The posterior interosseous nerve and the radial tunnel syndrome: an anatomical study

A. E. Portilla Molina¹, C. Bour², C. Oberlin³, A. Nzeusseu¹, R. Vanwijck¹

¹ Department of Microsurgery, Université Catholique de Louvain, Brussels, Belgium

² Department of Hand Surgery, Clinique Sainte Croix, Le Mans, France

³ Department of Orthopaedics, Université de Paris V, Paris, France

Accepted: 1 December 1996

Summary. *Twenty anatomical specimens were carefully studied in order to establish a possible connection between the posterior interosseous nerve and the radial tunnel syndrome. Our results show that the posterior interosseous nerve distal to the supinator muscle may be compressed by various structures. These include the distal border of the supinator muscle, the ramifications of the anterior and posterior interosseous vessels, and the septum between the extensor carpi ulnaris and the extensor digitorum minimi. The posterior interosseous nerve is also stressed during passive supination (elongation and rotation), and during passive pronation (compression). This suggests that the interosseous nerve distal to the supinator muscle should be explored in radial tunnel compression syndromes.*

Résumé. *Les auteurs ont étudié 20 spécimens anatomiques pour rechercher les liens entre le nerf interosseux postérieur et le syndrome du tunnel radial. L'étude montre que le nerf interosseux postérieur peut être comprimé par diverses structures au-delà du muscle court supinateur: le bord inférieur du court supinateur, les ramifications des vaisseaux interosseux antérieurs et postérieurs et le septum existant entre le cubital postérieur et l'extenseur propre du 5ème doigt. Le nerf interosseux postérieur est de plus soumis à des strictions lors de la supination passive (élongation et rotation) et lors de la pronation passive (compression). Ceci suggère que le nerf interosseux postérieur*

doit être exploré dans sa portion distale au-delà du court supinateur lors du traitement des syndromes du tunnel radial.

Introduction

The radial tunnel which contains the posterior interosseous nerve is formed by the musculo-aponeurotic septa of the distal part of the arm and of the proximal part of the forearm [9].

Some authors attribute the radial tunnel syndrome to compression of the posterior interosseous nerve within this space [1, 3, 5, 9, 11, 12, 15]. Kotani et al. [4] describe a case of simultaneous compression at several levels in the tunnel.

Others consider that the syndrome results from intermittent and dynamic compression of the nerve in the proximal part of the forearm associated with repeated pronation and supination [1, 4, 9, 14, 15]. This may explain the very slow development of symptoms, and macroscopic compression of the nerve in 46 to 88% of cases. These authors believe that the nerve is 'fixed' in the supinator muscle, with pronation/supination resulting in its elongation and rotation. This hypothesis is supported by the case described by Kotani [4] where the nerve appeared to be compressed during rotation.

The relation between the nerve distal to the supinator and the radial tunnel syndrome is not clearly understood. Several anatomical studies have shown the relation of the more proximal part of the nerve to the syndrome [3, 6, 8], but the only specific study of the distal part is described by Yoshino et al. [16]. However, these authors only

Reprint requests to: A. E. Portilla Molina, Service de Chirurgie Plastique, Cliniques Universitaires Saint Luc, Av Hippocrates 10, B-2000 Brussels, Belgium

Fig. 1. Sites of origin of the branches of the posterior interosseous nerve. The point 'O' represents the distal border of the supinator muscle. 'Negative' figures mean that the branch arises proximal to this border

Fig. 2. Number of branches of the posterior interosseous nerve to various muscles. The most variable are among those to the extensor digitorum and to the extensor indicis

describe in detail the innervation of the deep extensors, abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus and extensor indicis.

Our studies concern the distal part of the posterior interosseous nerve, and our aim was to confirm, or to exclude probable sites of compression, and to study the dynamics of the nerve during pronation and supination.

Methods and materials

Twenty forearms were used in the study; all were free from any previous disease. All the dissections were performed within 3–10 days of death, and simple loupe magnification was used. The dorsal skin of the forearm was removed, the aponeurosis between extensor carpi radialis brevis and extensor digitorum was incised and the septum was identified between these two muscles. Extensor digitorum was mobilised from the septum and partially detached from the epicondyle, and this allowed exposure of the proximal two-thirds of the posterior interosseous nerve. The aponeurosis between the extensor digiti minimi and extensor carpi ulnaris was incised longitudinally to allow exposure of the nerves and the muscles. Finally the

extensor retinaculum was excised at the wrist and extensor pollicis longus partially freed from its origin in order to allow exploration of the distal part of the nerve.

We considered the distal part of the posterior interosseous nerve to be between the distal border of the supinator muscle and its termination on the dorsal capsule of the wrist. The distance between the distal border of the supinator and Lister's tubercle was considered to be the length of the distal part of the nerve.

Having identified the nerve between the proximal and distal borders of the supinator muscle, we then pronated and supinated the forearm, as well as flexing and extending the elbow and wrist. Alterations of the anatomy and relations of the supinator and the nerve were noted.

With the aim of establishing any relation between the distal part of the posterior interosseous nerve and the arterial network at the distal border of the supinator muscle, 10 specimens were injected with latex proximal to the elbow.

