Prototyping of a human bladder model using SLS and mold casting for in vitro simulation of the transurethral resection of the prostate

T. Dorbandt[1], C. Knopf[2], S. Klein[1] and C. Damiani[1*]

[1] Medical Sensors and Devices Laboratory, Lübeck University of Applied Sciences (THL), Lübeck, Germany
[2] Olympus Winter & Ibe GmbH, Hamburg, Germany
* Corresponding author christian.damiani@th-luebeck.de

Introduction

- During transurethral resection of the prostate (TURP), the temperatures and pressure in the surrounding tissue and in the bladder increase.
- For better understanding of the thermomechanical effects during TURP, an *in-vitro* model has been built at the TH-Lübeck in cooperation with Olympus Winter & Ibe GmbH.
- To improve the model, an elastic and transparent bladder with thermal and mechanical properties similar to those of real tissue is needed.
- In this work, mechanical computer simulations were used to select a suitable material for the new bladder, and a prototype has been build using Selective Laser Sintering and mold casting of silicone.

Properties of Human Bladder

- The pressure of the irrigating fluid in the bladder (saline solution) can reach 60-70 mbar, leading to typical bladder volumes of approx. 500 ml and quasi-spherical shapes [1].
- Average thermal conductivity of bladder wall: 0.522 W/m*K [2], wall thickness in men with benign prostatic hyperplasia: aprox. 3.5 mm [3]

Materials and Methods

- The complete TURP simulation setup is shown in Fig. 1.

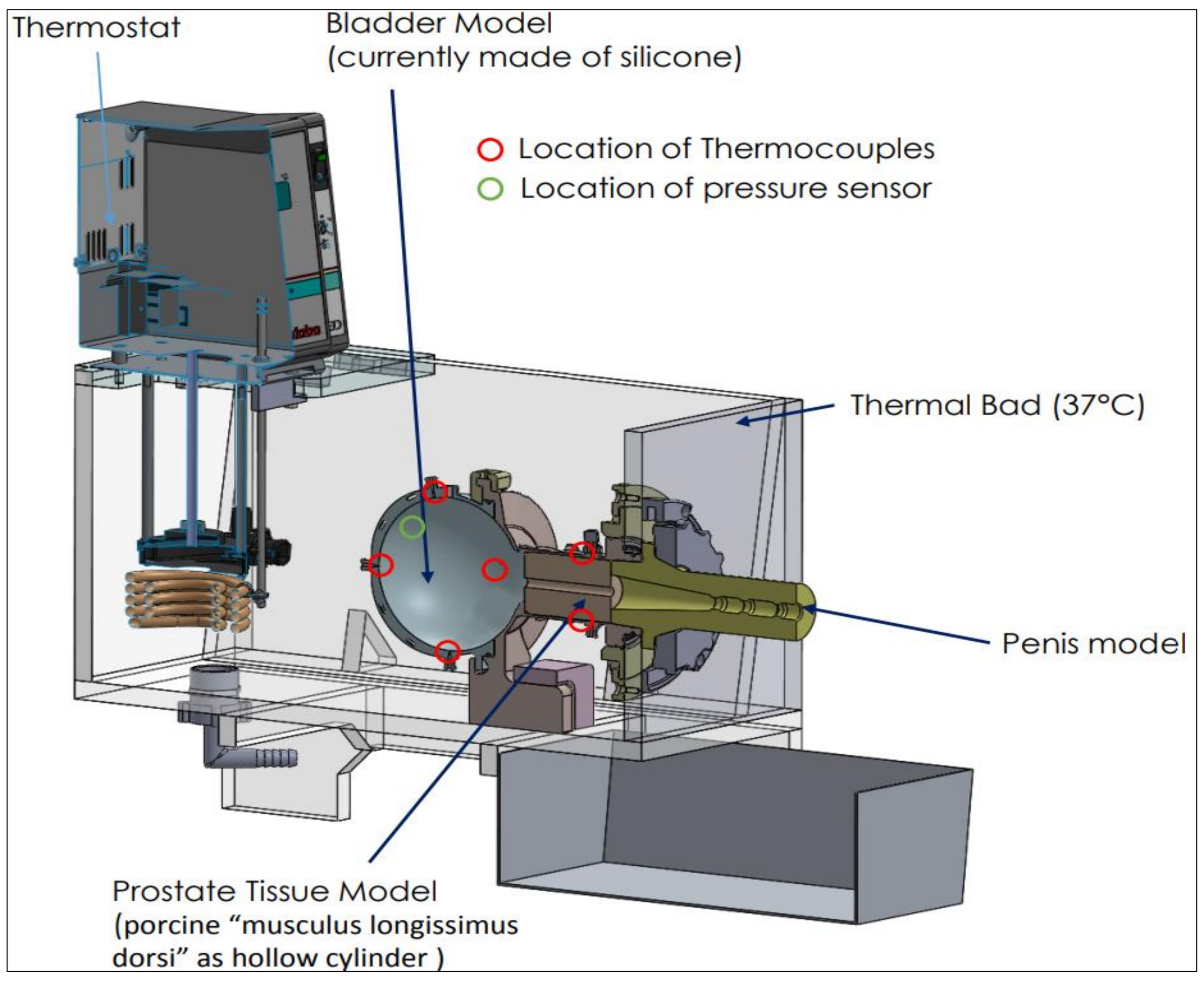

Fig. 1 – *in-Vitro* model for TURP simulation

Materials and Methods

- Considering the thermal and geometric properties of a human bladder, a spherical silicone rubber model with a wall thickness of 3.5 mm and an initial volume of 250 ml was chosen.
- The mechanical properties of seven Silicone Rubbers with Shore A hardness from 0 to 45 were tested according to DIN 53504.
- Mechanical FEM Simulations using a linear elastic model were use to identify a suitable silicone type for the model (Zhermack ZA8).
- The CAD model of the bladder was then used to create a 3-part casting mold for a single hemisphere.
- The mold was manufactured by SLS printing of PA12 followed by grinding and polishing of the surfaces.
- Two identical silicone hemispheres were casted and bonded together. (See Fig.2)
- The compliance of the model was measured

Fig. 2 – Silicone Bladder Model.

