Current concepts of surgical approach for radial nerve entrapment around the elbow

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ABSTRACT

Radial nerve entrapment is an uncommon diagnosis. The entrapment can occur at any location within the course of the nerve distribution, but the most frequent location of entrapment occurs around the elbow and involves the posterior interosseous nerve.

Several potential sites of radial nerve entrapment around the elbow are identified: the capsular tissue of the radiocapitellar joint; hypertrophic crossing branches of leash of henry; the leading proximal tendinous and medial edge of extensor carpi radialis brevis; the arcade of Frohse and distal border of the supinator between its two heads. The arcade of Frohse is the most common site of compression. The aim of this manuscript is to describe the common surgical methods to approach the radial nerve entrapments around the elbow and define the preferred surgical approach based on the site of compression.

Current concepts?

- Radial nerve entrapment is an uncommon diagnosis.
- The entrapment can occur at any location within the course of the nerve distribution.
- The most frequent location of entrapment occurs around the elbow involving the posterior interosseous nerve branch.
- The diagnosis is based on clinical examination, history and electrodiagnostic studies and different provocative maneuvers that elicited pain.

Future perspectives

- Surgical exploration and decompression may be carried out along the course of the nerve.
- Different surgical approaches can be used for the management of radial nerve entrapments around the elbow.
- An adequate preoperative evaluation of compression level may help determine the most suitable surgical approach in order to treat the entrapment with minimal damage to the surrounding tissues.

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INTRODUCTION

Radial nerve entrapment is a rare diagnosis, and it can manifest at any location along the nerve’s distribution. The most frequent location of entrapment is around the elbow, specifically involving the posterior interosseous nerve branch (PIN). The annual incidence rate of the posterior interosseous nerve entrapment is estimated to be 0.03% [1], with vulnerability to entrapment in the track that runs through the radial tunnel.

The radial tunnel spans 5 cm, extending from the humero-radial joint and running distally between the deep and superficial heads of the supinator. It is bounded laterally by extensor carpi radialis longus (ECRL) and extensor carpi radialis brevis (ECRB) muscles and medially by biceps tendon and the brachialis. The roof is forms by brachioradialis (BR). The floor of the radial tunnel is the elbow-joint capsule [2,3]. It is a longitudinal spiral space around the PIN that ends at the distal border of the supinator [4]. Several potential sites of entrapment have been identified, including the capsular tissue of the radiocapitellar joint; hypertrophic crossing branches of leach of Henry; the leading proximal tendinous and medial edge of ECRB; the arcade of Frohse; and distal border of the supinator between its two heads [4]. The arcade of Frohse is noted to be the most common site of entrapment [5].

There are two distinct entities of radial nerve (RN) entrapment around the elbow: radial tunnel syndrome (RTS) and PIN syndrome. RTS involves an intermittent nerve compression with pain occurring 4–5 cm distal to the lateral epicondyle of the elbow, without loss of motor function. On the other hand, PIN syndrome is a compression that causes progressive weakness and loss of motor function [4–6].

The diagnosis is based on clinical examination, patient history, electrodiagnostic studies, and various provocative manoeuvres designed to elicited pain [4–6].

Primarily, the clinical diagnosis is needed, based on the previously listed symptomatology. There are several manoeuvres to provoke pain as the rule-of-nine test [7]; pressure over mobile wad of Henry; the supinator muscle stress test, wrist extension test, middle finger test, RN stretch test, and sensory collapse test [8–10].

The aim of this manuscript is to delineate common surgical methods to approach the RN entrapments around the elbow and define the preferred surgical approach based on the site of compression.

Surgical approaches

There are four distinct surgical approaches for releasing RN entrapment around the elbow area: the BR-splitting approach, the BR and the extensor carpi radius longus (ECRL) approach, ECRB and extensor digitorum communis (EDC) approach, and extensile anterolateral exposure.

The patient is positioned supine, with the arm either alongside the body or on a table. The arm is exsanguinated using a specialised band to create a bloodless field. A tourniquet is applied at the base of the limb.

Brachioradialis-splitting approach

The BR-muscle-splitting approach provides precise localisation and exposure of the radial tunnel proximal segment, especially the arcade of Frohse. The original technique [11] entails a longitudinal skin incision from the elbow crease, laterally to the biceps tendon, over the BR muscle, continuing distally for 4–6 cm. Alternatively, a 4 cm transverse skin incision, centred on the distal edge of the radial head (RH), offers effective access with a smaller scar (Fig. 1A). Preoperative identification of the PIN and the arcade of Frohse on the anterior aspect of the elbow enables a reduction in the skin incision, facilitating nerve exposure by splitting the BR muscle.

