**Method**

We conducted simulations to further examine the properties of the GT20-PTH10 hydrogel, which exhibits a low stiffness but high adhesion at 37°C. The typical stomach volume of the mice used for the *in vivo* GP study ranges from 1.5-2 mL, and the maximum volume that can be infused into the stomach is approximately 0.1 mL. Therefore, we modeled the stomach as a hollow sphere with inner radius 7.10 mm and thickness of 0.5 mm, corresponding to literature values of the stomach wall thickness1. A mixed finite element formulation for displacements and pressures was implemented in FEniCS2,3, where the hyperelastic incompressible neo-Hookean material model was used (see supplemental). The material properties of the GT20-PTH10 hydrogel can be determined by assuming the material is close to incompressiblity, Poisson’s ratio of 0.49, and determining the Young’s modulus from the stress-strain curves in Fig. 2A. This calculation yields a shear modulus of 18.2 Pa for the hydrogel, and the shear modulus of a rat’s stomach was found from literature to be 2.86E4 Pa1.

For the first step, the hollow sphere modeled with the stomach material properties was prescribed an inner displacement to expand the sphere to an inner radius of 8.31 mm. This value is consistent with nine times the infusion volume, 0.9 mL, to examine stretches past the physiological limit. This displacement is then applied to the inner boundary of a dual material setup, and the nominal stresses and stretches on the plug surface can be determined from the displacements and pressures that are found from the simulation.

**Results**

The displacement on the inner surface is increased uniformly to a final radial stretch of corresponding to an infusion volume of 0.9 mL. Throughout each stage of the simulation, the adhesive hydrogel, which is softer from the native stomach tissue, experiences the lowest nominal stress magnitude, |**P**|. At the final deformation state, the nominal stress magnitude of the plug is 18.9 Pa. These findings are significant, because the approximate tensile stress for failure of the GT20-PTH10 hydrogel is 118 kPa, which is approximately four orders of magnitude larger than the maximum stress felt by the hydrogel plug. We also note that the final radial stretch will predict a higher stress magnitude than the radial stretch of corresponding to the physiological infusion volume of 0.1 mL.

After deformation the model is in a bi-axial stress state, where the hydrogel plug aligns with the x-y plane (). Therefore, to examine the stresses on the adhesive plug and the interface between the two materials more closely, we display the principal nominal stress component in the x direction, . While the interface of the outer surface experiences lower stresses from kPa, the interface on the inner surface displays the maximum stresses of = 25 kPa. High interfacial stresses can contribute to de-adhesion of the hydrogel material from the native stomach tissue, but the maximum interfacial stress reported from our simulation is an order of magnitude smaller than the shear strength of 251 kPa for GT20-PTH10.

The deformation gradient component corresponding to the nominal stress component is shown where the deformation gradient quantifies the change between the reference/undeformed and deformed configuration (see supplemental). Corresponding to the highest stresses, the highest deformations also occur within the inner surface close to the interface. We note that the sphere with a perfect interface between materials represents a highly idealized geometry, and in the experiments there is some overlap of the hydrogel over the hole which likely contributes to better performance *in vivo*. The stretches of the GT20-PTH10 hydrogel are and corresponding to strains of and .

**Supplemental**

The reference/undeformed coordinates are denoted by **X**, and the deformed coordinates are denoted by **x**, where displacement **u** is defined as:

Taking the gradient of this expression with respect to the reference configuration gives the deformation gradient, **F**

where **I** is a second order identity tensor. The right Cauchy-Green tensor, **C,** can be defined from the deformation gradient

The first invariant of the right Cauchy green tensor and the third invariant of the deformation gradient are defined as follows

The strain energy function of a neo-Hookean incompressible material model is given

where is the shear modulus, p is the pressure, and the corresponding nominal stress, **P**, is

**References**

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