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TEKSCAN FORCE MEASUREMENT ACCURACY FOR BIOMECHANICAL JOINT CONTACT MEASUREMENTS

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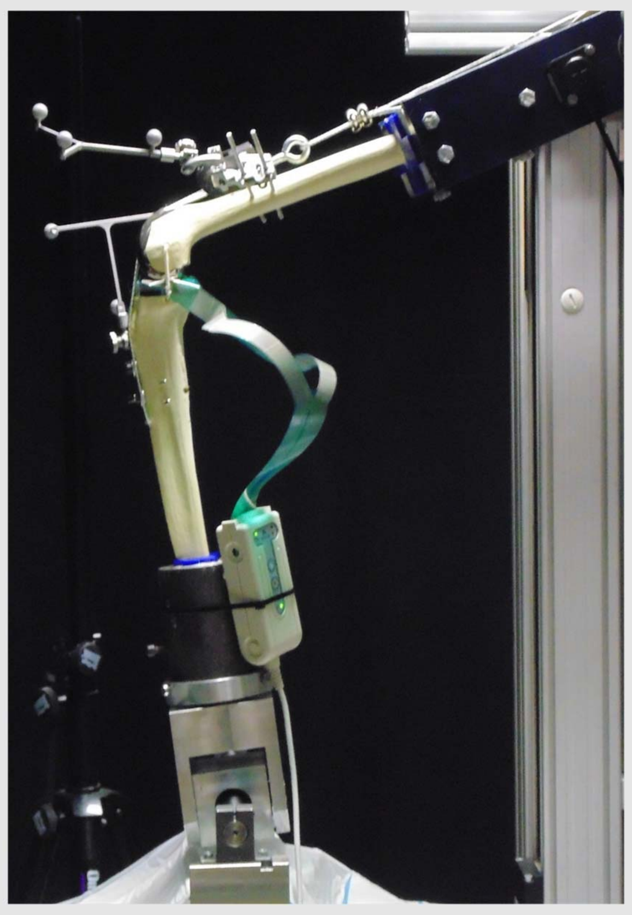
