Supporting Information

Conformable, Stretchable Sensor to Record Bladder Wall Stretch

*Stuart Hannah· †1 1 Pauline Brige, ‡ Aravind Ravichandran, † and Marc Ramuz †**

† Mines Saint-Etienne, Centre CMP, Department FEL, F – 13541 Gardanne, France

‡ Country Centre Européen de Recherche en Imagerie Médicale (CERIMED), Faculté de Médecine, Aix-Marseille Université, 13385 Cedex 5, Marseille, France.

Corresponding Author

*(M.R) E-mail: ramuz@emse.fr

Figure S1 presents supplementary information to support the data presented in Figure 1 of the manuscript. Figure S1 (a) shows Cr/Au sensor resistance as a function of stretch in mm to highlight the physical degree of stretch each sensor undergoes for a 50 % strain. Figure S1 (b) displays resistance as a function of the number of measurement steps for the sensors cycled continuously between 0 to 50 % strain. Each cycle consists of three measurement steps, as a measurement is taken initially at 0 % strain, then 50 % strain, and finally at 0 % strain. Figure S1 (c) shows microscope pictures of a Cr/Au sensor under stretch from 0 to 100 % strain.

1 Current affiliation: Dept. of Biomedical Engineering, University of Strathclyde, 40 George Street, Glasgow, G1 1QE, United Kingdom.

