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The Posterior Interosseous Nerve at the Proximal Forearm. Anatomical Study and Clinical Correlation

El Nervio Interóseo Posterior en el Antebrazo Proximal. Estudio Anatómico y Correlación Clínica

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SUMMARY: The deep branch of the radial nerve (DBRN) runs through the radial tunnel, which is a muscle-aponeurotic structure that extends from the humeral lateral epicondyle to the distal margin of the supinator muscle (SM). The Posterior Interosseous Nerve (PIN) originates as a direct continuation of the DBRN as it emerges from the SM and supplies most of the muscles of the posterior compartment of the forearm. The PIN can be affected by compressive neuropathies, especially at the "Arcade of Frohse". Its preservation is of special interest in surgical approaches to proximal radius fractures and in compressive syndromes release, for which surgeons must have an adequate anatomical knowledge of its course. This descriptive cross-sectional study evaluated 40 upper limbs of fresh cadavers. The diameters of the DBRN, the length of the radial tunnel, and the distances to the supinator arch, PIN emergence and PIN bifurcation were measured. The deep branch of the radial nerve (DBRN) has a course of 23.8 ± 3.7 mm from its origin to the supinator arch, presenting a diameter of 2.2 ± 0.3 mm at that level. The length of the radial tunnel was 42.2 ± 4 mm. The PIN originated 70.7 ± 3.5 mm distal to the lateral epicondyle. Type I corresponds to the division of the PIN during its journey through the radial tunnel, presenting in 35 % of cases, and Type II corresponds to the division of the PIN distal to its emergence from the radial tunnel presenting in the remaining 65 %. This study enriches the knowledge of the PIN and provides useful reference information on a Latin American mestizo sample. We propose the division pattern of the PIN into two types. Future studies may use this classification not only as a qualitative variable, but also include quantitative morphometric measurements.

KEY WORDS: Radial Nerve; Radial Neuropathy; Nerve Compression Syndromes; Hand Injuries; Anatomy.

INTRODUCTION

The radial nerve (RN) is the terminal branch of the posterior cord of the brachial plexus (C5-T1) (Drake *et al*., 2019; Dalley & Agur, 2022). While it passes around the spiral groove of the humerus, it innervates the triceps and anconeus muscles. It then pierces the lateral intermuscular septum between the brachialis muscle and the brachioradialis muscle (Tubbs *et al*., 2013). Thereafter, it crosses the elbow anterior to the lateral epicondyle and emerges between the brachioradialis muscle and extensor carpi radialis longus muscle (Sigamoney *et al*., 2017).

At this point, the RN bifurcates into a sensitive superficial and a motor deep branch (Caetano *et al*., 2020). Before entering the radial tunnel, the deep branch of the radial nerve (DBRN) innervates the extensor carpi radialis brevis and the supinator muscle (Cricenti *et al*., 1994). The DBRN runs through the radial tunnel, which is a muscle-aponeurotic structure that extends from the humeral lateral epicondyle to the distal margin of the supinator muscle (Portilla Molina *et al*., 1998; Tubbs *et al*., 2013; Caetano *et al*., 2020).

The posterior interosseous nerve (PIN) originates as a direct continuation of the DBRN as it emerges from the supinator muscle (Drake *et al*., 2019; Dalley & Agur, 2022). During its trajectory through the radial tunnel or after its emergence, the PIN bifurcates into a medial and a lateral branch (Thomas *et al*., 2000). The medial branch innervates the extensor carpi ulnaris, extensor digitorum communis,

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extensor digiti minimi and the lateral branch innervates the abductor pollicis longus, extensor pollicis longus, extensor pollicis brevis, and the extensor indicis proprius (Elgafy *et al*., 2000; Caetano *et al*., 2020).

There are five potential entrapment zones for the PIN, which are presented from proximal to distal in the following order: The fibrous fascial bands at the radial head, the radial recurrent vessels known as «Leash of Henry» at the radial neck, the fibrous edge of the extensor carpi radialis brevis muscle, the entrance point of the DBRN into the supinator muscle known as "Arcade of Frohse" and the distal edge of the supinator muscle (Sigamoney *et al*., 2017; Hohenberger *et al*., 2020). The "Arcade of Frohse" is considered the most frequent entrapment site (Spinner, 1968; Lister *et al*., 1979; Özkan *et al*., 1999; Ozturk *et al*., 2005).

The posterior interosseous nerve syndrome is characterized by a motor deficit of the extension of the fingers and thumb with preservation of the sensory territory of the radial nerve (Sigamoney *et al*., 2017). However, some patients may experience wrist pain. This could be attributed to the fact that the PIN receives sensory and proprioceptive afferent fibers of the wrist joint (Portilla Molina *et al*., 1998). The PIN could be injured in trauma of different etiologies, intraoperatively during elbow arthroscopy and in open approaches for proximal radius fractures treatment (Hackl *et al*., 2015). The incidence of the iatrogenic injury of the PIN can be reduced by a detailed knowledge of the anatomy of the nerve by the plastic and orthopedic surgeons.

