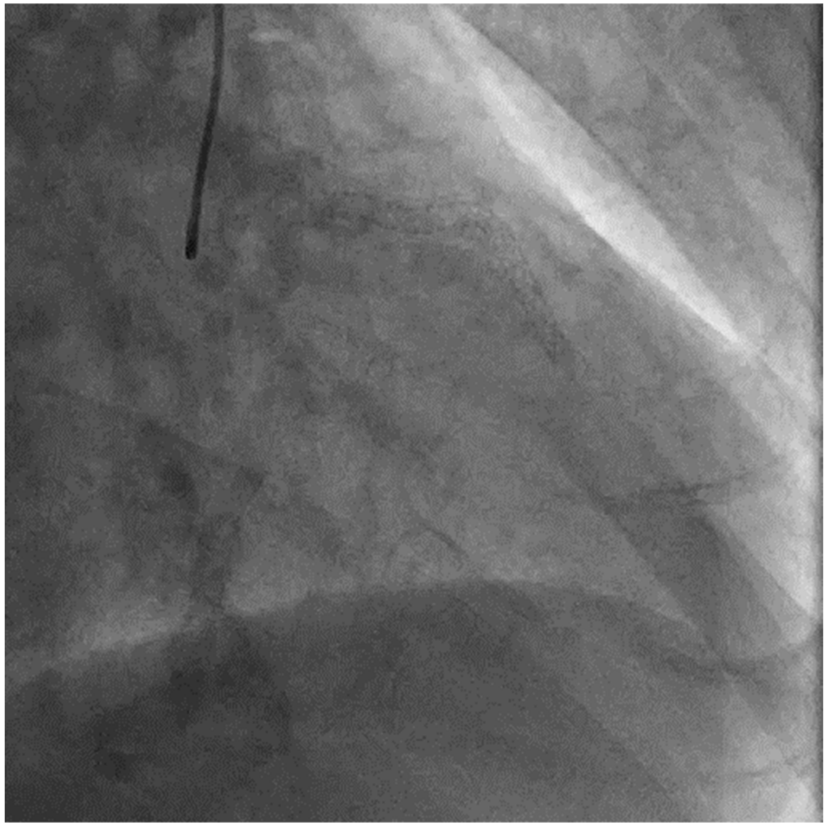
Case1

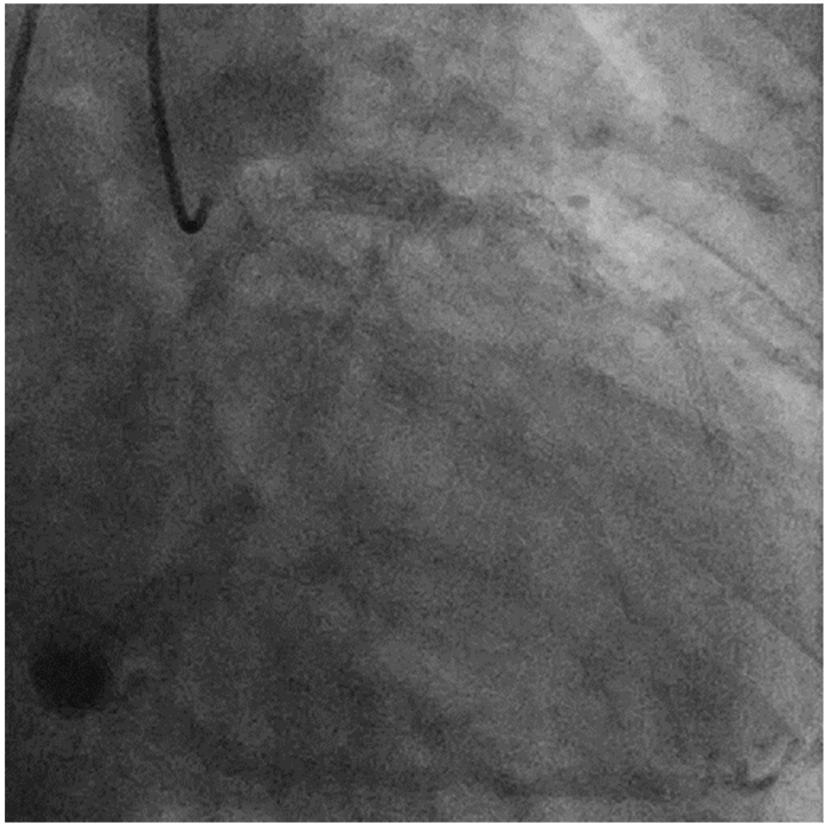
Distal LAD disease

Pre intervention



