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Abstract

Development and evaluation of a 3D-printed reversible stenosis for medical vessel phantoms

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Cardiovascular diseases (CVD) remain the leading cause of death globally.[1] CVDs like coronary heart disease or peripheral artery disease are generally treated with endovascular interventions like balloon angioplasty (*percutaneous transluminal angioplasty*, PTA). To develop and evaluate new instruments or to conduct training for interventional treatments anthropomorphic phantoms of blood vessels are a promising experimental setup.[2]-[4] The use of phantoms comes along with the potential of patient individualized training, the reduction of animal trials as well as possible cost savings.

Stenoses and occlusions of blood vessels are the main pathophysiological mechanism behind CVD. They are most commonly treated by PTA often followed by stenting. Our objective was to develop a versatile, reversible, and multi-use 3D-printed stenosis which can be installed into different 3D-printed vessel phantoms. The morphology of the stenosis can be individualized to fit the intended scenario. The key feature of the stenosis is its elastic formability, which allows a realistic treatment with a balloon catheter. This feature was realized through a hollow freeform design with a fluid filled cavity inside of the stenosis with a small, controlled drainage to the environment. To simulate a treatment via PTA a balloon catheter is placed and inflated at the stenosed site, compressing and deforming the stenosis. After removing the balloon, the stenosis stays compacted, leaving an increased vessel diameter representing the "therapeutic result". To reuse the stenosis for experimental or training purposes it can easily be refilled with fluid to recover its original shape. We evaluated this stenosis in a 3D-printed femoral artery phantom, representing a commonly affected vessel in peripheral artery disease.

Our preliminary evaluation showed the feasibility of conducting a simulated balloon angioplasty with our reversible stenosis in a femoral artery phantom. The next step is to evaluate whether our method is adequate to conduct patient individualized training with benefits like less complications and reduced intervention time. The achievement of such outcomes could pave the way to clinical on-site 3D-printing of the target anatomy for preinterventional training in the future.[4].

Author's statement

Conflict of interest: Authors state no conflict of interest. Ethical approval: The research related to human use complies with all the relevant national regulations, institutional policies and was performed in accordance with the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or equivalent committee.

References

[1] M. Di Cesare et al., The Heart of the World, Glob. Heart, Vol 19 No 1, Jan. 2024
[2] A. Dell et al., Stenosis simulation of femoral arteries using an adaptive 3D-printed actuator, Trans. Addit. Manuf. Meets Med., Vol 3 No 1, 2021
[3] Th. Friedrich et al, 3D-printing of elastic stenosis phantoms, Trans. Addit. Manuf. Meets Med., Vol 2 No 1, Sep. 2020
[4] J. Coles-Black et al., Accessing 3D Printed Vascular Phantoms for Procedural Simulation, Front. Surg., Vol. 7, Jan. 2021

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