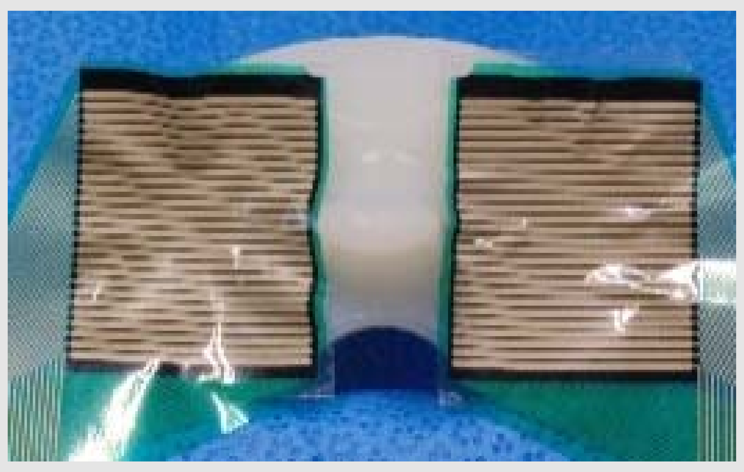
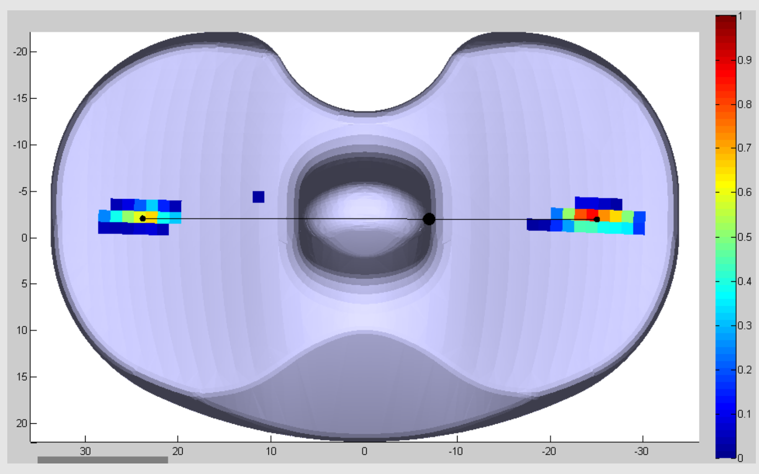
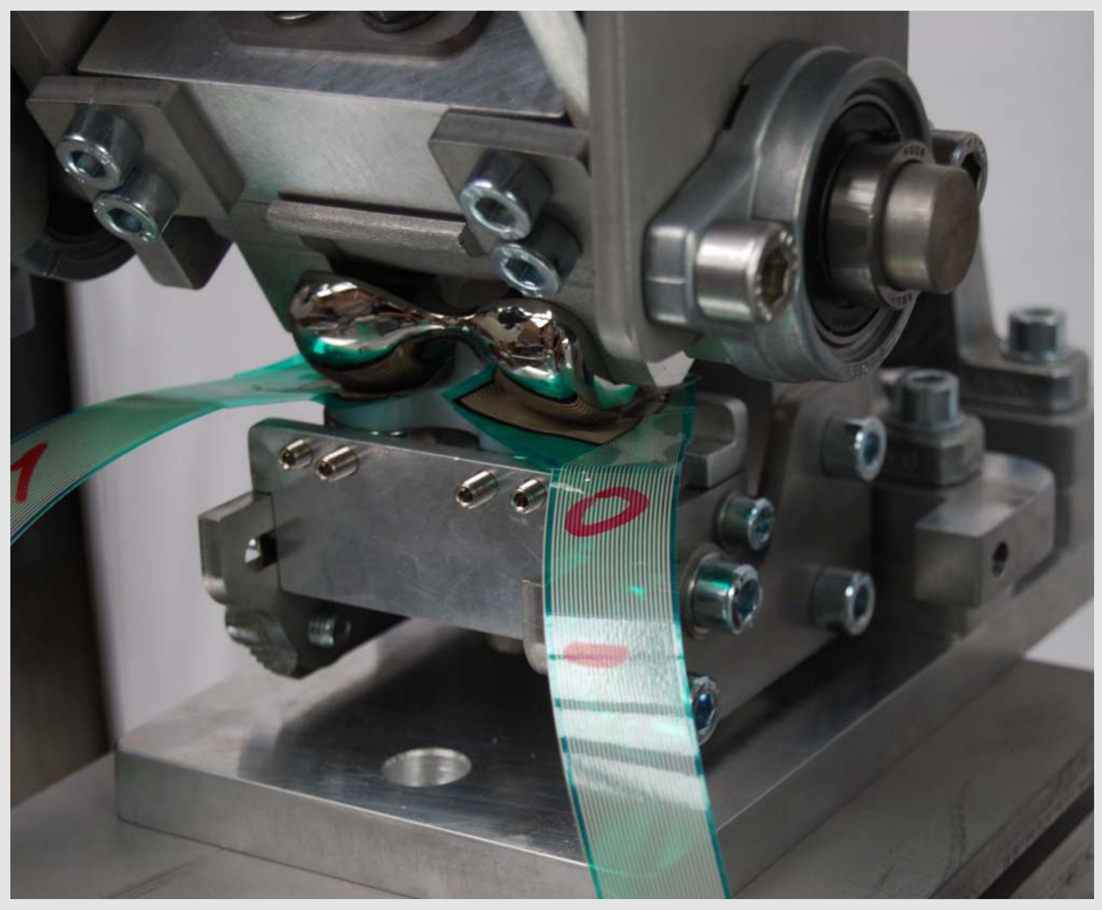
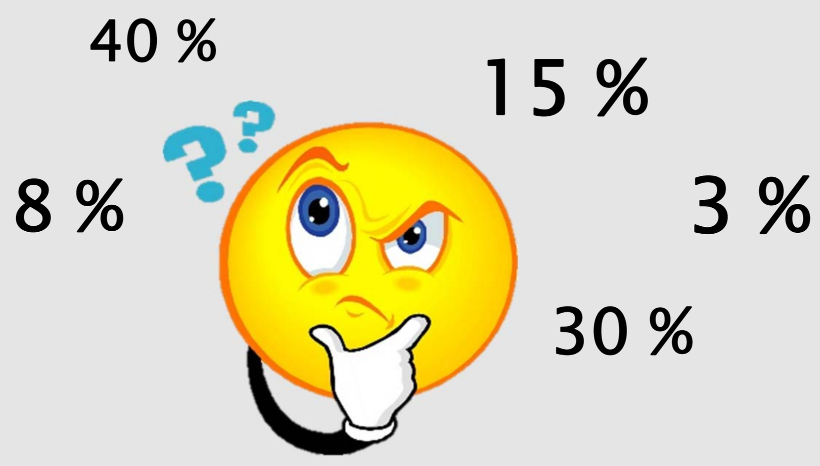