Results

- The proposed method successfully produced an elastic urinary bladder made of silicone.
- Fig. 3 shows the pressure-volume curves of the actual model, compared to those of the FEM-simulations and physiological values from the literature [4,5].
- In the range of pressures relevant for TURP (30 mBar to 70 mBar), the largest discrepancy between simulated and measured volumes is 15 % at 40 cmH20, which is smaller than the variability observed in physiological data.

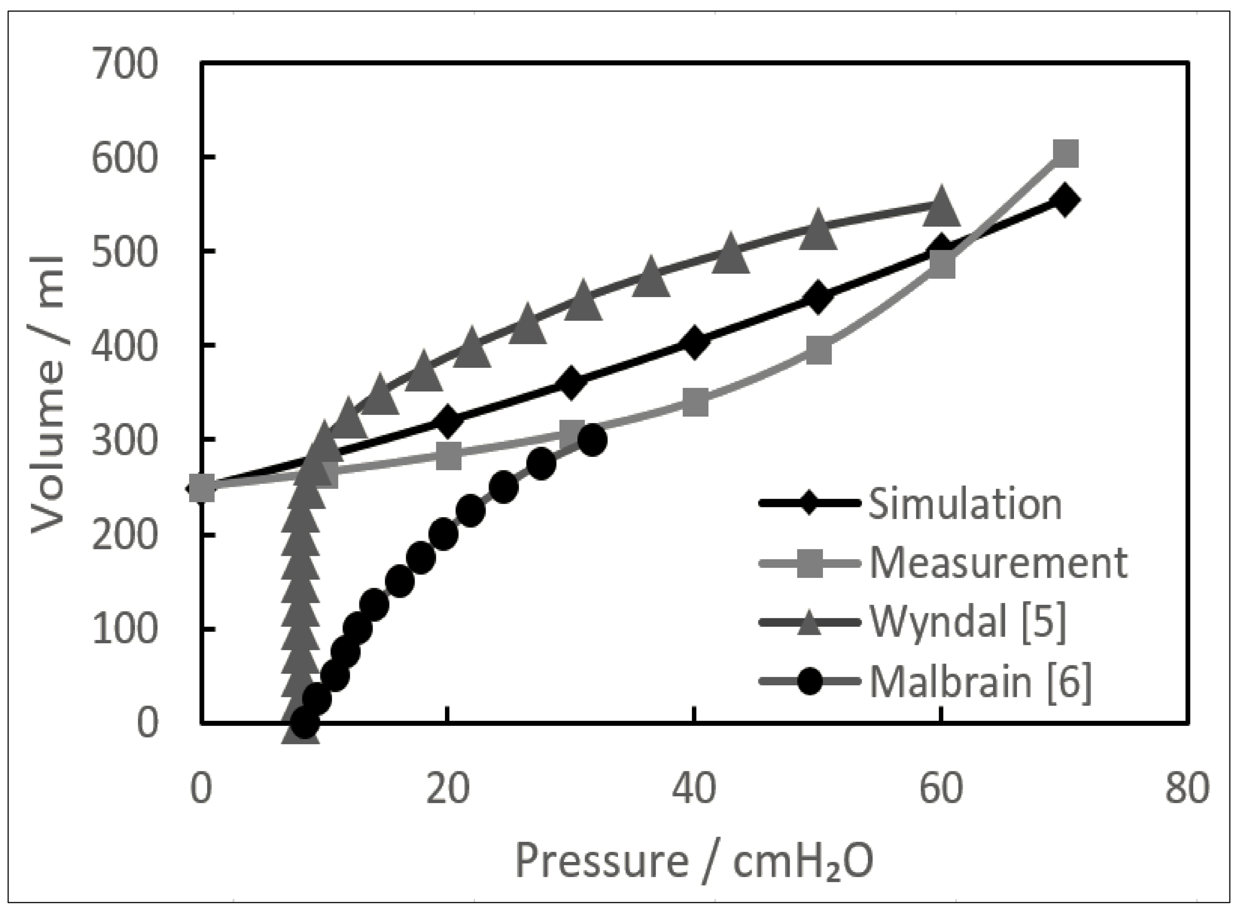

Fig. 3 Urinary bladder volume as a function of pressure. Simulation / Measurement (Zhermack ZA8) and Literature [5,6]

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Corresponding author
Dr. Christian Damiani.
Lübeck University of Applied Sciences (THL)
Medical Sensors and Devices Laboratory
Mönkhofer Weg 239, 23562 Lübeck, Germany
Christian.Damiani@th-luebeck.de

Acknowledgement
We thank Dr. Hanke and Olympus Winter & Ibe for their support for this project.