Il distacco ed il rimodellamento del vitreo

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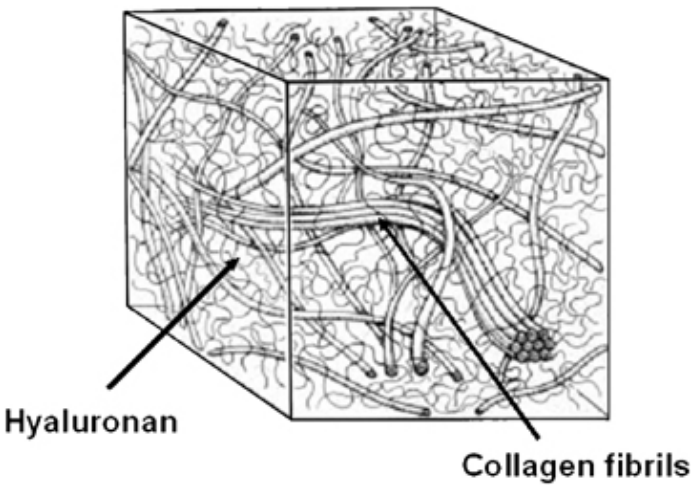
Milano, 25 Novembre 2011

Vitreous remodeling

With ageing the vitreous humor undergoes the processes of synchysis (liquefaction) and syneresis (dehydration and shrinkage)

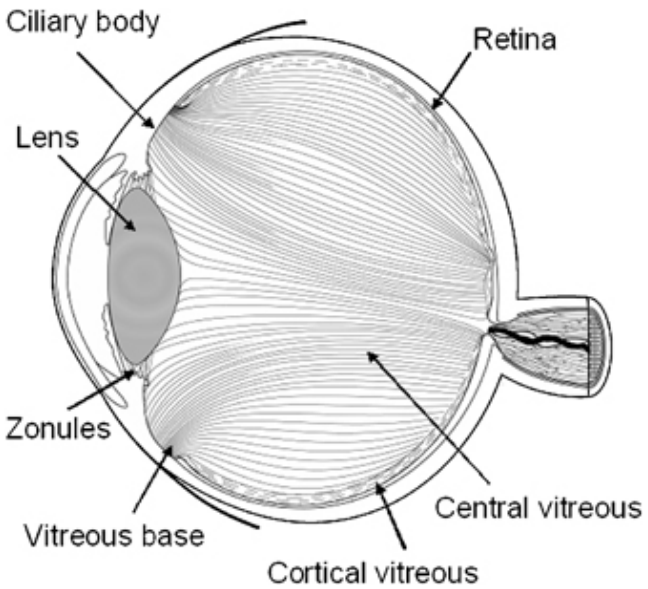
Vitreous remodeling



Schematic representation of the cooperation between two networks responsible for the gel structure of the vitreous. A network of collagen fibrils maintains the gel state and provides the vitreous with tensile strength. A network of hyaluronan fills the spaces between these collagen fibrils and provides a swelling pressure to inflate the gel.

[Le Goff and Bishop, Eye (22) 2008]

Vitreous remodeling



Orientation of collagen fibrils within the vitreous. The vitreous is subdivided into different regions including the central and cortical vitreous and the vitreous base. These regions have differing rheological properties as a result of differences in collagen fibrillar concentration and orientation.

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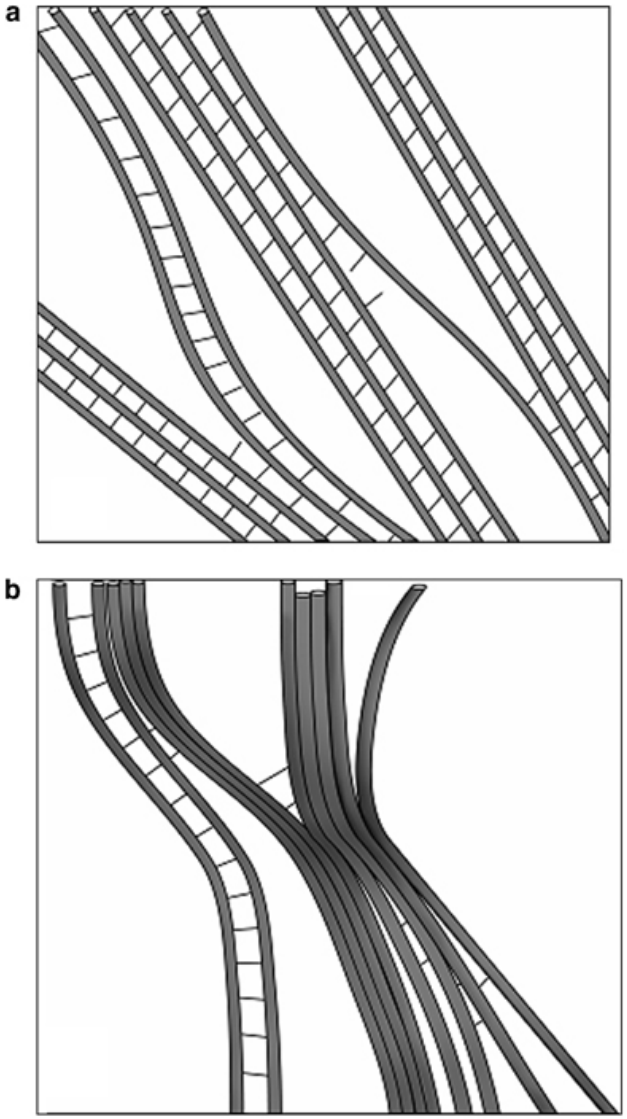
Vitreous remodeling



(a) The collagen fibrils (thick grey lines) form an extended network of small bundles. Within each bundle, the collagen fibrils are both connected together and spaced apart by type IX collagen chains.

(b) With ageing the loss of the type IX collagen from the fibril surfaces combined with an increased surface exposure of type II collagen results in collagen fibrillar aggregation.

[Le Goff and Bishop, Eye (22) 2008]

Vitreous remodeling

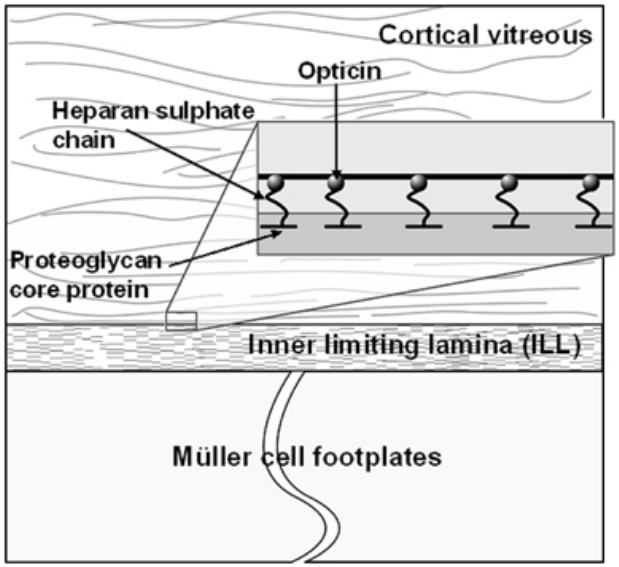
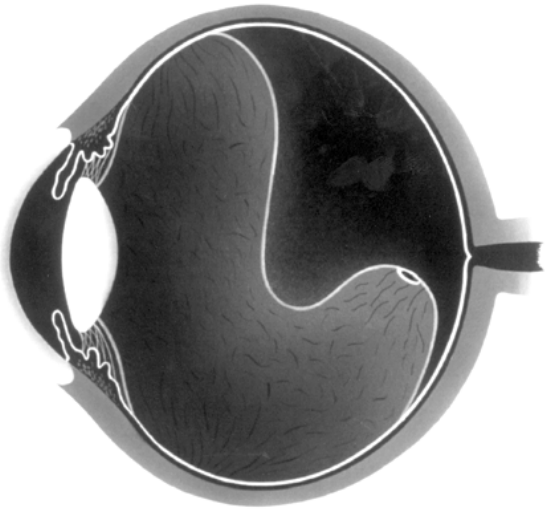


Diagram representing the postbasal vitreoretinal junction. Weakening of the adhesion at this interface predisposes to posterior vitreous detachment. Vitreoretinal adhesion may be dependent upon intermediary molecules acting as a 'molecular glue' and linking the cortical vitreous collagen fibrils to components of ILL. It is possible that opticin, because it binds to both vitreous collagen fibrils and HS proteoglycans in the ILL, contributes towards this 'molecular glue'.

[Le Goff and Bishop, Eye (22) 2008]

Posterior Vitreous Detachment

a)



b)

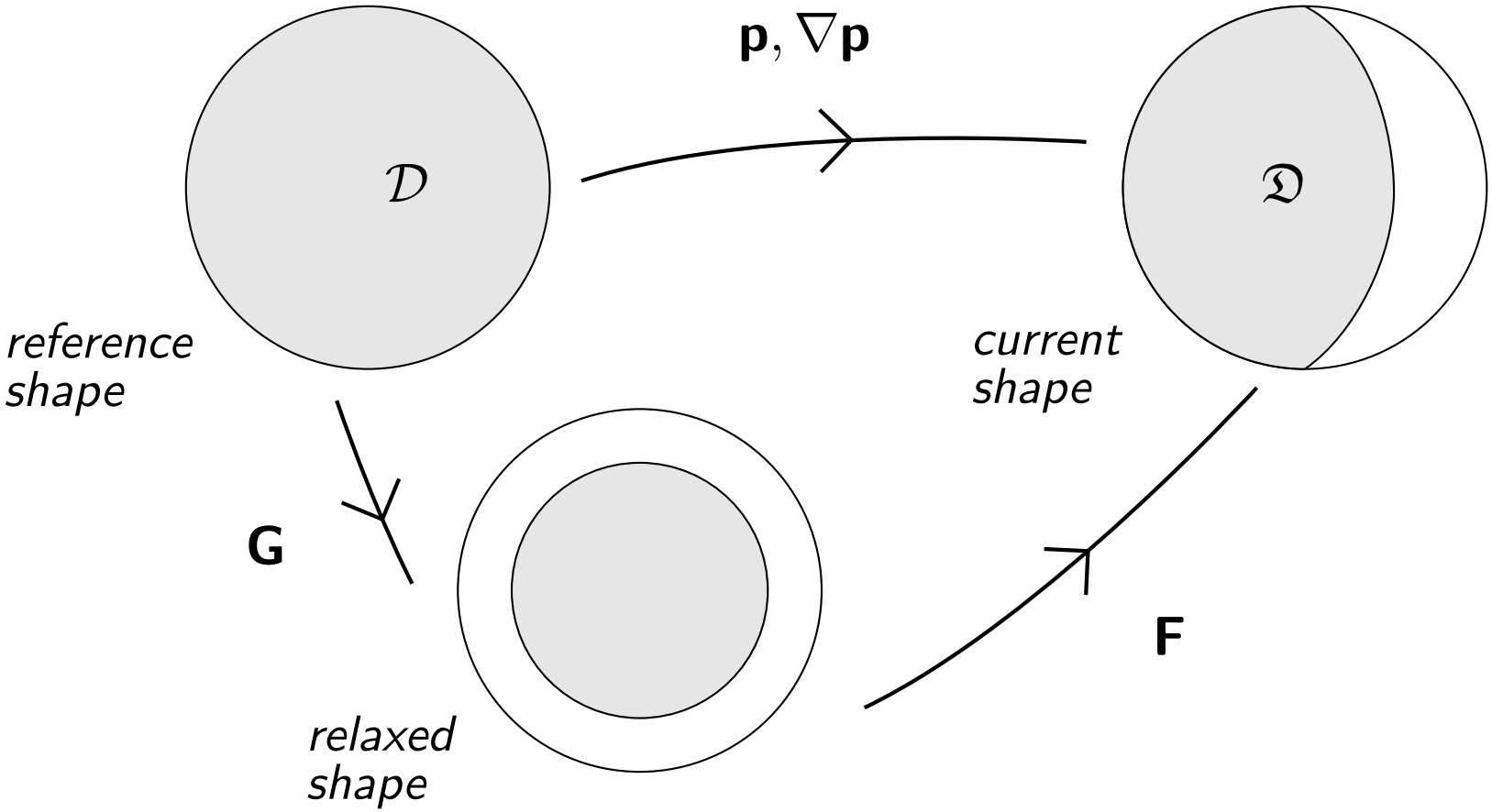
c)

d)

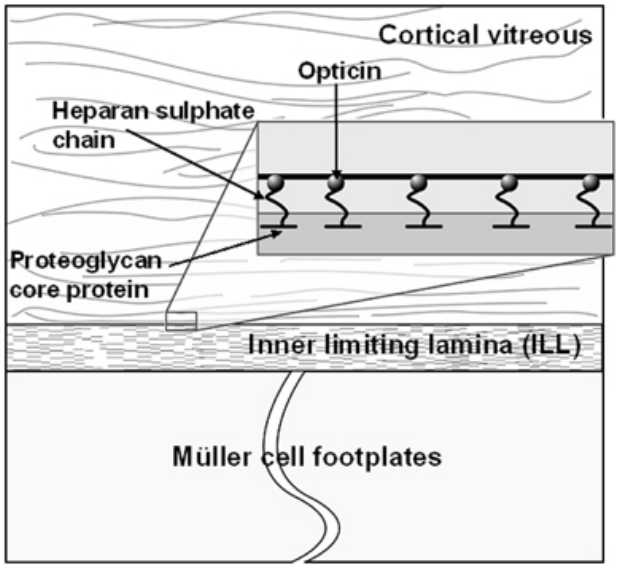
Types of Posterior Vitreous Detachment

(from Kakehashi et al.,1997)