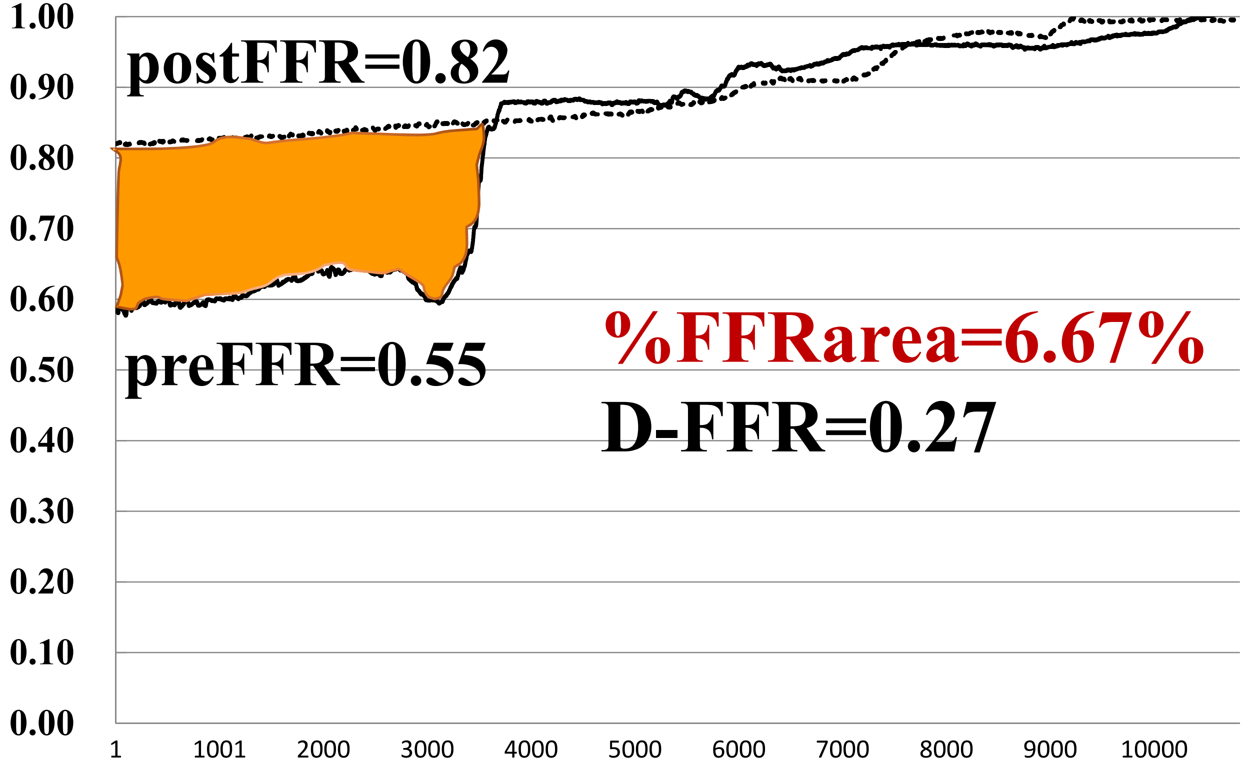
FFR=0.55

Post stent implantation



FFR=0.82

Case1



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