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Intermuscular Connections in Anterior Brachium: its Implications in Radial Nerve Entrapment Neuropathy

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SUMMARY

Background. Radial nerve (RN) is the largest branch arising from the brachial plexus, which supplies the extensor muscles and skin. This nerve may go for entrapment anywhere in its course. Muscular and tendinous variations have been implicated in various nerve entrapment syndromes along with other causes. The goal of this investigation was to observe for any connections between brachialis (BL) and brachioradialis (BR) muscles that may compress the radial nerve or its terminal branches.

Methods. The study was performed on 84 formalin fixed human cadaveric upper limbs. Meticulous dissection in and around the cubital region was carried out to expose the BL, BR and the RN. The connections between the two muscles were noted and classified as muscular split type, muscular slip type and tendinous type.

Results. Exploration of the cubital region revealed connecting bridges in 24 of the specimens (28.5% cases). 17 (20.2%) specimens exhibited split type, 6 (7.1%) specimens muscular slip type and 1 (1.2%) upper limb presented tendinous connection. In all these cases, the connecting bridge between the two muscles was oblique and crossed the RN.

Conclusions. The results of our study reveal that various types of connections exist between the two muscles, contributing to the factors leading to radial nerve compression. Knowledge about this anatomical entity will be helpful in further understanding the aetiology of radial nerve compression and in devising effective treatment.

KEY WORDS

radial nerve; radial nerve compression; radial nerve entrapment; radial tunnel syndrome

BACKGROUND

The brachial plexus gives off its biggest branch, the radial nerve (RN) in the axilla. It emerges as the continuation of the posterior cord carrying fibres from C5-T1. Near the elbow region, RN is related to the brachioradialis (BR) and brachialis (BL) in the upper part and extensor carpi radialis muscle in the lower part. Here in the cubital fossa the main RN ends to split into a superficial cutaneous branch (SBRN) and posterior interosseous nerve (PIN), a deeper branch which is motor. The RN provides motor innervation to the muscles of back of arm and forearm. It carries cutaneous sensation from posterior and lateral areas of arm, posterior part of forearm, back of the hand and back of the lateral three and a half digits (1,2). In RN compression above the elbow the patient may present with weakening of extension movements at the wrist and fingers which may result in 'wrist drop'. In compression below the elbow only the finger extensors may be involved. Sensory disturbances in the RN territory are observed when the main nerve or SBRN is compromised (3). The RN can be entrapped at any level, the most frequent site being the radial head region to the inferior limit of supinator muscle. This narrow region is known as the radial tunnel in which the PIN can get entrapped as it travels through it (4). The radial tunnel has the capsular ligament of the elbow joint posteriorly. Its medial boundary is the BL muscle and the tendon of biceps brachii, and the lateral boundary is made up of the extensor carpi radialis longus, extensor carpi radialis brevis and

BR muscles (5). Thus a connection between BL and BR would be responsible in compressing the PIN by narrowing the radial tunnel. The BL muscle is known to be fused or connected to the BR at the origin of BR muscle (6). Here this study was aimed to note and describe the morphological variations in the intermuscular connection between BL and BR muscles.

MATERIALS AND METHODS

We state that this anatomical research was conducted after obtaining ethical clearance from institutional ethical committee and in accordance to international ethical standards, which are required by the journal as per the opinion of Padulo et al. (7) The 84 formalin fixed human cadaveric upper limbs used in the present study were from the bodies donated to the institute for educational and research purposes. Cadaveric research is comparable to human subjects. The privacy and confidentiality of the donor was maintained and the bodies were treated humanely preserving the donor's personal values. The cadaveric oath was taken before dissecting them. Out of the total of 84 specimens 48 were of right side and 36 were left side. Meticulous dissection was done in and around the cubital region to expose the BL and BR muscles, connections between these two muscles were identified and classified (**figure 1**) depending on the morphology as mentioned below.

Muscular split type: BL muscle split into two, a larger medial part going for its usual insertion and the smaller lateral part joining the BR, it was termed as muscular split type (**figure 1**).

Muscular slip type: the muscle fibres arose from the lateral aspect of BL and merged with BR (**figure 1**).

Tendinous type: A tendinous band without muscle fibres connecting the two muscles (**figure 1**).

Further, dissection was carried out carefully deep to the connecting bridges to reveal the RN, SBRN and PIN.

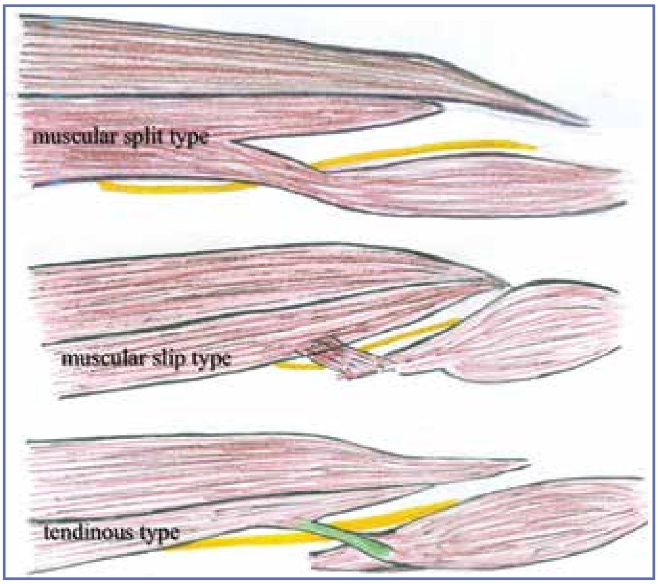

Figure 1. Pictorial representation of the intermuscular connections observed in the present study.

