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Use of Coronary CT Angiography to Facilitate PCI of CTOs; Insights from *CT-CTO trial*

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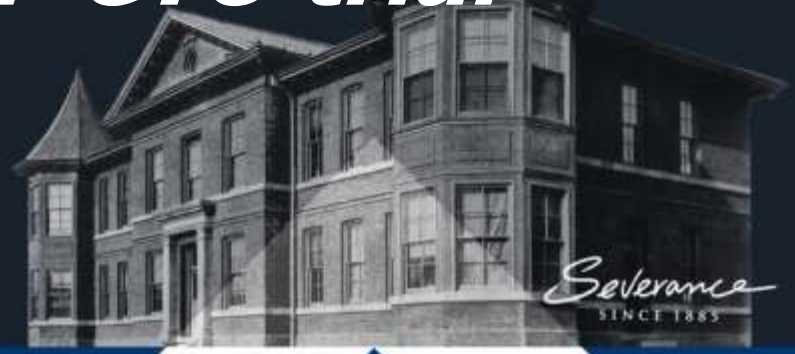


COMPLEX PCI 2020 VIRTUAL
MAKE IT SIMPLE! TECHNICAL FORUM A TO Z
November 26 - 27

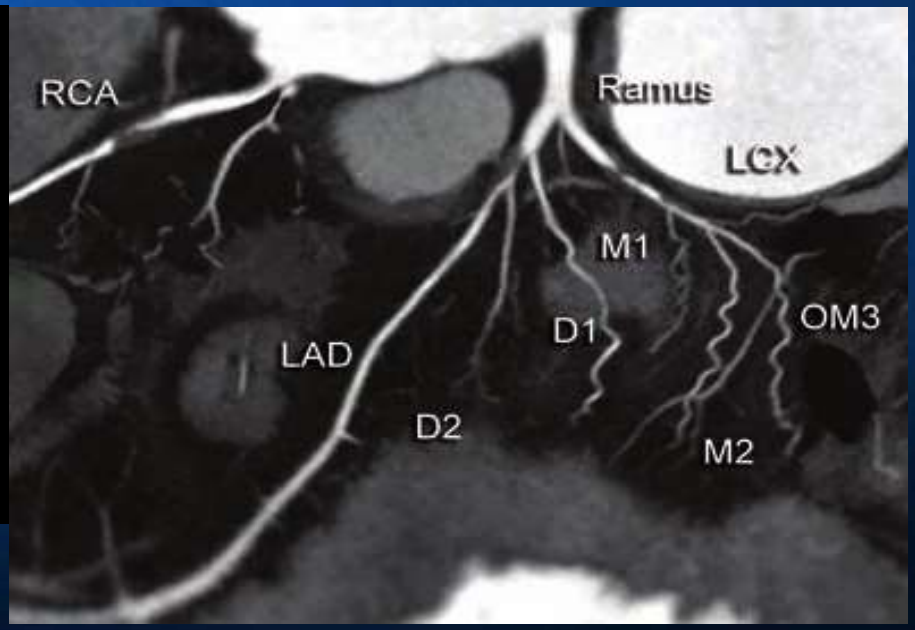
- Nothing to disclose

How to improve success rate of CTO?

- For the improvement of the success rate of CTO-PCI, many attempts have been made.

- Of these, **coronary computed tomography angiography (CCTA)** provides valuable information before PCI for CTO.

  → Essential for making a primary and secondary procedural plan with assessment of the risk and benefit of the procedure.



JACC: CARDIOVASCULAR IMAGING
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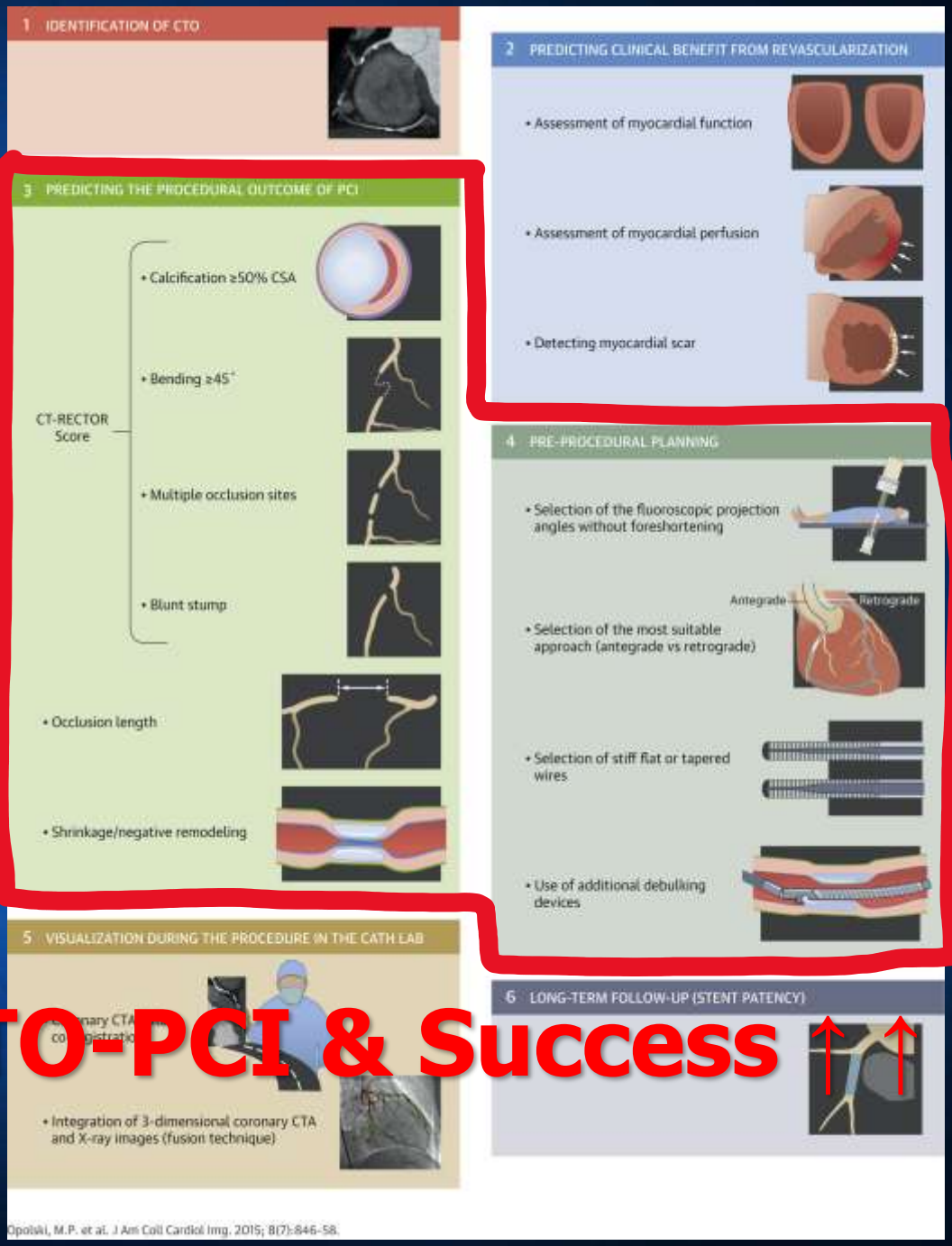
CT Angiography for Revascularization of CTO

Crossing the Borders of Diagnosis and Treatment

Maksymilian P. Opolski, MD,* Stephan Achenbach, MD†

Potential role of pre-procedural CCTA related with CTO success

3) ***predicting the procedural outcome of CTO-PCI;***
4) ***pre-procedural planning;***



Opolski, M.P. et al. J Am Coll Cardiol Img. 2015; 8(7):846-58.

