Biomimetic implant surfaces for enhancing implant-epithelial sealing

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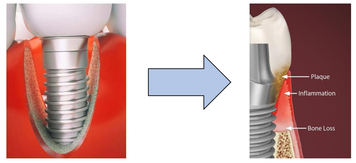
Introduction

- Epithelial cells (the outer-most cell layer of the skin) protect the body from infections.
- Percutaneous implants that break the epithelial barrier lack sealing with epithelium and are susceptible to infections and failure.
- PEEK and titanium are common percutaneous implant materials.

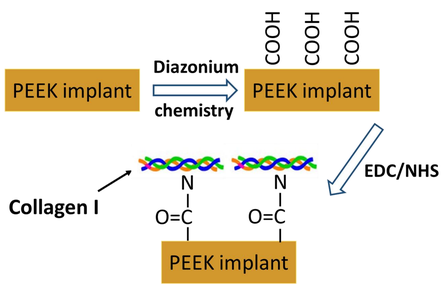


- Teeth break the epithelial barrier as well, but they have tight sealing with epithelium through basal lamina (BL) proteins adsorbed on their surface.
- Tooth proteins (90% of which are collagen I) increase BL protein adsorption, hence epithelial sealing, which prevent infections.

Aim

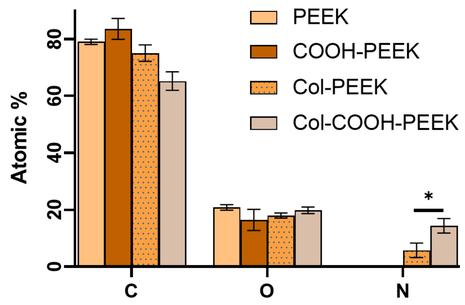
- To promote tight sealing of PEEK implants with adjacent soft tissue by modifying its surface with collagen I proteins.
  - To assess BL protein adsorption and epithelial cell interactions on modified and control PEEK.

Approach

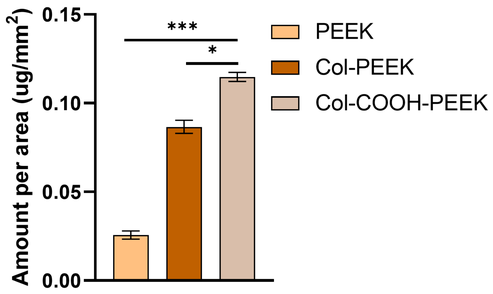


Results

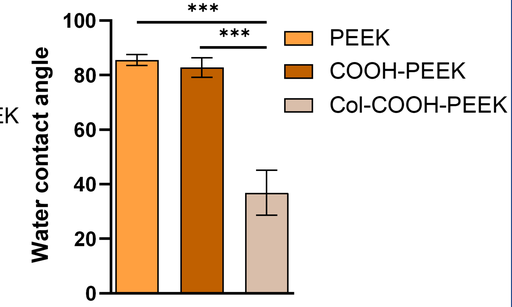
Elemental composition from XPS analysis of untreated PEEK surface, after diazonium reaction, with adsorbed collagen and with conjugated collagen



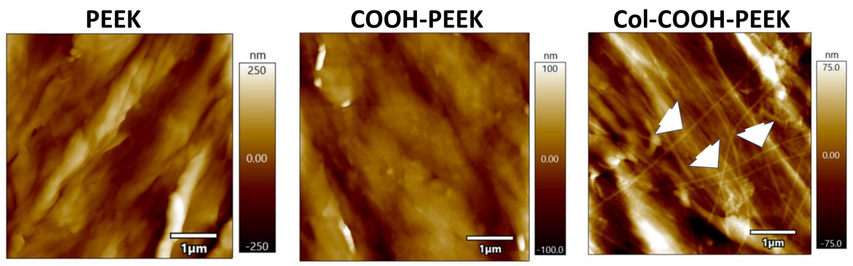
Quantification of collagen adsorbed on PEEK or conjugated on carboxylated PEEK



