Absolute flow after successful PCI of a CTO. The FLOW-CTO study

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Background

- ***Chronic total occlusion (CTO)*** causes abnormalities in the vascular bed distal to the lesion and related microvasculature.
- Percutaneous coronary intervention (PCI) of a CTO improves quality of life (QoL) and reduces angina.
- Positron emission tomography (PET) scans have shown improvement in myocardial blood flow and coronary flow reserve (CFR) after CTO PCI. Flow improvement is not immediate and can take weeks or months*.
- ***Manual bolus thermodilution techniques*** → indirect methods for the estimation of coronary flow and resistance, like CFR and index of microcirculatory resistance (IMR) have inherent limitations and require adenosine.

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- Schumacher SP et al. Recovery of myocardial perfusion after percutaneous coronary intervention of chronic total occlusions is comparable to hemodynamically significant non-occlusive lesions. Catheter Cardiovasc Interv. 2019;93:1059-1066.

Background

- ***Continuous thermodilution method***[1] : allows quantification of absolute coronary blood flow (mL/min) and absolute microvascular resistance (Wood units) → more reproducible and adenosine-free.
- A previous study with short follow-up (control angiogram ≤ 2 months) showed some in absolute coronary blood flow and resistance after CTO PCI[2].

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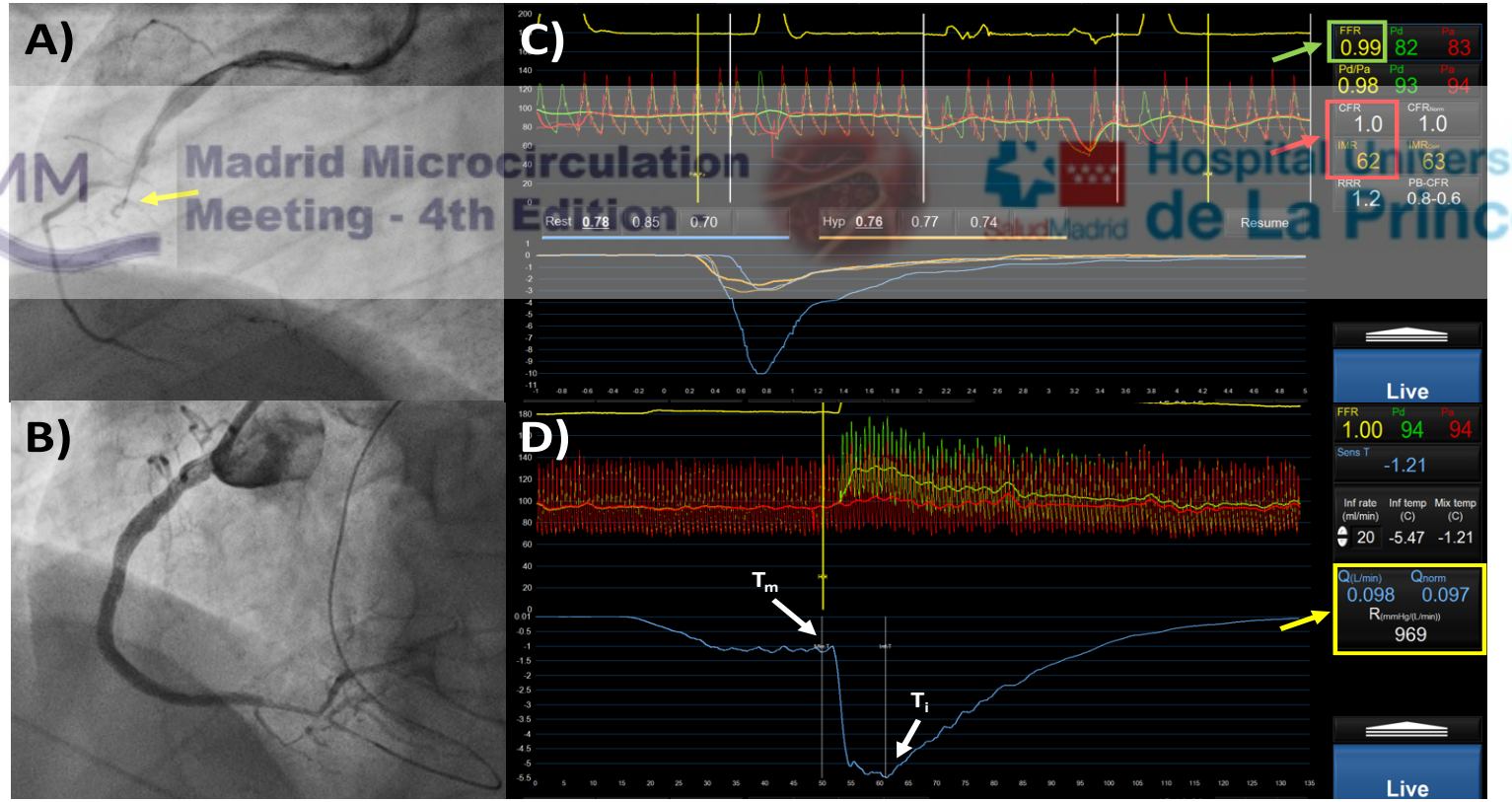
Objective: To assess absolute coronary flow (and resistance) measured by continuous thermodilution immediately after PCI of a CTO and 6 months after the procedure.

