FBG Tactile Sensor Structure Optimization

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Background

Sensory information is relayed through the human skin to provide the sense of feeling. This form of sensory information is also called tactile sensing, and is related to the sense of touch. Within this project we focus on creating and optimizing a tactile sensor using fiber bragg grating sensors (FBG's).

What are FBG's ?

FBG sensors use optical fibers which reflects wavelengths of light and disseminate all others.

Why are FBG's important?

These tactile sensors collect important information such as contact force, vibrations, texture and temperature.

Real world applications?

Tactile sensors can be used in minimally invasive robotics, microsurgeries, and automation of industry.

Research Question

Is there a more optimal structure design from the current FBG sensor design developed at the BDML?

Tasks

1. Using FEA (Finite Element Analysis) to conduct an analysis of the current design (Figure A).
2. Editing the structure from the FEA results to optimize its design.

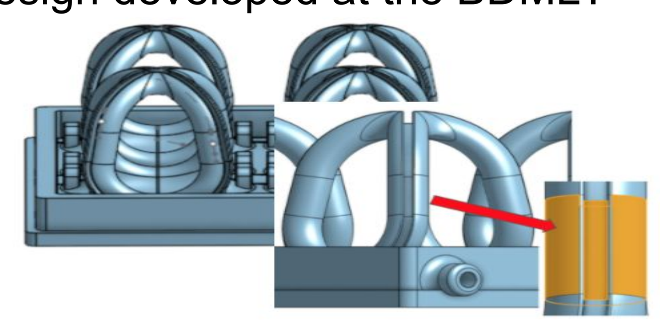


Figure A

Objective:

1. To increase the strain concentration within the area highlighted (this is where we will attach the sensor) in Figure A.
2. Apply normal and shear forces to the different structure designs to evaluate strain values. Figure B shows the direction of the forces (red arrows).

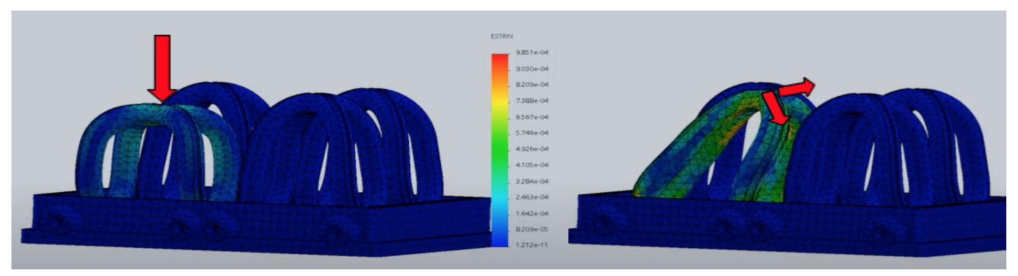
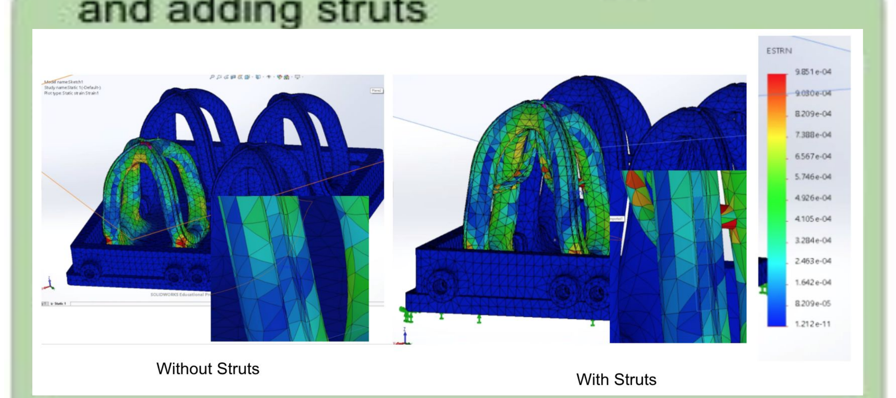


