Impact of Pullback Pressure Gradient (PPG) on Patient-Reported Outcomes in Patients With Coronary Artery Disease

Carlos Collet MD, PhD

On behalf of the PPG Global investigators

CRF®
TCT® TRANSCATHETER CARDIOVASCULAR THERAPEUTICS®

Disclosure of relevant financial relationships

Within the past 12+ months, Carlos Collet has had a financial interest/arrangement or affiliation with the organization(s) listed below.

Institutional support
- Abbott Vascular
- HeartFlow Inc
- GE Healthcare
- ShockWave Medical
- Boston Scientific
- Insight Lifetech
- Pie Medical
- Medis Medical Imaging

Equity/stock options
- Medyria
- Xenter

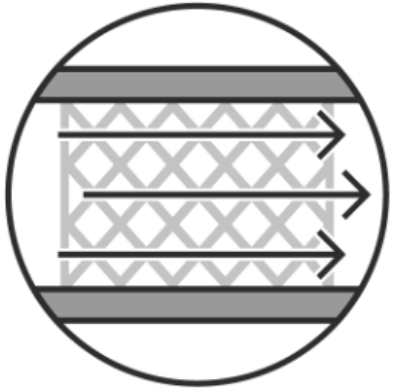
Consultancy fee
- Abbott Vascular
- HeartFlow Inc
- GE Healthcare
- Boston Scientific
- Insight Lifetech
- Early Bird
- Pfizer
- Siemens

Others

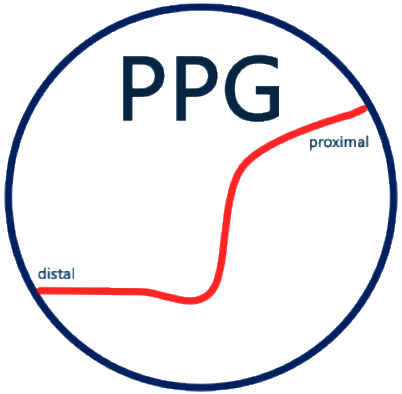
CoreAalst BV

Patents filed: US20220164950A1, US20220175260A1, WO2022136637A1 and WO2021224458A1

Background



The effectiveness of PCI is influenced by CAD patterns (focal vs diffuse).



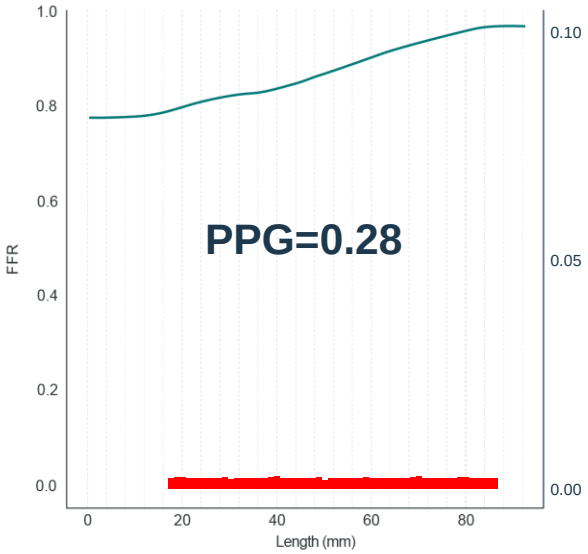
PPG quantifies focal and diffuse CAD and predicts blood flow improvements following PCI.

The magnitude of flow improvement (ΔFFR) is directly correlated with the relief of symptoms.

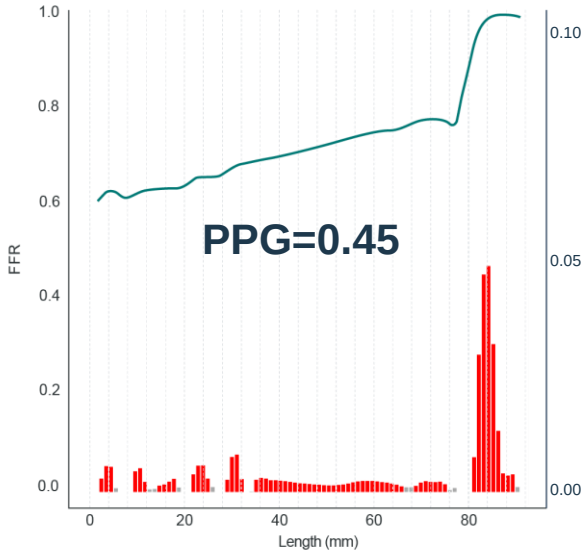
Collet C et al. Circulation. 2024 Aug 20;150(8):586-597.
Rajkumar et al, Circ Cardiovasc Int. 2021;14:e009891.
Collet et al JACC Cardiovasc Interv. 2022 Dec 26;15(24):2506-2518.

