simultaneously. Further, the subject’s control of his prosthesis was unaffected by the orientation of his limb in space, the relative position of the socket, or perspiration.³

Sensory Input

The absence of sensory input represents a fundamental limitation to externally powered upper-limb prostheses that prohibits users from associating their prostheses as part of themselves, seeing the prostheses as tools rather than an extension of themselves.⁴ Historically, the restoration of sensory input has been attempted through surrogate sensations, such as vibration, somewhere on the body’s surface. While this has demonstrated some benefit in laboratory settings, it has not been aggressively pursued, presumably because the surrogate sensations are not natural, and thus require additional user cognitive effort.⁴ Ideally, sensory feedback should be experienced more similarly to that associated by the natural limb. With the introduction of surgically implanted electrodes, the possibility of communicating sensory input to sensory nerves is currently being explored.⁴

The research team with the longest tenure of successful sensory implantation recently released a publication updating its status.⁴ Two subjects have been implanted with extraneural cuff electrodes, around the median, ulnar, and radial nerves of the forearm of one subject and the upper arm of the other subject, for 32 and 40 months, respectively. In both cases, the associated lead wires from the electrodes were routed percutaneously to exit the body at the lateral aspect of the arm.

With the cuff electrodes, several different stimulation types were found to be possible, including pressure, vibration, and paresthesia. Pressure was identified as the target sensory input. In addition, one of the subjects experienced flexion of his third digit. A prosthetic hand was instrumented with low-profile force sensors over the pads of the thumb and of the index and middle fingers. As the force applied to the sensors increased, the frequency of the sensory stimulation increased linearly. In addition, a bend sensor was installed to relay the relative opening aperture of the hand.⁴ For the subject who could experience third digit flexion, this sensor signaled that sensation. In the other subject, information from the bend sensor was translated into the sensation of relative pressure against the thenar eminence.⁴

This done, the subjects have participated in training sessions and functional tests. One such test, the object detection test, required the users to determine whether a wooden block had been placed within their grasp.