New Concept of Guidewire Manipulation in CTO PCI

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Disclosure

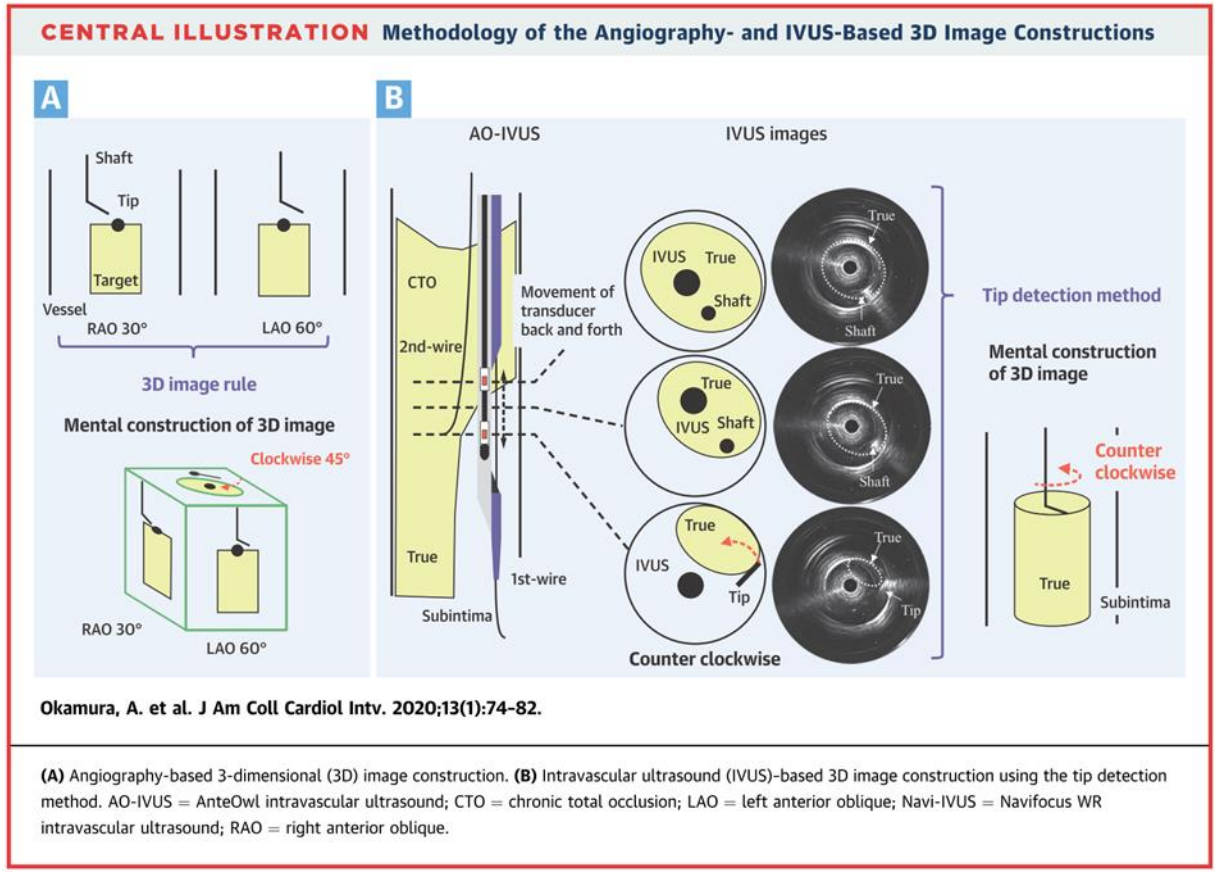
- Dr. Matsuno has nothing to disclose regarding this presentation.
- Drs. Nasu and Katoh have served as consultants for ASAHI INTECC.

Necessity and importance of GW navigation method

- Guidewire (GW) crossing is the most important part in CTO PCI, but GW needs to be advanced to the distal true lumen within 3D blinded space under 2D angiographic guidance, which is the reason why GW crossing is challenging.
- GW manipulation under 2 “perpendicular” angiographic projections and GW navigation method represented by “3D wiring” have been attempted to overcome this difficulty.

Are conventional GW navigation methods enough?

Angiography-based and IVUS-based "3D wiring" methods

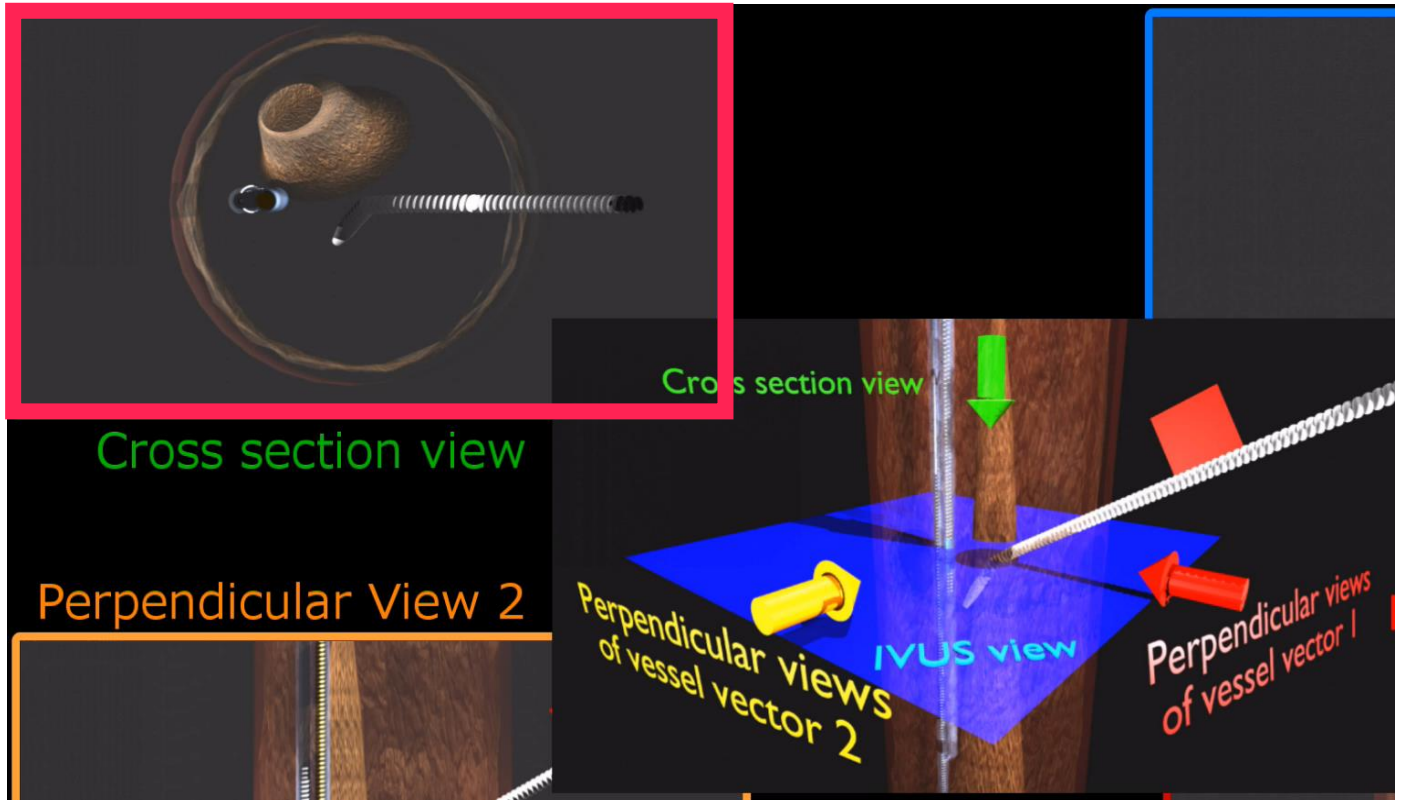


Okamura A, et al. JACC Cardiovasc Interv. 2020 Jan 13;13(1):74-82.

In the condition where the axes of GW shaft, distal true lumen and head-foot axis of the patient (or axis of IVUS catheter) are all parallel, rotation of GW tip can be understood in 2D way.

