Curved multi-planar reformat for assessing device deployment in neurovascular interventional treatment

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Aims and objectives

In this poster we present our experiences and findings in using curved multi-planar reformat (CMPR) in neurovascular interventional treatment, such as aneurysm treatment by either (stent-supported) coiling, or flow diverting stents. The CMPR visualizations were applied in the assessment of device deployment, such as stents, in contrast enhanced high-resolution cone-beam CT (VasoCT).

Methods and materials

Curved multi-planar reformat

Curved multi-planar reformat (CMPR) visualization can be used to represent vascular structures without foreshortening, by fitting a curved plane through the vascular centerline, and depicting this plane on a straight surface [1,2,3]. The vessel can be visualized either while maintaining the in-plane curvature (Figure 1), or completely straightened (Figure 2). The advantages of this representation are:

- There are no overlapping structures.
- There is no foreshortening, which benefits measurements and observations.
- The vessel (and all contained entities, such as intra-vascular devices, calcified plaque, etc) can be evaluated along its entire length at once.

Evaluation method

Twelve illustrative patients were selected to retrospectively assess the CMPR visualization method. On all patients a high resolution cone-beam CT (VasoCT, Philips Healthcare, Best, the Netherlands) was acquired immediately after device deployment [4,5]. The evaluation of the CMPR visualization was performed using these VasoCT datasets. To this means the devices depicted in the VasoCT data were first evaluated in traditional multi-planar reformats (MPR), and consequently using the CMPR method.

The resulting visualizations were scored on:

1. Ease-of-use
2. Assessment of stent apposition

The scoring was done using a 5 point scale, whereby 1 represented the best score and 5 corresponded to the worst score:

1. excellent
2. very good
3. good
4. fair
5. poor

Images for this section:

Fig. 1: Curved reformat view on a SURPASS flow diverting stent (Stryker Neurovascular, Fremont, CA). The curved view removes the out of plane curvature (z-direction), but maintains the in-plane curvature (xy-direction).

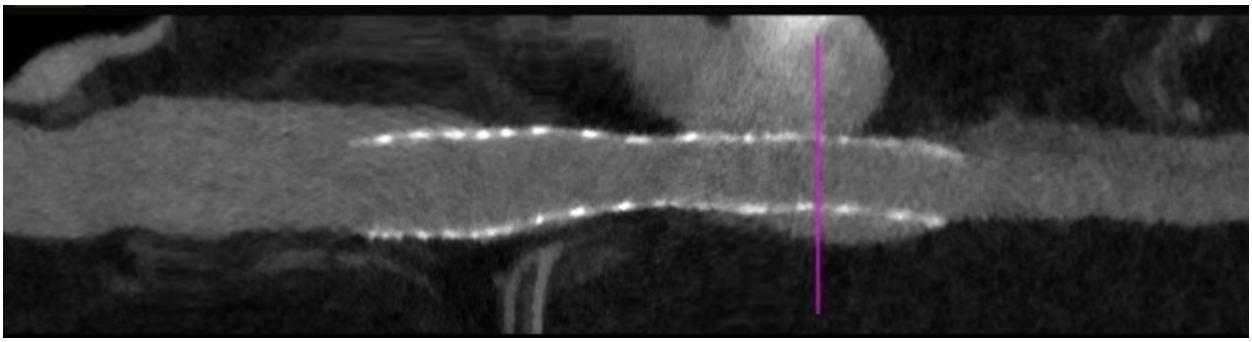

Fig. 2: Straightened reformat of the same vessel and stent as in Figure 1. The straightened reformat removes both the out of plane curvature, as well as the in-plane curvature by straightening the vessel center line.

Results

Illustrative cases

Case 1

For vessels with a certain degree of curvature, it becomes impossible to view the entire vessel lumen in a thin traditional MPR slice, as can seen below. Also rotating along the center line is a very cumbersome task for such traditional MPR sliced views of curved vessels.