PPG: Focal and Diffuse Disease on a Scale from 0 to 1

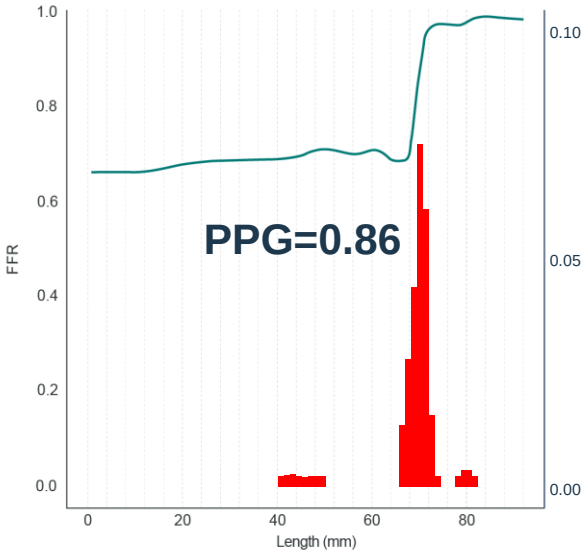
Diffuse CAD



Combined CAD



Focal CAD

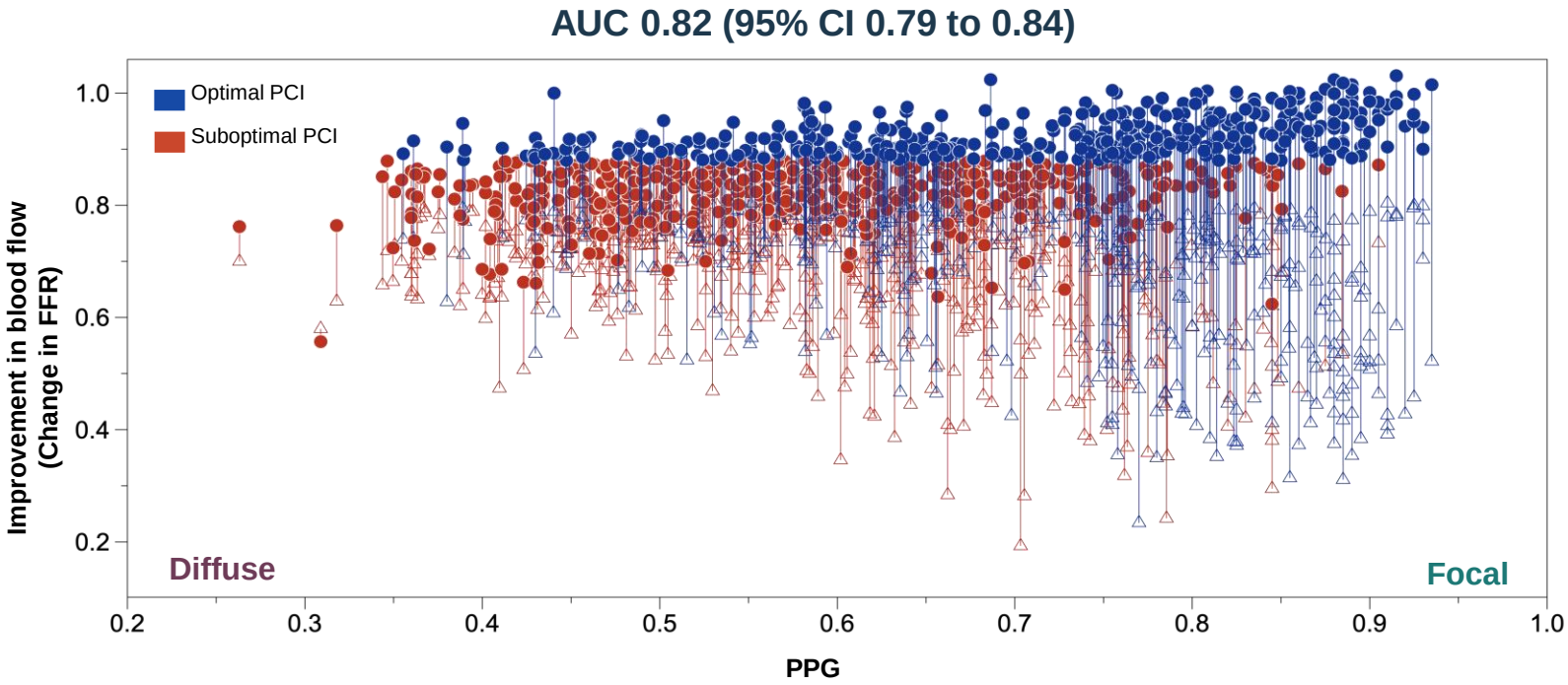


0 **Pullback Pressure Gradient (PPG)** **1**

Collet C et al. J Am Coll Cardiol 2019 Oct 8;74(14):1772-1784.

PPG and Blood Flow Improvement after PCI

PPG GLOBAL



Collet C et al. Circulation. 2024 Aug 20;150(8):586-597.

Study Objectives

To evaluate the impact of PPG on patient-reported outcomes in patients with hemodynamically significant CAD after one year.

To explore the impact of various treatment strategies on patient-reported outcomes, stratified by PPG.

Methods

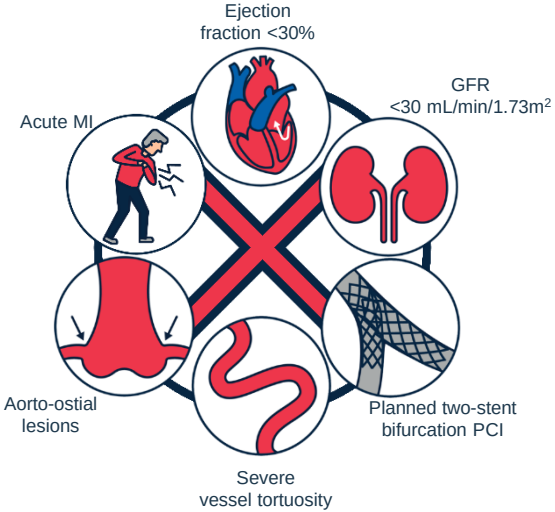
Study design

Investigator-initiated*, multicenter, international, and single-arm study (NCT04789317)

*Research grant from Abbott Vascular

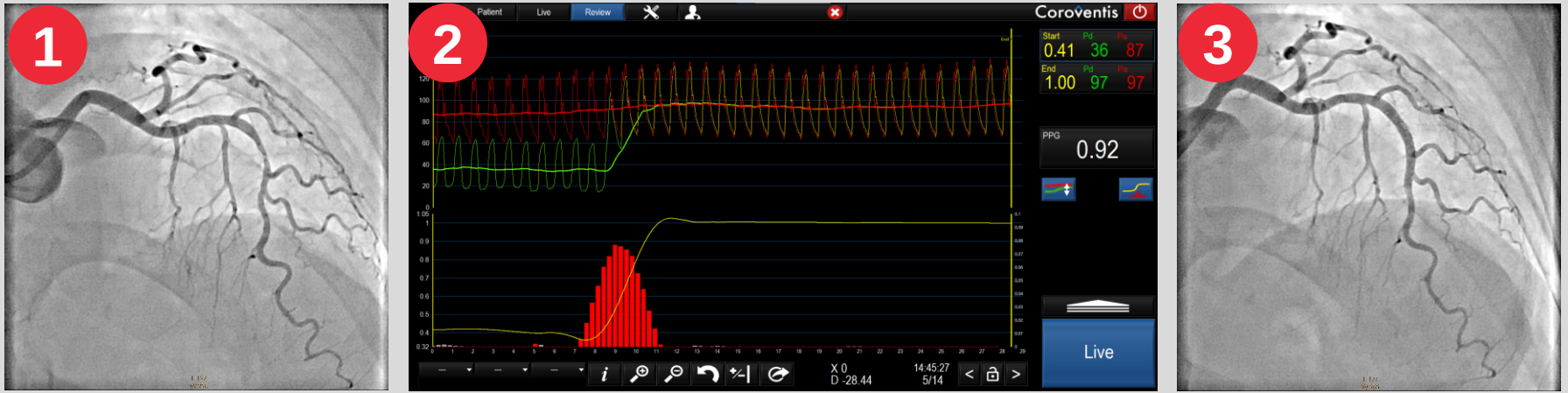
Stable patients* with at least one hemodynamically significant lesion (FFR ≤ 0.80) intended to be treated with PCI

*Non-culprit lesion after an acute coronary syndrome (ACS)



Exclusion Criteria

Invasive protocol



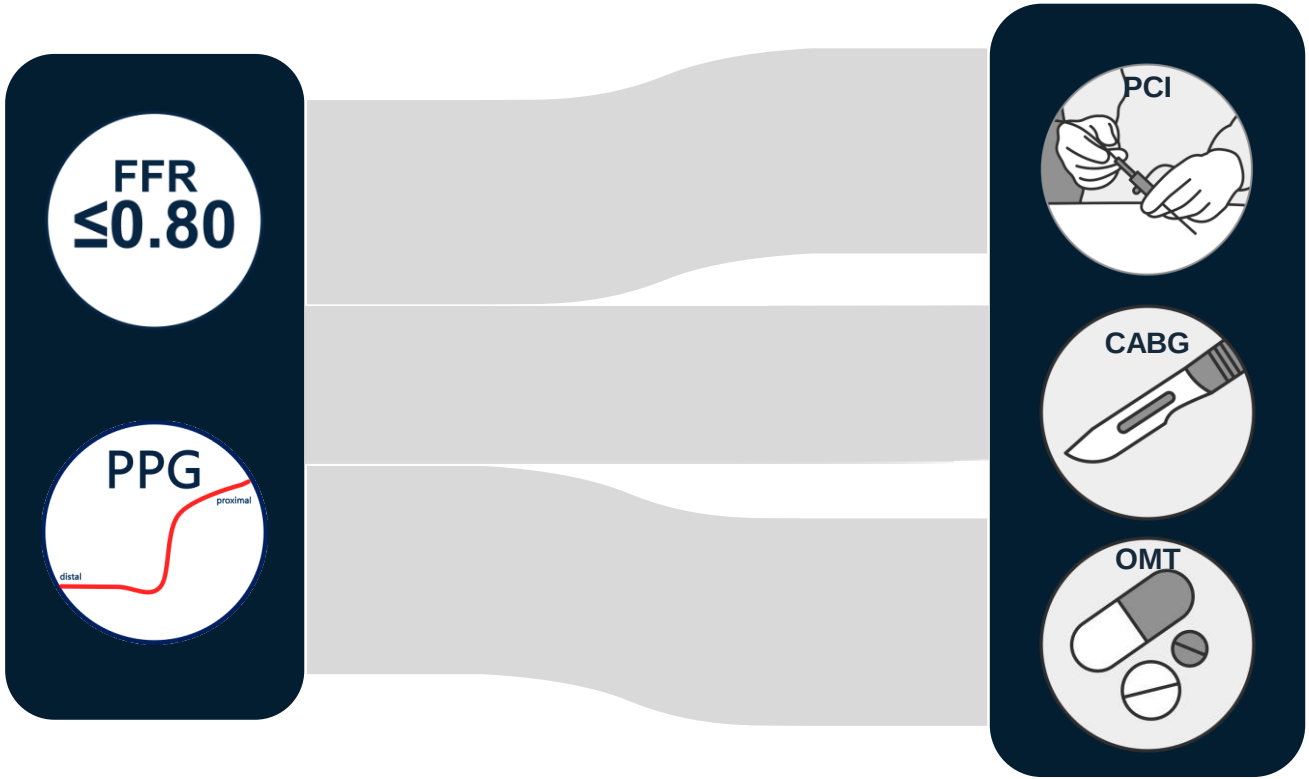
Lesion intended to be treated with PCI with FFR (single point) ≤ 0.80

Manual FFR pullbacks
Online PPG calculation

Post-PCI FFR

Munhoz D at el . Am Heart J. 2023 Nov;265:170-179.

