

# The Effects of Aging on Upper Limb Tendon Transfers in Patients With Tetraplegia

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**Purpose** To evaluate the effects of aging on hand function among patients with tetraplegia who had forearm tendon transfer surgery between 1982 and 1990.

**Methods** The study used a longitudinal cohort design that compared hand function outcomes in 2012 with those obtained 11 years earlier. A digital analyzer was used to measure key pinch and grip strength, and results were compared with those obtained in 2001 to determine changes in strength over time. The study also evaluated changes in participant's employment status, wheelchair use, and subjective changes in function using the Lamb and Chan questionnaire.

**Results** Participants had a mean key pinch strength force between 11.5 N (tenodeses) and 32.9 N (active transfers) and grip strength forces between 23 N (tenodeses) and 59 N (active transfers). Since 2001, people with active transfers either maintained strength or experienced decreased strength of 5% to 14%. Thumb tenodesis power decreased 40% to 51%, whereas finger tenodeses power increased 32% to 70%. Three activities in the Lamb and Chan questionnaire were identified by the majority of participants as being worse or much worse over the past 11 years. These were performing a pressure relief and propelling a manual wheelchair on level ground and up a ramp. These findings correspond with the increased number of participants who used a power wheelchair in 2012 (64%) compared with 2001 (26%). Close to half of the participants (46%) were employed compared with the 90% in 2001.

**Conclusions** Tendon transfers continued to provide pinch and grip function for individuals with tetraplegia for many years following spinal cord injury. The decrease in strength of those with active transfers over the 11-year period was within the reported aging loss for the normal population. The small number of participants with tenodesis, however, limited our ability to draw meaningful conclusions for this group. (*J Hand Surg Am.* 2014;39(2):317–323. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)

**Type of study/level of evidence** Prognostic III.

**Key words** Aging, hand function, tetraplegia, upper limb surgery.

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UPPER LIMB RECONSTRUCTIVE surgical procedures for individuals with tetraplegia were described by Moberg in 1975<sup>1</sup> and have since been adopted in many centers worldwide. The goals of surgery are to provide a person with tetraplegia sufficient pinch and/or grip strength to perform activities of daily living (ADL) more independently and without the need for adaptive equipment or orthoses. Although many centers have reported outcomes of upper limb reconstructive surgery,<sup>2,3</sup> little has been published on long-term outcomes.

In 1991, we reviewed 57 people with tetraplegia who had had upper limb reconstructive surgery between 1982 and 1991.<sup>4</sup> In 2001, we re-reviewed all people who had simultaneous bilateral tendon transfers to provide pinch and grip from the 1991 study ( $n = 24$ ). We found that participants had maintained or improved their grip strength during the 12 to 18 years following surgery. Whereas changes in testing procedures for pinch strength invalidated objective comparisons with pinch strength scores recorded in 1991, other more subjective data suggested that participants had maintained pinch strength.<sup>5</sup>

The aim of our present study was to further review the cohort who had tendon transfer surgery between 1982 and 1991 and determine the changes in grip and pinch strength, the subjective performance of ADL, and the effects of aging on their hand function.

## METHODS

### Research design and study group

We used a longitudinal cohort design that compared hand function outcomes in 2012 with those obtained 11 years earlier. The study group consisted of people with tetraplegia who had received simultaneous bilateral tendon transfers from 1982 to 1991 and who also had participated in follow-up studies conducted in both 1991 and 2001.<sup>4,5</sup> Ethical approval for the study was obtained from our institutional review board.

### Instruments and measures

We classified participants using the International Classification of Hand Surgery for Tetraplegia (ICSHT), a classification used to determine muscle and tendon transfer options for the upper limb in tetraplegia.<sup>6</sup> The ICSHT is considered more sensitive than the American Spinal Injury Association Impairment Scale for assessment of upper limb strength in tetraplegia.<sup>7</sup>

All participants performed key pinch and grip tests using a digital analyzer (DA) (MIE Medical Research Ltd, Leeds, England), a torsion dynamometer linked to a microprocessor digital analyzer. This was the same DA used to test participants in the 2001 study. We calibrated the DA prior to testing. Participants completed the Lamb and Chan questionnaire<sup>8</sup> and were asked to rate their change in function since 2001. The Lamb and Chan questionnaire consists of 25 questions related to the ability to perform everyday tasks using a 5-point scale: much worse, worse, unchanged, improved, and greatly

improved. This questionnaire was the one used in both the 1991 and the 2001 studies.

A single researcher (J.A.D.) experienced in the use of these instruments collected all data. For the pinch and grip measurements, we used the American Society of Hand Therapists standardized positioning protocol<sup>9</sup> that had also been used in 2001. Grip aids were not allowed, and the best of 3 attempts was recorded with a 1-minute rest period between attempts. For the measurement of pinch strength, the DA prongs were set 5 mm apart, which is the width of standardized pinch meters such as the Preston Pinch meter (JA Preston Corporation, Clifton, NJ). For the measurement of grip strength, the DA prongs were set 25 mm apart, which is the width of the second handle position of the Jamar dynamometer (Asimow Engineering Co, Los Angeles, CA) and the position recommended by the American Society of Hand Therapists for testing grip strength. All pinch and grip strength measurements were recorded in Newtons (N). All data were entered into an Excel spreadsheet for further analyses.

### Statistical analysis

We used customary descriptive statistics to characterize the study group, that is, age, sex, duration of spinal cord injury (SCI), and years since first tendon transfer surgery. In instances in which participants had different ICSHT ratings for each arm, we classified the participant by the limb with the lowest ICSHT rating. For example, if a participant's limbs were classified OCu4 and OCu2, we classified that patient OCu2 for analysis.

We separated pinch and grip strength data by side, type of surgery, tenodesis, and active transfers and used paired *t* tests ( $\leq 0.05$ ) to compare results. We calculated the percentage change in strength between 2001 and 2012 for each side and type of surgery.

We compressed the Lamb and Chan questionnaire scores from a 5-point scale to a 3-point scale: worse (worse or much worse), unchanged, and improved (improved or greatly improved). Although this reduced the level of resolution, it allowed us to have more participants within each response category.

We used both parametric and nonparametric tests depending on the distribution of variables under examination.

## RESULTS

### Study group

Of the 24 participants in the 2001 study, 19 participants were eligible for inclusion in the current study

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