1. Fournier S, et al. Normal values of thermodilution-derived absolute coronary blood flow and microvascular resistance in humans. EuroIntervention. 2021;17:e309-e316.
2. Keulards DCJ et al. Recovery of Absolute Coronary Blood Flow and Microvascular Resistance After Chronic Total Occlusion Percutaneous Coronary Intervention: An Exploratory Study. J Am Heart Assoc. 2020 May 5;9(9):e015669.

Methods

Inclusion criteria

- Patients with a clinical indication for PCI of a CTO in whom, a baseline study is performed after PCI and an angiographic follow-up at 6 months after the procedure.



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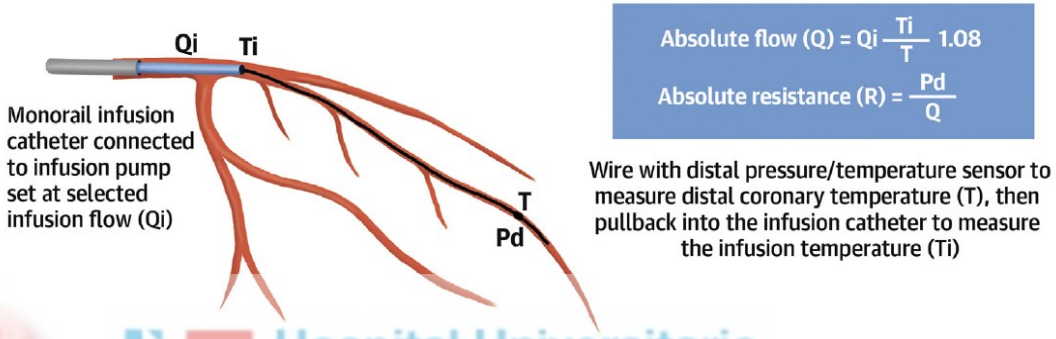
García-Guimarães M, Gutiérrez-Barrios A, Gómez-Lara J, et al. Microvascular dysfunction and invasive absolute coronary flow after percutaneous coronary intervention for a chronic total occlusion. The FLOW-CTO study. Rev Esp Cardiol (Engl Ed). 2022; 75:769-771.

Functional assessment - determinations

1. PressureWire X (Abbott Vascular, Santa Clara, California)

- Hyperemia with adenosine (bolus thermodilution method)
  - Fractional Flow Reserve (FFR)
  - Index of Microcirculatory Resistance (IMR)
  - Coronary flow reserve (CFR)