This study enriches the knowledge of this anatomical territory and provides useful reference information on a Latin American mestizo sample. The proper knowledge of this anatomical territory improves the understanding of the clinical signs of patients with PIN entrapment neuropathies and gives greater security and precision to plastic and orthopedic surgeons while planning and performing surgical approaches and dissections in proximal radius fractures, PIN traumatic injuries and release of compressive syndromes of the PIN.

MATERIAL AND METHOD

This descriptive cross-sectional study evaluated 40 upper limbs of 20 fresh cadavers that underwent autopsy at the National Institute of Legal Medicine and Forensic Sciences in Bucaramanga, Colombia. The sample met this selection criterion: individuals over 18 years old. Subjects with evidence of direct trauma or scars in upper limbs were excluded. This study was carried out in compliance with the AQUA checklist, ethics guidelines for the study of research specimens obtained from deceased human subjects (Henry *et al*., 2018). The research protocol was endorsed by the Scientific Research Ethics Committee of the Universidad Industrial de Santander (CEINCI-UIS).

A curvilinear incision was made from the dorsal region of the wrist to the distal third of the arm, thereby keeping the forearm in pronation. A dissection of the DBRN was carried out under 3,5X magnification with surgical magnifying glasses (ZEISS EyeMag Pro S), as well as its entrance at the level of the supinator arch, its route through the radial tunnel and later its emergence as PIN.

Morphometric variables were measured using a digital caliper (Mitutoyo 500 series). The diameters of the DBRN, the length of the radial tunnel, and the distances to the supinator arch, PIN emergence and PIN bifurcation were measured. The statistical analysis was performed with SPSS Statistics 27 software (IBM). The continuous quantitative variables were described with their means and standard deviations. The student's t-test was performed accepting an alpha error of 5 %.

RESULTS

There were 16 males (80 %) and 4 females (20 %). The average age of the specimens was 32.5 years old. The deep branch of the radial nerve (DBRN) had a course of 23.8 ± 3.7 mm from its origin to the supinator arch and had a diameter of 2.2 ± 0.3 mm at that level (Fig. 1). The supinator arch exhibited a fibrotendinous constitution in 34 (85 %) and membranous in 6 (15 %) of the evaluated forearms.

The length of the radial tunnel was 42.2 ± 4 mm (Fig. 1). The origin of the PIN was taken as the emergence of the supinator muscle. The PIN originated 70.7 ± 3.5 mm distal to the lateral epicondyle (Fig. 2).

Regarding the division pattern of the PIN into a medial and a lateral branch, two types were identified (Fig. 3). Type I corresponds to the division of the PIN during its journey through the radial tunnel, presented in 14 (35 %) cases, at an average distance of 8.9 ± 3.8 mm proximal to the emergence of the radial tunnel.

Type II corresponds to the division of the PIN distal to its emergence from the radial tunnel, presented in the remaining 26 (65 %) cases, at an average distance of 5.2 ± 1.2 mm distal to its emergence from the radial tunnel. No statistically significant differences were found between the sides and the evaluated variables ($p > 0.05$).

