

# Relationships Between the Posterior Interosseous Nerve and the Supinator Muscle: Application to Peripheral Nerve Compression Syndromes and Nerve Transfer Procedures

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## Abstract

**Background and Study Aims** Little information can be found in the literature regarding the relationships of the posterior interosseous nerve (PIN) while it traverses the supinator muscle. Because compression syndromes may involve this nerve at this site and researchers have investigated using branches of the PIN to the supinator for neurotization procedures, the authors' aim was to elucidate information about this anatomy.

**Materials and Methods** Dissection was performed on 52 cadaveric limbs to investigate branching patterns of the PIN within the supinator muscle.

**Results** On 29 sides, the PIN entered the supinator muscle as a single nerve and from its medial side provided two to four branches to the muscle. On 23 sides, the nerve entered the supinator muscle as two approximately equal-size branches that arose from the radial nerve on average 2.2 cm from the proximal edge of this muscle. In these cases, the medial of the two branches terminated on the supinator muscle, and the lateral branch traveled through the supinator muscle; in 13 specimens, it provided additional smaller branches to the supinator muscle. The length of PIN within the supinator muscle was 4 cm on average, and the diameter of its branches to the supinator muscle ranged from 0.8 to 1.1 mm. In 10 specimens, the PIN left the supinator muscle before the most distal aspect of the muscle. In two specimens with a single broad PIN, muscle fibers of the supinator muscle pierced the PIN as it traveled through it.

**Conclusion** This knowledge of the anatomy of the PIN as it passes through the supinator muscle may be useful to neurosurgeons during decompressive procedures or neurotization.

## Keywords

- ▶ anatomy
- ▶ compression
- ▶ neurosurgery
- ▶ peripheral nerve
- ▶ upper limb

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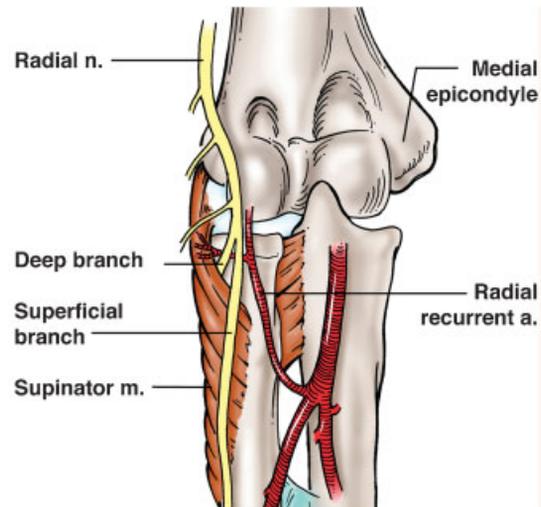
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## Introduction

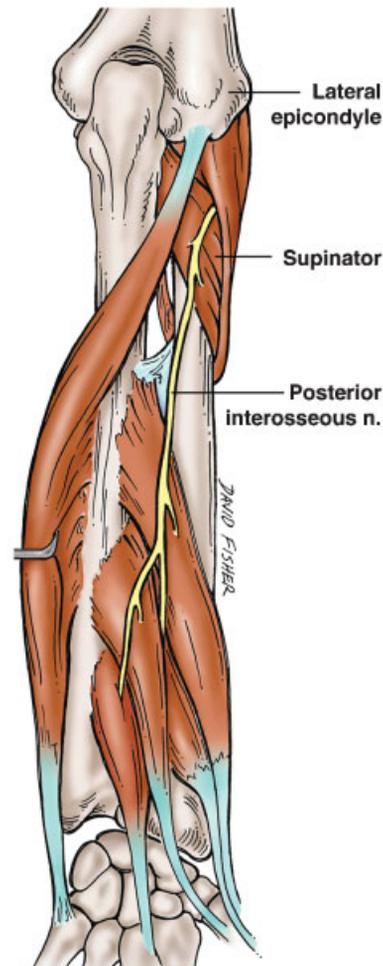
Radial nerve entrapment syndromes in the forearm make up approximately 1% of all nontraumatic lesions of the upper limb.<sup>1</sup> Two locations for such entrapments are within the radial tunnel and at the supinator muscle. Supinator (channel) syndrome, also known as posterior interosseous nerve (PIN) syndrome, involves irritation or compression of the PIN by the overlying layer (outer lamina) of the supinator muscle.<sup>2</sup> Carfi and Ma<sup>3</sup> proposed that supinator syndrome is a special case of the more general PIN syndrome. Many patients with supinator syndrome have reported prior trauma (e.g., elbow fracture or dislocation), penetrating wounds, or numerous supination movements that involve the supinator muscle. Nontraumatic dysfunction of the PIN has been seen with tumors, ganglion cysts, bursitis, and rheumatoid disease.<sup>4-7</sup> This syndrome may also result from an abnormally high amount of fibrous tissue in the proximal region of the muscle (arcade of Frohse).<sup>8-10</sup>