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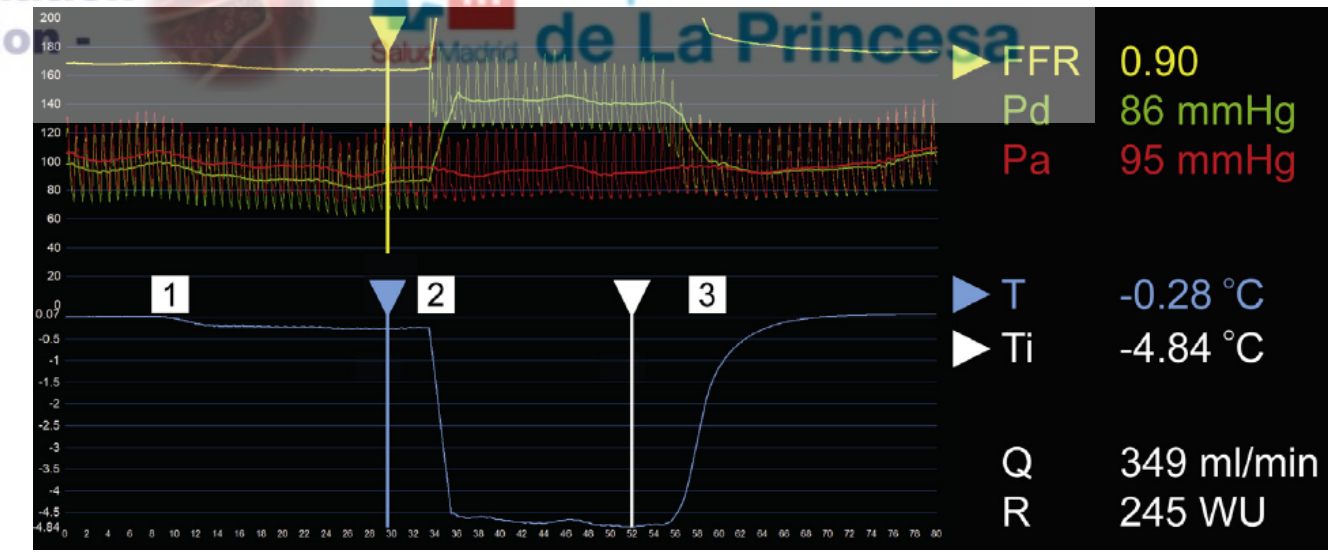


2. RayFlow (Hexacath, Paris, France)

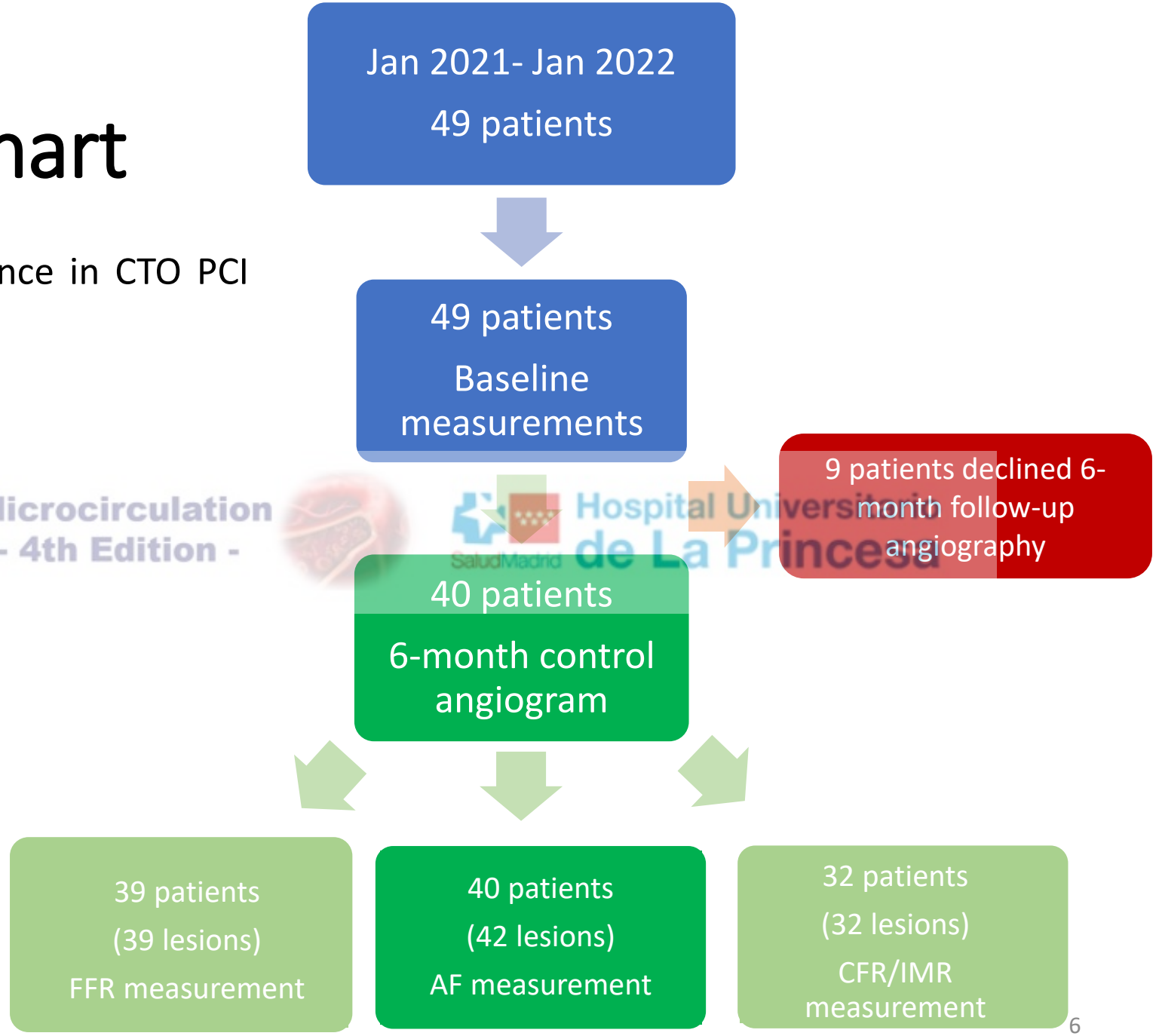
- Absolute Flow (mL/min)
- Resistance (Woods units)

