Localization of touch on a replanted or transplanted hand: evidence for late-occurring improvements that may reflect central adaptations

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Former amputees that have received replantation of their injured hands (heterotopic hand replants), or transplantation of a donor hand (allogeneic hand transplants) provide an unique opportunity to evaluate the extent to which the effects of deafferentiation can be reversed. Following sensory nerve transection and repair peripheral nerve regeneration is estimated to proceed at a rate of up to 2mm per day. Studies of non-human primates indicate that chronic disorganization of finger maps within the primary sensory (S1) hand representation persists even after the flow of afferent information to the cortex has been re-established. This reorganization may be a contributing factor to the persistent difficulties in localization of touch without vision following surgical nerve repairs in the hand or forearm in humans. We tested whether adaptations associated with chronic experience can mitigate these functional limitations in right-handed heterotopic replant (N = 4) and allogeneic hand transplant recipients (N = 3).

We used a modified version of the locognosia procedure (Noordenbos, 1972). Briefly, the participant dons a pair of red goggles and closes his/her eyes. While the participants’ vision is blocked, small pink dots are placed on 10 – 15 locations on the glabrous surface each hand (digit pads, base of each finger, and in some cases the thenar eminence and heel of the palm). The experimenter then randomly touches one marked location with a suprathreshold Semmes-Weinstein filament. The participant then opens his/her eyes and marks the location on the hand where the touch was perceived using a orange marker. The red goggles prevent the participant from seeing the marks, forcing them to rely on touch localization while still being able to see the position and posture of the hands. The experimenter uses a caliper to measure the distance between the stimulated mark, and the participant’s response. Performances are also video-recorded for off-line analysis.

On average, healthy adults localize touch with a very high level of precision, and exhibit no differences between left and right hands, (insert means and SDs for each hand here). Patients showed substantial variability with localization abilities positively related to time since hand replantation or transplantation. Two complete hand transplant recipients (8 and 10 years post-surgery) and one mid-palm replant recipient (3 years post-surgery), and one full hand replant (1.5 years post-surgery) exhibited the ability to localize stimuli on average within 95% confidence intervals of the control group.

Our findings suggest that the ability to localize touch may continue to improve for years peripheral nerve repair and regeneration, implying a role for experience-dependent adaptations in central mechanisms in recovery of function.

Only

two investigations (one detailed in the Preliminary results section below) have focused on cortical responses

to cutaneous sensory stimulation, and both find evidence for activity in S1 during early stages recovery (4,

7). The majority of case studies have instead employed volitional hand flexion-extension movement tasks

that involve both motor and sensory (feedback) processes. A limitation of this approach is that flexion and

extension of the hand involves forearm musculature that has not been transplanted. Nevertheless, these cases

do show some evidence for evolution of M1-S1 activity as function of recovery (5-8).