Novel passive implanted differential mechanism improves grasp function after tendon transfer surgery

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Novel passive implanted differential mechanism improves grasp function after tendon transfer surgery

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Abstract: *We use robotic and cadaveric hand preparations to evaluate the efficacy of a novel passive implant mechanism in the ECRL-to-FDP transfer tendon-transfer surgery. Compared with directly suturing the donor to recipient tendons, the implant enables passive differential grasp adaptation between the index and middle fingers.*

Keywords: *Tendon transfer, grasp restoration, implant*

Introduction

A tendon-transfer surgery for restoring grasp function following high median-ulnar nerve palsy involves re-routing and directly suturing all the FDP tendons to the ECRL muscle [1]. However, this surgery has the drawback that the flexion of all fingers is coupled, preventing adaptations when grasping irregular objects. We present an implantable strut inserted between the FDP tendons to create a "differential mechanism" which enables each finger to passively adapt to the grasped object's shape [2]. We use robotic and cadaveric hands to quantify the differential grasp adaptation and force redistribution the implant enables when compared with standard suturing. For simplicity, we focus on the differential action between only two fingers, namely the index and middle fingers.

Methods

The index and middle fingers of a right hand are fully abducted and splinted to restrict movement in all but the metacarpophalangeal (MCP) joint. The other fingers are fully flexed to mimic a "victory V" gesture. The tips of the index and middle fingers rest on the arms of a custom T-paddle instrumented with force sensors. The paddle's trunk is attached to an AdeptSix 300 robotic arm, which allows its axis to be aligned between the two fingers. By rotating the paddle, we can simulate instances where the two unconstrained fingers must adapt using differential action to make contact with objects. By sweeping rotation angles of ±3° to ±30° in step of ±3°, for donor tendon forces of 3N to 30N, in steps of 3N, to simulate various grasp strengths, we quantify the differential action and force redistribution in both suture-based and implant-based surgical procedures.

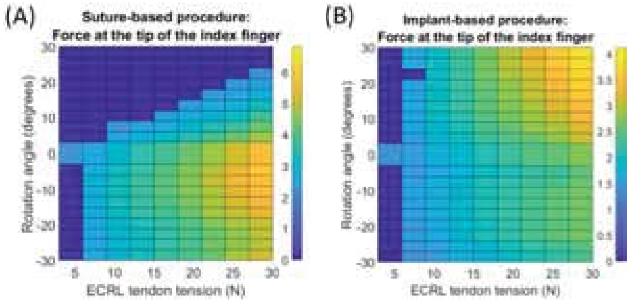

Figure 1: *The heatmaps depict the force at the index fingertip of the robotic testbed for different values of rotation angle and donor muscle force - panel (A) for the suture-based procedure, and panel (B) for the implant-based procedure. The colorbar transitions from dark blue (dentoing loss of contact) to yellow as the fingertip force increases. The middle finger showed similar distributions of force at the fingertip.*

Results & Discussion

The suture-based procedure shows significant loss of contact (see *Fig. 1, Panel A*) at rotation angles as small as 3° degrees, even with large tendon forces. In contrast, the implant-based procedure (see *Fig. 1, Panel B*) showed consistent contact for ±30° rotations at low and high tendon forces. The fingertip forces are also evenly distributed for the implant-based procedure. But the implant has some losses requiring higher donor (ECRL) tendon tension (≈6N) to actuate in comparison to the suture-based procedure (≈3N).

Future work will quantify grasp quality for a 4-finger grasp (where all FDP tendons are driven by a single donor muscle) along with force- and form-closure.

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References

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