Kröner-Lee decomposition of the deformation gradient $\nabla \mathbf{p}$



Boundary conditions



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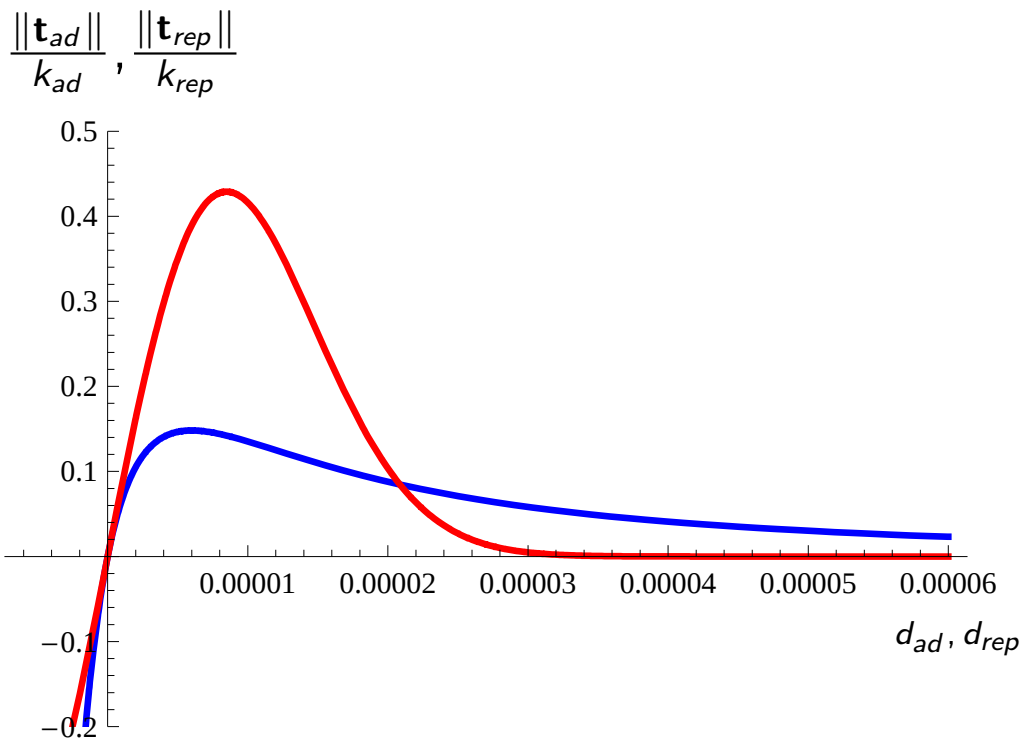
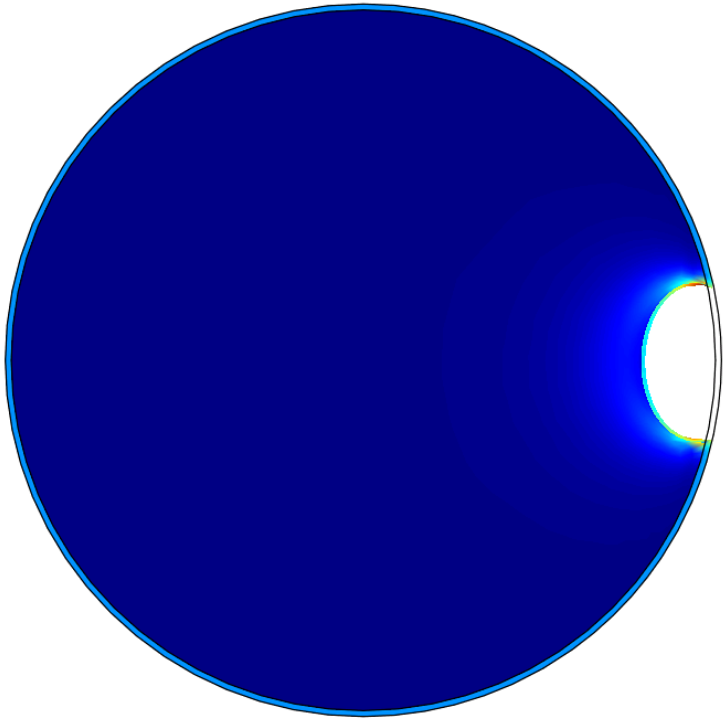
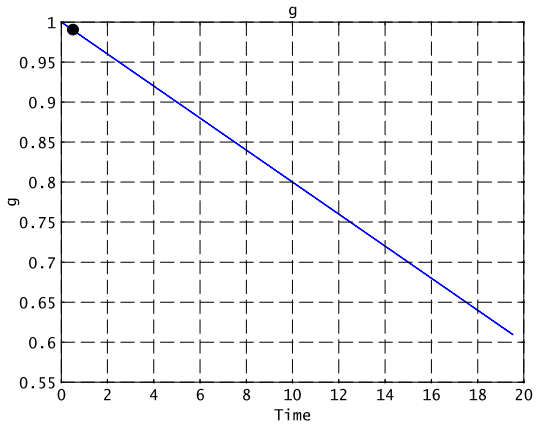


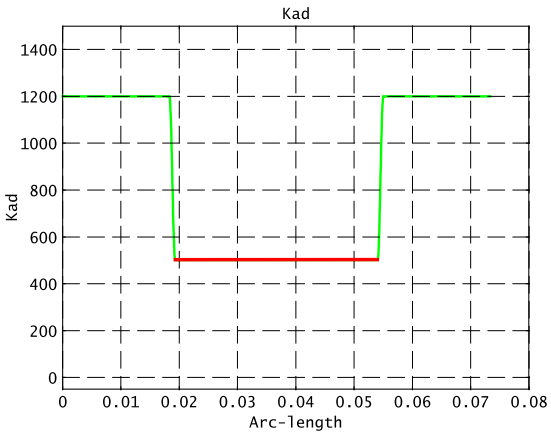
- Adhesive force $\mathbf{t}_{ad}$ (red line)
- Repulsive force $\mathbf{t}_{rep}$ (blue line)

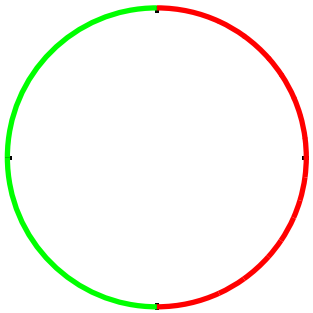
Case-02 (Strong adhesion)



[case_08]







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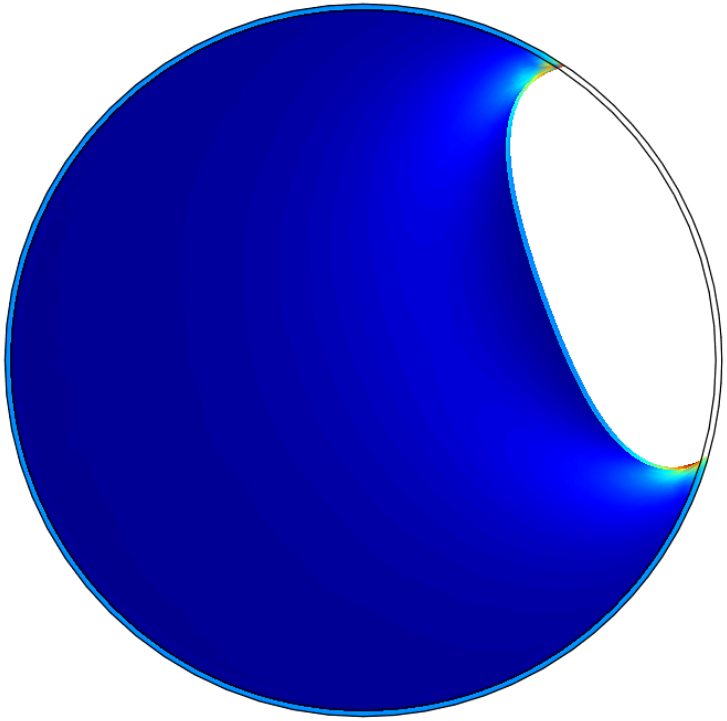

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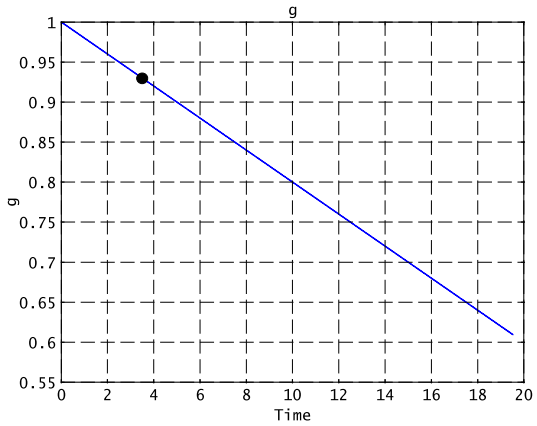

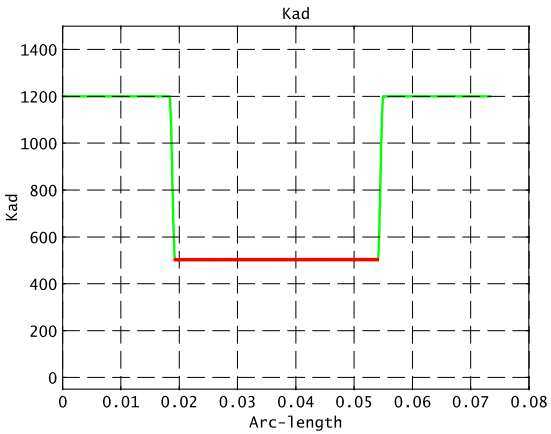

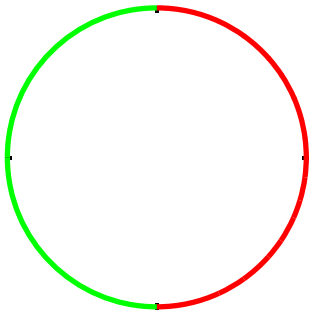

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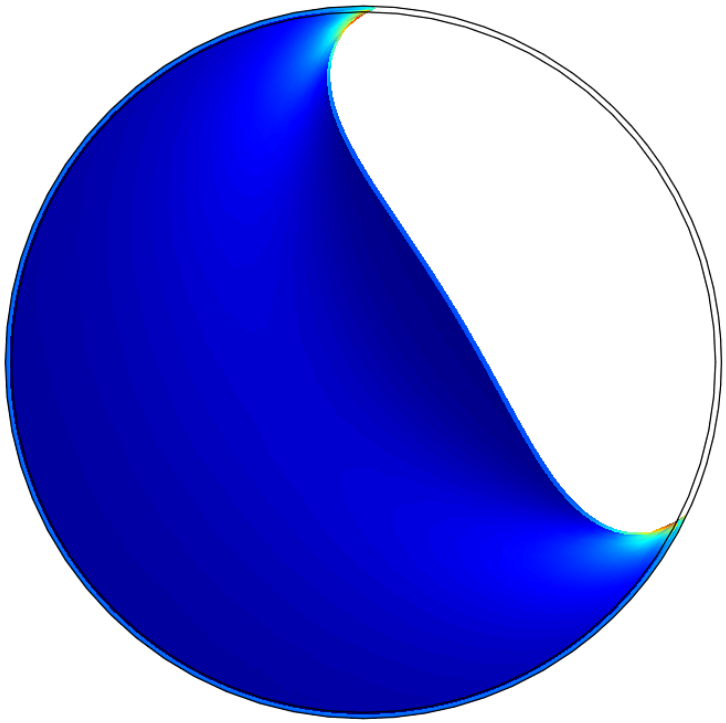

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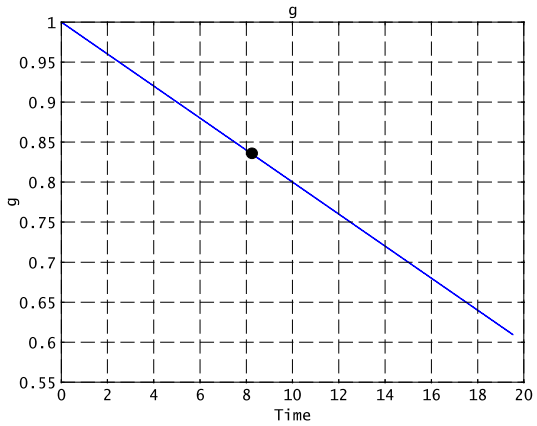

