ANALYSER ET TRAITER LES LÉSIONS CORONAIRES CALCIFIÉES

Caractériser les calcifications coronaires :
les outils indispensables

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☑ Je déclare les liens d'intérêt potentiels suivants :

- **Consulting : Abbott Vascular, Boston Scientific, Shockwave Medical**
- **Proctoring: Abbott Vascular, Boston Scientific**
- **Bourses de Recherche: Abbott Vascular, Fonds Montsouris**

The Cinefluorographic Detection and Recording of Calcifications Within the Heart

Results of 803 E

JOSEPH JORGENS, M.D., Ph.D.,[1] NORMAN BLA

IN THE PAST, many different methods have been employed for demonstrating calcifications within the heart, including roentgenography (1-4), roentgen kymography (5), and planigraphy (6). Each of these has definite limitations. Over the last two years there have been performed in the Veterans Administration Hospital, Minneapolis, Minn., 803 cinefluorographic examinations for this purpose, and it is the authors' opinion that cinefluorography is now the method of choice for detecting and localizing cardiac calcification.

In the diagnosis, treatment, and prognosis of cardiac disease (7), the detection

graphic examinations of the heart were performed during the last two years at

coronary artery in 58. In 20 cases the right coronary artery was calcified without

The Lancet · Saturday 25 April 1964

DETECTION OF CORONARY-ARTERY CALCIFICATION DURING LIFE

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CALCIFIED lesions of the coronary arteries were one of the earliest abnormalities of these vessels to be recorded. Calcification was described by Bellini in Italy in 1643, and by Thebesius in Germany in 1686. John Hunter (1778) was the first to undertake a postmortem on a man "who had died in a violent transport of anger" and who had previously had angina of effort. He found calcification in the coronary arteries "... the two coronary arteries, from their origin to many of their ramifications upon the heart, were become one piece of bone".

The first radiographs of calcified coronary arteries were published in 1908 by Simmonds, who studied hearts excised at necropsy. Blankenhorn and Stern (1959), who found 43% of excised hearts showed calcification, classified the types of the calcification into three radiographic patterns:

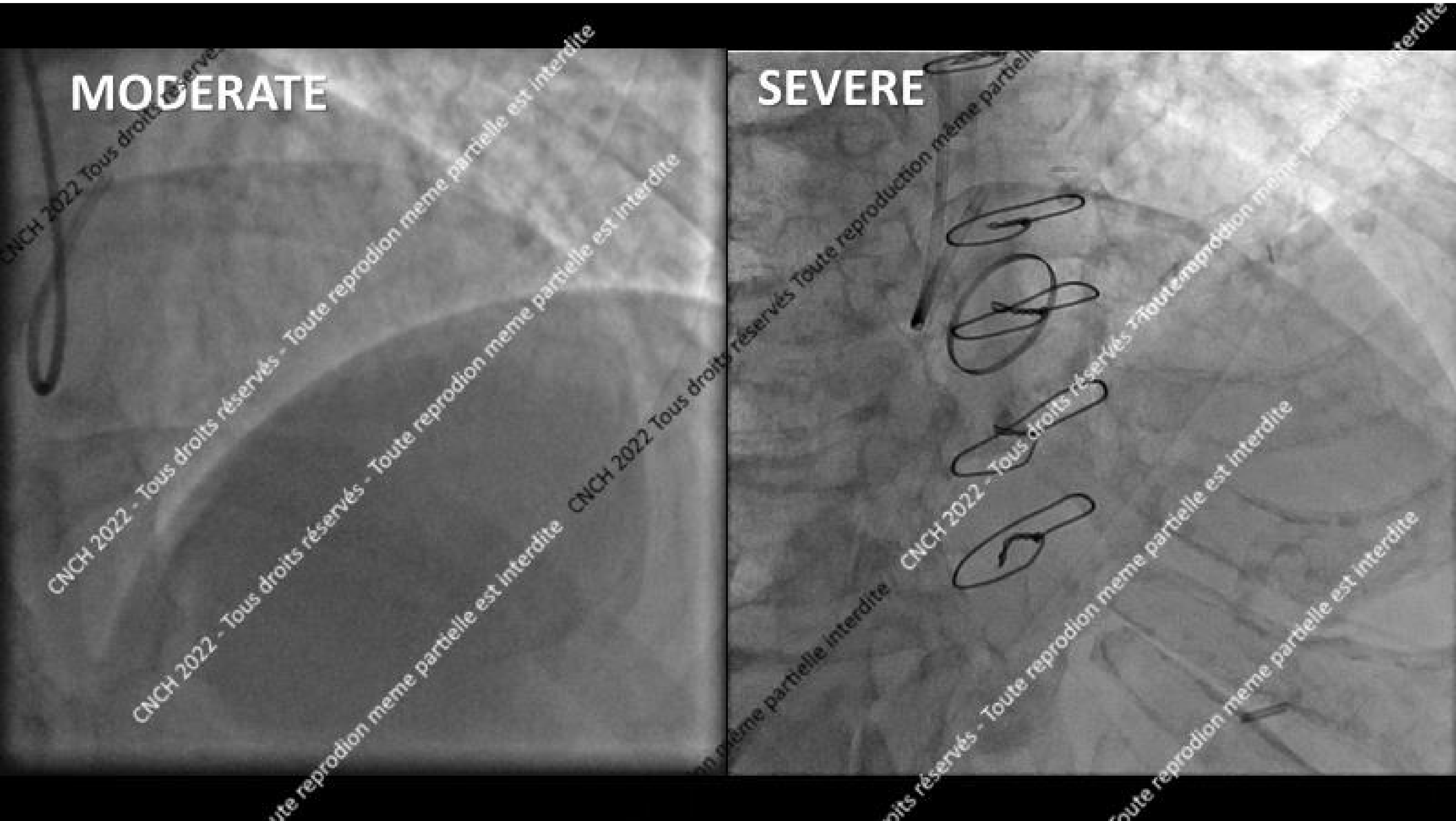
been confirmed at necropsy. These authors used a Potter-Bucky diaphragm with a short exposure time, and they emphasised the need for correct positioning for visualisation of the coronaries. Of a series of patients investigated by Hobbe and Wright (1950), 3% showed coronary calcification. According to these authors, the significance of calcified coronary arteries has to be evaluated on an individual basis: the younger the patient, the more important the finding.

The present paper describes an investigation of cardiac calcification in 250 patients with ischæmic heart-disease and 250 control subjects matched for age and sex. The radiological techniques used are described, and the incidence of calcification detected during life by these means is documented.

The Subjects

250 patients with ischæmic heart-disease were compared with 250 control patients matched for age and sex. All those with ischæmic heart-disease had electrocardiographic evidence of myocardial infarction or of myocardial ischæmia at rest or after an exercise test using the standard Master two-step test. In all subjects blood-pressure was read after 5 minutes' sitting in a chair, blood was taken for serum-cholesterol estimation, and an electrocardiogram was obtained. Serum-cholesterol was estimated by the method of Jurand and Albert-Recht (1962).

Most of the controls were patients attending a general medical outpatient department with such conditions as fibrositis, headaches, varicose veins, dyspepsia, and various non-specific complaints for which no obvious organic cause was apparent. The remaining controls were orthopædic outpatients, in-patients admitted for a non-cardiac cause (and with no evidence of cardiovascular disease), and healthy members of the staff. Control subjects with diastolic blood-pressure over 100 mm. Hg, systolic blood-pressure over 180 mm. Hg, or serum-cholesterol over 275 mg. per 100 ml. were excluded.

