



# Using Computational Mechanics to Improve Preterm Birth Risk Assessment

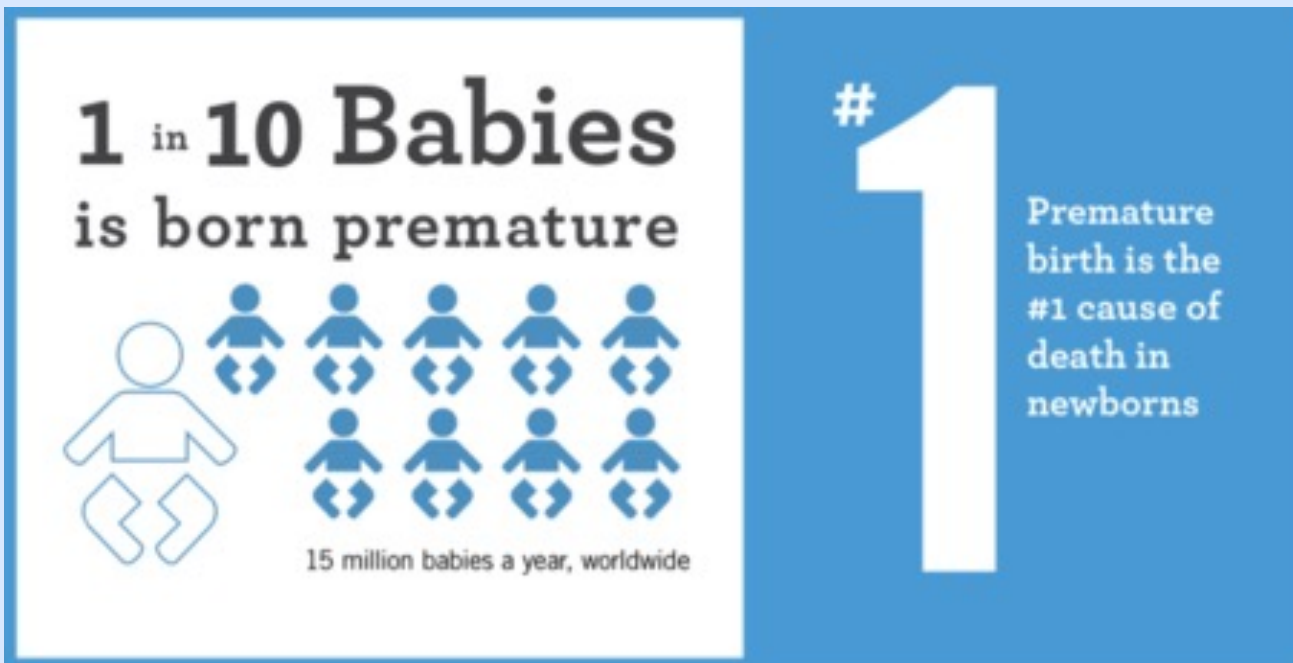


Jayla McCoy<sup>1</sup>, Camilo A. Duarte-Cordon, Ph.D.<sup>2</sup>, Abigail Lauthlin<sup>2</sup>, Kristin M. Myers, Ph.D.<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, University of Kentucky, Lexington, KY

