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Forearm supination and the posterior interosseous nerve: a cadaveric study with surgical implications

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ABSTRACT

Introduction: The lateral and anterior approaches to the proximal radius are often used in the surgical treatment of radius shaft fractures. Posterior interosseous nerve injury is among the complications of these procedures. This nerve is also known as the deep branch of the radial nerve. It innervates several muscles of the posterior compartment of the forearm. The posterior interosseous nerve runs close to the radiocapitellar joint and pierces the supinator muscle beneath the Frohse's arcade. There is great debate in the literature whether to supine or to pronate the forearm in order to avoid iatrogenic injuries of this nerve. The present work aims to measure the distance between the posterior interosseous nerve and the distal biceps tendon during forearm pronation or supination. Material and Methods: A sample of 30 cadavers (15 male and 15 female) were dissected and the posterior interosseous nerve was traced to the Frohse's arcade. The distance between its point of entrance and the distal biceps tendon, the radial head and the radiocapitellar joint were measured during forearm pronation and supination with the aid of a digital caliper. Statistical analysis was performed with the IBM SPSS 23 software, $p < 0.05$ was considered significant. Results: It was observed that the distance increased significantly ($p < 0.05$) during supination. Conclusions: Maximum supination of the forearm may be an excellent maneuver to increase the distance between the posterior interosseous nerve and several anatomical landmarks thus helping to avoid damage during the Henry's and Kocher's approaches to the elbow.

Keywords: posterior interosseous nerve, supinator muscle, frohse's arcade, elbow surgery

INTRODUCTION

The anterior (Henry's) and the postero-lateral (Kocher's, Cadernat's, among others) approaches to the proximal third of the forearm are widely used to treat fractures in this region, specially radius shaft fractures and distal biceps tendon (DBT) repair, although they can be used to treat posterior interosseous nerve (PIN) neuropathies [1-3].

The PIN is considered as the deep branch of the radial nerve, which penetrates the supinator muscle beneath the arcade of Frohse. It innervates several muscles of the forearm involved in extension and supination of the hand/forearm complex [4-6]

Iatrogenic injuries to this nerve are the most prevalent – albeit rare - complications of the aforementioned procedures, although it can also be injured in fractures of the radial head or neck and even distal humeral fractures. Furthermore, it may be compressed due to the presence of tumors or by the Frohse's arcade itself [4, 7-9].

Measures such as forearm supination are seem to diminish the probability of iatrogenic injury of the PIN during these procedures, although other works observed that supination would provide better

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outcomes, thus, there uncertainty regarding this matter [9, 10]

This work aims to observe the distance of the NIP to the DBT, the radial head (RH) and the center of the radiocapitellar joint (RCJ) during supine and pronation movements of the forearm associated with hand flexion and extension in 30 cadaveric specimens in order to assess which preventive measures is more effective to avoid iatrogenic injury of the NIP.

MATERIAL AND METHODS

The present work was approved by board meeting of the Morphology Department of the Fluminense Federal University and was conducted in the same institution. Furthermore, the work presented herein complies with the declaration of Helsinki.

15 male and 15 female cadavers had their both forearms dissected in order to observe the relationship between the NIP and the BDT, radial head (RH) and the radiocapitellar joint (RCJ) during pronation and supination of the forearm. All cadavers were fixated in a 10% formalin solution.

The dissection protocol was performed according to standard dissection textbooks and the minimum amount of structures was dissected and manipulated in order to avoid conflicts or discrepancies during measurements. The points of measurements are depicted in Figure 1.

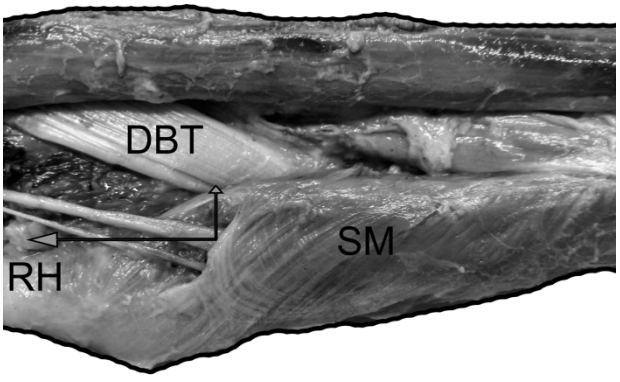

Figure 1: Anterior surfasse of the elbow. Measurements performed in the present study.

RESULTS

The mean distance between the PIN and the DBT during supination on the left and right forearms was 19.7±2.5 mm and 20.2±2.7 mm, respectively. The mean distance between the PIN and the DBT during pronation was 15.9±2.1 mm on the left side and 16.4±2.2 mm on the right side ($p < 0.05$).

The mean distance between the PIN and the RH during supination was 24.5±2.4 mm on the left and 25.1±2.3 mm on the right side, while the same distance during pronation was 21.1±1.7 mm on the left and 22.3±1.8 mm on the right side ($p < 0.05$).

The mean distance between the PIN and the RCJ during supination on the left and right forearms was 28.3±5.9 mm and 29.1±5.2 mm, respectively, and the same measurement during pronation was 23.1±4.2 on the left side and 24.1±5.7 on the right side ($p < 0.05$). Detailed data can be observed in Table 1.

Furthermore, there were no significant differences between sides or sexes ($p > 0.05$) and 65% of the forearms had a tendinous Frohse arcade, while the remaining sample had a membranous arch. No variations of the PIN or the supinator muscle were found in this study.