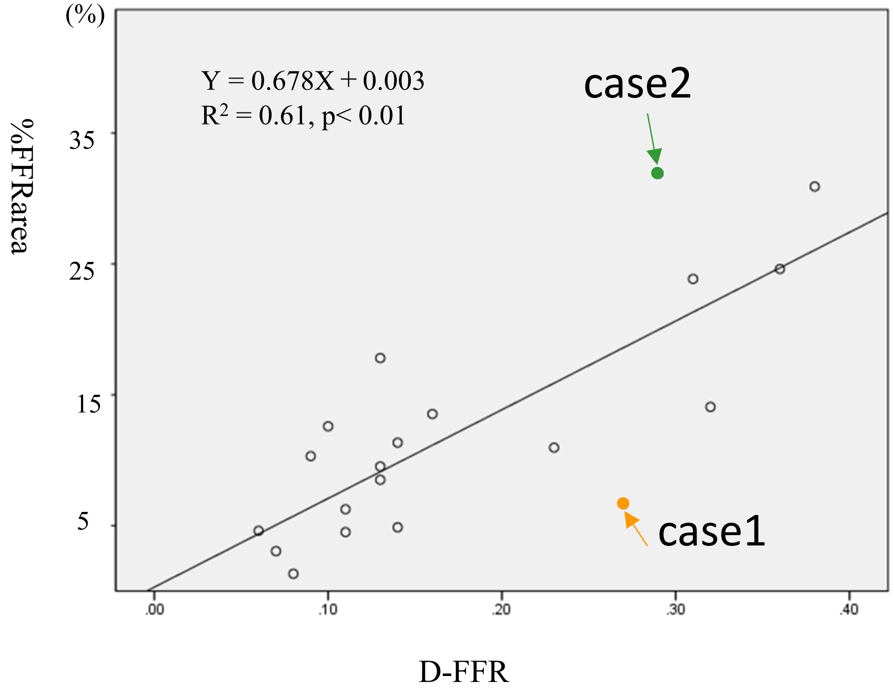
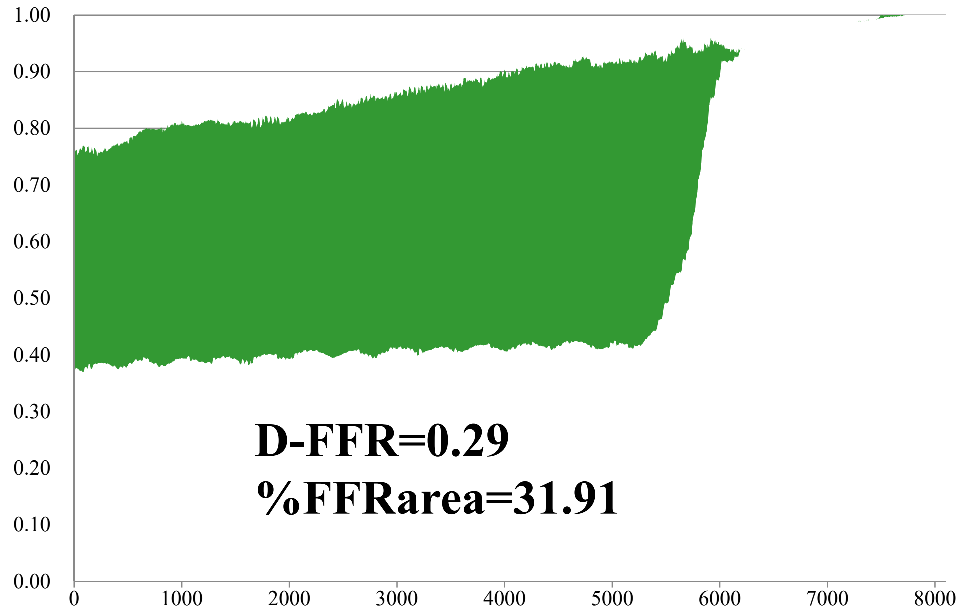
The %FFRarea doesn't always represent D-FFR