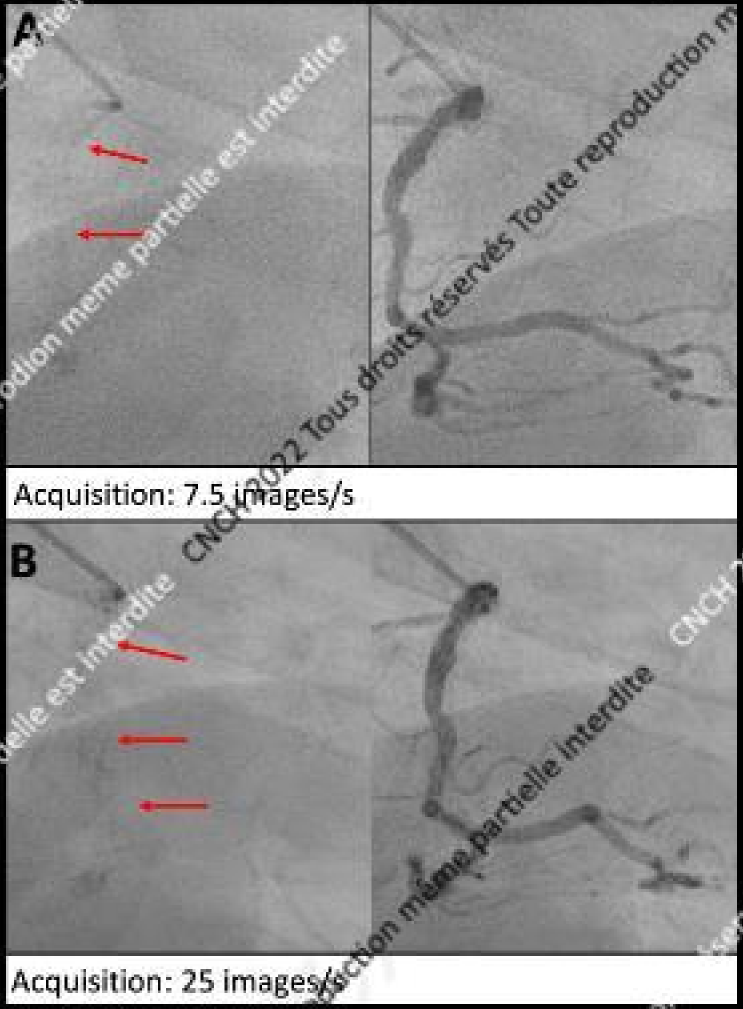

MODERATE
SEVERE

CLASSIFICATION OF CALCIFIED LESIONS SEVERITY ON CORONARY ANGIOGRAPHY

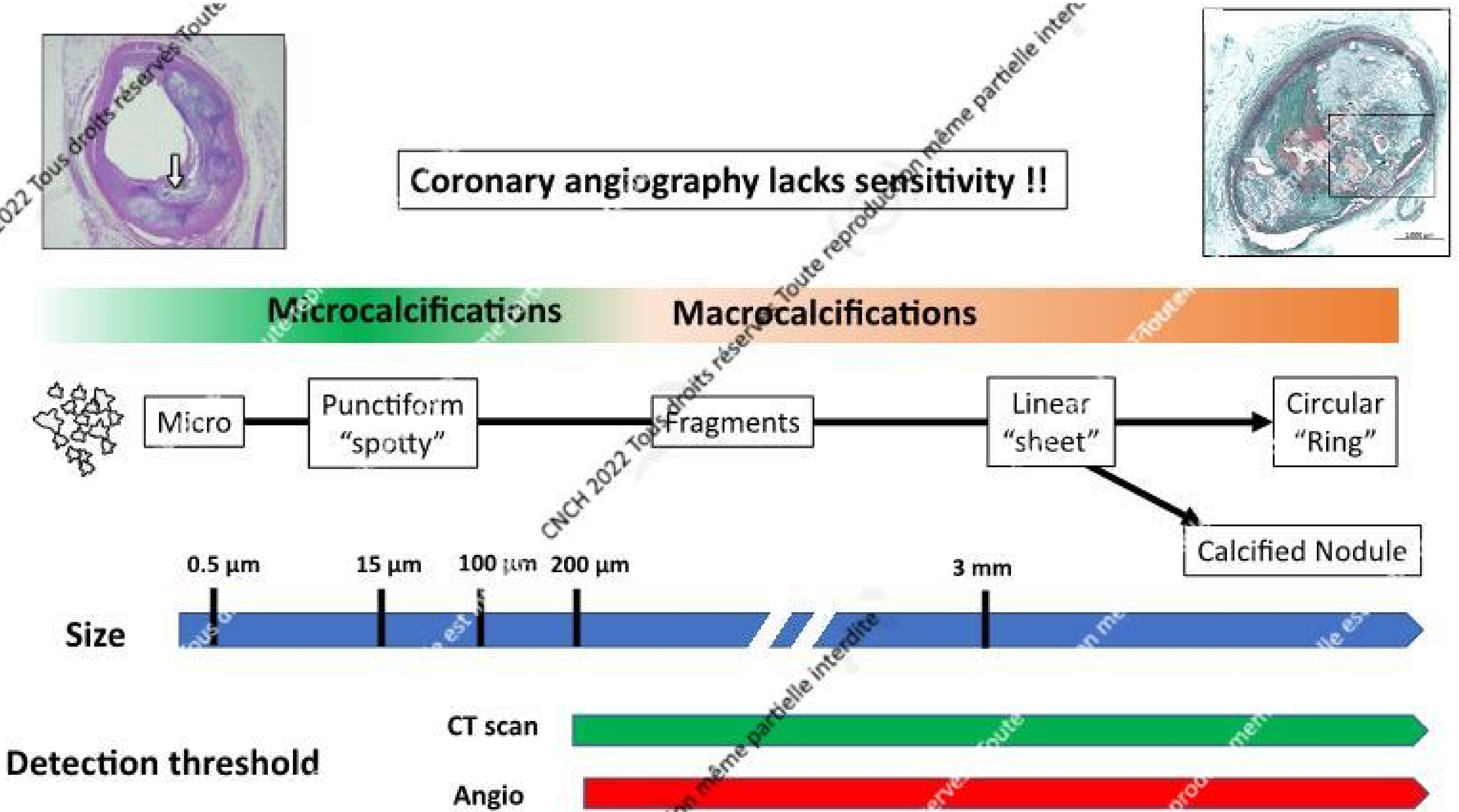
- Moderate : lesion with radio-opacities noted only during the cardiac cycle before contrast dye injection
- Severe: lesion with radio-opacities seen without cardiac motion before contrast dye injection, visible on both sides of the arterial lumen

Mintz G. et al. Circulation. 1995;91:1959–1965.

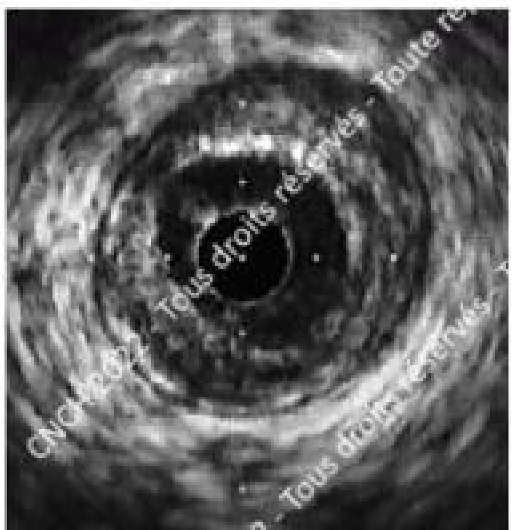
HOW TO IMPROVE CALCIUM DETECTION ON ANGIO : INCREASED IMAGE FREQUENCY ?

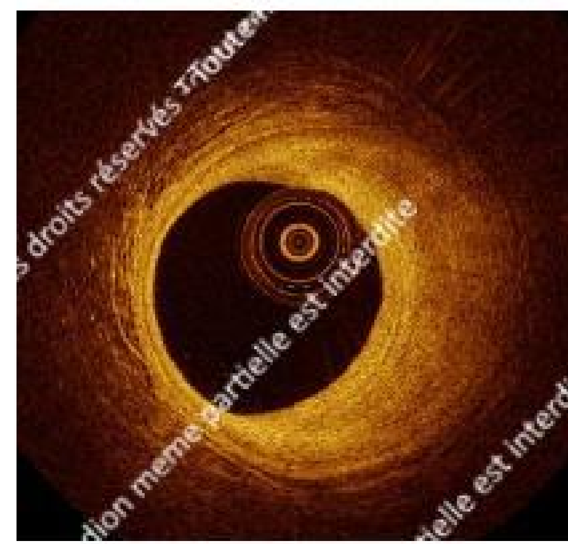


Amabile N et al., Ann Cardiol Angeiol 2


Coronary angiography lacks sensitivity !!
Microcalcifications
Macrocalcifications
Micro
Punctiform "spotty"
Fragments
Linear "sheet"
Circular "Ring"
Calcified Nodule
0.5 µm
15 µm
100 µm
200 µm
3 mm
Size
Detection threshold
CT scan
Angio

Better calcifications identification → Intra coronary imaging ?

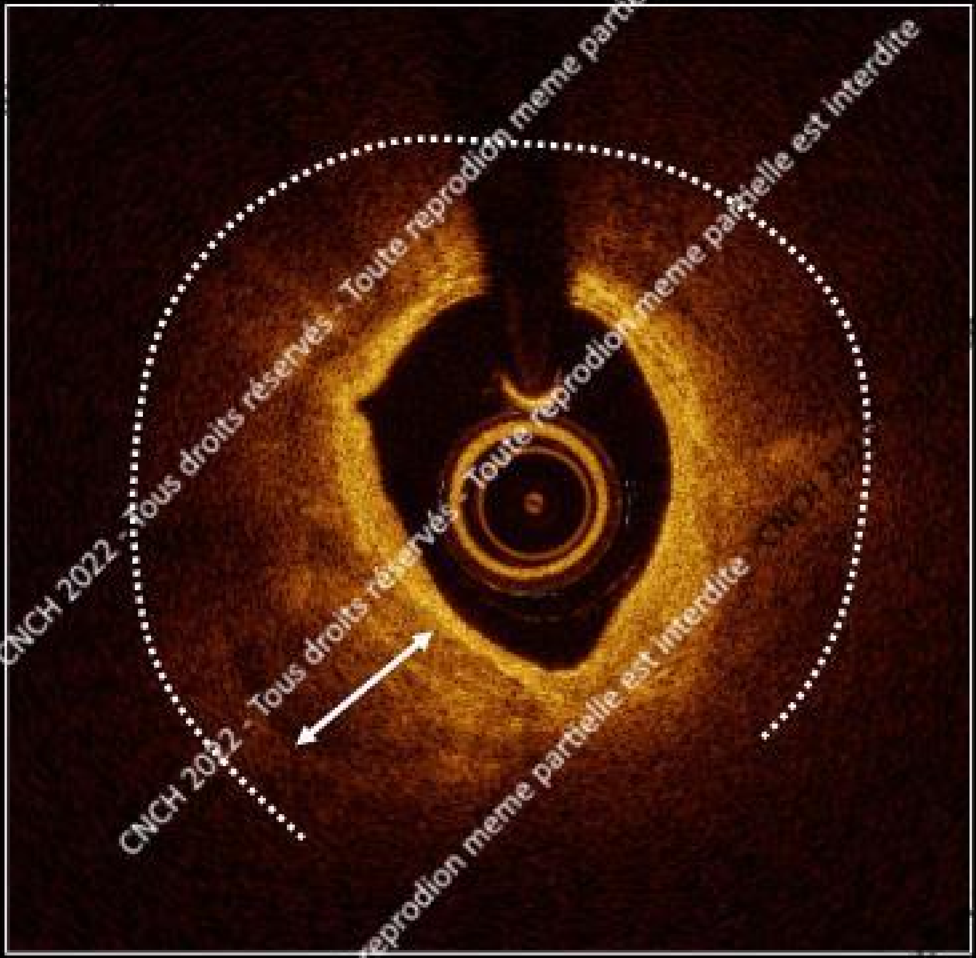




IVUS ?

OCT ?