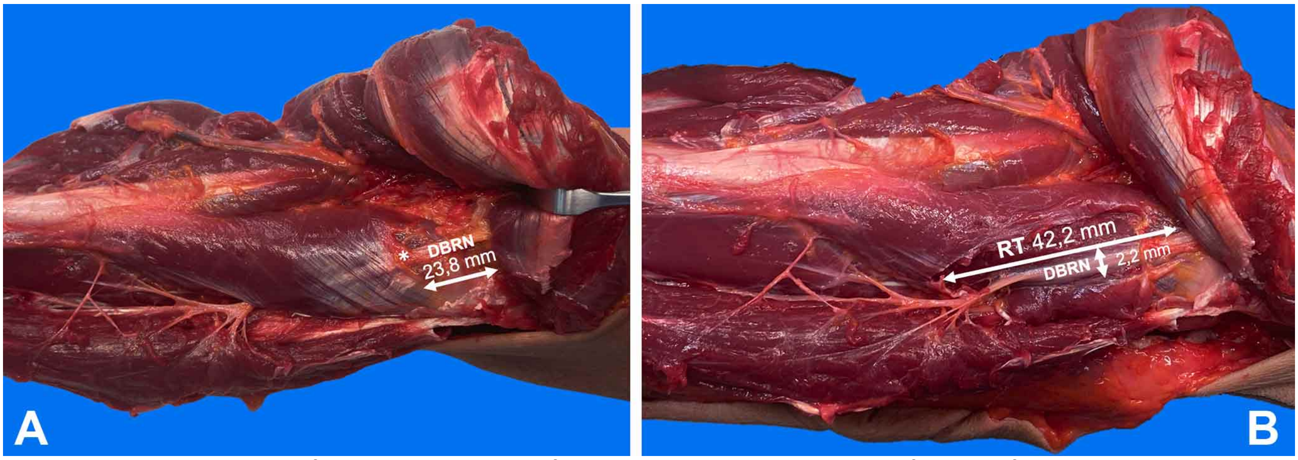

Fig. 1. Posterolateral approach of the elbow and proximal forearm. A) The DBRN has a course of 23.8 mm from its origin to the supinator arch B) A longitudinal incision of the supinator muscle was made to expose the RT. The DBRN presented a diameter of 2.2 mm and its trajectory through the RT was 42.2 mm. DBRN: Deep branch of the radial nerve. (*): Supinator arch. RT: Radial tunnel.

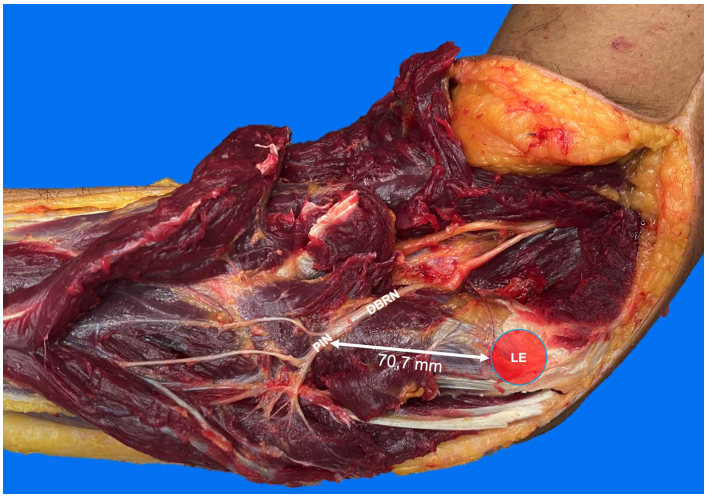

Fig. 2. Posterolateral approach of the elbow and proximal forearm. A longitudinal incision of the supinator muscle was made to expose the RT. The PIN had an origin 70.7 mm distal to the LE. PIN: Posterior Interosseous Nerve. DBRN: Deep branch of the radial nerve. LE: Lateral epicondyle.

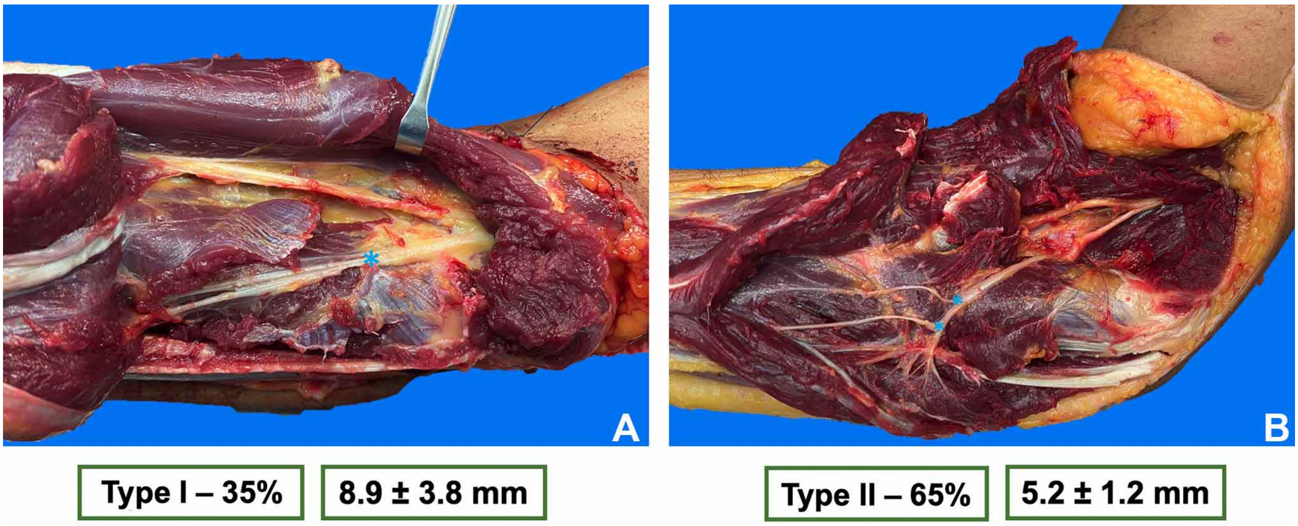

Fig. 3. Division patterns of the PIN. A) Type I corresponds to the division of the PIN during its journey through the radial tunnel. B) Type II corresponds to the division of the PIN distal to its emergence from the radial tunnel. (*) Location of the division site.