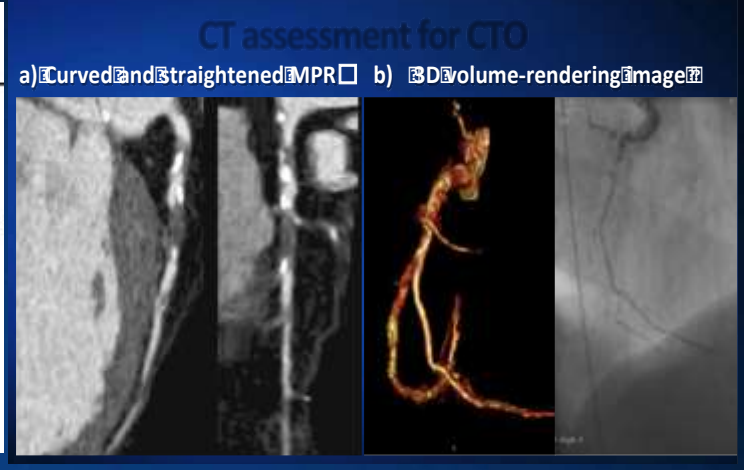
→ **Facilitate CTO-PCI & Success ↑↑**

Int J Cardiovasc Imaging (2013) 29:1819–1827
DOI 10.1007/s10554-013-0258-y

ORIGINAL PAPER

Preprocedural coronary CT angiography significantly improves success rates of PCI for chronic total occlusion

Andreas Rolf · Gerald S. Werner · Annika Schuhbäck · Johannes Rixe · Helge Möllmann · Holger M. Nef · Constantin Gundermann · Christoph Liebetrau · Gabriele A. Krombach · Christian W. Hamm · Stephan Achenbach



Compare the success rate between the pre-CT group and control

- ***Pre-CT group (n=30)* vs. Control without CT scan (n=43)**

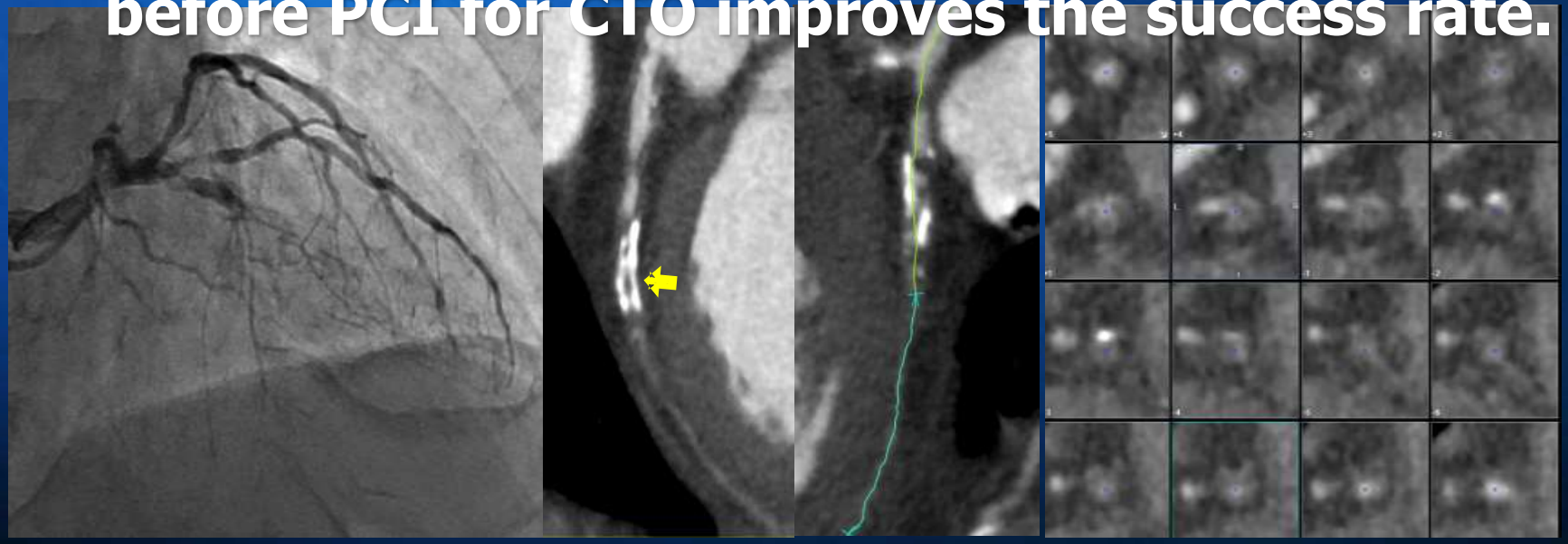
  The intervention success rate in pre-CT group was higher than in conventional group.

  - **Matched : 90% (27/30) vs. 63% (27/43), p=0.009**
  - **Unmatched : 88% (22/25) vs. 64 (16/25), p=0.003**

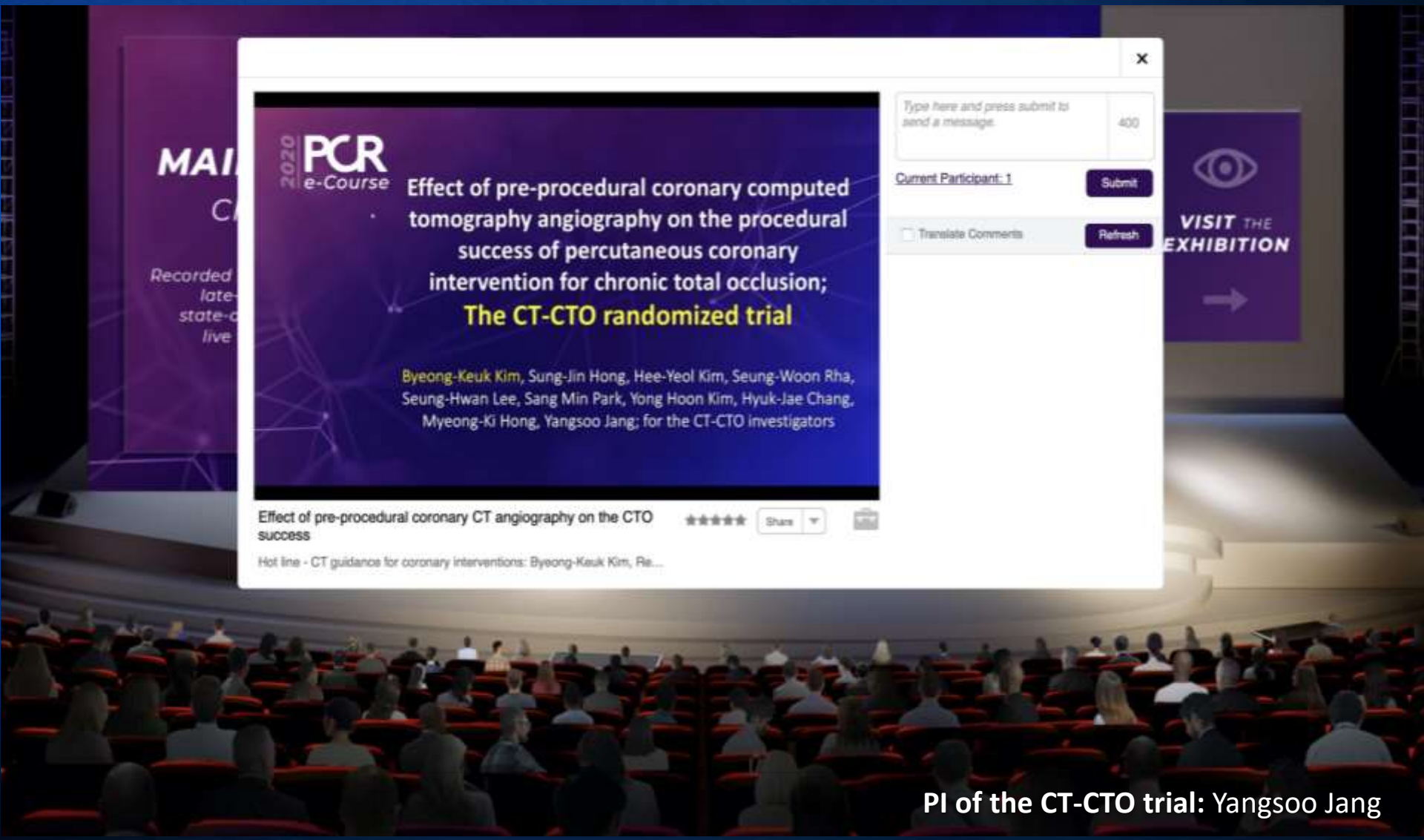
However, the results were from non-randomized study.