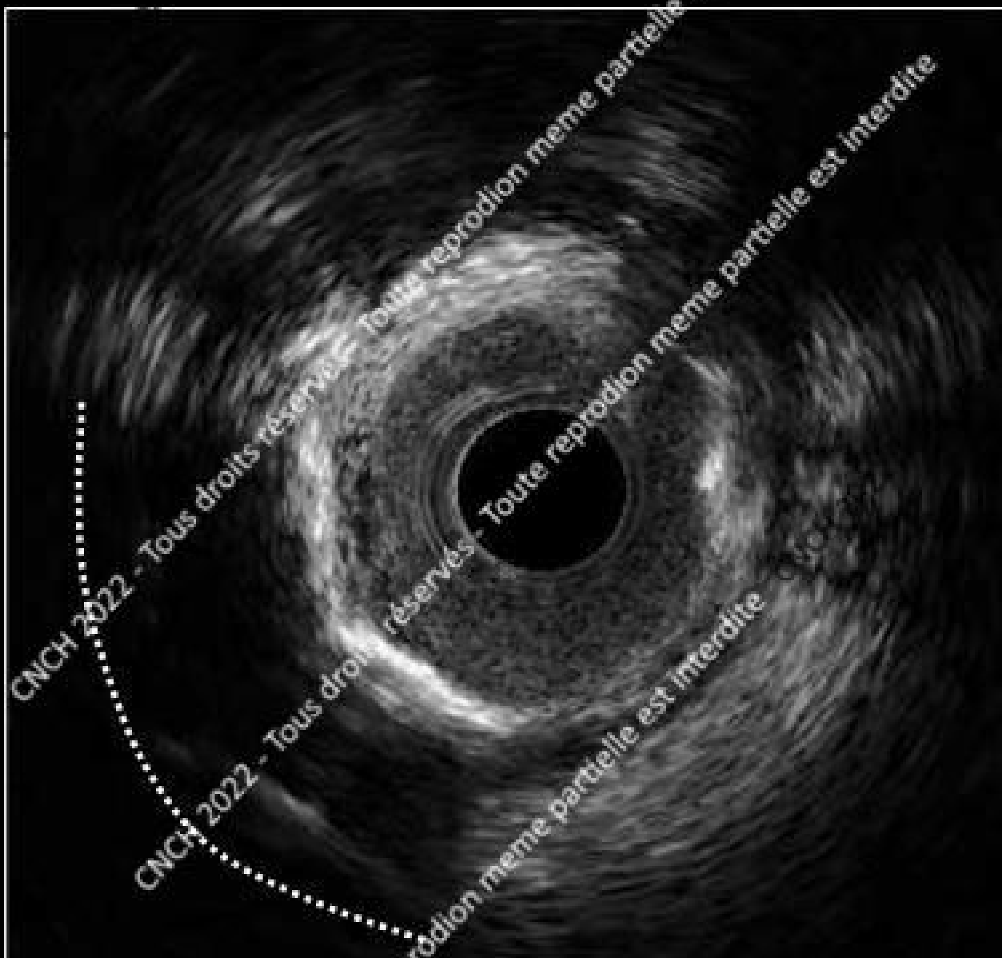
Intra coronary calcification identified by OCT

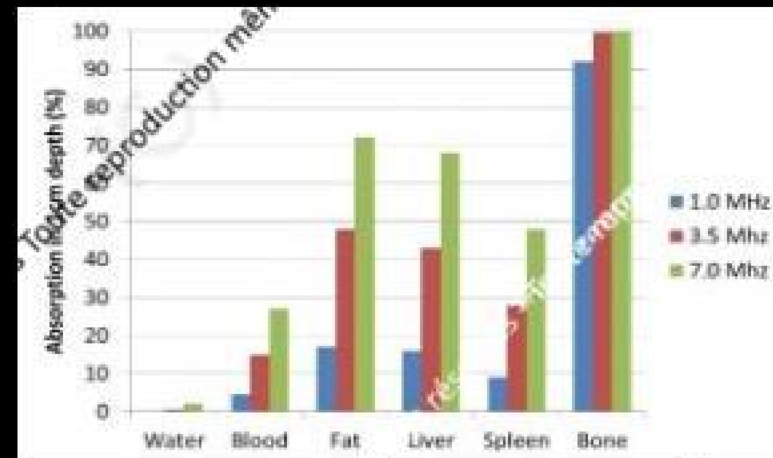


Plaque Type	Backscattering (mm^{-1})	Attenuation (mm^{-1})
Calcium	**4.9 ± 1.5**	**5.7 ± 1.4**
Fibrous	**18.6 ± 6.4**	**6.4 ± 1.2**
Lipid	**28.6 ± 8.9**	**13.7 ± 4.5**
	Signal strength	***Light loss***

- Subintimal hyposignal image with sharp borders
- Moderated backscattering
- Limited signal attenuation

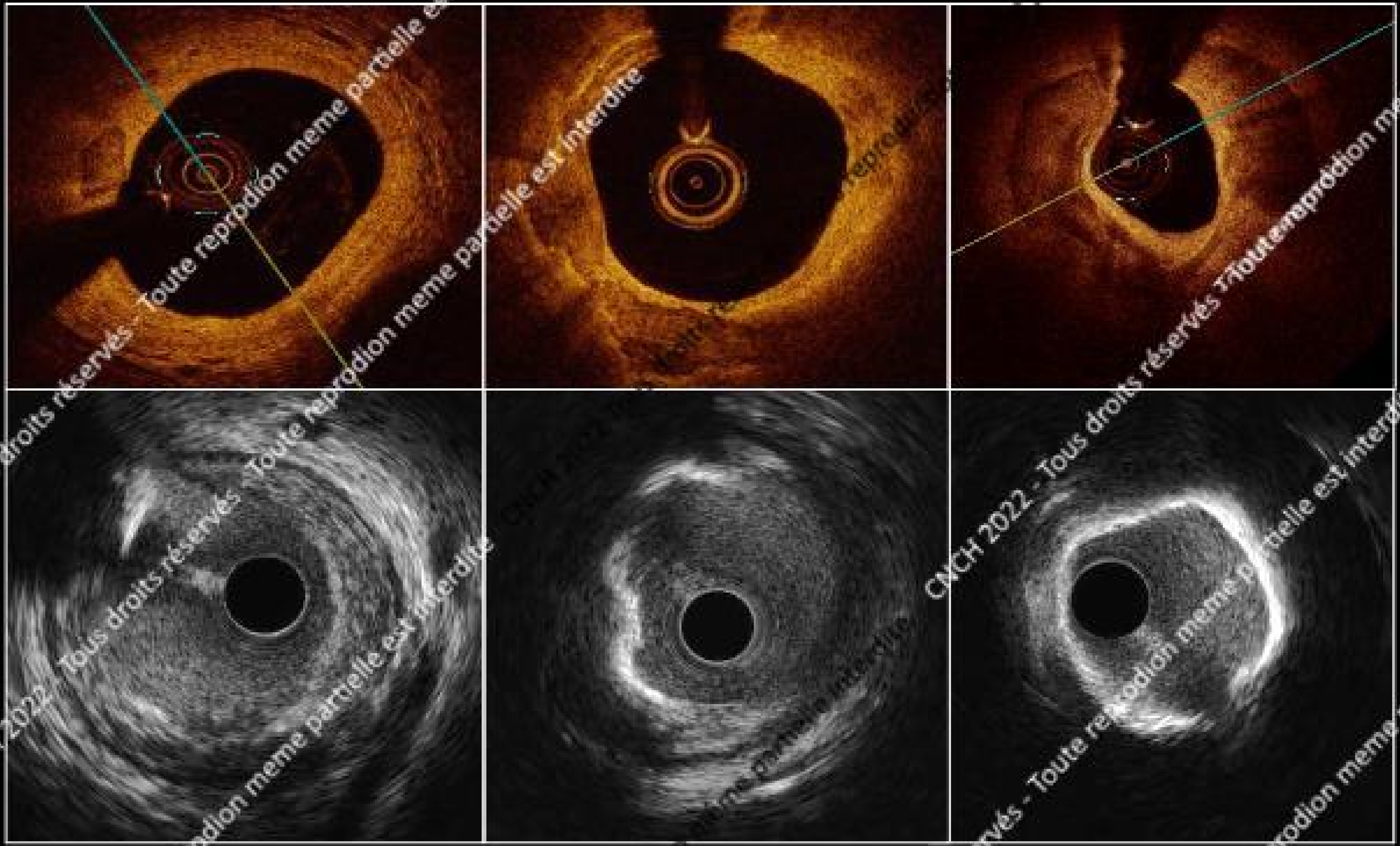
Intra coronary calcification identified by IVUS





- Bright hyperreflective image
- Underlying signal void due to US attenuation « accoustic shadowing »

Calcification morphology assessed by IC imaging



Spotty Eccentric Concentric

Calcification morphology assessed by IC imaging : calcified nodule

IVUS & OCT for calcifications: Validation with pathology

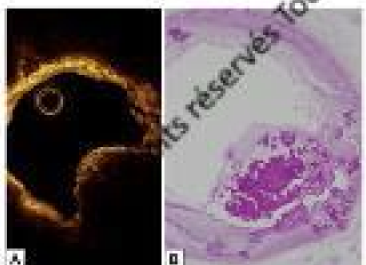
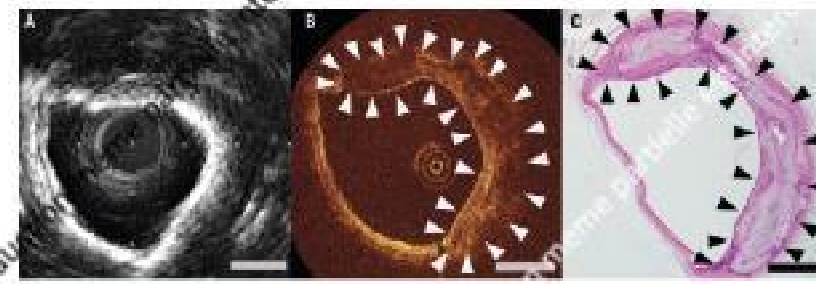


Table 3. Assessment of IB-IVUS and Conventional IVUS for Plaque Characterization

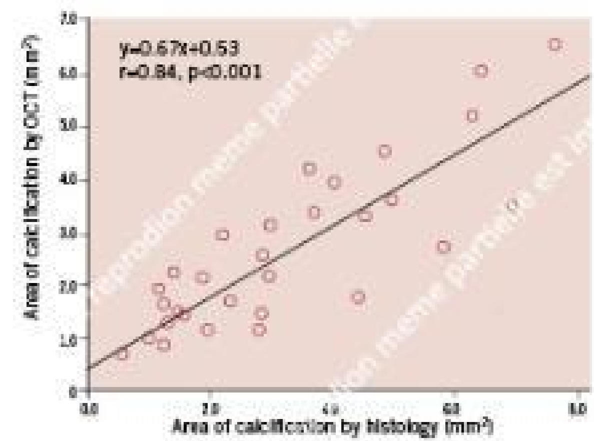
	Sensitivity	Specificity	PPV	NPV
OCT				
CL (n = 7)	100 (98–100)	100 (98–100)	100 (98–100)	100 (98–100)
FI (n = 88)	98 (95–100)	94 (89–99)	98 (95–100)	94 (89–99)
LP (n = 19)	95 (85–100)	98 (92–100)	90 (77–100)	99 (99–100)
IH (n = 7)	86 (60–100)	100 (98–100)	100 (98–100)	99 (98–100)
IB-IVUS				
CL (n = 7)	100 (99–100)	99 (92–100)	88 (66–100)	100 (99–100)
FI (n = 82)	94 (89–99)	84 (76–92)	94 (89–99)	84 (76–92)
LP (n = 19)	84 (68–100)	97 (83–100)	84 (68–100)	97 (83–100)
IH (n = 6)	67 (40–100)	99 (91–100)	80 (48–100)	99 (91–100)
Conventional IVUS				
CL (n = 7)	100 (99–100)	99 (92–100)	88 (64–100)	100 (99–100)
FI (n = 80)	93 (87–99)	61 (50–72)	87 (80–94)	74 (67–87)
LP (n = 15)	67 (44–90)	95 (84–100)	67 (47–87)	95 (84–100)

Data are percentages. Number in parentheses are 95% confidence intervals.
NPV = negative predictive value; PPV = positive predictive value; other abbreviations as in Tables 1 and 2.