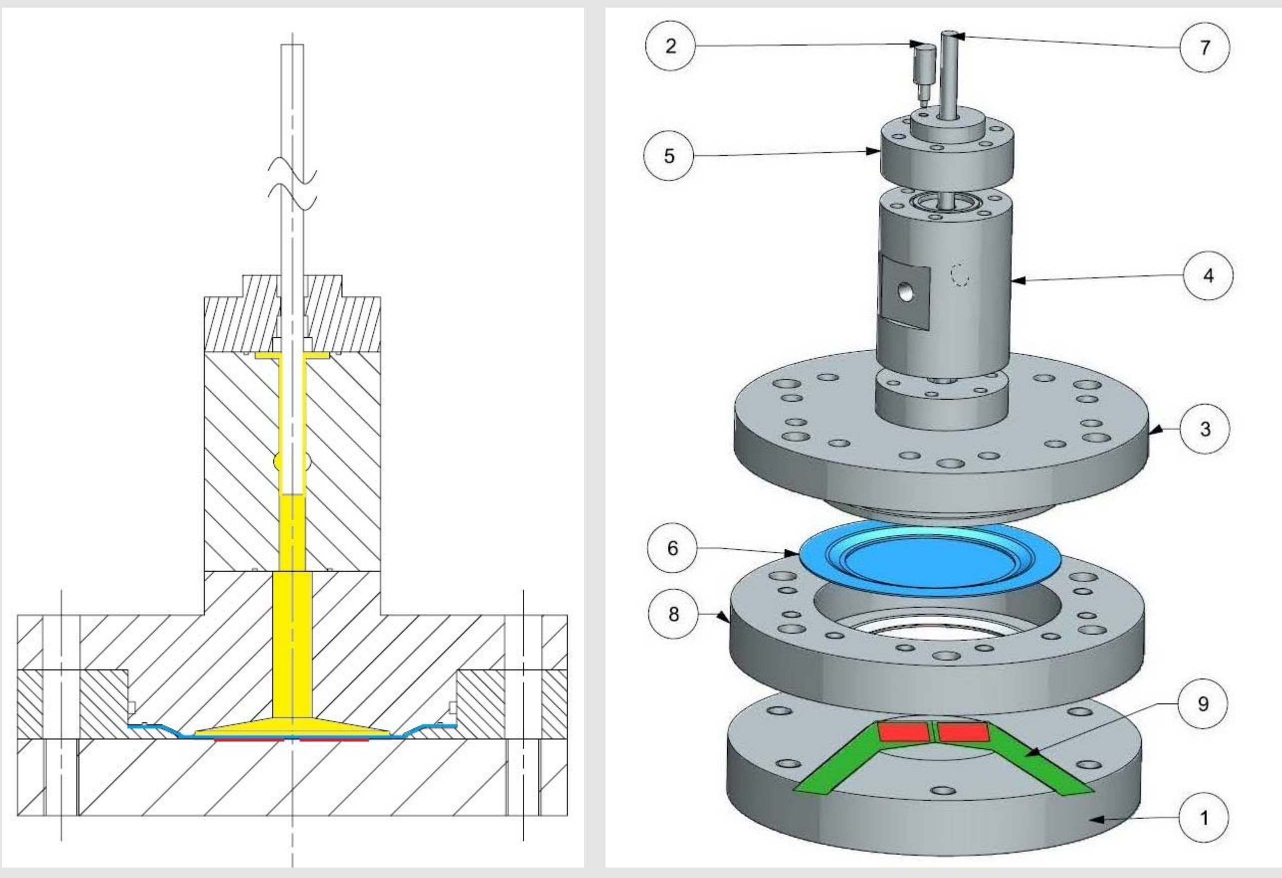
Accuracy?



