FINITE ELEMENT ANALYSIS OF ENDOVASCULAR/BILIARY STENTS

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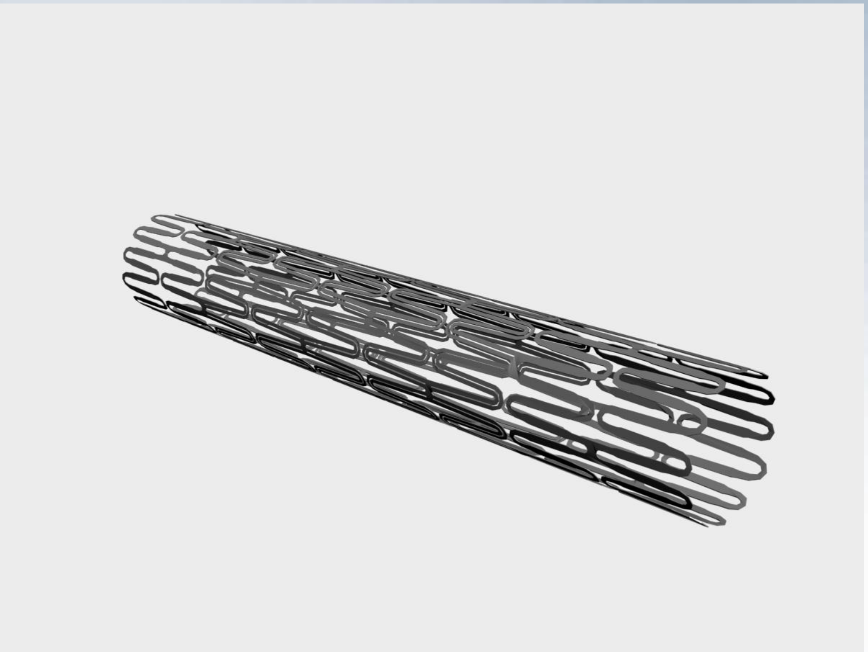
What are Stents?



- Stents are medical devices designed to be permanently implanted within the human body to provide mechanical support of weakened non-endovascular tubes (such as a biliary ducts) or endovascular tubes (such as arteries).

Background

- During the summer of 2004, an engineering cadet at the Virginia Military Institute prepared the graphics for a medical malpractice case. These graphics were constructed using engineering software used for finite element analysis.

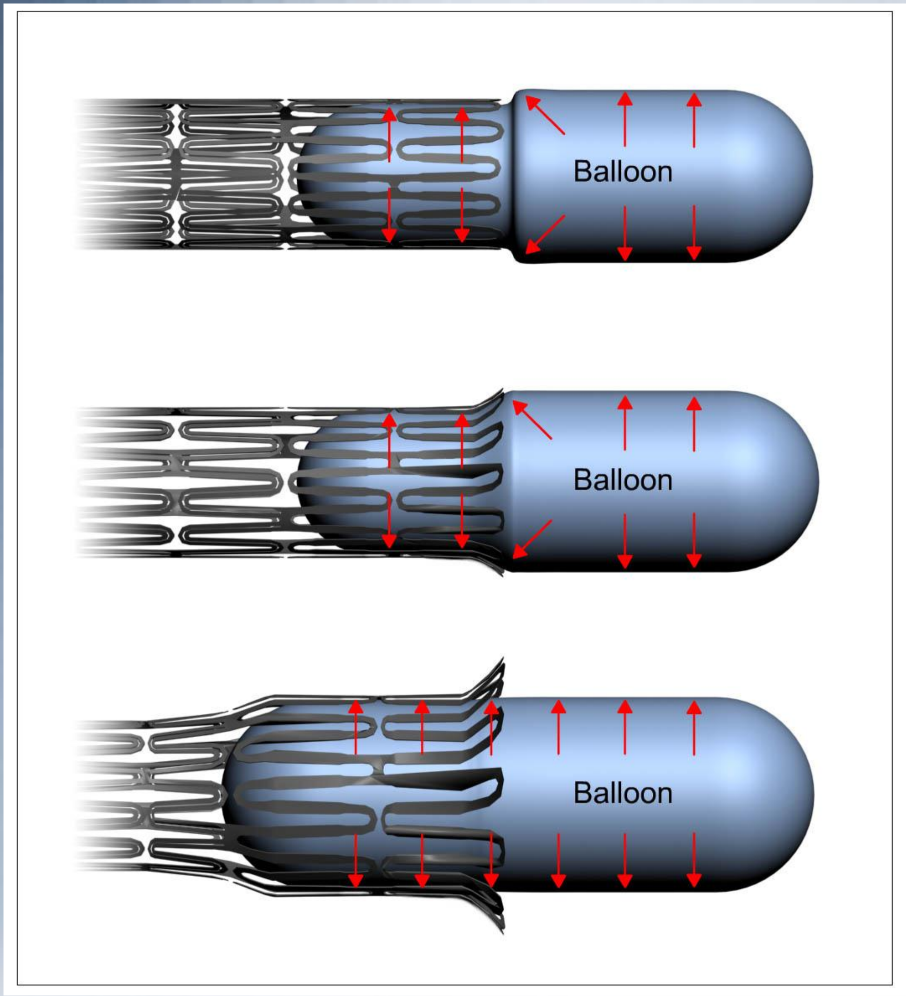
- This medical malpractice case involved a failure of a stent designed for a bile duct but deployed in an aortic artery. The stent's mechanical failure and resulting clinical complications will be analyzed and used to create general design rules to allow any non-endovascular stent to resist end-flare and thus avoid one failure mechanism that can be fatal in endovascular situations.