3. Measurements were analyzed with **Coroventis (Coroflow, Uppsala, Sweden)**.

Results – flow chart

4 Spanish centers with broad experience in CTO PCI and coronary physiology:

- Hospital del Mar, Barcelona
- Hospital Universitari de Bellvitge, Barcelona
- Hospital Puerta del Mar, Cádiz
- Hospital de La Princesa, Madrid



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Results - background

	N=40
Sex (male)	36 (90)
Age (years)	63 [55-69]
Height (cm)	171 [169-174]
Weight (kg)	79 [73-88]
BMI (kg/m^2)	27 [25-29]
Overweight (BMI >=25)	30 (75)
Obesity (BMI >=30)	9 (23)
Systemic hypertension	29 (73)
Hyperlipidemia	27 (68)
Diabetes mellitus	15 (38)
Insulin dependent DM	6/15 (40)
Smoking habit	
Never	18 (45)
Ex-smoker	10 (25)
Current habit	12 (30)
Peripheral arterial disease	4 (10)
Family history IHD	5 (13)
CKD (eGFR <60 ml/min/m^2)	5 (13)

	N=40
Previous IHD	24 (60)
Previous MI	14 (35)
MI location	
Anterior	3/14 (21)
Inferior	6/14 (43)
Lateral	2/14 (14)
Undetermined	3/14 (21)
Previous PCI	21 (53)
Previous CABG	2 (5)
LVEF (%)	55 [45-61]
LV systolic dysfunction (LVEF<40%)	6 (15)
Anginal symptoms	36 (90)
Angina CCS class	
I	4 (11)
II	28 (78)
III	4 (11)
IV	0
Previous HF	5 (13)
HF NYHA class	
I	0
II	4 (80)
III	1 (20)
IV	0

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Results - background

	N=40
Ischemia/viability test	23 (58)
Type of ischemia/viability test	
Stress echocardiogram	5 (22)
SPECT/PET	9 (39)
cMR	9 (39)
Inducible ischemia	23 (58)
Viability	40 (100)
Aspirin	36 (90)
Clopidogrel	8 (20)
Ticagrelor	18 (45)
Prasugrel	2 (5)
DAPT	26 (65)
Oral anticoagulation	2 (5)
Betablockers	36 (90)
ACEi-ARBs	33 (83)
Statins	38 (95)
Calcium channel blocker	6 (15)
Nitrates	11 (28)
Ranolazine	5 (13)
Ivabradine	1 (3)
Trimetazidine	1 (3)

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Results – CTO characteristics

	N=42
CTO vessel	
LAD	11 (26)
LCX	7 (17)
RCA	24 (57)
Main collateral vessel	
LAD	26 (62)
LCX	5 (12)
RCA	11 (26)
Bridge collaterals	15 (36)
Retrograde filling	42 (100)

	N=42
Collateral size (Werner)	
0	2 (5)
1	17 (40)
2	23 (55)
Rentrop classification	
0	0
1	6 (14)
2	13 (31)
3	23 (55)
J-CTO tapered blunt	24 (57)
J-CTO calcification	16 (38)
J-CTO bending	12 (29)
J-CTO length	18 (43)
J-CTO retry	5 (12)
J-CTO total score	
0	4 (9.5)
1	15 (36)
2	11 (26)
3	11 (26)
4	1 (2.4)