Pain localized to the posterior forearm; compression pain distal to the lateral epicondyle; and rarely, gradual weakness of the extensor muscles are signs of the supinator syndrome. The pain may be aggravated by forced supination or wrist extension against resistance.<sup>3,11</sup> A point of tenderness may be elicited 2 finger-breadths distal to the elbow crease.<sup>3</sup> Symptoms often imitate those seen in lateral epicondylitis; however, assessment of wrist extension in the presence of resistance is used in differentiating between inflammation and nerve entrapment.<sup>3,11</sup> Imaging tests are recommended to rule out any lesions that may be involved with PIN syndrome.<sup>12</sup> Rest (8-12 weeks) is generally indicated for those with negative results, and if the tests show signs of lesion or an abnormal mass, surgery is usually indicated.<sup>13</sup>

After arising from the radial nerve in the cubital fossa near the radiohumeral joint line, the PIN descends, passing over the anterior aspect of the radiohumeral joint, and travels deep to the superficial lamina of the supinator muscle. At this point, this branch is sometimes simply referred to as the deep branch of the radial nerve (►Fig. 1). Proximal to this region, the radial nerve travels in the radial tunnel. This approximately 5-cm-long canal begins at the humeroradial joint and extends to the proximal supinator muscle.<sup>8,12,14</sup> From the cubital fossa, the PIN then travels to the posterior aspect of the forearm around the lateral side of the radius, exiting between the two layers of the supinator muscle, and is prolonged distally to the middle of the forearm (►Fig. 2). After coursing through the supinator muscle, the PIN divides and typically gives off six branches to the extensor carpi ulnaris, extensor digiti minimi, extensor digitorum communis, extensor pollicis brevis and longus, abductor pollicis longus, and extensor indicis muscles. In some cases, the PIN also gives branches to both radial extensors of the wrist before it enters the supinator muscle. Considerably diminished in size, the PIN travels posterior to the interosseous membrane, anterior to the extensor pollicis longus muscle, to the dorsum of the carpus, where it sends filaments to the ligaments and articulations of the dorsal carpus. Additionally, this distal articular segment may supply the periosteum of the radius and the interosseous



**Fig. 1** Schematic drawing (anterior view) of the proximal posterior interosseous nerve (deep branch of radial nerve) before its entrance into the supinator muscle.



**Fig. 2** Schematic drawing (posterior view) of the posterior interosseous nerve as it leaves the supinator muscle in this case before traveling throughout the muscle's entirety.

membrane. In an earlier report, we found that the PIN exited the distal edge of the supinator on average 18 cm proximal to the styloid process of the ulna and 12 cm distal to the lateral epicondyle of the humerus.<sup>13</sup>

Because the anatomy of the PIN within the supinator muscle has not been well studied in regard to entrapment syndromes and there has been recent interest in transferring supinator motor branches to the PIN,<sup>15,16</sup> the present study was performed.