Aim of this study: Improve and determine the accuracy and reliability of Tekscan intra-articular contact pressure measurements after arthroplasty

Hydraulic homogeneous pressure applicator

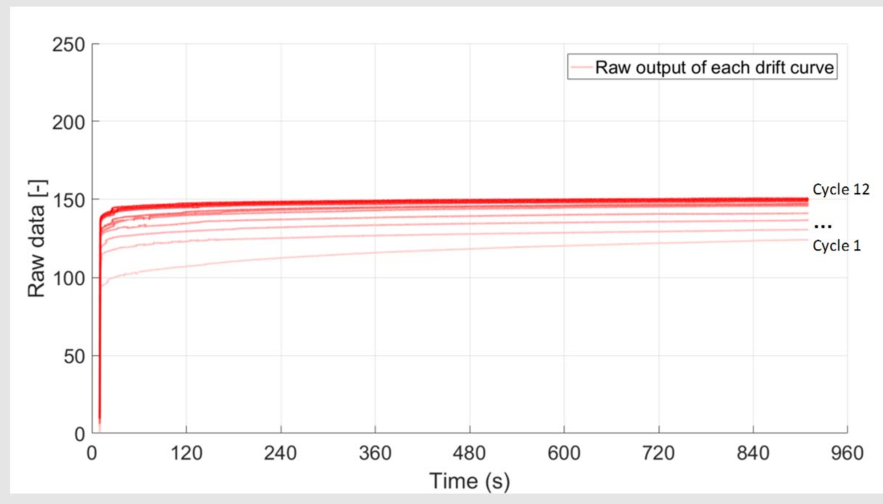
- Application of homogeneous pressure up to 30 Mpa to mimic the contact pressure in a knee joint with implants
- The volumetric plunger system is loaded in a conventional MTM
- The oil pressure is transferred to the sensor by the membrane



1. Base plate
2. Bleeding valve
3. Top block
4. Cylinder
5. Cylinder head
6. Membrane
7. Plunger
8. Ring
9. Tekscan sensor

Dynamic sensor preconditioning

- Four Tekscan 4000 sensors are loaded and unloaded cyclically with a homogeneous pressure of 15 MPa and a cycle time of 15 min
- The figure on the right shows the total sensor output as a function of time and load cycle
- The change in sensitivity and drift is calculated and presented as a function of the number of applied cycles