Kawasaki M et al. , J Am Coll Cardiol 2006;48:81– 8



	OCT (n=32)	IVUS (n=32)	Histology (n=32)	p
Lumen CSA (mm²)	5.3±2.6	5.4±2.6	4.7±2.3	0.361
Arc of calcification (°)	169±98	162±95	163±93	0.999
Area of calcification (mm²)	2.7±1.5	1.3±1.0*†	3.0±1.9	<0.001
EEM CSA (mm²)		14.7±4.1	13.2±3.7	0.133
Plaque plus media CSA (mm²)		9.3±2.4	7.6±2.9	0.011
Plaque burden (%)		64±9	58±18	0.071



Kume T et al. , Eurointervention 2011; 6:768-772

IVUS

Pros:

- No Contrast use
- Deep calcification assesement
- Excellent sensitivity & specificty

Limitations:

- Accoustic shadowing
- Limited microcalcifications assessment
- Calcium thickness assessment
- Calcium area measurement

OCT

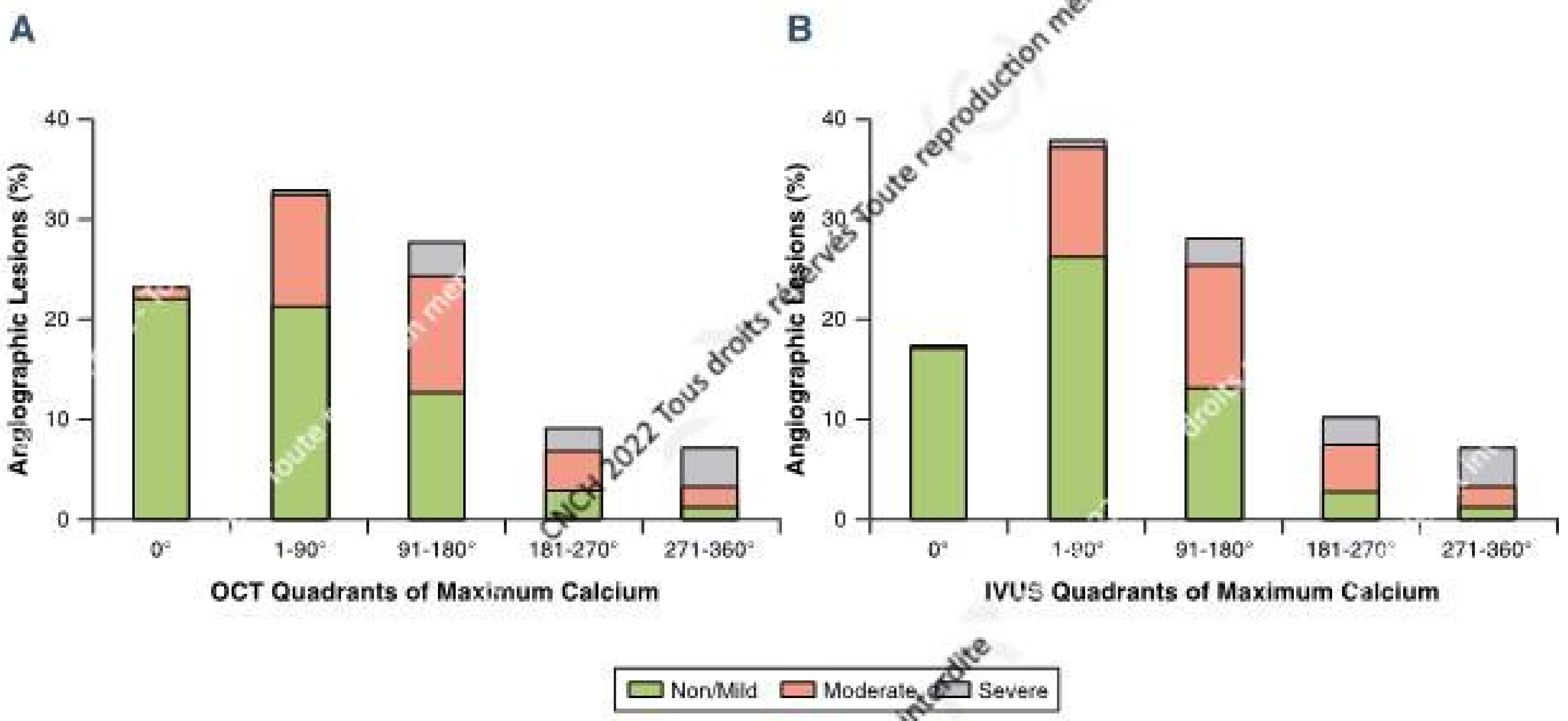
Pros:

- Fast
- Excellent spatial resolution
- Excellent sensitivity & specificty

Limitations:

- Mixed plaque with large lipid pool (false neg.)
- Deep calcifications assessment
- No plaque burden assessment
- Contrast use

Coronary calcifications : IVUS vs. OCT



(A) Coronary angiography detected 35% of 1-quadrant calcium, 55% of 2-quadrant calcium, 70% of 3-quadrant calcium, and 84% of 4-quadrant calcium seen by OCT. **(B)** Coronary angiography detected 31% of 1-quadrant calcium, 54% of 2-quadrant calcium, 75% of 3-quadrant calcium, and 83% of 4-quadrant calcium seen by IVUS. Abbreviations as in Figure 1.

Wang X. et al. J Am Coll Cardiol Img 2017;10:869–79

IVUS / OCT / Angio for Ca2+ diagnosis , in brief…

- Calcifications are identified in 35-40 % of cases by angio
- Severe calcifications are identified in 12% of cases by angio
- Calcifications are identified in 75-80% % by IC imaging
- IVUS and OCT performances are comparable for calcifications identification
- Angio severity is poorly correlated with radial extent
- Angio severity is modestly correlated with calcium thickness and length

Use of ICI in daily practice for calcified lesion management

Use of ICI in daily practice for calcified lesion management

1. High risk lesions identification

2. Preparation planning

3. Results evaluation

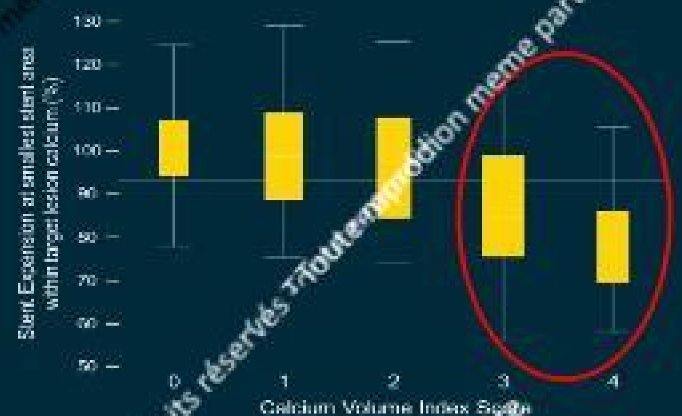
Influence of Ca^{2+} on Stent Expansion by OCT

OCT-Based Calcium Volume Index Score[1]

1. Maximum Calcium Angle (°)	≤ 90°	► 0 point
	90° < Angle ≤ 180°	► 1 point
	> 180°	► 2 points
2. Maximum Calcium Thickness (mm)	≤ 0.5 mm	► 0 point
	> 0.5 mm	► 1 point
3. Calcium Length (mm)	≤ 5.0 mm	► 0 point
	> 5.0 mm	► 1 point
Total score	**0 to 4 points**	

Rule of 5's

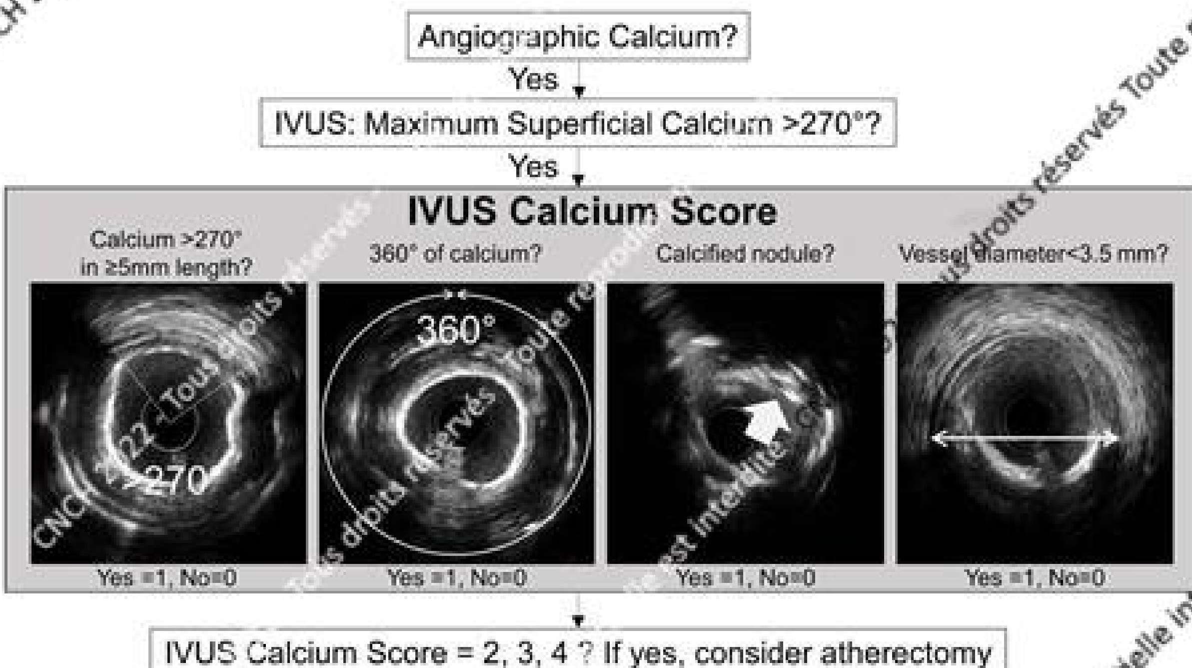
- 0.5 mm thickness
- 5.0 mm long
- 50% vessel arc

