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Original Research Article

Distal Arcade of Superficial Layer of Supinator Muscle: An Anatomical Study

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Abstract:

Background: The supinator muscle is located in the forearm and plays a role in the rotation of the forearm. Understanding the anatomy of the supinator muscle, including its layers and specific regions like the distal arcade, is important for healthcare professionals, especially in fields such as anatomy, physical therapy, and Orthopaedics.

Aim and Objectives: To make a detailed anatomic description of the distal arcade of the supinator muscle and its relation with the PIN.

Materials and Method: This was an observational study done on 50 upper limbs belonging to 25 adult cadavers (17 males and 8 females) available in the Department of Anatomy, Chalmeda Anand Rao Institute of Medical Sciences, and Karimnagar. The age of the cadavers ranged from 35 to 86 years. Study was conducted after getting permission from institutional ethical committee and after following inclusion and exclusion criteria given below for the duration of 2 years.

Results: In the present study 50 forearms and elbows were dissected. The nature of the distal arcade of superficial layer of supinator muscle that was most commonly seen was the muscular type 21(42%), followed by the musculotendinous and tendinous types.

Conclusion: Knowledge of the anatomic findings of the distal arcade of the superficial layer of the supinator and the localization of the PIN are important in the surgical management of PIN entrapment.

Keywords: Supinator Muscle, Posterior interosseous nerve, Radius, Upper limb.

Introduction

The supinator muscle is located in the forearm and plays a role in the rotation of the forearm. It has two layers: a deep layer and a superficial layer. The superficial head originates from the lateral epicondyle, the annular ligament and the radial collateral ligament of the elbow joint. The deep head originates from the supinator crest on the posterolateral surface of the ulna. The two heads wrap around the posterior and lateral aspects of the head, neck and proximal shaft of the radius to insert on the lateral surface of the shaft of the radius. The supinator helps in supination of the forearm and hand and is innervated by the deep branch of the radial nerve (DBRN) called the posterior interosseous nerve (PIN).

The PIN syndrome is a compressive neuropathy of the PIN which affects the nerve supply of the forearm extensor muscles. The pain in the PIN syndrome is insidious in onset and is felt just distal to the lateral epicondyle. There is weakness of wrist and finger extension. The pain is exacerbated by repetitive acts of pronation [1]. The most frequent site of entrapment of PIN is found to be at the proximal arcade of the superficial layer of supinator muscle (arcade of Frohse) [2-4]. Another site that can cause compression is at the distal arcade of the superficial layer of supinator muscle.

The distal arcade is a term that refers to a portion of the superficial layer of the supinator muscle. The supinator muscle originates from the lateral epicondyle of the humerus and the supinator crest of the ulna. It wraps around the radius, forming a kind of "arcade." The distal arcade of the superficial layer is a specific region of this muscle, likely referring to the part closer to the hand or distal end. Understanding the anatomy of the

supinator muscle, including its layers and specific regions like the distal arcade, is important for healthcare professionals, especially in fields such as anatomy, physical therapy, and orthopedics. Knowledge of these structures is crucial for diagnosing and treating conditions related to the forearm and hand. There are not many studies on the distal arcade of the superficial layer of supinator muscle and its relation to adjacent landmarks in the Indian population. Thus, current study we have undertaken to make a detailed anatomic description of the distal arcade of the supinator muscle and its relation with the PIN.

Materials and Method

This was an observational study done on 50 upper limbs belonging to 25 adult cadavers (17 males and 8 females) available in the Department of Anatomy, Chalmeda Anand Rao Institute of Medical Sciences, and Karimnagar. The age of the cadavers ranged from 35 to 86 years. Study was conducted after getting permission from institutional ethical committee and after following inclusion and exclusion criteria given below for the duration of 2 years.

Inclusion criteria: All normal upper limbs were included in the study.

Exclusion criteria: Deformed limbs and limbs which showed signs of trauma were excluded from the study.