Limitations of conventional GW navigation methods

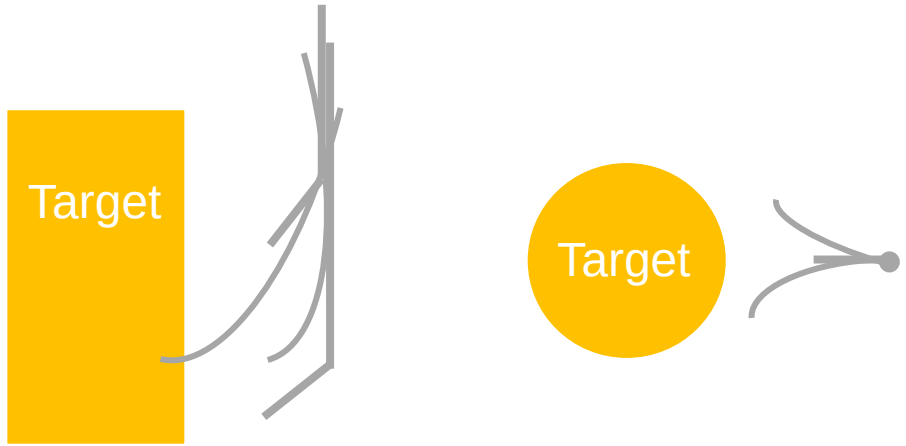
The axes of GW shaft, distal true lumen and view angle direction are rarely parallel in clinical setting



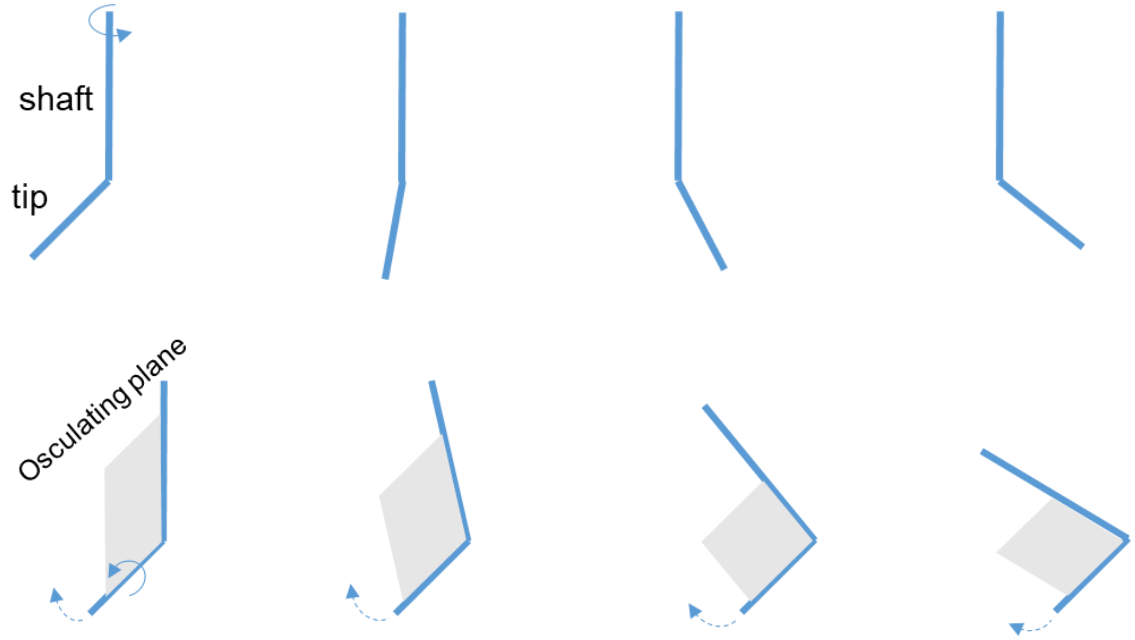
It is very difficult to intuitively know how GW tip behaves and which direction to rotate GW to direct the target.

Limitations of conventional GW navigation methods

"3D-wiring" doesn't guarantee that GW will reach distal true lumen



We can't predict or control degree and direction of GW tip deflection.

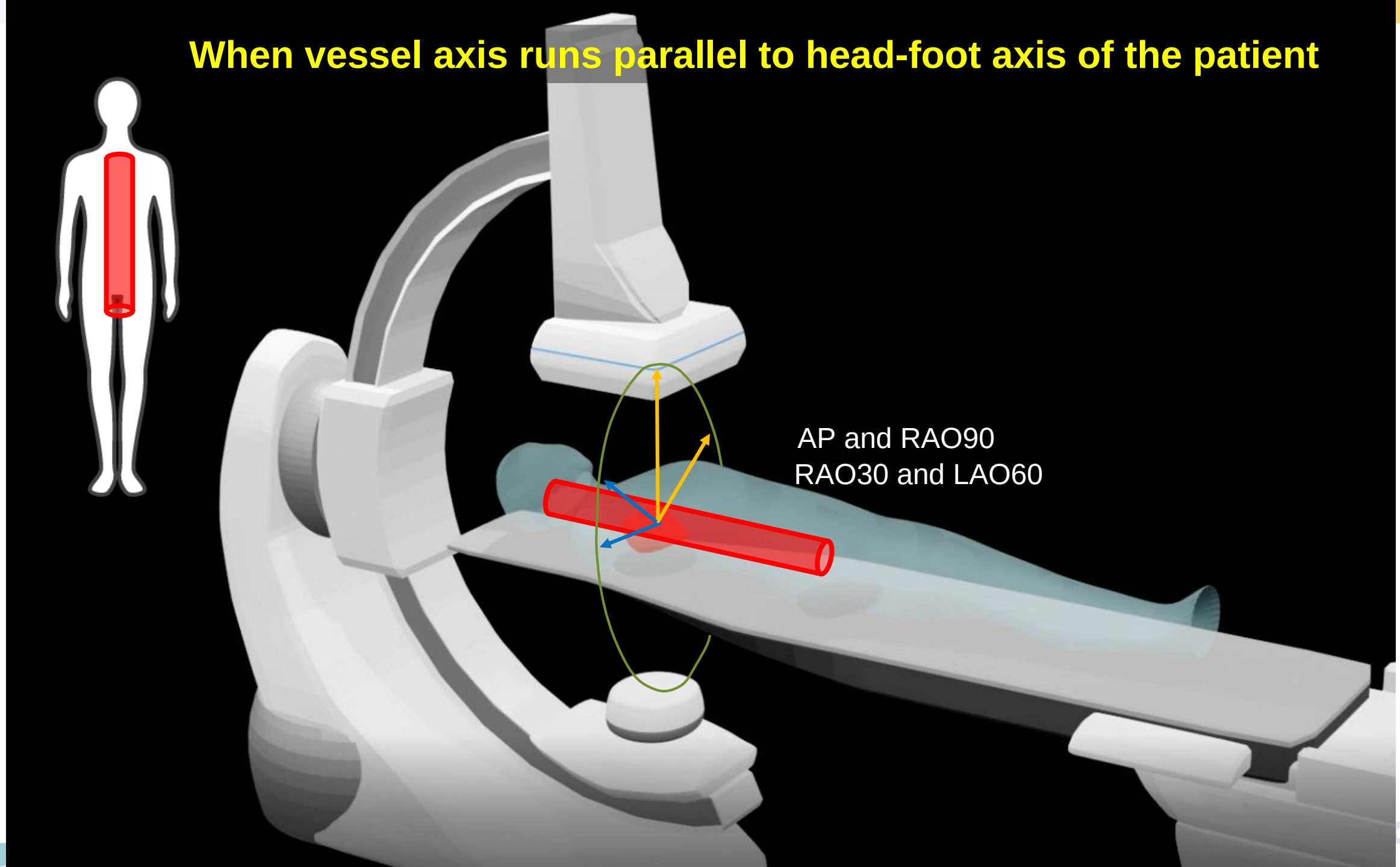


Even if the direction of the GW tip is the same, GW trajectory can go any direction of 360deg in 3D CTO segment.

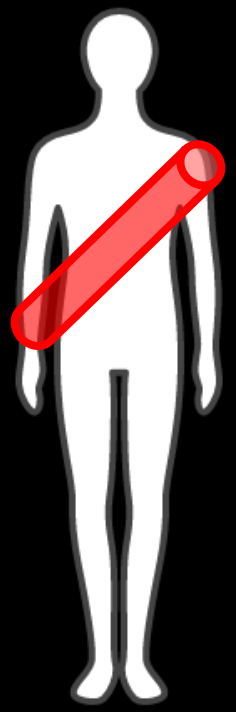
Difficulty in 3D GW control within CTO segment

