ANATOMIC-BASED ANALYSIS TO SCREEN POST ENDOVASCULAR ANEURYSM REPAIR PATIENTS

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Introduction

Endovascular aneurysm repair (EVAR) is a reliable minimally invasive alternative to open-chest surgery, in the treatment of abdominal aortic aneurysm (AAA). EVAR results in redirection of blood through the deployed endovascular graft (EG), and in reshape of the iliac bifurcation, altering hemodynamics and adversely affecting its performance [1]. As geometry shapes the flow, we study the impact that different EG systems have on local anatomy. A morphometric analysis is carried out on subjects undergoing EVAR and results are compared with healthy subjects. The rationale of the study is that the delineation of geometric features associated with commercially available EGs could promote the personalization of treatment offered to aneurysmal patients and inspire ideas to improve EG design.

Methods

Subjects suffering from AAA were treated with two EG systems, N=10 with the Endurant® (Medtronic, CA, USA), and N=10 with the Excluder® (Gore Medical, AZ, USA). CT scans were obtained before and one month after EVAR [1]. Five subjects with no sign of aneurysmal disease underwent CT angiography. Acquired images were segmented and 3D models reconstructed [1] (Fig. 1). Centreline-based analysis was carried out on reconstructed models.

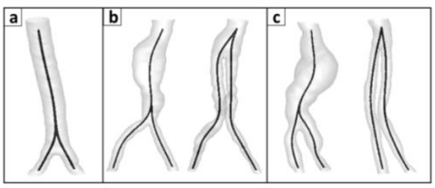

Figure 1: Examples of reconstructed models and centerlines of (a) healthy case, (b) Endurant pre and postoperative, (c) Excluder pre and postoperative

Points belonging to the geometric locus of the centres of the maximum inscribed spheres in the anatomic model were extracted [2]. Free-knots regression splines were used as a basis of representation to provide a noise-free, analytical formulation for centerlines, that were characterized in terms of curvature (κ) and torsion (τ) [2]. Cross-sectional area A and its variation rate R along the curvilinear abscissa were also calculated.

Results and Discussion

Geometric features in preoperative models are very similar and, as expected, greater than postoperative and the healthy models (Fig. 2). Subjects treated with Excluder present κ and A average values lower than subjects with Endurant, except for κ in body area (Fig. 2a-2b). Moreover, the anatomy of subjects treated with the Excluder is closer to healthy cases, except for κ in the body zone and A in the right branch. The two stent graft present reversed τ values (Fig. 2c), with exclusion of the right branch. Average R values are independent of the EG model in the branches, but lower than healthy subjects, while subjects treated with the Excluder present an average R value lower than Endurant and closer to healthy case (Fig. 2d).

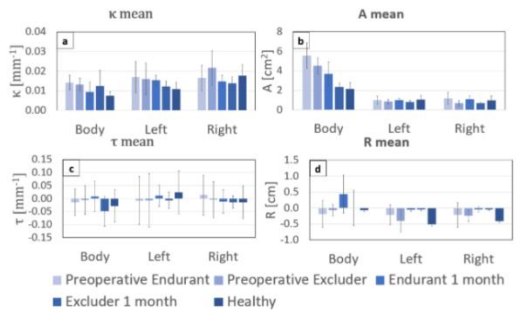

Figure 2: Average values of (a) curvature, (b) cross-sectional area, (c) torsion, and (d) cross-sectional area variation-rate.

The anatomy-based analysis highlights that Excluder restores anatomic features closer to the healthy ones, at one month from implantation. In future, hemodynamic analysis will be combined with the geometric analysis, to better understand how the specific EG design features alter local hemodynamics and adversely affect EVAR performance.

References

1. Raptis, A et al., Comput. Methods Biomech. Biomed. Engin., 0:1-8,2016.
2. Gallo, D et al., *Comput. Fluid*, 141:54-61, 2016.