Original Article

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Anatomy Section

# Morphometric Parameters of the Fibrous Arch of Flexor Digitorum Superficialis: A Cross-sectional Cadaveric Study in the Indian Population

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## ABSTRACT

**Introduction:** The Flexor Digitorum Superficialis arch (FDS arch) serves as a connection between the humero-ulnar and radial heads of the FDS muscle. This arch can potentially compress the median nerve, leading to the development of pronator syndrome.

**Aim:** To describe the morphometric parameters of the FDS arch in the Indian population.

**Materials and Methods:** A two-year cross-sectional cadaveric study was conducted at the Department of Anatomy, Christian Medical College, Vellore, India, from December 2018 to November 2020. Thirty-four forearms from 17 adult cadavers (8 male and 9 female) were included in the study after excluding those with forearm deformities caused by trauma, congenital malformations, or scars. Measurements were taken for the distance from the medial epicondyle to the apex of the FDS arch and the thickness of the arch. The type of FDS arch (tendinous or muscular, distinct or indistinct) was also observed. Descriptive statistics, including means, standard deviations, and range, were calculated using STATA/IC 16.0.

**Results:** Among the specimens, the FDS arch was tendinous in 20 (58.8%) and muscular in 14 (41.2%) cases. The mean distance from the medial epicondyle to the apex of the FDS arch was 65.8±12.8 mm, and the mean thickness was 0.80±0.43 mm. A distinct arch was observed in 25 (73.53%) specimens, while an indistinct arch was found in 9 (26.47%) specimens.

**Conclusion:** The findings of this study contributed valuable insights for surgical interventions aimed at decompressing the median nerve entrapment in the proximal forearm.

**Keywords:** Entrapment neuropathy, Forearm, Median nerve, Pronator syndrome

## INTRODUCTION

The median nerve, formed by the junction of the lateral and medial fasciculi of the brachial plexus, originates from nerve fibers within the spinal roots of C5 to T1. After passing between the humeral and ulnar heads of the pronator teres muscle, the median nerve traverses beneath the fibrous arcade formed by the humeral, ulnar, and radial insertions of the FDS muscle [1-3].

In 1951, Seyffarth coined the term "pronator syndrome" [4]. Pronator syndrome is a rare compressive neuropathy characterised by insidious onset of indistinct pain in the proximal forearm, paraesthesia in the distribution of the median nerve, and pain during activity. It occurs due to compression of the median nerve in the proximal forearm by various anatomical structures [5-10]. The etiology of pronator syndrome varies, with the pronator teres accounting for 33% to 76% of cases, the bicipital aponeurosis accounting for 0% to 42%, and the FDS arch accounting for 14% to 36% [2,11-13]. Pronator syndrome can be mistaken for carpal tunnel syndrome, but the absence of nocturnal pain and reduced sensation in the distribution of the palmar cutaneous branch of the median nerve helps differentiate the two conditions [11]. Provocative tests have limited reliability in determining the site of nerve compression [1,3,14]. Tinel's sign can provide valuable information regarding the location of compression.

The fibrous arch connecting the humero-ulnar and radial heads of the FDS muscle (FDS arch) is one potential factor implicated in the compression of the median nerve in the proximal forearm, leading to pronator syndrome [15]. Surgical exploration and decompression are warranted in cases with signs of deficit, and a better understanding of the FDS arch would ensure reliable and effective exploration [16].

Studies on the FDS arch have been conducted in other populations, like the Caucasian, American, and Brazilian populations [15-17]. However, similar studies have not been conducted in the Indian population. Therefore, the present study was undertaken with the aim of describing the morphometric parameters of the FDS arch in the Indian population.

## MATERIALS AND METHODS

A cross-sectional cadaveric study was conducted at the Department of Anatomy, Christian Medical College, Vellore, India, from December 2018 to November 2020. The study received approval from the Institutional Ethical Committee (IRB Min No.11635 (OBSERVE) dated 08.11.2018).

**Inclusion criteria:** A total of 17 adult cadavers (8 male and 9 female) making to 34 forearms with ages ranging from 48 to 110 years (average age 77 years) were included in the study.

**Exclusion criteria:** Forearms that exhibited deformities due to trauma, congenital malformations, or scars were excluded from the study.