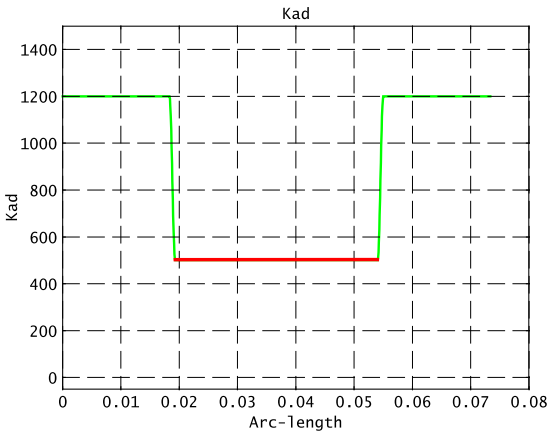

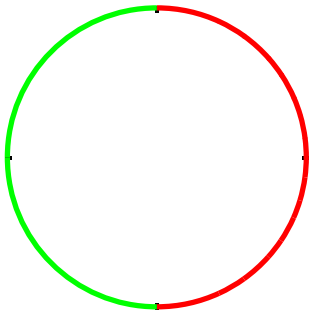

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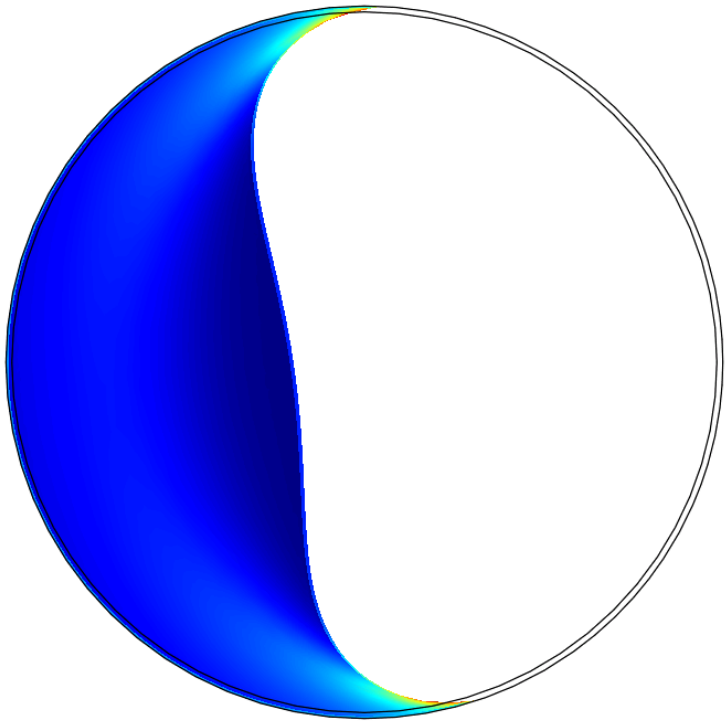

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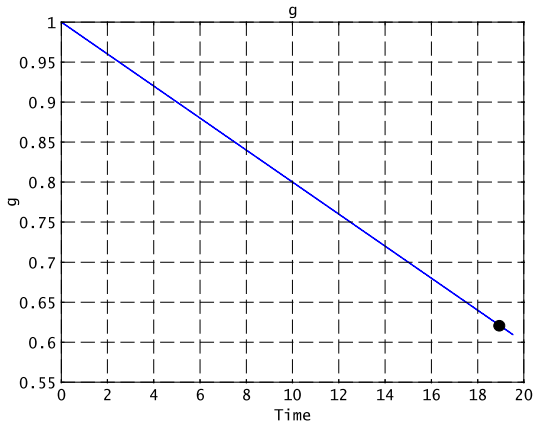

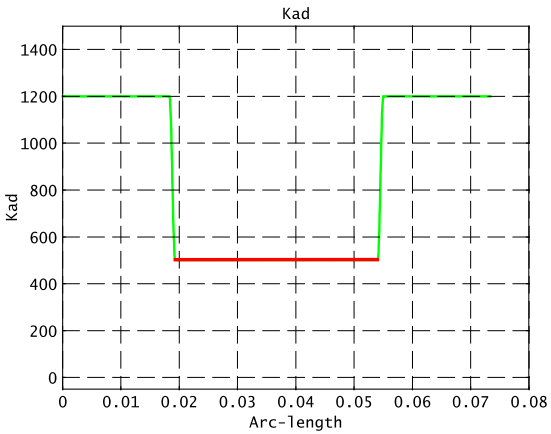

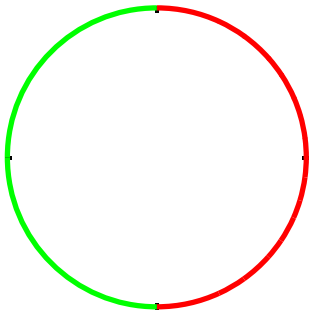

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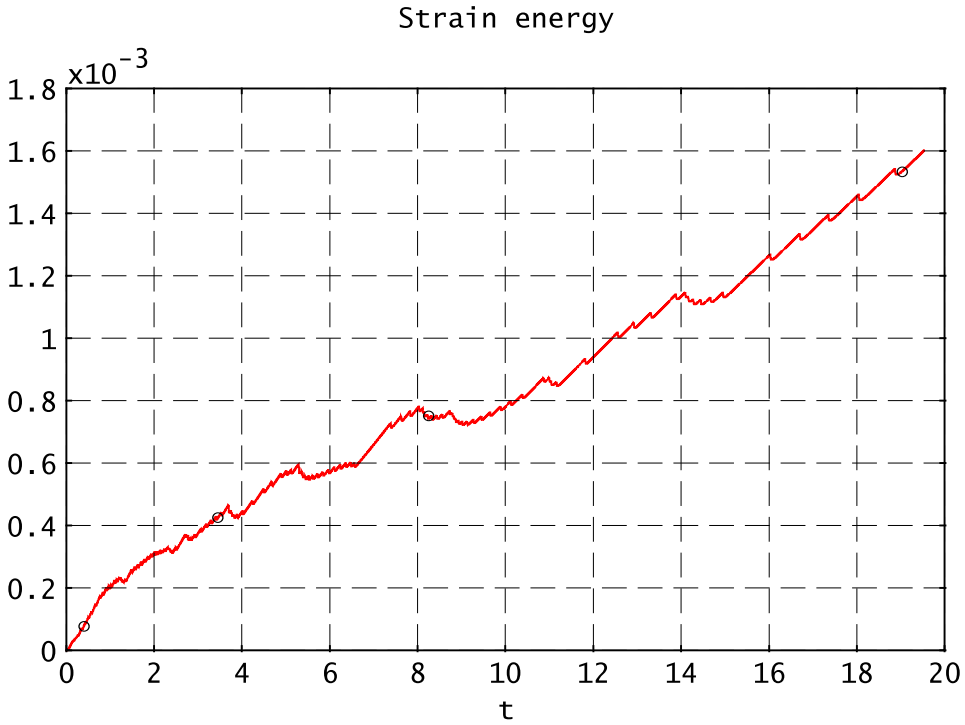

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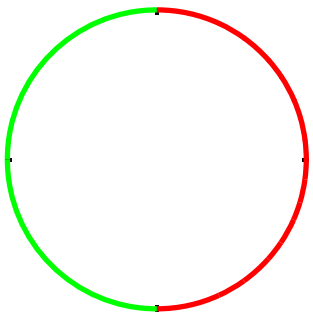

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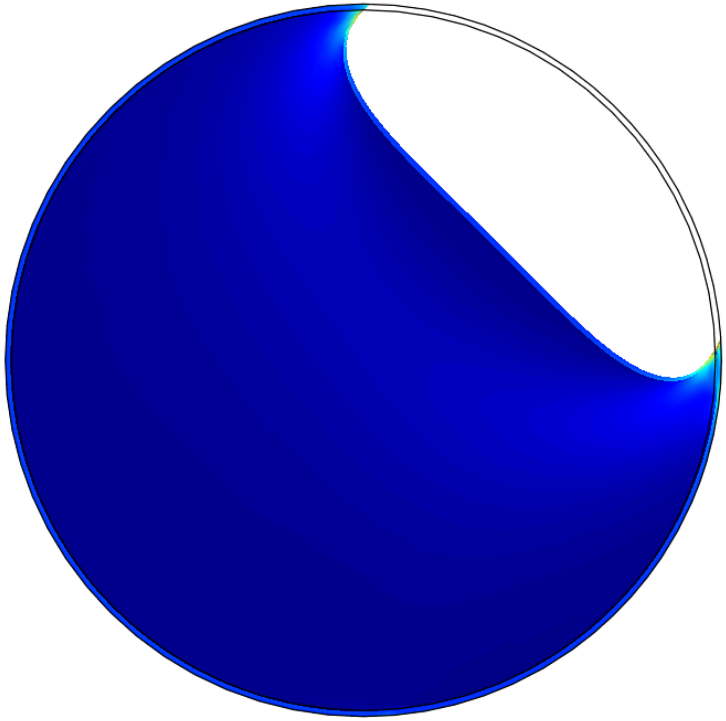

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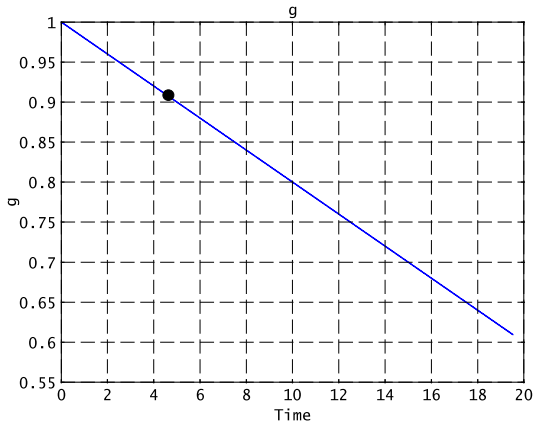

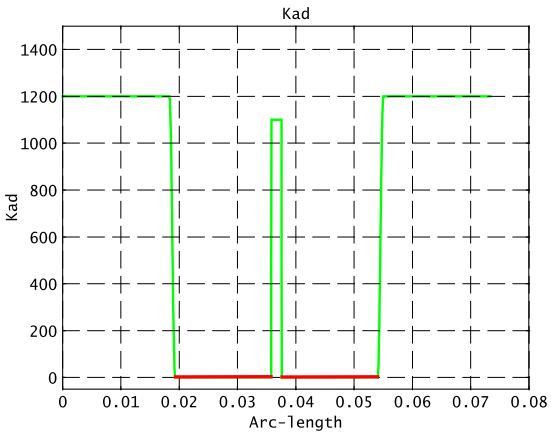

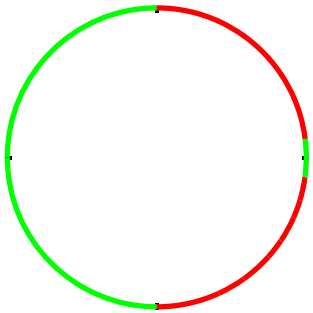

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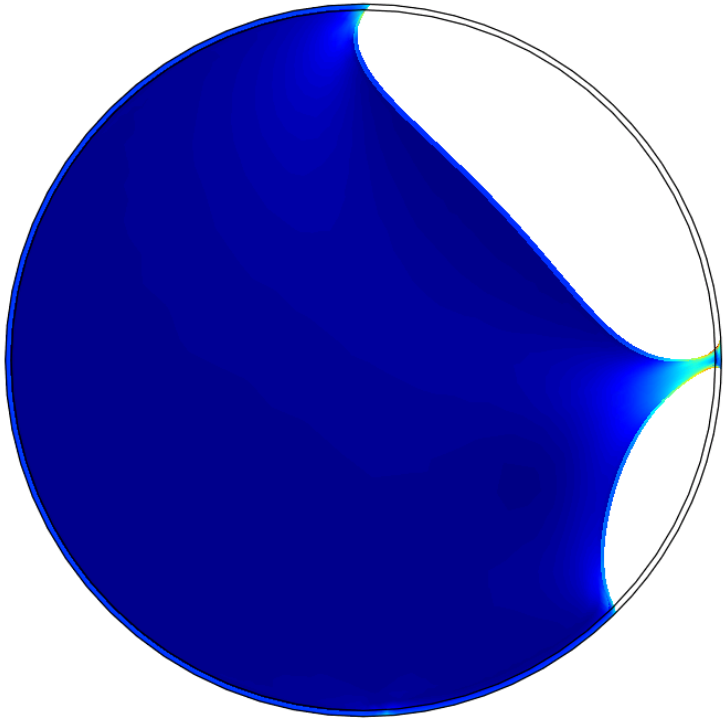

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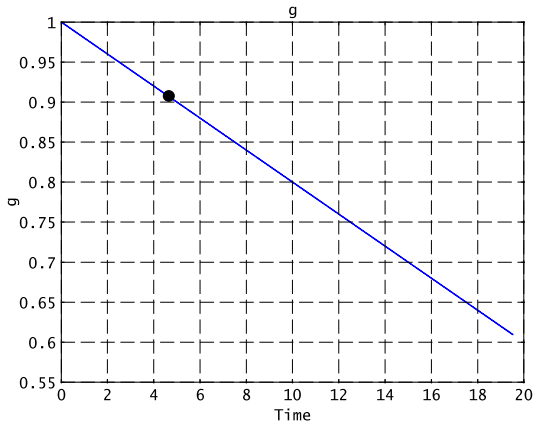