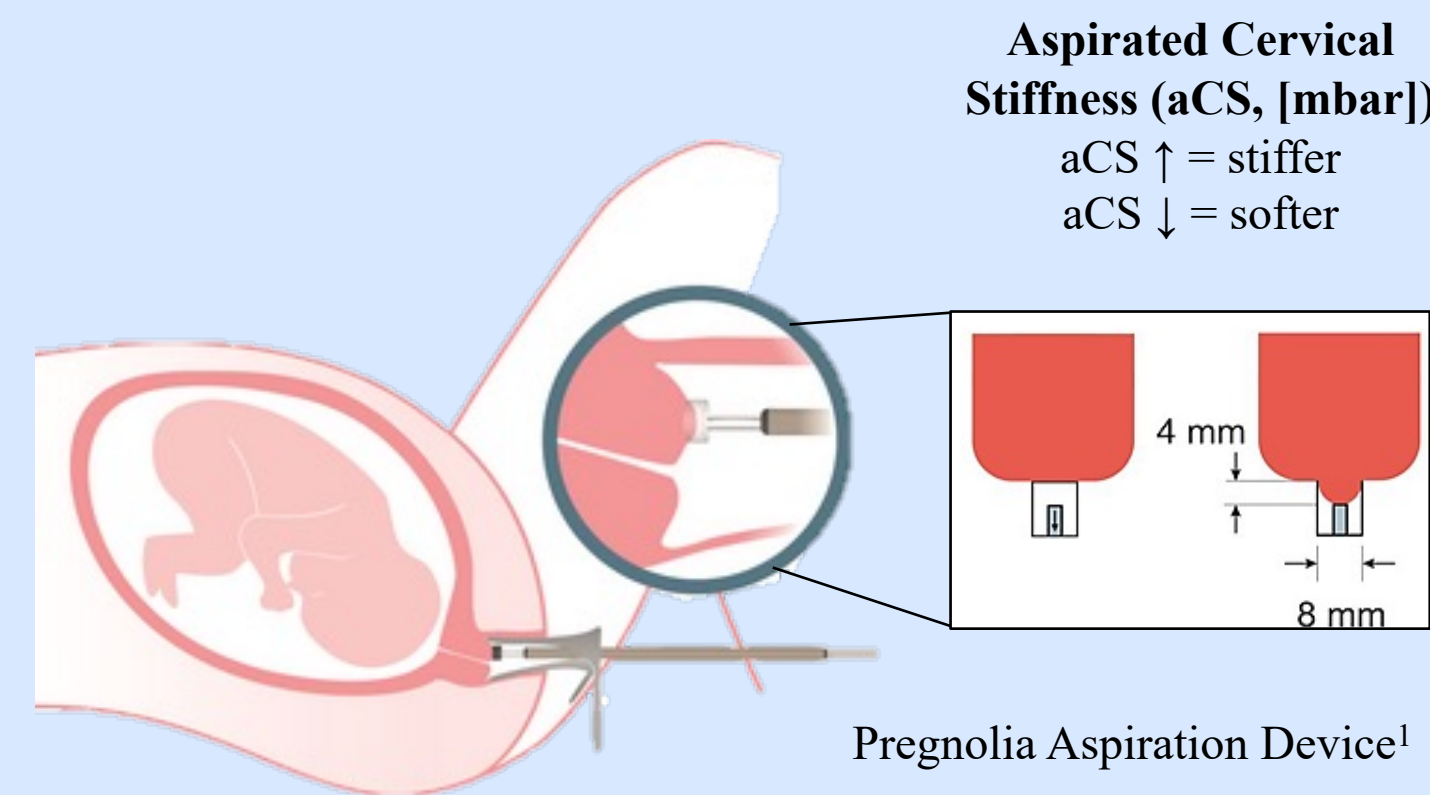
<sup>2</sup>Department of Mechanical Engineering, Columbia University, New York, NY