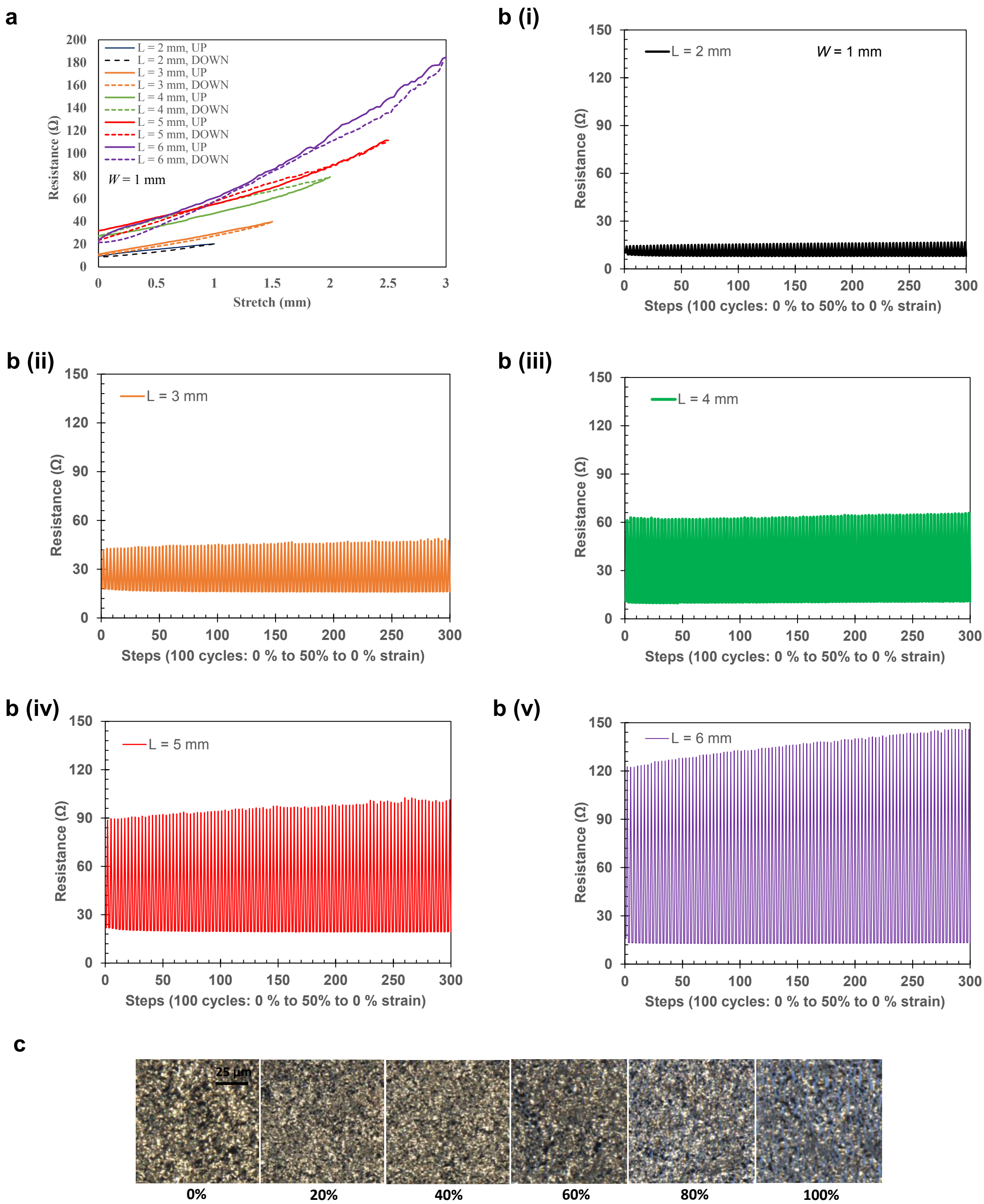

Figure S1. (a) Cr/Au sensor resistance as a function of stretch in mm for sensors featuring dimensions W = 1 mm and L = 2, 3, 4, 5 and 6 mm. (b) 100 x cycling tests performed on Cr/Au sensors, (i), L = 2 mm. (ii), L = 3 mm. (iii), L = 4 mm. (iv), L = 5 mm. (v), L = 6 mm. Each graph shows plot of resistance measured at 0 %, then 50 % strain, and then back to 0 % strain during a single cycle. Each cycle consists of three measurement steps, hence for 100 cycles, the graphs display 300 steps. (c) Microscope pictures of Cr/Au sensor under stretch. Presence of micro-cracks explains the augmentation of resistance.

Figure S2 presents additional data to support the data presented in Figure 2 of the manuscript. The figure shows additional data taken from the stretching tests performed on the two biocompatible adhesives, giving additional data points to those shown in Figure 2. The figure shows the same photographs as shown in the manuscript, plus 3 additional ones for both the hydrogel and silicone adhesive to provide a clearer picture of the effect of stretching on the two adhesives.