Proposed Research

- The objective of this project is to devise a set of design rules that will permit existing biliary stent geometries to be adapted for use in systems that may require them to be safely end-flared without axially contracting, such as in large-diameter endovascular arteries.

- Using finite element analysis, I will analyze specific stent geometries in order to determine how increasing the thickness of the end rings relative to the center rings reduces end flare.

What is End Flare?



• Biliary stents are expanded using a single inflation with the balloon centered inside the stent.

• Use of stents in endovascular environments often requires expansion of the balloon partially outside the stent (for example, to oppose the stent against the wall of a vessel increasing in diameter).

• If a biliary stent is not perfectly centered (as shown to the left), the non-constrained end of the balloon will inflate first, causing the stent to flare at its end. This can injure the surrounding artery, and contribute to several major long-term health problems.

Hypothesis

- Increasing the ratio of the thickness of the end rings of a stent relative to the stent's internal ring thickness limits endflare during asymmetric balloon inflation.

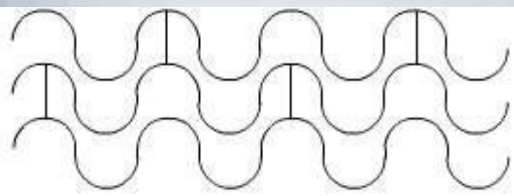
- The ratio of end ring thickness to limit endflare is relatively independent of the details of the stent geometry.

Methods

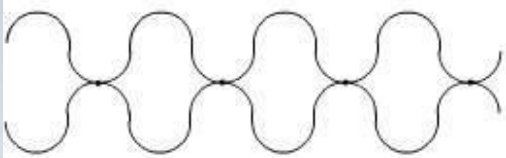
- A variety of stent geometries will be simulated in three dimensions as their end ring thickness ratio is varied between 1 and an upper bound. Percent endflare will be computed using the Finite Element Analysis software ANSYS.

- ANSYS is commonly used in design engineering for all types of real world engineering simulation.

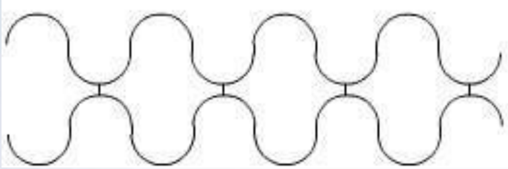
Proposed Stent Geometry for Research



This stent model is characterized by the struts that connect every other offset parallel cell.



Rows of cells run transversly to one another and are attached at every midpoint.



Rows of cells run transversely, are attatched at every midpoint but instead of spot attatchments, struts are used.