## Materials and Methods

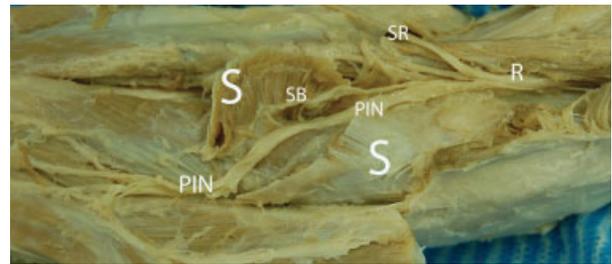
While placed in the supine position, 26 human adult cadaveric upper limbs (52 sides) underwent dissection of the proximal forearm with removal of the soft tissues overlying the supinator muscle. This group of formalin-fixed cadavers consisted of 14 male and 12 female specimens with an age range of 55 to 98 years (mean, 78 years) at death. With the supinator muscle exposed, the PIN at the distal humerus was identified and followed to this muscle. The superficial layer of the supinator muscle was reflected with scissors and the branching pattern of the PIN observed. Branches were measured with rulers and calipers. Relationships of this nerve to the supinator muscle were documented. No specimen was found to have pathology or past surgical incisions to the areas dissected. Statistical analysis between sides and sexes was performed using Statistica for Windows with significance set at  $p < 0.05$ .

## Results

Most commonly, the PIN entered the supinator muscle as a single nerve ( $n = 29$  sides), which provided branches to the supinator muscle and then continued and then left the confines of the supinator muscle to innervate the remaining musculature of the dorsal forearm. When entering the supinator muscle as a single branch, these were most often broad and fanlike in appearance with 2 to 4 branches (mean, 2.4), usually from the medial side, supplying the supinator muscle. On the remaining sides (23 sides), the nerve entered the supinator muscle as two approximately equal-size branches that arose from the radial nerve 2 to 4 cm (mean, 2.2 cm) proximal to the proximal edge of the supinator muscle (→Figs. 3 and 4). In these cases, whereas the medial of the two branches terminated on the supinator muscle, the lateral branch traveled through the supinator muscle and in 13 specimens provided additional smaller branches to the supinator muscle. One specimen, however, with two branches entering the supinator muscle, was reversed to this orientation. The total number of branches to the supinator muscle ranged from 1 to 6 (mean, 2.5). The length of the PIN within the supinator was on average 4 cm (range, 2.9–5.2 cm), and the diameter of its branches ranged in size from 0.8 mm to 1.1 mm (mean, 1 mm). In 10 specimens, the PIN left the supinator muscle before the most distal aspect of the muscle. In six specimens, there was very little overlying (outer lamina) supinator muscle, and in four specimens, there was minimal underlying



**Fig. 3** Left posterior forearm from a male cadaver. For reference, note the reflected brachioradialis and radial wrist extensors (BR), reflected extensor digitorum (ED), biceps brachii (B), and supinator muscles (S). Observe the radial nerve dividing into multiple branches before entering the supinator muscle. In this case, the superficial cutaneous branch is seen most superiorly, and the remaining branches are destined to travel to the supinator muscle. One branch, the posterior interosseous nerve, is seen continuing through the supinator muscle to innervate the remaining posterior forearm musculature.



**Fig. 4** Specimen seen in Fig. 3 following reflection of the outer lamina of the supinator muscle (S). Note the radial nerve (R), superficial cutaneous branch of the radial nerve (SR), posterior interosseous nerve, and supinator branch (SB).

(inner lamina) supinator muscle. In two specimens, in which a single broad PIN was found, muscle fibers of the supinator muscle pierced the PIN as it traveled through the supinator muscle. No specimen exhibited gross compression of the PIN at the proximal edge of the supinator muscle (i.e., at the arcade of Frohse). Although PIN branches tended to be shorter in female specimens, this did not reach significance. No statistical differences were noted between sides.