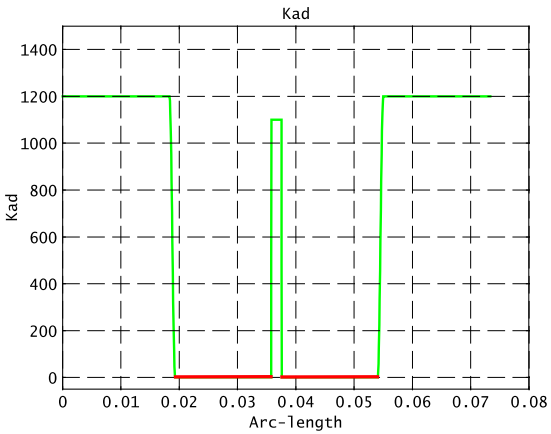

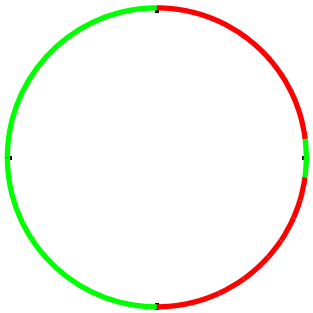

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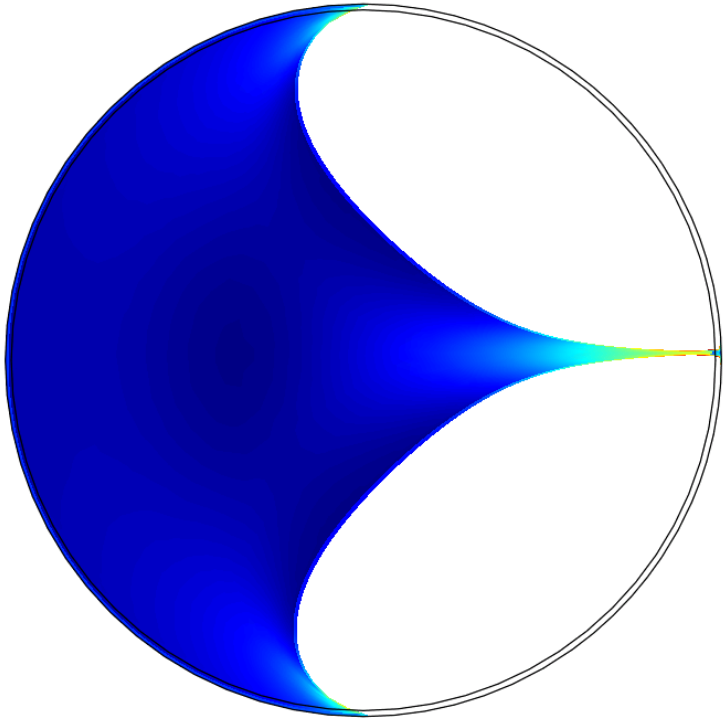

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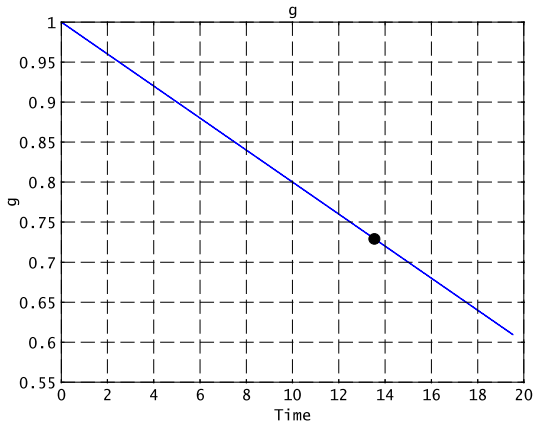

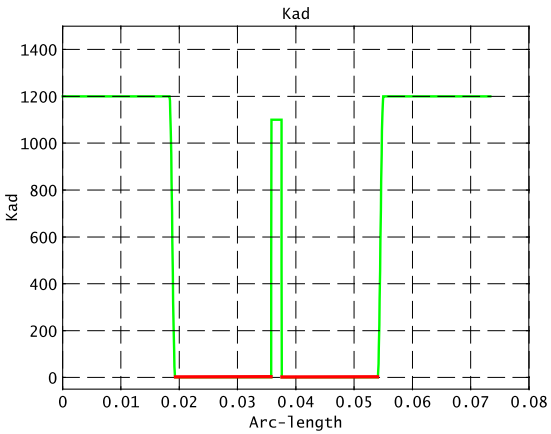

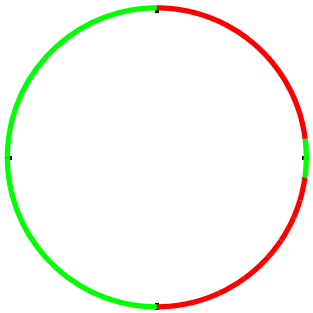

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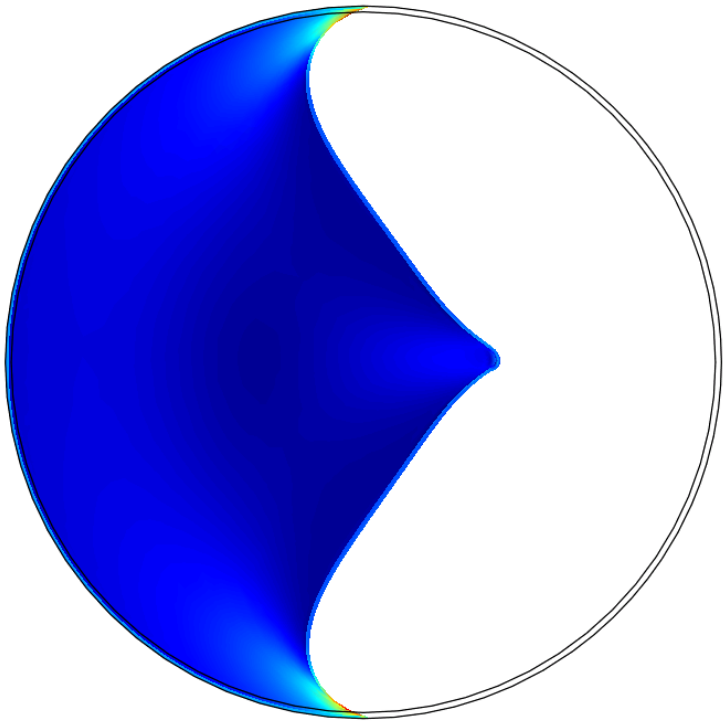

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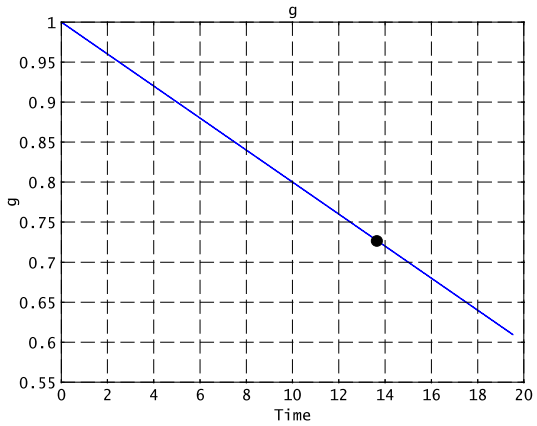

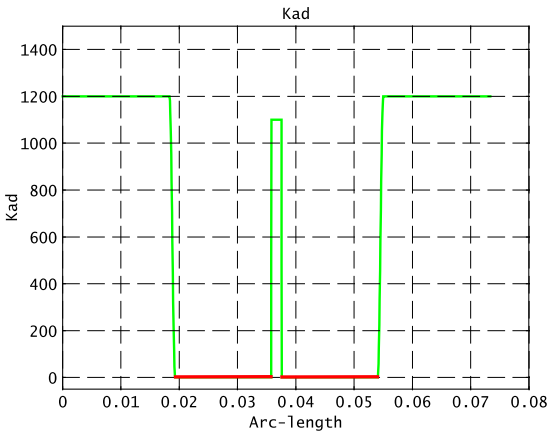

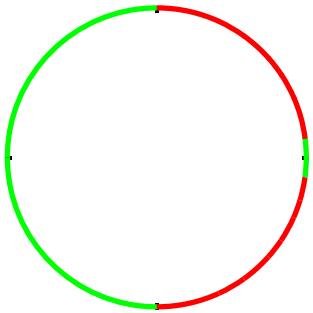

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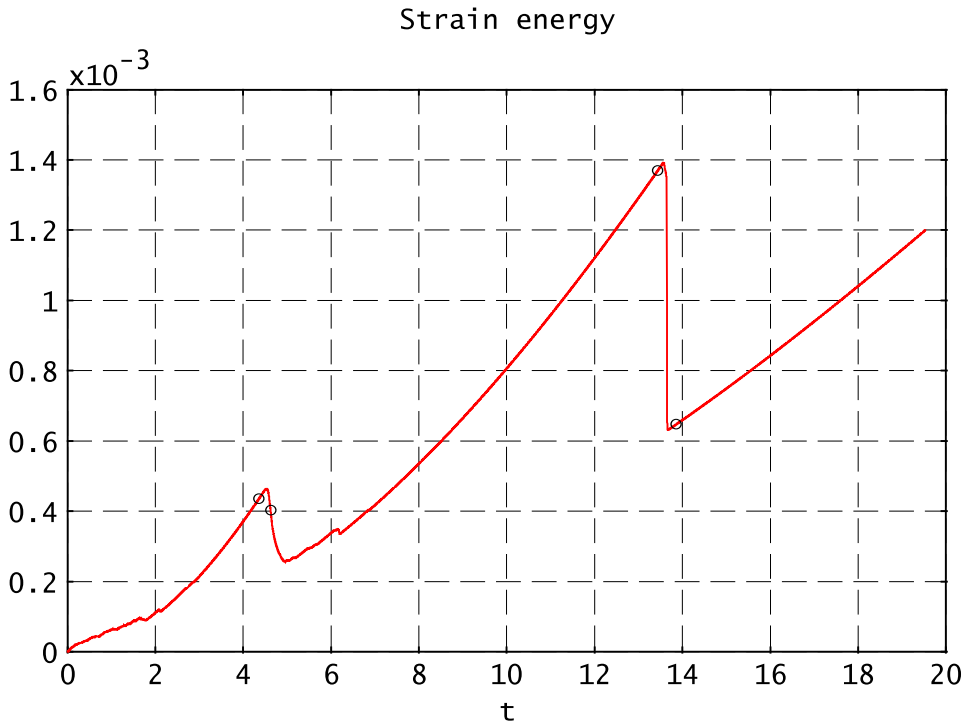

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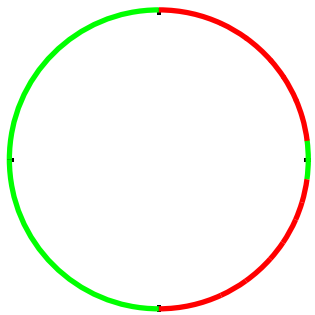

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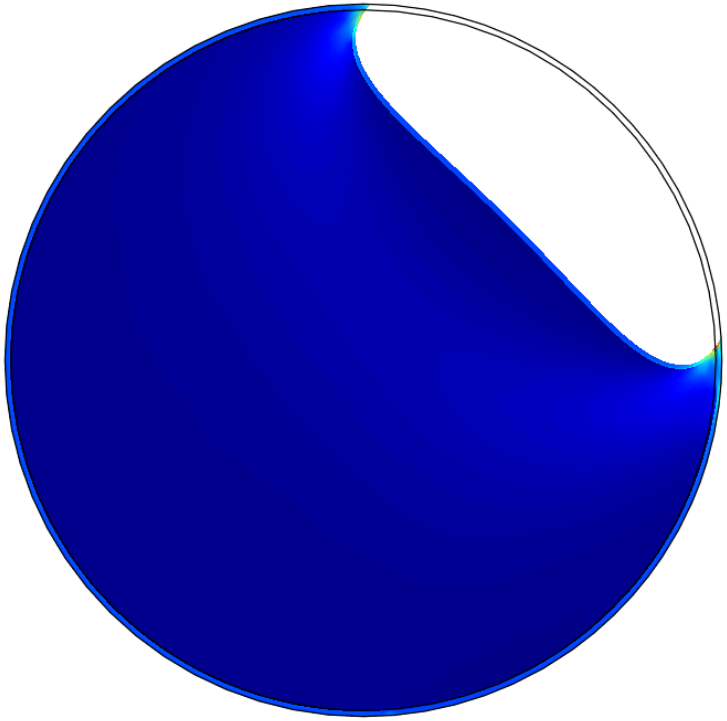
Case-04 (Strong focal adhesion)



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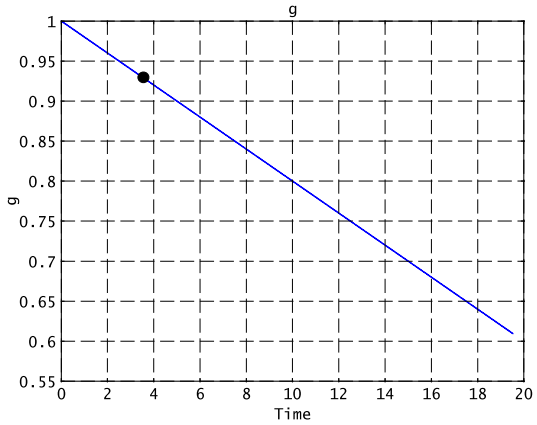

