Effect of strut curvature on the crimpability of mitral valve stents

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Abstract

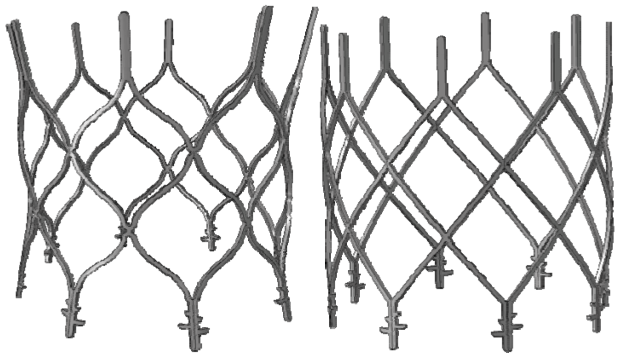
Background: The superelastic, shape memory, biocompatibility, and fatigue resistance properties of nitinol, a nickel–titanium alloy, have made the material attractive for medical devices such as self-expandable heart valve stents. Nitinol based self-expandable stents with specific features are used in percutaneous valve replacements to prevent transcatheter valves from getting migrated, thereby providing anchorage. Finite element analyses (FEAs) of these stent designs reduce testing and manufacturing time by optimizing them and coming out with ideal ones before deploying them appropriately. Stent crimping is an essential process in the design, delivery and deployment of valve stents for percutaneous heart valve replacement. Failure during crimping will affect its expansion when deployed in the anatomical position.

Methods: This paper discusses the usage of FEA to optimize nitinol based mitral valve stent designs based on the total strain developed during crimping of stents with straight struts and curved struts. The total strain which is the sum of the elastic strain, transformation strain and the plastic strain would determine functional efficacy of the stent during implantation. Two different stent designs, one with straight struts and the other with curved struts were analyzed in the paper. The stents were modelled using Solidworks (Dassault Systemes, MA) and FEA was done using ABAQUS (Dassault Systemes, MA). Figure 1 shows the two designs generated using Solidworks.

Results: The results of this work show that a stent with curved struts had lower crimping strain of 7.1 % when crimped to 18 F compared to the one with straight struts whose crimping strain was 7.68 %. Figure 2 shows the crimped configuration of both the designs.

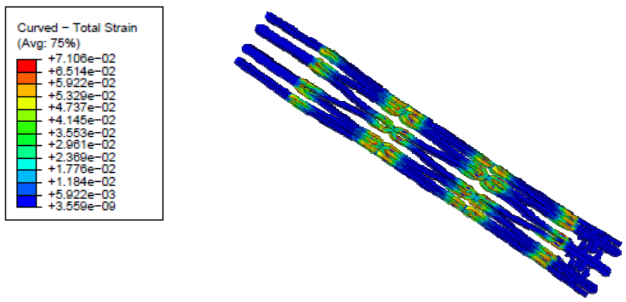
Conclusion: It can be concluded that stents with curved struts would be suitable for mitral valve replacement owing to their better crimpability to 18 F which is an essential requirement for such procedures.

Keywords: Mitral valve stent; finite element analysis; Nitinol; crimping; mesh convergence



(a) **(b)**

Figure 1 (a) Stent with curved struts; (b) stent with straight struts



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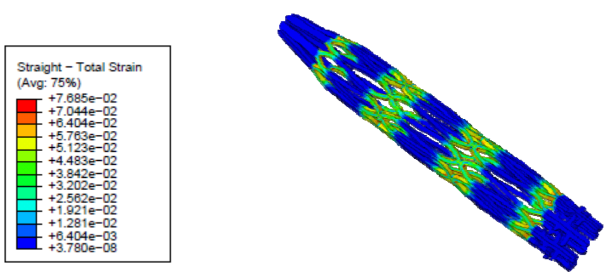

(b)

Figure 2 (a) Maximum strain in the stent modeled with curved struts; (b) Maximum crimping strain in the stent modeled with straight struts

References

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