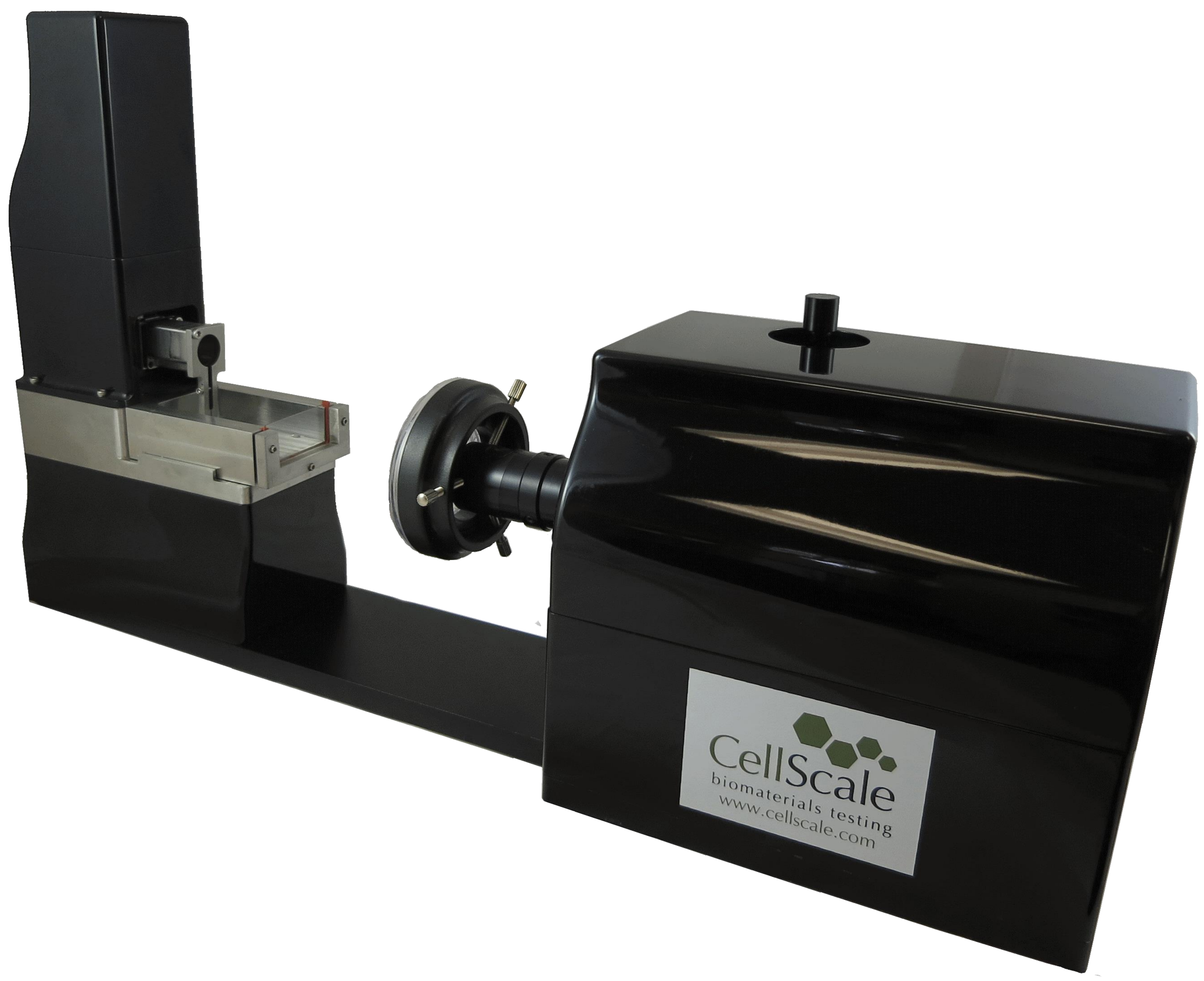
Compression Testing of Soft Materials

Overview

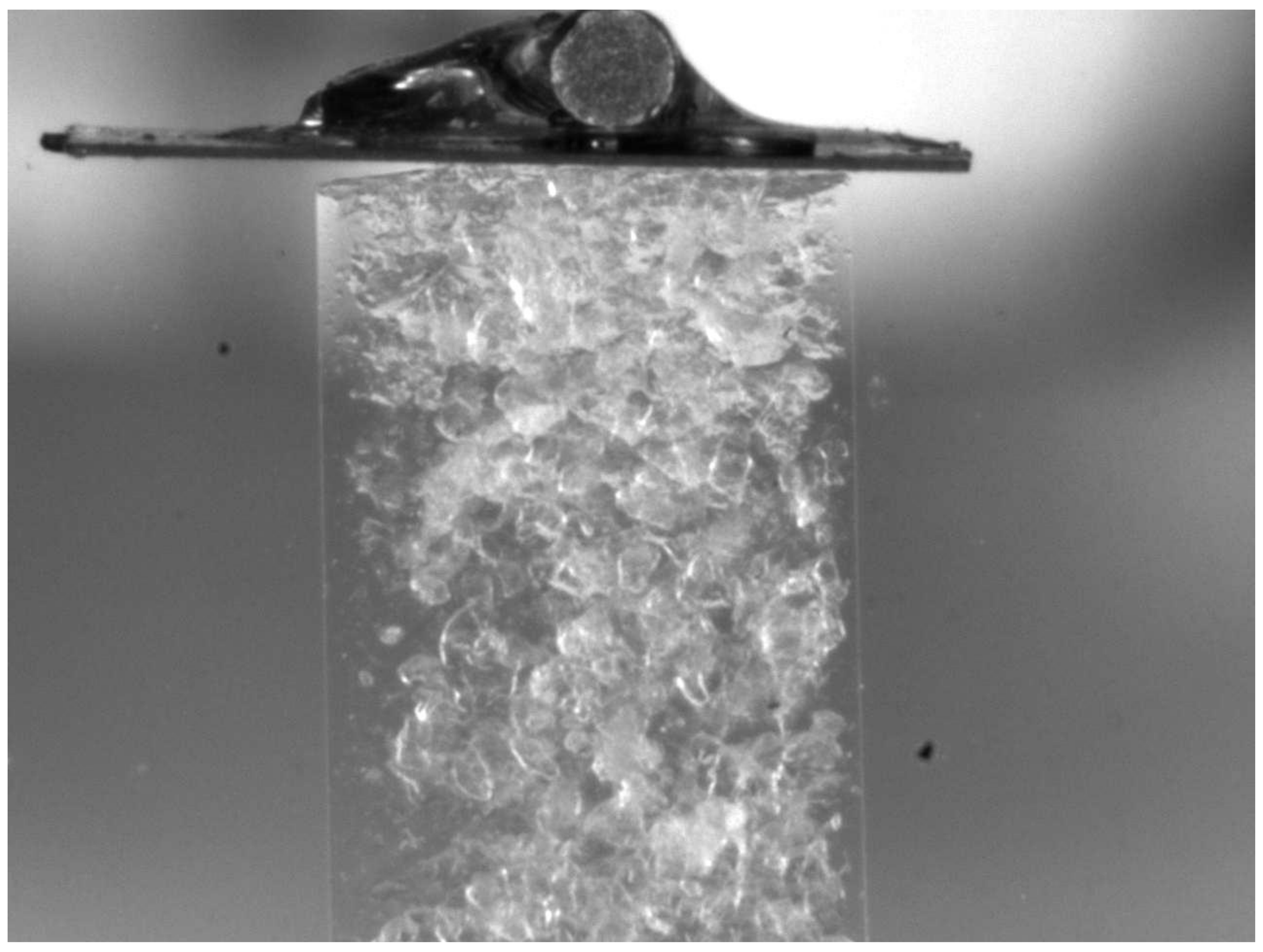
The MicroSquisher has been designed to perform tension and compression testing at low forces. This report outlines the results of compression testing of a soft gel material using 3 methods: cylindrical specimen compression of cylindrical specimens, compression of spherical specimens, and indentation testing using a spherical indentor. The results show that all three techniques are viable for measuring the stiffness of gel materials.