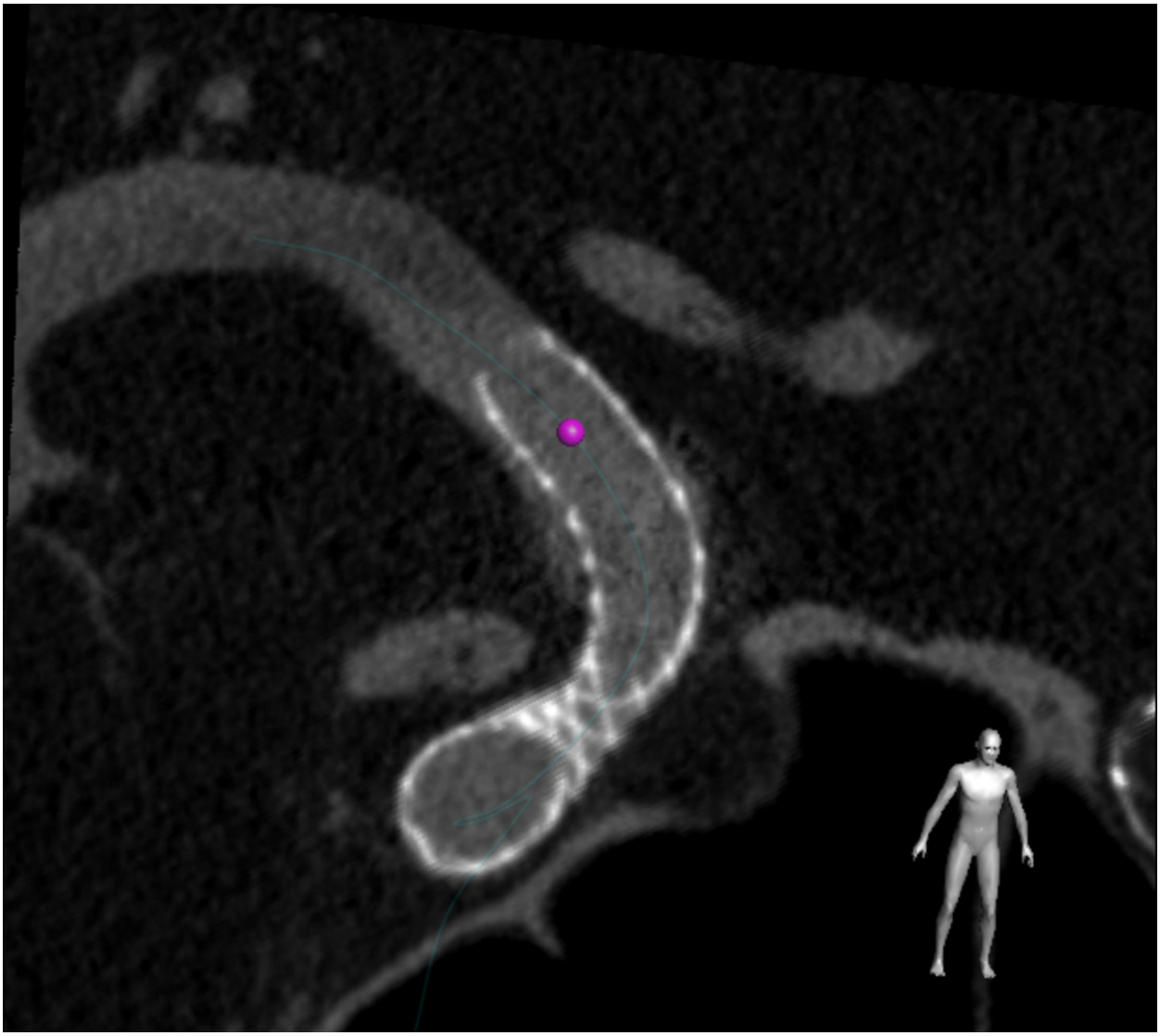

Fig. 3: Tradition MPR slice is unable to depict a cross-sectional view of the vessel lumen along the entire center line.
References: NEURI center, Department of NRI, Bicêtre University hospital Paris, France

The CMPR technique alows to inspect the vessel lumen along its entire legnth at once, as shown below (for the same stent). It can be easily rotated around its center line. In this case the CMPR revealed that the stent was distally underdeployed, while the proximal end was not fully touching the vessel wall. Both effects have been corrected by ballooning the deployed stent. It should be noted that the CMPR visualization may stretch or compress structures outside the vessel, such as is the case with the aneurysm below.

