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A Study of Muscle Muscle Morphology of Anterior Group of Forearm Muscles

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Abstract

The study was done on 60 upper limbs (56 males and 4 females) of embalmed adult human cadavers obtained from the department of anatomy, govt. Medical college, patiala. The muscle fibre length, tendon length and total muscle length of the anterior group of forearm muscles were measured in all the 60 upper limbs. Amongst wrist flexors Flexor Carpi Ulnaris had the longer muscle belly than Flexor Carpi Radialis. In Flexor Digitorum Superficialis (FDS), FDS-Index had the longest muscle belly. In Flexor Digitorium Profundus (FDP), FDP-Middle had the longest muscle belly. The Pronator Quadratus had the smallest muscle belly with no tendon. Ratio of Muscle Fibre Length and Total Length for Flexor Carpi Ulnaris was more than Flexor Carpi Radialis. In FDS it was maximum for FDS-Index and in FDP it was maximum for FDP-Ring. As muscle length is related to the isokinetic strength, it is believed that the isokinetic strength of FCU is more than FCR and among FDS it is higher for FDS-Index and in FDP for FDP-Ring.

Keywords: Isokinetic Strength, Muscles, Muscle-Fibre-Tendon Ratio, Tendon Compliance

Introduction

Motions are the result of co-ordination by a number of muscles and tendons, some of them causing most of the motion, other deviating the direction of the motion and still other holding back the motion to make it slow and controlled (*Bunnel, 1948*).

The functional effect of a long, compliant tendon in series with muscle fibres was to increase the functional operating range of the muscle- tendon unit. The tendon compliance had its greatest functional effect in muscle- tendon unit with high tendon length/fibre length ratios. Thus in addition to muscle architecture, tendon length and tendon properties can also be considered important design criteria, which should be considered in transfer procedure *(Zajac, 1989)*.

Tendon injuries are one of the most problematic in hand surgery with respect to the restoration of normal function. To deal with these problems adequately, it is also essential to know certain facts about flexor tendon anatomy, function and physiological behaviour (*Kleinert et al, 1986*).

Tendon transfers are used primarily to improve function following damage to major nerve trunks, the brachial plexus or the cord and the brain and to substitute for motion lost through trauma to muscles in the forearm and the hand *(Boyes, 1970)*.

Materials & Methods

The material for this study comprised of 60 upper limbs (56 males and 4 females) of embalmed adult human cadavers obtained from the department of Anatomy, Govt. Medical College, Patiala.

The specimens were dissected to expose the muscles and tendons of flexor compartment of the forearm. The length of the fleshy part of the muscle was measured as the distance from the origin of the most proximal muscle fibres to the insertion of the most distal fibres into the tendon of the muscle. The length of the tendon was taken from the beginning of the tendon from the muscle fibre to its bony insertion and the total length of the muscle was measured from the origin of the most proximal muscle fibres to the bony insertion of tendon.

Unbraided silk thread was placed along the whole length of the fleshy part of the muscle. The most proximal and most distal points were marked with Indian ink. The length was calculated using metal measuring roller. Length of tendon and total length of the muscle was also taken in a similar manner. In case of multiple tendons of a muscle, the length of the longest and shortest tendon was recorded and average tendon length was calculated.

Muscle fibre – tendon ratio was calculated according to the following equation:

$$\text{Muscle Fibre to Tendon Ratio} = \frac{\text{Length of the fleshy part of the muscle}}{\text{Tendon length}}$$

$$\text{Muscle fibre to Total muscle length ratio} = \frac{\text{Length of the fleshy part of the muscle}}{\text{Total Muscle length}}$$

Results & Discussion

Table 1: Average Muscle fibre length, Tendon length and total muscle length

Muscles	MFL (cm)	TDL (cm)	TL (cm)	MFL :TDL	MFL :TL
PT	13.84 ±1.97	6.73 ±1.58	14.78 ±2.18	2.14 ±0.48	0.9 ±0.05
FCR	16.28 ±1.97	18.0 ±3.03	32.31 ±3.15	0.94 ±0.24	0.50 ±0.05
PL	12.40 ±1.75	18.19 ±2.40	28.61 ±3.03	0.63 ±0.25	0.43 ±0.04
FCU	23.69 ±2.50	10.35 ±2.90	31.52 ±3.86	2.50 ±0.87	0.75 ±0.04
FDS-I	22.19 ±2.02	18.37 ±0.37	38.91 ±2.32	1.21 ±0.11	0.57 ±0.03
FDS-M	17.99 ±0.81	21.64 ±2.81	38.21 ±3.03	0.85 ±0.11	0.47 ±0.03
FDS-R	15.65 ±0.43	18.98 ±2.38	33.15 ±1.17	0.81 ±0.04	0.47 ±0.01
FDS-S	10.42 ±0.54	15.28 ±1.04	23.89 ±1.10	0.69 ±0.07	0.44 ±0.02
FPL	15.96 ±1.64	17.49 ±0.84	30.80 ±2.31	0.92 ±0.11	0.52 ±0.02
FDP-I	13.29 ±0.56	29.77 ±2.38	40.60 ±2.30	0.45 ±0.04	0.33 ±0.02
FDP-M	21.48 ±2.96	25.99 ±3.05	43.98 ±4.40	0.84 ±0.18	0.49 ±0.05
FDP-R	20.47 ±0.52	17.72 ±2.05	35.59 ±1.68	1.15 ±0.11	0.58 ±0.03
FDP-S	15.79 ±0.70	16.23 ±1.40	29.36 ±1.59	0.98 ±0.11	0.54 ±0.03
PQ	4.12 ±0.47	-	-	1	-