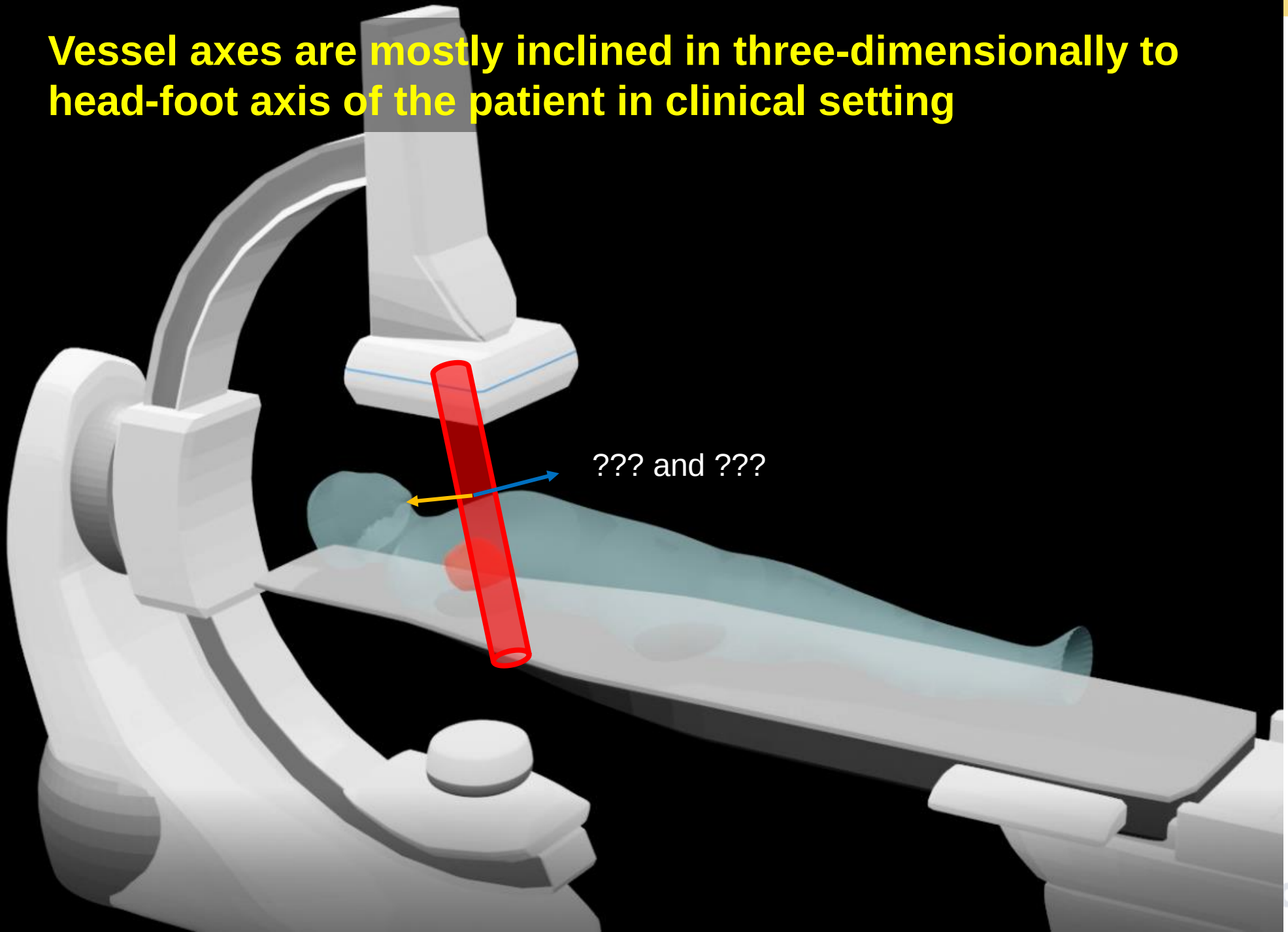
- It is difficult or even impossible to instantly understand 3D movement of GW tip during GW manipulation.
- Mechanical guidewire has fundamental limitations such as whipping, tip deflection, creation of semilunar space and lack of penetration efficiency, which makes GW control in 3D CTO segment more difficult.
- GW crossing becomes simpler and more reproducible if 3D GW control can be converted to 2D wire control on properly set angiographic views.

When vessel axis runs parallel to head-foot axis of the patient



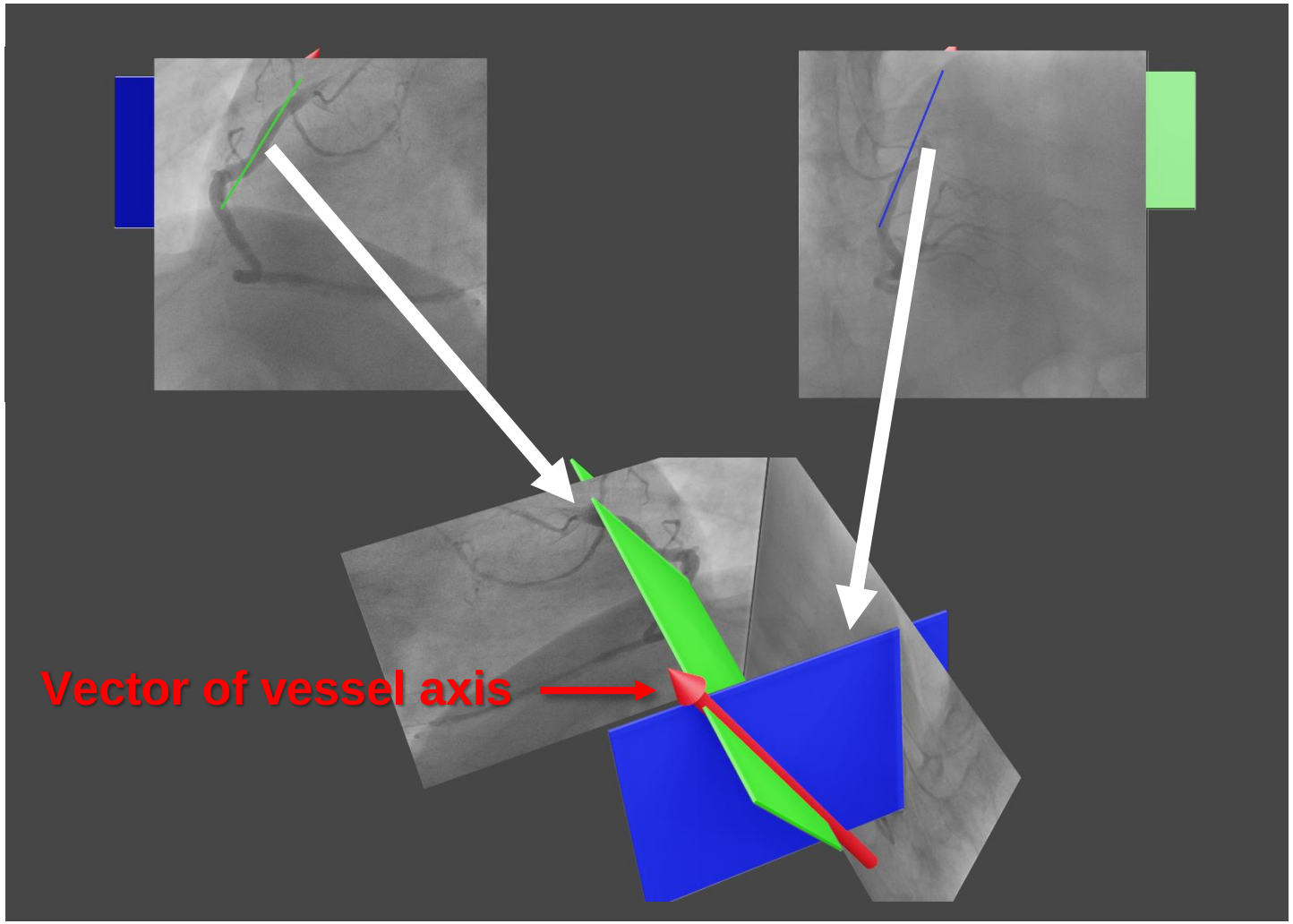
Vessel axes are mostly inclined in three-dimensionally to head-foot axis of the patient in clinical setting





How to detect accurate perpendicular views?

Detection of vessel vector of target segment by using vector projection



As the angiography is a projection image of coronary artery, vessel vector of short segment of CTO segment or distal true lumen can be conversely reconstructed from 2 angiographic images.