Results

Specimens were taken from people who had died at an average age of 80 years (range: 61–98). There were 7 women and 3 men. The average length of the posterior interosseous nerve within

Fig. 3. The *asterisk* marks the intermingling of the anterior and posterior interosseous vessels with the posterior interosseous nerve. The *thick arrow* marks the proximal part of the nerve. *S* covers the superficial layer of the supinator muscle which has been divided. *E* is the common extensor muscle

Fig. 4. The *arrow* shows the posterior interosseous nerve being stretched and rotated where it passes around the neck of the radius during supination. *S* marks the superficial layer of the supinator muscle which has been divided, and *E* marks the common extensor muscle

the supinator muscle was 2.9 cm (range: 2–6). There was a considerable difference between the right and left forearms in 7 of the subjects (70%). Great variation in the branches of the nerve was noted, but an attempt was made to divide the distal part into 3 equal 'zones': – Zone I proximal, Zone II middle and Zone III distal.

Zone I (the most complex) is the area where most of the motor branches arise. In all specimens, the branches to the superficial layer of muscles (extensor digitorum, extensor carpi ulnaris and extensor digiti minimus) arise immediately (0–1.5 cm) distal to the supinator muscle.

In 4 forearms (20%) there was a plexus at the origin of the nerves to this superficial layer of muscles. In 7 (35%) we found branches to ab-

Fig. 5. a The posterior interosseous nerve is relaxed in pronation (*thick arrow*). *S* marks the superficial layer of the supinator muscle which has been divided. *EDC* is extensor digitorum communis, and *ECRB* is extensor carpi radialis brevis. **b** *S* indicates the superficial layer of the supinator muscle which is taut in passive pronation, especially along the distal border (*small arrow*). The *thick arrow* marks the proximal part of the posterior interosseous nerve. *E* is the common extensor muscle

ductor pollicis longus and to extensor pollicis brevis. In 2 (10%) there were also accessory branches to extensor carpi radialis brevis.

In 3 forearms (15%) the distal aponeurosis of the superficial layer of the supinator muscle was very fibrous. In 15 forearms (75%) the aponeurosis of extensor digiti minimi was also fibrous and was crossed by the nerves to the extensor carpi ulnaris and to extensor digiti minimi.

There was great variation between subjects in the origins of nerve branches from the posterior interosseous where it left the supinator muscle (Fig. 1) and the number of branches for each muscle (Fig. 2).

In the fibro-fatty tissue at the distal border of the supinator we found in all the specimens a vascular network between the anterior and posterior interosseous branches of the radial artery (Fig. 3).

Zone I is characterised by a dense fibro-fatty layer which in all the specimens covered the first 2 cm of the posterior interosseous nerve, and also by the close association of the vascular network from the anterior and posterior interosseous vessels. These intermingle with the first branches which arise from the main nerve.

Zone II contains the origins of the nerves to the deep layer of muscles (abductor pollicis longus, extensor pollicis brevis and extensor indicis). In this Zone the distal part of the posterior interosseous nerve lies between the superficial (extensor carpi and extensor carpi radialis brevis) and deep (abductor pollicis longus, extensor pollicis brevis and extensor pollicis longus) muscles.

Zone III corresponds to the terminal part of the posterior interosseous nerve; the junction of Zones II and III is situated between extensor pollicis longus and extensor indicis proprius. In all specimens, except for several motor branches to extensor indicis proprius, it is essentially a sensory branch which supplies the wrist. It is accompanied by an interosseous artery, and this neurovascular bundle is always surrounded by fibro-fatty tissue which attaches it firmly to the interosseous membrane. In all specimens this sensory branch ended in the posterior fibrous capsule of the wrist joint at the level of the 3rd to 4th space.

The posterior interosseous nerve undergoes passive displacement during pronation/supination. In supination it moves laterally, away from the median line, and this produces a lengthening and an anti-clockwise rotation (Fig. 4), while the superficial layer of the supinator muscle is relaxed.

In pronation, the reverse movements tighten the superficial layers of the supinator, and compress the nerve passively (Fig. 5a, 5b).

Discussion

This anatomical study has allowed us to confirm that the posterior interosseous nerve is always a mixed nerve, motor for the extensor muscles of the forearms, sensory and proprioceptive for the posterior capsule of the wrist joint.

The very great variation of its distribution makes it impossible to simplify all the anatomical possibilities.

We have not found any cause for compression in Zone II and Zone III, but by contrast in Zone I there are several possible sites. The distal border of the supinator muscle was fibrous in 15% of the specimens, and appeared to compress the nerve during passive pronation. This site was described by Sponseller [12]. The vascular network between

the anterior and posterior interosseous vessels, which lie in the fibro-fatty tissue distal to the lower border of the supinator muscle, is intimately related to the nerve. In this area the branches of the extensor digiti minimi and the extensor carpi ulnaris can also, in 75% of cases, be compressed where they cross the aponeurosis of extensor digiti minimi. To the best of our knowledge these sites of potential compression have not been recorded previously.