Figure B

Methods

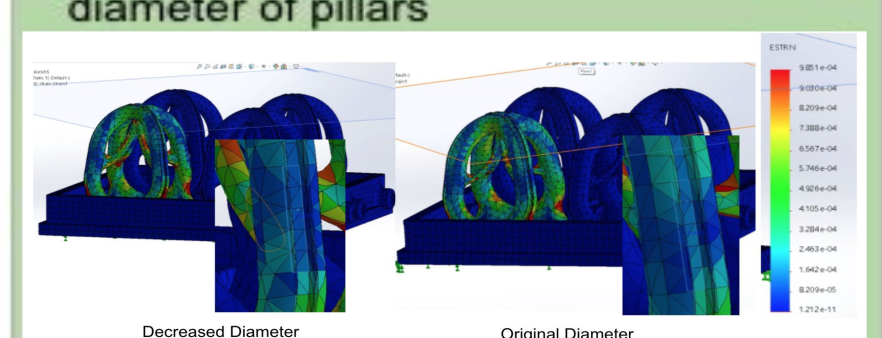
To optimize the current FBG design using FEA within Solidworks to evaluate the magnitude of strain concentration in the desired area.

Edit 1: Creating shallower grooves and adding struts



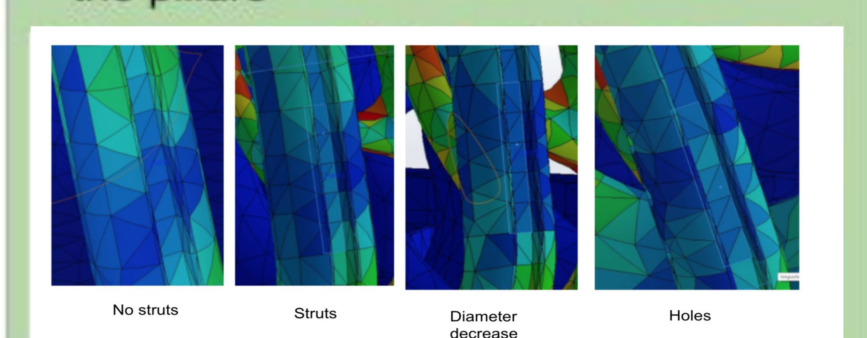
Results: The structure with struts lowered the overall strain value

Edit 2: Adding fillets and decreasing diameter of pillars



Results: The decrease diameter increased the overall strain value

Edit 3: Adding holes perpendicular to the pillars



Results: The holes were the most effective and increased the overall strain value