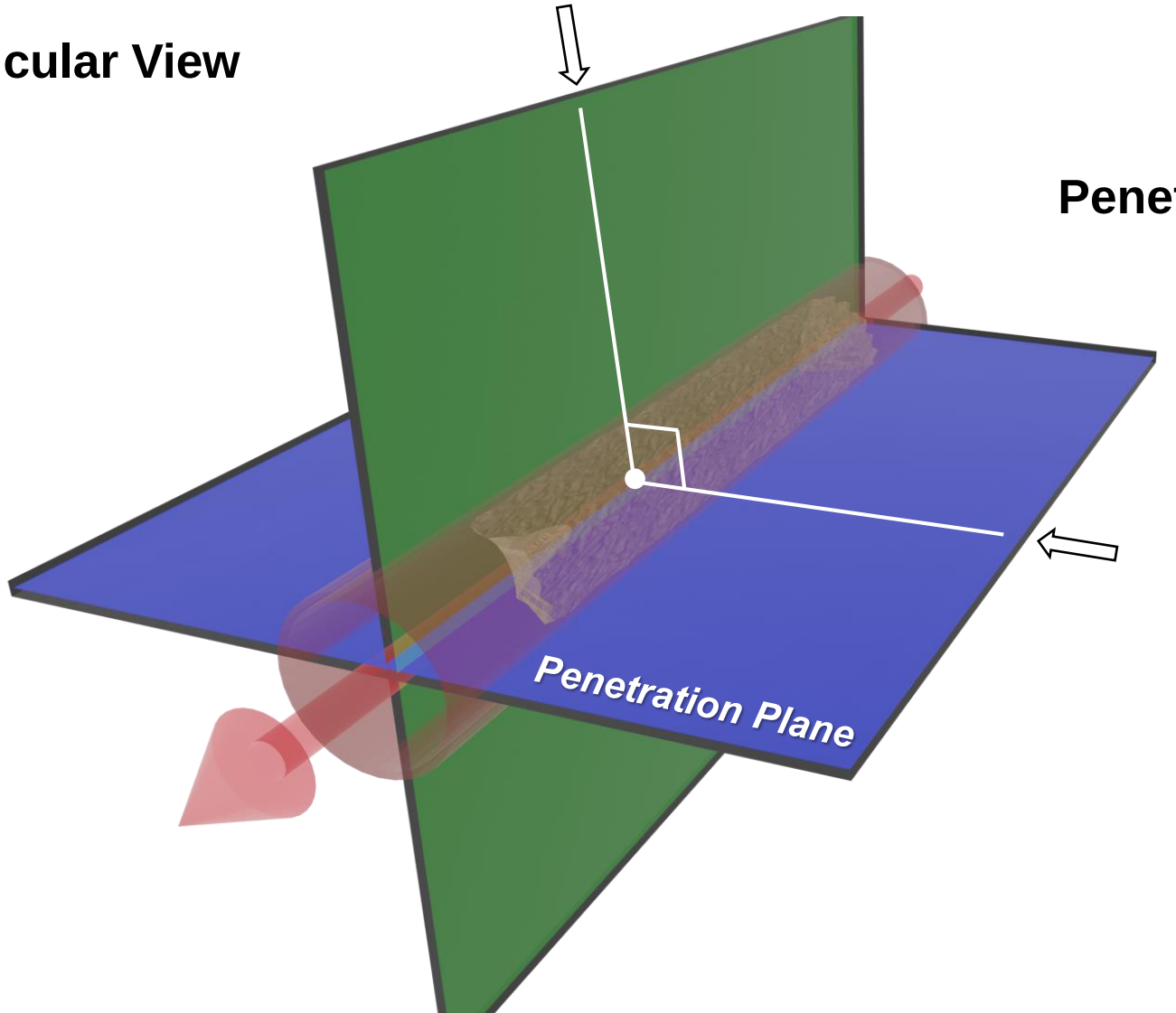
1. Planes are inserted to the target segment on randomly selected 2 angiographic projections.

2. Vessel vector of the target segment can be detected as a straight line where 2 planes intersect behind the screen.

How to detect exact perpendicular views?

Setting up 2 planes containing vessel vector and being orthogonal to each other

Objective Perpendicular View (OPV)

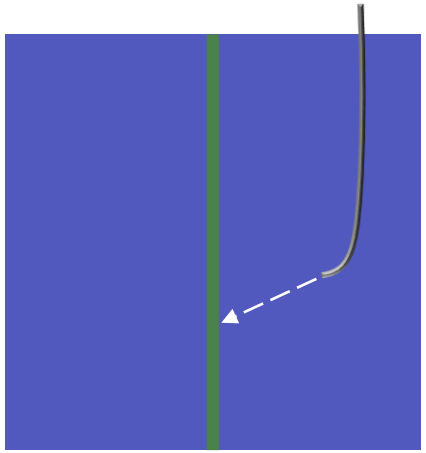


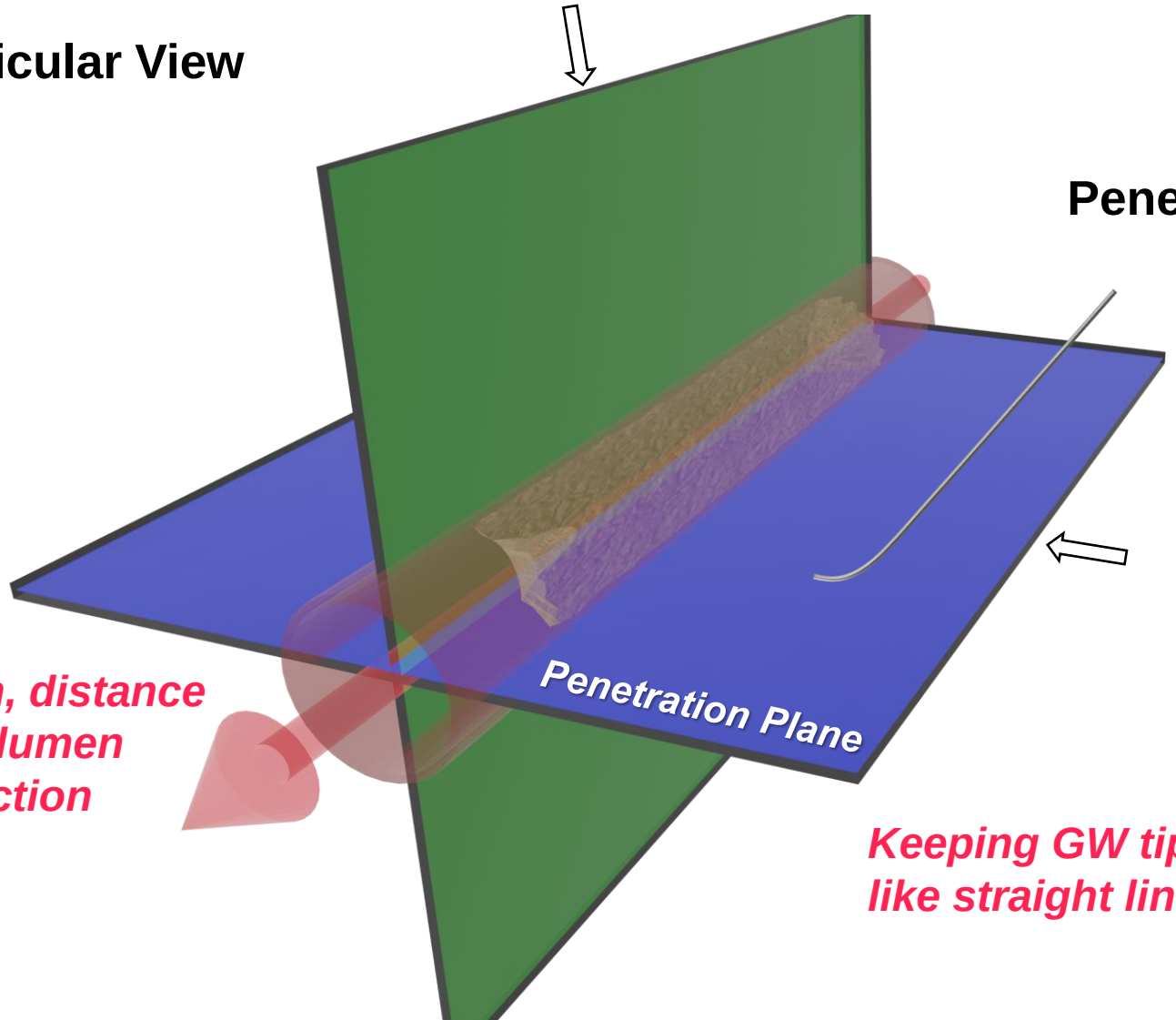
Penetration Plane View (PPV)

GW manipulation using penetration plane method

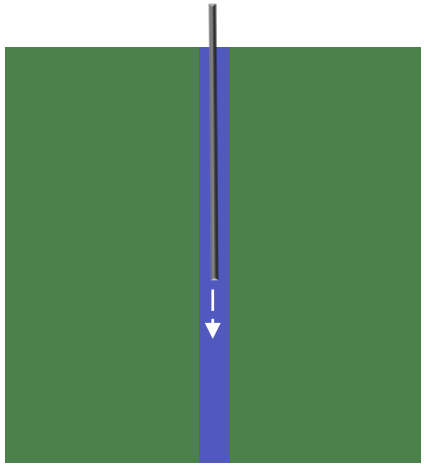
3D wire control can be converted to 2D wire control on the plane

Objective Perpendicular View (OPV)





Penetration Plane View (PPV)