## Introduction



Preterm birth (PTB) Statistics<sup>2</sup>

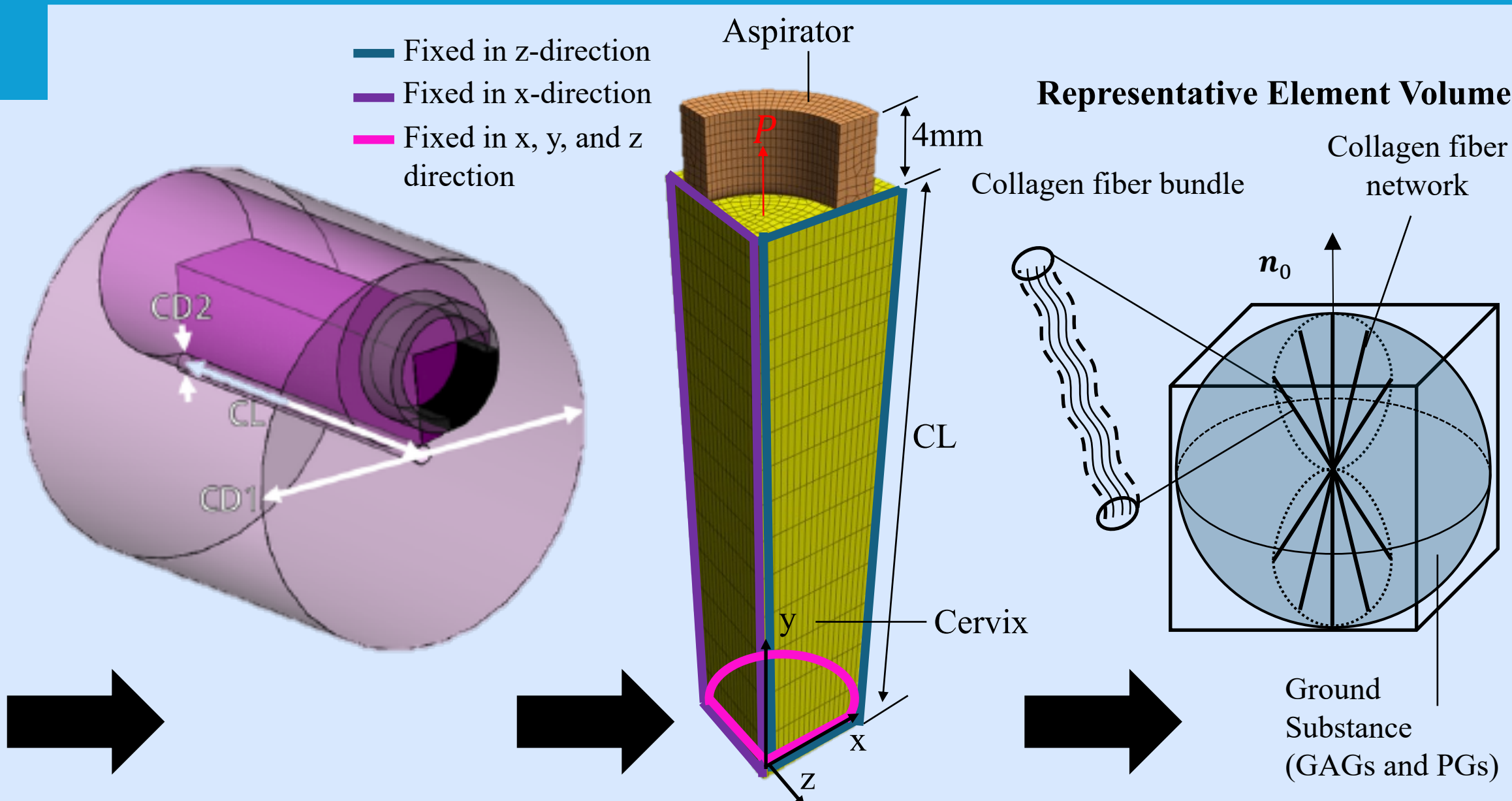
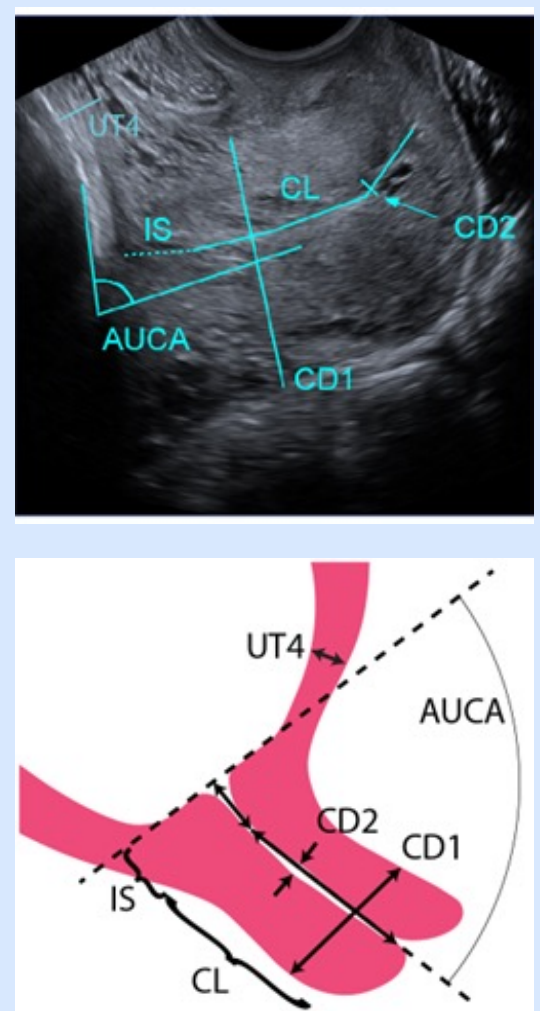
- Currently, there is no reliable method to predict spontaneous preterm birth (sPTB). For routine check-ups, Transvaginal ultrasound measurement of cervical length (TVCL) is the preferred method<sup>3</sup>.
- The Pregnolia aspiration system<sup>1</sup> is a new device that can help us better understand cervical remodeling and predict sPTB.
- Computational modeling tools, such as finite element modeling (FEM), can be combined with data from the device to give insights into the deformation and stress of the cervix during pregnancy.