Method:

The cadaver was placed in supine position on the dissection table. Both the upper limbs were extended and placed in mid prone position and tied to the arm boards. The palpable bony landmarks like the lateral and medial epicondyles, head of the radius, radial styloid process, and ulnar styloid process were identified. A longitudinal incision was made from 5cm above the cubital fossa till the wrist. Transverse incisions were made at the proximal and distal ends of the longitudinal incision. The skin flaps were reflected. The superficial fascia with cutaneous nerves and vessels was removed. The deep fascia covering the muscles was cleaned. The Brachioradialis muscle, extensor carpi radialis longus and extensor carpi radialis brevis muscles were defined. The medial margin of extensor carpi radialis brevis muscle was defined. The superficial layer of the supinator muscle was identified. The proximal and distal borders of the superficial layer of supinator muscle were exposed. The radial nerve was identified between the brachioradialis muscle and the brachialis muscle and the division of the nerve into superficial branch and the posterior interosseous nerve was dissected. The fatty fibrous tissue around the head of the radius was also removed. The posterior interosseous nerve was seen to enter the arcade of Frohse. The nature and knowledge of distances of the structures that cause compression of the PIN from bony landmarks is necessary to decompress the PIN in the treatment of posterior interosseous nerve entrapment.

The following variables were examined and analysed:

- Nature of the distal arcade of superficial layer of supinator muscle (in males and females)
- Distance between tip of lateral epicondyle and proximal arcade (arcade of Frohse) of superficial layer of supinator muscle
- Distance between proximal and distal arcades of superficial layer of supinator muscle
- Distance between humeroradial joint line and distal arcade of superficial layer of supinator muscle
- Distance between transepicondylar line and distal arcade of superficial layer of supinator muscle
- Distance between lateral epicondyle and entrance of PIN at arcade of Frohse.
- Distance between lateral epicondyle and exit of PIN from supinator.

Statistical Analysis:

Collected data was entered in the Microsoft Excel 2016 for further statistical analysis. Categorical data was expressed in frequency and percentage and quantitative data was expressed in terms of mean and standard deviation. Mean length difference between two sides of upper limbs was assessed with the help of t-test. P-value<0.05 was considered as statistically significant at 5% level of significance.

Observation and Results:

In the present study 50 forearms and elbows were dissected. The nature of the distal arcade of superficial layer of supinator muscle that was most commonly seen was the muscular type 21(42%), followed by the musculotendinous and tendinous types shown in below table and figure.

Table 1: Nature of distal arcade of superficial layer of supinator muscle among gender

Gender	Nature of distal arcade			Total
	Tendinous	Musculotendinous	Muscular	
Male	5(14.3%)	14(40%)	16(45.7%)	35(100%)
Female	5(33.3%)	5(33.3%)	5(33.3%)	15(100%)
Total	10(20%)	19(38.0%)	21(42%)	50(100%)