CT-guided CTO intervention, really improve the success of CTO-PCI?

- **Until now, there has been a strong belief but no definite evidence !!!**
- **No randomized data exist whether CCTA before PCI for CTO improves the success rate.**



CT-CTO randomized trial



PI of the CT-CTO trial: Yangsoo Jang

2020 PCR e-Course

Byeong-Keuk Kim

Methods (1)

- **CT-CTO trial** (ClinicalTrials.gov Identifier: NCT02037698), an investigator-initiated, multicenter, randomized trial conducted at 12 centers in South Korea.

Inclusion Criteria	Exclusion Criteria
• Patients (age >19 yrs) with CTO (TIMI=0 & duration of occlusion at least 3 months) • Typical symptomatic angina or positive functional test for ischemia • Eligible patients for CT scan and CAG	• Cardiogenic shock or EF <25% • ISR CTO or graft occlusion lesion • Significant left main stenosis • AMI within 48 hours • Retry of same CTO within 2 weeks

- **Primary endpoint: Rate of the successful recanalization**

  defined as a final TIMI flow grade ≥2 and ≤30% residual stenosis on the final CAG without death or fatal complications during the procedure requiring emergent operation.

  ✓ **Procedure success** - a final TIMI flow grade ≥2 without death or fatal complication

  ✓ **Device success** - residual stenosis ≤30% after successful stent implantation

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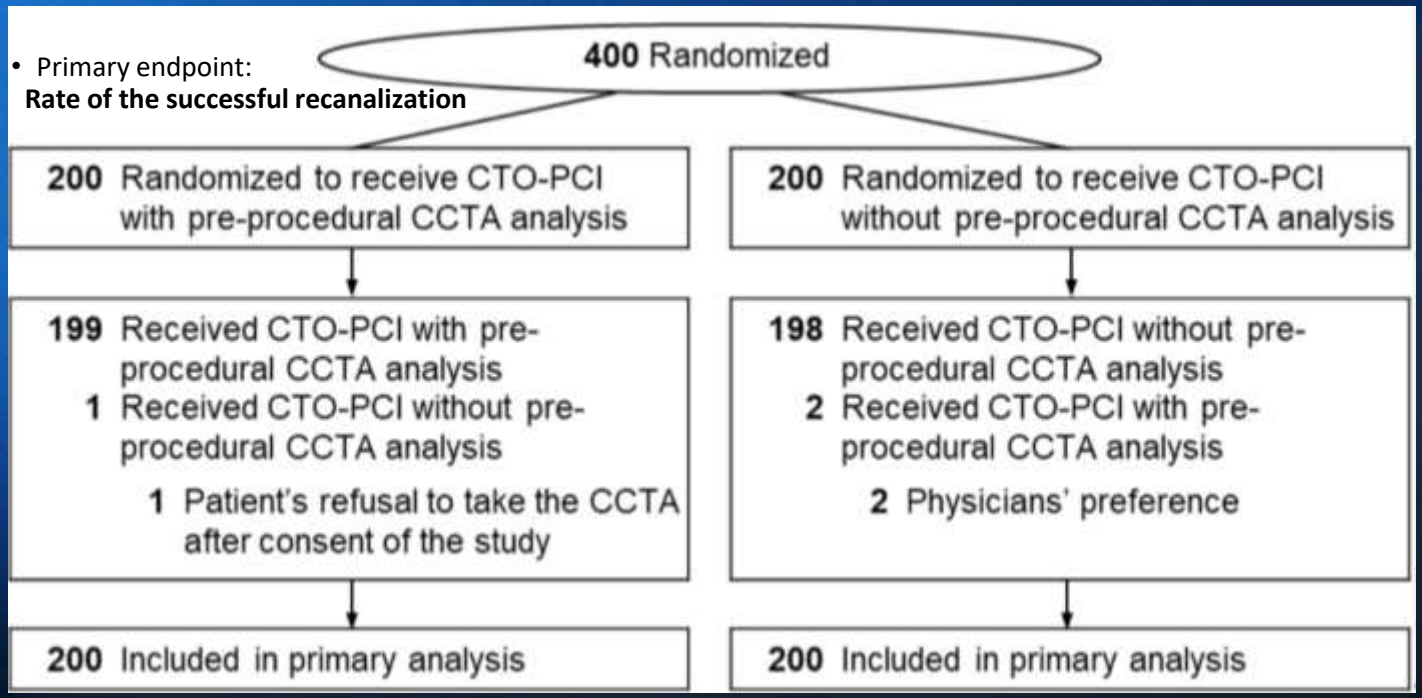
Methods (2)

- **Sample size calculation:**

  Assumption, **"The success rate of the CCTA guidance would be superior to the angiography guidance"**

  → A total of **200 patients in each arm** with a superiority comparison for the primary endpoint
  (Power 80%, type 1 error 5%, and drop-out rate 5%).