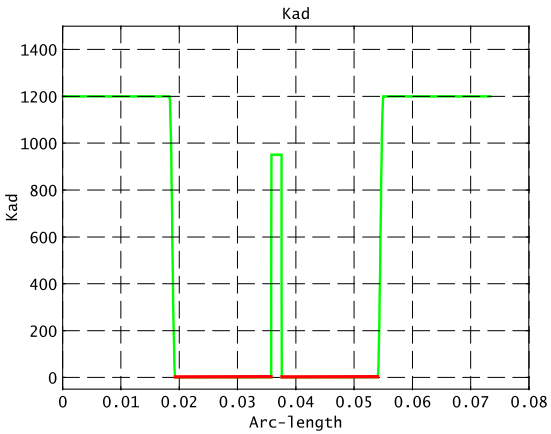

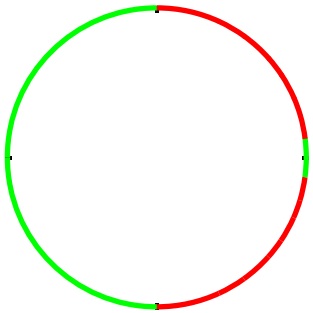

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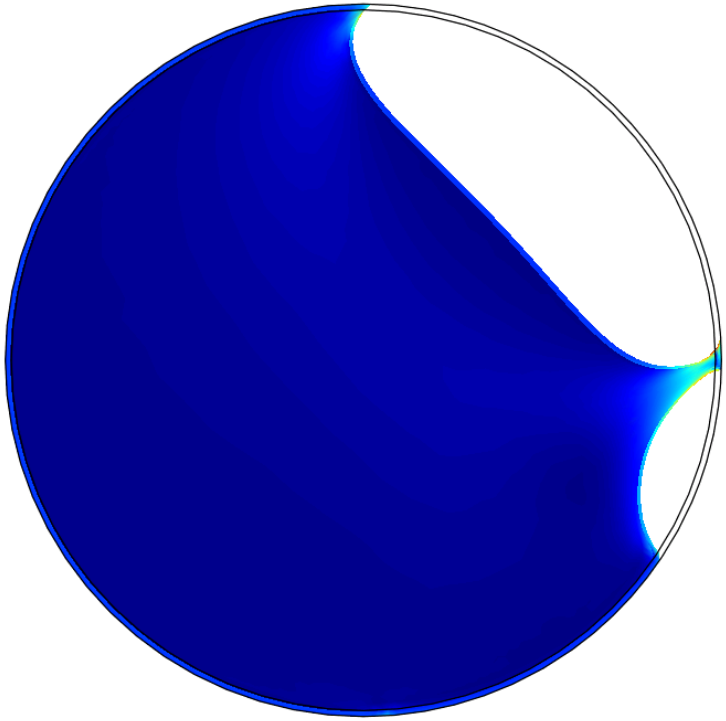

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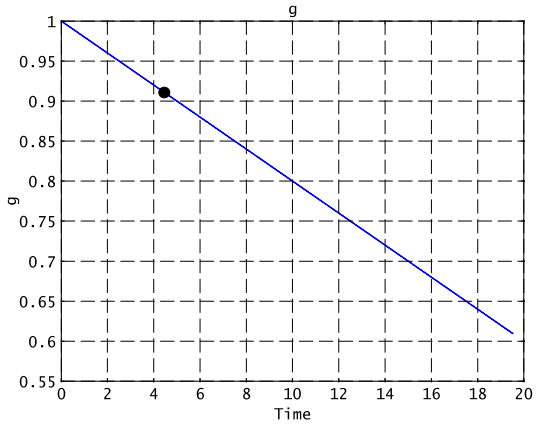

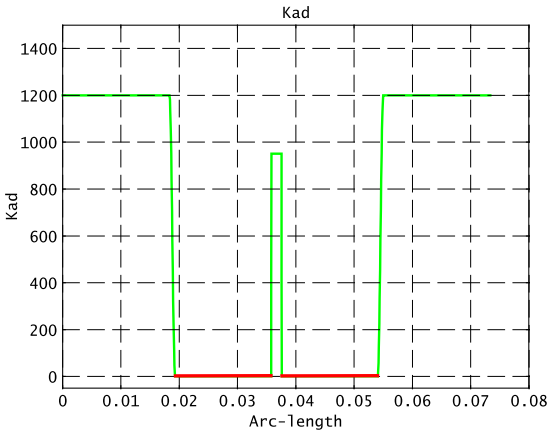

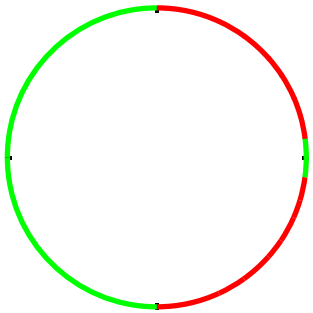

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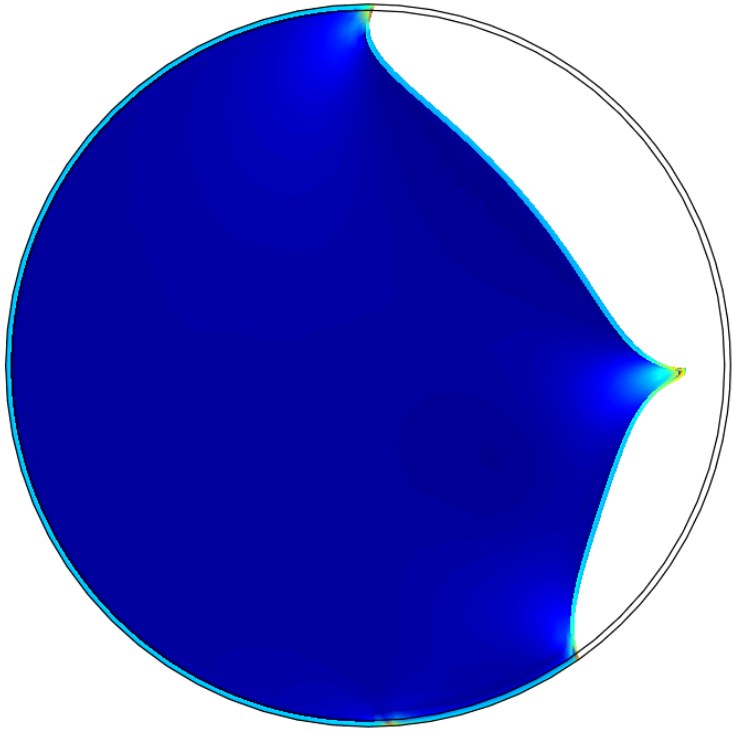
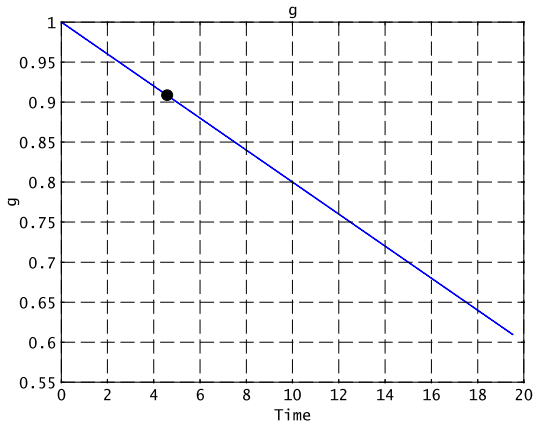
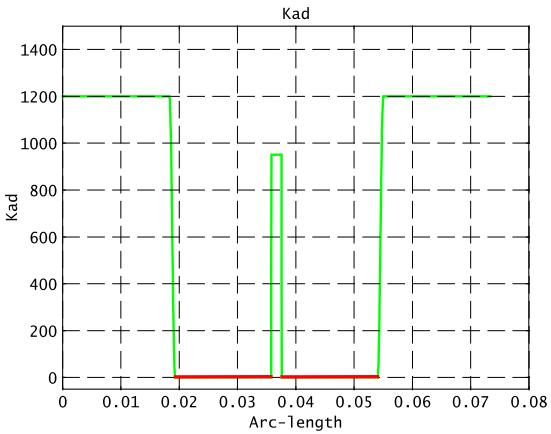
$$\mu = 0.1 \quad \text{Pa s}$$

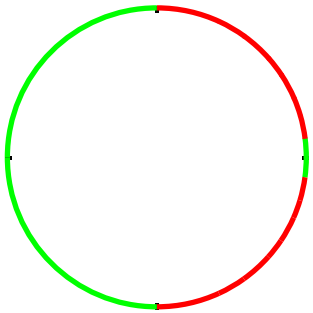
Case-04 (Strong focal adhesion)



[case_02]







$$c_0 = 5 \quad \text{Pa}$$

$$m_0 = 10 \quad \text{Pa}$$

$$\mu = 0.1 \quad \text{Pa s}$$

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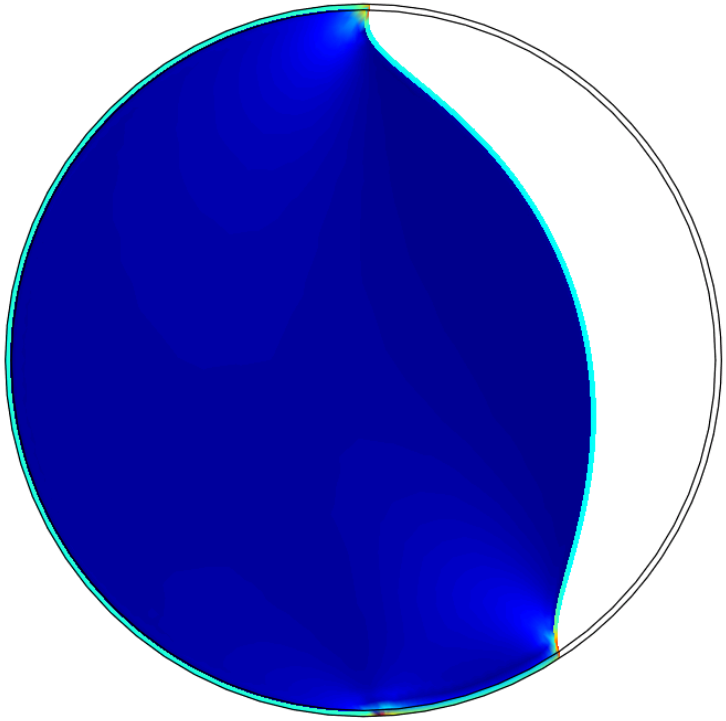
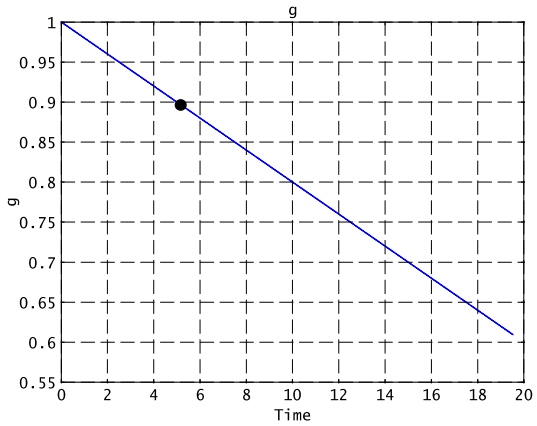
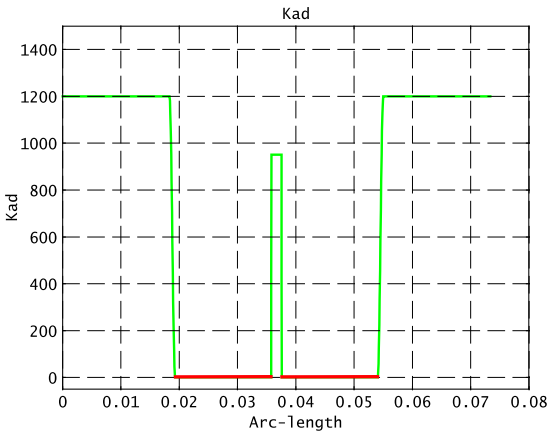
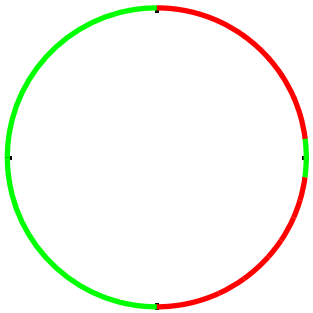


[case_02]







$$c_0 = 5 \quad \text{Pa}$$

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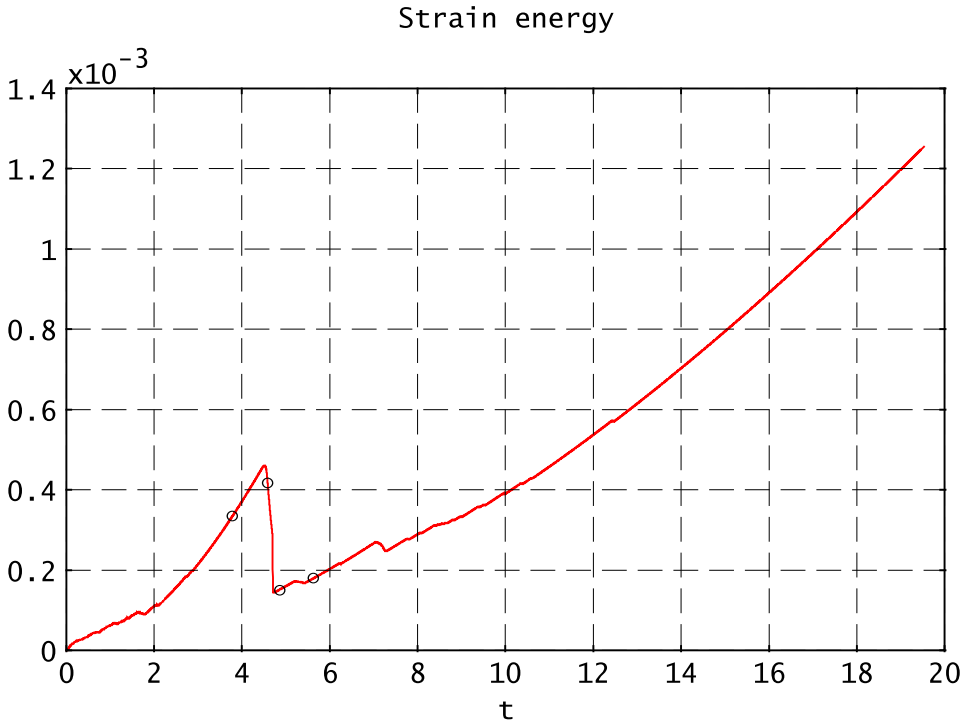
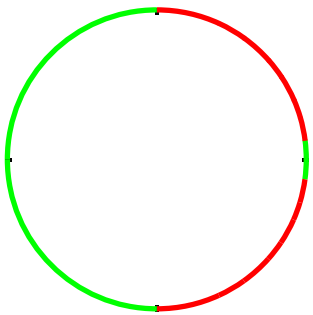