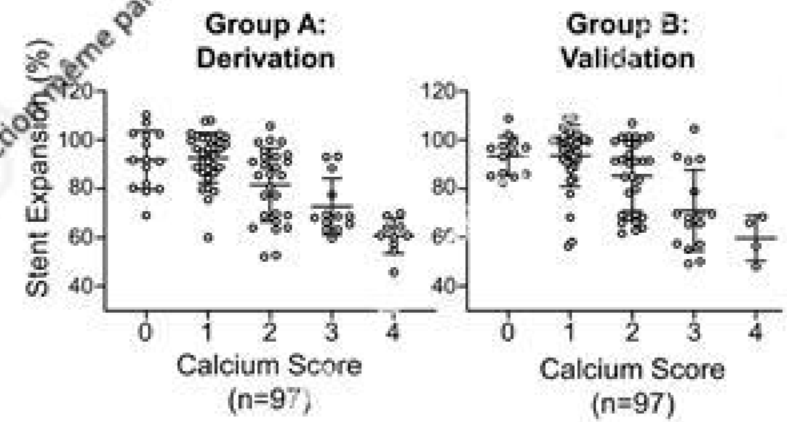


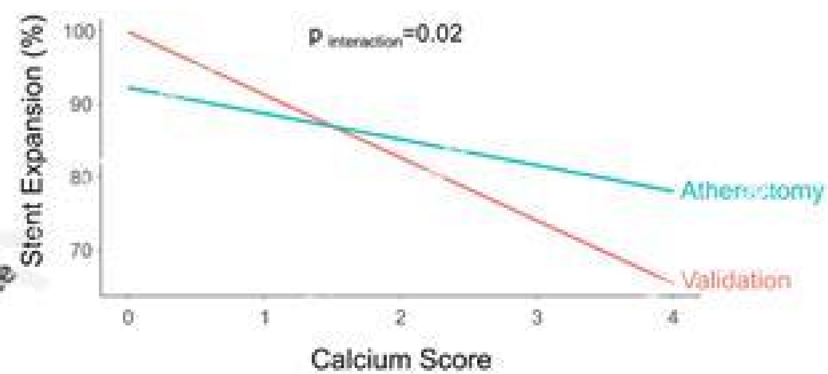
Fujino A. et al. Eurointervention. 2018 ; 13(18):e2182-e2189

ORIGINAL ARTICLE

Intravascular Ultrasound–Derived Calcium Score to Predict Stent Expansion in Severely Calcified Lesions

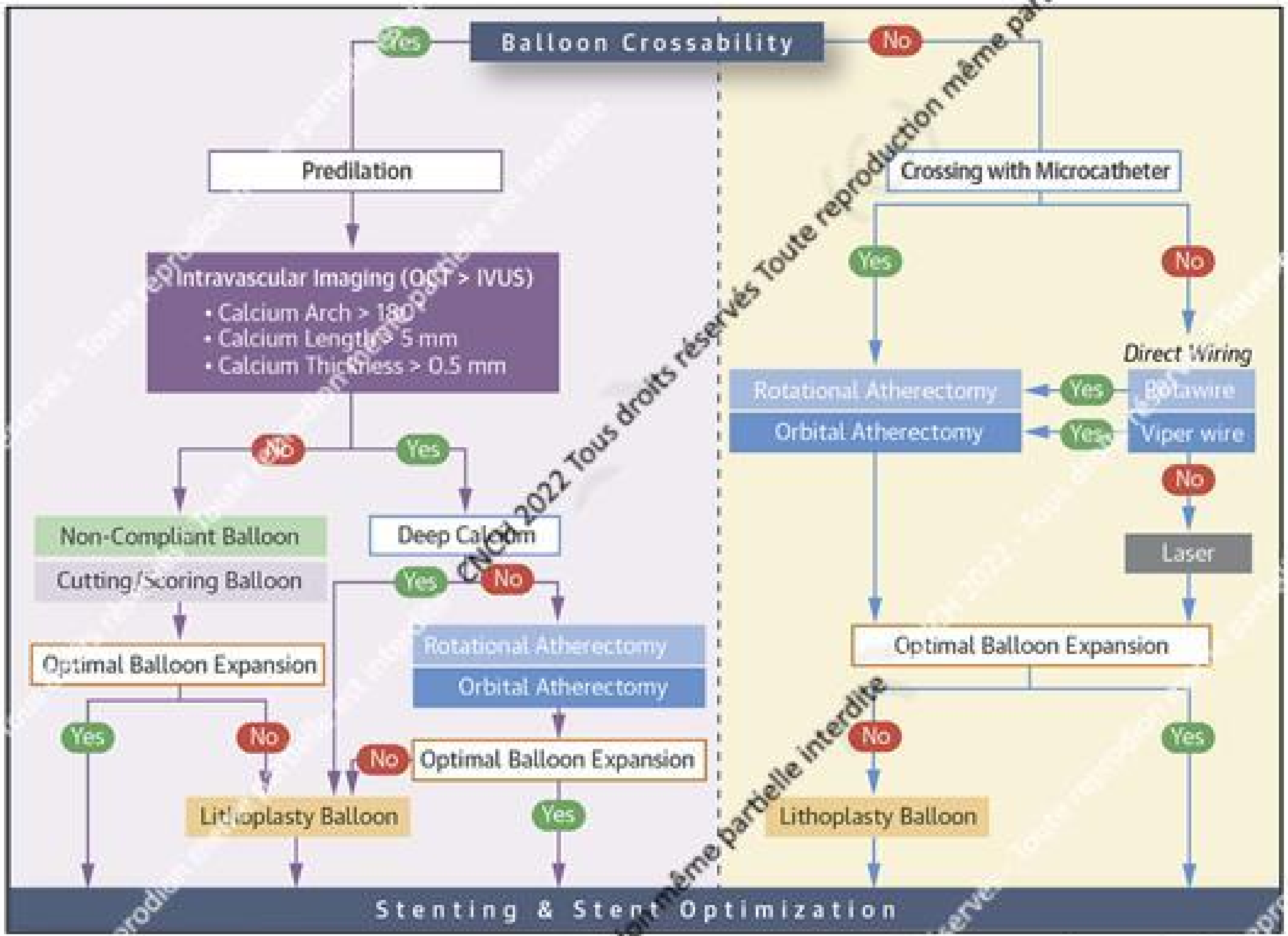






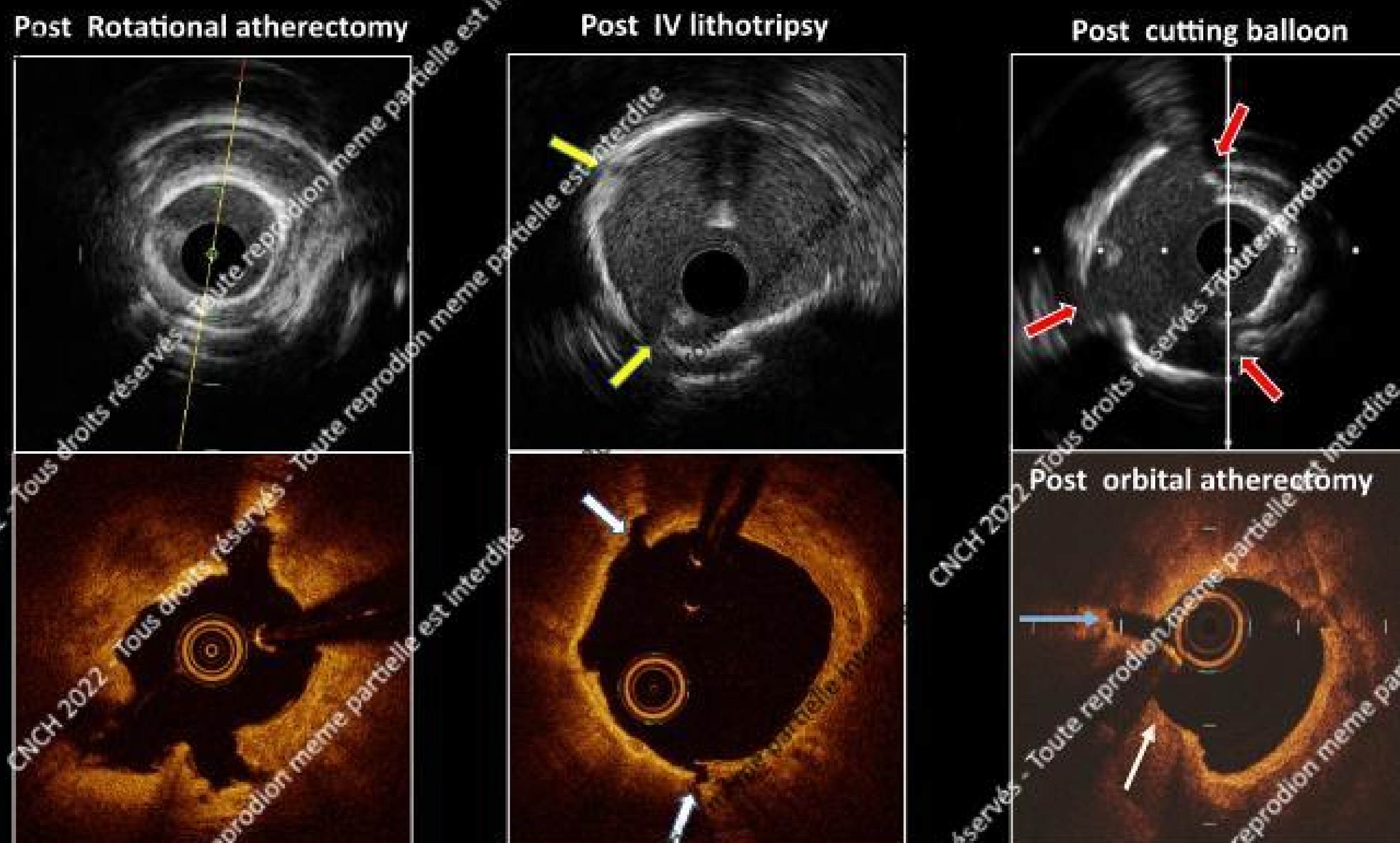
Zhang M. et al. Circ Cardiovasc Interv. 2021;14:e010296.