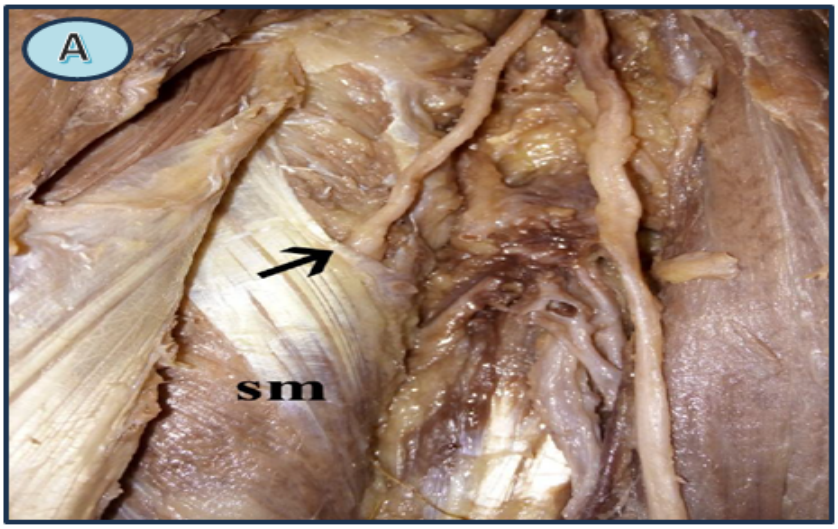

Figure A: Tendinous arcade of Frohse

Figure B: Musculotendinous arcade of Frohse

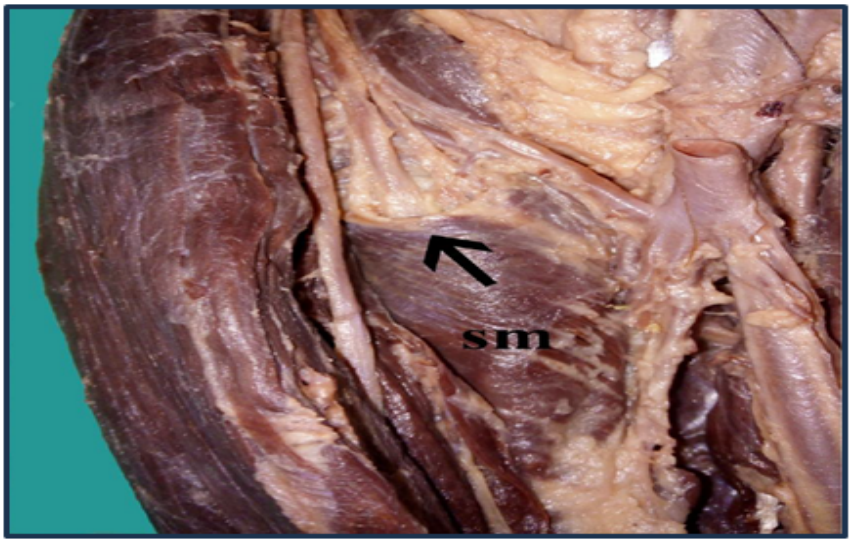

Figure C: Muscular arcade of Frohse

Table 2: Distances from the distal arcade and Posterior Interosseous Nerve (PIN) to important anatomical landmarks

Parameter	Right Side (Mean ± SD) mm	Left Side (Mean ± SD) mm	t-test	P-value
Distance between tip of lateral epicondyle and proximal arcade of superficial layer of supinator muscle	61.20±8.49	58.32±9.45	1.6031	0.1121
Distance between proximal and distal arcades of superficial layer of supinator muscle	56.12±12.14	52.36±13.45	1.4674	0.1455
Distance between humeroradial joint line and distal arcade of superficial layer of supinator muscle	92.46±10.49	88.26±12.45	1.8242	0.0712
Distance between transepicondylar line and distal arcade of superficial layer of supinator muscle	104.23±13.24	105.69±11.47	0.5893	0.557
Distance between lateral epicondyle and entry of PIN into supinator at the proximal arcade	61.27±9.36	60.31±10.57	0.4808	0.6317
Distance between lateral epicondyle and exit of PIN from supinator	87.26±11.63	86.43±10.64	0.3723	0.7105

Discussion

The supinator muscle is closely associated with the motor branch of the radial nerve, also known as the PIN. This nerve traverses the confined space between the superficial and deep layers of the supinator muscle, and compression during this course may result in a persistent, dull ache experienced on the lateral side of the elbow and the proximal area of the lateral forearm. [5].

The consistency of the Superficial layer of the supinator muscle is believed to possess the ability to exert compression on the PIN (Posterior Interosseous Nerve). [6]. Other factors implicated in the entrapment of the PIN (Posterior Interosseous Nerve) include the inner side of the Extensor Carpi Radialis Brevis (ECRB) muscle, the vascular arcade of the radial recurrent artery along with its branches, and a group consisting of the joint capsule, tendon, and aponeurosis situated on the front side of both the humeroradial joint and the radial head. [7-9].

Paralysis of the PIN (Posterior Interosseous Nerve) has been attributed to various structures, including neuromas, schwannomas, traumatic aneurysms of the posterior interosseous artery, neurofibromas, ganglion cysts, and myxomas, according to reported cases. While paralysis of this nerve can result from trauma, it's important to note that numerous instances of PIN entrapment occur without any preceding history of injury. [10].

Tennis players frequently experience the syndrome of PIN entrapment. [11]. primarily a motor syndrome, it is characterized by a decrease or absence of extension in all digits and the atrophy of posterior forearm muscles, excluding the brachioradialis and extensor carpi radialis longus. As the extensor carpi radialis longus muscle is typically innervated by the radial nerve trunk, wrist drop is usually absent. During the assessment of wrist extension, radial deviation may occur due to the contraction of the extensor carpi radialis longus muscle. [12]. The common factor frequently linked to the causation of the PIN syndrome is the proximal border of the superficial layer of the supinator muscle, known as the arcade of Frohse. [2,9].