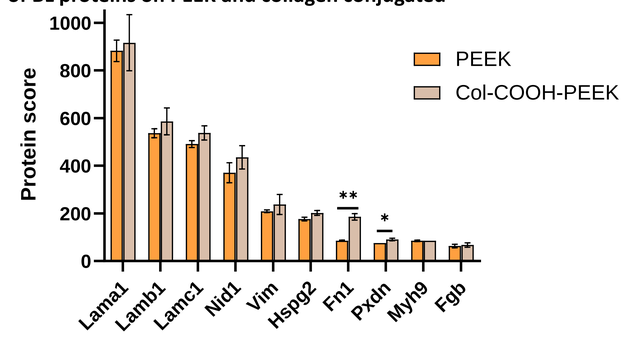
Wettability analysis of untreated PEEK, after diazonium reaction and with conjugated collagen



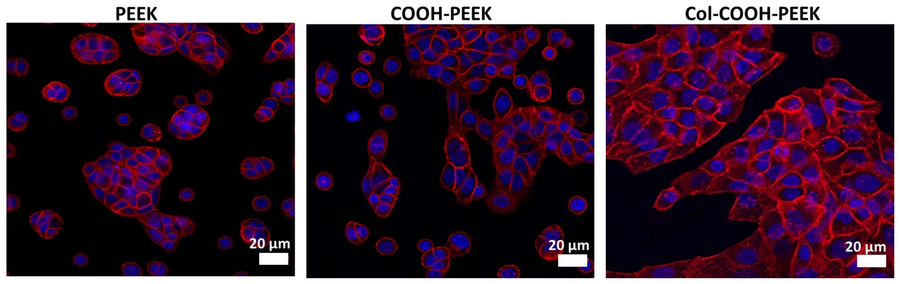
AFM images of PEEK surface, PEEK after diazonium reaction, and with conjugated collagen



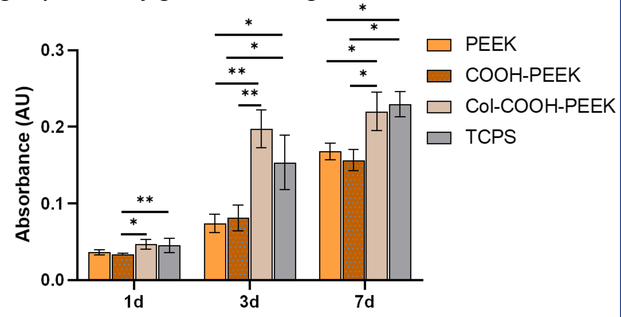
Protein scores measured by mass spectrometry for the adsorption of BL proteins on PEEK and collagen conjugated



Fluorescent images taken by confocal microscopy of HaCat epithelial cells after 1 day of seeding on untreated PEEK, PEEK after diazonium reaction and with conjugated collagen



HaCaT cell proliferation using MTS assay on PEEK, with carboxylic groups and conjugated with collagen



Discussion

- Collagen conjugation on PEEK is confirmed using XPS, wettability and AFM analyses and quantified using BCA assay.
- Conjugating collagen I on the surface of PEEK improved its bioactivity by enhancing the biomaterial's ability to adsorb key BL proteins and promote epithelial cell growth and adhesion.
- Epithelial cell proliferation and spreading results match BL protein adsorption results: the functionalization of PEEK with collagen I improved adsorption of key BL proteins (laminin, nidogen and fibronectin) that possess cell adhesive binding sites.

Conclusion

- Inspired by the most abundant protein present in a natural percutaneous organ, the tooth, collagen I was successfully conjugated to PEEK implant surface.
- The biomimetic implants can be used in other percutaneous devices that breach the epithelial barrier such as catheters.

Acknowledgments

- We would like to acknowledge the fund from NSERC and MEDA scholarship award.

References

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