ICI guidance for plaque preparation : potential algorithm



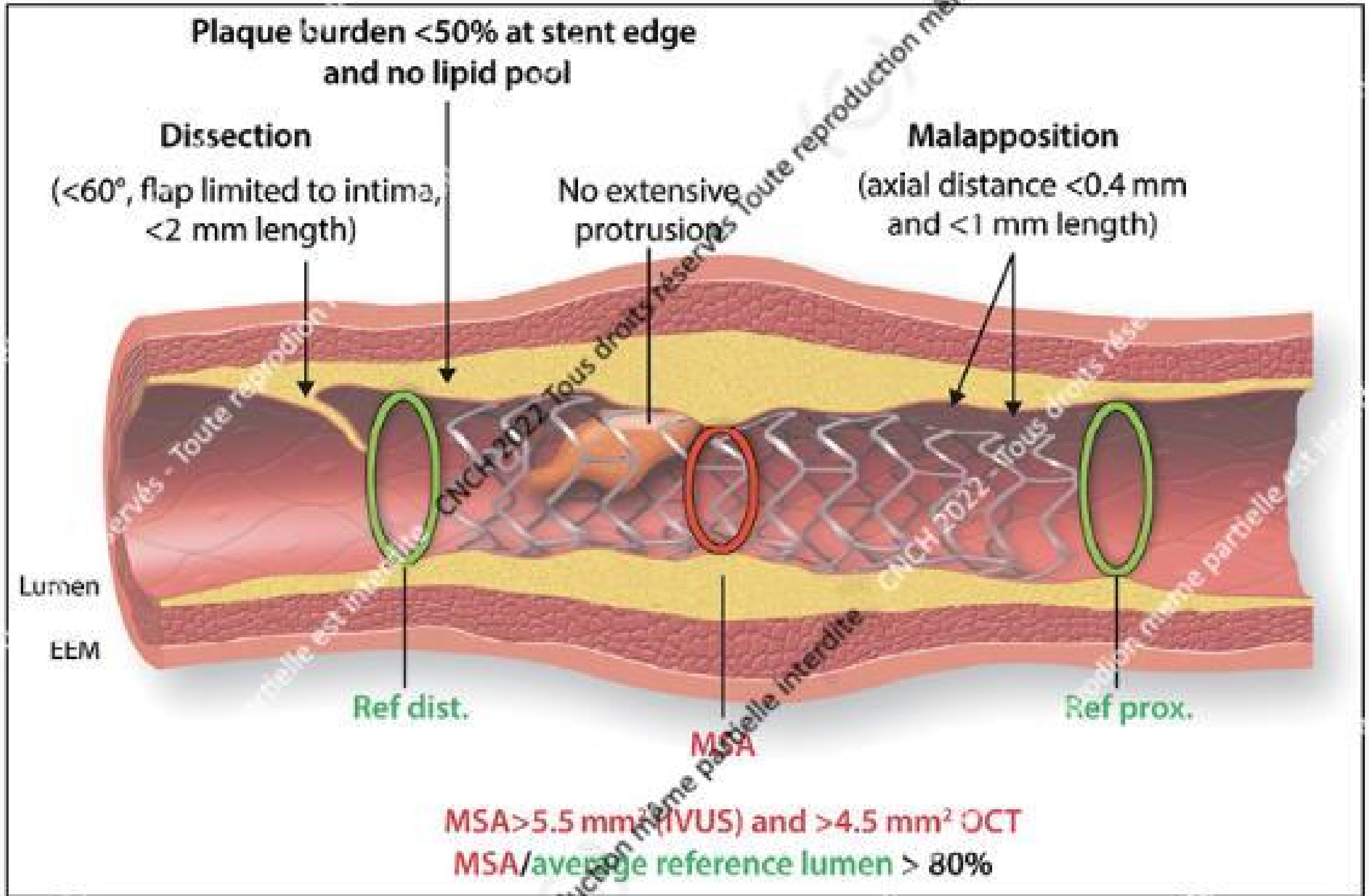
De Maria GL . et al. J Am Coll Cardiol Intv 2019;12 (15):1465–7

Plaque preparation results assessed by IC imaging



Amabile N et al., Ann Cardiol Angeiol 2

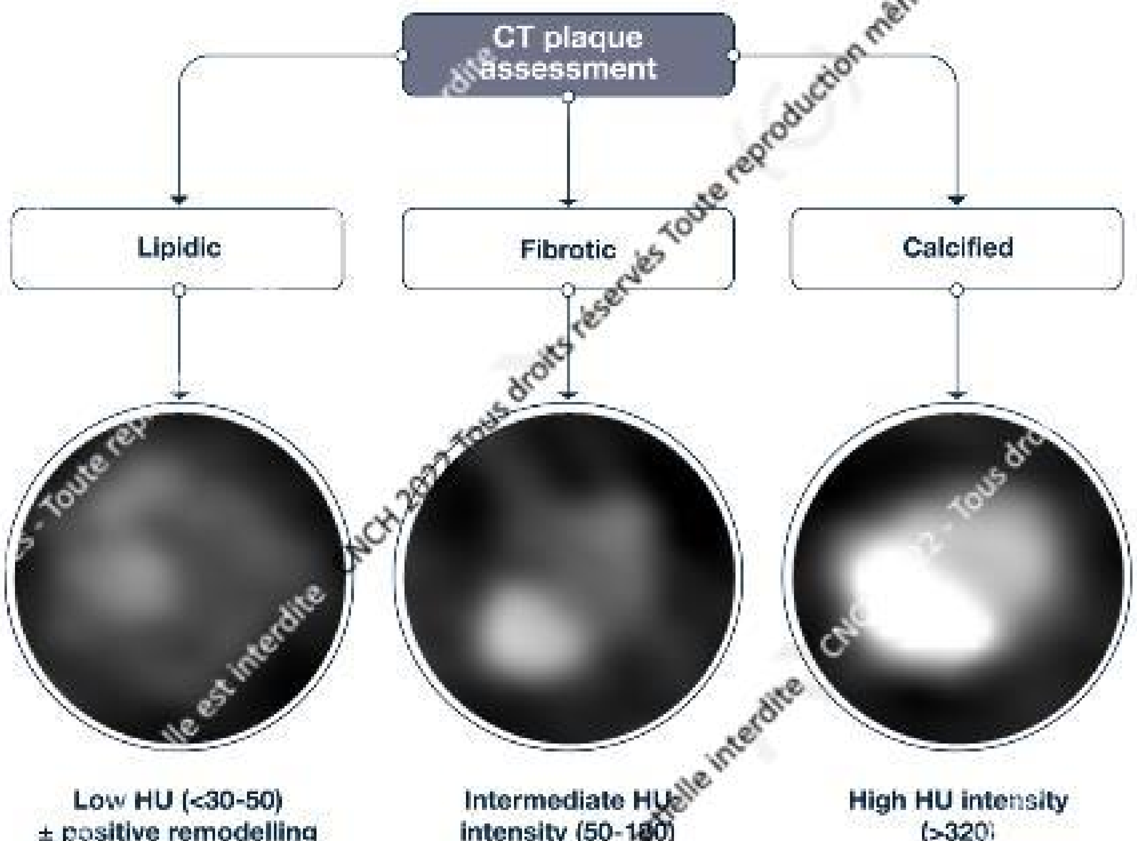
Post stenting assessment : EAPCI criteria for optimal PCI



