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Morphometry and anatomical variations of flexor digitorum superficialis

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Abstract

Introduction: Flexor digitorum superficialis (FDS) takes its origin by two heads: humero ulnar and radial.. The FDS is considered to be potential flexor of proximal interphalangeal, metacarpophalnageal and wrist joints through its insertion to the middle phalanges of lateral 4 fingers. Aim of the study was to conduct a morphometric study on FDS and to evaluate its variants in cadaveric limbs. **Materials and Methods:** The study was carried out on 25 right and 23 left upper limbs belonging to formalin fixed adult cadavers. Lengths of humeral, ulnar, radial heads of the muscle as well as its tendons were separately measured using digital caliper. Mean length of muscle bellies of humeral head, tendinous length and musculotendinous length tabulated. **Results:** A unique muscle belly arising from the deeper surface of left FDS as a tendon, proximal to flexor retinaculum, entering in the palm after passing through the carpal tunnel was observed. The muscle was inserted into the middle phalanx of index finger. **Conclusion:** Studies on absolute length of FDS are rare. The present study has significant influence on length tension relationship of afore mentioned muscle. The hazardous effects of anomalous belly of FDS and its consequences were also discussed.

Keywords: flexor digitorum superficialis, index finger, forearm, middle phalanx, muscle, tendon.

1 Introduction

The muscles of the flexor compartment are arranged in superficial and deep groups. Flexor digitorum superficialis (sublimis) (FDS), largest of the superficial muscles, takes its origin by two heads: humero ulnar and radial. The muscle proceeds by dividing into two lamella directed to the 2-5 digits. Superficial lamella divides into two tendons for third and fourth digits after joining radial head laterally where as deep lamella provides a muscular slip to join the superficial fibres oriented to the ring finger then gets its attachment to the first and fifth digits in the form of two tendons after passing beneath the flexor retinaculum. The FDS is considered to be potential flexor of proximal interphalangeal, metacarpophalnageal and wrist joints (STANDRING, 2005).

The variations of FDS are considered as retrogressive denoting the remnants of connections between two sheets of muscle and progressive in case of occasional separation (upto their origin) of individual muscle bellies (BERGMAN, AFIFI and MIYAUCHI, 2006; NAYAK, RAMANATHAN and PRABHU et al., 2007).

The flexor digitorum profundus, superficialis and flexor pollicis longus are major muscles contributing for force generation during exertions of the hand. Tendons of these muscles run through the carpal tunnel (ARMSTRONG and CHAFFIN, 1978). The carpal tunnel is the space beneath the transverse carpal ligament occupied by median nerve and nine tendons (MITCHELL et al., 2009). Compression of median nerve results in carpal tunnel syndrome (CTS). Compression may be due to presence of aberrant tendons and muscles present in the forearm and tunnel (RODRIGUES, NAYAK and RAO et al., 2009). Etiology of CTS was explained by Entin (1968) in the following manner: those minimizing the capacity of tunnel; those increasing the amount of its contents and those that form part of a systemic condition. Carpal tunnel syndrome is characterised by brachialgia paresthetica nocturna, refer to nocturnal hand pain, unpleasant sensations like tingling, numbness, causalgia (OYEDELE, SHOKUNBI and MALOMO , 2002). Phalen's test and revesrse Phalen's test can be used as a diagnostic tool for CTS (STEPHENS, MARQUES and LIVINGSTON, 2007).

Aim of the study was to establish a descriptive morphometric analysis of FDS and to evaluate its variants in cadaveric limbs.

2 Materials and Methods

A study was carried out on 25 right and 23 left upper limbs belongs to adult cadavers, perfused with 10% formalin, to evaluate the morphometry of FDS muscle. Dissections were performed. Limbs with decomposition, degenerative changes and major trauma were excluded from the study. Origins of aforementioned muscle were carefully examined and length of humeral head, ulnar head, radial head as well as its tendon were separately measured using digital calliper. Muscle length was gauged using unbraided silk thread as distance from most

proximal fibre of origin to most distal fibres of its insertion, applied for all specimens. Digital photographic documention was performed. Statistical analysis excluded the anomalous muscles.

3 Results

Data recorded for the length of humeral, ulnar, radial heads and tendon of FDS were tabulated (Table 1). Mean lengths of above mentioned parameters were calculated. Mean length of humeral head 9.2 inches, ulnar head 7.7 inches, and radial head 6.5 inches was measured. Mean tendinous length and mean musculotendinous length was 6.5 inches and 15.6 inches respectively. Choice of these parameters and results were not based upon gender and sides comparison.

A unique muscle belly was incidentally encountered during dissection. It was arising from the deeper surface of left FDS in a single specimen proximal to flexor retinaculum, entering in the palm after passing through the carpal tunnel. Further, the tendon of this muscle was inserted into the middle phalanx of index finger (Figure 1).

4 Discussion

Contraction of a muscle fibre is based upon number of sarcomeres within each myofibril. Shortening of the muscle fibre is directly proportional to its length (LIEBER, JACOBSON and FAZELI et al., 1992; ZAJAC, 1992; BRAND, BEACH and THOMPSOM, 1999). Fibre length plays an important role in the magnitude of joint motion resulting from a muscle contraction. Joint movement is initiated by the shortening of the muscle, characterising its basic property (RASSIER, MACINTOSH and HERZOG, 1999). Lieber et al suggested that frequency of shortening is greater in the parallel fibres than the pinnate muscle since former is composed of long fibres, believed to produce more absolute shortening (LIEBER, JACOBSON and FAZELI et al., 1992). Absolute stretch and contraction sustained by a muscle is influenced by the individual muscle and joint. The muscle spans two or more than two joints experience more contraction and relaxation rather than a muscle crossing only one joint. Force outcome of a muscle crossing multiple joints is induced by length-tension relationship (RASCHKE and CHAFFIN, 1996). An increased isometric contraction results in greater value on electromyogram (EMG) (SEROUSSI and POPE, 1987; DOLAN and ADAMS, 1993).

