Original Article

An Anatomical Attributes Ascribing Radial Tunnel Syndrome

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Abstract

Background: The most frequent location for compression of the radial nerve surrounding the radial tunnel and the ulnar nerve on the medial side is the elbow. Radial neuropathy prognosis can be greatly impacted by early diagnosis and treatment. Studies on the prevalence and incidence of ulnar neuropathy are scarce. Our study emphasises the importance of the anatomical review prior to surgical management for patients with this condition by comparing the morphological characteristics of structures such as the arcade of Frohse, Extensor carpi radialis brevis, and leash of Henry around the tunnel on both limbs with the clinical correlation. **Material and Methods:** The morphological characteristics of the arcade of the frohse, the distal edge of the supinator, the extensor carpi radialis brevis, and the henry's leash around the radial tunnel were recorded after 42 formain fixed upper limbs were dissected. **Results:** Out of the 42 upper limbs that were dissected, the right upper limb had 57% tendinous, 24% membranous, and 10% muscular, whereas the left upper limb had 48% muscular, 25% membranous, and 14% tendinous type of arcade of Frohse. In the right and left upper limbs, the distal supinator edge was fibrous in 71% and 59.5%, respectively. Additionally, practically all limbs, regardless of side, have radial recurrent arteries running above them. **Conclusion:** An unusual interaction between the Radial nerve and its surrounding structures around the Radial tunnel may have an impact on the sensory-motor activity of the entire dorsal upper limb. It is crucial for radiologists and surgeons to understand the anatomical changes surrounding the radial tunnel in order to assess the nature of issues associated with radial nerve neuropathy.

Keywords: Radial nerve, Tunnel syndrome.

Received: 15 June 2026 **Revised: 07 July 2026** **Accepted: 28 July 2026** **Published: 31 July 2026**

Introduction

Peripheral neuropathy anatomy is essential for improving focused treatment interventions and diagnostic precision, particularly in the setting of sports medicine.[1]

Parts of the back of the arm, forearm, wrist, and hand get movement and sensory function from the radial nerve, a peripheral nerve. The main trunk of the radial nerve supplies the triceps muscles on the back of the upper arm to straighten the elbow, while the posterior interosseous nerve supplies the extensors of the forearm to straighten the wrist and hand. This is why the nerve is called the radial nerve because it runs alongside the radial bone for the majority of its length.[2] The radial nerve splits into a deep motor branch and a superficial sensory branch at the lateral epi condyle of the humerus. The skin on the inner upper arm and outer forearm receives touch, pain, and temperature sensations from the sensory branch. and the terminal phalanges that are closest to the thumb, as well as the back portion of the wrist and the lateral 31/2 of the dorsum hand and fingers.

The terminal motor branch, which runs in the supinator tunnel at the elbow and then between muscles in the back of the forearm, stimulates upper limb extension (e.g., when you open your hand from a clenched fist position) and, crucially, aids in forearm rotation (supination, as in keeping food in the mouth). The location of the pathology or compression, which is frequently around the supinator tunnel, determines the motor deficits associated with this motor branch (posterior interosseous nerve) paralysis.

Disrupted extension of the thumb's and fingers' metacarpophalangeal joints as well as the thumb's interphalangeal joint, known as "finger drop," are signs of PIN impairment. Normal perception is maintained. Radial deviation of the wrist during extension is the outcome of extensor carpi ulnaris paralysis. "Wrist drop" is the term for the impairment of wrist extensors brought on by an RN injury. Extensor carpi radialis longus, brevis, and digitorum weakness is the cause of this ailment.[4] Elbow, wrist, hand, and finger straightening difficulties brought on by a wrist drop deformity (limply hanging wrist that is unable to lift). It results in unpleasant difficulties grabbing, pinching, or picking up objects, which restricts daily tasks. Radial tunnel syndrome is typically diagnosed using a multimodal method that involves magnetic resonance imaging, ultrasonography, and electromyography.[5]

Professionals with mild pronosupination motions, like

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DOI:
10.21276/amit.2026.v13.i2.889

How to cite this article: Begum A, Sangeetha K, Vrushali PK. An Anatomical Attributes Ascribing Radial Tunnel Syndrome. Acta Med Int. 2026;13(2):1411-1415.

musicians, are susceptible to radial tunnel syndrome. Computer programmers who use wrist extensions on a keyboard.