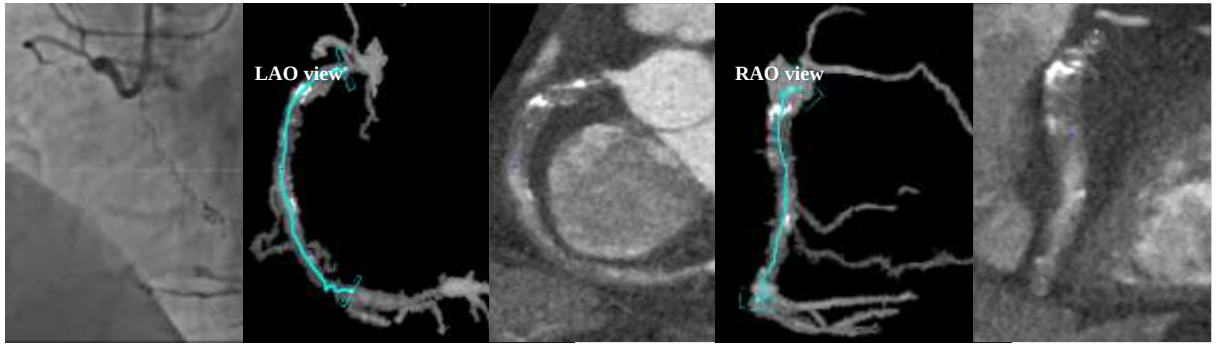
Study Flow of the CT-CTO trial



CCTA image analyses in the CCTA-guided group

1. Making two orthogonal CT images matching with angiogram

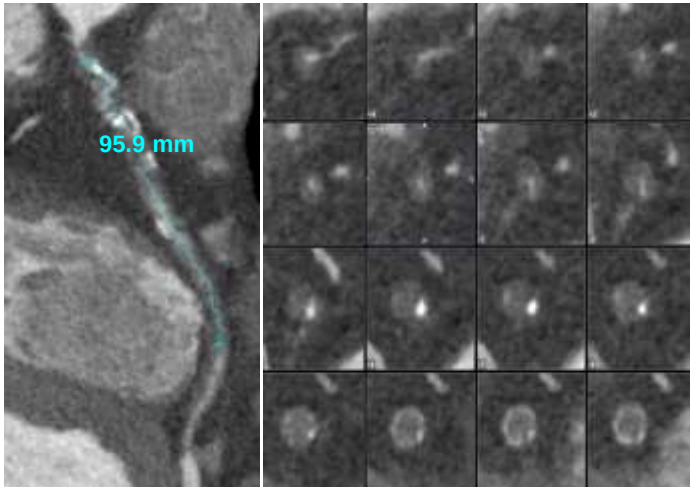
- **CTO courses** (how CTO course goes & what the hidden route is within CTO segment)
- **Anatomical location associated with side branches**



2. Qualitative and quantitative analyses of CTO from MPR images

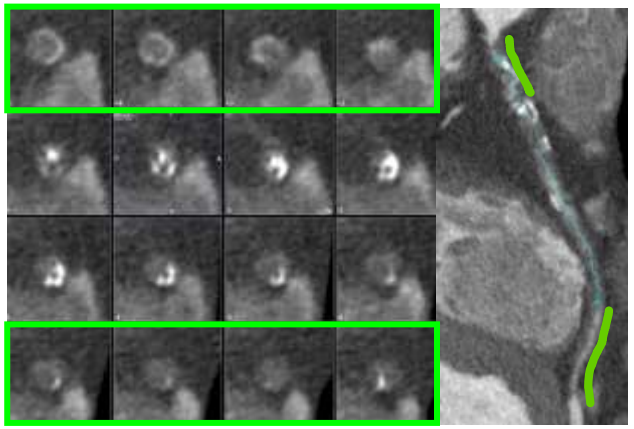
1) **CTO length and the shapes of proximal and distal CTO ends**
2) **Calcification; longitudinal & cross-sectional analyses**
   - Maximal cross-sectional extent; <50% or ≥50%
   - Length of calcification with cross-sectional extent >50% segment
   - Calcification shape; semicircular <180°, circular ≥180°, or 360° (full moon)
   - Location of calcium on CTO lesion

   → **"Geographic calcification-mapping"**



3. Analyses of the segments around CTO

- **Check the size of vessel and lumen and the tortuosity in proximal and distal reference segments**