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Results – CTO PCI

	N=42
Antegrade access	
Radial	2 (5)
Femoral	39 (93)
Ulnar	1 (2)
Brachial	0
Retrograde access	
Radial	20 (48)
Femoral	20 (48)
Ulnar	0
Brachial	2 (5)
Antegrade guiding size (French)	
6 F	5 (12)
7 F	25 (59)
8 F	12 (29)

	N=42
CTO technique	
AWE	30 (71)
RWE	7 (17)
ADR	5 (12)
RDR	0
Amount of contrast (mL)	267 [205-345]
Procedural time (min)	116 [90-155]
Fluoroscopy time (min)	37 [29-45]
Total number of stents implanted	2 [1-3]
Total stent length (mm)	60 [41-76]
Maximal stent diameter	3.26 ± 0.4
Minimal stent diameter	2.7 ± 0.4
Final TIMI flow	
0	0
1	0
2	2 (5)
3	40 (95)
QCA analysis post-PCI (in-segment)	
Minimal diameter (mm)	1.9 ± 0.5
Maximal diameter (mm)	3.8 ± 0.8
Mean diameter (mm)	2.9 ± 0.5
Minimal area (mm^2)	3.0 ± 1.5
Segment length (mm)	64 [49-76]
% Diameter stenosis (DS)	28 ± 10
CAAS vFFR	0.89 [0.85-0.94]

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Results – coronary physiology immediately after CTO PCI

	N=42
FFR	0.89 [0.82-0.94]
FFR ≤ 0.80	9 (21)
CFR	2.0 [1.4-2.5]
IMR	13 [8-21]
MVD (CFR<2.0 ± IMR ≥25)	24 (57)
AF Q (mL/min)	188 [127-240]
AF Qnorm (mL/min)	197 [138-263]
R (WU)	451 [315-625]

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Results – 6 months control angiogram

	N=42
Time to follow-up (months)	6 [5-8]
QCA analysis post-PCI (in-segment)	
Minimal diameter (mm)	1.9 ± 0.5
Maximal diameter (mm)	3.5 ± 0.7
Mean diameter (mm)	2.7 ± 0.4
Minimal area (mm^2)	3.1 ± 1.3
% Diameter stenosis (DS)	24 ± 12
Binary restenosis	6 (14)
CAAS vFFR	0.89 [0.82-0.94]
Coronary physiology	
FFR	0.87 [0.82-0.92]
FFR ≤ 0.80	7/39 (18)
CFR	2.75 [1.6-3.6]
IMR	13 [10-24]
MVD (CFR<2.0 ± IMR ≥25)	1/32 (3)
AF Q (mL/min)	214 [149-277]
AF Qnorm (mL/min)	236 [172-300]
R (WU)	349 [287-433]

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Results – baseline vs follow-up

	Baseline	Follow-up	p-paired
FFR	0.88 ± 0.08	0.85 ± 0.10	0.0820
CFR	1.99 ± 0.9	2.7 ± 1.3	0.0086
IMR	15 ± 9	13 ± 8	0.2543
MVD (CFR<2.0 ± IMR ≥25)	18/32 (56)	1/32 (3)	<0.001
AF Q (mL/min)	187 ± 68	223 ± 95	0.0077
AF Qnorm (mL/min)	208 ± 87	262 ± 130	0.0081
R (WU)	474 ± 203	368 ± 140	0.0004

