

Anatomical localization of motor entry points of flexor digitorum superficialis



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ABSTRACT

Background: The knowledge about dense zones of motor entry points (MEPs) of muscles commonly involved in spasticity will be helpful for clinicians to inject the neurolytics into the ideal site. **Aims and Objectives:** The aim of the study was to identify the total number and dense zone of MEPs of flexor digitorum superficialis (FDS) and compare it with the vertical reference line. **Materials and Methods:** Thirty upper limbs from formalin-fixed cadavers were used. Proximal and distal MEPs to FDS were measured from the inter-epicondylar line. The dense zone of MEPs was identified and expressed in quartiles of the vertical reference line. Statistical analysis used: All analysis was done using Statistical Package for the Social Services software Version 21.0. **Results:** The ideal site for injecting neurolytic agents for FDS is in the second and third quartile of the vertical reference line from the inter-epicondylar line. **Conclusions:** Along with the guidance of ultrasound, neurolytic agents could be injected into the second and third quartile for FDS.

Key words: Flexor digitorum superficialis; Spasticity; Motor entry points; Dense zone

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INTRODUCTION

Spasticity of forearm flexors is common in medical disorders such as cerebral palsy, stroke, and multiple sclerosis. This can cause structural as well as functional deformities of the upper limb.¹ The treatment includes drugs like Baclofen, Dantrolene, Diazepam and Gabapentin,² neurectomy and chemo-denervation by injecting neurolytic agents such as phenol, alcohol or botulinum toxin into the affected muscle.³ The accurate injection of neurolytics into the dense zone of motor entry points (MEPs) will help patients to achieve maximum desirable effects, will be cost effective and have minimal side effects.⁴

Aims and objectives

The aim of this study is to find the dense zone of MEPs to flexor digitorum superficialis.

The objectives are

1. Find the distance between Proximal MEP (PEP) and Distal MEP (DEP)
2. Compare the distance between PEP and DEP with the vertical reference line.

MATERIALS AND METHODS

In this study, 30 upper limbs from 15 formalin-fixed adult cadavers of median age of 78 years (Range: 55–92), male-8 and female-7, donated to the Department of Anatomy of Christian Medical College, Vellore were used.

Sample size calculation: Based on the study done by Zawawy et al.,⁵ a minimum of 27 specimens were required to obtain, 95% confidence interval, so that the sample mean would not differ from the population mean by more than 2 units.

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$$n = \frac{Z^2(1 - \frac{\alpha}{2}) * \sigma^2}{d^2}$$

- Standard deviation (σ)=5.2
- Precision=2
- Z-value for 95% Confidence interval=1.96.

Inclusion criteria

Both sides of the same cadaver were used to compare the motor dense zones between sides and used almost equal male-female ratio for comparing the results between them.

Exclusion criteria

The specimens with any deformities, fractures, or prosthetics were excluded from the study.

Dissection

The disc number, age, and sex of the cadaver were noted. Before dissection, the cadaver was kept in the supine position with the upper limb abducted to 90° with the upper limb in supination.

Instruments used

Scalpel, Toothed and non-toothed forceps, Scissors, Measuring tape, Goniometer, Vernier Caliper.

Others

Thread, Pins, Cotton, and Gauze.

Anatomical landmarks

The anatomical landmarks used in this study were, the medial and lateral epicondyles of humerus, radial, and ulnar styloid processes.¹ The MEPs to flexor digitorum superficialis were studied in relation to these surface anatomical landmarks.

Incisions

A horizontal incision was made 5 cm above the elbow so that no MEPs were missed. A vertical incision was made in the forearm from the midpoint of this horizontal incision till it met the midpoint of a horizontal incision made at the wrist connecting radial and ulnar styloid processes. The forearm skin was reflected to either side. The medial epicondyle and lateral epicondyle were located and pinned and tied a thread connecting both. Then the length of the tied thread (horizontal reference line/X-axis/inter-epicondylar line) was measured and its midpoint was pinned. Following this, a thread was tied connecting the pins on the ulnar and radial styloid processes (inter-styloid line). Using a goniometer, a thread was placed at 90° to the inter-epicondylar line at its midpoint till it reached the inter-styloid line. This vertical line was considered as the Y-axis/ Vertical reference line. The length of this vertically placed thread is taken as the length of the vertical reference line.

The length of the forearm is usually measured from midpoint of inter-epicondylar line to midpoint of the inter-styloid line.¹ Hence, the length of the vertical reference line described in this study will be comparable with the forearm length. Figure 1 shows the measurement of the vertical line.

Following this, the specimen was cleaned, and the median nerve was located at the cubital fossa. After cutting and detaching the attachment of pronator teres from the radial shaft, the median nerve was traced. The tendon of palmaris longus and flexor carpi radialis was cut two cm proximal to the distal horizontal line. This made flexor digitorum superficialis visible. After removing the fat and loose connective tissue, the flexor digitorum superficialis was pushed aside to see the MEPs from the deeper aspect.