The PIN and the arcade of Frohse are situated over the anterior aspect of the radial neck, positioned 4–6 cm from the radiocapitellar joint, with the RH serving as a useful landmark. The muscle is longitudinally split, and dissection is along the muscle fibres progresses towards the radial neck. After splitting the muscle fibres for approximately 5 cm, a self-retaining retractor is applied, revealing the oblique fibres of the supinator muscle and the superficial RH branch, with the arcade of Frohse and the PIN beneath, surrounded by a mesh of radial recurrent vessels (Fig. 1B).

Identification and protection of PIN branches to the ECRB muscle precede the nerve’s passage under the arcade of Frohse. Bipolar electrocautery, applied to the radial recurrent vessel mesh, facilitates the excision of the fibrous edge of the supinator muscle, nerve mobilisation, and lysis. Drawbacks of this approach include postoperative pain and limited access to the distal edge of the supinator muscle [6–10].

According to several authors, the disadvantage of this approach is considered to be the challenge in releasing the nerve from the distal portion of the supinator muscle, as difficult to identify [3–10]. However, in 2018, a cadaveric study of the brachioradialis-splitting approach highlighted the potential to completely release the nerve using this approach without the need for additional anatomical windows [12].

Brachioradialis and extensor carpi radius longus approach

Before the surgery, it is crucial to precisely mark the incision at the interval between the ECRL and BR muscles, more specifically along the posterior bound of the BR muscles. This marking should occur while the patient is actively flexing the elbow against resistance, with the forearm held in a neutral position. This manoeuvre facilitates the visualisation of the contraction of the BR muscle, guiding the accurate placement of the incision for optimal surgical access [9] (Fig. 2A).

This exposure method, as formulated by Hall et al. [13], is suitable for individuals presenting with both lateral epicondylitis (LE) and RTS.

The skin incision begins proximal to the RH and extends distally for 6–8 cm. The proximal limb of the incision facilitates the exposure of the lateral epicondyle and the insertion points of the ECRL and BR muscle. A slight colour difference between these muscles simplifies the identification of this muscular interval. The BR muscles appear redder because their fascia is thinner than that of the ECRL muscle, which has a lighter appearance [14].

Subsequent reflection of subcutaneous tissue enables the visualisation and protection of the lateral terminal branches of the cutaneous nerve (CN) of the forearm, located exactly at the junction between the fascia of BR muscles and ECRL muscles. The fascia covering the mobile wad is incised, and the interval between the BR and the ECRL is discerned and expanded, revealing the PIN, the superficial radial sensory branch (most volar) and smaller branch to ECRB; it is important to identify and protect it. The PIN is the most dorsal branch that runs obliquely to other nerves (Fig. 2B).

Performing the release of the ECRB, the superficial head of the supinator muscle is identified and subsequently incised entirely, facilitating the release of the underlying PIN.

With this approach, it is feasible to perform the tenotomy of the ECRB tendon if there is clinical suspicion of epicondylitis [6–14].

Extensor carpi radialis brevis and extensor digitorum communis approach

The approach between the ECRB and extensor digitorum communis (EDC), enabling exposure of the proximal and middle thirds of the posterior surface of the radius, was initially delineated by Thompson in 1918 [15] and was primarily advocated for fracture fixation.

The forearm is pronated. A longitudinal skin incision, approximately 10 cm straight, is executed in this area, spanning from the lateral epicondyle to Lister’s tubercle at the wrist. The dissection proceeds through subcutaneous tissue and the fascia overlaying the muscles. The posterior CN of the forearm is usually located anterior to this incision and should be identified and protected. The interval between these muscles can be identified distally and the dissection begins from distal to proximal (Fig. 3A). In case of LE, it is possible to detach the ECRB tendon from the epicondyle. The supinator muscle can be identified deep to the extensor muscles in the proximal third of the incision, with its characteristic shiny oblique fibres (Fig. 3B).
This procedural approach facilitates the comprehensive visualisation of the entire supinator muscle and the distal branches of the PIN (Fig. 3C).

The superficial head of the supinator is incised along its entire length to achieve full PIN exposure, encompassing the arcade of Fröhse, the fibrous edge of the ECRB, and the fibrous bands positioned between the two heads of the supinator (Fig. 3D and E).

Distally, precautions are taken to preserve the recurrent motor nerve to the EDC when retracting the extensor digitorum muscle for the exposure of the supinator muscle [2,6,10,16].

Extensile anterolateral approach

This approach is indicated in case of direct trauma involving the main nerve trunk and the soft tissue around the elbow.

The incision is made along the distal segment of the lateral bicipital groove, running medially along the flexion crease close to the anterior border of the BR muscle. The length of the incision is contingent upon the extent of the radius requiring exposure.

Identification of the cephalic vein and the lateral CN of the forearm occurs within the subcutaneous tissue, followed by the incision of the antebrachial fascia (Fig. 4A).