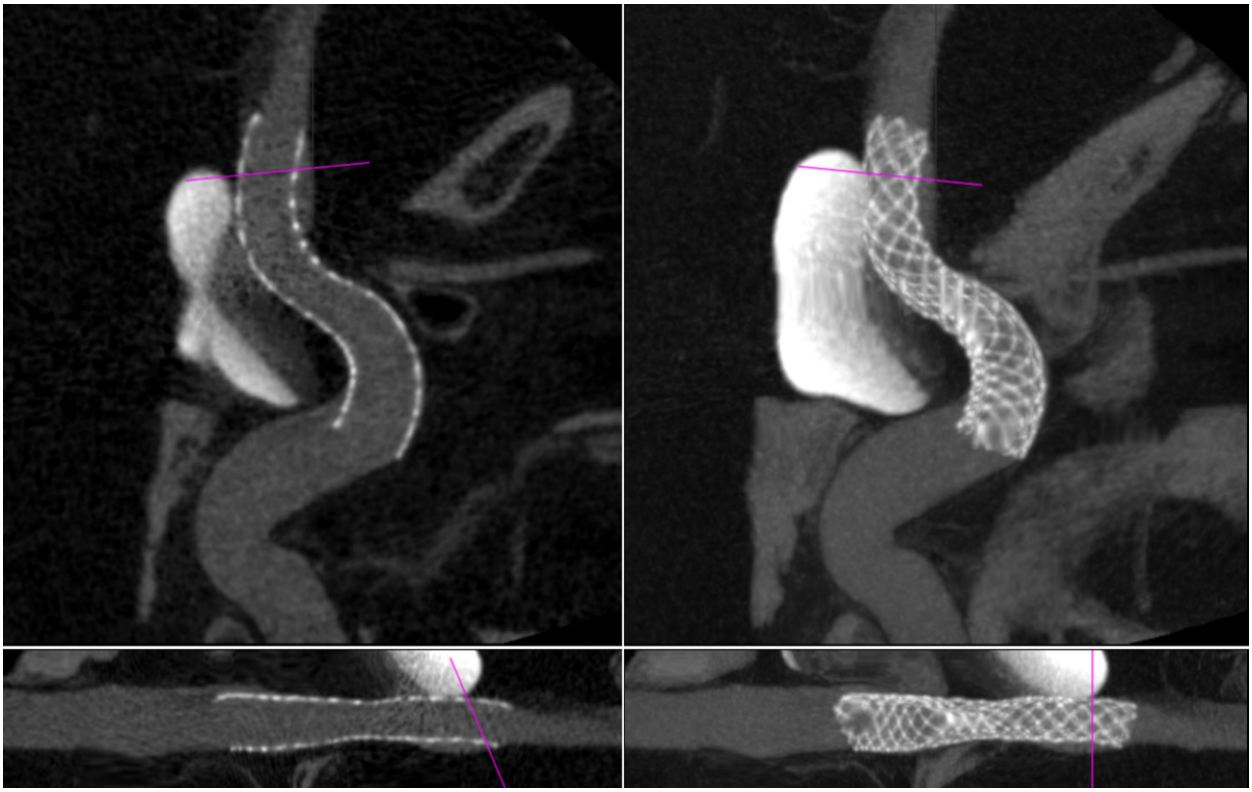

Fig. 4: The CMPR view allows to inspect the deployment of the stent along the entire lumen at once.
References: NEURI center, Department of NRI, Bicêtre University hospital Paris, France

Case 2

In another case the CMPR method (depicted below) clearly showed that the proximal part of the stent was not properly touching the vessel wall, which was corrected by balloon inflation.

Fig. 5: The CMPR visualization enables an easy and complete assessment of the stent deployment.
References: NEURI center, Department of NRI, Bicêtre University hospital Paris, France

The CMPR after ballooning clearly shows the improved proximal deployment:

Fig. 6: CMPR visualization after ballooning.
References: NEURI center, Department of NRI, Bicêtre University hospital Paris, France

Overall scores

The traditional MPR visualization method scored on average 2.8 out of 5 (lower is better) with a standard deviation of 0.97 on ease-of-use and 2.9 out of 5 (stddev = 1.08) on assessment of stent apposition, while the CMPR visualization method scored on average

1.8 out of 5 (stddev = 1.06) on ease-of-use and on average 1.3 out of 5 (stddev = 0.62) on assessment of stent apposition.

	Ease of use		Assessment of stent apposition	
	Traditional MPR	Curved MPR	Traditional MPR	Curved MPR
Average	2.8	1.8	2.9	1.3
Std dev	0.97	1.06	1.08	0.62

Conclusion

The CMPR visualizations have been found to be easier to use than the MPR visualizations (average of 1.8 vs. 2.8 on a 5 point scale, lower is better), while also scoring better on assessment of stent apposition (average of 1.3 vs. 2.9). Overall, it can be concluded that the CMPR visualizations are considered a valuable tool during the assessment of device deployment in interventional vascular treatment.

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References

[1] A. Kanitsar, D. Fleischmann, R. Wegenkittl, P. Felkel, M. E. Gröller, "CPR - Curved Planar Reformation", in Proceedings of IEEE Visualization 2002

[2] J. A. Garcia, S. Bhakta, J. Kay, K.-C. Chan, O. Wink, D. Ruijters, J. D. Carroll: "On-line multi-slice computed tomography interactive overlay with conventional X-ray: A new and advanced imaging fusion concept", International Journal of Cardiology 133(3): e101-e105, 2009. doi:10.1016/j.ijcard.2007.11.049

[3] T. Ochi, K. Shimizu, Y. Yasuhara, T. Shigesawa, T. Mochizuki, J. Ikezoe, "Curved Planar Reformatted CT Angiography: Usefulness for the Evaluation of Aneurysms at the Carotid Siphon", AJNR 20: 1025-1030, 1999

[4] O. Kizilkilic, N. Kocer, G. E. Metaxas, D. Babic, R. Homan, C. Islak, "Utility of VasoCT in the treatment of intracranial aneurysm with flow-diverter stents", J Neurosurg 117: 45-49, 2012. doi:10.3171/2012.4.JNS111660

[5] J. Caroff, C. Mihalea, H. Neki, D. Ruijters, L. Ikka, N. Benachour, J. Moret, L. Spelle: "Role of C-Arm VasoCT in the Use of Endovascular WEB Flow Disruption in Intracranial Aneurysm Treatment", AJNR 35(7), 1353-1357, 2014. doi:10.3174/ajnr.A3860

[6] www.linnc.com