The total number of branches to the muscle was noted and the site of the PEP and DEP were pinned. Distance between the DEP and PEP was found and compared with the vertical reference line. Since FDS have MEPs on its deeper surface, the MEPs were identified either by reflecting the muscle or by separating the muscle fibers longitudinally without bisecting it and pinned keeping the muscle in the normal position. From this pin, the shortest distance to the vertical reference lines was taken. Figure 2 shows the motor entry points to FDS. The length between the median of the PEP and DEP for all the limbs gave the distance of the dense zone of MEPs. This distance was

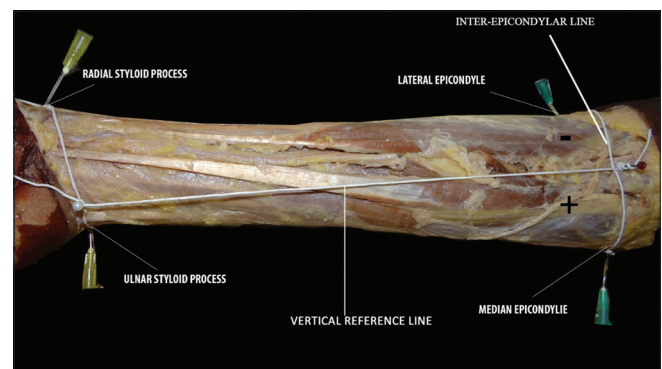


Figure 1: Inter epicondylar line and vertical reference line

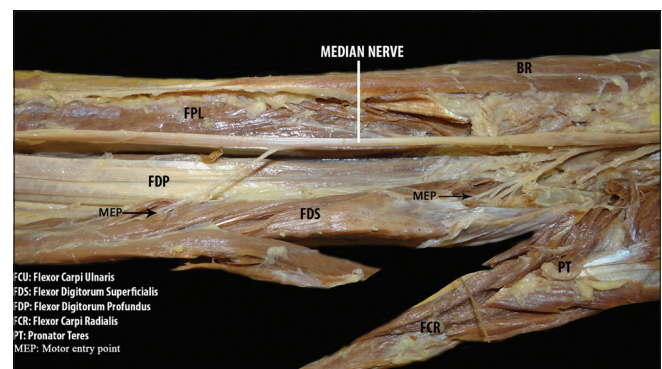


Figure 2: Motor entry point to flexor digitorum superficialis

Table 1: Comparison of length of the vertical reference line

Study	Length of the vertical reference line (cm)	Sample size	Population
Parot and Leclercq ⁸	26.2	22 (9F+13M)	French
Ye et al. ⁹	23.4	46 (26M+24F)	Chinese
Won et al. ¹	22.1	23 (9M+14F)	Korean
Roberts et al. ¹⁰	28	20 (12M+8F)	English
Lepage et al. ¹¹	23	30 (17F+13M)	French
Liu et al. ¹²	26	10	Singapore
Safwat and Abdel-Meguid ¹³	23.2	23	Saudis
Present study	24.25	30 (16M+14F)	South Indian

Table 2: Comparison of dense zone of motor entry points to FDSs

Study	PEP to DEP (cm)	PEP to DEP (%)	Mean (cm)	Mean (%)
Parot and Leclercq ⁸	(4.8–7.7)–(10.4–22.4)	(20–30)–(38–77)		
Lepage et al. ¹¹			6.25–14.5	27–62.8
Roberts et al. ¹⁰				19.4–34
Won et al. ¹				
1 branch				18.1
2 branches				35.9
Present study	5.65–16.95	23.30–69.78		

FDS: Flexor digitorum superficialis, PEP: Proximal motor entry point, DEP: Distal motor entry point

converted into percentage according to the length vertical reference line. Then the quartile of the vertical reference line where the dense zone was present for each FDS was calculated. The first 25% of the vertical reference line from the inter-epicondylar line was considered as the first quartile, 26–50% as the second quartile, 51–75% as the third quartile, and 76–100% as the 4th quartile.

RESULTS

For 30 upper limbs, the median of the length of vertical reference line was 24.25 cm and inter-quartile range was 2.47 cm.

The mode for a total number of MEPs to flexor digitorum superficialis is 6.

The dense zone of MEPs to FDS is between 23.30% and 69.78% of the vertical reference line from the inter-epicondylar line which is at the second and third quartile.

DISCUSSION

Injection of neurolytics to the involved muscles is used as a treatment procedure for spasticity. One of the commonly used neurolytics is botulinum toxin obtained from the obligate anaerobe bacteria, *Clostridium botulinum*.^{3,6} Upper limb flexor muscles are commonly involved in spasticity.⁷ Physical factors such as dose, concentration, volume of the injectate, bore of the needle, number of injections per muscle, site of the injection, muscle size, presence of muscle fascia and the distance of the needle tip from the

neuromuscular junction and speed of injection have been identified to influence the spread of botulinum toxin after injection.³ The knowledge about dense zones of MEP to these muscles help in accurate injection and efficacy of botulinum toxin.

Length of the vertical reference line

In this study, the vertical reference line was measured as the length of the perpendicular line drawn from the midpoint of the inter-epicondylar line till it meets the inter-styloid line. The median length of the vertical reference line was 24.25 cm with a minimum length 20 cm and a maximum 31 cm.

Table 1 provides the information regarding the length of the vertical reference line in previous studies.

Table 2 is comparison of dense zone of motor entry points to FDS from previous studies.

Limitations of the study

Sample size could be more for improving the accuracy of the results. Paediatric dense zones could be different.

CONCLUSIONS

In this study, the median length of the vertical reference line described was found to be 24.25 cm. In addition, there were six MEPs identified for the flexor digitorum superficialis muscle. The dense zone of this muscle, where these entry points were concentrated, spanned between 23.30% and 69.78% of the vertical reference line, primarily falling within the second and third quartiles of the measurement.

It was observed that there was no significant correlation between the increase in the length of the vertical reference line and the number of MEPs. Furthermore, gender did not play a role in the distribution of the dense zones, as no significant difference was found between males and females. Similarly, the side of the body had no significant impact on the dense zones of the flexor digitorum superficialis.

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