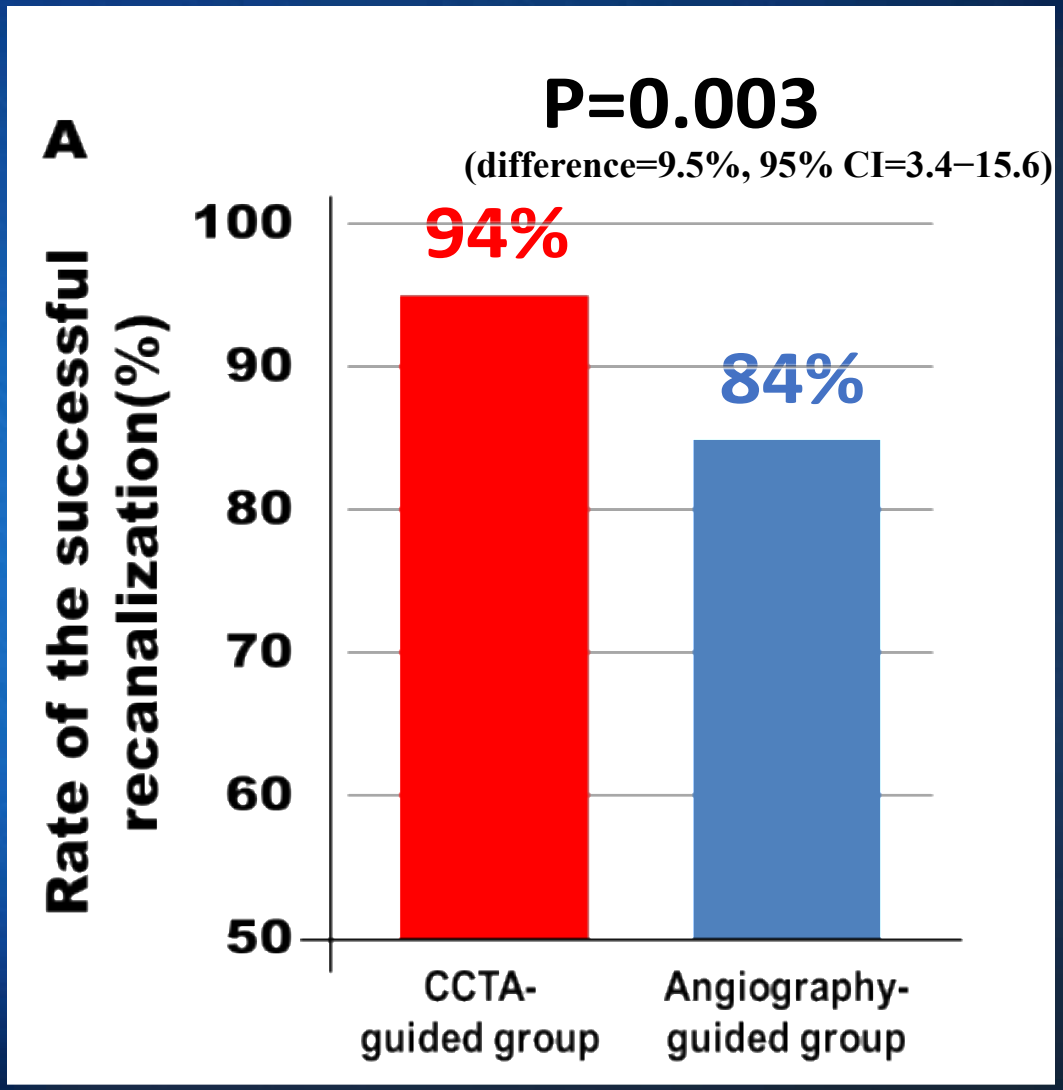
Baseline characteristics

*Baseline clinical and angiographic characteristics**	CCTA-guided (n=200)	Angiography-guided (n=200)
Age (years)	62 ± 10	61 ± 11
Men	160 (80%)	166 (83%)
Body mass index (kg/m^2)	25.2 ± 3.4	25.3 ± 3.4
Diabetes mellitus	79 (40%)	80 (40%)
Chronic kidney disease	6 (3%)	9 (5%)
Left ventricular EF (%)	59 ± 10	57 ± 10
Target vessel, LAD	88 (44%)	84 (42%)
J-CTO score	**1.70 ± 1.02**	**1.68 ± 0.88**
Reattempt of failed CTO-PCI	28 (14%)	35 (18%)
CTO length (mm)	24.3 ± 12.6	25.3 ± 12.9
Total lesion length (mm)	44.9 ± 21.8	44.7 ± 22.4
Reference vessel diameter (mm)	2.77 ± 0.55	2.68 ± 0.44
Femoral artery for vascular access	173 (86%)	176 (88%)
Contralateral angiogram	135 (68%)	128 (64%)
Retrograde approach	45 (23%)	43 (22%)
Use of IVUS	118 (59)	105 (53)

***There were no significant differences between the study groups.**

Kim BK on behalf of CT-CTO investigators, presented 2020 PCR late-breaking, e-course

Primary Endpoint: Rate of the successful recanalization



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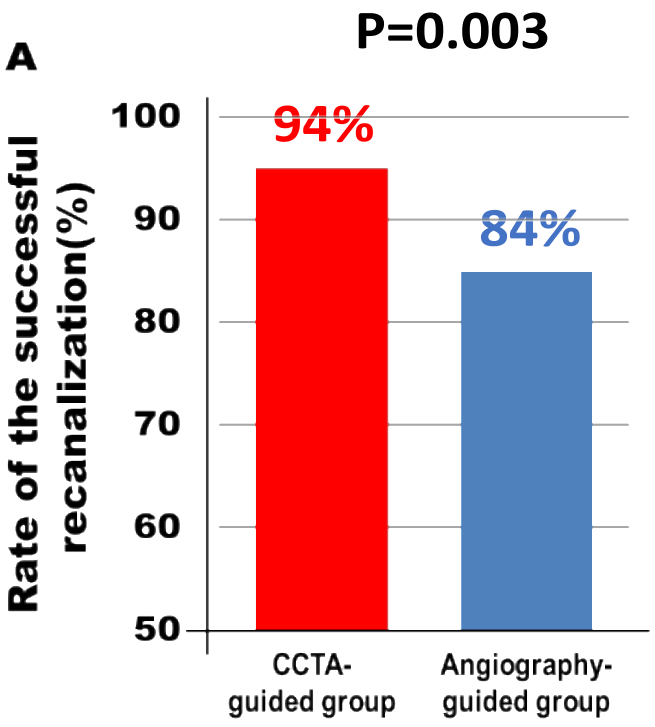
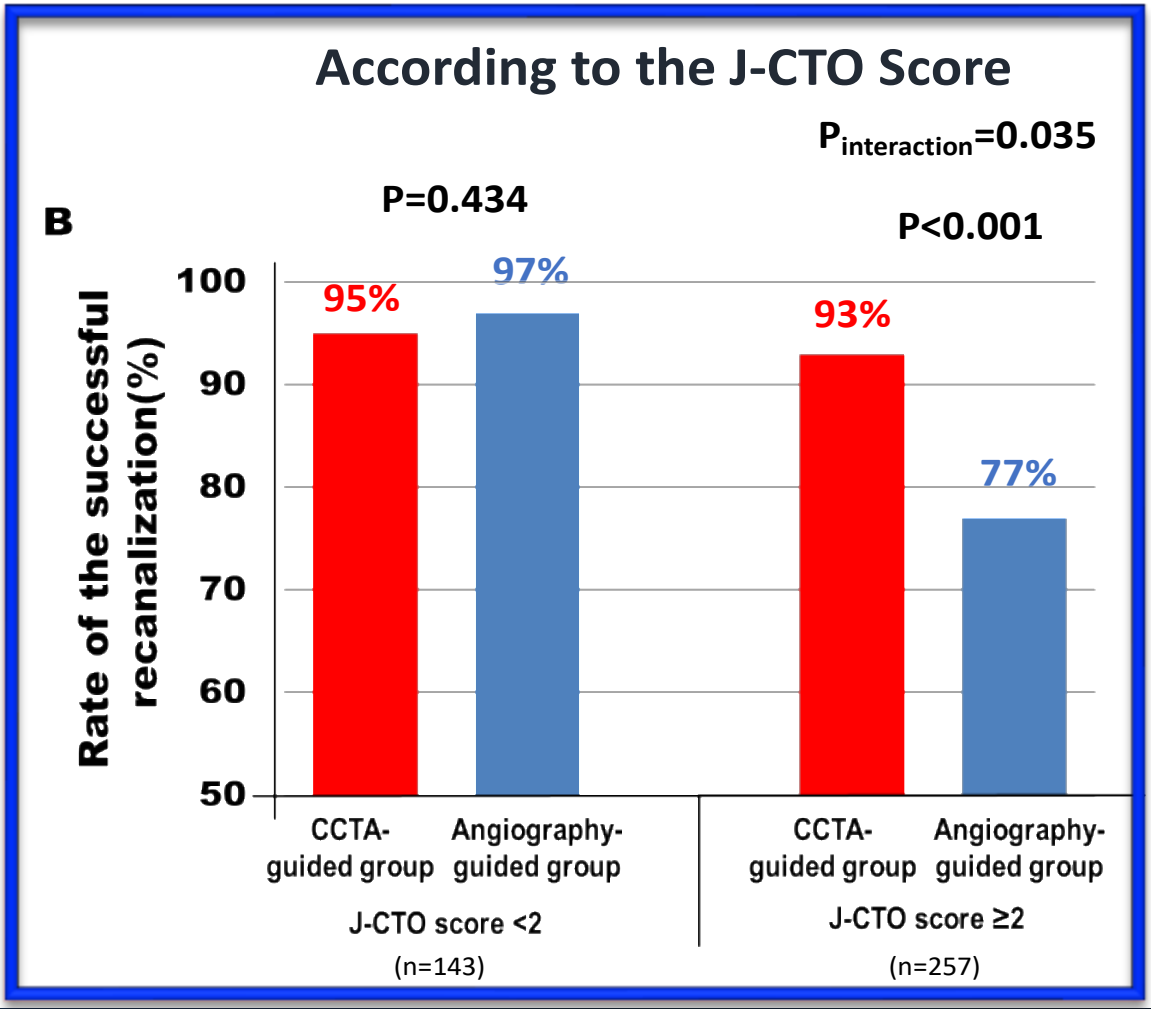
Success rates according to the J-CTO score