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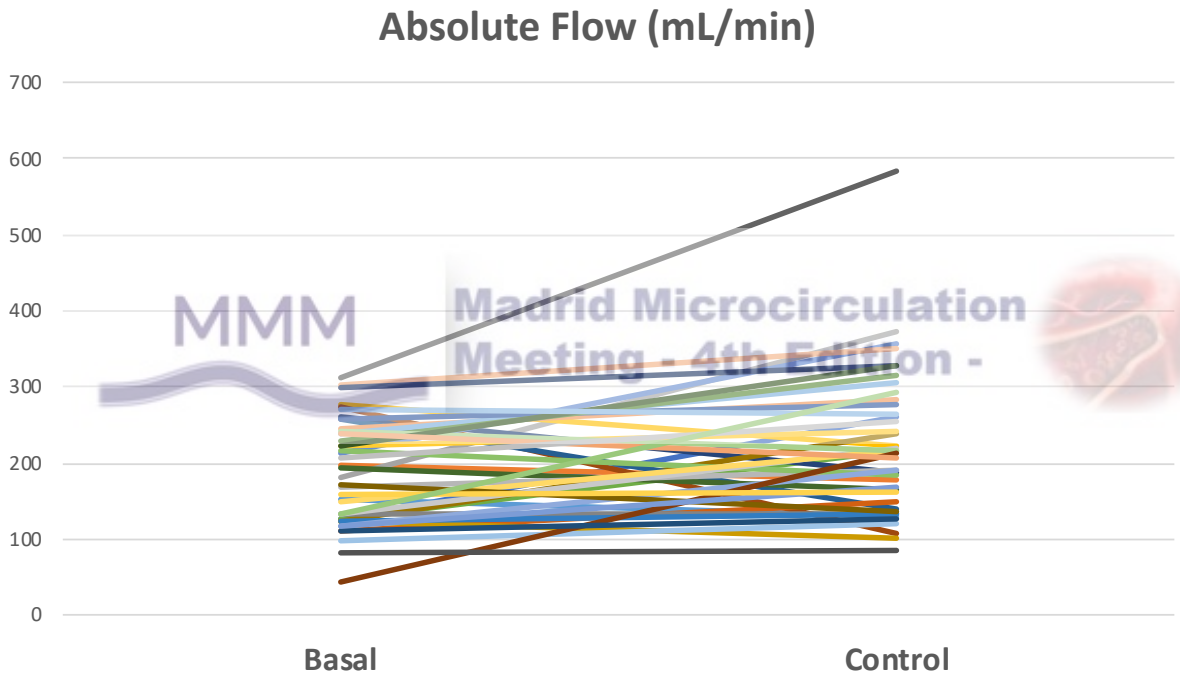
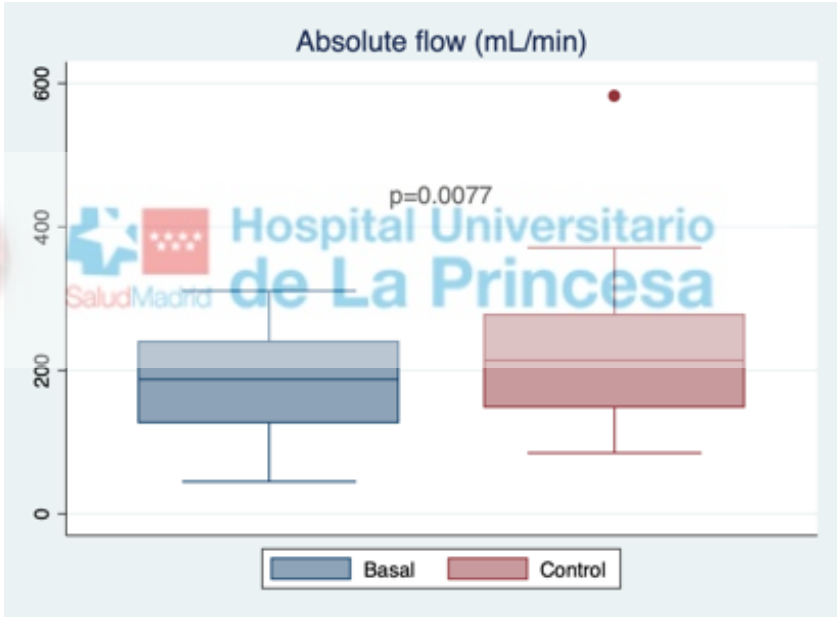
Results – Absolute flow