### Procedure

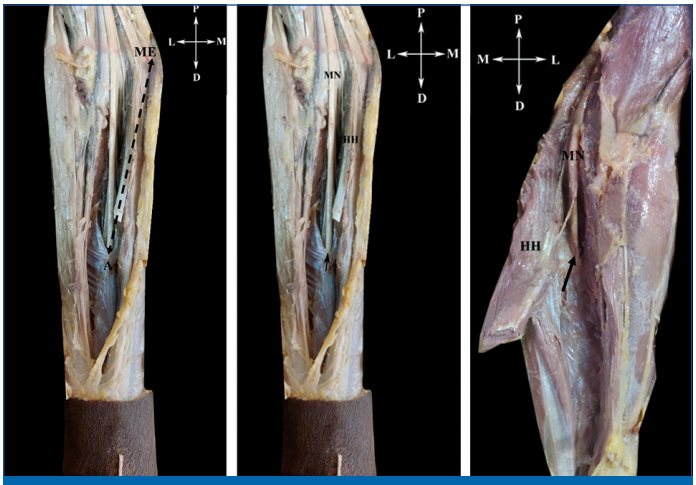
A midline incision was made from 5 cm above the cubital fossa to the middle of the forearm. The median nerve was identified in the distal third of the arm, along the medial margin of the biceps brachii muscle, and dissected distally into the forearm. Careful dissection of the FDS arch was done and the type of arch (tendinous or muscular) was observed. The arch was considered distinct if it exhibited a clearly visible fibrous transverse sling, with the median nerve passing beneath it. In cases where the arch had hazy margins and vertical muscle fibers overlying it, making the arch's outline unclear, it was classified as indistinct. Measurements were taken, including the thickness of the arch and the distance from the medial epicondyle to the apex of the arch [Table/Fig-1] [17]. All measurements were obtained using a digital vernier caliper.

## STATISTICAL ANALYSIS

Descriptive statistics, including means, standard deviations, and ranges, were calculated for the collected data. All statistical calculations were performed using STATA/IC 16.0.

## RESULTS

The humero-ulnar and radial heads of the FDS were present in all 34 dissected limbs (100%). The FDS arch was observed in all specimens, with 20 (58.8%) specimens exhibiting a tendinous arch and 14 (41.2%) specimens showing a muscular arch [Table/Fig-2-4].




**[Table/Fig-1]:** Distance from medial epicondyle (ME) to apex of FDS arch (A).
**[Table/Fig-2]:** Tendinous FDS arch.
**[Table/Fig-3]:** Muscular FDS arch. (Images from left to right)
MN: Median nerve; HH: Humeral head of pronator teres; FDS: arch (arrow)

| Types | Right | Left | Total (N=34 limbs) |
|---|---|---|---|
| **Tendinous** | 10 (29.4%) | 10 (29.4%) | 20 (58.8%) |
| **Muscular** | 7 (20.6%) | 7 (20.6%) | 14 (41.2%) |
| **Parameter** | Right | Left | Mean±SD |
| **Distance from the medial epicondyle to the apex of the arch** | 66.5±14.3 mm | 65.1±11.4 mm | 65.8±12.8 mm (40-100 mm) |
| **Thickness of arch** | 0.70±0.33 mm | 0.9±0.50 mm | 0.80±0.43 mm (0.15-17 mm) |

**[Table/Fig-4]:** Type and morphometric parametersof FDS arch.

The mean distance from the medial epicondyle to the apex of the FDS arch was found to be 65.8±12.8 mm, ranging from 40 to 100 mm. The average thickness of the arch was 0.80±0.43 mm, ranging from 0.15 to 17 mm [Table/Fig-4].

A distinct FDS arch was observed in 25 (73.53%) specimens [Table/Fig-5], while an indistinct arch was seen in 9 (26.47%) specimens [Table/Fig-6]. Among the specimens with an indistinct arch, overlying muscle fibers were found to obscure the proximal extent of the arch. None of the specimens with a distinct arch exhibited overlying muscle fibers.

## DISCUSSION

Several potentially compressive structures, including the FDS arch, can intersect with the median nerve in the elbow and proximal forearm [16]. Repetitive activities like pronation and supination can increase compressive force, leading to pain and paresthesia. Tubbs RS et al., found that elbow extension exerted pressure on the median nerve through the FDS muscle's arcade in their dissection of 60 forearms [17]. Compression caused by the bicipital aponeurosis resulted in vague discomfort, while pressure from the FDS arch caused sharp localised pain [13]. Symptoms of median nerve compression can be produced when resistance is applied while flexing the middle finger, causing the FDS arch to exert pressure on the median nerve [18].