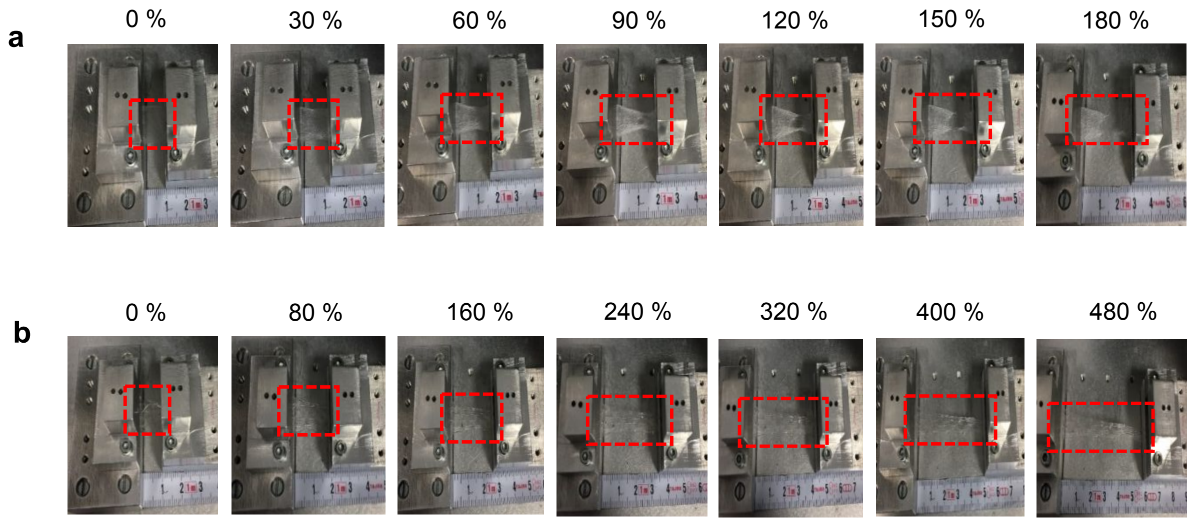

Figure S2. Additional data associated with the data in Figure 2. (a) Effect of stretching on biocompatible hydrogel adhesive to 180 % strain. (b) Effect of stretching on biocompatible silicone adhesive to 480 % strain.

Figure S3 presents additional data to support the data presented in Figure 3 of the manuscript. The figure shows additional data taken from *in vitro* testing of Cr/Au sensors on the pig's bladder.

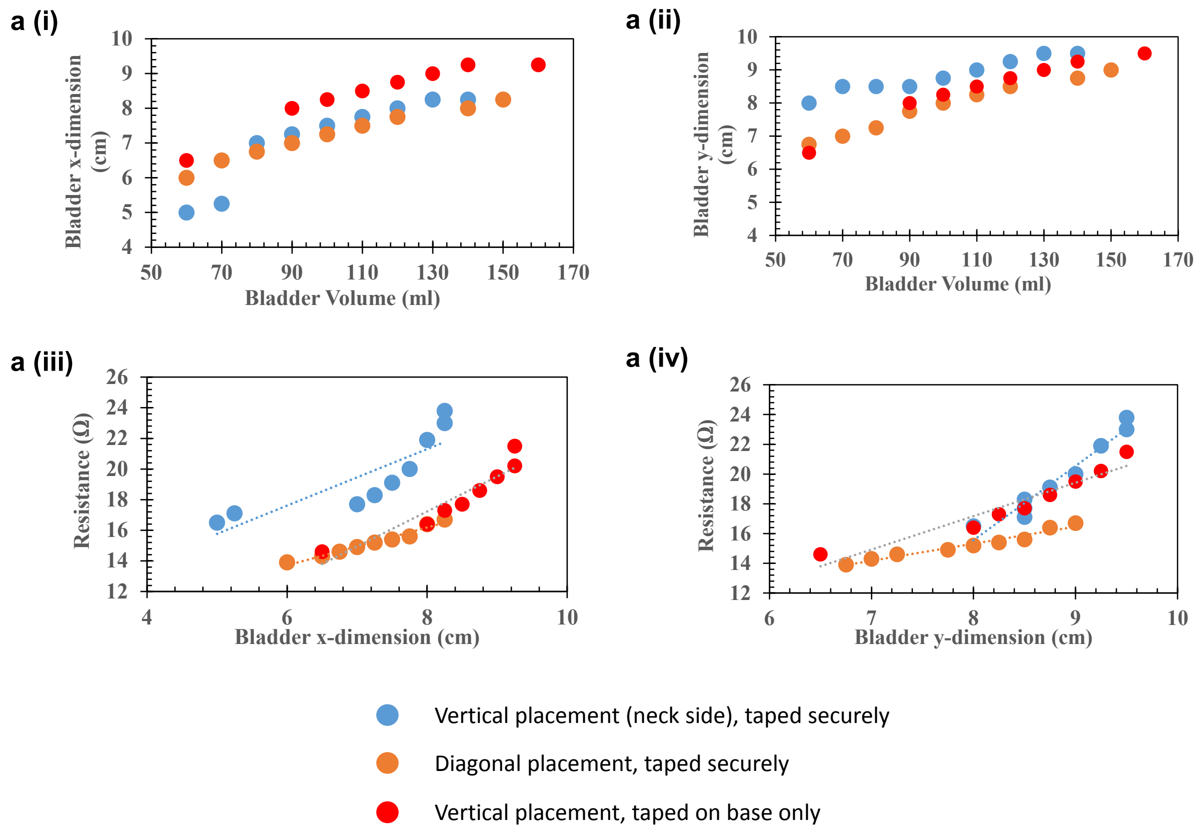

Figure S3. Additional data recorded from *in vitro* testing of sensors on the pig's bladder associated with the data in Figure 3. (a) (i) Bladder x-dimension size as a function of bladder volume. (a) (ii) Bladder y-dimension size as a function of bladder volume. (a) (iii) Sensor resistance as a function of bladder x-dimension size (a) (iv) Resistance as a function of bladder y-dimension size.

