New vibrations in old tools allow surgeons to feel what they can't touch

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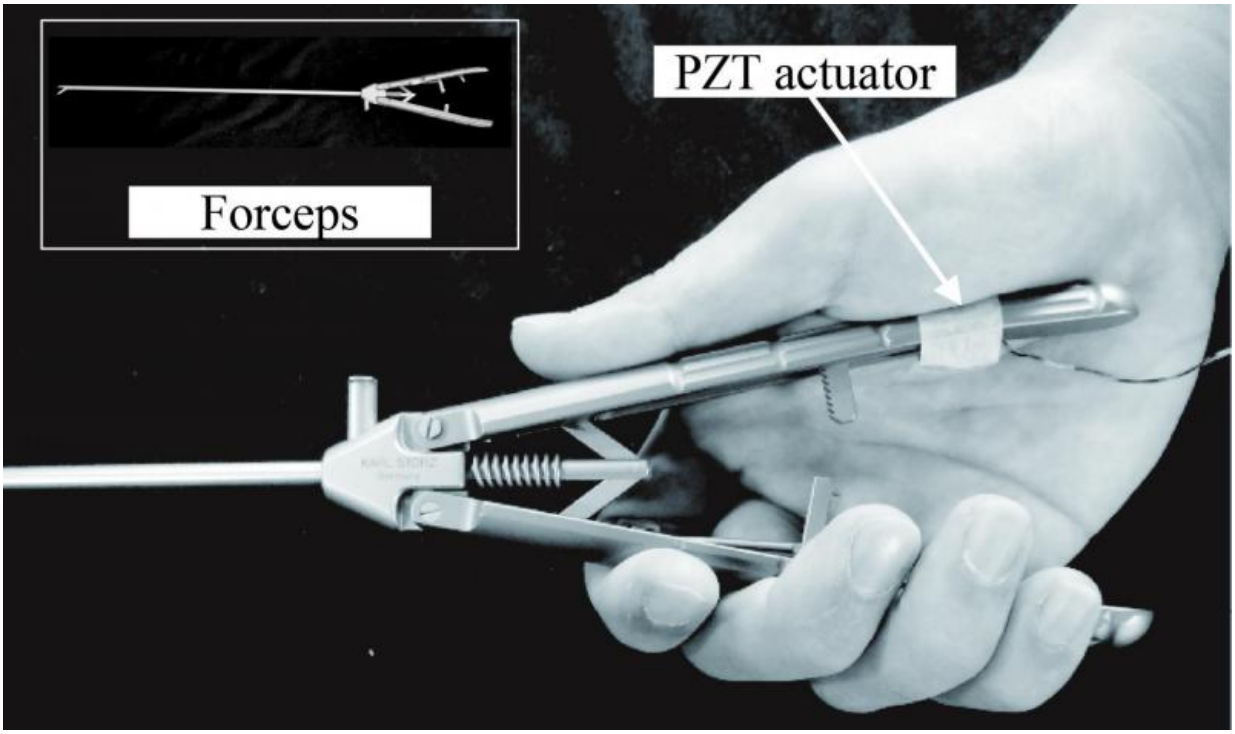


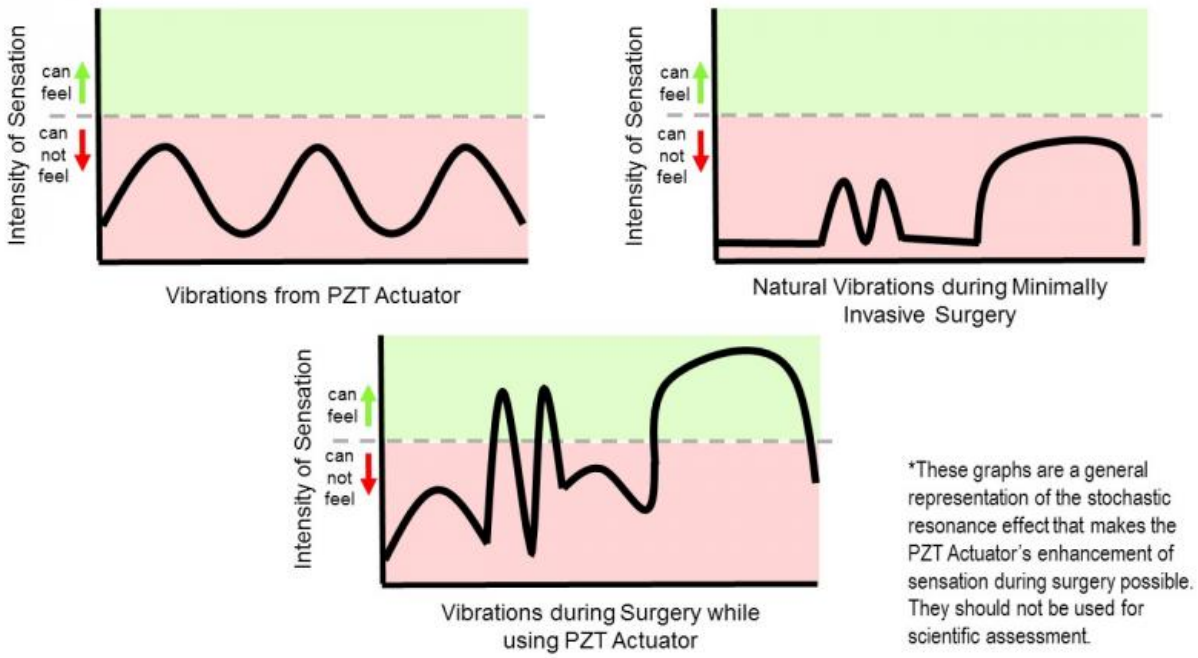
View of the PZT Actuator attached to standard surgical forceps using during laparoscopic surgery. The vibration device created by Hiroshima University researchers can be slipped onto any surgical tool and vibrate against the surgeon's palm, improving the ability to sense the details of a patient's internal tissues and organs. The PZT Actuator may improve patient outcomes by allowing surgeons to better understand their patients' bodies during minimally invasive surgeries. Credit: Yuichi Kurita, Hiroshima University

