SCIENTIFIC ARTICLE

Distal Biceps Brachii Tendon Transfer for Re-establishing Extrinsic Finger Function: Feasibility Study in Cadavers

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Purpose To determine the anatomic feasibility of transferring the biceps brachii tendon into either the extensor digitorum communis (EDC) or flexor digitorum profundus (FDP), determine the excursion imparted to EDC and FDP tendons after transfer, and compare the work capacity of the cadaver biceps to previously published data on the biceps as well as the recipient muscles by calculating the physiologic cross-sectional area (PCSA).

Methods Four fresh-frozen cadaver shoulder-elbow-wrist specimens were used to measure tendon excursion that can be obtained with transfer of the distal biceps tendon into either the EDC or FDP. Two cadavers had distal biceps-to-EDC transfer performed, and the other 2 had distal biceps-to-FDP performed. Passive ranging of each elbow from flexion to extension and active loading at 90° of elbow flexion were then performed on each specimen to determine tendon excursion. An analysis of the PCSA of the biceps muscle was performed on each specimen.

Results Distal biceps-to-EDC transfer resulted in an average of 24 mm of tendon excursion with passive loading, and 24 mm of tendon excursion with active loading. Distal biceps-to-FDP transfer resulted in an average of 24 mm of tendon excursion with passive loading, and 24 mm of tendon excursion with active loading. The average PCSA was 3.6 cm^2.

Conclusions Transfer of the distal biceps tendon into the EDC or FDP is anatomically feasible and provides roughly 24 mm of tendon excursion to the tendon units. The PCSA in the specimens used is slightly lower than other published data; it closely approximates the PCSA of the EDC, but is only half of the PCSA of the FDP in previously published data.

Clinical relevance The findings suggest potentially novel transfer options for restoring finger flexion and extension in patients lacking FDP or EDC function. *(J Hand Surg Am. 2017;■(■):1.e1-e7. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Tendon transfer, tetraplegia.

Online Exclusive

Tendon transfer in the upper extremity has evolved with certain well-known tenets. These include transfer through an uninjured or healed surgical bed, optimization of passive motion of the joint across which the tendon transfer travels, expendability and preserved voluntary muscle control of the transferred muscle, appropriate line of action of the transferred muscle with or without the establishment of

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a pulley, and synergism between the transferred muscle's original function and its new function. Adhering to these principles increases the effectiveness of the muscle transfer in performing its new action.[1]

Conditions such as Volkmann's ischemic contracture, brachial plexus palsy, and tetraplegia involve upper extremity dysfunction in which the forearm muscles controlling finger extension and/or flexion are nonfunctional, whereas muscles of the arm such as brachialis or biceps may be spared. These muscles normally traverse the elbow to position the forearm and hand in space and insert in proximity to the origin of muscles controlling finger extension and flexion. This positional relationship may allow for transfer of working muscles to denervated or nonfunctional musculotendinous units to restore function that has been lost. This "redistribution of assets" can provide important clinical improvements in selected patients.[1]

Various methods of restoring function in the hand have been used including reinnervating denervated motor units, transfer of viable and expendable muscle units, and free muscle transfer. There are a limited number of appropriate motor units for transfer, with availability depending on the degree of injury in Volkmann's contracture or brachial plexus injury or the level of spinal cord injury in tetraplegia. The possible availability of the biceps for use in re-establishing finger flexion or extension in patients with limited options may be beneficial.

The purpose of this study was to investigate both the biomechanical feasibility of biceps transfer and the tendon excursion that results from transfer into the extensor digitorum communis (EDC) or flexor digitorum profundus (FDP) musculotendinous unit in both passive and active modes using anatomical data collected from fresh-frozen cadaver specimens.

METHODS

Surgical technique

Four fresh-frozen cadavers of the upper extremity including the lateral clavicle and scapula were used for this study. Demographic data of the cadavers are shown in Table 1. Each specimen was thawed to room temperature before dissection. Passive range of motion of the elbow, wrist, and digits was measured by physical examination and noted to be full in each specimen. No evidence of previous surgery or deformity was noted in any limb. Transfer of the distal biceps to the EDC was performed in 2 cadavers (specimens 1 and 2) and transfer to the FDP was performed in 2 separate cadavers (specimens 3 and 4). After transfer, passive and active testing was performed on each of the specimens.

TABLE 1. Cadaver Specimen Demographics

Specimen	Sex	Age	Weight (lb)	BMI
1	Male	78	112	17
2	Male	63	130	22
3	Male	70	244	36
4	Male	34	141	20
Mean		61.25	156.75	23.75

BMI, body mass index.

For transfer of the distal biceps tendon to the EDC, an extensile skin incision was made to simulate surgical exposure of the distal biceps tendon through an anterolateral approach to the elbow. The biceps tendon was identified along its course across the elbow into its insertion on the radial tuberosity, along with the lacertus fibrosus. The lacertus fibrosus was released from its fascial attachment and incorporated into the bulk of the biceps tendon. The biceps tendon was released sharply from its radial insertion, retrieved from the wound, and positioned more superficially across the wrist extensors. Soft tissue adhesions into the distal arm were bluntly released. The distal portion of the incision was made over the outcropping muscles to the thumb, and followed proximally, identifying the EDC and extensor carpi radialis brevis tendons through the posterior Thompson interval. The musculotendinous portion of the EDC was exposed. The biceps was then transferred into the EDC tendons using a Pulvertaft weave. The extensor fascia was then closed over the transfer site, effectively creating a pulley through which the transfer acted. Elbow flexion of approximately 60° was required to ensure that the biceps could be woven 2 to 3 times into the EDC tendons without excessive tension.

For transfer to the FDP, dissection proceeded distally and ulnarly. A McConnell-type approach was performed, identifying the flexor digitorum superficialis (FDS) and flexor carpi ulnaris interval, and protecting the underlying ulnar artery and nerve. The FDP muscle was identified deep to the FDS and adjacent to the ulnar neurovascular bundle. The biceps muscle was tunneled deep to the FDS muscle belly and sutured into the FDP musculotendinous junction with the elbow positioned at approximately 60° of flexion. Tunneling the tendon through the FDS muscle belly created a fulcrum for the transfer and prevented bowstringing of the tendon.

To facilitate the measurement of tendon excursion, a metal marker was embedded into the recipient tendon. For the FDP, a central tendon was selected