

# Hearing and touch mediate sensations via osseointegrated prostheses

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Driving is an example of when the patients benefit from osseoperception – perception arising from mechanical stimulation of an osseointegrated prosthesis. Credit: Susanne Lindholm

A new study has found that people with a prosthesis attached directly to their skeleton can hear by means of vibrations in their implant. This sound transmission through bones is an important part of osseoperception – sensory awareness of the patient's surroundings provided by their prosthesis. The discovery sheds new light on the tactile and auditory perception of humans and can be used to develop improved prostheses.

How can we help amputees regain tactile sensations and other natural feelings while grasping an object or walking on uneven ground?

An international group of researchers in Sweden and Italy offers a new answer. They have demonstrated for the first time that [patients](#) with implanted osseointegrated prostheses (ones attached directly to the skeleton) are able to perceive external stimuli better by hearing through their limb implants.

The investigation was conducted jointly in Sweden by Chalmers University of Technology, Sahlgrenska University Hospital, and the University of Gothenburg; all collaborating closely with Scuola Superiore Sant'Anna in Italy.

In a recent paper in *Nature Scientific Reports*, the researchers presented a discovery that opens up new scenarios for developing novel artificial limbs. Even though the transmission of sound through skull bones is a well-known phenomenon, widely studied by Professor Bo Håkansson at Chalmers who was a participant in this study, it was not clear whether this also occurs through bones in the arms and legs and thus contribute to osseoperception – "feeling" arising from the mechanical stimulation of an osseointegrated prosthesis.

"Until now, the consensus was that the sense of touch played the primary role in osseoperception for patients with [artificial limbs](#) fixated into their skeletons", says Max Ortiz Catalan, head of the Biomechatronics and Neurorehabilitation Laboratory (BNL) at Chalmers and supervisor of the research.

Francesco Clemente, who conducted the experiments as a visiting PhD student at BNL from the Biorobotics Institute of Scuola Superiore Sant'Anna, comments:

"Using four different psychophysical tests, we have demonstrated that even subtle sensory stimuli can travel through the body and be perceived as sound. This hearing increases the individual's sensory awareness, even in patients with osseointegrated implants in their legs."

These results show that osseointegration, which allows for stable mechanical attachment of robotic prostheses directly to the skeleton through a titanium implant, improves patients' functionality, comfort, and ability to perceive the world around them.

The researchers tested twelve patients with various degrees of amputation, both upper and lower limb amputees. All tests indicated that patients could perceive mechanical vibrations applied to their titanium implants, through hearing as well as touch. In particular, and synchronously with the vibrations in their arms or legs, patients reported audible sound. During the experiments, the researchers found that subjects with osseointegrated prostheses could perceive very small stimuli and react more quickly to them due to additional perception by hearing.

"In practice, the stimuli received by the patients are perceived more strongly and carry more information because they are composed of two modalities; touch and hearing," says Max Ortiz Catalan. "This is an important step forward in understanding the osseoperception phenomenon and, more generally, the tactile and auditory perception of humans. This discovery may offer a new starting point for implementing novel prostheses that provide enriched sensory feedback to the user."

**More information:** Francesco Clemente et al. Touch and Hearing Mediate Osseoperception, *Scientific Reports* (2017). [DOI: 10.1038/srep45363](https://doi.org/10.1038/srep45363)

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