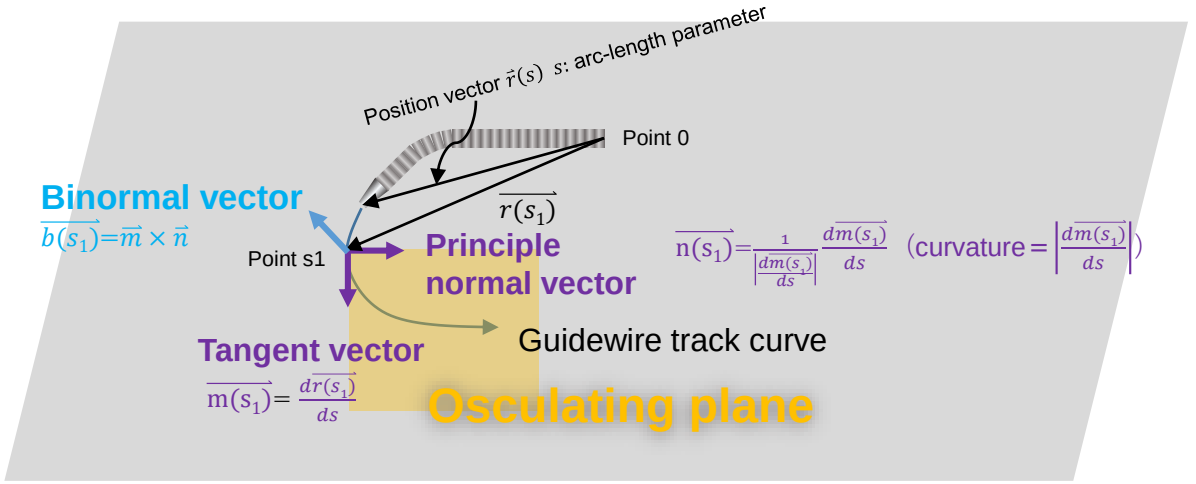
Checking GW tip direction, distance from GW tip to distal true lumen and changing GW tip direction

Keeping GW tip and adjacent GW shaft like straight line

Rationale for penetration plane method

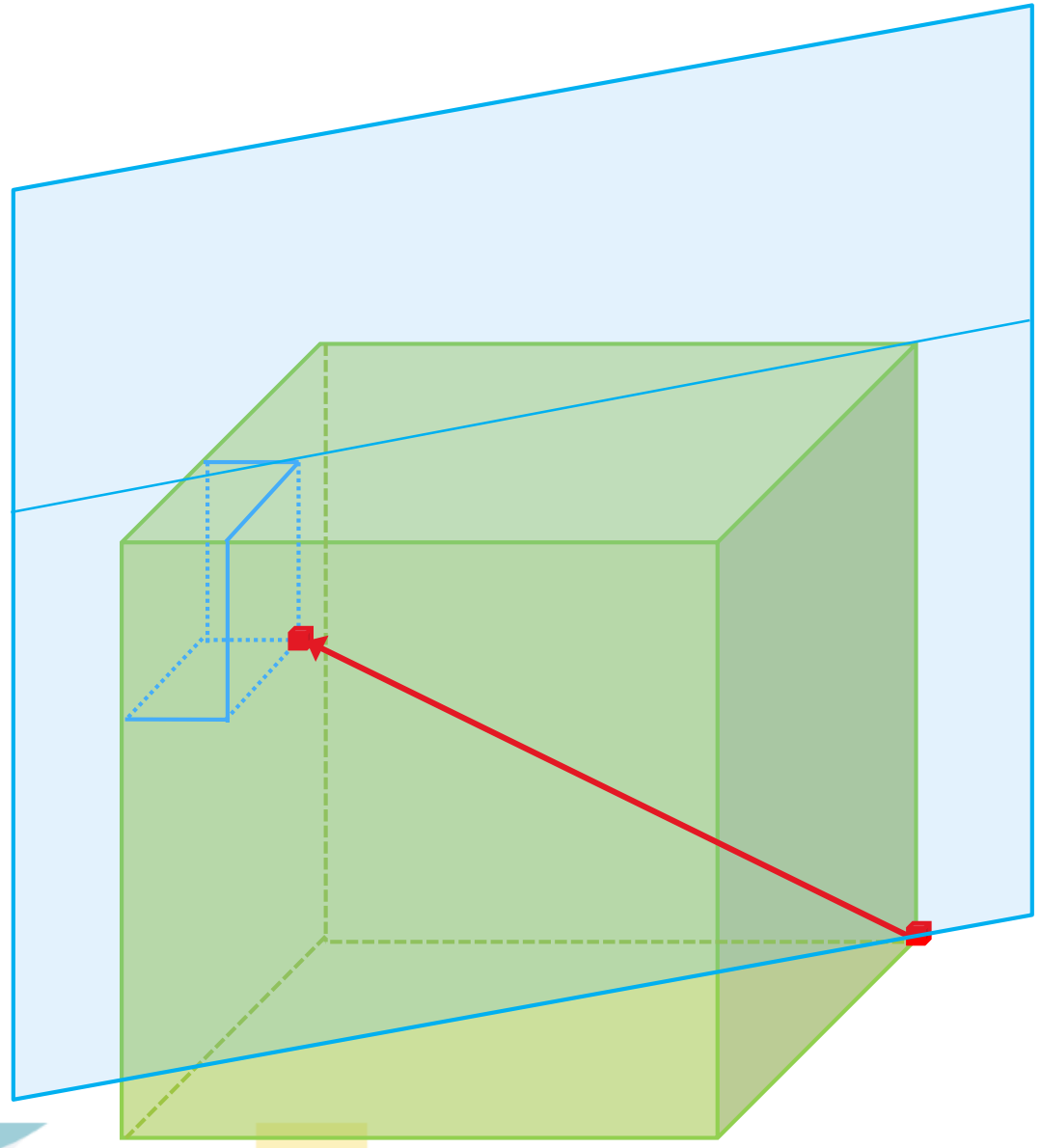
Principle of GW control using tip deflection and importance of penetration plane

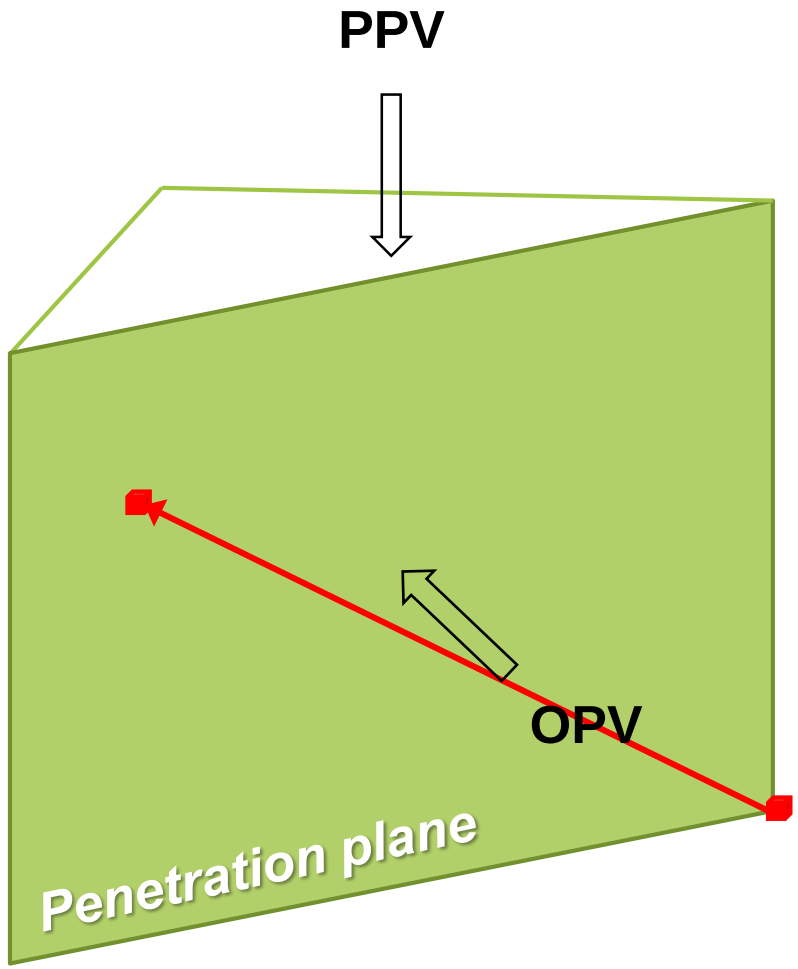
The plane formed by the GW tip and the adjacent GW shaft is identical to the osculating plane (the plane formed by tangent and principle normal vectors) of the GW track curve.



If the GW tip direction is controlled to keep on the plane, we can keep the GW on the plane and control GW track curve as a plane curve (= 2D wire control becomes feasible).