Final Results

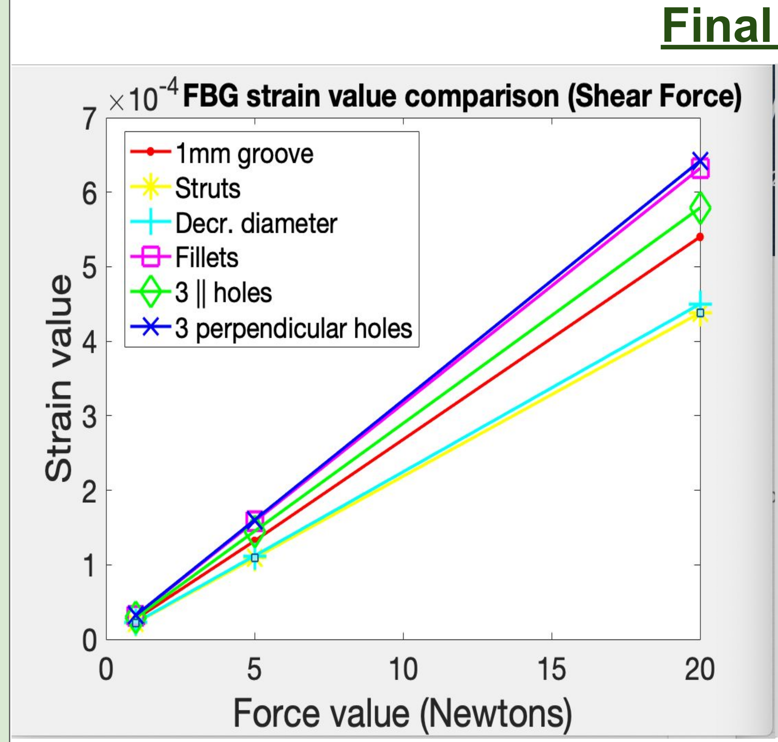


Figure C

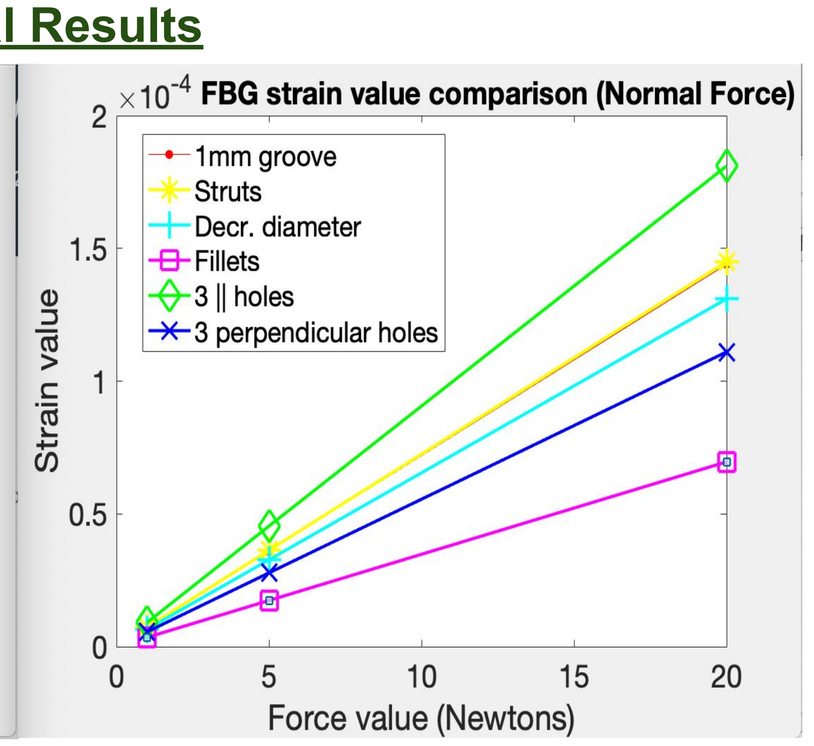


Figure D

Conclusion

As seen in Figure C the highest strain values results from adding perpendicular and parallel holes. **Therefor, the new design will incorporate three perpendicular holes.**

Future Work

1. Editing the original design to have perpendicular holes, print the structure, test it with actual forces.
2. Run FEA's with new structure design, but apply a ceramic material to the structure within the analysis.
3. Perform sensor calibration to verify the FEA strain values

Fatigue Analysis of Annuloplasty Ring for Mitral Valve

By: Zulekha Karachiwalla Lab: Biomimetics and Dexterous Manipulation Lab (BDML) Department: Mechanical Engineering, Stanford
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Background

Mitral Regurgitation (MR) is the most prevalent cause of valvular heart disease. MR is a disease of the mitral valve (MV) that is characterized by the malcoaptation of the mitral leaflets, leading to retrograde systolic flow from the left ventricle into the left atrium. Current treatment for MR is mitral valve repair which often includes implantation of an artificial annuloplasty ring around the native annulus(1). Currently researchers at the BDML lab have created an annuloplasty ring to help treat MR and this project focuses on testing and analyzing the durability of the current design.

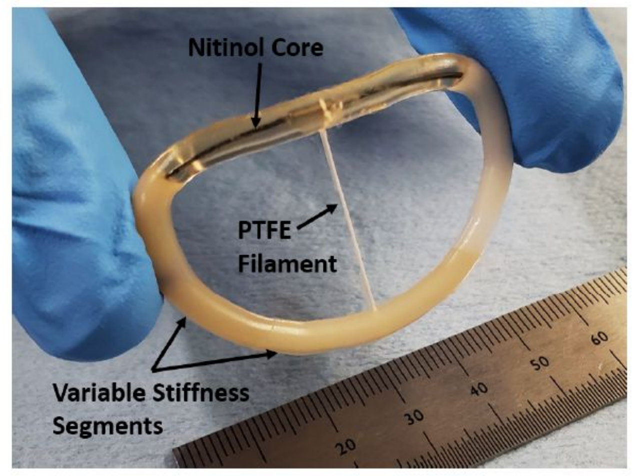


Fig A: Current design (created in the BDML lab) of the annuloplasty ring that will be tested in this project

Research Question

Is the current ring design durable enough to withstand over half a billion heart cycles (which is around the amount of cycles the heart goes through in around 10 years) ?