Case2

Proximal LAD disease



Matsuo A.Cardiovasc Interv and Ther 2018

Discussion

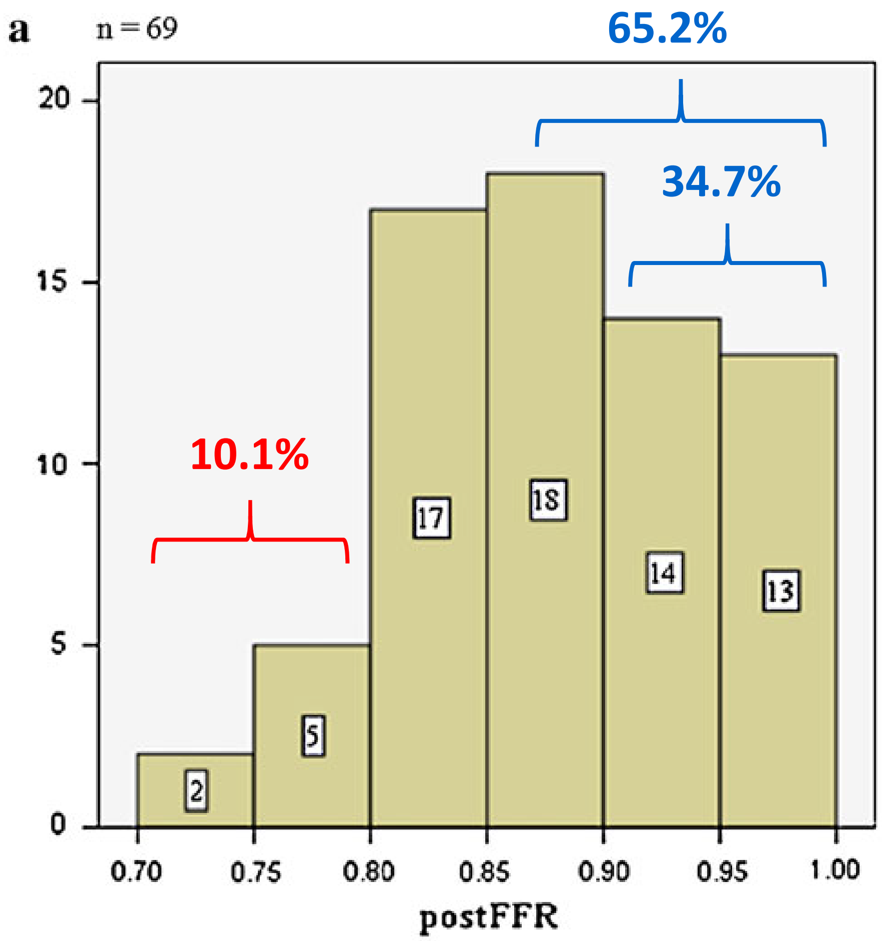
Optimal cutoff vales of post-stent FFR

Variations in post-stent FFR are linked to what the endpoint is, the duration, different coronary arteries, and the subset of patients