Aspirated Cervical Stiffness (aCS, [mbar])  
aCS ↑ = stiffer  
aCS ↓ = softer

Pregnolia Aspiration Device<sup>1</sup>

## Methods

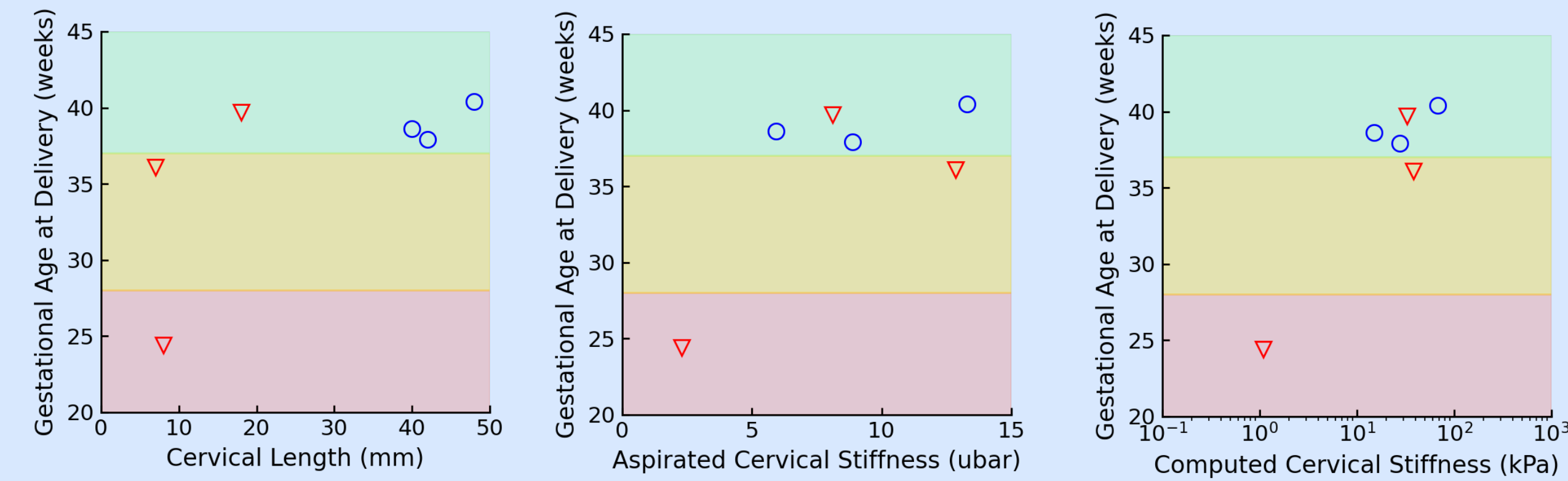


Patient #	Delivery (weeks)	Cervical Length (mm)	aCS (ubar)	cCs (kPa)
Low Risk				
7	40.4	48	13.300	67.696
16	37.9	42	8.867	27.391
32	38.6	40	5.933	15.098
High Risk				
1	39.7	18	8.100	32.584
2	36.1	7	12.850	38.319
6	24.4	8	2.300	1.083