The compression of the PIN beneath the arcade of Frohse can be encouraged by recurrent pronation and supination movements. [8,13]. It was noted that only fibrous or tendinous arcades exert pressure on the PIN. [14, 15]. The arcade of Frohse was initially identified as a typical anatomical tendinous structure by Frohse F and Frankel M in 1908. [2].

Spinner proposed that in newborn full-term fetuses, the most proximal segment of the superficial layer of the supinator muscle is consistently muscular, transforming into a semicircular structure in adults as a result of repetitive rotational movements involving forearm pronation and supination. Tatar I et al. documented identical observations in their examination of forearms in 40 fetal subjects. [16].

The distal arcade within the superficial layer of the supinator muscle is identified as another factor that may lead to compression of the posterior interosseous nerve (PIN). The distal arcade was initially recognized by Sponseller PD and Engber WD in 1983 as a possible source of compression for the PIN as it emerges from the supinator. [17]. In their research, Riffaud L et al. discovered that the majority of distal arcades exhibited a muscular composition [9].

In contrast, studies conducted by Berton C et al., Konjengbam M and Elangbam J, and Prasartritha T et al. indicated a tendinous nature. [1,8,18]. In comparable investigation conducted by Hohenberger GM et al. ad Caetano EB et al., a greater number of speciments revealed that the distal arcade exhibited a muscular nature rather

than a tendinous one [19, 20]. The findings in the present study, regarding the nature of the distal arcade, are in accordance with those of Riffaud L et al., Hohenberger GM et al., and Caetano EB et al., [9,19, 20].

The repetitive movements of pronation and supination can exacerbate the compression of the posterior interosseous nerve (PIN) as it exits the supinator muscle beneath the distal arcade. Among males, the prevalent occurrence of the muscular form of distal arcade aligns with their robust body build. Understanding the distances between the entrance and exit points of the PIN from the supinator muscel is crucial for surgical interventions addressing Pin entrapment. In our study, we observed that the distances from the lateral epicondyle to the PIN entrance at the arcade of Frohse and the PIN exit at the distal arcade ware 61.47 mm and 85.60 mm respectively.

These finding align with Tubbs RS et al.'s study, where the mean distance from the lateral epicondyle to the PIN entrance at the arcade of Frohse was 60mm (ranging from 45 to 75 mm), and the mean distance from the lateral epicondyle to the PiN exit at the distan arcade was 120mm (Ranging from 100-150mm) [12]. Additional anatomical reference points for pinpointing the location of the posterior interosseous nerve (PIN) include the humero-radial joint line and the trans-epicondylar line. [1].

In cases where there is no improvement in functional recovery or if symptoms worsen after three months of conservative therapy, surgical treatment is recommended for a compressed posterior interosseous nerve (PIN). The operative release of the PIN is generally successful. [21], providing relief to the patient is a primary goal. The current study's findings will assist surgeons in decompressing the posterior interosseous nerve (PIN) with minimal surgical morbidity.

While the distal arcade is recognized as a compression zone for the PIN, it has not been thoroughly described. The identification of a predominantly muscular distal arcade in this study is significant because persistent pronation-supination movements can lead to alterations in this muscular structure, resulting in actual pathology. Understanding the PIN's localization in relation to the lateral epicondyle is valuable during PIN neurolysis. Knowledge about the distal arcade's position concerning the humero-radial and trans-epicondylar lines can be beneficial for surgeons aiming to decompress the PIN in the surgical management of lateral elbow pain.

Conclusion

Understanding the anatomical characteristics of the distal arcade within the superficial layer of the supinator muscle is crucial in comprehending the pathophysiology of the posterior interosseous nerve (PIN) syndrome. Prior to surgical management of PIN neuropathy, it is essential to have knowledge about the distances between the distal arcade of the superficial layer of the supinator and specific anatomical landmarks. Localizing the entrance and exit points of the PIN with respect to a reference point, such as the lateral epicondyle, is important to prevent inadvertent injuries during the treatment of PIN entrapment. Further investigations using fresh cadaveric specimens are necessary to obtain anatomical data that can be directly applied to clinical settings in the treatment of PIN entrapment.

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