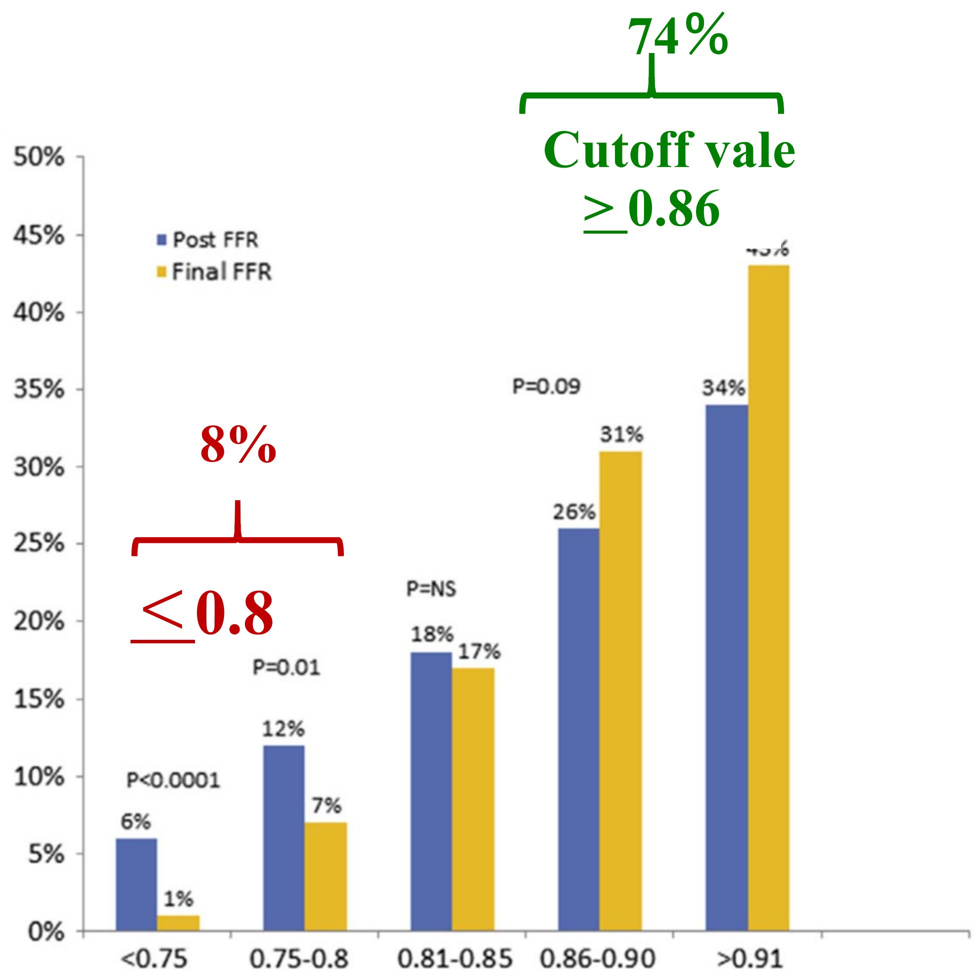
First author, year of publication	Design	Indication for PCI	PCI technique	Cut-off for low FFR - group	FFR technique: Adenosine	FFR technique: Pressure wire pullback	Definition of MACE
Bech *et al.*, [18]	Retrospective	Stable angina	POBA	<0.9	i.v.	NA	MACE (death, MI, recurrent angina, CABG, repeated PTCA)
Pijls *et al.*, [31]	Prospective, observational	All comers	"stent" (type NA)	≤ 0.9	i.v. or i.c.	No	MACE (death, MI, CABG, TVR)
Klauss *et al.*, [30]	Retrospective	Stable angina	BMS	< 0.95	i.c.	Not mandatory	MACE (death, MI, TVR)
Nam *et al.*, [19]	Retrospective	2/3 ACS, 1/3 stable angina	DES	≤ 0.9	i.c.	No	MACE (death, MI, TVR)
Leesar *et al.*, [9]	Prospective, interventional	Stable angina	DES > BMS	< 0.96	i.c.	No	MACE (death, MI, TLR)
Ito *et al.*, [23]	Retrospective	92 % stable angina, 8 % unstable angina	DES plus IVUS	≤ 0.9	i.c.	No	MACE (cardiac death, MI, TVR, stent thrombosis)
Reith *et al.*, [24]	Prospective, observational	Stable angina	DES > BMS plus OCT	≤ 0.905	i.c.	No	MACE (death, MI, TLR)
Doh *et al.*, [22]	Prospective, observational	1/3 ACS, 2/3 stable angina	DES plus IVUS	< 0.89	i.v. or i.c.	Not mandatory	TVF (death and MI attributed to target vessel, TVR)