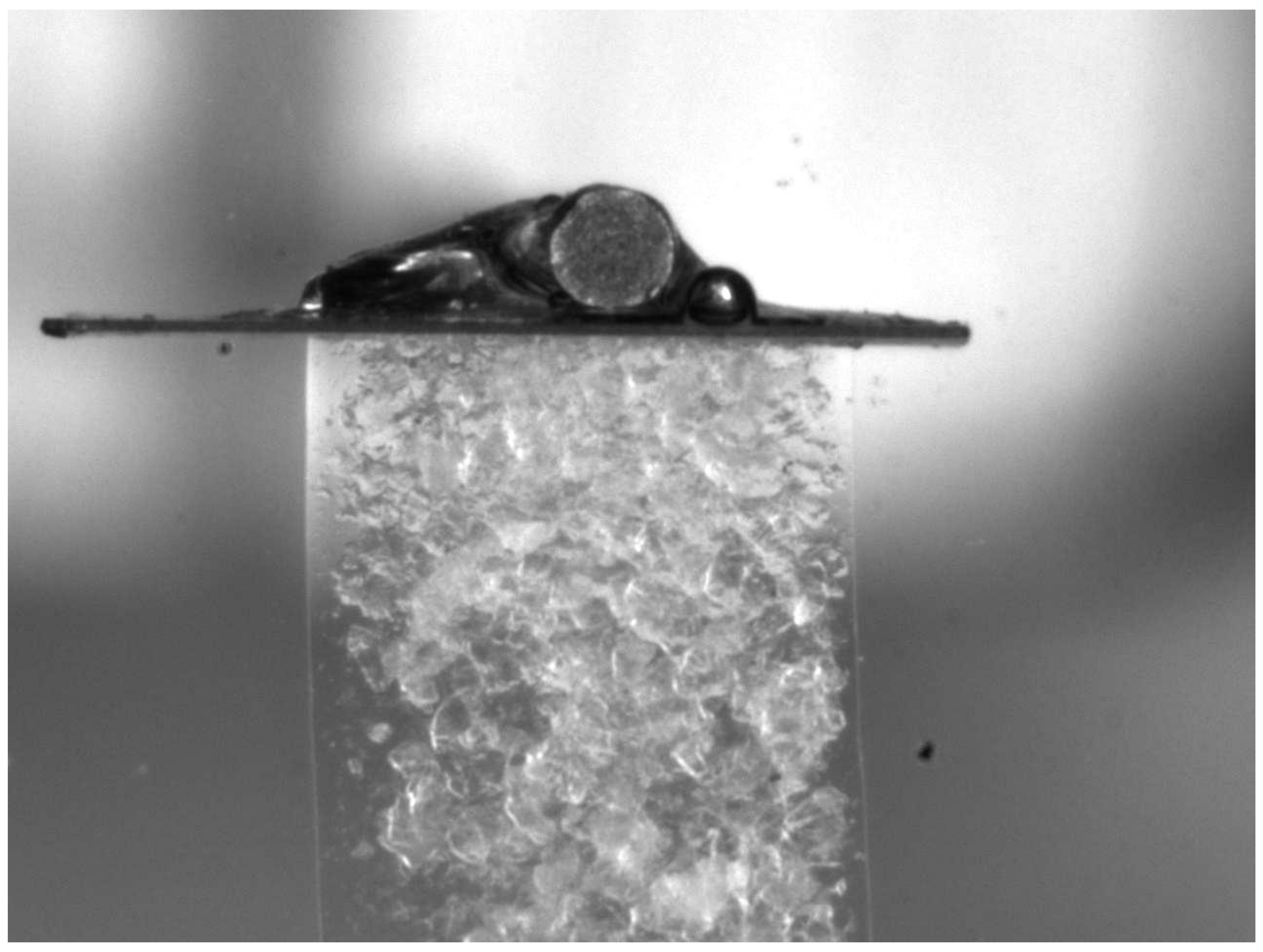
The testing was completed using the MicroSquisher and a 20mN capacity force transducer. The testing was performed on agar agar gel mixed at 20g/L. All specimens were placed in room temperature distilled water for at least 1 hour prior to testing.



Compression of a Cylindrical Specimen

Using a syringe, the liquid agar agar was pulled into a plastic tube with a 2mm inside diameter and allowed to cool to room temperature. After 1 hour, the gel was ejected from the tube and cut into sections 4.7mm long using a parallel razor blade tool. The specimens were prepared with a height to diameter ratio of more than 2 in order to minimize the impact of friction caused by Poisson's Ratio-driven radial expansion during the compression test. The cylinders were compressed to more than 15% nominal strain in 60 seconds while collecting data at 1Hz.