[case_02]

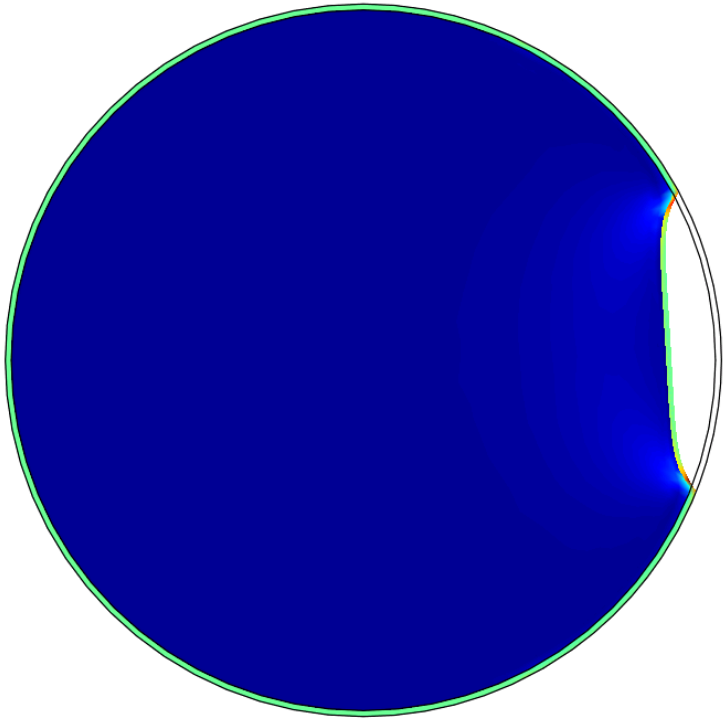


$$c_0 = 5 \quad \text{Pa}$$

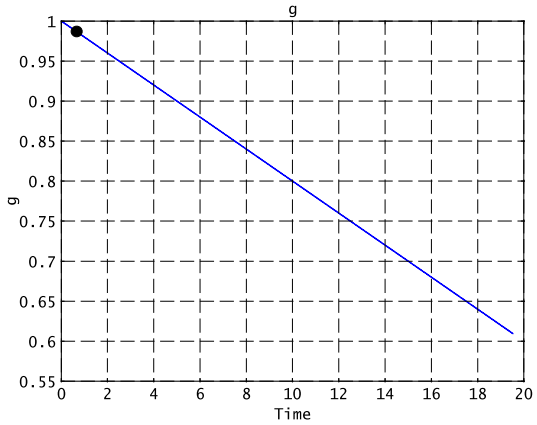
$$m_0 = 10 \quad \text{Pa}$$

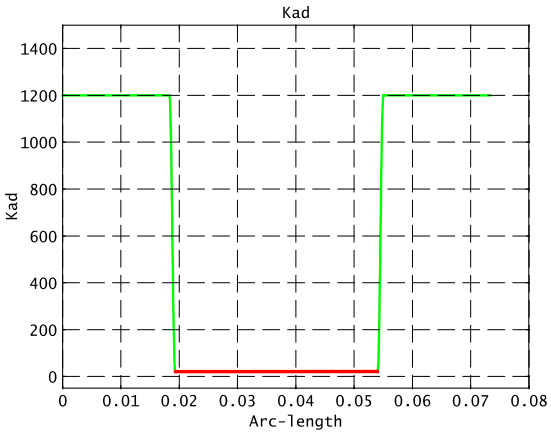
$$\mu = 0.1 \quad \text{Pa s}$$

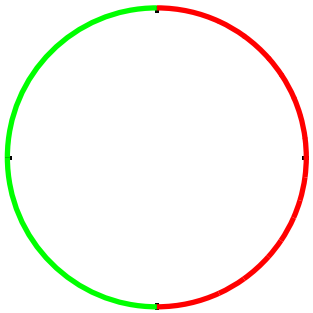
Case-05 (Weak adhesion and stiff cortex)



[case_05]







$c_0 = 5$ Pa

$m_0 = 10$ Pa

$\mu = 0.1$ Pa s

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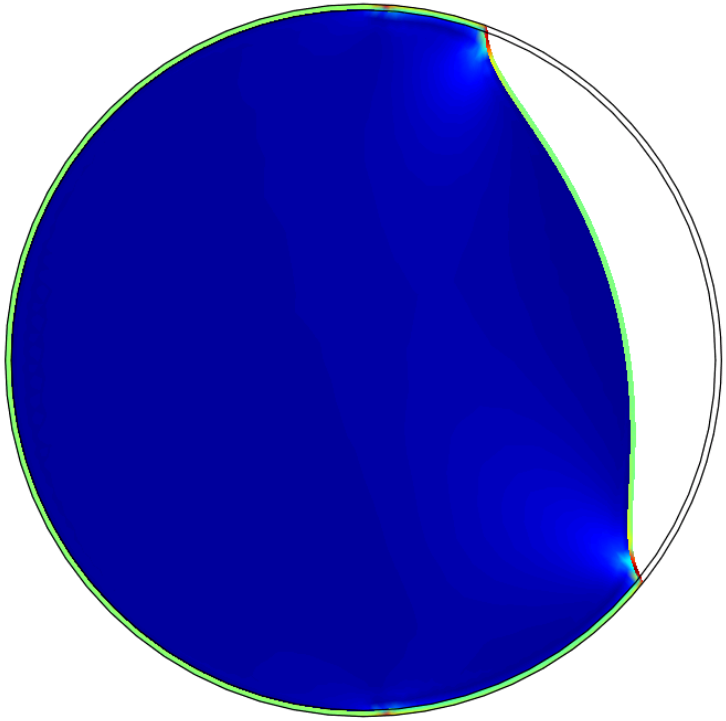
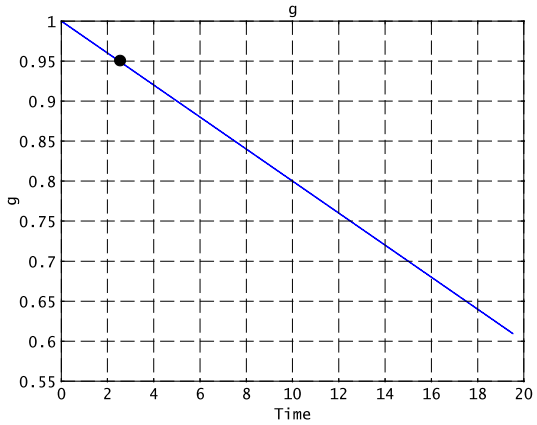
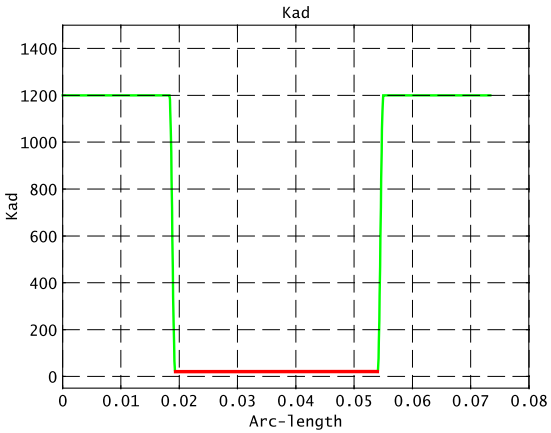
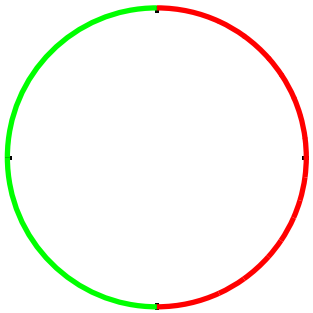


[case_05]







$c_0 = 5$ Pa

$m_0 = 10$ Pa

$\mu = 0.1$ Pa s

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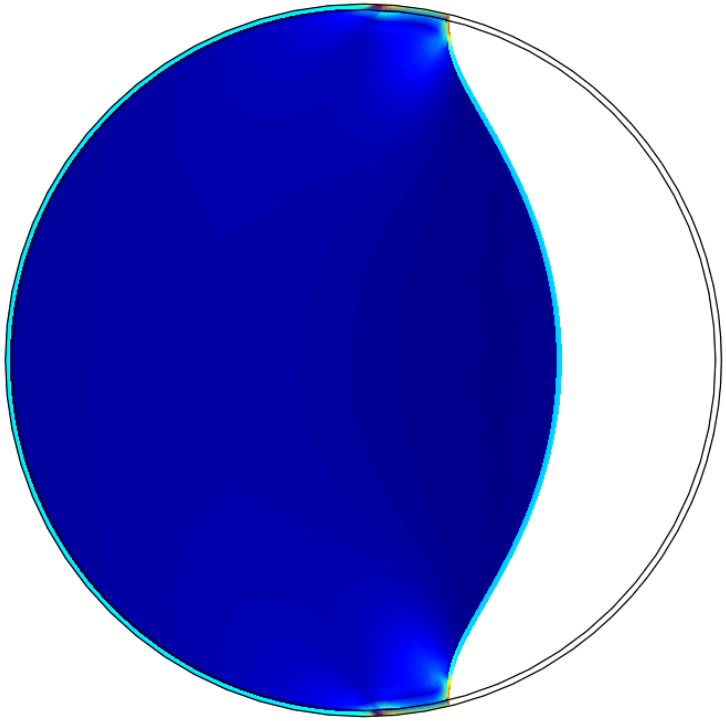
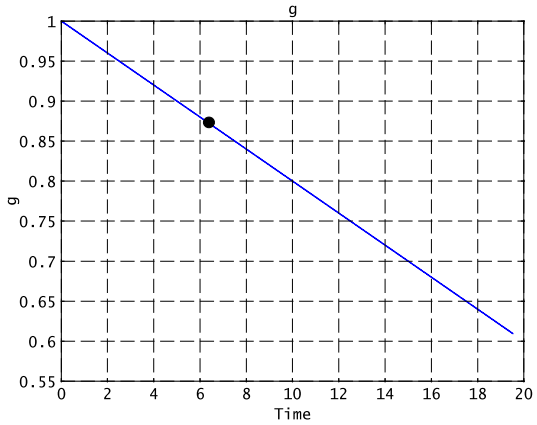
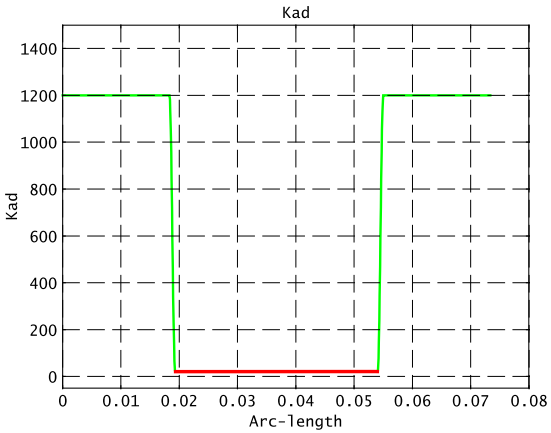
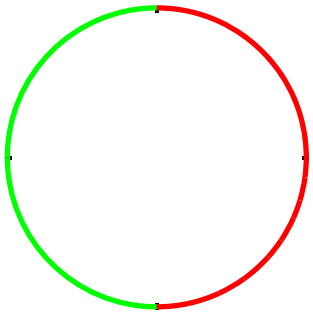


[case_05]