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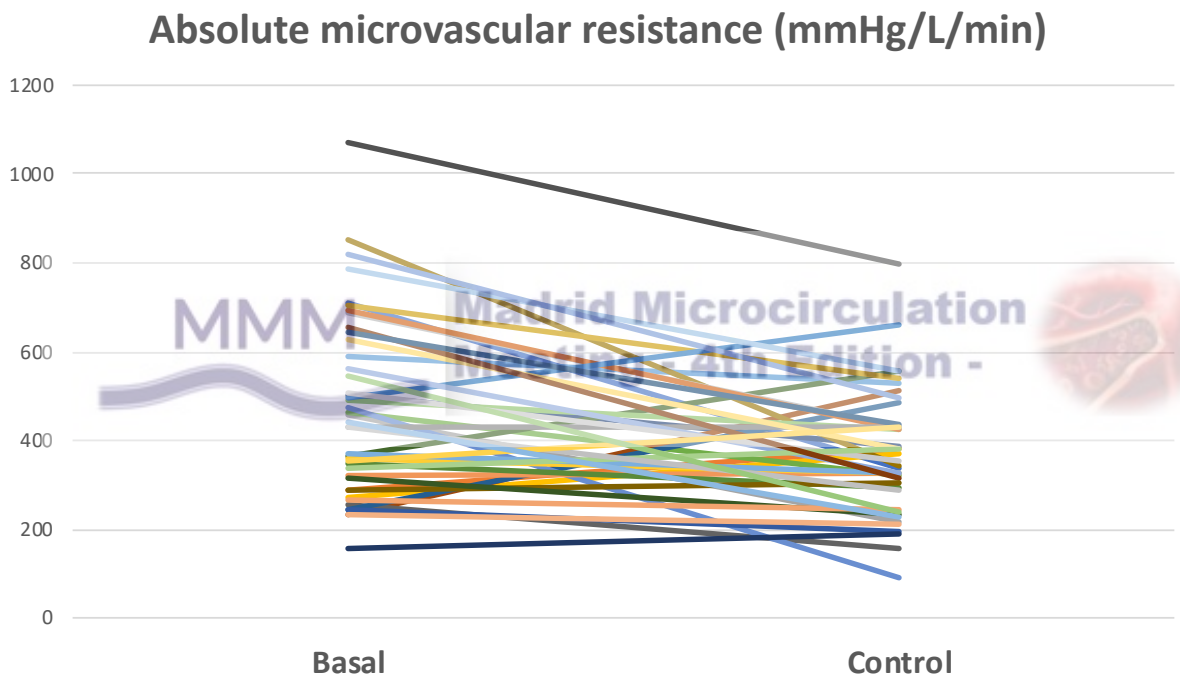
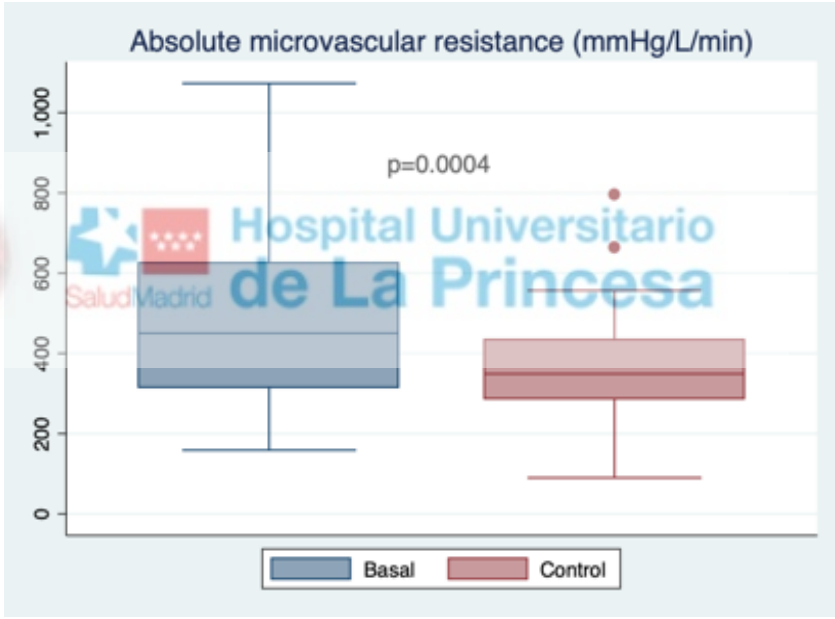
67% lesions AF increased
Mean change 19% increase