Task/Objective

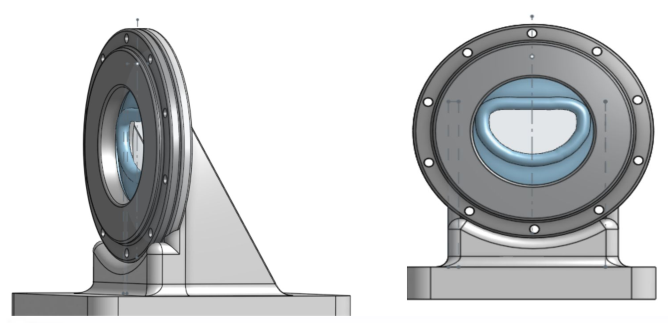
Design an effective mechanism that can test the durability of the annuloplasty ring. Run through over half a billion cycle within a time span of two to three weeks.

Methods

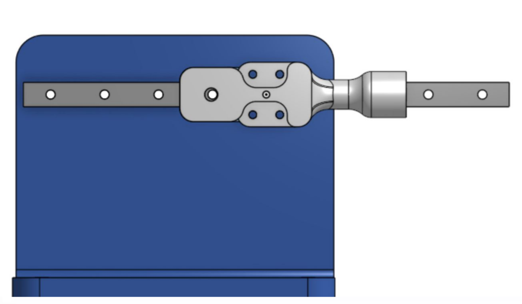
The set-up was designed within On-Shape, a CAD program, and will be 3D printed in the next phase of the project.

Design Idea:

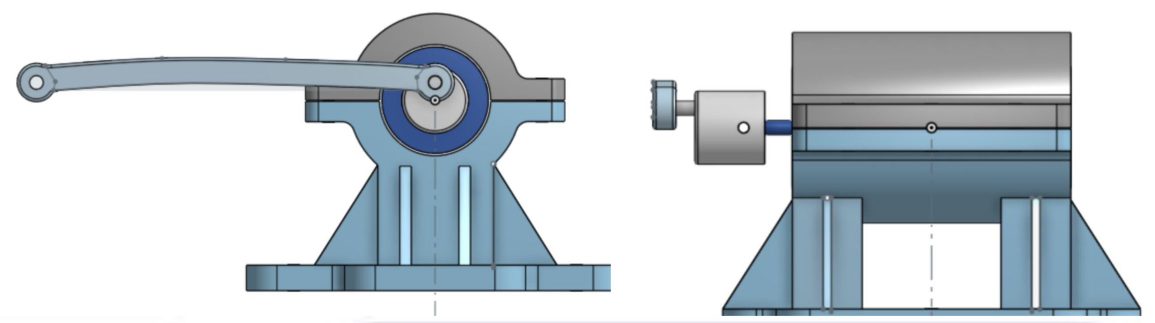
To create a set-up similar to an oscillating crank shaft to move a piston in and out of the ring to test the durability of the ring.



Valve Cuff: This design was created to hold the mitral valve ring



Linear rail & carriage: This design was created to move the piston linearly back and forth through the ring.



Crank shaft: This design was created to hold a motor that will attach to a crank that will oscillate and move the linear carriage.

Calculations

Centripetal Force:

$$[(2\pi * rpms)/60]^2[rod\ length][mass]$$

$$[(2\pi * 5000/60)]^2[.06][.025] = 41.12N$$

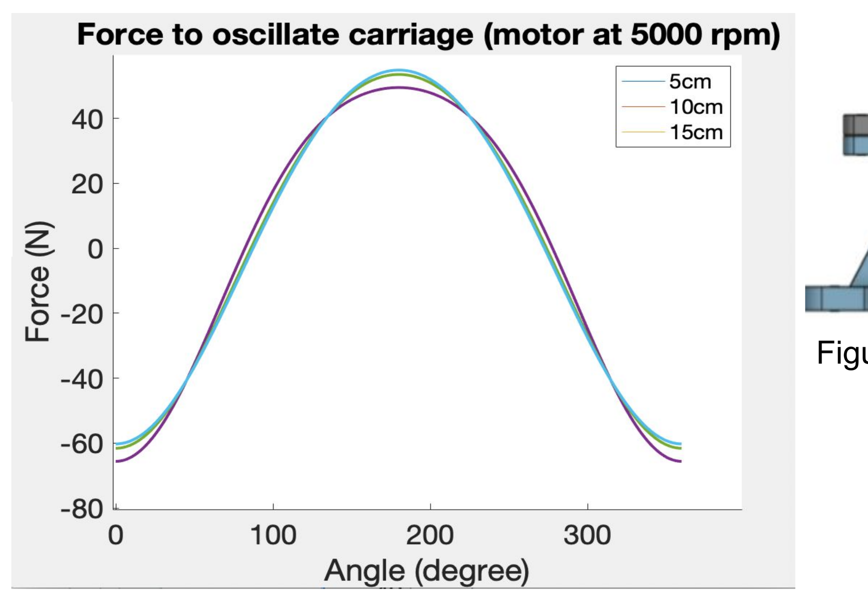


Fig E: This graph shows the range of forces being applied to the carriage (which holds the piston), as the crank oscillates to different degrees

Final Experimental Design

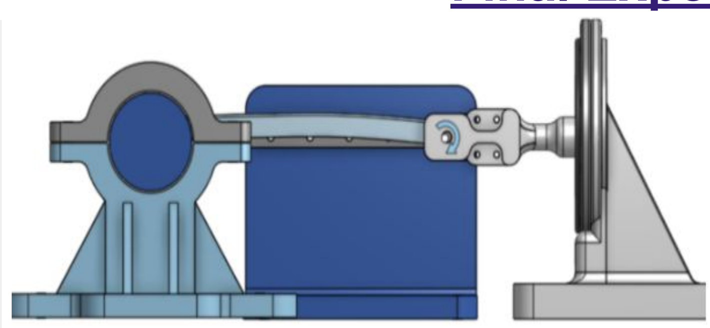


Figure B: Front view of the design set-up

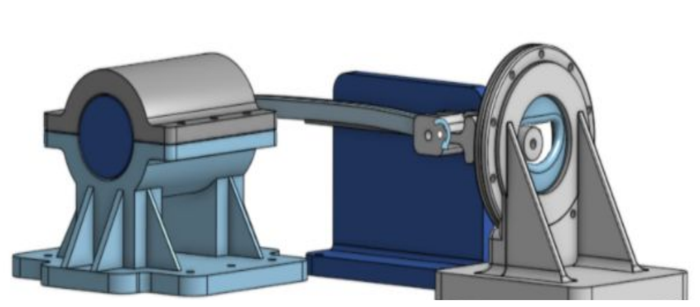


Figure C: 45 degree view of the design set-up

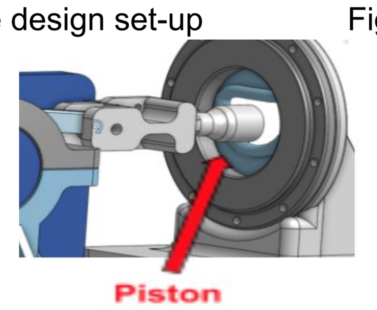


Figure D: Zoomed in view of the piston which is design to move within the ring

Conclusion

Our current design yields a result of 41.12N centripetal force and a maximum linear force of 60N to accelerate the carriage. This satisfies our motor specifications.

Future Work

1. Now that we have a preliminary set-up designed, our next step is to 3D print and fatigue test the ring.
2. Creating software to run the motor and track the cycles

References

Fisherman, S., Knight, A., Pirozzi, I., Imbire-Moore, A. M., Paulsen, M. J., Woo, J. Y., & Cutkosky, M. R., (2020). SELECTIVELY COMPLIANT ANNULOPLASTY RING TO ENABLE ANNULUS DYNAMICS IN MITRAL VALVE REPAIR EVALUATED BY IN-VITRO STEREOVISION. *Design of Medical Devices Conference*.

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