$c_0 = 5$ Pa

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$\mu = 0.1$ Pa s

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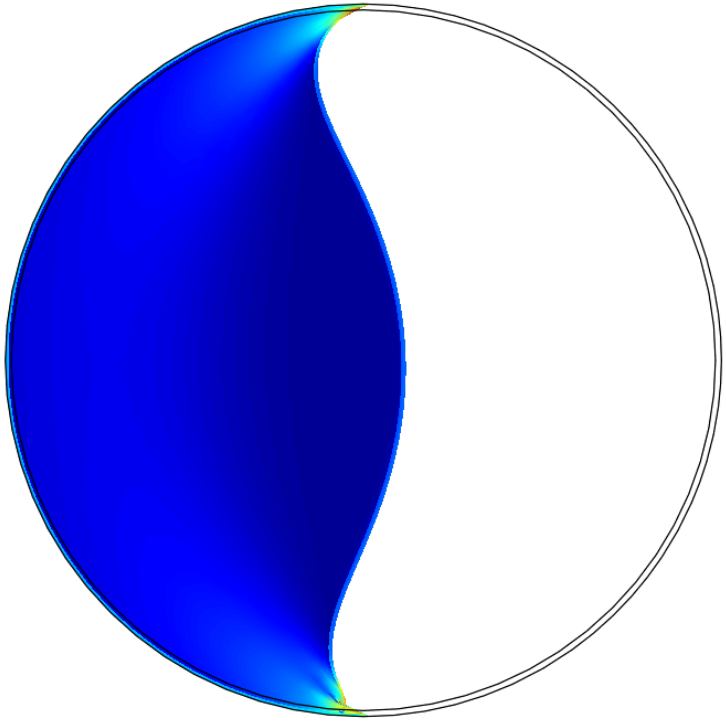
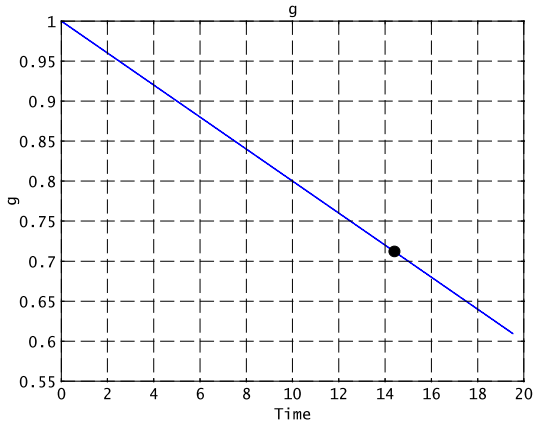
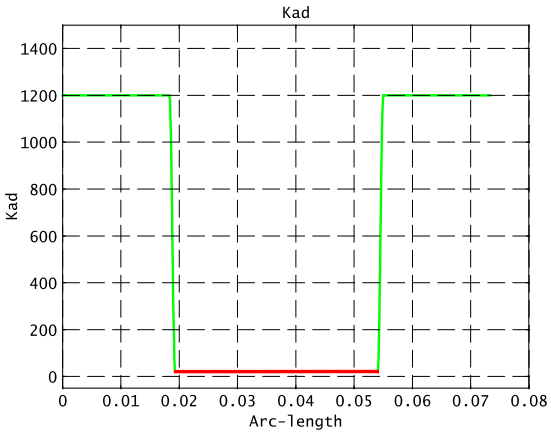
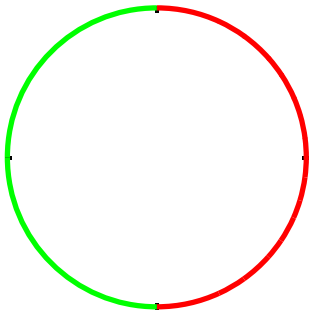


[case_05]







$c_0 = 5$ Pa

$m_0 = 10$ Pa

$\mu = 0.1$ Pa s

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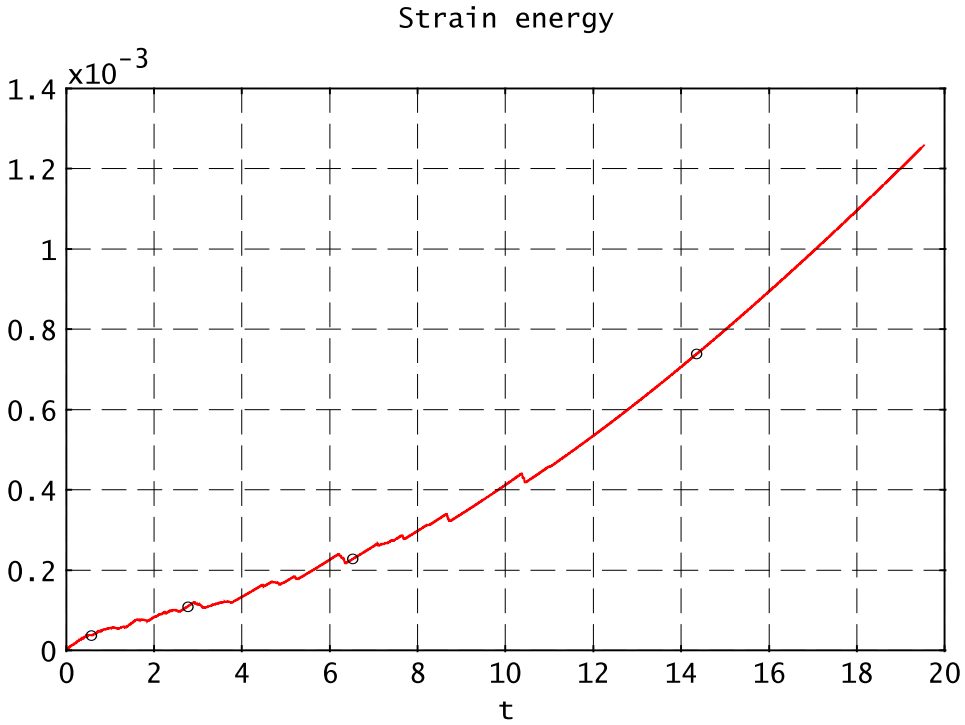
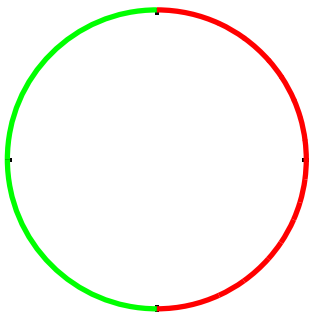


[case_05]

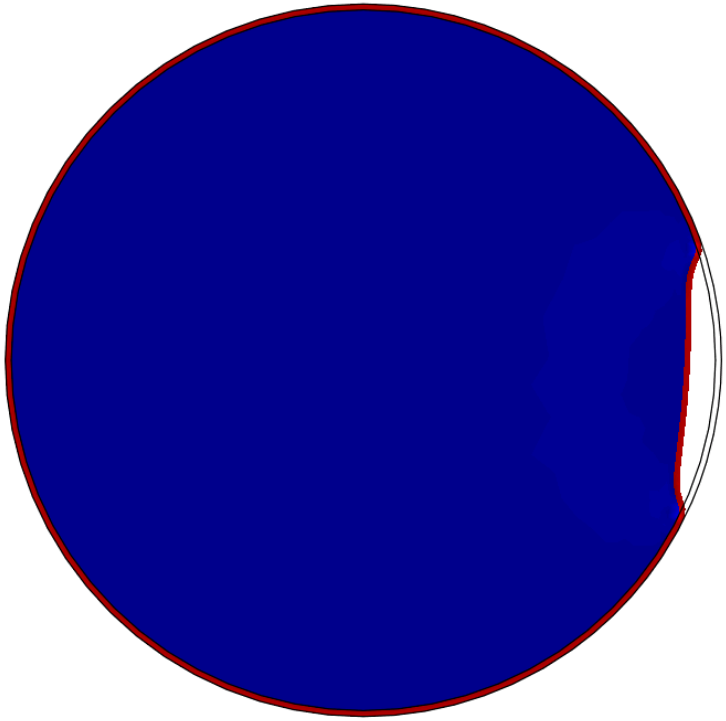


$$c_0 = 5 \quad \text{Pa}$$

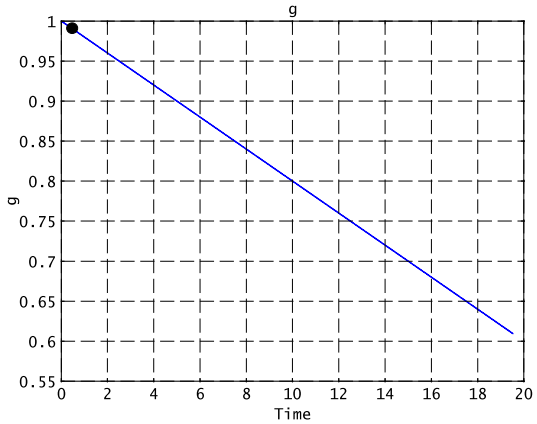
$$m_0 = 10 \quad \text{Pa}$$

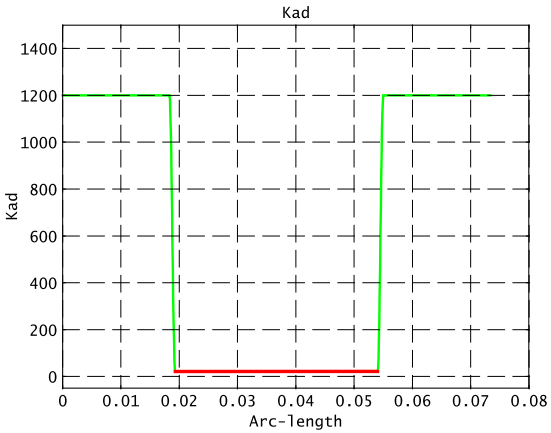
$$\mu = 0.1 \quad \text{Pa s}$$

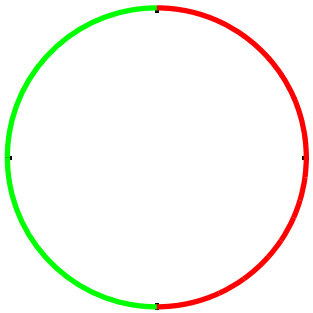
Case-06 (Weak adhesion and stiffer cortex)



[case_06]





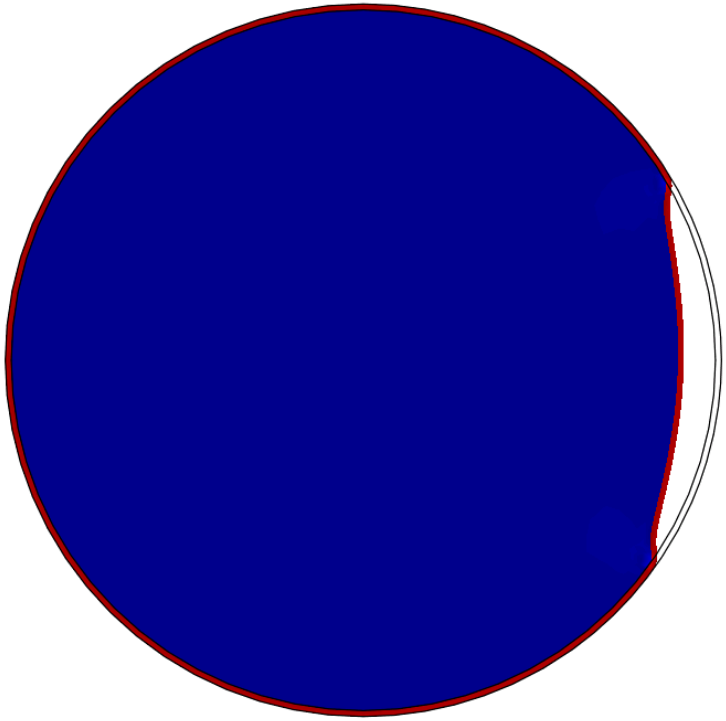


$$c_0 = 5 \quad \text{Pa}$$

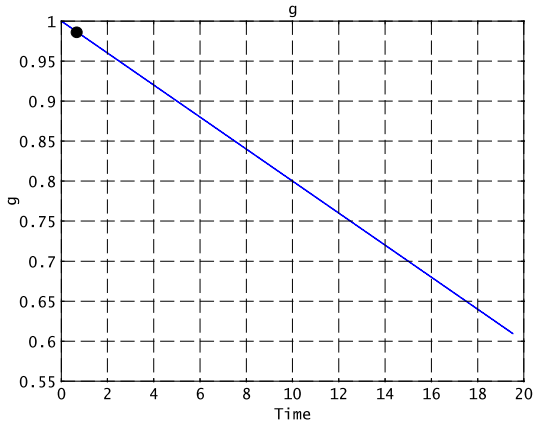
$$m_0 = 1000 \quad \text{Pa}$$

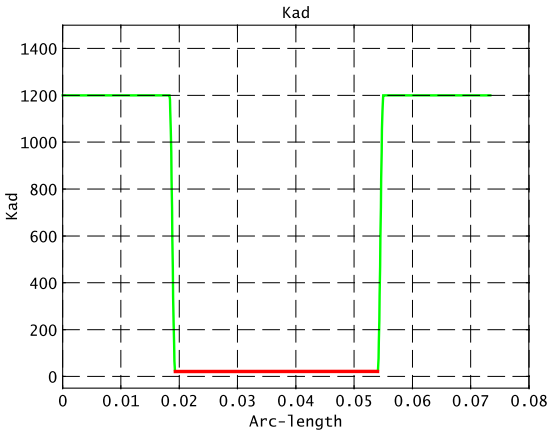
$$\mu = 0.1 \quad \text{Pa s}$$

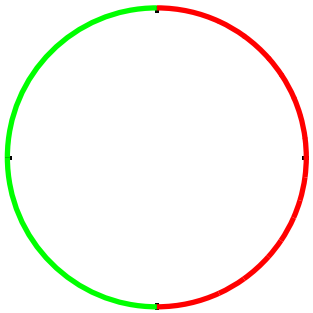
Case-06 (Weak adhesion and stiffer cortex)