Invasive protocol and decision making



Methods

Patient-reported outcomes (PRO)

Seattle Angina Questionnaire (SAQ-7) at baseline and 1-year follow-up.

CoreLab analysis

Angiographic and physiologic data underwent centralized analysis by CoreAalst BV core laboratory.

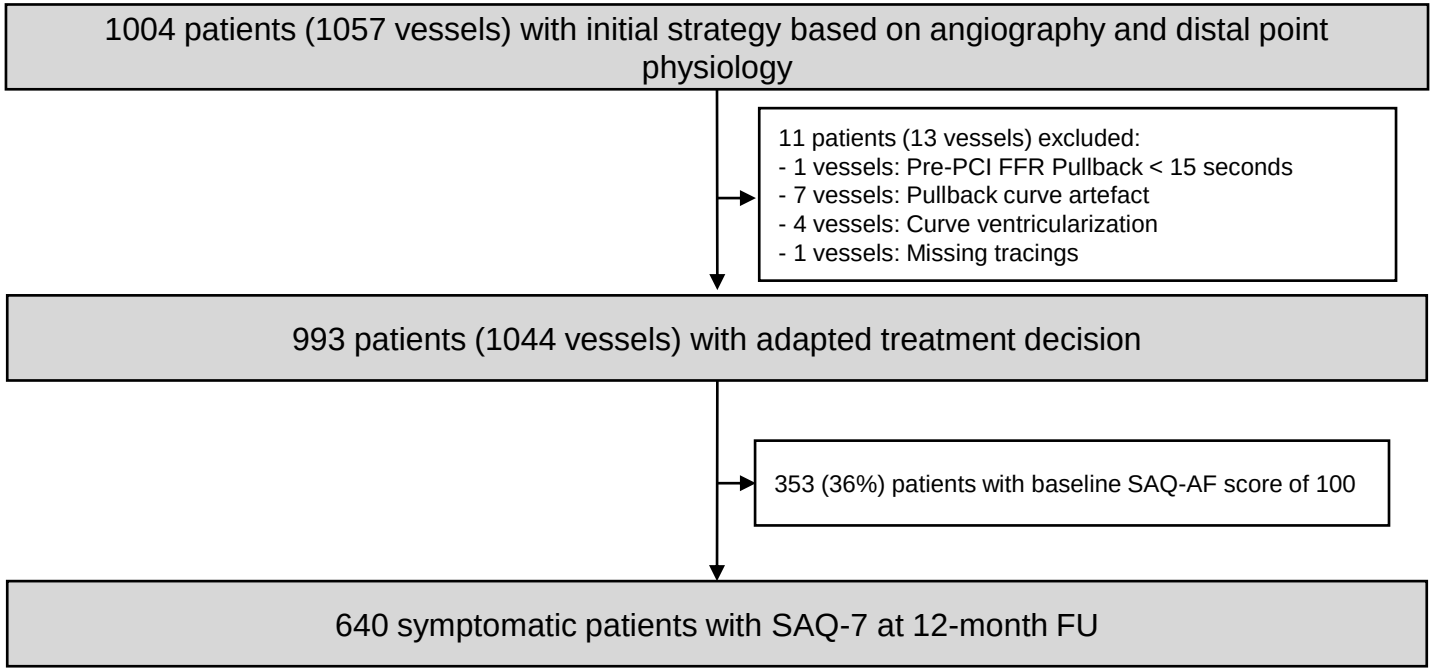
Definitions and adjudication

An independent clinical events committee (CEC) adjudicated adverse events.

Munhoz D at el . Am Heart J. 2023 Nov;265:170-179.
Thygesen K et al. J Am Coll Cardiol. 2018 Oct 30;72(18):2231-2264.