Even though some cases are treated conservatively, others call for appropriate surgery, which necessitates knowledge of the anatomical characteristics affecting the presenting symptoms and the associated prognoses. The surrounding structures surrounding the radial tunnel, such as the Arcade of Frohse, Extensor carpi radialis brevis, and Leash of Henry, are typically thought to be the cause of radial nerve compression or Supinator tunnel syndrome. Our current work attempts to correlate the anatomical traits with the laterality of frequently used limbs, whereas other studies concentrated on morphological variables.

Therefore, the current study's goal is a) to examine the anatomical characteristics, consistency, and morphological aspects of the structures around the radial tunnel.

B) to classify the variables that may worsen compression and correspond with the accompanying clinical characteristics.

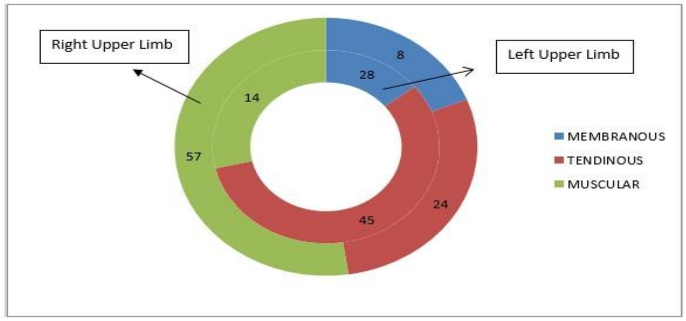
Materials and Methods

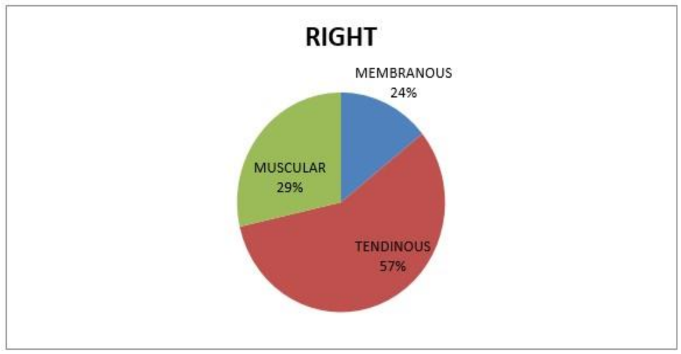
Methodology: We examined 44 upper limbs in 22 cadavers (12 males and 10 females) who were older than 60 to 70 years during the routine dissection of upper limbs of embalmed adult cadavers in the anatomy department. There were no obvious abnormalities or signs of surgery on the skin around the dissected area in the cadavers under study.

To see the radial tunnel, arcade of Frohse, distal edge of the supinator, leash of Henry, and extensor carpi radialis brevis, as well as their differences in anatomical features, the skin, superficial fascia, and deep fascia were separated and different muscles were reflected. The results were classified as membrane, fibrous, or muscular ECRB, arcade of frohse, and distal edge of supinator. It was also observed how the radial recurrent artery branched around the PIN at the Frohse arcade.

All specimens were photographed, and all measurement findings are presented as the mean (minimum–maximum) and analysed in Excel. The statistical program SPSS 16.0 was used to analyse the data collected from foetuses. The parameters' mean values and standard deviations were calculated by trimester. The statistical analysis's significance level was established as $p < 0.05$. The groups were compared to one another using variant analysis (One Way ANOVA).

