INTRODUCTION

Occlusion of peripheral arteries
- Superficial Femoral Artery
- Perforator
- Proximal Aorta
- Afterload

Cycle loads e.g. lap movements

Multiple non-proportional axis of stress and strain in vivo device

Fatigue failure and other possible complications (e.g., stent fracture)

Predict in-vivo device fatigue behavior

- Standard test case scenarios for testing compliant stents
- The most suitable fatigue criteria should be used for Nitinol

The community used fatigue damage parameters are the first principal strain/stress or the von Mises equivalent strain to the first principal mean stress at a constant life diagram (Pelton et al. 2008, Reiner et al. 2017, Desai et al. 2019)

Recently, design-specific fatigue approaches are more indicated for multi-axis and non-proportional loads (Dutta et al. 2015, Manni et al. 2019)

All: To analyze different loading conditions (combined axial, bending, torsion) in:
- Assess the most dangerous combination with loading interaction
- Optimization of filter experiment campaign
- Compare the predictions of different fatigue criteria: selection of the most sensitive.

MATERIALS AND METHODS

Comparison of different fatigue prediction criteria

FEA examples of the two stents

Stent A 
Stent C

Nitinol Fatigue Limit

The fatigue limit is obtained experimentally by varying strain and magnitude (100 cycles) on three batches of samples with the same dimensions and manufacturing treatments of the stent (h=200 μm)

A constant life diagram is built using the first principal mean stress as the single variable

Case 0 (P = 0)
Case 1 (P = 0.001)
Case 2 (P = 0.005)
Case 3 (P = 0.01)
Case 4 (P = 0.02)

Comparison of different fatigue prediction criteria

- Criterion for proportional loading based on equivalent strain

\[
\sigma_{eq} = \sqrt{\frac{1}{2} (\sigma_x^2 + \sigma_y^2 + \sigma_z^2 + \sigma_y^2 + \sigma_z^2 + \sigma_z^2 + \tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)}
\]

- Criterion for non-proportional loading based on the critical plane

RESULTS

Effect of the design

Fatigue limit according to each criterion

A coupled FEA and experimental approach showed to convert the fatigue limit according to each fatigue criterion.

Stent A – Case A, B, C

Stent C – Case A, B, C

Preliminary FEA vs experimental campaign – Case 0

The model predicted the experimental failure location in both the start geometries

CONCLUSIONS

- A counterphase axial load results in the most critical loading case
- Brown-Miller and Smith-Watson-Topper criteria seem to give the most accurate fatigue prediction whereas Von Mises equivalent strain and Fatemi-Socie criteria seem to underestimate the risk of failure
- The methodology should be applied to more devices in different loading conditions.
- Other fatigue criteria (e.g., Derj Van) should be considered
- The fatigue limit curve is assessed through axial tests
- K and B are taken from literature