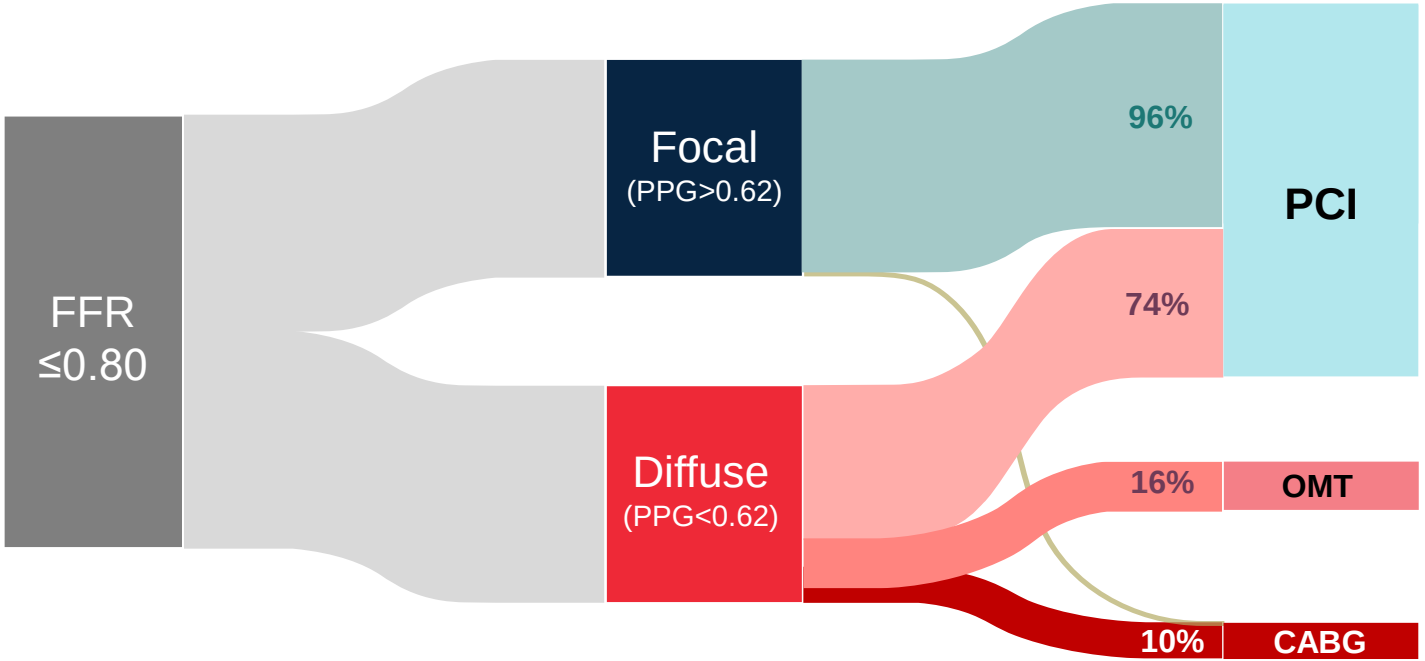
Results

Study Flowchart

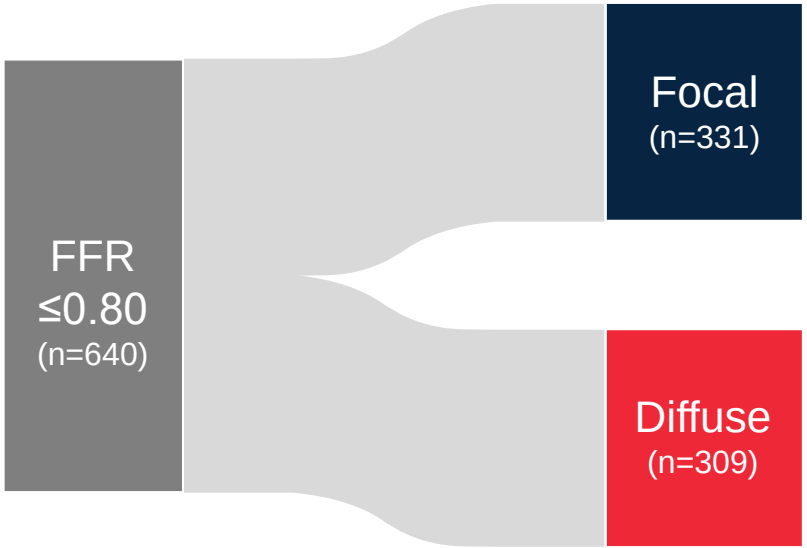


Treatment decision in focal vs diffuse disease

PPG GLOBAL



Treatment decision in symptomatic patients



Baseline and clinical characteristics stratified by PPG

PPG GLOBAL

Variable	Focal CAD	Diffuse CAD	p-value
Number of patients*	331	309	
Age (years), mean ± SD	68.3 ± 10.4	67.2 ± 10.2	0.211
Gender (male), n (%)	238 (71.9)	239 (77.3)	0.137
BMI, kg/m2 (%), mean ± SD	26.7 ± 9.6	27.5 ± 9.7	0.272
Dyslipidemia, n (%)	234 (70.7)	224 (72.5)	0.677
Hypertension, n (%)	231 (69.8)	218 (70.6)	0.901
Diabetes mellitus, n (%)	92 (27.8)	88 (28.5)	0.917
Current smoking, n (%)	53 (16.0)	49 (15.9)	1.000
Prior MI, n (%)	55 (16.6)	60 (19.4)	0.413
Clinical presentation, n (%)			0.117
Acute Coronary syndrome**, n (%)	38 (11.5)	50 (16.2)	
Stable angina, n (%)	293 (88.5)	259 (83.8)	
Symptoms severity***			0.117
Silent ischemia	16 (4.8)	22 (7.2)	
CCS I	125 (37.8)	92 (30.0)	
CCS II	96 (29.0)	90 (29.3)	
CCS III	39 (11.8)	29 (9.4)	
CCS IV	9 (2.7)	7 (2.3)	

For patients with multivessel interrogation, the lowest PPG was used for the patient-level analysis.

****Non-culprit vessels after an acute coronary syndrome.***

*****As assessed by the treating physician.***

Physiological and procedural characteristics stratified by PPG

Variables	Focal CAD	Diffuse CAD	p-value
Number of vessels	359	312	
Vessel type			<0.001
LAD	194 (54.0)	276 (88.5)	
LCX	68 (18.9)	11 (3.5)	
RCA	97 (27.0)	25 (8.0)	
Serial lesions, n (%)	53 (14.8)	69 (22.2)	0.017
Reference vessel diameter (mm), mean ± SD	2.75 ± 0.60	2.58 ± 0.52	<0.001
Diameter stenosis (%) QCA, mean ± SD	57.2 ± 13.2	44.7 ± 12.4	<0.001
FFR, mean ± SD	0.62 ± 0.14	0.71 ± 0.08	<0.001
PPG, mean ± SD	0.76 ± 0.09	0.49 ± 0.08	<0.001
Number of stents*, mean ± SD	1.16 ± 0.41	1.35 ± 0.57	<0.001
Stent length (mm)*, mean ± SD	27.5 ± 12.8	37.7 ± 18.8	<0.001
Stent diameter (mm)*, mean ± SD	3.08 ± 0.48	2.96 ± 0.39	0.002
Intracoronary imaging PCI (%)*, n (%)	170 (49.4)	91 (40.1)	0.035
Pre dilatation*, n (%)	301 (87.5)	199 (87.7)	1.000
Post dilatation*, n (%)	239 (69.5)	178 (78.8)	0.019
Post-PCI FFR*, mean ± SD	0.89 ± 0.07	0.84 ± 0.06	<0.001
Delta FFR*, mean ± SD	0.27 ± 0.14	0.13 ± 0.08	<0.001

For patients undergoing PCI.

Physiological and procedural characteristics stratified by PPG

Variables	Focal CAD	Diffuse CAD	p-value
Number of vessels	359	312	
Vessel type			**<0.001**
LAD	**194 (54.0)**	**276 (88.5)**	
LCX	**68 (18.9)**	**11 (3.5)**	
RCA	**97 (27.0)**	**25 (8.0)**	
Serial lesions, n (%)	53 (14.8)	69 (22.2)	0.017
Reference vessel diameter (mm), mean ± SD	2.75 ± 0.60	2.58 ± 0.52	<0.001
Diameter stenosis (%) QCA, mean ± SD	57.2 ± 13.2	44.7 ± 12.4	<0.001
FFR, mean ± SD	0.62 ± 0.14	0.71 ± 0.08	<0.001
PPG, mean ± SD	0.76 ± 0.09	0.49 ± 0.08	<0.001
Number of stents*, mean ± SD	1.16 ± 0.41	1.35 ± 0.57	<0.001
Stent length (mm)*, mean ± SD	27.5 ± 12.8	37.7 ± 18.8	<0.001
Stent diameter (mm)*, mean ± SD	3.08 ± 0.48	2.96 ± 0.39	0.002
Intracoronary imaging PCI (%)*, n (%)	170 (49.4)	91 (40.1)	0.035
Pre dilatation*, n (%)	301 (87.5)	199 (87.7)	1.000
Post dilatation*, n (%)	239 (69.5)	178 (78.8)	0.019
Post-PCI FFR*, mean ± SD	0.89 ± 0.07	0.84 ± 0.06	<0.001
Delta FFR*, mean ± SD	0.27 ± 0.14	0.13 ± 0.08	<0.001

For patients undergoing PCI.

Physiological and procedural characteristics stratified by PPG

Variables	Focal CAD	Diffuse CAD	p-value
Number of vessels	359	312	
Vessel type			<0.001
LAD	194 (54.0)	276 (88.5)	
LCX	68 (18.9)	11 (3.5)	
RCA	97 (27.0)	25 (8.0)	
Serial lesions, n (%)	53 (14.8)	69 (22.2)	0.017
Reference vessel diameter (mm), mean ± SD	2.75 ± 0.60	2.58 ± 0.52	<0.001
Diameter stenosis (%) QCA, mean ± SD	57.2 ± 13.2	44.7 ± 12.4	<0.001
FFR, mean ± SD	0.62 ± 0.14	0.71 ± 0.08	<0.001
PPG, mean ± SD	0.76 ± 0.09	0.49 ± 0.08	<0.001
Number of stents*, mean ± SD	**1.16 ± 0.41**	**1.35 ± 0.57**	**<0.001**
Stent length (mm)*, mean ± SD	**27.5 ± 12.8**	**37.7 ± 18.8**	**<0.001**
Stent diameter (mm)*, mean ± SD	**3.08 ± 0.48**	**2.96 ± 0.39**	**0.002**
Intracoronary imaging PCI (%)*, n (%)	170 (49.4)	91 (40.1)	0.035
Pre dilatation*, n (%)	301 (87.5)	199 (87.7)	1.000
Post dilatation*, n (%)	239 (69.5)	178 (78.8)	0.019
Post-PCI FFR*, mean ± SD	0.89 ± 0.07	0.84 ± 0.06	<0.001
Delta FFR*, mean ± SD	0.27 ± 0.14	0.13 ± 0.08	<0.001

For patients undergoing PCI.