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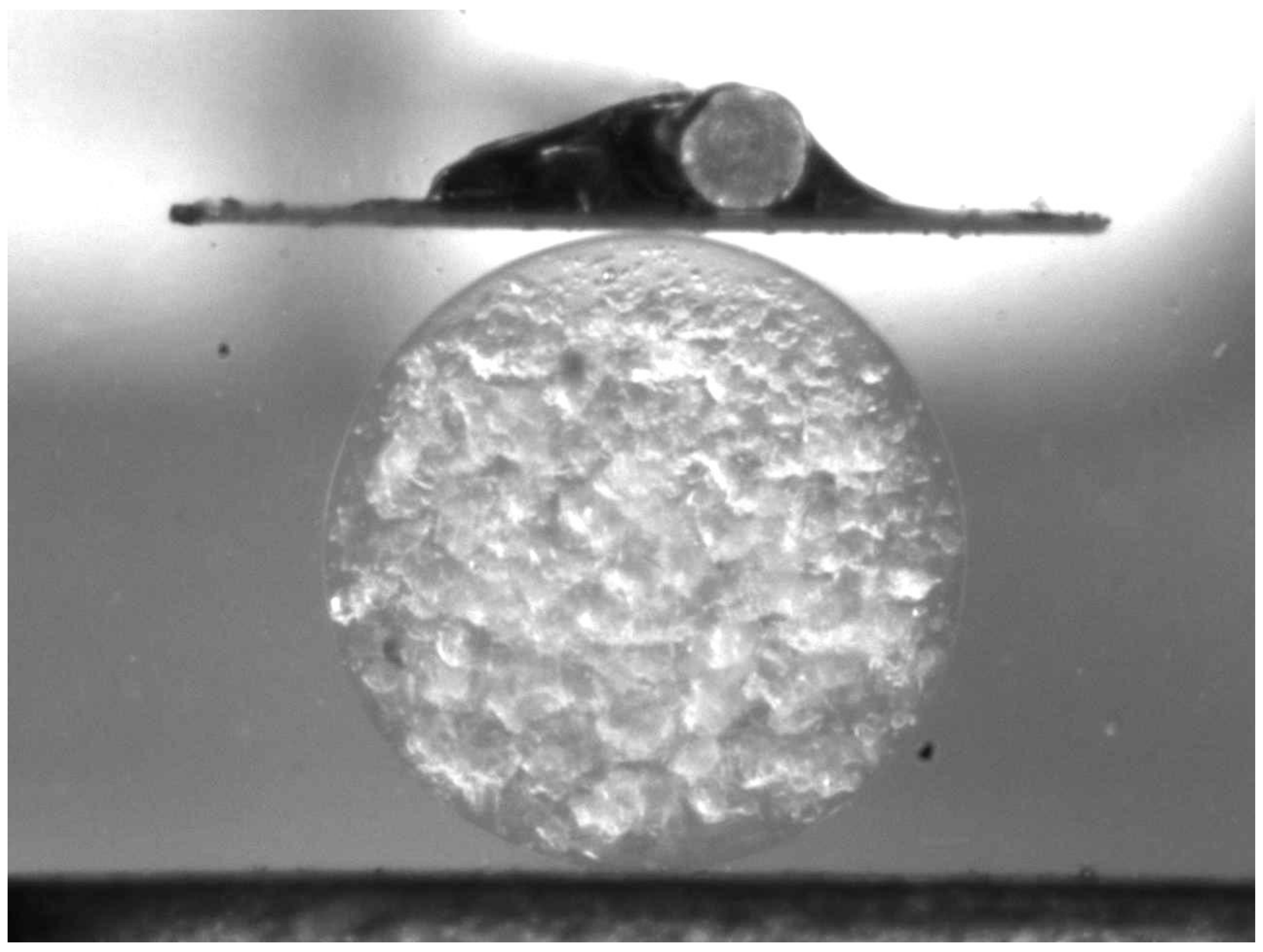