Results – Resistance





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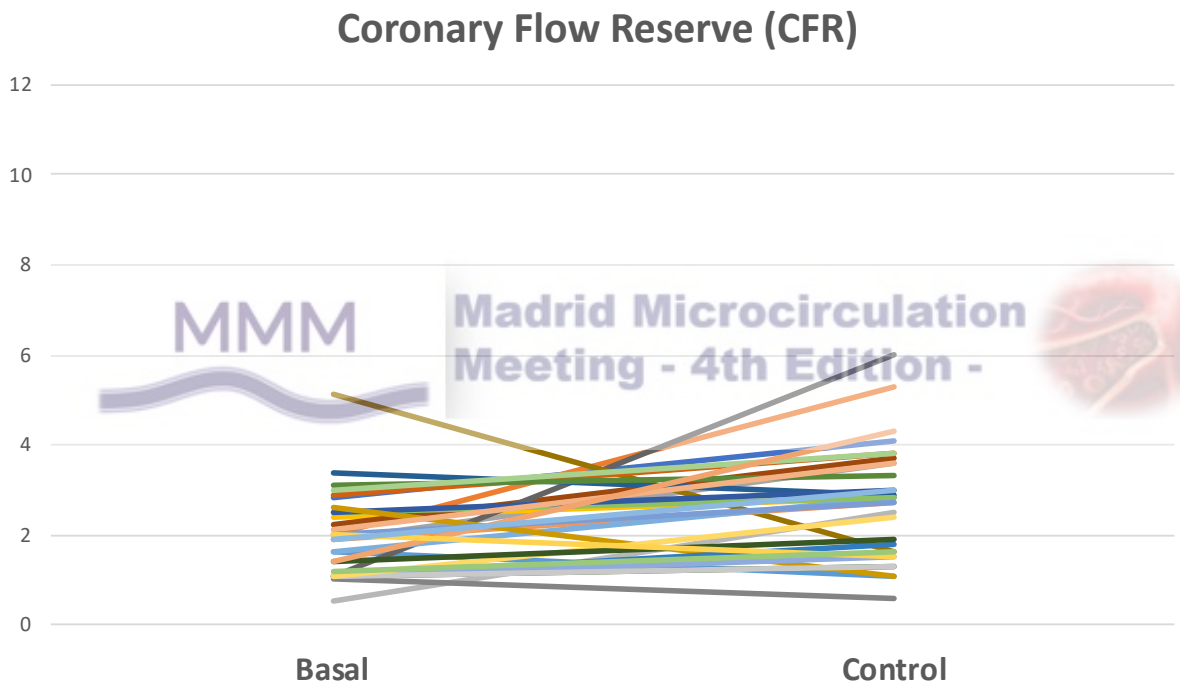
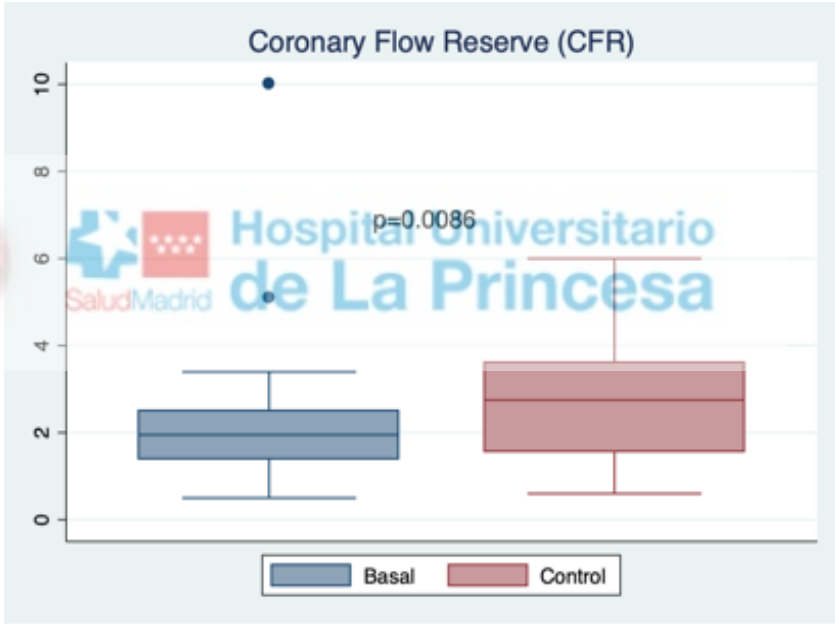
71% lesions R decreased
Mean change 29% decrease

Results – Coronary Flow Reserve





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78% lesions CFR increased
Mean change 36% increase

Conclusions

1. A significant percentage of patients (57%) undergoing PCI of a CTO have criteria of MVD (based on CFR and IMR) immediately after coronary artery recanalization. This percentage is markedly reduced at 6 months follow-up.
2. We observed a significant increase in the CFR values (by 39%) at 6-month follow-up versus baseline.
3. Using the continuous thermodilution method, we observed a significant increase in absolute coronary flow (by 19%), accompanied by a decrease in microvascular resistance (by 29%) at 6-month follow-up.
4. Further studies are needed to assess the relationship between changes observed during follow-up in flow and resistance profile and improvement in symptoms and myocardial function after CTO PCI.

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Thank You for your attention.

Any questions?

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