Training model for GW control on penetration plane

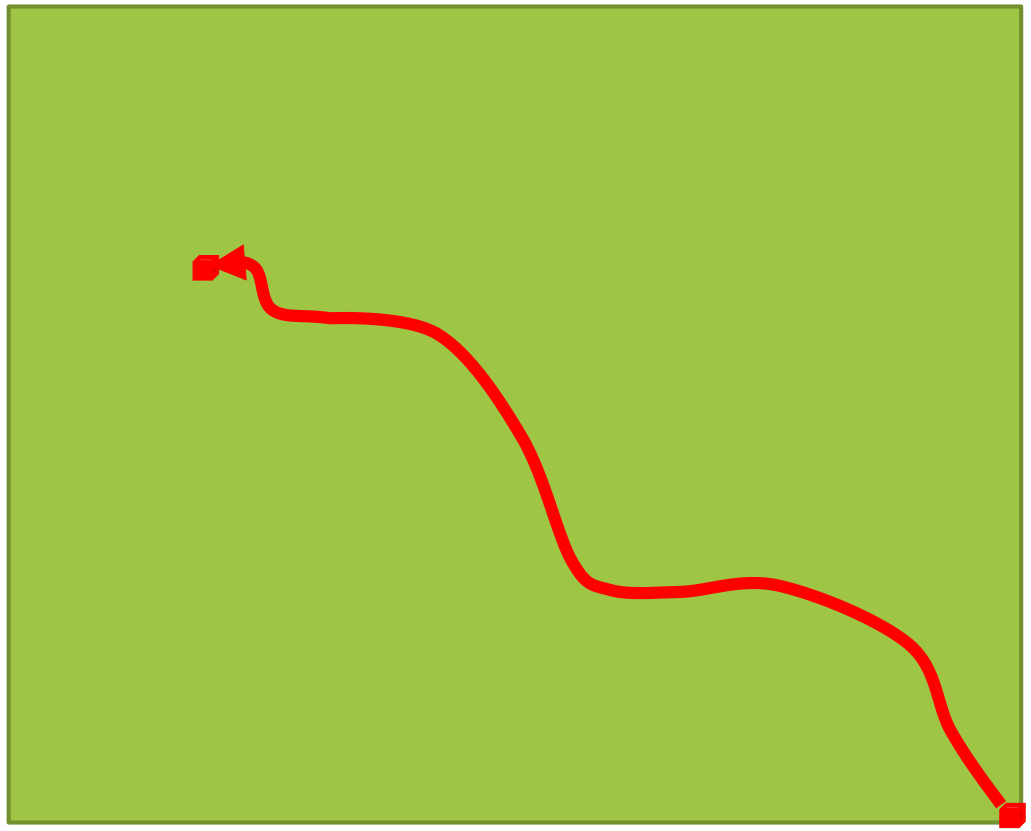




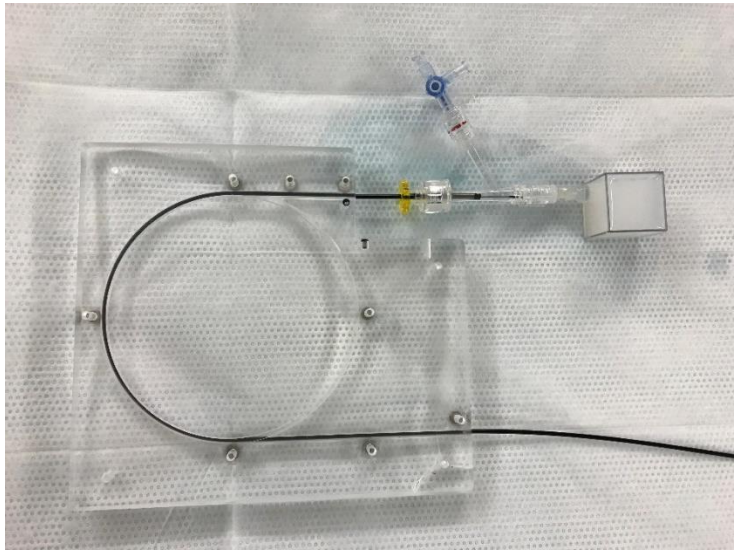
GW manipulation on the penetration plane

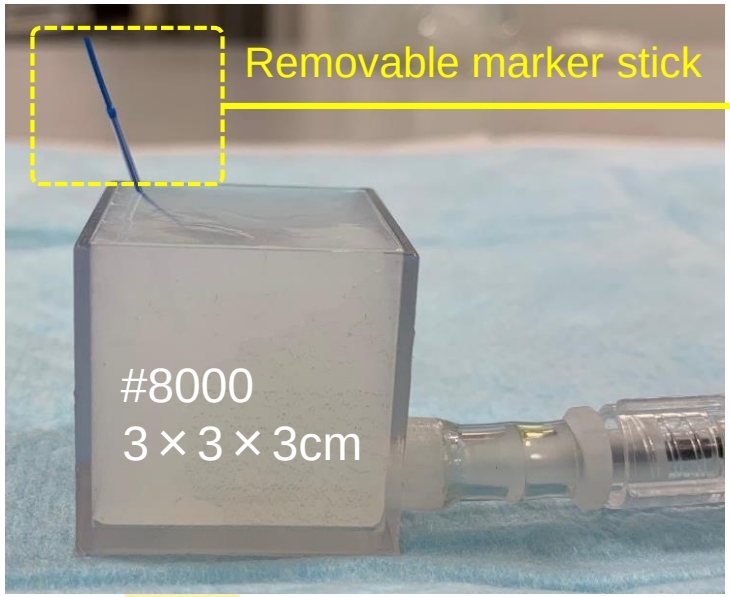
On PPV: keeping GW course like straight line