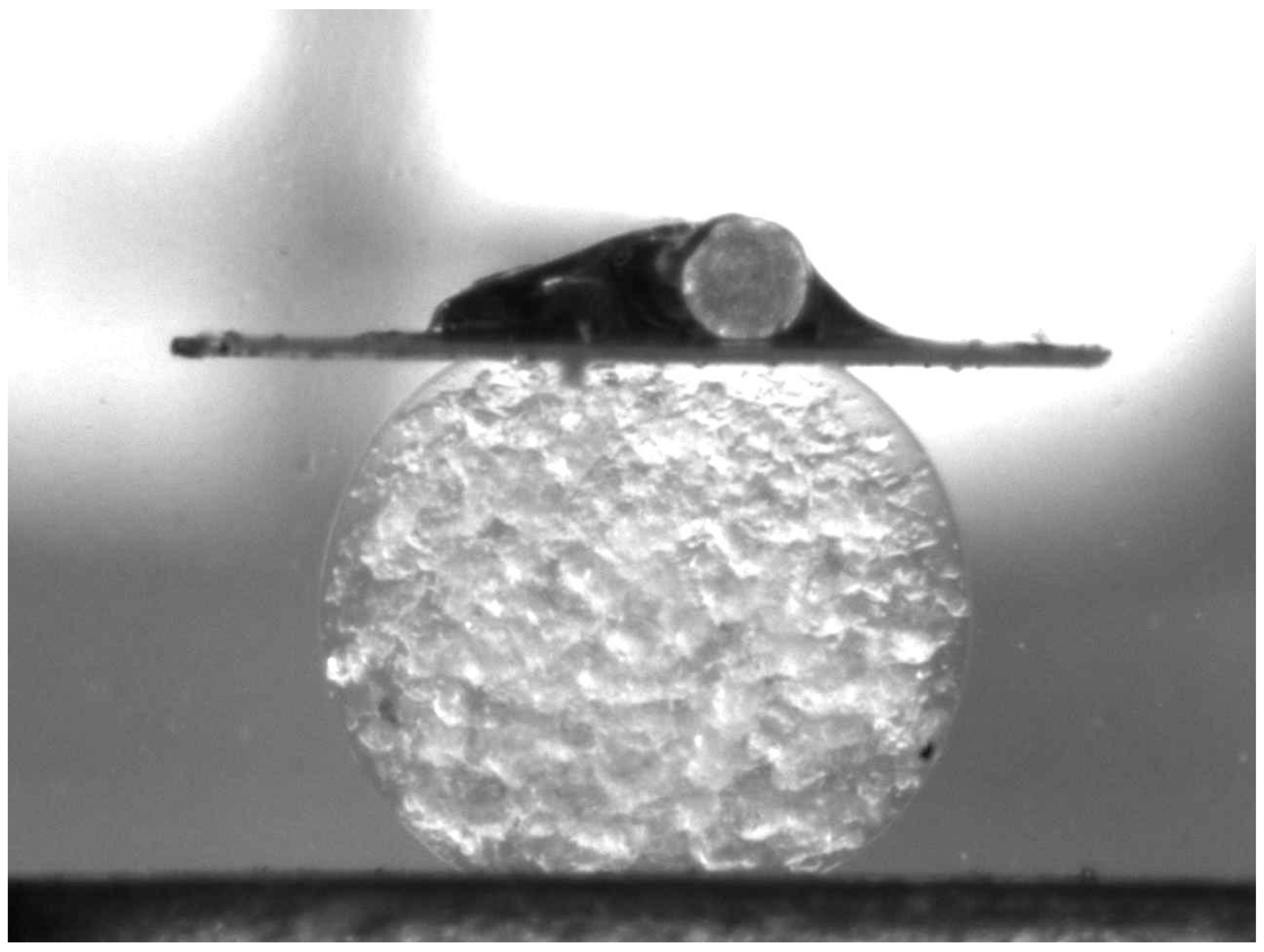
Compression of a Spherical Specimen