Figure S4 presents additional data to support the data presented in Figure 3 of the manuscript. The figure shows additional data taken from *in vitro* testing of sensors on two different pig's bladders for comparison purposes.

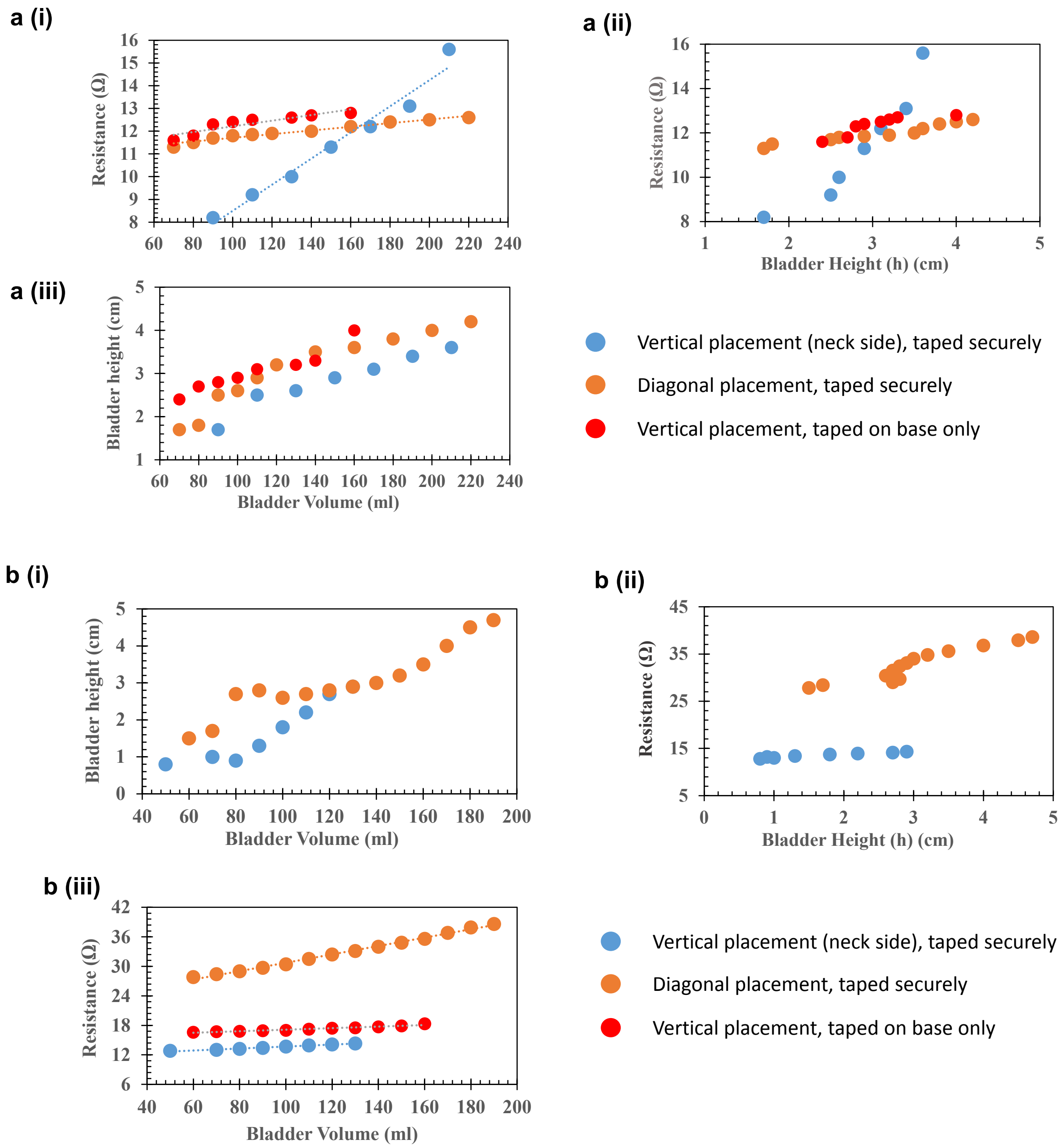

Figure S4. Data was measured on two bladders different from the data shown in Figure 3 of the manuscript. (a) presents data from one bladder and (b) presents data recorded using a different bladder. The data is shown for comparison purposes and to support the data shown in Figure 3. (a) (i) Sensor resistance as a function of bladder volume. (a) (ii) Resistance as a function of bladder height. (a) (iii) Bladder height as a function of bladder volume. (b) (i) Bladder height as a function of bladder volume. (b) (ii) Resistance as a function of bladder height. (b) (iii) Resistance as a function of bladder volume.

Table S5 provides sensitivity data measured in Ω/%-strain for various sensor lengths (L = 2 – 6 mm) related to the UP and DOWN strain ramps presented in Figure 1 (c).

Table S5. Cr/Au sensor sensitivity as a function of sensor length for UP and DOWN strain ramps. Sensitivity is measured in Ω/%-strain.

Sensor L [mm]	S – UP Ramp [Ω/%-strain]	S – DOWN Ramp [Ω/%-strain]
2	0.21	0.23
3	0.56	0.57
4	1.01	1.02
5	1.54	1.69
6	3.18	3.11

Table S6 presents an overview of the relative advantages/disadvantages of various glues and adhesives that were tested for possible use as adhesives to attach the sensor to the balloon/bladder. All adhesives were initially tested on the balloon model and subsequently, only two adhesives (Polymer Science INC PS2066 and PS1446) were later transferred to the pig's bladder for *in vitro* testing due to issues surrounding biocompatibility.