Although there are several clinical tests available to differentiate the location of nerve compression, it is difficult to clinically differentiate


**[Table/Fig-5]:** Distinct arch of Flexor Digitorum Superficialis (FDS) (arrow).
**[Table/Fig-6]:** Indistinct arch of Flexor Digitorum Superficialis (FDS) (arrow head) median nerve (arrow). (Images from left to right)
MN: Median nerve; HH: Humeral head of pronator teres

the exact site of compression clinically [19]. The FDS arch exhibits the most variation in location among different specimens [16,17]. Measurements like the distance from the medial epicondyle to the FDS arch, along with palpation, can assist surgeons in localising the site of compression [17]. In a study by Dubois de Mont-Marin G et al., involving 36 forearms, the FDS arch was found to be 4.5 to 7 cm distal to the bi-epicondylar line [16]. In the present study, the FDS arch was located 6.5 cm from the medial epicondyle. The occurrence of the FDS arch in different studies is shown in [Table/Fig-7] [2,13-15,17,20]. Morphometric parameters of the FDS arch observed in different studies are shown in [Table/Fig-8] [16,17,21]. Knowledge of the exact location of the FDS arch can contribute to successful procedures and minimise postoperative complications.

| Year | Authors | Type of study | Forearms | Fibrous arcade | Percentage |
|---|---|---|---|---|---|
| 1979 | Johnson RK et al., [2] | Anatomical | 40 | 12 | 30% |
| 1981 | Hartz CR et al., [13] | Clinical (Surgical) | 32 | 12 | 33.5% |
| 1987 | Dellon AL and Mackinnon SE [14] | Anatomical | 31 | 11 | 36% |
| 2010 | Tubbs RS et al., [17] | Anatomical | 60 | 45 | 75% |
| 2014 | Guo B and Wang A [20] | Anatomical | 38 | 16 | 42% |
| 2018 | Caetano EB et al., [15] | Anatomical | 50 | 32 | 50% |
| 2021 | Present study | Anatomical | 34 | 20 | 58.8% |

**[Table/Fig-7]:** Occurrence of FDS arch in different studies [2,13-15,17,20, Present study].

| Parameter | Tubbs RS et al., [17] | Fuss FK and Wurzl GH [21] | Dubois de Mont-Marin G et al., [16] | Present study |
|---|---|---|---|---|
| **Distance from the medial epicondyle to the apex of the FDS arch** | 81 mm | - | - | 65.8±12.8 mm |
| **Distance from bi-epicondylar line to the apex of the FDS arch** | - | 65 mm | 45-70 mm | - |
| **Thickness of the arch** | - | - | - | 0.80±0.43 mm |

**[Table/Fig-8]:** Morphometric parameters of FDS arch in different studies [16,17, 21, Present study].

Among 39 patients who underwent surgery for median nerve compression in the proximal forearm, 22 of them experienced compression due to the FDS arch, 13 due to the pronator teres muscle, and 4 had compression from both [12]. Another study

involving 36 patients reported that 12 of them had median nerve compression caused by the FDS arch [13]. However, Johnson RK et al., noted FDS arch compression of the median nerve in only 7 out of 51 cases operated [2].

In their study on 38 cadavers, Guo B and Wang A found distinct arches in 16 (42%) specimens and indistinct arches in 22 (58%) specimens [20]. The outline of indistinct arches could not be clearly seen due to the presence of overlying muscle fibers in 17 specimens (77%), requiring additional dissection to visualise this structure. In the current study, the majority of cadavers, 25 specimens (73.53%) had a distinct type of arch, and none of them had overlying muscle fibers. Indistinct FDS arches with overlying muscle fibers require a longer incision and meticulous dissection for the surgical release of the median nerve. Failure to recognise the type of FDS arch during surgery can lead to inadequate decompression of the median nerve and absence of symptomatic relief.

Caetano EB et al., observed a fibrous arcade in 32 forearms (64%), a muscular arcade in 11 (22%), and a transparent arcade in 4 (8%) during their dissections [15]. Tubbs RS et al., dissected 60 forearms from 30 cadavers and found a tendinous arcade in 45 specimens (75%) and a muscular arcade in 15 (25%) [17]. Dellon AL and Mackinnon SE identified the presence of a fibrous arcade in 11 out of 31 (36%) dissected limbs [14]. Johnson RK et al., dissected 40 cadavers and identified a fibrous arcade in 12 (30%) [2]. In the present study, a tendinous arcade was observed in 20 specimens (58.8%) [Table/Fig-4]. Further studies are required to evaluate if symptomatic patients necessitating surgical release for pronator syndrome are more inclined to a specific variant of the FDS arch.

### Limitation(s)

The present study was conducted on formalin-fixed cadavers. Data obtained from fresh cadavers could provide information applicable to the clinical setting during decompression procedures for median nerve entrapment.

## CONCLUSION(S)

The findings of this study can contribute to the management of patients with proximal median nerve entrapment. Knowledge of the distance between the FDS arch and the medial epicondyle can assist in localising the arch. An indistinct arch requires a longer incision for complete decompression and a successful outcome.

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