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Single transducer for measurement of small displacements or forces

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ABSTRACT

Introduction: One of the limits to characterization of tissues at the microscopic level is the substantial costs associated with the instrumentation required for such investigations. The use of strain gages for displacement or force measurements can be adapted to this microscopic scale provided the gages are incorporated into a transducer consisting of a curved geometry.

Materials and Methods: *U*niaxial strain gages 13 mm (L) × 6 mm (W) were secured to 0.2-mm thick brass shim stock fabricated to yield a 12.5-mm diameter semicircle with mounting tabs on either end. The terminal ends of the strain gage mounting pads were connected to an adjustable strain gage amplifier with adjustable gain and offset. For displacement calibration, the transducer was secured to the jaws of a digital caliper. Caliper displacement was set to ±0.25 mm increments from 0 to a maximum of ±1.5 mm. In this configuration, positive represents tension. Amplifier Gains were set to 500, 1000, and 5000 to observe nonlinearity. For each of three displacement calibration runs, output voltage from the transducer was recorded at each distance with the mean output at absolute distances averaged across each of three runs for each of six transducers. Using the same transducers, a mass balance was used to identify the unique individual mass associated with a total of 10 masses to within ±10 µg. The masses were sequentially secured to the transducer and the respective output voltage recorded. Amplifier Gains were set to 500, 1000 and 5000. For each of three force calibration runs, output voltage from the transducer was recorded with respect to the force generated by the suspended masses. The mean output across each of three runs for each of six transducers was subjected to linear regression.

Results and Discussion: *A*ll transducers displayed good linearity when calibrated for displacement with regression R^2 values of 0.9994, 0.9967, and 0.9941 for amplifier gains of 500, 1000, and 5000, respectively. Further, in displacement mode, the transducers provided a mean output of 0.66, 1.01, and 3.86 V/mm at amplifier gains of 500, 1000, and 5000, respectively. In force mode, regression R^2 in excess of 0.9995 were observed over all amplifier gain settings examined. When employed as force transducers, the devices provided mean outputs of 0.60, 1.15, and 5.85 V/N at amplifier gains of 500, 1000, and 5000, respectively. The response of these devices to either applied displacement or force permits the use of a single device type to be used as either a displacement or force transducer. The electrical output in either mode at modest amplification gains of 5000 combined with excellent linearity affords the use of these devices for studies where characterization of tissues requires mN and µm level resolution.

Conclusions: A transducer employing a strain gage had been configured so as to function as either a displacement or force measuring instrument. The resulting device displays high linearity and electrical output even at modest amplifier gains.