Present study evaluates the highest and lowest mean length of humeral head and radial head of FDS respectively. The results of ulnar head were falling in between the other two. As we have discussed before muscle contraction is directly proportional to muscle length, keeping this view in mind we can conclude that humeral head of FDS will shorten maximally followed by ulnar head and finally radial head. Over all shortening will result in the contraction of muscle which may lead to strong grip.

Variations or anomalies of FDS in the palm are occassional findings which results in a painful mass in living and are difficult to diagnose due to its resemblance with many other soft tissue tumours (lipoma, ganglions, giant cell tumours and hamaratomas). These anomalies were first depicted by MAC ALISTER (1868) in postmortem dissections, and subsequently by GRAPER (1917) and Mainland (1927) (STEPHENS, MARQUES and LIVINGSTON, 2007). Vichare suggested that such anomalies are usually asymptomatic and are of academic interest and away from discussion because of their rare prevalence but become a serious surgical issue if symptomatic (VICHARE, 1970).

Mainland found a rare variation of left FDS showing two bellies with their separate tendons in the distal forearm and a belly in the volar aspect of cadaveric hand (MAINLAND, 1927). A clinical case of anomalous muscle was observed in 19 years old patient with a history of painful swelling in the right palm. The belly was extending into palm through carpal tunnel down to the level of metacarpo-phalangeal joint (VICHARE, 1970). A similar finding in 30 years old woman showed an aberrant belly originating from actual FDS and ended in palmar facia (NEUMEISTER, MOWLAVI, RUSSELL et al., 2005). As per the previous literatures, only three cases of abnormal belly of FDS was recorded till year 2007 which served the index finger. First type involved the extension of muscle belly from forearm till carpal tunnel. It did not make its presence in the palm. A digastric form approaching between forearm and palmar bellies by way of a tendon hit the second type. Finally, third type revealed an anomalous belly confined solely in the palm (STEPHENS, MARQUES and LIVINGSTON, 2007).

Our finding was atypical and not in the favour of any of these classifications. We observed the extension of a strange belly from the distal forearm into the palm and fasten the middle phalanx of index finger as a tendon.

Variations and anomalies of muscle on the forearm and hand can be diagnosed using computed tomography and magnetic resonance imaging. An abnormal muscle may simulate a

Figure 1. A unique muscle belly arising from the deeper surface of left FDS proximal to flexor retinaculum, entering in the palm after passing through the carpal tunnel and inserted into the middle phalanx of index finger.

ganglion or a soft tissue tumour (NAYAK, RAMANATHAN, PRABHU et al., 2007). It can be an important factor for CTS causing compression of median nerve as suggested by ENTIN et al in 1968. Since it is located with the close proximity of other palmar structures like nerves and vessels, it may cause pressure symptoms resulting in pain and reduced grip strength.

Table 1. Length of various segments of flexor digitorum superficialis (inches).

No. of specimens	Humeral head	Ulnar head	Radial head	Tendon length
1	10.75	8.75	7.5	5.75
2	8.25	7.25	6	6
3	9	7.25	6	6.25
4	9	7.5	6	6.75
5	9.75	8.5	7	7
6	10.25	8.25	6.5	7.25
7	9.25	7.75	6	7.25
8	9.5	8.25	7	6.5
9	10.25	8.5	7.25	6.5
10	9	8.25	7	8
11	8.75	7	5	7.25
12	9	7.75	6	6.5
13	7.75	6.25	4.25	7.25
14	8.75	7.5	6.25	6
15	9.5	8.25	7	6
16	9.25	8	7	5.5
17	10.75	9.25	8.5	7.25
18	9.25	8	6.75	6.25
19	10.25	8.5	6.75	7
20	11	9.25	7.75	6.25
21	10.25	8.5	7	7.25
22	9.25	7.5	6.25	6
23	10	8.25	6.5	6
24	9.25	8	7.75	6
25	9	7.25	4.75	7.25
26	9.75	8.25	6.75	6
27	10.25	9	7	6
28	9	8	6.25	6.5
29	8	7	4.75	7
30	9	7.75	5.25	7
31	9.5	7.75	6.75	5.75
32	9.5	8	6.5	8
33	8	7	6.8	5.3
34	10.1	8.8	8.5	5.6
35	9.1	8	7.5	6.2
36	8	6.8	6.5	7.5
37	9	7.2	7	4.3
38	9	7.7	7.5	4.5
39	10.5	8	7.7	7
40	8.5	7	6.8	6.5
41	10.5	9	8.5	5.5
42	10	8.5	8	6.5
43	8.5	7.2	7	6.5
44	9	7.5	7	7.5
45	9	7	6.7	6.5
46	8.5	7	6.5	6.2
47	9	8	7.8	6
48	9.5	8.5	8.3	5.5
MEAN	9.2	7.7	6.5	6.5
SD	0.78	0.68	0.95	0.78

Surgical removal of muscle is required in painful conditions. if it serves as a functional anatomical unit without any harmful effect then its removal is not recommended (STEPHENS, MARQUES and LIVINGSTON, 2007).

5 Conclusion

The present study is a morphometric study on FDS explaining the fuctional significance of length variation of muscle belly and tendon. We have also focused on the hazardous effects of anomalous belly of aforementioned muscle and its consequences.

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