- Using ultrasounds from three patients at high risk for sPTB (CL < 25 mm) and three patients at low risk for sPTB (CL > 25 mm), we built simplified FE models of the cervix and the Pregnolia aspiration device.
- Models were then meshed in Hypermesh and imported to FEBio Studio 2.7, where relevant boundary conditions were applied.
- Inverse Finite Element Analysis (iFEA) was used to determine the stiffness of the fibers from the simulations, generating a computed cervical stiffness (cCS) index for each patient.

## Results

### Computed Cervical Stiffness (cCS) could predict PTB

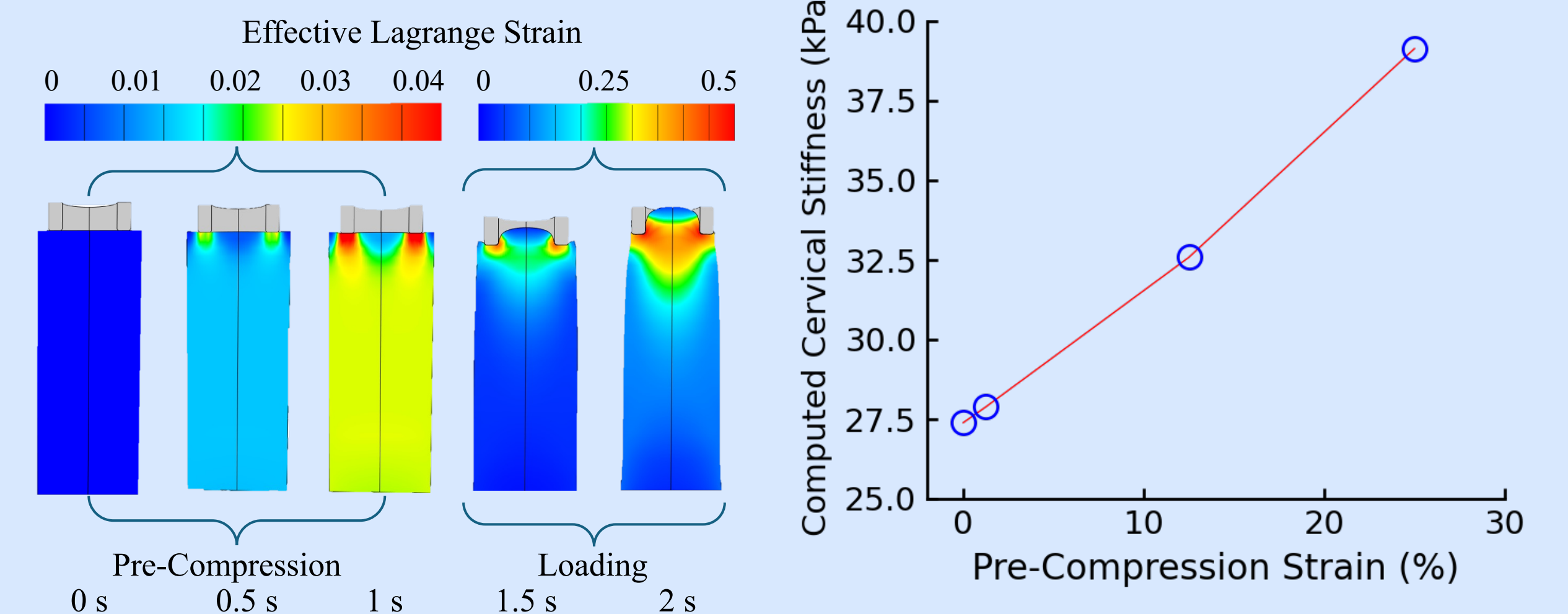


▽ = High Risk    □ = Normal    □ = Extremely PTB  
○ = Low Risk    □ = PTB

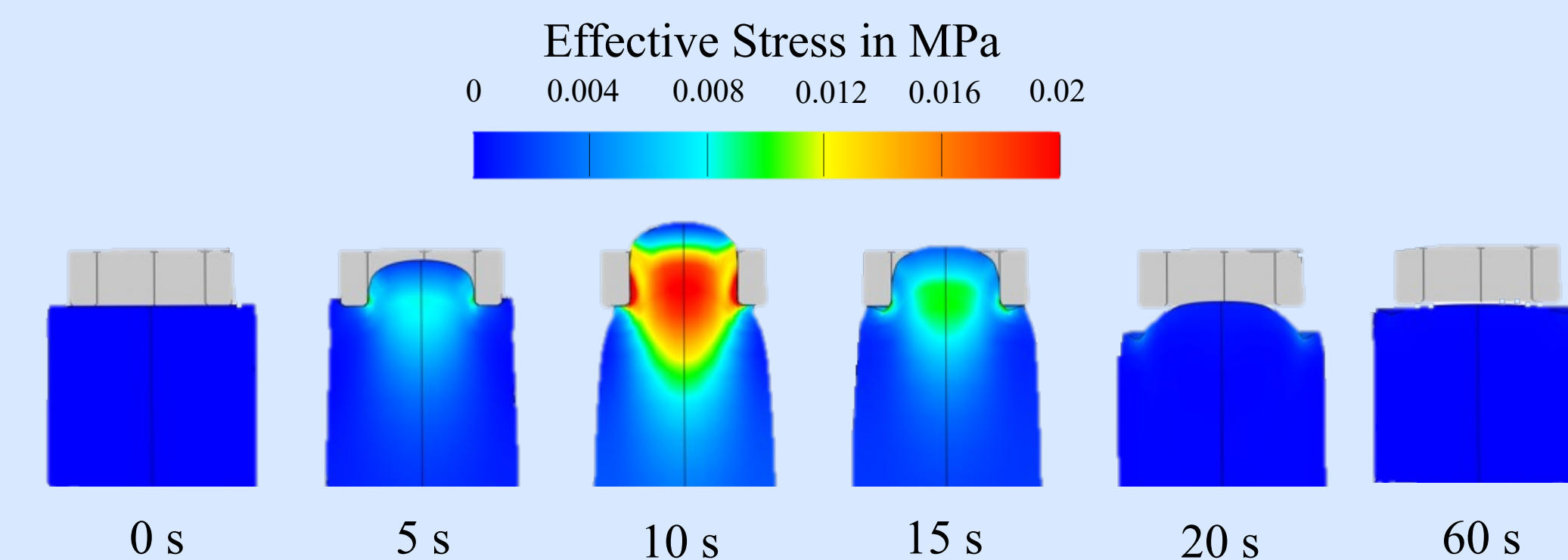
- The patient with the lowest cCS index corresponds to the patient who delivered extremely preterm (24 weeks).
- Computed cervical stiffness index shows a stronger correlation to gestational outcomes than CL or aCs index.

### Precompression affects cCs values

- As the level of precompression increases, the cCS index obtained from iFEA also increases exponentially.
- Physicians must be careful not to press significantly on the cervix during testing.



### Viscoelasticity and relaxation time affect aCS measurements



- The relaxation of cervical tissue when taking consecutive measurements with the probe may affect the aCS index obtained from the Pregnolia aspiration device.
- In FE models, the displacement of cervical tissue is affected by the viscoelastic relaxation time, thus reinforcing the importance of letting the tissue relax to equilibrium before taking measurements.

## Conclusions

- This study shows that FE models can be reliable tools to enhance the potential of the Pregnolia system for sPTB risk assessment.
- cCS could correlate to sPTB risk level and has the potential to be used for routine check-ups as a complementary quantity to TVCL.
- Precompression and viscoelasticity of the cervix during examination affect the calculation of the cCS index. Future testing in more patients is needed to determine if cCS index can be used to predict sPTB.

## References

- [1] Kyvernitakis I, Lauer P, Malan M, Badir S, Maul H. *Plos One*, (2023).
- [2] World Health Organization, "Preterm Birth", 2023.
- [3] J. Owen and J. D. Iams, *Seminars in Perinatology*, vol. 27, no. 3, pp. 194–203, (2003).

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