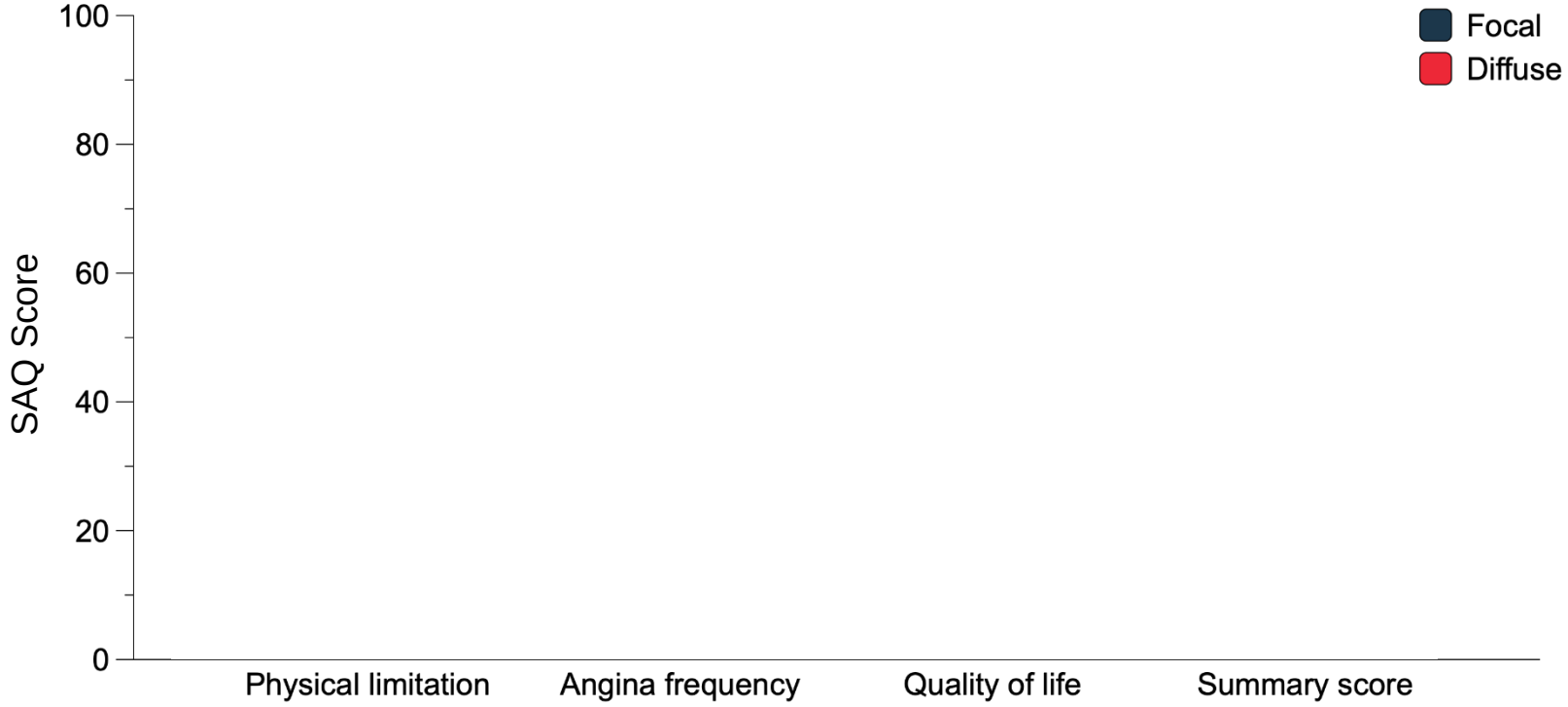
Physiological and procedural characteristics stratified by PPG

Variables	Focal CAD	Diffuse CAD	p-value
Number of vessels	359	312	
Vessel type			<0.001
LAD	194 (54.0)	276 (88.5)	
LCX	68 (18.9)	11 (3.5)	
RCA	97 (27.0)	25 (8.0)	
Serial lesions, n (%)	53 (14.8)	69 (22.2)	0.017
Reference vessel diameter (mm), mean ± SD	2.75 ± 0.60	2.58 ± 0.52	<0.001
Diameter stenosis (%) QCA, mean ± SD	57.2 ± 13.2	44.7 ± 12.4	<0.001
FFR, mean ± SD	0.62 ± 0.14	0.71 ± 0.08	<0.001
PPG, mean ± SD	0.76 ± 0.09	0.49 ± 0.08	<0.001
Number of stents*, mean ± SD	1.16 ± 0.41	1.35 ± 0.57	<0.001
Stent length (mm)*, mean ± SD	27.5 ± 12.8	37.7 ± 18.8	<0.001
Stent diameter (mm)*, mean ± SD	3.08 ± 0.48	2.96 ± 0.39	0.002
Intracoronary imaging PCI (%)*, n (%)	170 (49.4)	91 (40.1)	0.035
Pre dilatation*, n (%)	301 (87.5)	199 (87.7)	1.000
Post dilatation*, n (%)	239 (69.5)	178 (78.8)	0.019
Post-PCI FFR*, mean ± SD	**0.89 ± 0.07**	**0.84 ± 0.06**	**<0.001**
Delta FFR*, mean ± SD	**0.27 ± 0.14**	**0.13 ± 0.08**	**<0.001**

For patients undergoing PCI.