L.Raber et al. Eurointervention 2018

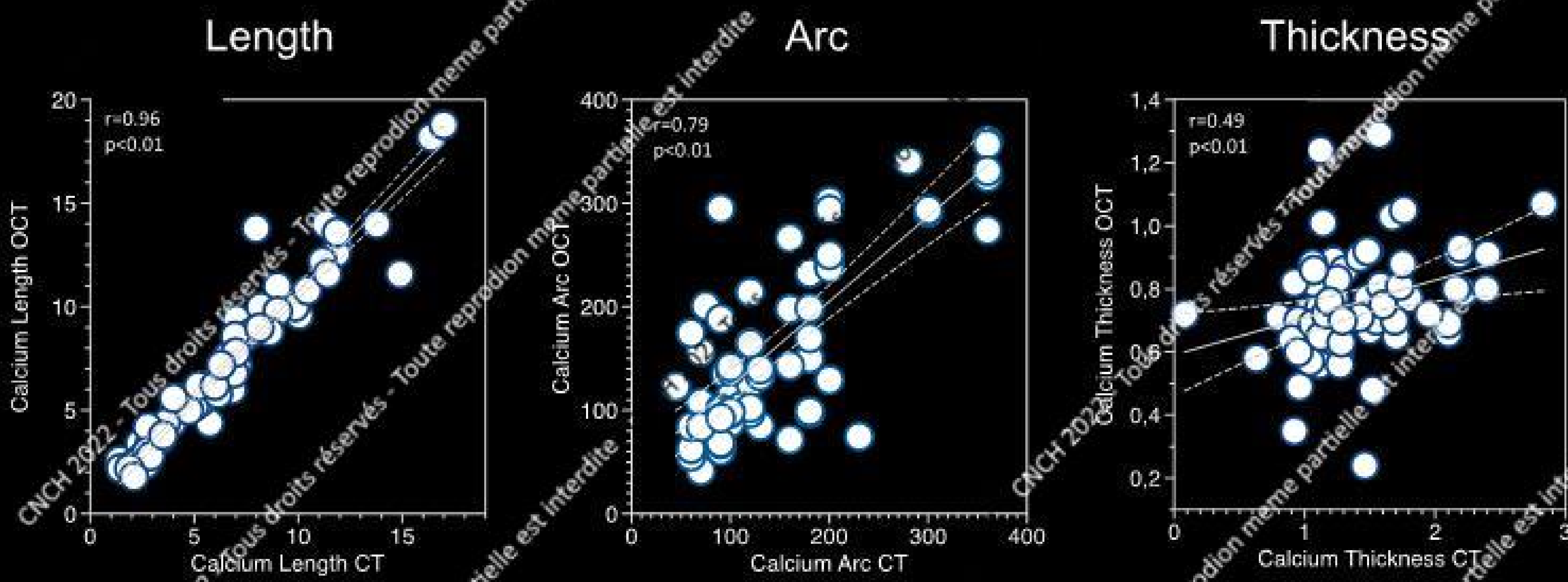
At last, but not least…

Coronary CT Plaque Characterisation



Courtesy Carlos Collet/ Hartcentrum OLV Aalst

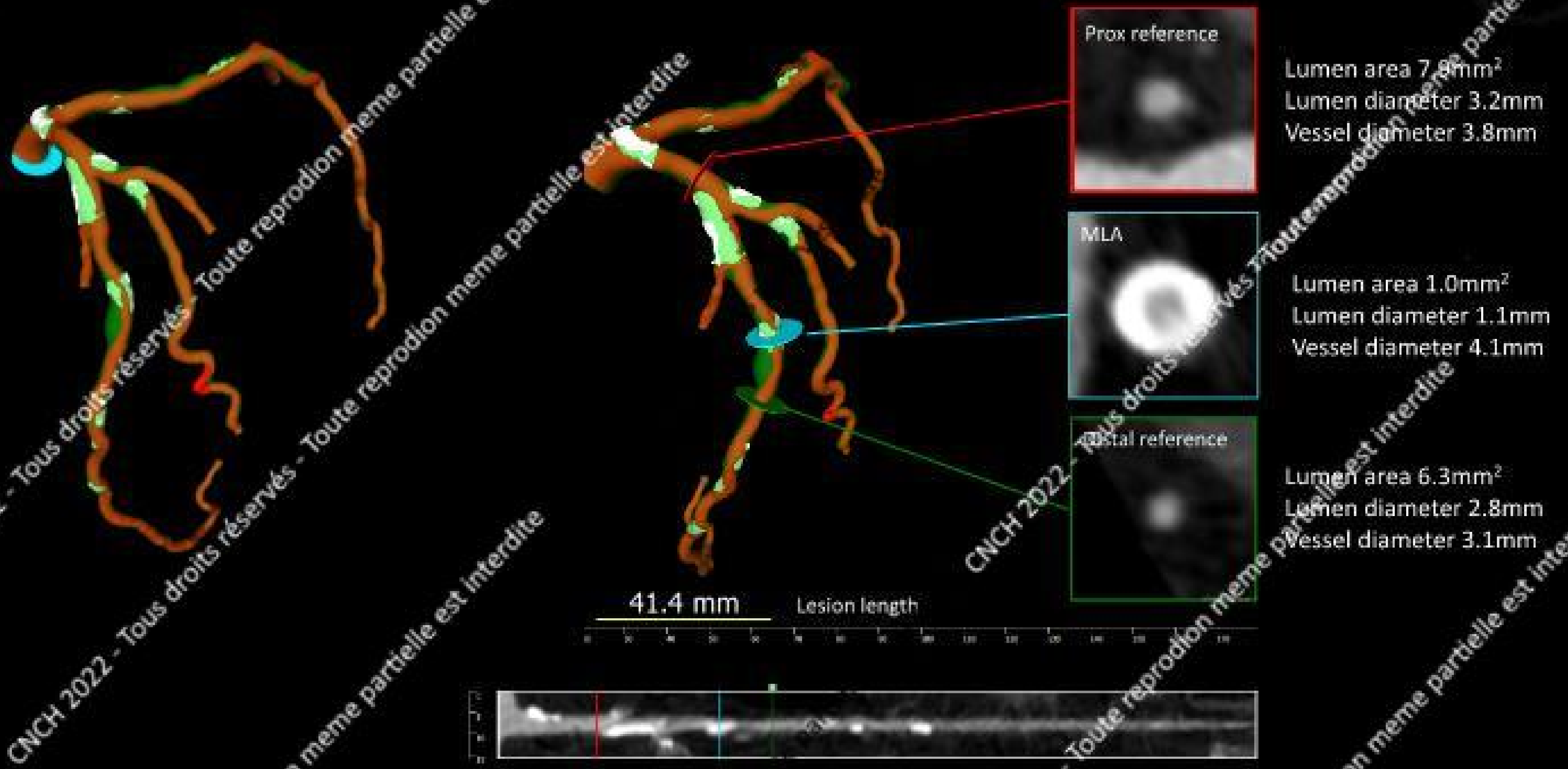
Calcium: Coronary CT versus OCT



Monizzi G, Collet et al. Int J Cardiovasc Imaging. 2020 Dec;36(12):2393-2402.

Courtesy Carlos Collet/ Hartcentrum OLV Aalst

CT-guided PCI in Calcific Lesions

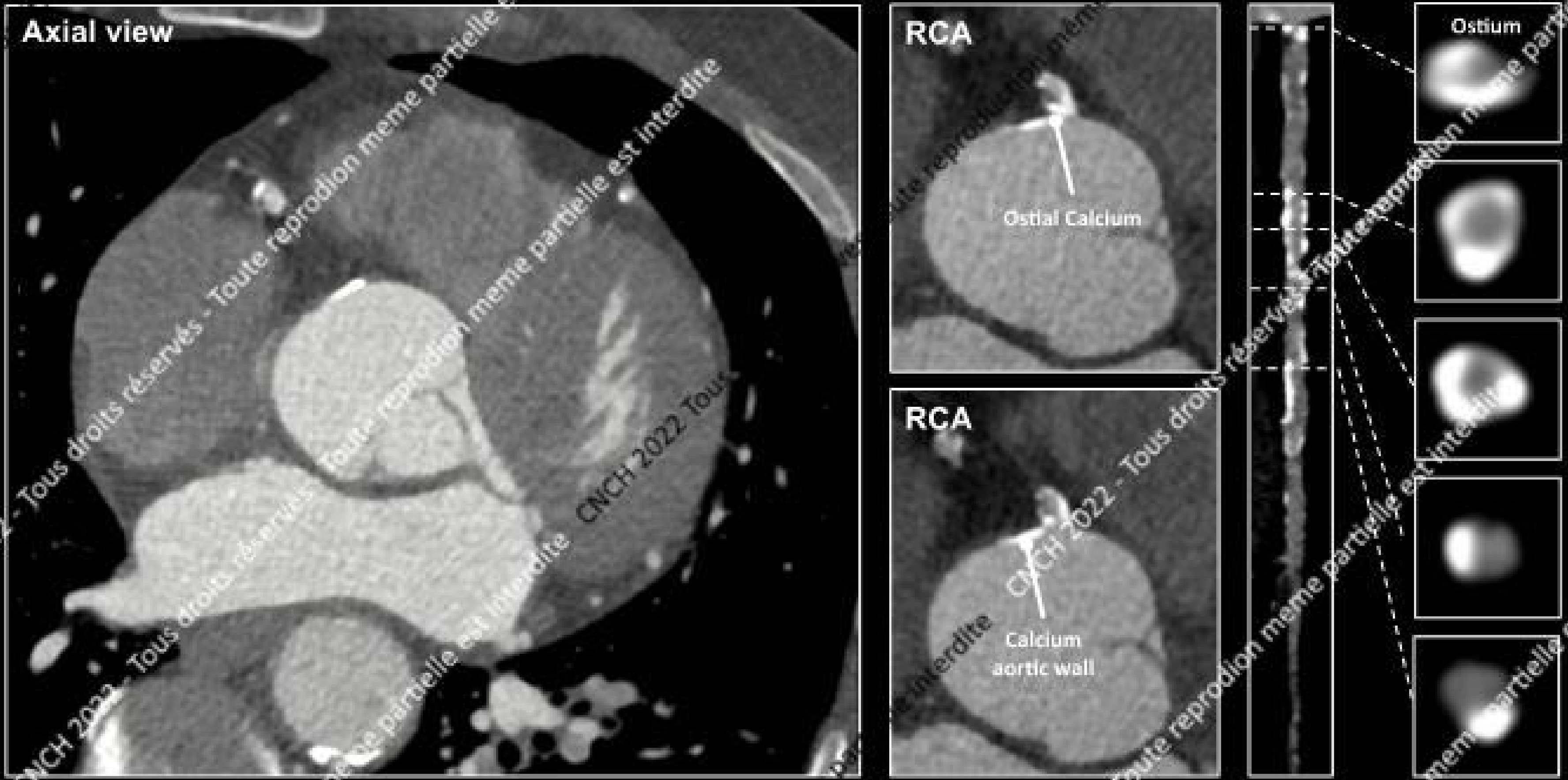


Courtesy Carlos Collet/ Hartcentrum OLV Aalst

CT 3D Calcium Map

Courtesy Carlos Collet/ Hartcentrum OLV Aalst

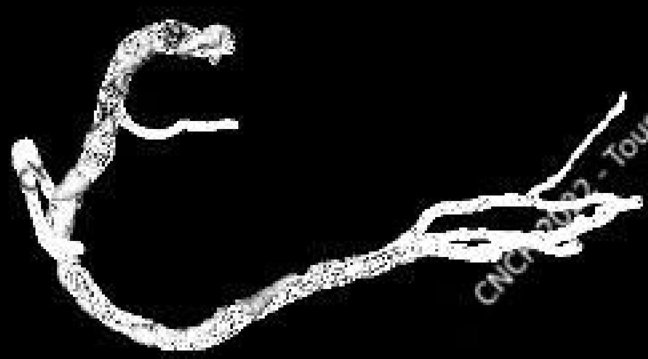
Coronary CTA: Ostial Disease



Axial view

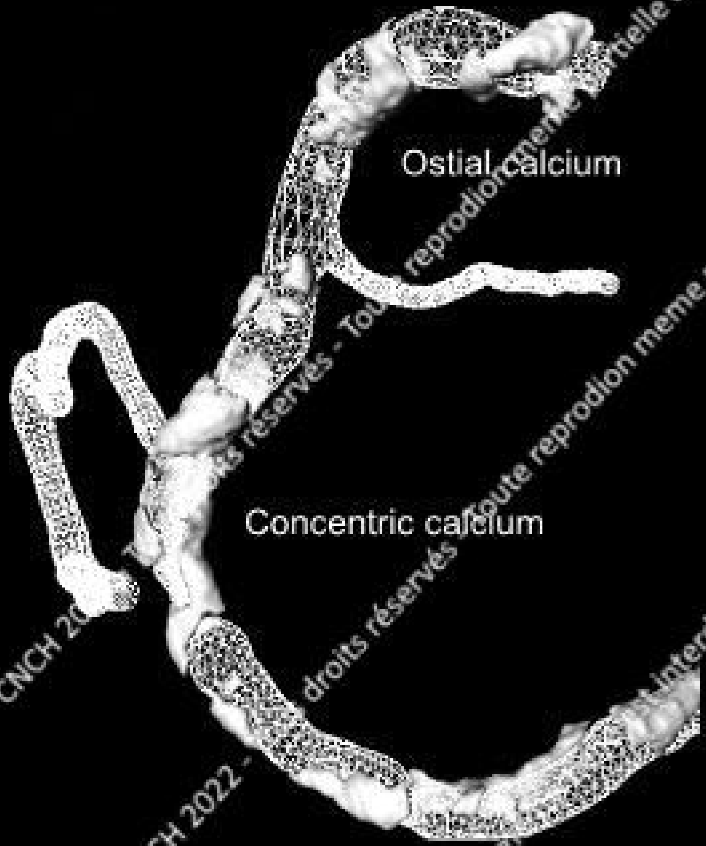
Courtesy Carlos Collet/ Hartcentrum OLV Aalst