## Discussion

Carfi and Ma<sup>3</sup> stated that there are four commonly accepted, normally present anatomical structures that may compress the PIN. These are (1) fibrous bands traveling anterior to the radial head, (2) radial recurrent artery vessels or the so-called leash of Henry, (3) tendon of the extensor carpi radialis brevis muscle, and (4) the arcade of Frohse. Some have also mentioned the distal edge of the supinator muscle as a point of possible compression.<sup>17</sup> We did not identify any specimen in which the proximal PIN appeared to be compressed by the arcade of Frohse or distal supinator muscle.

For variations of the supinator muscle, Bergman et al<sup>18</sup> described the following: The division of the muscle into two lamellae may be more pronounced than is normally the case. An accessory fasciculus from the lateral epicondyle has been observed, as well as fibers inserted into the tendon of insertion of the biceps, the bursa under the tendon, and the

tuberosity of the radius. The most proximal part of the superficial head of the supinator muscle may be tendinous and form a fibrous arch and is implicated in the paralysis of the PIN. The PIN passes in a plane between the two heads of the supinator beneath the arch forming the origin of the muscle. The arch arises in a semicircular manner from the tip of the lateral epicondyle; its fibers dip downward approximately 1 cm, and it attaches to the medial aspect of the lateral epicondyle just lateral to the articular surface of the capitulum. The PIN passes beneath the edge of the fibrous arch, where it may become entrapped or compressed. In adult specimens, there is considerable variation in the thickness of the fibrous arch and in the size of the opening for the interosseous nerve. In addition to its origin from the radial notch of the ulna, the superficial head of the supinator muscle arises from the lateral aspect of the lateral epicondyle. The medial half of the arcade was membranous and pliable, being inserted into the medial aspect of the lateral epicondyle adjacent to the capitulum. The muscle may be doubled. A cleft may be found where the PIN perforates it. A slip may insert on the tubercle of the radius. A similar slip was found joining the pronator teres muscle. A second or supinator brevis accessorius may be present; it is a slip from the lower border of brachialis muscle inserted onto the tubercle of the radius, a slip from this muscle inserted into the biceps tendon and a slip into the bursa tubercularis of the radius.

Sunderland<sup>19</sup> described six variations of the division of the radial nerve into its superficial cutaneous branch and its deeper motor branch (PIN). Of these, five types demonstrated innervation of the supinator muscle after this division, and one type had innervation of this muscle before and after such a division. In two specimens, we found that the PIN had muscle fibers penetrating it within the supinator muscle, a finding that, to our knowledge, has not been previously reported. This suggests that to verify that the PIN is fully decompressed during surgical procedures, the entire supinator muscle (outer lamina) would need to be opened, not just its proximal edge (i.e., the arcade of Frohse).

In Turkish fetuses, Tatar et al.<sup>1</sup> found that the radial nerve (motor branch) divided into terminal branches before its entrance into the supinator in 5%, after its entrance into the supinator muscle in 10%, and distal to the supinator muscle in 85%. Our findings are much different compared with these authors' findings and may represent differences in fetal versus adult specimens or ethnic variations. We identified some specimens in which the branches to the supinator muscle arose from outside the supinator muscle. Such cases would shed light on preservation of the supinator muscle function in patients with PIN entrapment within the supinator muscle.

Regarding the recent descriptions of nerve transfers of the supinator branch of the PIN, our findings indicate that the entirety of the supinator muscle should be opened to visualize whether the muscular branches to the supinator muscle arise primarily from the PIN or from a separate parallel branch, as found in a significant number of our specimens.

## Conclusions

Variations in the branching pattern of the PIN proximal to and within the supinator muscle were identified in the present study. Such anatomic variations may be appreciated on preoperative imaging (e.g., magnetic resonance neurography) or intraoperative ultrasonography.

## Conflict of Interest

None

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