[case_06]







$$c_0 = 5 \quad \text{Pa}$$

$$m_0 = 1000 \quad \text{Pa}$$

$$\mu = 0.1 \quad \text{Pa s}$$

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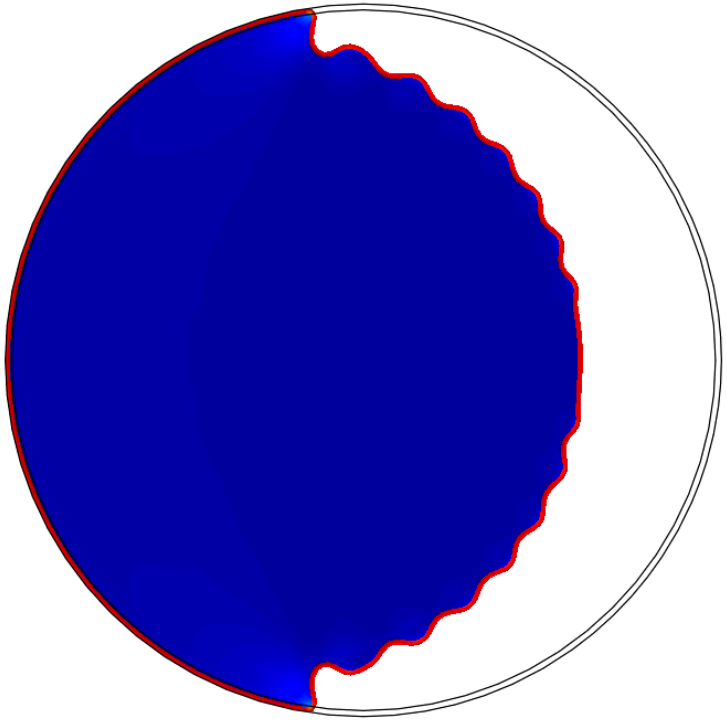
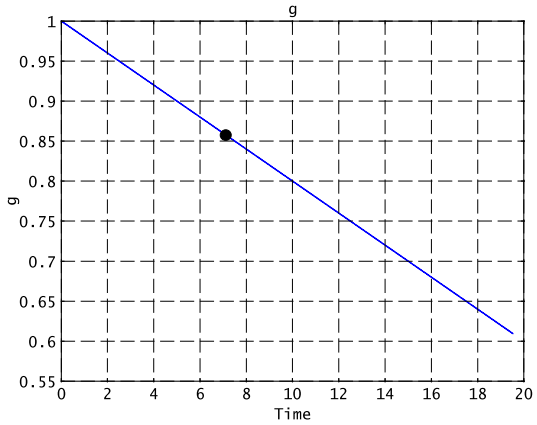
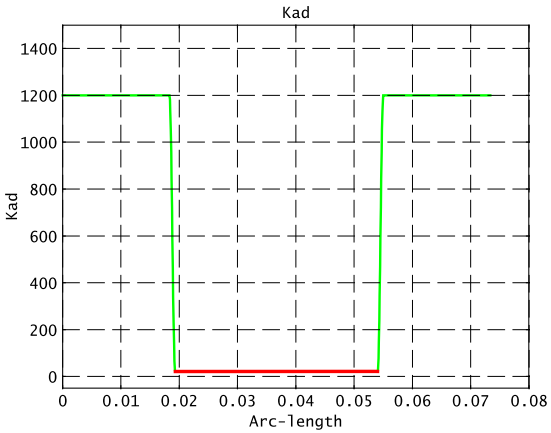
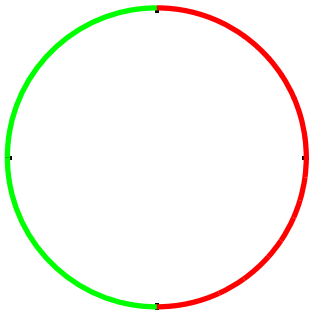


[case_06]







$$c_0 = 5 \quad \text{Pa}$$

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$$\mu = 0.1 \quad \text{Pa s}$$

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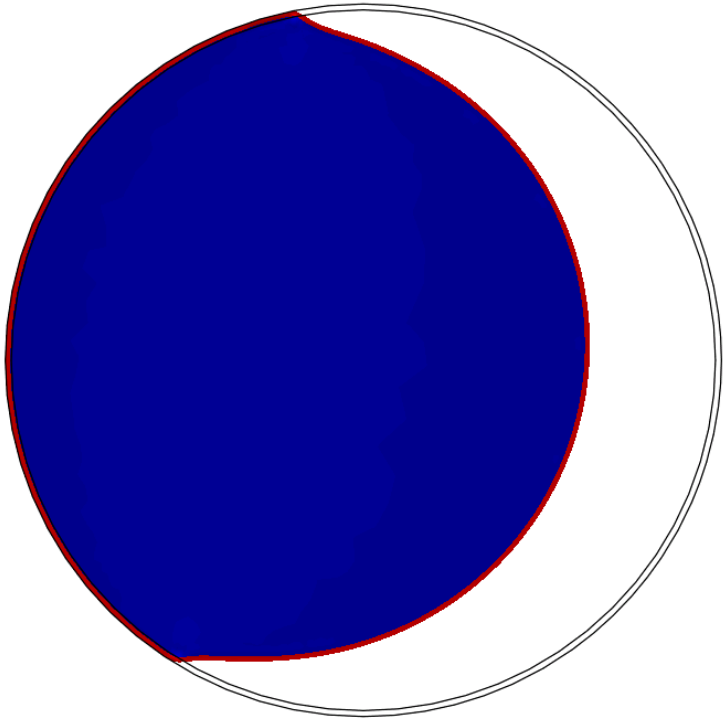

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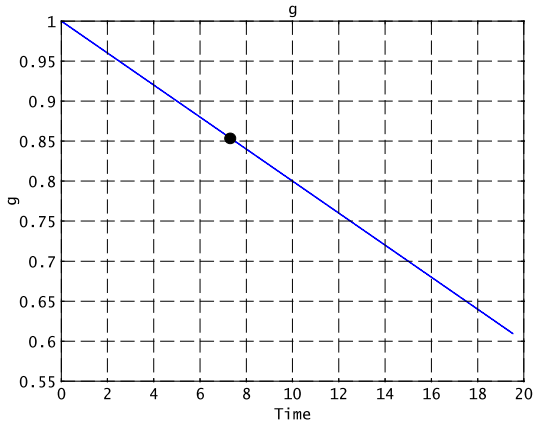

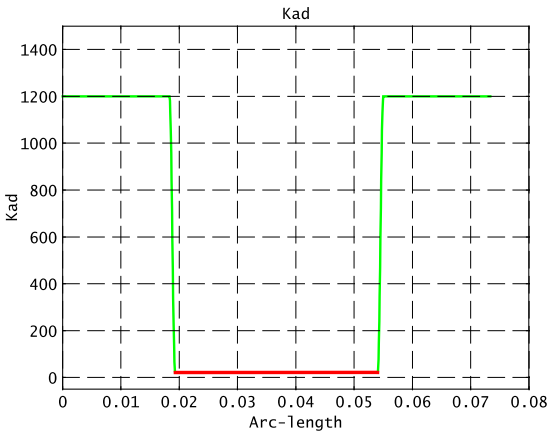

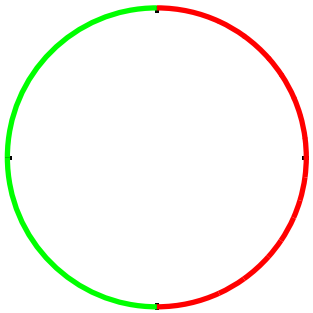

$$c_0 = 5 \quad \text{Pa}$$

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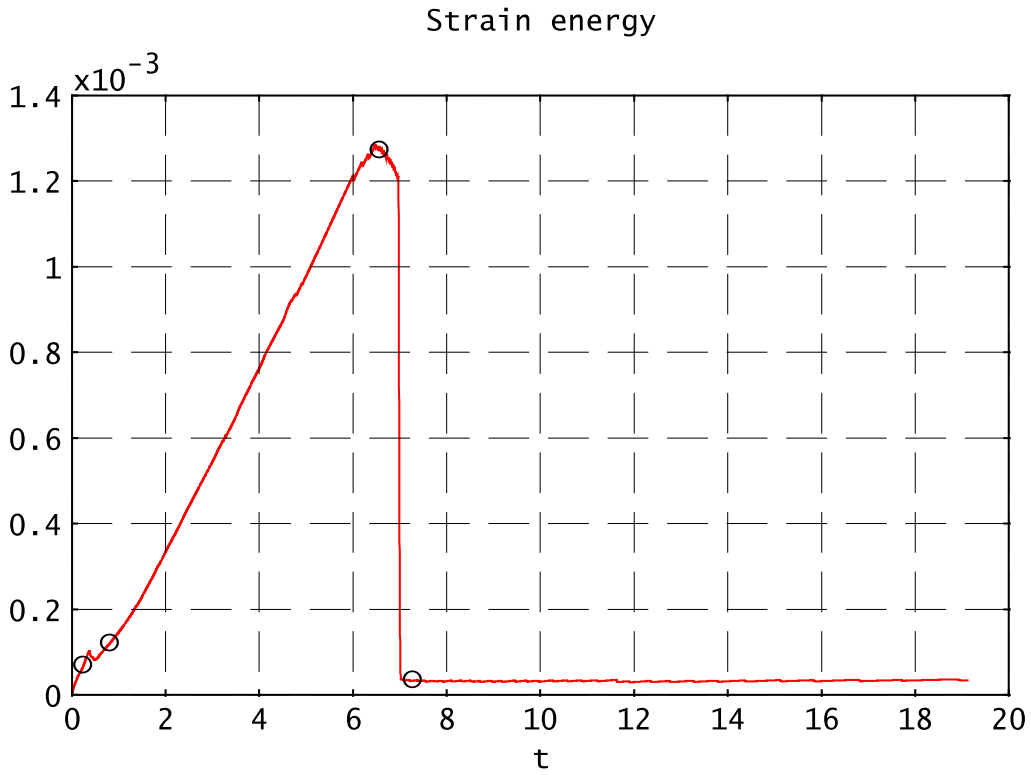
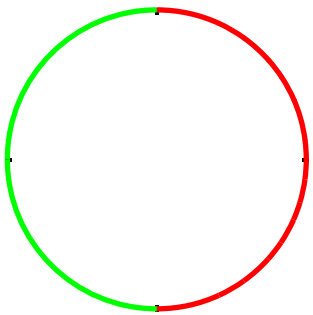
Case-06 (Weak adhesion and stiffer cortex)



[case_06]

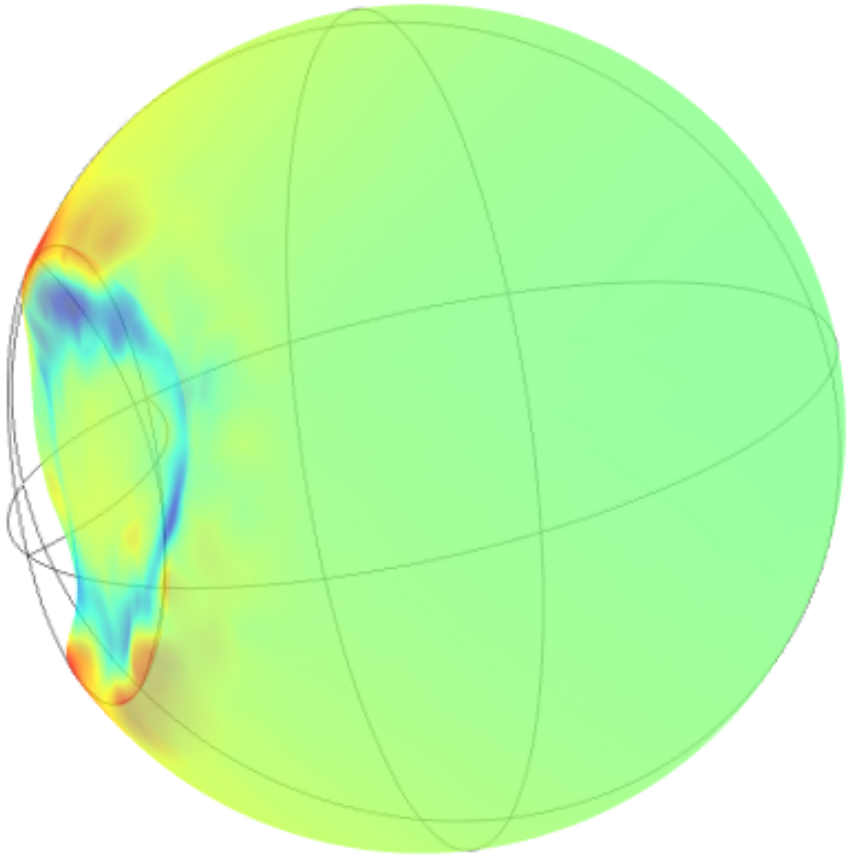


$$c_0 = 5 \quad \text{Pa}$$

$$m_0 = 1000 \quad \text{Pa}$$

$$\mu = 0.1 \quad \text{Pa s}$$

Posterior vitreous detachment (A 3d model)



Conclusions

- At the attachment points between the membrane and the rigid exterior boundary, large values of the traction force are attained during the shrinkage;
- The shrinkage process induces an additional contribution to the traction, which is independent of the eye movements;
- The PVD shapes obtained through the simulations look like the observed PVD shapes, even with a simple spherical shrinkage.