Expected Results

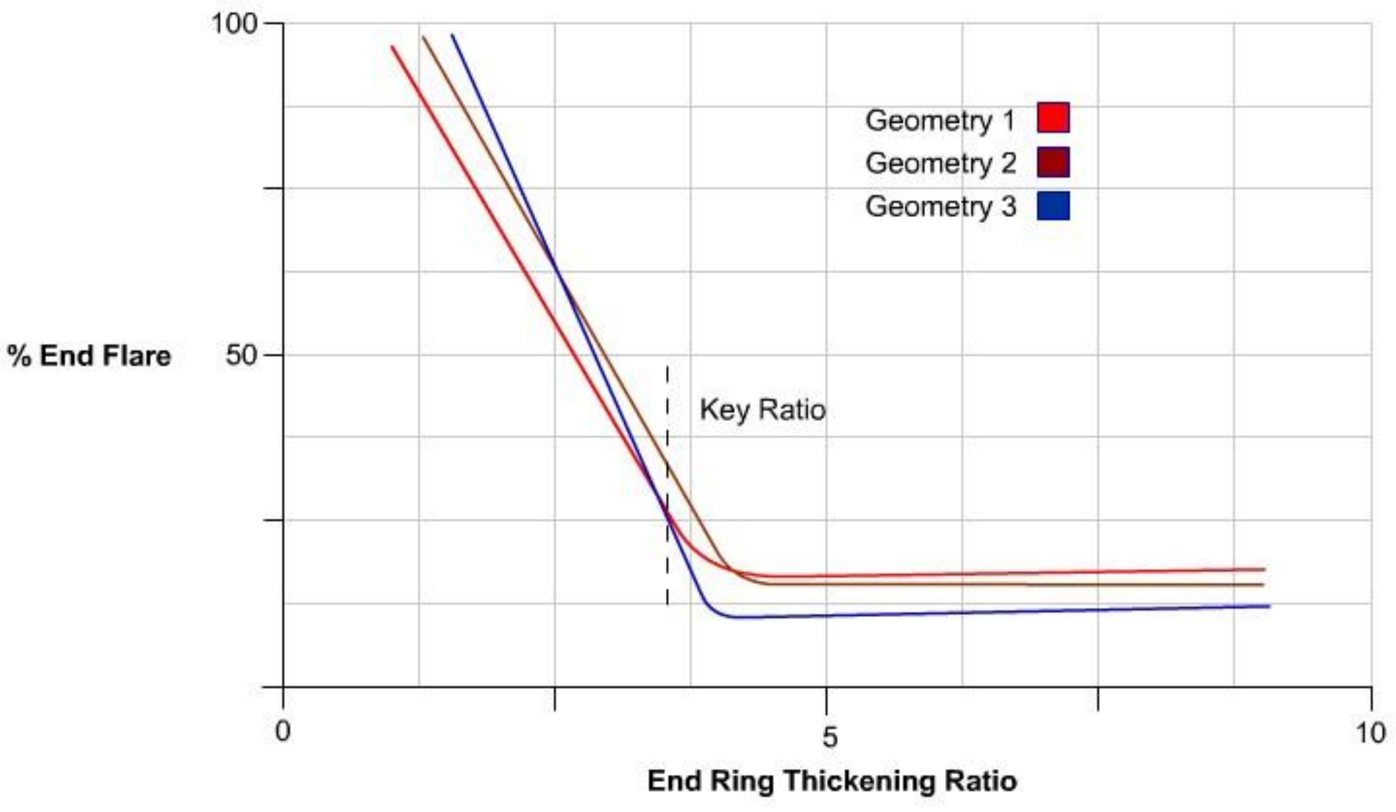


Fig. 2.0

Importance of this Project

- This research will result in a specific design rule that can be applied to any non-endovascular stent to prevent it from exhibiting end-flare, one important characteristic required for endovascular use.
- This is important since there is currently only a single FDA-approved stent for use in a large diameter vessel, and it is highly inflexible, yet there are a number of flexible non-endovascular stents approved by the FDA for use in large diameter lumens, such as the bile-duct, that may cause less harm than inflexible designs.