Results





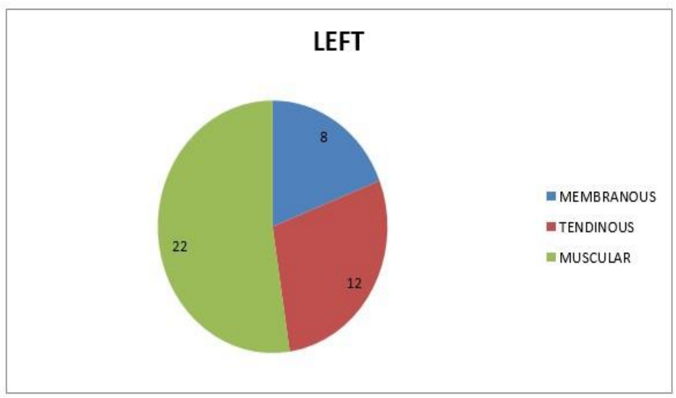


Table 1: ?

Order	Location	Basis for compression for deep branch of Radial Nerve.	RIGHT LIMB	LEFT LIMB
1)	The entire length of radial tunnel (Bony Landmark-Lateral epicondyle)	- Average The point of entry- The point of exit-	6.3 ± 0.5cm 4.1 + 0.2 cm 10 + 0.3cm.	5.21± 0.3cm 3.9 + 0.2 cm 9 .3+ 0.3cm.
2)	The proximal part of supinator muscle- Arcade of Frohse	Membranous- Fibrous/Tendinous Muscular-	6(24%) 24(57%) 12(10%)	8(28%) 12(45%) 22(14%)
3)	Distal edge of radial tunnel	-FIBROUS Muscular	30(71.4%) 12(28.5%)	27(59.5%) 15(40.4%)
4)	Leash of Henry	ABOVE THE NERVE- BELOW THE NERVE- MOTOR BRANCH- ABOVE THE NERVE- BELOW THE NERVE-	39(92.8) 1 3(71.4) 0% 42(100%)	40(95.2%) 2 1(2.3) 1(2.3%) 41(97.6%)

Figure 1A: arcade of frohse membranous edge, Figure 1B: arcade of Frohse -fibrous edge, Figure 3C: arcade of frohse -muscular edge Figure 4D: leash of henry with radial nerve

Discussion

Typically, the three main nerves of the upper limb—the ulnar, median, and radial nerves—enter the forearm from the arm by travelling between the heads of the forearm compartment muscles. For example, the ulnar nerve passes between the heads of the flexor carpi ulnaris, the median nerve passes between the heads of the pronator teres, and the radial nerve passes between the supinator.

They are vulnerable to compression because to their intramuscular route and surrounding structures, which can result in radial tunnel syndrome, pronator teres syndrome, and cubital tunnel syndrome, respectively. The radial nerve begins as a branch of the posterior cord of the brachial plexus in the axilla. It travels through the lower triangular space between the triceps and the spiral grove of the humerus before ending in front of the lateral epicondyle, where it splits into a superficial and deep in front of the elbow.

The deep branch travels between the superficial and deep heads of the supinator to enter the back of the forearm and supply the forearm's extensors, while the superficial branch becomes cutaneous and runs along the radial border.[3] The deep motor branch nerve that passes inside the supinator (radial tunnel) to reach the back of the forearm is susceptible to compression neuropathy in part because of the variable features of the structures surrounding the supinator tunnel as well as partially because of occupational practices. In contrast, the trunk of the radial nerve that passes in the arm in direct contact with the humerus is prone to traumatic injuries.[4-6] However, mimicking the symptoms of other illnesses and the number of compressing factors might provide a serious clinical difficulty.[7]

A fibrous band that connects the two heads of the supinator muscle forms the arcade of frohse. In 1908, Fritz Frohse, a German anatomist, was honoured with the name. The DBRN's entrapment by the AF was first documented by Kopell and Thompson in 1963. In 1966, Capener documented the DBRN's vulnerability at the AF. In 1968, Spinner reported the DBRN compression at the AF. Although infrequently observed, Genç et al. noted the use of Canadian crutches, suggesting mononeuropathies caused by external compression. According to reports, the most frequent location for radial nerve compression is the AF.[8]

According to Frohse and Frankel's 1908 description, the AF is a typical tendinous structure seen near the superior edge of the superficial lamina of the supinator. However, later research classified two types of AF based on the consistency of the fibres that make up the AF: the tendinous,[8-10] and the membranous.[11,12]

A review of the literature reveals that the percentage of tendinous AF varies greatly (from 30% to 100%), but the side discrepancies are not explained.