DISCUSSION

The aim of this study was to evaluate the anatomy of the PIN at the proximal forearm in a Latin American mestizo sample. Most of the previous studies had been carried out in North American and European populations and therefore it is necessary to have reference information on our mestizo population.

Thomas *et al*. (2000) studied an American population sample and reported a length of the DBRN of 36 mm. In our series, we found a lower length, which could be explained by a shorter length of the evaluated forearms due to smaller height of the specimens in mestizo population or to the division of the RN at a proximal level in their sample, which gives rise to a longer DBRN.

In previous studies, the most common reported configuration of the supinator arch was the fibrotendinous, which is found in a range between 57 % to 87 % of the evaluated specimens (Prasartritha *et al*., 1993; Özkan *et al*., 1999; Ozturk *et al*., 2005). Similarly, our findings show a similar range to what had been reported. This parameter may favor PIN entrapment in individuals with hypertrophy of the supinator muscle due to their work or physical activity.

Levina & Dantuluri (2021) informed a radial tunnel length of 50 mm. We found a slightly lower length, which could also be explained by the shorter length of the forearms in our mestizo population.

In relation to the exit of the PIN from the supinator, Keogh *et al*. (2018), reported a distance of 73 mm from the lateral epicondyle. Our findings are consistent with this parameter. Other authors report the distance to the emergence of the PIN from the radius head, hence [D1] these measurements cannot be compared with our findings (Hazani *et al*., 2008; Hohenberger *et al*., 2020).

We recommend that the distance from the emergence of the PIN to the lateral epicondyle should be assessed in surgical approaches of this anatomical territory, with the aim of reducing the probability of iatrogenic injuries of the PIN, which represents a major complication due to its important functional repercussion.

In this study we propose the division pattern of the PIN into two types, based on the emergence from the distal edge of the supinator muscle as the reference point. Extrapolating the findings of previous studies to this classification, Hohenberger *et al*. (2020), informed a type I division in 18 % and type II division in 82 % of the evaluated specimens. However, they did not quantitatively assess the location of the PIN division.

CONCLUSIONS

This study enriches the knowledge of the Posterior Interosseous Nerve and provides useful reference information on a Latin American mestizo sample for anatomists, clinicians, and surgeons. It is advisable that safety parameters for surgical approaches are adapted to the measurements of our mestizo population. We propose the division pattern of the PIN into two types based on the emergence from the distal edge of the supinator muscle. Future studies may use this classification, not only as a qualitative parameter, but also include quantitative morphometric measurements that determine the location of the PIN division.

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RESUMEN: El ramo profundo del nervio radial (RPNR) discurre por el túnel radial, que es una estructura músculo-aponeurótica que se extiende desde el epicóndilo lateral del húmero humeral hasta el margen distal del músculo supinador (MS). El nervio interóseo Posterior (NIP) se origina como una continuación directa del RPNR cuando emerge del MS e inerva la mayoría de los músculos del compartimiento posterior del antebrazo. El NIP puede verse afectado por neuropatías compresivas, especialmente en la “Arcada de Frohse”. Su conservación es de especial interés en los abordajes quirúrgicos de las fracturas proximales de radio y en la liberación de síndromes compresivos, para lo cual los cirujanos deben tener un adecuado conocimiento anatómico de su curso. Este estudio descriptivo transversal evaluó 40 miembros superiores de cadáveres frescos. Se midieron los diámetros de la RPNR, la longitud del túnel radial y las distancias al arco supinador, la emergencia del NIP y la bifurcación del NIP. El RPNR tenía un recorrido de 23,8 ± 3,7 mm desde su origen hasta el arco supinador, presentando un diámetro de 2,2 ± 0,3 mm a ese nivel. La longitud del túnel radial fue de 42,2 ± 4 mm. El NIP se originó 70,7 ± 3,5 mm distal al epicóndilo lateral. El tipo I corresponde a la división del NIP durante su recorrido por el túnel radial presentándose en el 35 % de los casos, y el tipo II corresponde a la división del NIP distal a su salida del túnel radial presentándose en el 65 % restante. Este estudio enriquece el conocimiento del NIP y proporciona información de referencia útil sobre una muestra de mestizos latinoamericanos. Proponemos el patrón de división del NIP en dos tipos. Futuros estudios pueden utilizar esta clasificación no solo como una variable cualitativa, sino también incluir medidas morfométricas cuantitativas.

PALABRAS CLAVE: Nervio Radial; Neuropatía radial; Síndromes de compresión nerviosa; Lesiones en las Manos; Anatomía.

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