A small vibrating device added to surgical tools could improve surgeons' sensitivity to different shapes and textures inside their patients' bodies. Engineers from Hiroshima University have designed the small vibrating device to attach to any existing hand-held surgical tool and be used instantly, without requiring extra training for doctors.

During minimally invasive surgeries, surgeons rely on long, thin, metal tools to explore their patients' bodies. Such laparoscopic surgeries benefit patients by reducing the size of surgical cuts and minimizing scarring, but surgeons can no longer use their fingers to directly touch patients to sense essential information about their organs.

"We started this work six years ago, trying to enhance human fingertip sensitivity, but in 2012 I had the idea that increased sensitivity could be valuable during minimally invasive surgeries. Typical medical tools obtain information about the patient's condition. There are very few devices that aim to enhance the doctor's skill," said Yuichi Kurita, Ph.D., lead author of the study and Associate Professor at Hiroshima University.

The vibrator, called PZT Actuator, attaches to a surgeon's favorite surgical tool and vibrates in the surgeon's palm at a constant rate. The vibrations are so subtle they cannot be sensed. However, this constant, uniform vibration enhances the surgeon's sensitivity to other, irregular sensations. The natural variations of touching different tissues with a metal tool may normally be too subtle for the surgeon to detect, but the constant vibrations supplied by the PZT Actuator boost the sensation to a noticeable level.



Artistic representations of how the PZT Actuator can improve sensation for surgeons during minimally invasive surgeries. The vibration device created by Hiroshima University researchers works due to the stochastic resonance effect, a mathematical principle that describes how a constant and regular signal can boost the strength of another irregular signal. The PZT Actuator can be slipped onto any surgical tool and vibrate against the surgeon's palm, improving the ability to sense the details of a patient's internal tissues and organs. Credit: Caitlin E. Devor, Hiroshima University

Volunteers were blindfolded and asked to use surgical forceps with the PZT Actuator attached to the handle to identify different textures of sandpaper and find a small Styrofoam ball inside a cup filled with silicone. These tests mimic detecting tissue texture and identifying a solid tumor.

The results of these tests and other analysis revealed that there is a range of vibration intensity that significantly improves anyone's sensitivity.

The tool does not need to be fine-tuned to each user's unique sense of touch, meaning the PZT Actuator should be robust and simple to use.

The PZT Actuator remains safe for patients because the device is only on the handles of the surgeon's tools, not inside the patient's body. The vibrations are so subtle that they do not shake the tool. The electrical power supply is also safe for doctors and patients.

"Our next set of experiments will confirm the usefulness of the PZT Actuator in surgical situations. Before we can give this tool to surgeons, we must also develop a method to maintain good hygiene of the device so it is always safe for patients," said Kurita.

The research team responsible for the PZT Actuator includes mathematical and medical engineers. Researchers first tested the device through mathematical modeling using calculations of four types neurons and their response to different levels of mechanical stimulation. The mathematical term describing the phenomena of a constant undetectable signal enhancing a simultaneous irregular signal is called the stochastic resonance effect.

More information: Yuichi Kurita et al. Surgical Grasping Forceps with Enhanced Sensorimotor Capability via the Stochastic Resonance Effect, *IEEE/ASME Transactions on Mechatronics* (2016). DOI: 10.1109/TMECH.2016.2591591

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