DISCUSSION

It was hypothesized in the literature that the muscle traction of the forearm mass may cause the PIN to contract or retract due to its spatial relation with these muscles [10-13].

Our results observed that supination increased the distance of the PIN to the BDT, the RH and the RCJ with a statistically significant difference ($p < 0.05$) against pronation.

There is a confusing mosaic in the literature regarding these preventive measures. Some authors propose that forearm supination is effective [9, 14-16], while others state that it does not increase the safe space significantly [10, 12, 17]. The results presented herein corroborate the fact that forearm supination increased the distance between the PIN and the BDT, the RH and the RCJ thus lowering the probability of possible injury.

Table 1. Measurements between the anatomical landmarks. Results are expressed as mean±SD (mm).

Measurement	Supination		Pronation		P value*
	Left	Right	Left	Right	
PIN x DBT	19.7±2.5	20.2±2.7	15.9±2.1	16.4±2.2	< 0.05
PIN x RH	24.5±2.4	25.1±2.3	21.1±1.7	22.3±1.8	< 0.05
PIN x RCJ	28.3±5.9	29.1±5.2	23.1±4.2	24.1±5.7	< 0.05
P value**	> 0.05		> 0.05		-

PIN: posterior interosseus nerve; DBT: distal biceps tendon; RH: radial head; RCJ: radiocapitellar joint centre . *supination vs pronation; **left vs right.

The relation between the PIN and the radial head or RCJ can vary, as it may directly press the radius periosteum, although according to multiple reports this disposition seems highly variable (2-57% of cases). Despite that, the NIP is always in contact with the antero-lateral aspect of the RCJ [5, 12, 16, 18].

As previously stated, the anatomical relationships of the PIN with the forearm muscles may induce its mobility [5, 6, 19]. As such, anatomical variations of these relationships would affect the efficacy of preventive measures that involves forearm movement. The PIN, however, is not very prone to vary, although it can pass above the supinator muscle (instead of beneath) or it can divide in two branches before entering the Frohse's arcade [18], thus, diminishing the effect of forearm supination. There were no variations of the PIN or the supinator muscle.

Awareness of these variables and anatomical relationships are also significant when the surgeon needs to broaden its field of vision, as the bands of the supinator muscle must be clearly divided. Another way to do so is to access the radius after release (to the ulnar side of the forearm) of the supinator muscle [1, 5, 14, 20].

Iatrogenic lesions of the PIN can cause movement loss in several regions of the forearm. Despite that, this nerve can be compressed by the presence of schwanomas, aneurysms or by the Frohse's arcade and cause similar symptoms. Furthermore, radius shaft and humeral fractures have been associated with PIN injury [3, 4, 8, 13, 21-24].

The Frohse's arcade is a fibrous arch on the proximal edge of the supinator muscle. This edge, however, may by membranous or tendinous [18]. 65% of the sample studied herein had a tendinous arch, while the remaining cadavers had a membranous arcade. Similar results were found in the literature, whereas the tendinous arcade was more prevalent [2]

The treatment for PIN compression or injury and proximal radius shaft fractures are performed via the Henry's and Kocher's accesses [22]. Forearm supination and careful dissection are among the preventive measures to reduce operative injuries [5, 12, 14, 25, 26]. Thus, knowledge of the surgical anatomy of the region and possible pitfalls are essential to the surgeon to do so.

CONCLUSIONS

In summary, forearm maximum supination during Henry's and Kocher's accesses may reduce the probability of iatrogenic injury of the PIN, as the distance between this nerve and the RH, the RCJ and the DBT are increased.

Knowledge of the PIN variations is also significant to the surgeon, as they may change the course of the operation. We propose that further studies should be performed in living patients to better elucidate this debate.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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RESUMO

Supinação do antebraço e o nervo interósseo posterior: estudo em cadáveres com implicações cirúrgicas

Introdução: Os acessos lateral e anterior do rádio proximal são frequentemente utilizados no tratamento cirúrgico das fraturas diafisárias radiais. A lesão do nervo interósseo posterior está entre as complicações desses procedimentos. Este nervo também é conhecido como o ramo profundo do nervo radial. Inerva vários músculos do compartimento posterior do antebraço. O nervo interósseo posterior corre perto da articulação radiocapitelar e perfura o músculo supinador abaixo da arcada de Frohse. Há um grande debate na literatura sobre se deve supinar ou pronar o antebraço para evitar lesões iatrogênicas desse nervo. O presente trabalho tem como objetivo medir a distância entre o nervo interósseo posterior e o tendão do bíceps distal durante a pronação ou supinação do antebraço. Material e Métodos: Uma amostra de 30 cadáveres (15 masculinos e 15 femininos) foi dissecada e o nervo interósseo posterior foi traçado até a arcada de Frohse. A distância entre o ponto de entrada e o tendão do bíceps distal, a cabeça do rádio e a articulação radiocapitelar foram medidas durante a pronação e supinação do antebraço com o auxílio de um paquímetro digital. A análise estatística foi realizada com o software IBM SPSS 23, $p < 0,05$ foi considerado significativo. Resultados: Observou-se que a distância aumentou significativamente ($p < 0,05$) durante a supinação. Conclusões: A supinação máxima do antebraço pode ser uma excelente manobra para aumentar a distância entre o nervo interósseo posterior e vários marcos anatômicos, ajudando a evitar danos durante os acessos de Henry e Kocher ao cotovelo.

Palavras-chave: nervo interósseo posterior, músculo supinador, arcada de Frohse, cirurgia de cotovelo