Testut [13] described the displacement of the posterior interosseous nerve which occurs during pronation and supination as similar to those of a skipping rope. In supination it moves laterally and away from the midline, together with elongation and anti-clockwise rotation. We have noted that the supinator muscle is relaxed in passive supination, but we do not know if active contraction of this muscle can compress the nerve. Some instances of passive rupture of the nerve by stretching during sporting activities have been reported [7], and compression at several levels, notably during rotation [4], seems to confirm our observations.

Lateral and rotatory displacement and stretching of the nerve, together with 'cyclical' compression by the superficial part of the supinator muscle, with passive compression in pronation, can produce significant compression of the nerve. This can be responsible for the radial tunnel syndrome in a significant number of patients in whom electromyography is normal [2, 10].

The value of EMG examination is controversial, and intermittent compression is probably the reason that there is no diminution in the speed of conduction when the forearm is in neutral rotation. Roxen et al. [10] noted that supination can increase the conduction time of the nerve within the supinator muscle when compared to control subjects. They explain this slowing by compression at the distal border which becomes taut in supination. We do not agree with this, as in supination the superficial layer of the muscle is relaxed (Fig. 4) and the nerve is displaced laterally, stretched and rotated; we believe that this explains the EMG changes.

We have found accessory branches supplying the extensor carpi radialis brevis in 10% of cases, and this observation lessens the value of an EMG examination of this muscle in distinguishing between compression at the proximal or distal borders of the supinator.

Several surgical approaches have been suggested in relation to the probable site of compression. In our experience we have found that the postero-external approach of Thompson gives excellent exposure of the posterior interosseous

nerve, both within the supinator muscle, and then more distally.

The results of treatment of the radial tunnel syndrome are very variable (10–93% good results) [5, 14], and the prognosis less reliable giving considerable uncertainty about the underlying pathology.

The posterior interosseous nerve is continuously subjected to dynamic stresses, and to passive compression. Our observations suggest that other sites of compression in the more distal regions may be responsible for some of the failures of treatment. There are no reports in the literature of the effect of dividing the superficial layer of the supinator muscle, and we are considering trying the effect of doing this, and of exploring Zone I of the nerve.

Acknowledgements. We wish to thank Professor C. Hilloy of l'Institut d'Anatomie de l'Universite de Paris V for permission to undertake this work in his laboratory.

References

1. Comtet JJ, Chambaud D (1975) Paralysie "spontanee" du nerf inter-osseux posterieur par lesion inhabituelle. Deux observations. *Rev Chir Orthop* 61: 533–541
2. Comtet JJ, Lalain JJ, Moyen B, Genety J, Brunet-Guedj E, Lazo-Henriques R (1985) Les epicondylalgies avec compression de la branche posterieure du nerf radial. *Rev Chir Orthop [Suppl II]*: 89–93
3. Fuss FK, Wurzl GH (1991) Radial nerve entrapment at the elbow: surgical anatomy. *J Hand Surg [Am]* 16: 742–747
4. Kotani YH, Miki T, Senzoku F, Nakagawa Y, Ueo T (1995) Posterior interosseous nerve paralysis with multiple constrictions. *J Hand Surg [Am]* 20: 15–17
5. Moss SH, Switzer HE (1983) Radial tunnel syndrome: a spectrum of clinical presentations. *J Hand Surg [Am]* 8: 414–420
6. Prasarthitha T, Prasert L, Rojanakit A (1993) A study of the posterior interosseous nerve (PIN) and the radial tunnel in 30 Thai cadavers. *J Hand Surg [Am]* 18: 107–112
7. Prochaska V, Crosby LA, Murphy RP (1993) High radial nerve palsy in a tennis player. *Orthop Rev*: 90–92
8. Rath AM, Perez M, Mainguence C, Masquelet AC, Chevrel JP (1993) Anatomic basis of the physiopathology of the epicondylalgias: a study of the deep branch of the radial nerve. *Surg Radiol Anat* 15: 15–19
9. Roles NC, Maudsley RH (1972) Radial tunnel syndrome resistant tennis elbow as a nerve entrapment. *J Bone Joint Surg [Br]* 54: 499–508
10. Rosen I, Werner C-O (1980) Neurophysiological investigation of posterior interosseous nerve entrapment causing lateral elbow pain. *Electroencephalogr Clin Neurophysiol* 50: 125–133
11. Spinner M (1968) The arcade of Frhose and its relationship to posterior interosseous nerve paralysis. *J Bone Joint Surg [Br]* 50: 809–812
12. Sponseller PD, Engber WD (1983) Double-entrapment radial tunnel syndrome. *J Bone Joint Surg [Am]* 8: 420–423
13. Testut L (1911) *Traite d'anatomie Humaine*. Tome III, 6th edn. O Doin et fils, Paris
14. Verhaar J, Spaans F (1991) Radial tunnel syndrome. An investigation of compression neuropathy as a possible cause. *J Bone Joint Surg [Am]* 73: 539–544
15. Younge DH, Moise P (1994) The radial tunnel syndrome. *Int Orthop* 18: 268–270
16. Yoshino H, Horiguchi M (1992) The innervation of deep muscles of the human forearm extensors. *Kaibogaku Zasshi* 67: 83–99