Any activity requiring wrist extension, pronation, or supination during manual labour, housework, or hobbies is regarded as a significant contributing factor to this injury, which is frequently described as work-related. Sports include bodybuilding/weightlifting, frisbee, gymnastics, tennis/racquetball, and swimming; violinists, symphonic conductors, bartenders, corsetiers, and dairy workers have also been mentioned. Exposure of the arms to vibration and sustained high-intensity handgrip force on an extended elbow have been recognised as work-related risk factors for employees,[12] causing limited painful forearm activities and deaf pain in the dorso-radial part of the proximal forearm. Additionally, as demonstrated by violinists and other artists, playing an instrument can exacerbate this illness. Furthermore, it has been demonstrated that extreme pronation in cadavers increases pressure on the supinator and the nerve beneath the SASM.[13,14]

The intraoperative findings of a fibrotic AF and swollen nerve indicate that occupational factors, ranging from heavy manual labourers to musicians, may contribute to the hypertrophy of this structure. The tendinous consistency of the supinator arch/aof is thought to develop in adults as a result of repeated pronosupinatory rotary movements that cause muscle hypertrophy.[14] Instead of classifying the different fibres of the arcade of frohse as musculo aponeurotic as Debouck & Rooze,[15,16] did, we looked for aof to be muscular (i.e., consisting of skeletal muscle fibres), membranous (i.e., consisting of connective tissue), tendinous/fibrous (i.e., consisting of collagen fibres) only. While a fibrous or tendinous edge combined with repeated pronation may result in a mild to moderate rise in pressure in the tunnel, the membranous and muscular edges of the supinator may cause pronosupinatory movements. Supination may be a risk factor for radial nerve compression in the radial tunnel.

Our findings of tendinous margin (62% in the right upper limb vs. - in the left upper limb) are consistent with the fact that the condition does not exist bilaterally and is frequently work-related, which suggests that the disease pathology is frequently seen in dominant limbs (usually the right limb). in contrast to the left upper limbs' prominent muscular-membrane borders.[15,16]

Two forms of Frohse arcades were described by Spinner et al. and Prasarthrita et al. from their cadaveric research. One is of the fibrous type (57%, thick and immobile), while the other is of the membranous kind (43%, thin, movable). Spinner and associates. 30% of adults and none of full-term foetuses had fibrous arches, which led to the theory that the fibrous arcade was most likely secondary acquired in reaction to recurrent forearm rotation.

According to Bene's' meta-analysis,[14] the pooled prevalence of Frohse's arcade was 66% in adults and 0% in foetuses. This corroborates our findings regarding the fibrous characteristic in the dominant right limb of activity. This suggested that prolonged, repetitive pronation-supination movements of the forearm in some activities had led to the development of the fibrous arcade of frohse.

In clinical research, Werner (89%, 80/90 patients) and Lister et al. (100%, 20/20 patients) observed significant percentages of tendinous AOF. Eighty-seven percent of the tendinous AOF was found in our study. Additionally, Spinner,[16] noted that when a tendinous AF is present, especially if it is thick, and the nerve's passageway is small, entrapment of the DBRN becomes a clear possibility. Only 8% of AF openings in our current study were semicircular, while 36% and 72%, respectively, had semi-oval and oblique elongated AF.