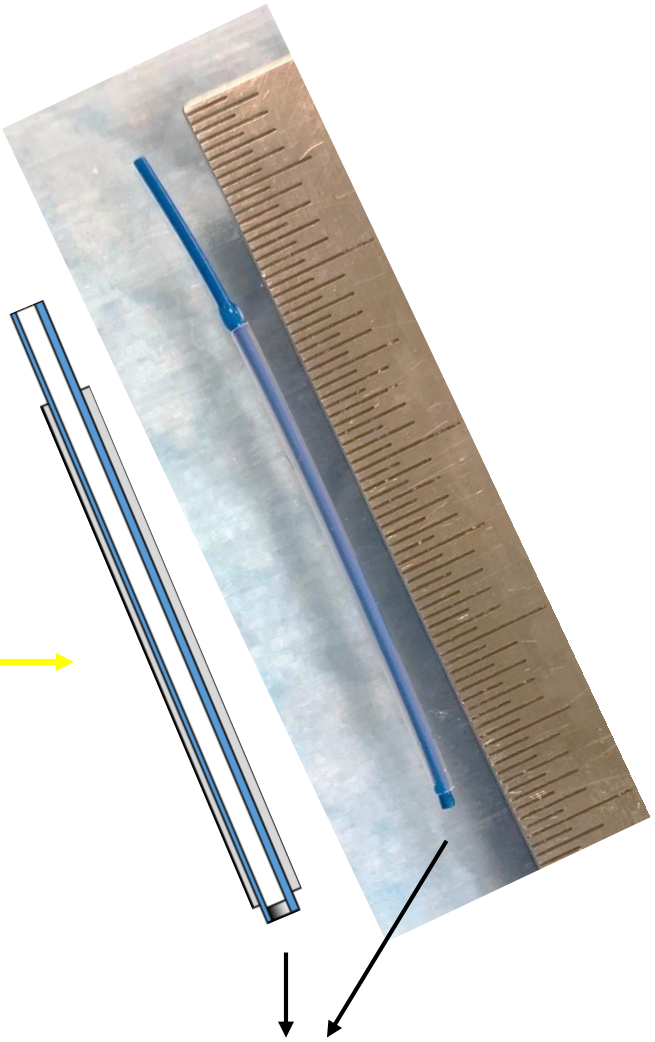
On OPV: changing GW tip direction



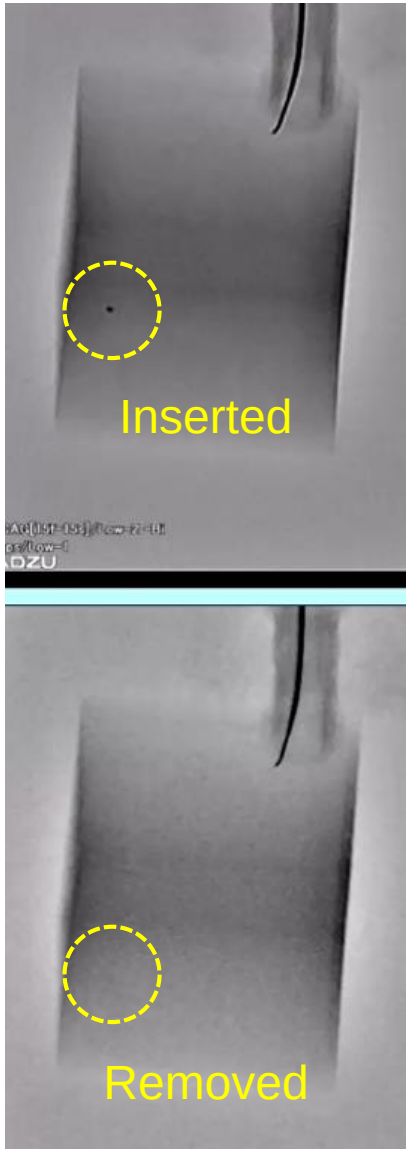
ETOSS CUBE training model



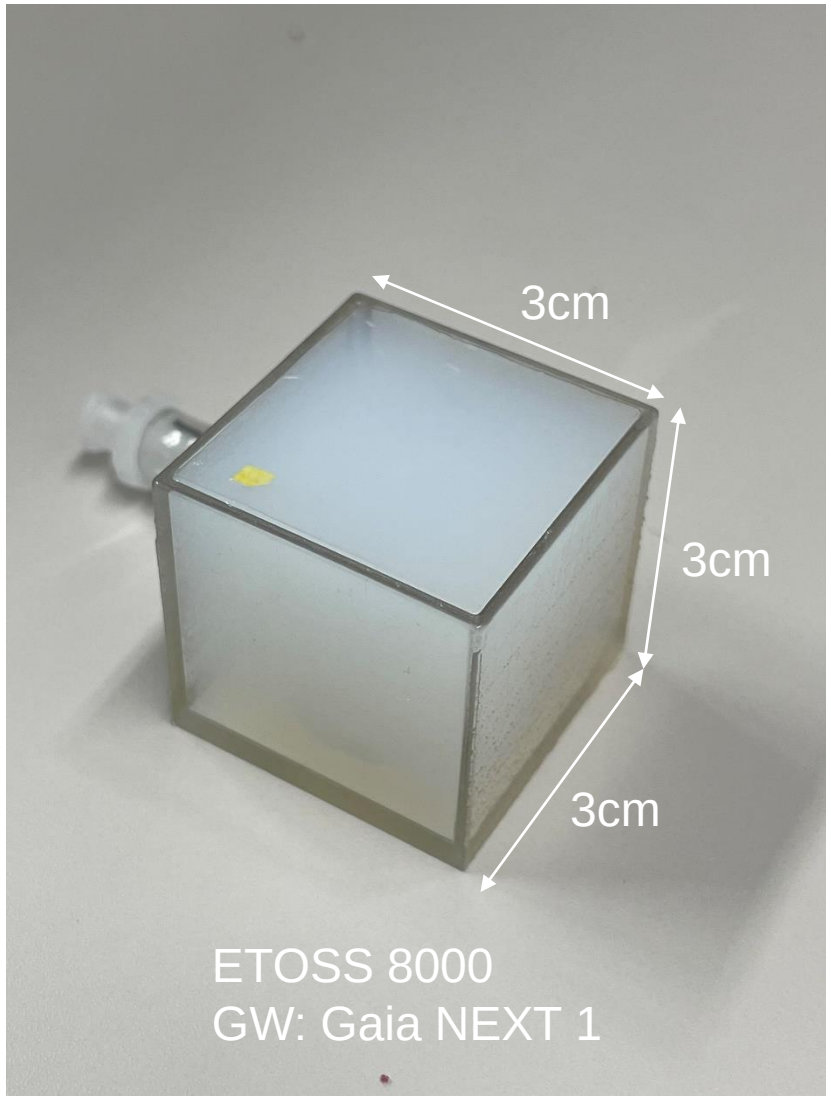


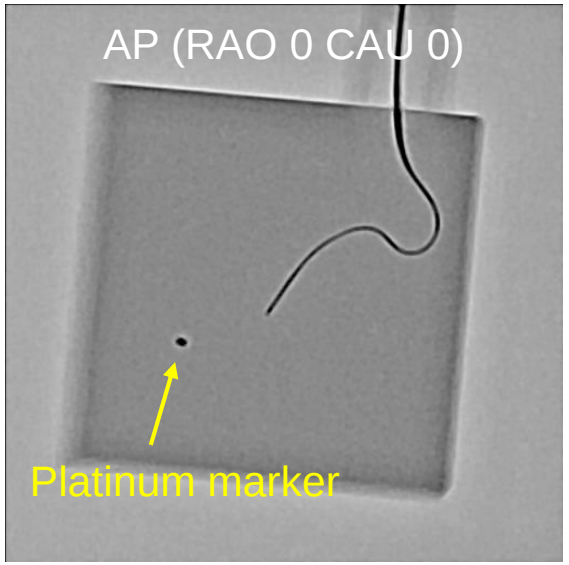


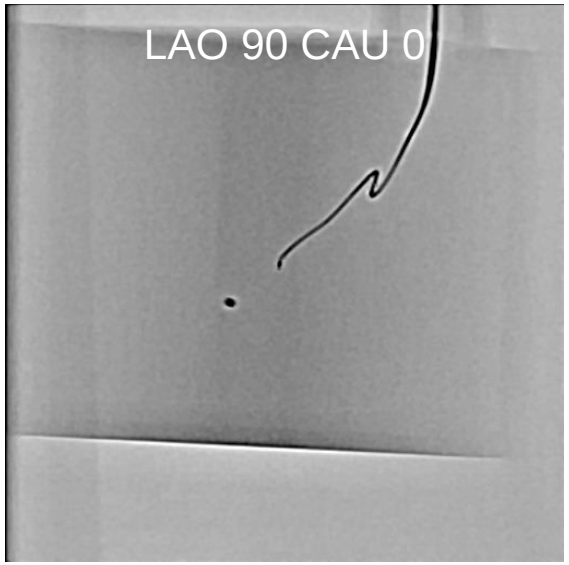
Target marker ring (Platinum)



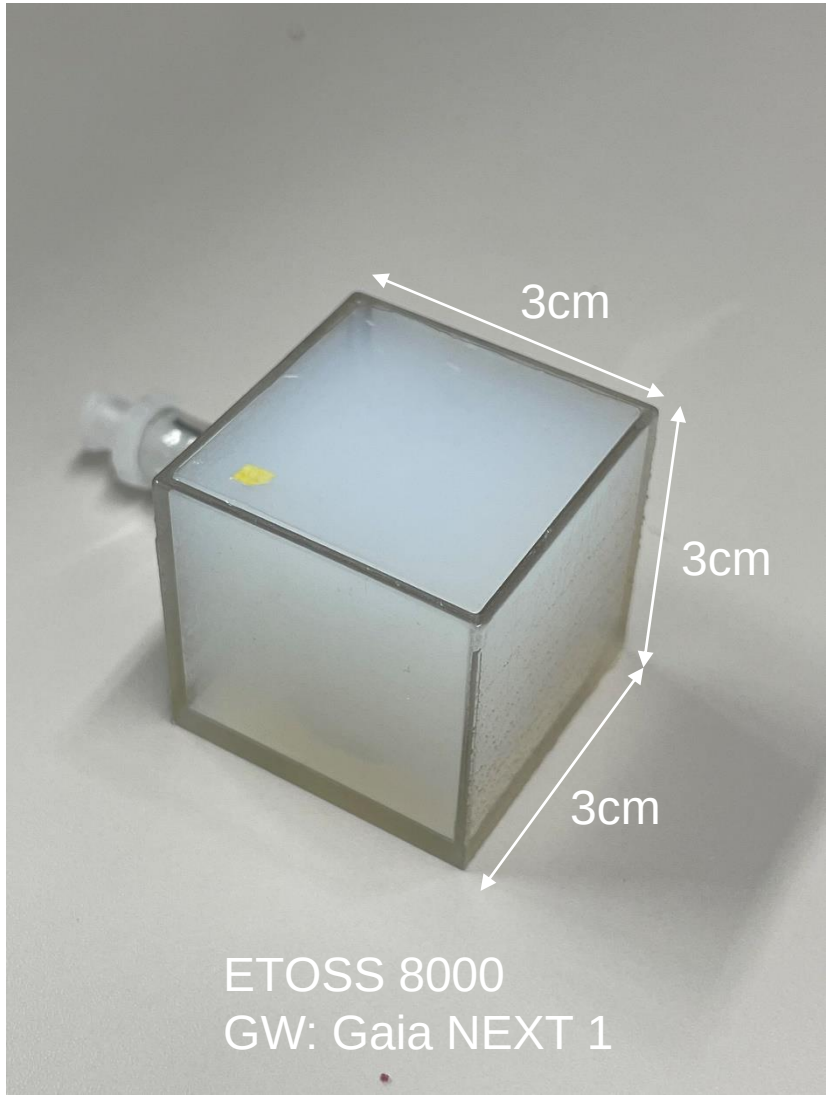
GW manipulation without setting penetration plane