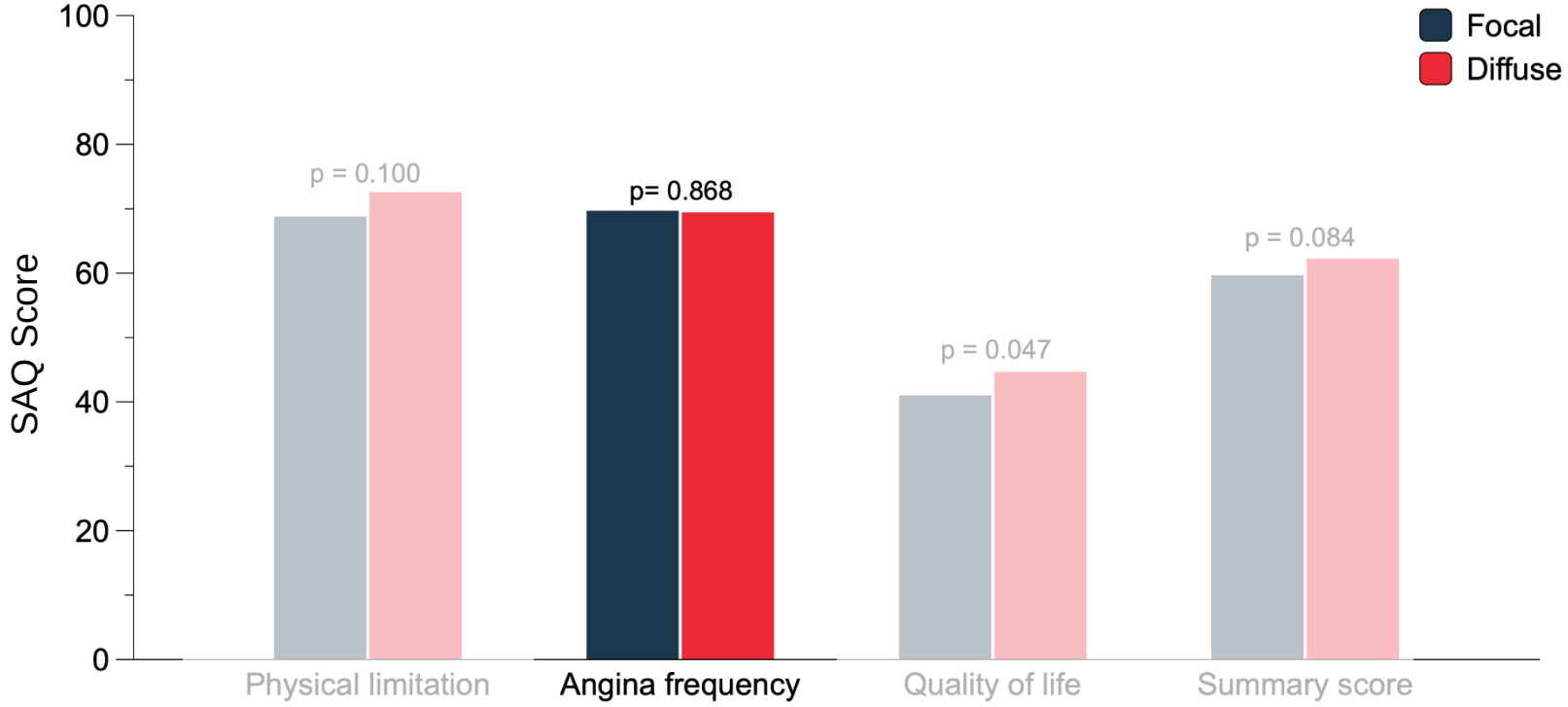
Baseline Symptoms Stratified by PPG

PPG GLOBAL

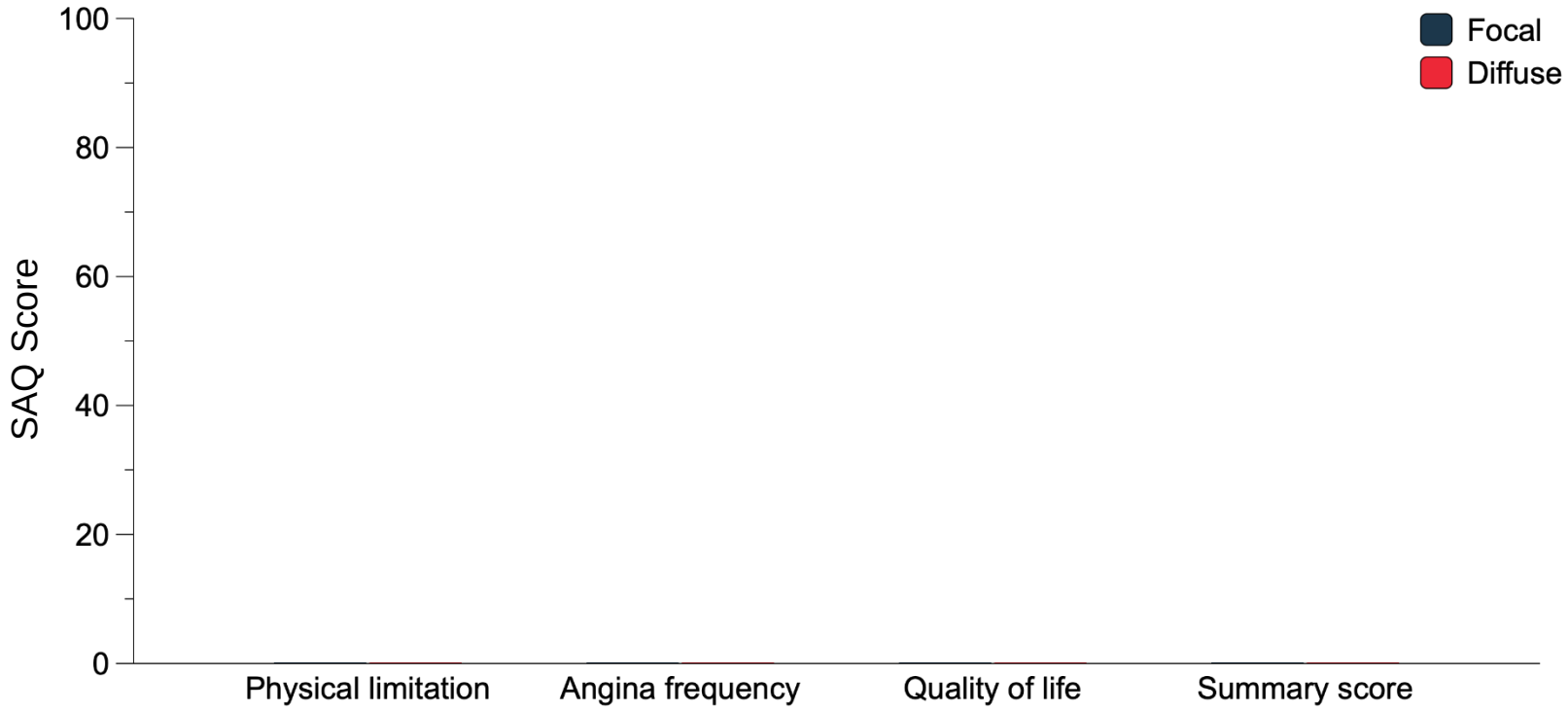


Baseline Symptoms Stratified by PPG

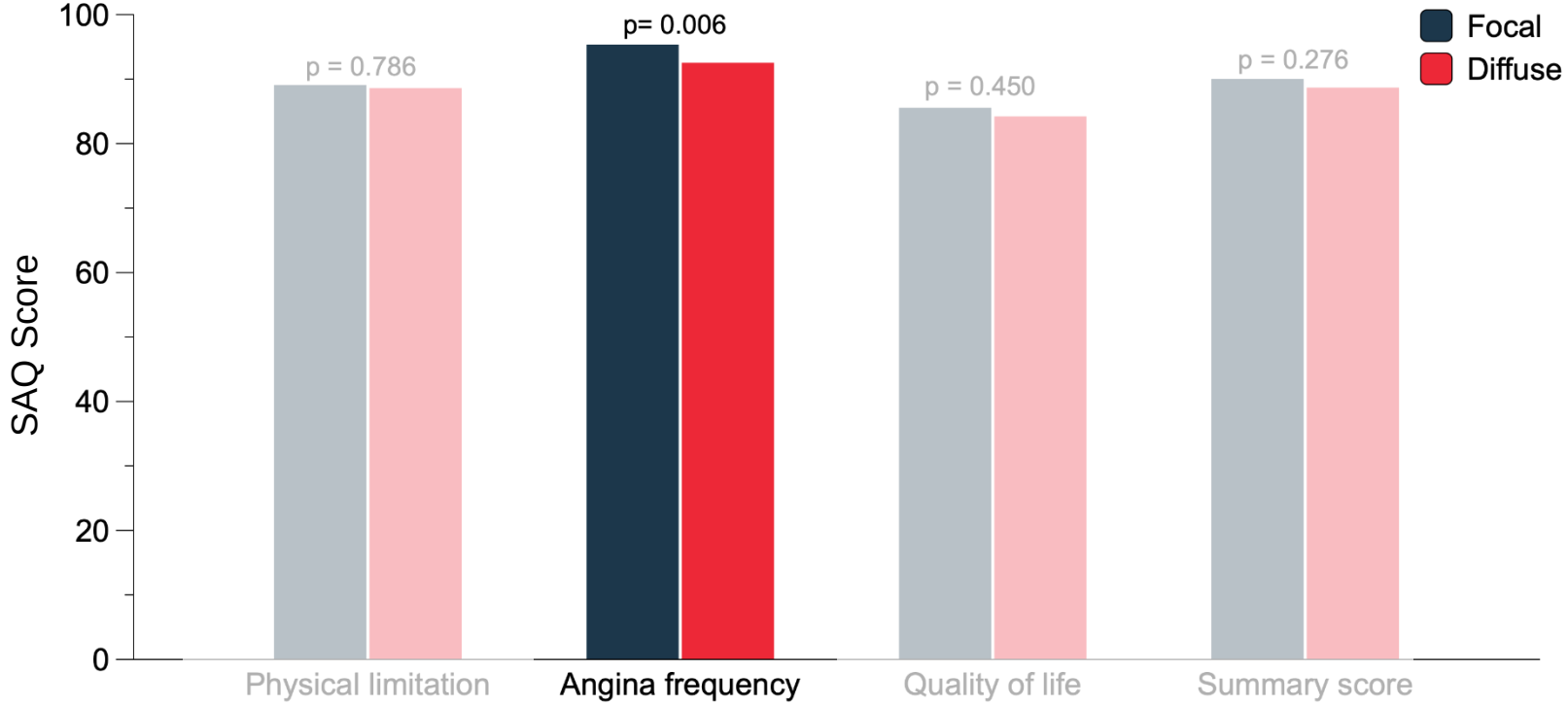
PPG GLOBAL



PPG and Patient Symptoms at 1-Year Follow-Up

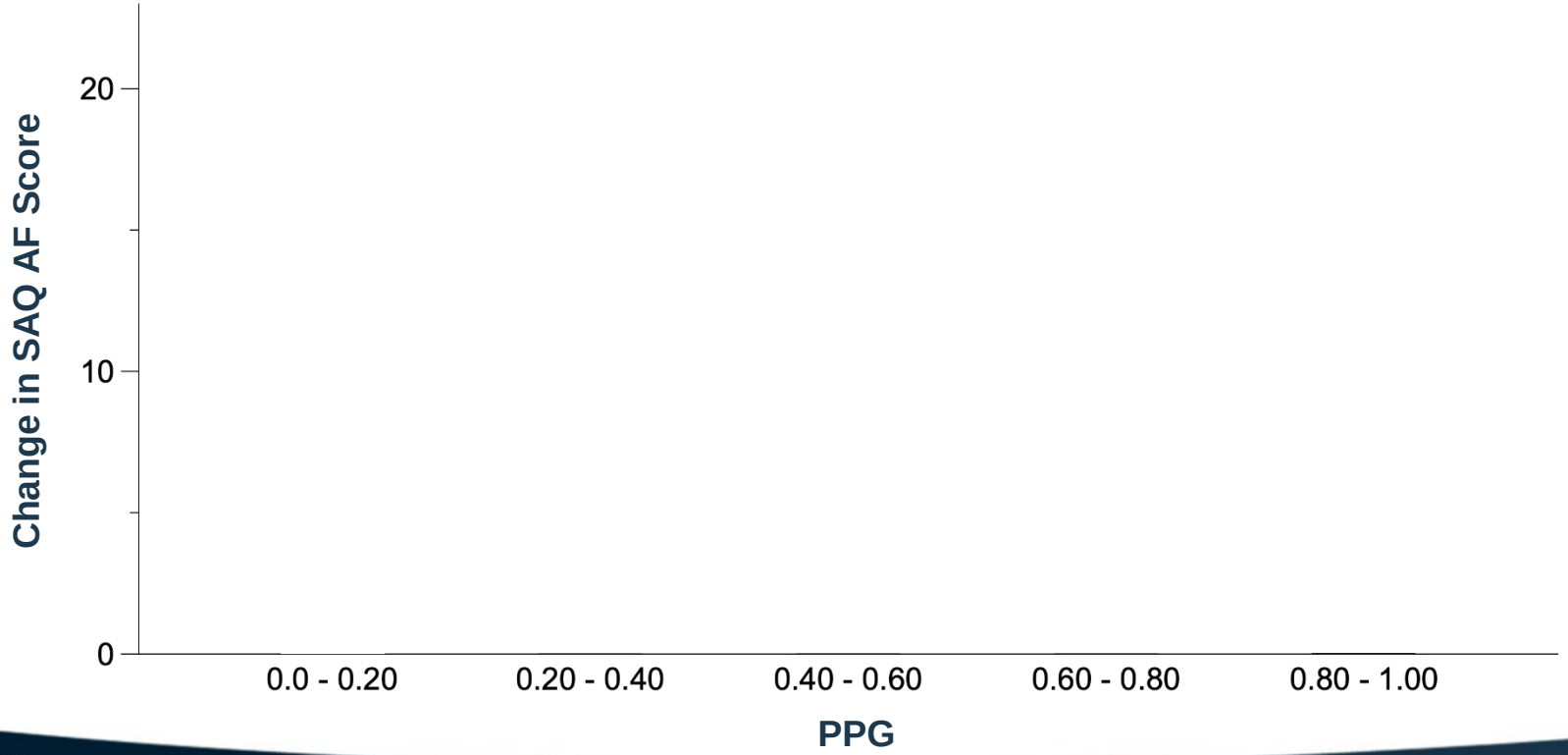