RCA Ostium

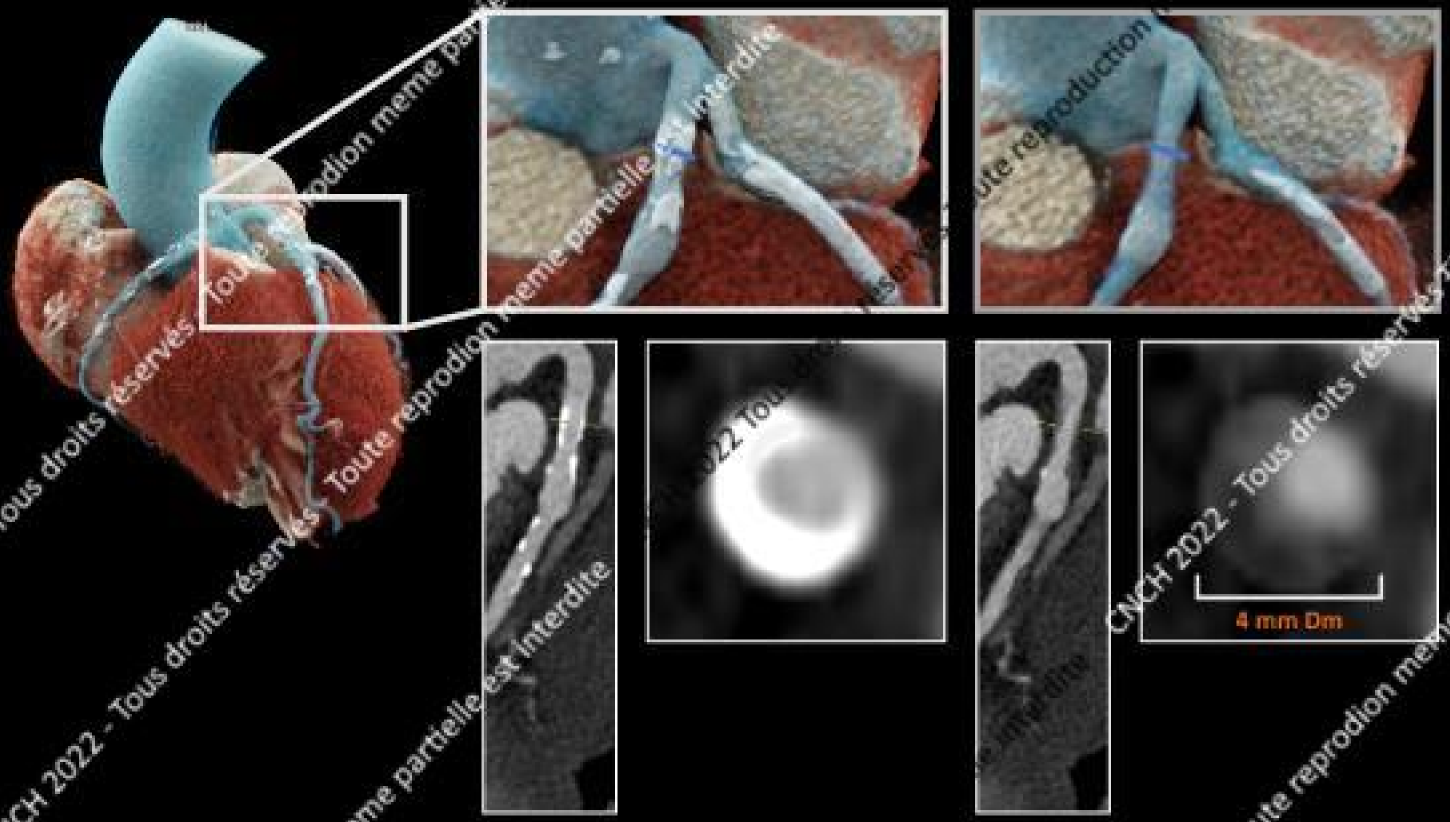


Courtesy Carlos Collet/ Hartcentrum OLV Aalst

RCA Ostium

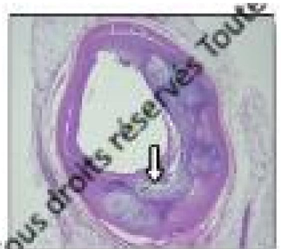


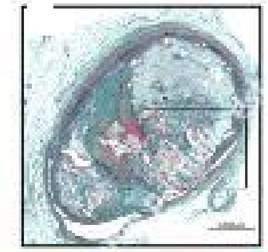
Photon Counting: Removing the Effect of Calcification

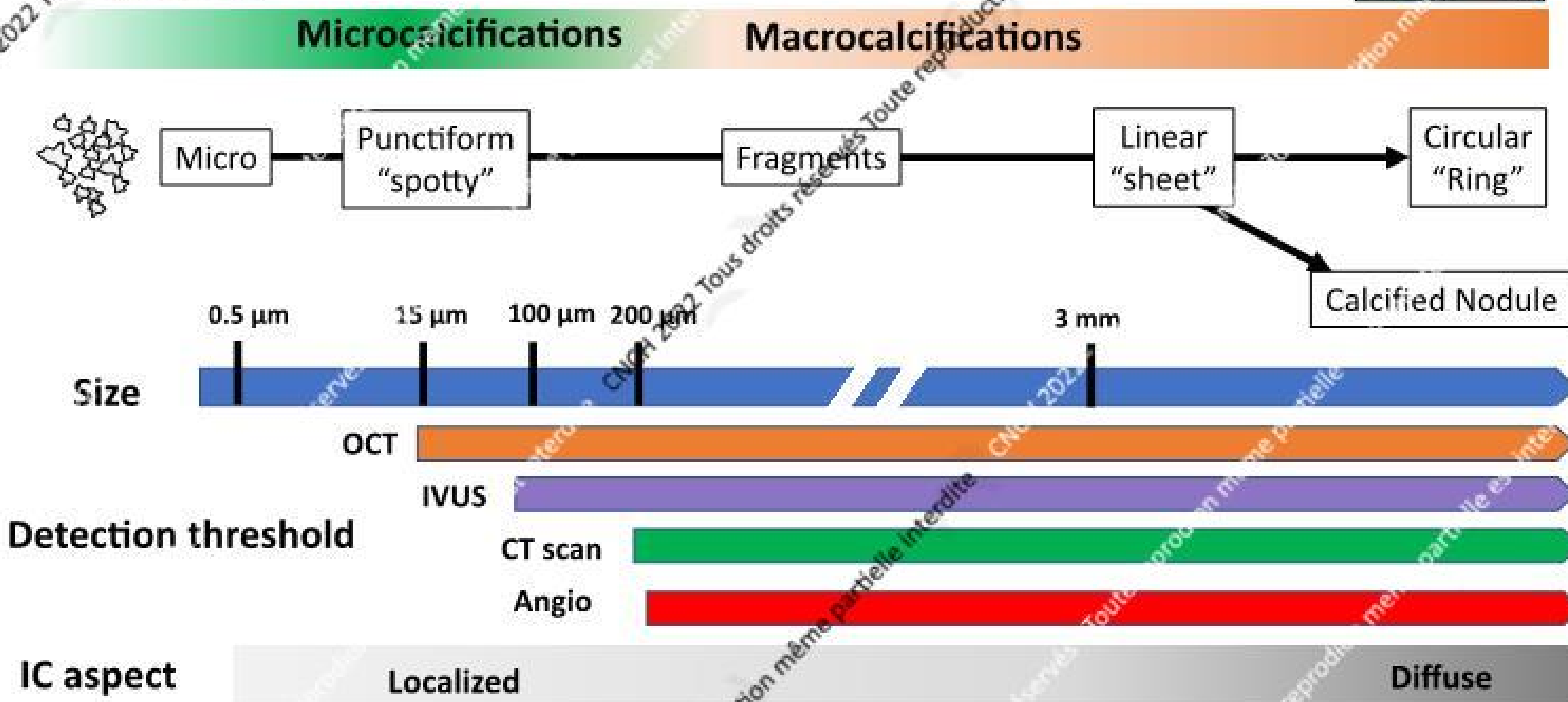


Courtesy Carlos Collet/ Hartcentrum OLV Aalst

Final WRAP-UP







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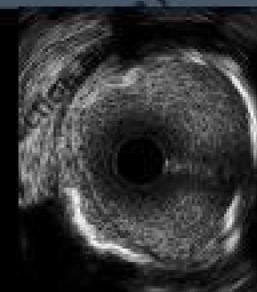
	Coronary angiography	CT scan	IVUS	OCT
				
Ca2+ detection threshold	> 220-250 µm	> 220 µm	>100 µm	>10 µm
Sensitivity for Ca2+ detection	+	+++	+++	++++
Calcium location detection	+	+++	+++	++++
Quantification: Ca2+ thickness	+	+++	+	++++
Quantification : Ca2+ radial extension	+	+++	+++	+++

Amabile N et al., Ann Cardiol Angeiol 2

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