The cleavage plane between the BR muscle and the biceps and brachialis muscles is then revealed.

Retracting the BR muscle and the biceps tendon facilitates the visualisation of the RN and the radial recurrent artery (Fig. 4B).

The posterior interosseous nerve entering the supinator brevis muscle becomes visible, alongside the superficial branch of the RN coursing...
along the forearm in tandem with the radial artery.

During the dissection of the proximal third of the radius, the posterior interosseous nerve is vulnerable; however, its lateral displacement is minimised with full supination of the forearm, mitigating the risk. The origin of the supinator muscle is identified on the anterior aspect of the radius (Fig. 4B).

The radial recurrent artery is ligated, and the supinator muscle is detached and reflected laterally along with the posterior interosseous nerve [6,17,18].

**DISCUSSION**

Lateral elbow pain is a common symptom associated with various pathologies affecting the joint, including entrapment of the RN at the elbow. Although the latter is not very common, it is more frequently observed in male workers or athletes, often due to muscular hypertrophy leading to entrapment. As mentioned earlier, there are several compression zones including fibrous bands between the BR muscle and joint capsule at the level of the RH, leash of Henry, an arcade of anastomosing branches of the radial recurrent artery, distal to the RH, tendinous edge of the overlying ECRB muscle and the Arcade of Fröhse along the proximal and distal aspect of the supinator muscle. However, the causes of compression can vary, including trauma and micro-trauma, proliferative rheumatoid synovitis, lipoma or ganglion, inflammatory nerve diseases (mononeuropitis, chronic inflammatory demyelinating polyneuropathy), and iatrogenic injuries following procedures such as biceps reattachment, elbow arthroscopy, and RH reconstruction [10].

A thorough physical examination is crucial for diagnosing RN entrapment, complemented by instrumental exams. Following these assessments, a decision can be made regarding whether to proceed with initial conservative treatment or opt for direct surgical intervention.

Our literature review [1–18] revealed a notable absence of comprehensive works associating to specific causes of entrapment with a more suitable surgical approach. This comprehensive exploration aims to offer guidance in selecting the most appropriate surgical approach based on the area of compression and the reported symptomatology by the patient. The review thus provides valuable insights to the limited existing literature on surgical approaches for the treatment of the RN entrapment at the elbow.

It is crucial to have a better understanding of the surgical approach to use and when to use it as most common cause of treatment failure is the incomplete release of the PIN [16].

We have categorised the use of the surgical approaches based on the type and level of compression of the RN, attempting to define the best surgical approach strategy to enable nerve release with minimal damage to the soft tissues (Fig. 5).

The focus of our review extends to the indications of the different surgical approaches:

- Extensile anterolateral approach: particularly beneficial in cases of trauma, lacerated wounds with nerve injury, and pathologies of the radiocapitellar joint. However, its limitation lies in the inability to visualise the nerve distally, making it impossible to free the nerve in all compression sites. It offers good exposure of the nerve at the proximal level from the radial tunnel to the
entrance to the arch of Fröhse, with less exposure of the RN of the entrance into the supinator muscle and its distal portion [3] (Fig. 5).

- BR (Brachioradialis) approach: found useful in cases of neoplasms or for freeing the nerve proximally or within the radial tunnel. The drawback associated with this approach is the splitting of the muscle, making it a traumatic surgical technique. A study conducted on cadavers reveals the possibility of completely freeing the nerve through this approach [4,12] (Fig. 5).
- BR/ECRL approach: used when pathology is associated with epicondylitis or joint cysts. It allows for good exposure of the nerve in particular in the radial tunnel area, although it is less complete and secure than the ECRB/ECD approach [4–9] (Fig. 5).
- ECRB/ECD approach: undoubtedly the most used approach for PIN with an extensile exposure in the supinator muscle. It allows visualisation of the nerve's course subject to compression and potential intervention on ECRB in case of associated epicondylitis or suspicion of it [6] (Fig. 5).

Conclusion

Surgical exploration and decompression may be carried out along the course of the nerve. Different surgical approaches can be used for the management RN entrapment around the elbow.

Surgical release of the RN (PIN and radial tunnel entrapments) consists in freeing the nerve: at the level of the proximal superior fibrous edge of the supinator muscle (arcade of Fröhse) or along its entire course between the two heads of the muscle. Additionally, the release can be carried out under the leading tendinous edge of the ECRB insertion and, if present, from any abnormal fibrous bridge at its origin, including the fibrous tissue anterior to the radiocapitellar joint and from ectatic vessels (radial recurrent artery and vein: leash of Henry), which may envelop and compress the nerve. An adequate preoperative evaluation of the level of compression enables the most suitable surgical approach, aiming to treat the entrapment with minimal damage to the soft tissues.

Declaration of competing interest

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References

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