Primary Endpoint: Rate of the successful recanalization

For overall patients



According to the J-CTO Score



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Procedural Outcomes - 1

Immediate procedural outcomes	CCTA-guided (N=200)	Angiography-guided (N=200)	*P*
Device success	189 (95)	168 (85)	0.001
Procedure success	187 (94)	168 (84)	0.003
Successful recanalization – Primary Endpoint	187 (94)	168 (84)	0.003
Total number of stents	1.74 ± 0.76	1.76 ± 0.79	0.770
Total length of stents (mm)	53.9 ± 26.1	56.0 ± 27.0	0.455
Mean stent diameter (mm)	3.08 ± 0.34	2.95 ± 0.30	0.004
Type of drug-eluting stent			0.393
Everolimus-eluting stent	89 (47)	82 (48)	
Zotarolimus-eluting stent	94 (50)	86 (51)	

Kim BK, presented 2020 PCR late-breaking, e-course

Procedural Outcomes - 2

Immediate procedural outcomes	CCTA-guided (N=200)	Angiography-guided (N=200)	*P*
Device success	189 (95)	168 (85)	0.001
Procedure success	187 (94)	168 (84)	0.003
Successful recanalization – Primary Endpoint	187 (94)	168 (84)	0.003
Total number of stents	1.74 ± 0.76	1.76 ± 0.79	0.770
Total length of stents (mm)	53.9 ± 26.1	56.0 ± 27.0	0.455
Mean stent diameter (mm)	3.08 ± 0.34	2.95 ± 0.30	0.004
Type of drug-eluting stent			0.393
Everolimus-eluting stent	89 (47)	82 (48)	
Zotarolimus-eluting stent	94 (50)	86 (51)	
Total procedure time (min)	93 ± 52	94 ± 57	0.943
Fluoroscopic time (min)	46 ± 32	44 ± 29	0.537
Contrast used (ml)	284 ± 115	301 ± 117	0.145
Coronary perforation ≥ type II	2 (1)	8 (4)	0.055
Emergent pericardiocentesis or surgery	0	0	>0.999
Post-procedural peak creatine kinase-MB, ng/mL	4.6 ± 7.2	6.8 ± 31	0.342
PPMI (CK-MB ≥10× the UNL), n (%)	0	4 (2)	0.123

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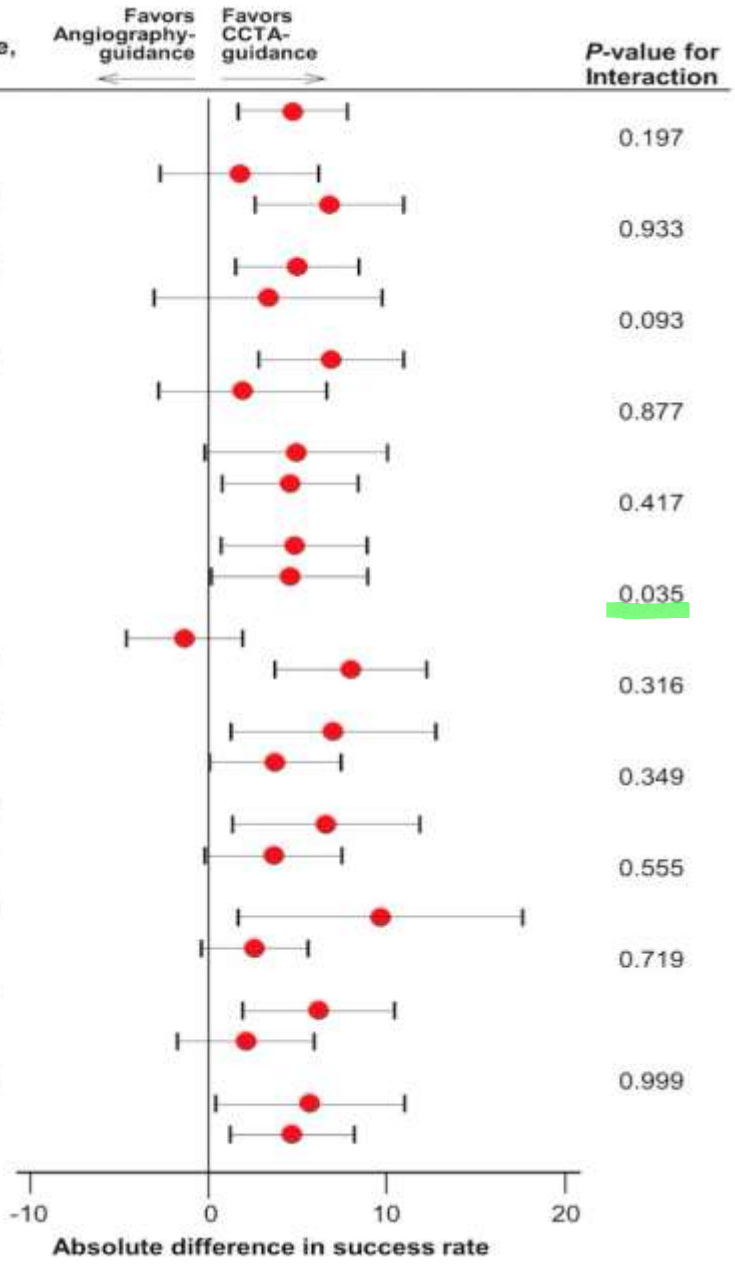
Pre-specified subgroup analyses for the primary endpoint

Subgroup	No. of success/ total (%) CCTA-guidance	Angiography-guidance	Absolute difference, % (95% CI)	*P*-value for Interaction
Overall patients	**187/200 (93.5)**	**168/200 (84.0)**	**9.5 (3.4 to 15.6)**	
Age, years				0.197
<60	75/81 (92.6)	73/82 (89.0)	3.6 (-5.3 to 12.4)	
≥60	112/119 (94.1)	95/118 (80.5)	13.6 (5.3 to 21.9)	
Sex				0.933
Men	149/160 (93.1)	138/166 (83.1)	10.0 (3.1 to 16.9)	
Women	38/40 (95.0)	30/34 (88.2)	6.8 (-6.0 to 19.5)	
Hypertension				0.093
Yes	110/115 (95.7)	90/110 (81.8)	13.8 (5.7 to 21.9)	
No	77/85 (90.6)	78/90 (86.7)	3.9 (-5.5 to 13.3)	
Diabetes				0.877
Yes	73/79 (92.4)	66/80 (82.5)	9.9 (-0.3 to 20.1)	
No	114/121 (94.2)	102/120 (85.0)	9.2 (1.6 to 16.8)	
Target vessel				0.417
Left anterior descending	85/88 (96.6)	73/84 (86.9)	9.7 (1.5 to 17.8)	
Left circumflex or right coronary	102/112 (91.1)	95/116 (81.9)	9.2 (0.4 to 17.9)	
J-CTO score				0.035
<2	69/73 (94.5)	68/70 (97.1)	-2.6 (-9.1 to 3.9)	
≥2	118/127 (92.9)	100/130 (76.9)	16.0 (7.5 to 24.5)	
Blunt stump at entry				0.316
Yes	64/67 (95.5)	44/54 (81.5)	14.0 (2.6 to 25.5)	
No	123/133 (92.5)	124/146 (84.9)	7.5 (0.2 to 14.9)	
Calcification within the CTO				0.349
Yes	77/81 (95.1)	54/66 (81.8)	13.2 (2.8 to 23.7)	
No	110/119 (92.4)	114/134 (85.1)	7.4 (-0.3 to 15.0)	
Bending >45°				0.555
Yes	36/41 (87.8)	37/54 (68.5)	19.3 (3.4 to 35.2)	
No	151/159 (95.0)	131/146 (89.7)	5.2 (-0.7 to 11.2)	
Occlusion length ≥20 mm				0.719
Yes	114/124 (91.9)	101/127 (79.5)	12.4 (3.9 to 20.9)	
No	73/76 (96.1)	67/73 (91.8)	4.3 (-3.4 to 11.9)	
Reattempt of failed CTO				0.999
Yes	28/28 (100.0)	31/35 (88.6)	11.4 (0.9 to 22.0)	
No	159/172 (92.4)	137/165 (83.0)	9.4 (2.5 to 16.4)	



The effects of CCTA guidance on CTO success was more **prominently observed in the difficult CTO (J-CTO ≥2)** !