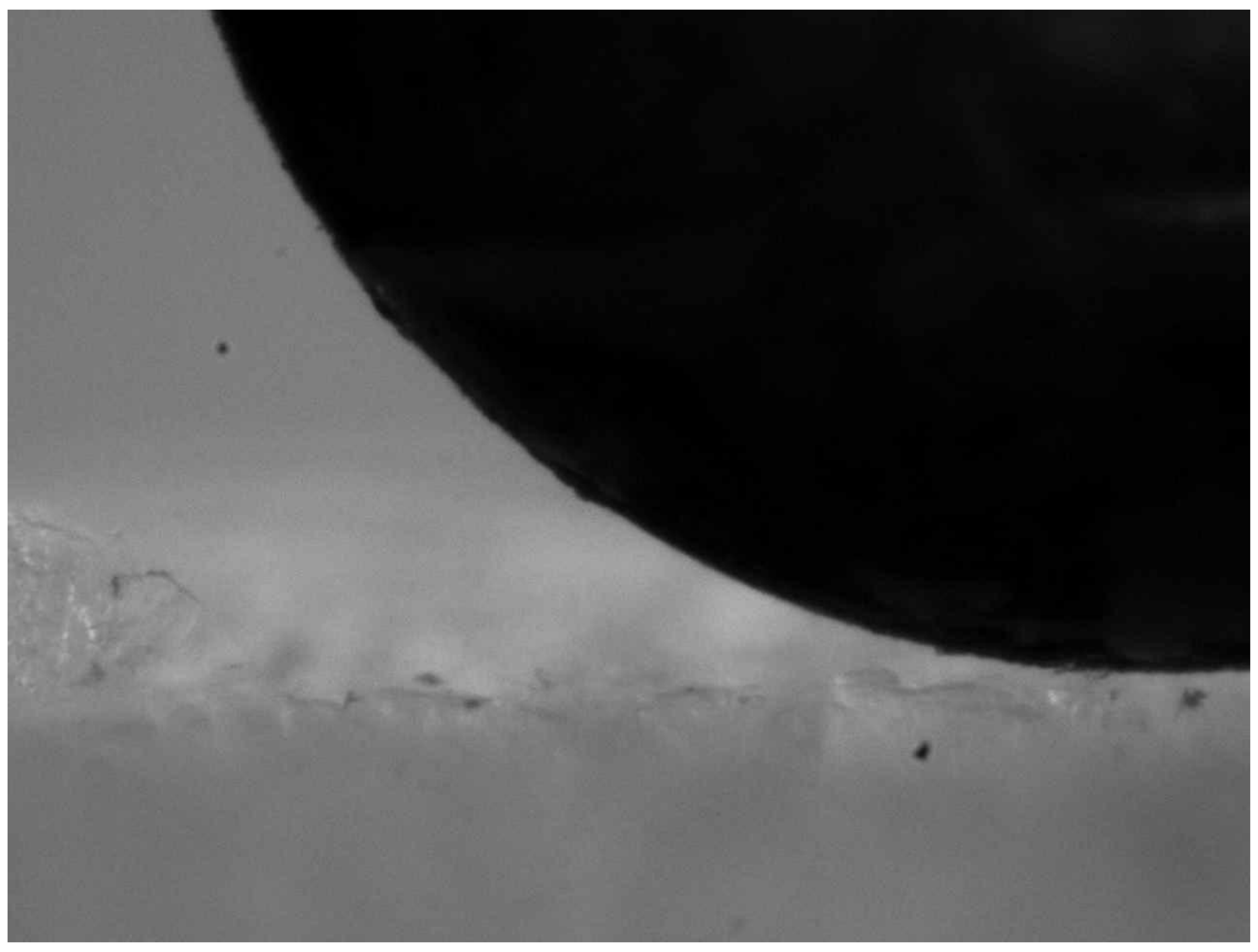
The liquid agar agar was dribbled into a tall container of cold vegetable oil using a syringe. This technique, called cold spheritization, led to the formation of agar agar spheres in a range of sizes settling to the bottom of the oil. The majority of the oil was drained off and the spheres were then rinsed with distilled water several times. Spheres between 2 and 3mm in size were selected for testing. These were placed in the MicroSquisher and compressed by more than 15% nominal strain in 60 seconds while collecting data at 1Hz.