PPG and Patient Symptoms at 1-Year Follow-Up



Angina improvement and PPG

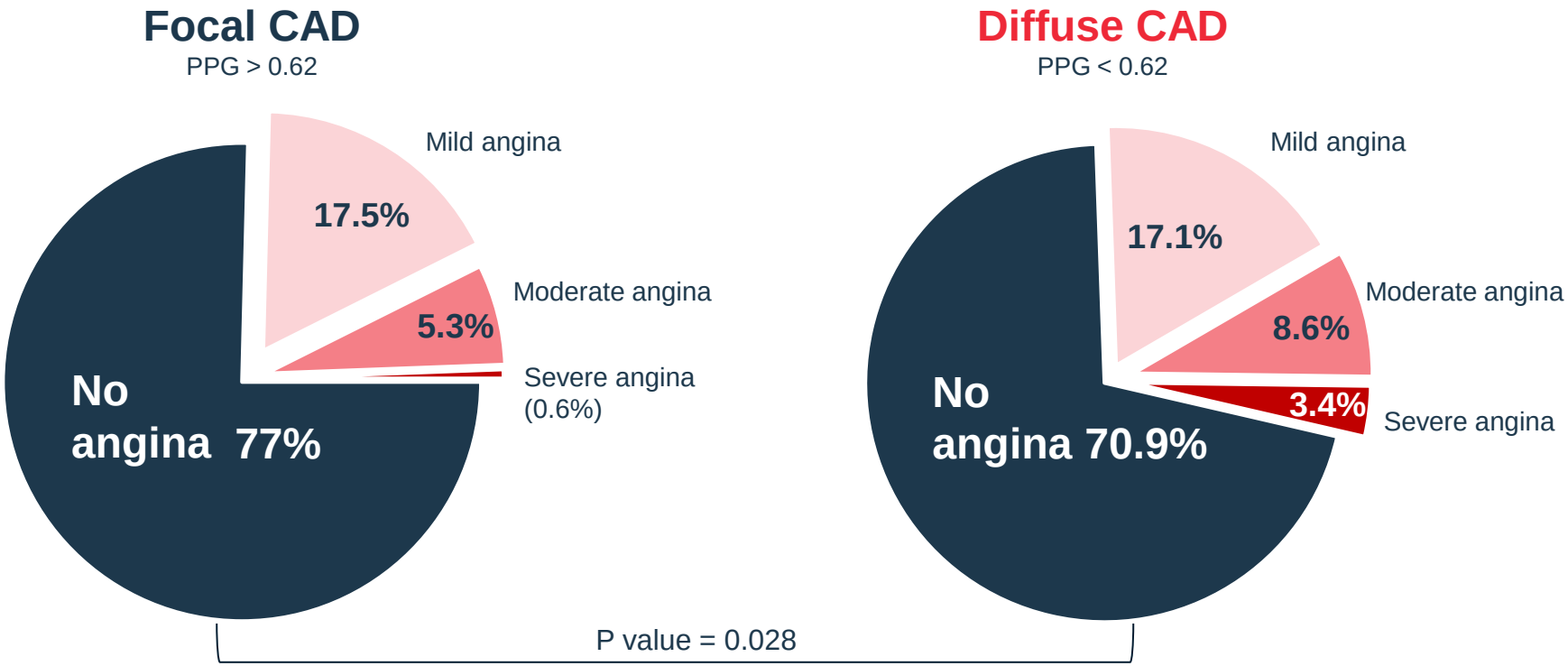
Change in Angina Frequency from Baseline to 1-year Follow-Up



Includes patients treated with different modalities

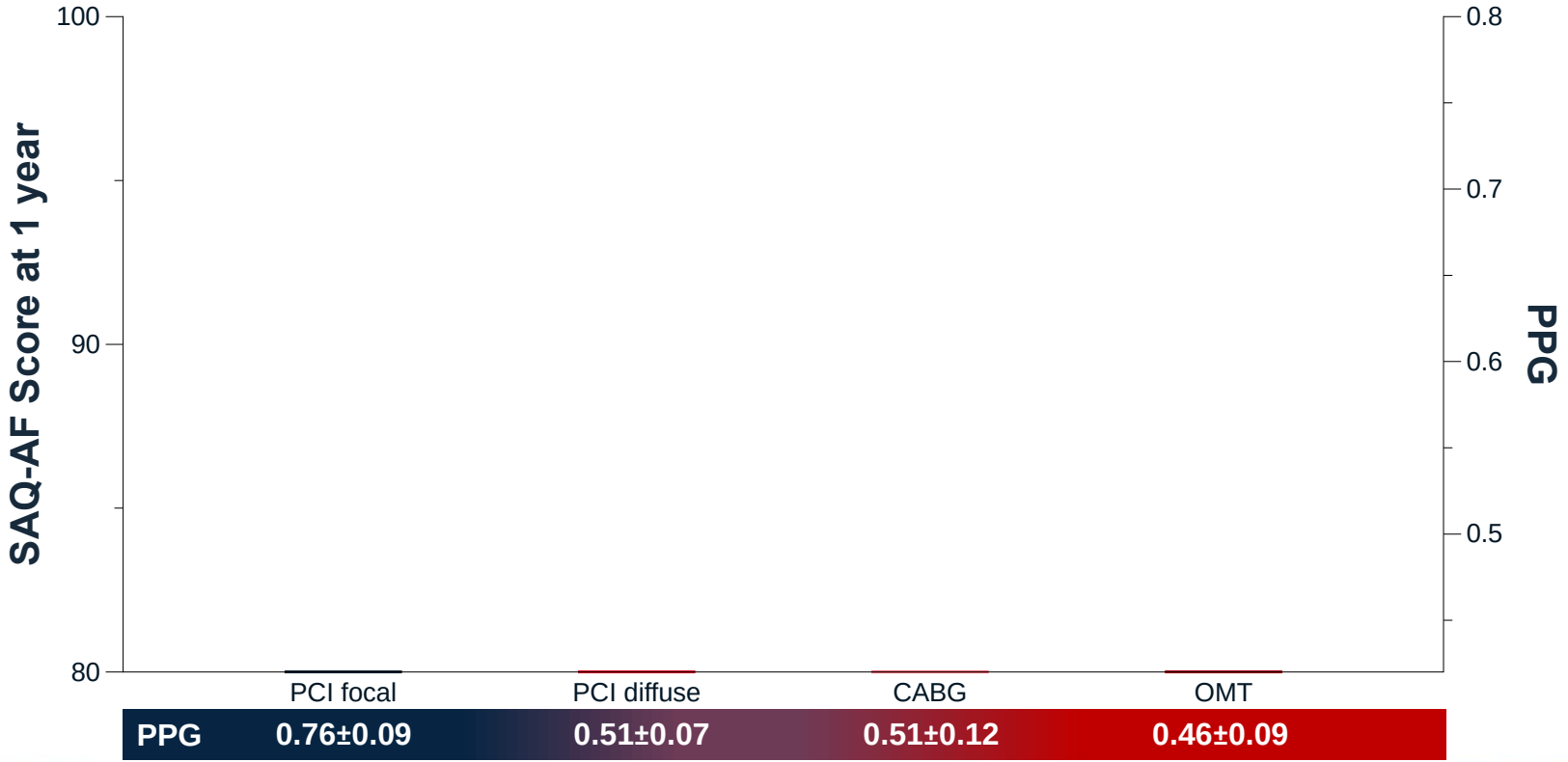
Residual Angina at 1-Year Stratified by PPG