- **Blunt stump or long tortuous CTO;**

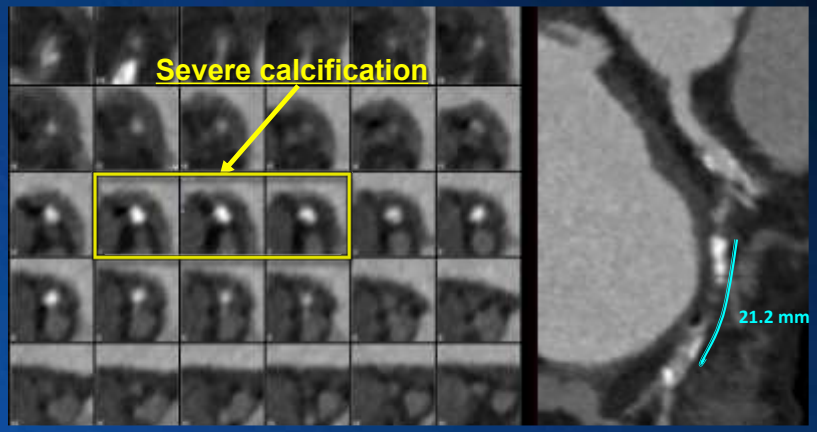
Pre-procedural CCTA could **show the exact anatomical location related with the adjacent side branches and the courses** from proximal to distal CTO cap.

Reasons for CTO-failure in the CT-CTO	CCTA-guidance	Angiography-guidance	*P*
Number of failed antegrade-only approach, n	10	17	
Failure to enter the cap due to anatomical ambiguity	**0 (0%)**	**6 (35%)**	**0.033**

The effects of CCTA guidance on CTO success was more **prominently observed in the difficult CTO (J-CTO ≥2) !**

- **CTO with severe calcification;**

Calcification arc 180-360° & CSA ≥50%

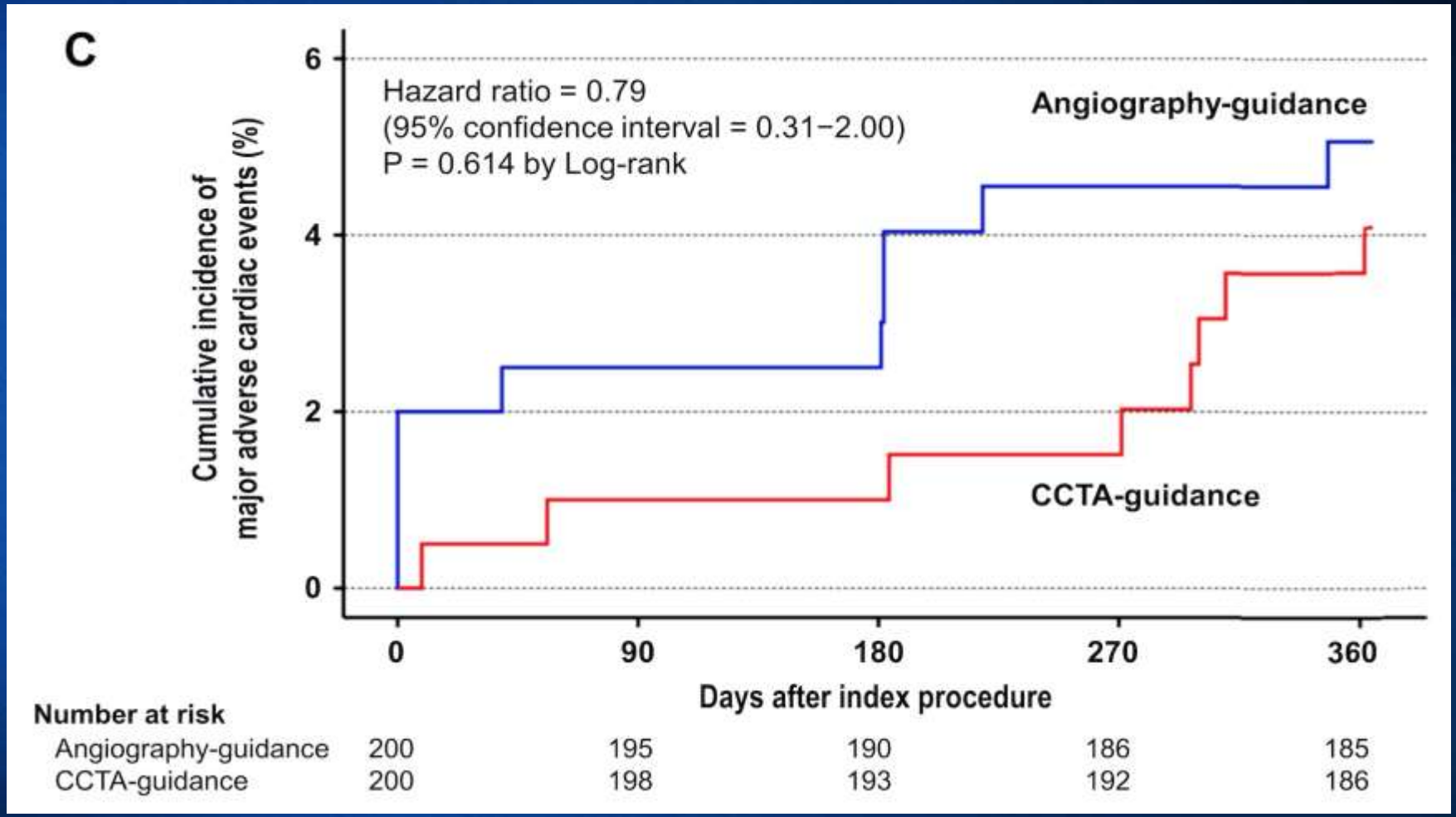


CCTA **visualizing the CTO course and plaque characteristics** (calcification geometry) could be helpful **for navigating and selection of the proper antegrade and retrograde wires and devices without increasing the risks of procedural complication.**

- **Reattempted CTO-PCI after previously failure;**

CTO success could be improved by **adopting the strategy for re-attempt based on the various information from the longitudinal and cross-sectional results of CCTA analyses.**

Clinical outcomes



Major adverse cardiac event occurrence; a composite of cardiac death, target-vessel related MI, or ischemia-driven TVR at 12 months.

