The use of a castellated mesh for resistance calculations of upper airways

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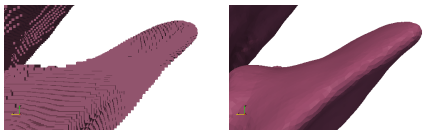
I. Introduction

Nowadays, Computational Fluid Dynamics (CFD) is accepted as an important tool for analyzing treatments for respiratory diseases. Previous studies showed that, in sleep apnea patients, the change in upper airway resistance after mandibular repositioning correlates very well with the clinical outcome [1]. A full automatic system based on open source software would help the acceptance of CFD in clinical practice. The problem is that regular automatic mesh generators can not guarantee the mesh quality as skewness problems can be situated at the boundaries. When using castellated meshes, the quality is always good as this mesh does not follow the boundary perfectly (figure 1(a)), however this means that geometrical errors are introduced compared to regular (snapped) meshes (figure 1(b)). In this study, CFD calculations are performed using the open source CFD code OpenFOAM (OpenCFD Ltd, UK) in order to test if castellated meshes are suited for resistance calculations of upper airways.

II. Materials and methods

An upper airway is segmented from computed tomography scans, from the hard palate to the vocal cords. The open source SnappyHexMesh (OpenCFD Ltd, UK) is used for the generation of a castellated mesh and a snapped mesh. As a verification, a tetrahedral grid is created using a validated commercial mesh generator TGrid 5.0.6 (Ansys, Lebanon, USA). All meshes contain about 1.000.000 cells. Calculations are performed laminar and second order discretization algorithms are chosen.



(a)Castellated mesh (b)Regular mesh

Figure 1. Meshes

III. Results

The difference in resistance between the TGrid mesh and the snapped SnappyHexMesh mesh is only 0.4%. However, the difference between the results of these meshes and the castellated mesh is 10%.

IV. Conclusions

Castellated meshes are not suitable for resistance calculations of upper airways. The introduced errors at the boundaries are too big in these complex geometries. However, snapped meshing with SnappyHexMesh shows to be a promising tool in further research.

References

[1] J.W. De Backer, O.M. Vanderveken, W.G. Vos, A. Devolder, S.L. Verhulst, J.A. Verbraecken, P.M. Parizel, M.J. Braem, P.H. Van de Heyning, and W.A. De Backer, "Functional imaging using computational fluid dynamics to predict treatment success of mandibular advancement devices in sleep-disordered breathing," *Journal of Biomechanics*, vol. 40, no. 16, pp. 3708–3714, 2007.

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