Study	Study Group	FFR/Outcomes	Follow-Up, mo	Comment
Bech, 1999[8]	58 pts with SVD undergoing BA	Threshold of 0.9 identified as best cut point for MACE(45% vs 10%)	24	50% pts with optimal BA results (<35% residual stenosis) had post-PCI FFR<0.9
Pijls, 2002[9]	750 BMS pts	Graded association between post-PCI FFR and MACE: FFR>0.95, 4.9%; FFR<0.90, 20.3%;FFR <0.80, 29.5%(*P*<0.05)	6	Post-PCI FFR and stent length were independent MACE predictors at 6 mo
Klauss, 2005[10]	119 pts (75% pts were part of the FFR poststent registry)	FFR>0.95 had lower MACE	6	Post-PCI FFR<0.95 and LV dysfunction were independent MACE predictors
Dupouy, 2005[11]	100 BMS pts	Progressively higher pressure inflations required to optimize post-PCI FFR; FFR>0.95 as predictor: Pts who achieved FFR>0.95 (81%) had decreased angina frequency vs FFR<0.95 (19% vs 52%)	6	50% of pts with adequate angiographic results had FFR<0.95 requiring higher inflation pressures
Jensen, 2007[12]	98 SVD SIHD pts with BMS	Step up in FFR between distal vessel and stented area associated with higher binary restenosis rate (44% vs 8%;*P*<0.001)	9	
Leesar, 2011[17]	66 pts with SVD (57% DES)	53% pts achieved post PCI FFR >0.96. MACE was lower in the FFR>0.96 group (6% vs 28%;*P*=0.02)	24	
Ishii, 2011[15]	31 SIHD pts with DES	Angiographic follow-up 8 mo: Pts with restenosis had lower post-PCI FFR (0.81 vs 0.91; *P*≤0.01)	8	
Nam, 2011[14]	80 DES pts	12 mo MACE; FFR cutoff >0.90: MACE was 12.5% in low-FFR group, 2.5% in high-FFR group	12	
Matsuo, 2013[16]	69 SIHD pts with DES	Angiographic follow-up at 6–9 mo: 16% pts with TLR; these pts had lower post-PCI FFR group (0.84 vs 0.88; *P*≤0.01)	7.5	39% pts had post-PCI FFR>0.91
Doh, 2015[13]	107 DES pts	TVF; FFR cutoff >0.89: (89.3% vs 61.1%, *P*=0.03).	36	
Agarwal, 2016[19]	574 pts (79% DES)	MACE; FFR cutoff >0.86 (17% vs 23%; *P*=0.02)	31	FFR<0.86 had incremental prognostic value over clinical and angiographic variables for MACE prediction.
Li, 2017[21]	1476 DES pts	TVF; FFR cutoff>0.88: a better TVF-free survival (4% vs 8%; *P*=0.03)	36	FFR<0.88 only independent predictor of TVF
Piroth, 2017[22]	639 pts	Event rate negatively correlated with post-PCI FFR tertiles	24	

Failure of FFR improvement after intervention



Matsuo A, et al. Cardiovasc Interv and Ther 2013



Agarwal SK,J Am Coll Cardiol Intv 2016

Post-FFR ≤0.8 and pre-post FFR/pre-FFR<0.1

	No improved	Improved	p
Pre-procedure	n=9 (8%)	n=103	
Pd/Pa	0.88±0.07	0.87±0.08	0.65
FFR	0.73±0.04	0.72±0.09	0.13
WFFR	0.16±0.08	0.15±0.07	0.72
Gradual pattern	8 (88.9%)	19 (18.4%)	0.01
Post-procedure			
FFR	0.74±0.06	0.87±0.05	0.01
Change ratio	0.01±0.06	0.23±0.16	0.01

It is not easy to achieve high post-stent FFR values!
PCI can’t entirely resolve coronary diseases.

New concept of physiological endpoint of PCI

Trans-stent FFR

the FFR gradient across the stent

≥ 0.004

Trans-stent FFR/ length

HM Yang. Catheter Cardiovasc Interv. 2019

%FFR increase >15%

$$\frac{\text{post-PCI FFR pre-PCI FFR}}{\text{pre-PCI FFR}}$$

LM Lee. J Am Coll Cardiol Intv 2018

D-index

$$\frac{\text{Delta FFR between far distal and distal stent edge}}{\text{Distance between stent distal and far distal}}$$

> 0.017

Hoshino M. Eurointervention 2019

Not only post-stent FFR value!
Consider biomarkers of occult diseases and to what extent the FFR value could increase.

Conclusions

Pullback tracing using motorized pullback of the pressure guidewire was able to accurately identify the extent and location of stenosis. The present method would facilitate decision-making with respect to appropriateness of coronary intervention in patients with stable coronary artery disease.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Thank you for your attention!