2020 Manuscript submitted

CONCLUSION

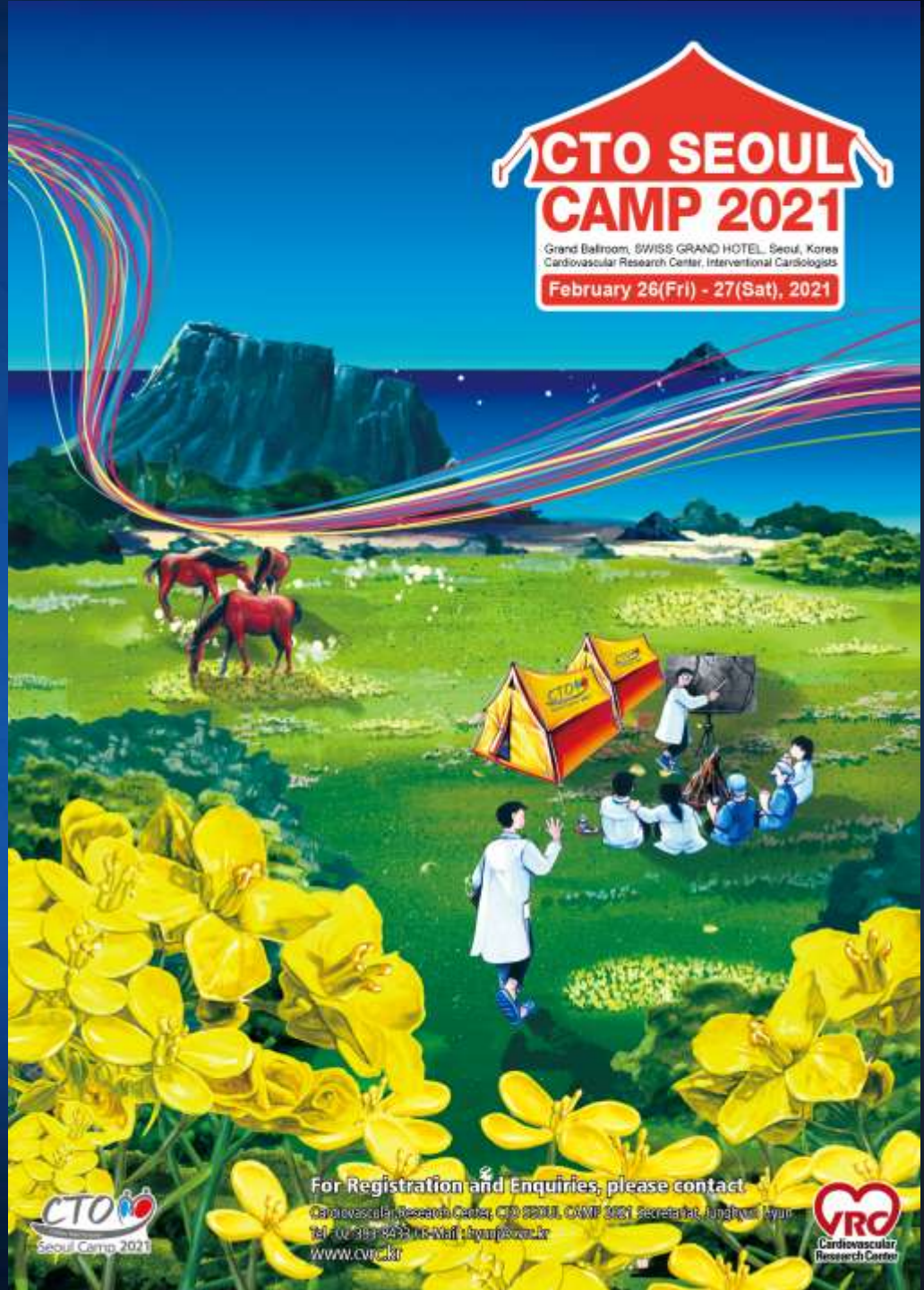
Although there have been various beneficial roles of the CCTA before CTO-PCI, it has not been established whether the CCTA before CTO could guide CTO-PCI and finally improve the success rate.

- In this randomized CT-CTO trial, we firstly demonstrated that **CCTA-guided CTO-PCI based on the pre-procedural CT planning resulted in a higher rate of successful recanalization** for CTO-PCI with a **lower trend of complications (esp. coronary perforation)** during CTO procedures.

- Moreover, the effect of **pre-procedural CCTA** was prominently observed in CTO-PCI patients with **high angiographic scores that predicted difficulty in procedural success.**

Severance

Thank you for your attention!



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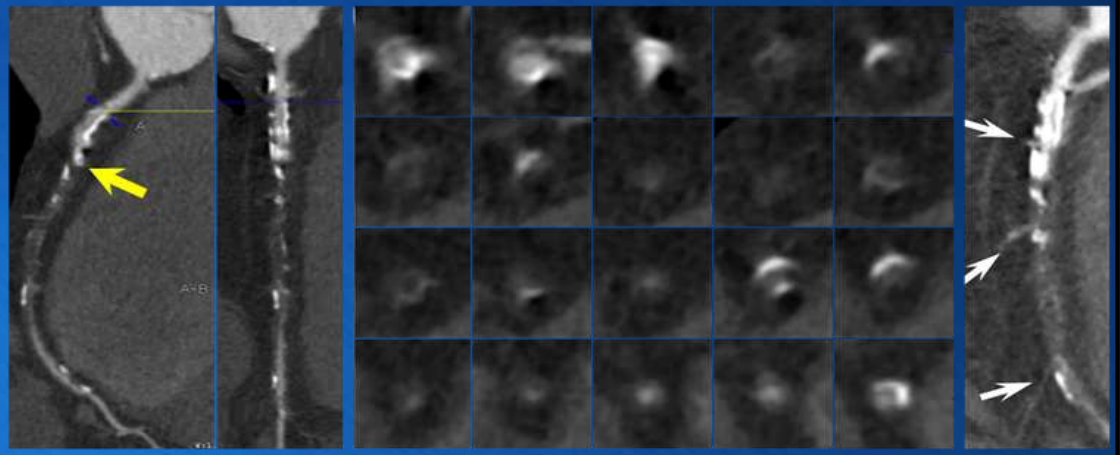
2. **Post-processed images including thin-slab maximum intensity projection and multiplanar reconstruction** (the start points of the stumpless CTO [yellow arrow], major side branches related with CTO segment [white arrows], and distribution of calcification)



3. **CTO length (mm)**	46.2 mm
4. **Shape of proximal CTO end**	Blunt
Shape of distal CTO end	Sharp
5. **Calcification analyses**	
A. Proximal segment	
• Cross-sectional calcification arc (none / <180° / ≥180°)	<180°
• Presence of the cross-sections with maximal calcification extent >50%	No
• Length of calcification with maximal calcification extent >50% (mm)	3 mm
B. CTO body	
• Cross-sectional calcification arc (none / <180° / ≥180°)	<180°
• Presence of the cross-sections with maximal calcification extent >50%	No
• Length of calcification with maximal calcification extent >50% (mm)	0 mm
C. Distal segment	
• Cross-sectional calcification arc (none / <180° / ≥180°)	<180°
• Presence of the cross-sections with maximal calcification extent >50%	No
• Length of calcification with maximal calcification extent >50% (mm)	1 mm
6. **Proximal reference diameter (mm)**	3.2 mm