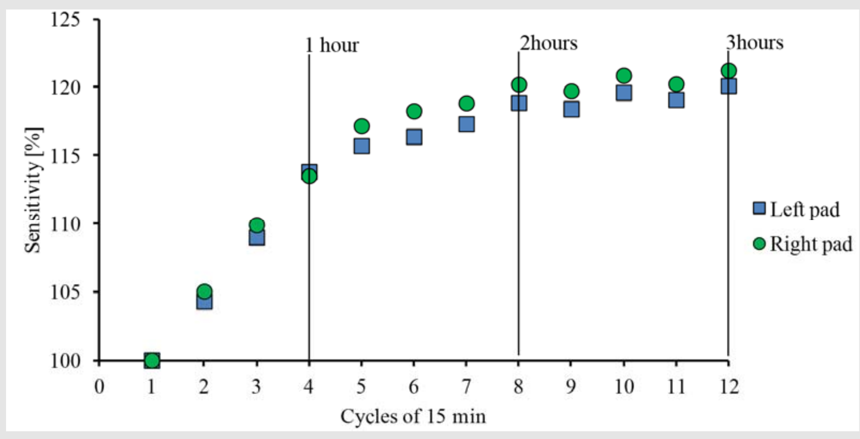


Sensor drift as a function of time and applied load cycle

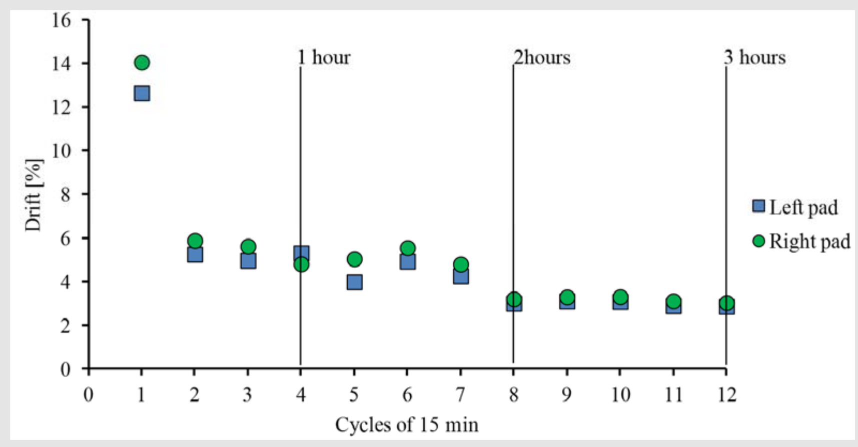
➢ After 10 cycles the sensor output is stabilized

$$\text{Sensitivity change} = \frac{\frac{\text{raw output}}{\text{applied pressure}}}{\text{sensitivity of cycle 1}}$$

$$\text{Drift} = \frac{\text{raw output}(900s) - \text{raw output}(100s)}{\text{raw output}(900s)}$$