Numerous studies,[20-24] discuss the morphological characteristics of the Frohse arcade; however, the distal edge of the supinator is rarely or never mentioned in earlier studies.[25-28] It is evident that both the proximal and distal edges of the supinator have tendinous/fibrous margins in the right and left limbs in every specimen dissected (cases). This suggests that when the radial nerve travels through a supinator tunnel, if both the inner and outer edges have fibrous structure, the tunnel passage may narrow with increasing pressure during prolonged, repeated forearm rotatory movements caused by supinator contractions, thereby contributing to radial neuropathy. Consequently, during release operations, it becomes even more crucial to monitor both supinator margins.

Extensor Carpi Radialis Brevis: According to ECRB,[28,29] this edge, which resembles an arch, is present in the aspect superomedially of the ECRB and is tendinous in 29.1% of its specimens, muscular in 11.1%, and lacking in 59.7%.

The radial nerve at the ARCADE OF FROHSE may eventually be compressed due to the anatomical characteristics of this tendinous edge. When treating radial tunnel syndrome surgically, it should be taken into account.(30) However, the radial nerve first passes between the brachialis and the extensor carpi radialis longus muscles, according to our current study.

It then moved posteriorly, passing between the deep and superficial heads of the supinator muscle and puncturing its belly. It was an unusual source of compression because it had no interaction with the ECRB edge. There were no ECRB muscle variations that we came across. Few studies have mentioned that the nerve coming into contact with the ECRB muscle may be the cause of lateral epicondylitis, and the relationship to the deep branch of the radial nerve is not well explained in earlier literature. But it's important to keep in mind that the tenderness point of lateral epicondylitis is at the lateral epicondyle, which is too different from the tenderness point of radial nerve neuropathy, which is a few inches below the lateral epicondyle. As a result, these two conditions are distinct clinical scenarios with different aetiologies.

Leash of Henry: The radial artery gives rise to the radial recurrent artery, usually shortly after its development. usually lies on the supinator muscle and rises proximally between the radial nerve's branches. supplies blood to the elbow joint and muscles such as the brachioradialis, supinator, and brachialis.[31] It anastomoses with the Profunda brachii artery's radial collateral artery, which is a branch of the arm's deep artery.

It is clear from considering the strong nature of nerve vessel relationships, particularly nerve vascular crossings under different forearm postures, that nerve vessel compression can result in focal demyelination and mechanical nerve irritation,[32] making diagnosis challenging, despite being a very uncommon cause of mono-neuropathy. The radial nerve's motor branch is susceptible to compression due to its near proximity to the radial recurrent artery's branches. Atypical positioning or chronic pulsatile trauma can result in chronic neural damage, such as punched nerve syndrome.[33,34] Compared to lower limb neuropathies, ulnar and radial nerves have been shown to experience chronic neural damage as a result of repetitive pulsatile compression, particularly when compression occurs by crossing branches of the recurrent radial artery- When considering surgical exploration of mononeuropathies, clinicians and intervention radiologists should consider the so-called hypertrophic "leash(es) of Henry" (LOH) as crucial alerts for aetiologies on their differential. Loizides reported in his ultrasonographic studies two cases with patients exhibiting a distinct topographic hypoechoeic textural change of the deep radial nerve due to the causative hypertrophic crossing artery.

Similar compression neuropathy at the level of the arcade of frohse, caused by the fat plane dividing the nerve from the vessel, was also documented by Mohan.Below is a radial recurrent ascending branch. Our research revealed the radial recurrent ascending branch crossing below in -18% (7/42 cases) and above the nerve in -62% (26/42), the muscular branch crossing below (6/42), and the DBRN only muscular branch above (3/42) were the most prevalent neurovascular crossing patterns. Our study's only use of cadavers and lack of gender distinction is one of its limitations. A larger sample size with gender inclusion could potentially improve the findings.

Conclusion

A disorder known as "radial tunnel syndrome" is commonly observed in people who work or participate in sports. For these patients, the possibility of pain treatment and a speedy recovery from surgery are frequently of utmost importance.

During such open surgery, hand surgeons may be able to predict and more easily identify the specific anatomic changes indicated, improving the effectiveness and safety of this routine procedure.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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