PPG GLOBAL



Outcomes by treatment modality

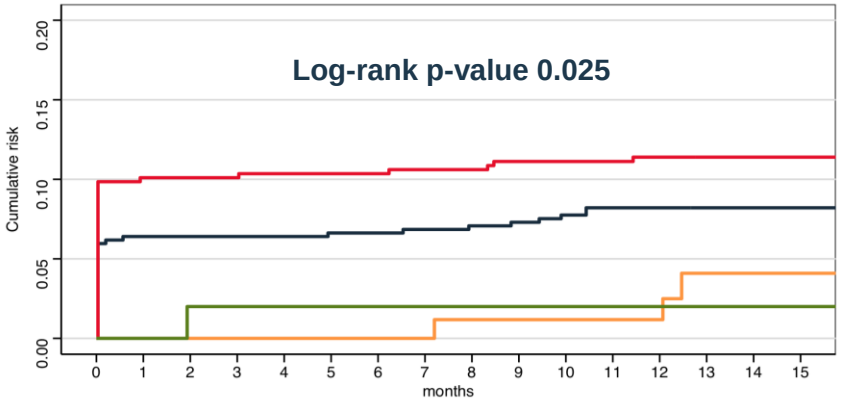
SAQ Angina Frequency by Treatment at 1-Year



Target Vessel Failure Stratified by PPG and Treatment at One year

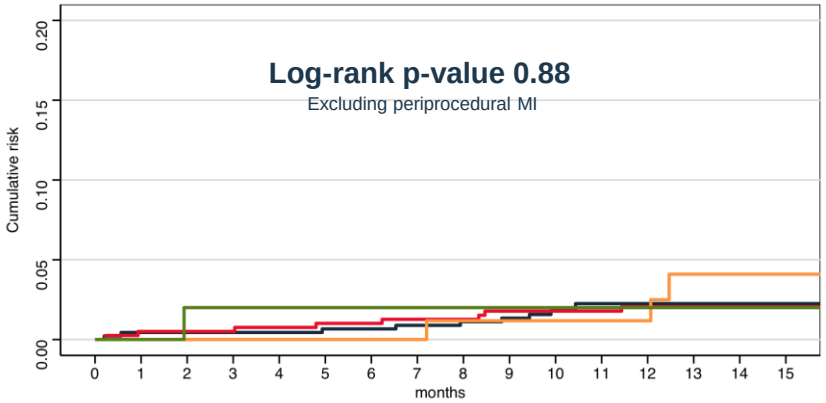
PPG GLOBAL

PCI focal PCI diffuse CABG diffuse OMT diffuse



Number at risk

	453	422	422	422	421	420	418	417	412	411	407	402	357	258	232	226
	396	356	355	355	354	353	353	352	350	347	346	340	299	211	191	185
	85	85	85	85	85	85	85	85	84	84	82	82	75	54	51	48
	50	50	49	49	49	49	49	49	49	48	48	48	40	24	22	20



Number at risk

	452	448	448	448	447	446	444	443	438	437	433	428	380	270	240	234
	396	394	393	393	392	390	390	389	386	383	382	375	330	229	208	202
	85	85	85	85	85	85	85	85	84	84	82	82	75	54	51	48
	50	50	49	49	49	49	49	49	49	48	48	48	40	24	22	20

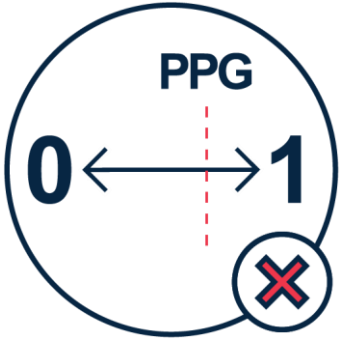
TVF: cardiac death, target vessel MI, and target vessel revascularization

Study limitations

SAQ-7

Utilization of the 7-Item Seattle Angina Questionnaire at Two Time Points.

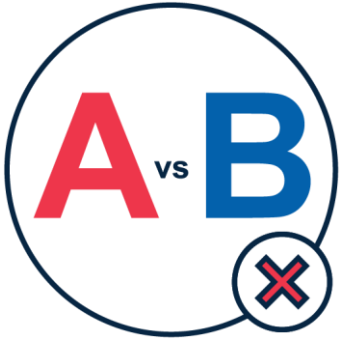
Demonstrates less sensitivity to change, particularly in populations with milder symptoms.



PPG Cutoff

No pre-specified PPG threshold for clinical decision-making.

PPG was different for patients treated with PCI, optimal medical therapy, and CABG.



Clinical Outcomes

The study was not powered to detect differences in clinical outcomes.

An RCT is required to assess the benefit of PPG for clinical decision-making

In conclusion

Take-home Message

Patients with high PPG treated with PCI reported less angina at 1-year follow-Up

PPG was independently associated with angina relief

No differences in hard clinical outcomes between diffuse and focal CAD regardless of the treatment strategy

PPG Global highlights the utility of PPG as a predictive tool for improving patient outcomes in stable CAD, representing a novel application of coronary physiology.

With thanks to all investigators

PPG GLOBAL

Onze-Lieve-Vrouw Ziekenhuis, Aalst, Belgium
Jeroen Sonck

Gifu Heart Center, Gifu, Japan
Hitoshi Matsuo & Masafumi Nakayama

Aichi Medical University, Aichi, Japan
Tetsuya Amano

Showa University, Tokyo, Japan
Toshiro Shinke

Monash Cardiovascular Research Centre, Melbourne, Australia
Brian Ko

Ferrara University, Ferrara, Italy
Simone Biscaglia

Rigshospitalet, Copenhagen, Denmark
Thomas Engstrøm

Hospital Universitario de La Princesa, Madrid, Spain
Fernando Rivero

Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy
Antonio Maria Leone

Stanford University, Stanford, United States of America
Willian Fearon

Memorial Hermann Texas Medical Center, Houston, United States of America
Nils P. Johnson

CHUV, Laussane, Switzerland
Stéphane Fournier

Concord Repatriation General Hospital, Sydney, Australia
Andy Yong

Karolinska Institutet, Stockholm, Sweden
Liyeuw Desta

Institut Arnault Tzanck, Nice, France
Julien Adjedj

Hospital Clinico San Carlos, Madrid, Spain
Javier Escaned

Radboud UMC, Nijmegen, The Netherlands
Lokien X Van Nunen

Guy's and St. Thomas' NHS Foundation Trust, London, United Kingdom
Divaka Perera

Aalborg University Hospital, Aalborg, Denmark
Ashkan Eftekhari

St. Francis Hospital, New York, United States of America
Ziad Ali

Catharina Ziekenhuis, Eindhoven, The Netherlands
Frederik Zimmermann

Aarhus University Hospital, Aarhus, Denmark
Evald Christiansen

PPG GLOBAL

With thanks to

Abbott

Coroventis
Turning ideas into reality

CoreAalst

OPTIMA