Carotid artery endarterectomy vs. stenting: are there any relevant morphological and hemodynamic implications?

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Abstract

Background. Carotid endarterectomy (CEA) and carotid artery stenting (CAS) are interventional therapeutic alternatives for the treatment of carotid stenosis (CS), which is partially triggered by hemodynamic conditions regulated from the bifurcation morphology. The predictive potential of morphological and hemodynamic features was recently examined in the post-CEA setting, suggesting that arteriotomy repair should avoid a large widening of the carotid bulb, which is linked to restenosis via the generation of flow disturbances [1,2]. Here, we study the impact of CAS vs. CEA with patch-plasty on carotid bifurcation geometry and hemodynamics, supported by patient-based computational simulations.

Methods. After digitally recording CT data of patients treated with CAS (n=2) or CEA (n=2), the 3D carotid bifurcation geometries were reconstructed. As geometry shapes the flow, which is in turn implied in the restenosis process, a centerline-based geometric analysis was carried out on the reconstructed geometries (Figure 1). Hemodynamics-informed geometric descriptors were calculated, i.e., carotid flare (a measure of the carotid bulb expansion) and tortuosity, as suggested elsewhere [2-3]. Complementary, computational fluid dynamics simulations were performed to determine the extent of luminal surface area exposed to low and oscillatory wall shear stress, a hemodynamic condition widely recognized as "disturbed shear", with acknowledged atherogenic [4] and restenosis risk potential [2].

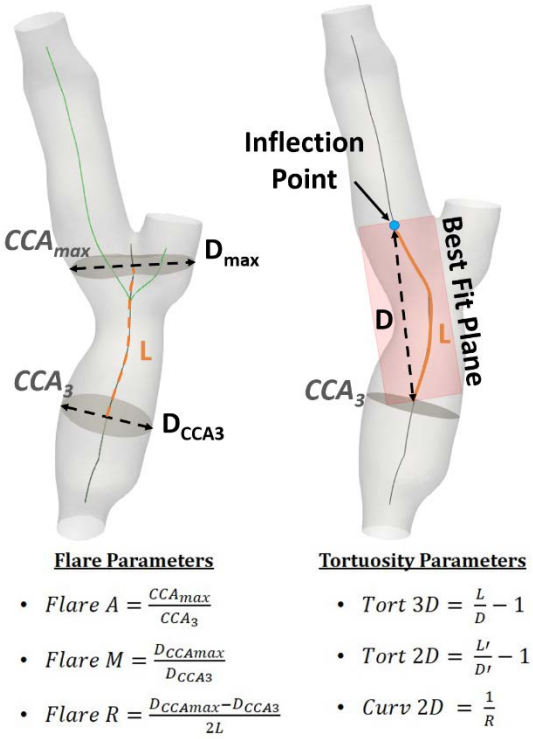

Figure 1. Geometrical variables used in the definition of the flare and tortuosity parameters [2].

Results. A different reshaping of the carotid bifurcation was observed as a consequence of CAS vs. CEA. In general, stent implantation led to reduced tortuosity, while no significant variation was observed for flare with respect to the pre-operative geometry.

Conversely, CEA led to a significant increase of flare and to minor variations of tortuosity. As for hemodynamics, larger areas at the luminal surface exposed to disturbed shear were observed in stented cases (Figure 2).

Conclusion. CAS and CEA reshape the carotid bifurcation in a different way, suggesting that different restenosis trajectories are possible in the long term. The larger disturbed shear area in CAS cases might be ascribed to the decrease in tortuosity [2-3], although the complex interaction between geometry and the underlying disturbed shear will be subject of future investigations. The present results confirm very recent findings [2] suggesting that geometric and hemodynamic analyses hold potential for the virtual exploration of personalized post-operative scenarios, providing useful indications on (1) the best treatment strategy (e.g., CEA vs. CAS), and (2) the stratification of post-intervention restenosis risk.

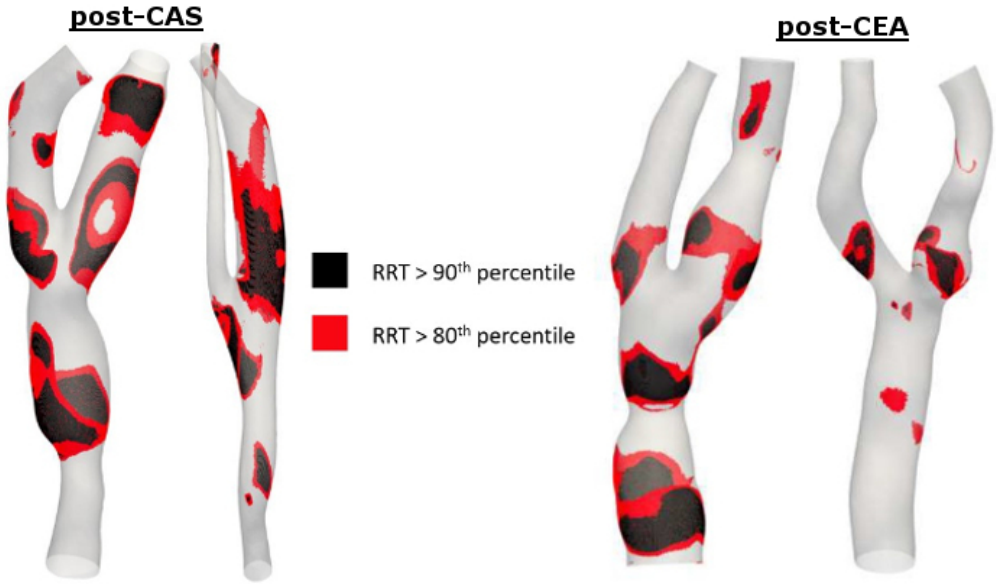

Figure 2. Areas exposed to low and oscillatory wall shear stress (RRT) after CAS and CEA with patch-plasty.

References

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