PT – Pronator teres, FCR – Flexor carpi radialis, PL – Palmaris longus, FCU – Flexor carpi ulnaris, FDS-I – Flexor digitorum superficialis – Index, FDS-M - Flexor digitorum superficialis – middle, FDS-R - Flexor digitorum superficialis – Ring, FDS-S Flexor digitorum superficialis – Small, FPL – Flexor pollicis longus, FDP-I – Flexor digitorum profundus – Index, FDP-M - Flexor digitorum profundus – Middle, FDP-R - Flexor digitorum profundus – Ring, FDP-S - Flexor digitorum profundus – small, PQ – Pronator quadratus, TDL-Tendon length, TL – Total length, MFL – Muscle fibre length.

In the present study, the muscle fibre length, tendon length and total muscle length of the anterior group of forearm muscles were measured in all the 60 upper limbs. Amongst wrist flexors FCU had the longer muscle belly (23.69±2.50 cm) than FCR (16.28±1.97 cm). In flexor digitorum superficialis FDS-I had the longest muscle belly (22.19±2.02cm).

In flexor digitorum profundus FDP-M had the longest muscle belly (21.48±2.96 cm). The PQ had the

smallest muscle belly (4.12±0.47 cm) and there was no tendon for this muscle. The length of the muscle belly of PT was 13.84±1.97 with shortest tendon i.e. 6.73±1.58cm.

Table 2. Comparison between the lengths of anterior group of forearm muscles

MFL(cm) Muscles	*Lieber et al* (1992)	Present study (2003)
PT	13.0 ± 0.47	13.84 ± 1.97
FDS-I	20.7 ± 1.07	22.19 ± 2.02
FDS-M	18.3 ± 1.15	17.99 ± 0.81
FDS-R	15.5 ± 0.77	15.65 ± 0.43
FDS-S	10.3 ± 0.63	10.42 ± 0.54
FDP-I	14.9 ± 0.38	13.29 ± 0.56
FDP-M	20.0 ± 0.82	21.48 ± 2.96
FDP-R	19.4 ± 0.70	20.47 ± 0.52
FDP-S	15.0 ± 0.47	15.79 ± 0.70
FPL	16.8 ± 1.0	15.96 ± 1.64
PQ	3.9 ± 0.23	4.26 ± 0.66

The present findings of the muscle lengths were compared with those of Lieber et al 1992 and were found to be in accordance with there findings (Table 2).

The ratio between muscle fibre length and tendon length (MFL: TDL) and ratio between muscle fiber length and total muscle length (MFL: TL) had been studied and calculated as shown in table-1.

The MFL:TL for FCU (0.75±0.04) was more than FCR (0.50±0.05) and in FDS it was maximum for FDS-I i.e. 0.57±0.03 and in FDP it was maximum for FDP-R i.e. 0.58±0.03

Tendon length was studied because it is one of the important parameter for the selection of muscle during tendon transfer procedure. A tendon transfer is that procedure in which the tendon of insertion or of origin of a functioning muscle is mobilized, detached or divided and reinserted into a bony part or into another tendon to supplement or substitute for the action of the recipient tendon.

A theoretical review by *Zajac (1989)* suggested that functional effect of a long compliant tendon in series with muscle fibres was to increase the functional operating range of the muscle tendon unit. He demonstrated that tendon compliance had its greatest functional effect in muscle tendon unit with high tendon length to fiber length ratio. Thus in addition to muscle architecture, tendon lengths and tendon properties can also be considered important design criteria which should be considered in transfer procedure.

The contractile component seems to determine the strength of a muscle which was also supported by *Behncke (1998)* in his study on human dorsal and plantar flexor muscles that increase in gross muscle length, a muscle tendon ratio indicating a longer muscle length is positively related to maximal isokinetic strength in the lower limb.

Hence the findings in the present study suggest that the isokinetic strength of FCU is more than FCR and among FDS it is maximum for FDS-I and in FDP for FDP-R.

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