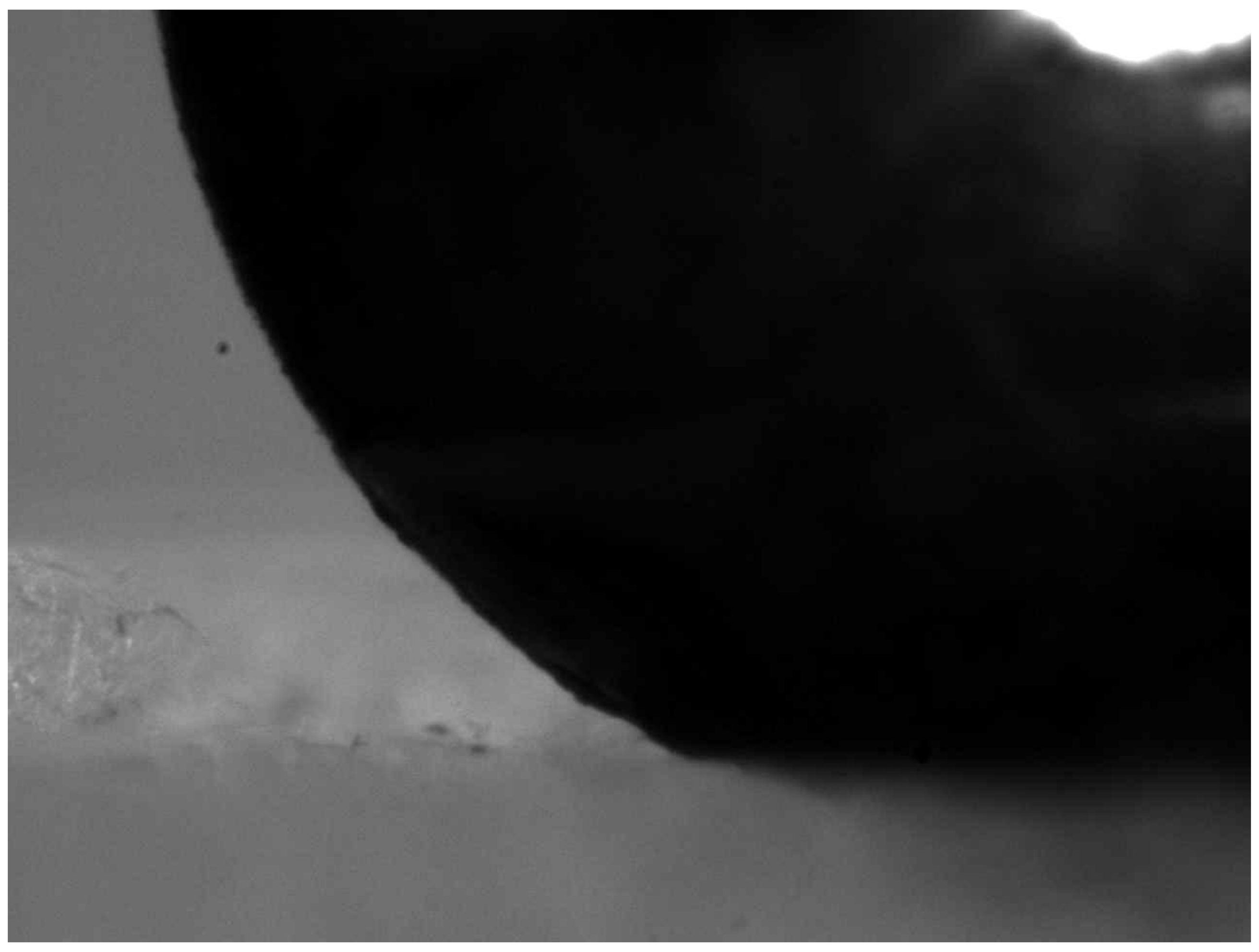




Indentation of a Planar Specimen

The liquid agar agar was poured into a petri dish and allowed to gel. After 1 hour, sections of the gel layer approximately 15mm long by 6mm wide by 3mm thick were removed and placed in a distilled water bath. The sections were indented using the MicroSquisher with a 3mm stainless steel ball fixed to the end of the force probe. The ball was indented into the agar agar by more than 0.3mm in 60 seconds while collecting data at 1Hz.





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Results

The stiffness values for the cylindrical compression tests were calculated as the nominal stress value divided by the nominal strain value at 10% nominal strain. The stiffness values for the sphere compression tests were calculated based on equations 1-4 using the force and displacement values at 10% nominal compression of the sphere (equations based on a modified Hertz model, Kim et al. DOI 10.1002/jbm.a.32338). The stiffness values for the indentation tests were calculated using equation 1-4 using force and displacement values at an indentation of 10% of the indenter radius.

1. $$\emptyset = cos^{-1}\left[\frac{R-\delta}{R}\right]$$

2. $$a = (R - \delta)\ tan\phi$$

3. $$f(a) = \frac{2(1+\nu)R^2}{(a^2+4R^2)^{3/2}} + \frac{1-\nu^2}{(a^2+4R^2)^{1/2}}$$

4. $$E = \frac{3(1-\nu^2)F}{(4\delta a)} - \frac{f(a)F}{\pi\delta}$$

F = applied force

R = sphere radius

δ = displacement

ν = Poisson's ratio (0.5)

E = Young's Modulus

	Cylinder Specimen	Sphere Specimen	Indentation Test
Test 1	12.6	11.7	11.9
Test 2	11.4	12.1	14..5
Test 3	11.6	12.0	12.7
Average	**11.9**	**11.9**	**13.1**

Conclusions

This testing shows that the MicroSquisher is capable of measuring the stiffness of a soft gel (~12kPa) using at least three different test methods.

CellScale biomaterials testing

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