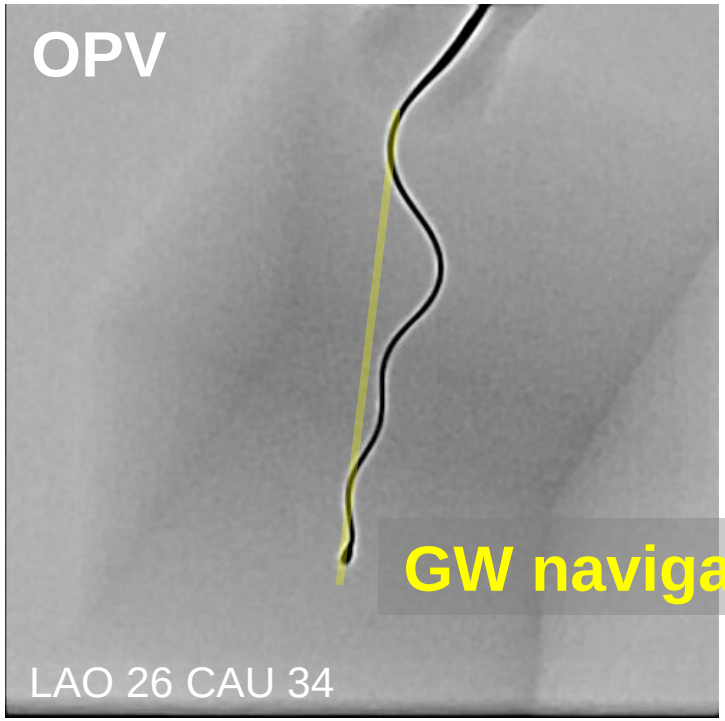


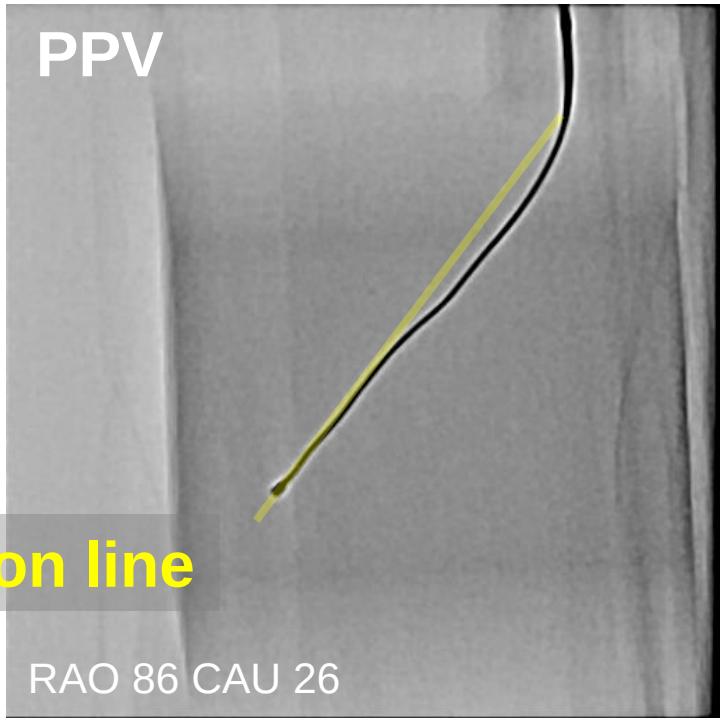




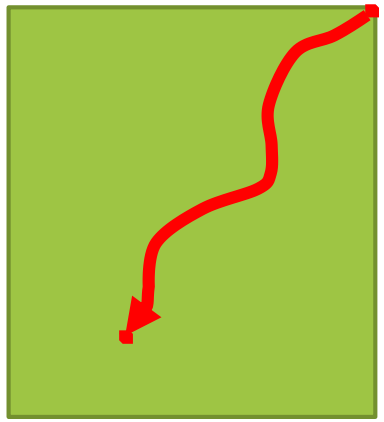
GW manipulation using penetration plane method





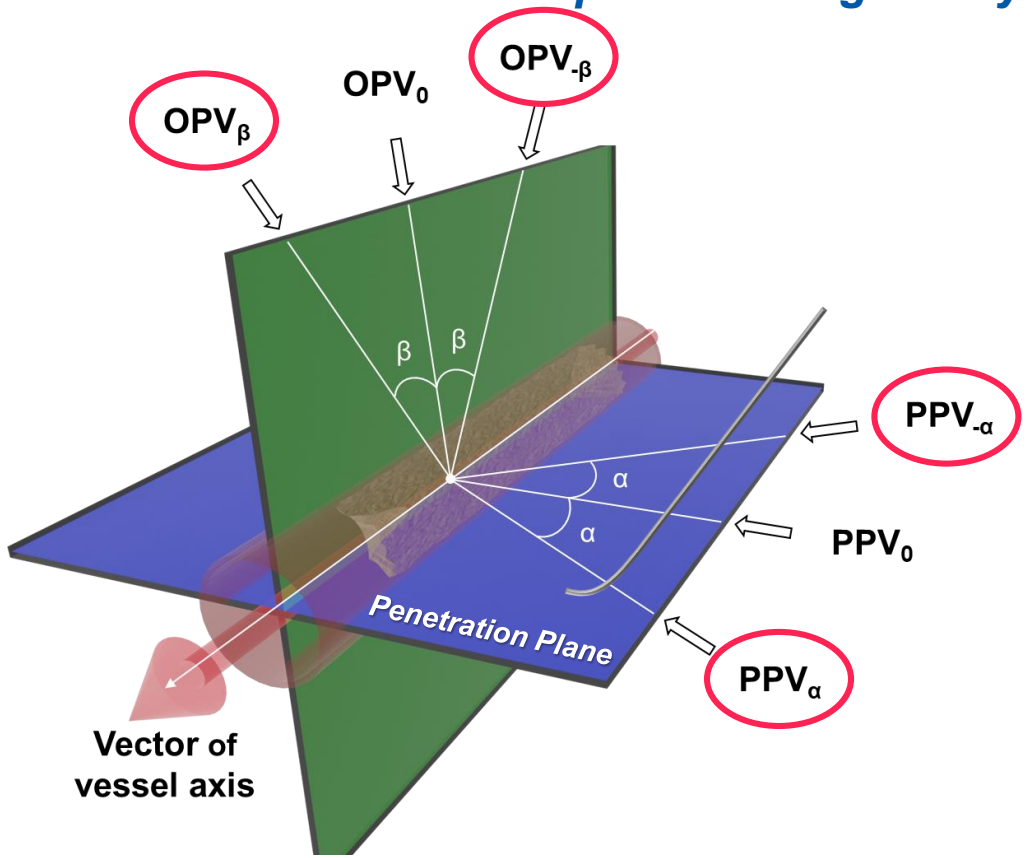


GW navigation line



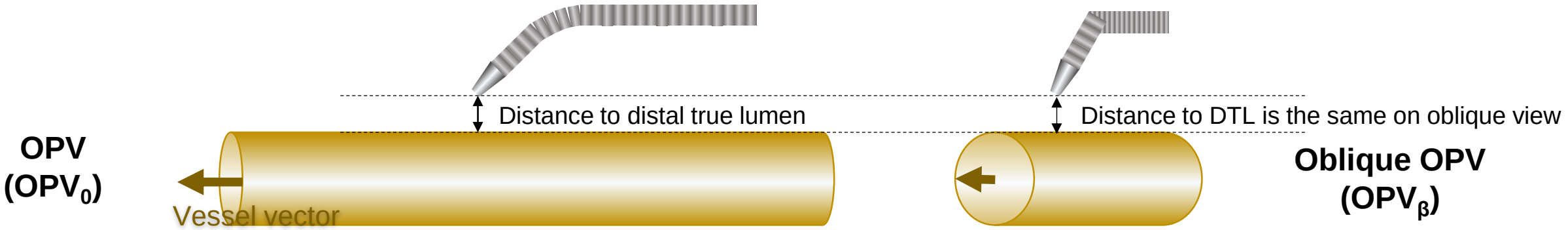
PPV and OPV are sometimes out of movable range

Oblique views to overcome the limitation- concept of "orthogonality" in CTO PCI

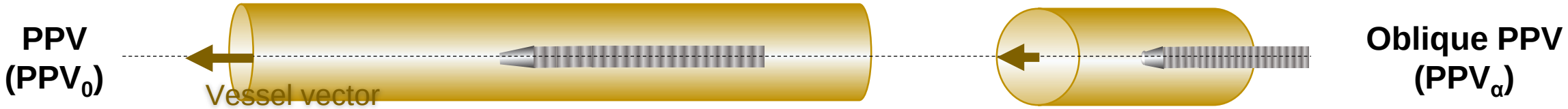


Oblique PPV (PPV$_\alpha$) and oblique OPV (OPV$_\beta$) are not orthogonal geometrically, but are **defined to be "orthogonal" as 2 planes formed by vessel vector and 2 oblique views are orthogonal.**

Oblique PPV and OPV for linear vessel axis



“Oblique views” should be strictly oblique to vessel vector.



We can get the same information from PPV_{α} and OPV_{β} as PPV_0 and OPV_0, respectively.

Conclusion

- **Conventional GW navigation methods have some critical limitations** and thus it doesn’t sufficiently contribute to reliable GW control within 3D CTO segment.
- **Penetration plane method** using 2 orthogonal planes containing the vector of vessel axis of the CTO segment **enables 2D GW control and makes GW crossing simpler and more reproducible**.

Thank you for your kind attention!