Table S6. Review of various adhesives tested on the balloon model used to mimic bladder operation.

Adhesive	Advantages	Disadvantages
Pattex Kraftkleber Super Glue	Very strong adhesion	Causes PU shrinkage, loses adhesion under stretch, flammable, toxic, irritant

Pattex Hot Pistol Glue	Instant drying, waterproof, good adhesion to PU, non-toxic	Poor balloon attachment, high temperature application, thick layer produced
Noch Latex Adhesive	Good adhesion when stretched, easy to remove from balloon, non-toxic	Not biocompatible, avoid contact with eyes and skin
UHU Rubber Glue	Relatively fast drying time, very strong adhesion	Causes PU shrinkage, difficult to detach from PU
UHU PVC Glue	Fast drying, water-resistant, easy to peel off from PU	Some PU shrinkage, weak adhesion, glue remains attached to PU when removed from balloon
La Colle Pro Superglue	Quick drying time, good adhesion when stretched	Reacts with the PU film, cannot be peeled off PU, irritant, tears PU when removed
UHU Plus 2-Component Glue	Quick use, forms a thin-layer, good adhesion strength	Glue cannot be removed from PU, toxic, irritant
Pattex Silicone Sealant Gun Application	Biocompatible, easy application, good adhesion, transparent, removed cleanly, some degree of stretch	Long (3h) dry time, thick glue layer formed
Polymer Science INC PS2066, Silicone Adhesive	Biocompatible, no drying required, good adhesion, easy to peel off balloon and remove adhesive from PU	Relatively difficult to detach from trilaminate layers, poorer adhesion than Polymer Sci Hydrogel film
Polymer Science INC PS1446, Fixation Hydrogel	Biocompatible, good adhesion, easy to peel off, good adhesion when stretched	No real disadvantages, best adhesive tested