Sensor sensitivity change as a function of applied load cycle

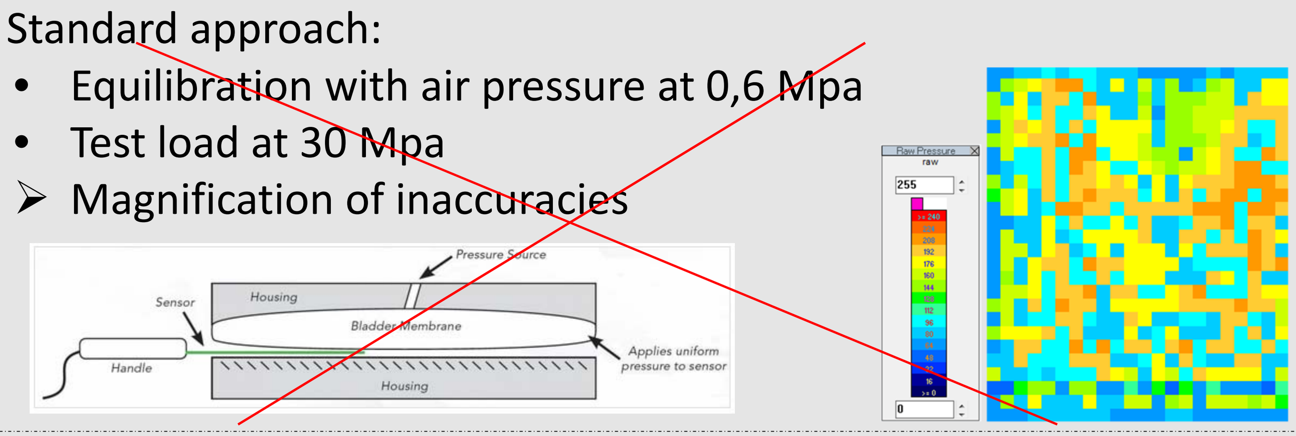


Sensor drift change as a function of applied load cycle

Sensor equilibration

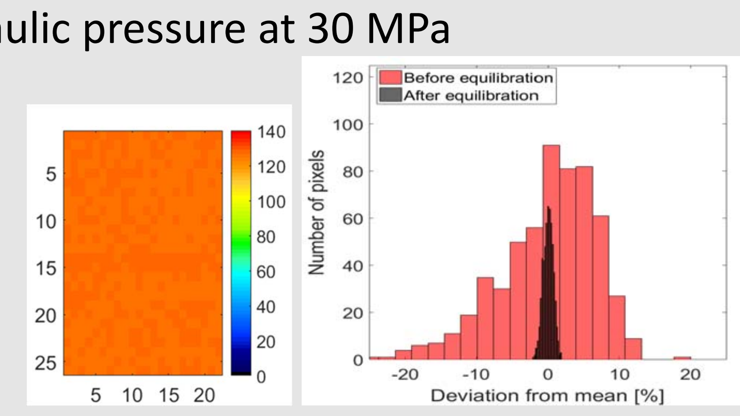
Standard approach:

- Equilibration with air pressure at 0,6 Mpa
- Test load at 30 Mpa
- ➢ Magnification of inaccuracies



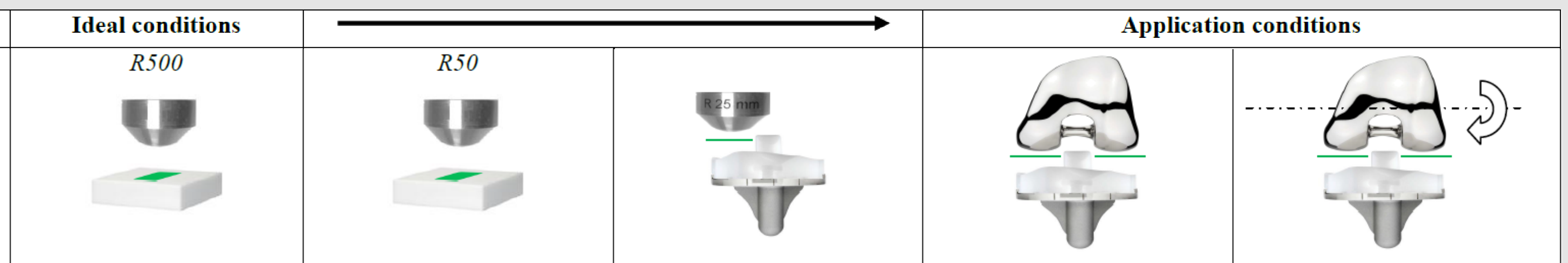
Optimized approach:

- Equilibration with hydraulic pressure at 30 MPa
- Test load at 30 Mpa
- ➢ Homogeneous pixel sensitivity in whole measurement range
- ➢ Precondition at level test pressure essential!



Overview error sources in true application conditions

- The error is quantified going from the ideal to the real application conditions
- A stepped and random load profile is applied to each configuration
- The difference between the applied load and the total measured load by the sensor is calculated



	Ideal conditions		→				Application conditions				
	R500		*R50*								
Loading conditions.	Ideal conditions		Smaller load area		Smaller load area Curved contact surface		Variable load area Curved contact surface		Flexion-extension motion Constant force		
Load type	Stepped	Random	Stepped	Random	Stepped	Random	Stepped	Random	100 N	180 N	300 N
Mean error [N]	22,3	27,6	22,1	26,2	15,0	24,0	18,4	17,5	17,9	12,3	53,1
Standard deviation [N]	18,8	26,0	18,1	13,8	16,6	23,1	18,3	15,2	10,8	13,1	21,0
Applied force range[1]	0 to 2000 N		0 to 450 N		0 to 350 N		0 to 300 N		0 to 300 N		
Percentage error [2][%]	1,2	1,5	5,5	5,8	5,0	6,8	6,1	5,8	17,9	6,8	17,7
Standard deviation [%]	1,0	1,4	4,5	3,0	5,5	6,6	6,1	5,1	10,8	7,2	7,0

Conclusions:

- Inadequate preconditioning of the sensor can lead to a measurement error of 21.1% (SD=6.2%)
- Reduction of contact area and introduction of motion decreases the accuracy significantly
- With optimal sensor preconditioning and data post-processing by drift compensation, an error of 17.9 % (SD=10.8 %) can be expected for tibiofemoral implant contact measurements

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