RESULTS

The study revealed a connecting bridge in 28.5% cases (24 upper limbs, 13 right and 11 left). The connection was of muscular split type (**figure 2**) in 17 (20.2%) specimens (9 right and 8 left sided) and muscular slip type (**figure 3**) in 6 (7.1%) specimens (3 right and 3 left sided). In 1 right limb (1.2%) the connection was tendinous (**figure 4**). In all cases the connecting bridge between the two muscles was oblique and crossed the terminal part of RN, SBRN and PIN.

DISCUSSION

Nerve entrapment syndromes occur due to a structural abnormality like anomalous muscles, fibrous bands, tumours and bony deformities. These are responsible for compression, traction or displacement of the nerve giving rise to signs and symptoms of neuropathy (8). Several studies have described the different morphological anomalies of BR muscle compressing the SBRN. SBRN may be passing between the two slips of BR (Wartenberg syndrome) or it may be caught within the fascia covering BR (9-13). Also, several cases of PIN entrapment have been reported as the PIN Syndrome and RTS (radial tunnel) syndrome (14-15). The RN and PIN can be entrapped at 5 locations, these include the lateral part of elbow joint, fibrous margin of extensor carpi radialis brevis, arcade of Frohse, inferior margin of radial tunnel and leash of Henry (4,16). However, compression of the entire RN along with its branches under a muscular/tendinous band anterior to the elbow joint as in our study has been seldom reported. In the present study the muscular or tendinous bridge between BL and BR crossed the main RN, SBRN and the PIN. Therefore, this connecting band has the potential to compress all the three nerves. And as mentioned earlier it could narrow the radial tunnel to entrap the PIN.

Compressive neuropathy or entrapment neuropathy can give rise to symptoms that are quite distressing to the patient. It can result in pain, sensory abnormalities and functional deficits in the limbs. If not treated promptly it may lead to considerable morbidity and some of these may become permanent disabilities. To pin point the cause, finding loca-

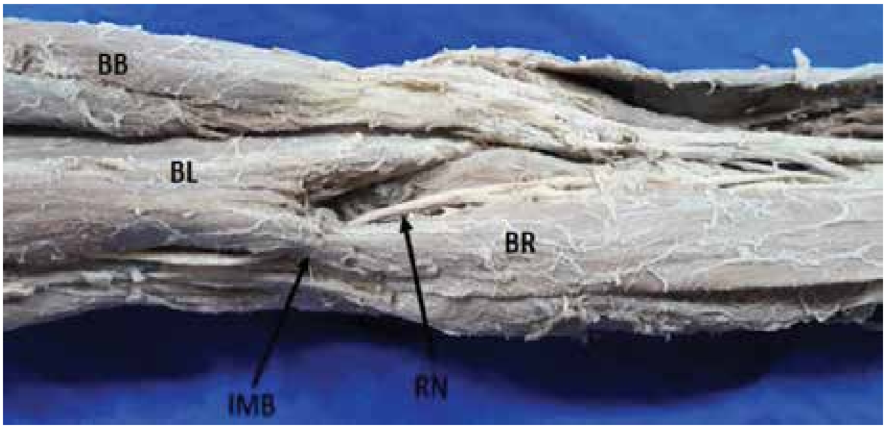

Figure 2. Right upper limb showing radial nerve entrapment by intermuscular bridge (muscular split type) connecting brachialis and brachioradialis (BB-biceps brachii; BL-brachialis; BR-brachioradialis; RN-radial nerve; IMB-intermuscular bridge).

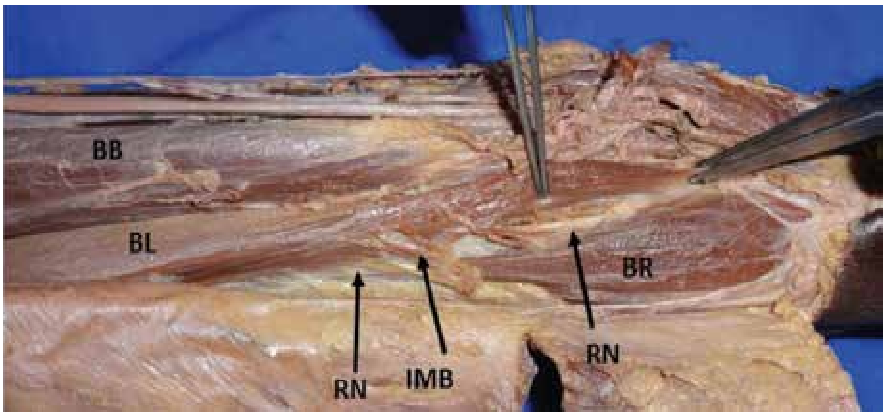

Figure 3. Right upper limb showing radial nerve entrapment by intermuscular bridge (muscular slip type) connecting brachialis and brachioradialis (BB-biceps brachii; BL-brachialis; BR-brachioradialis; RN-radial nerve; IMB-intermuscular bridge).

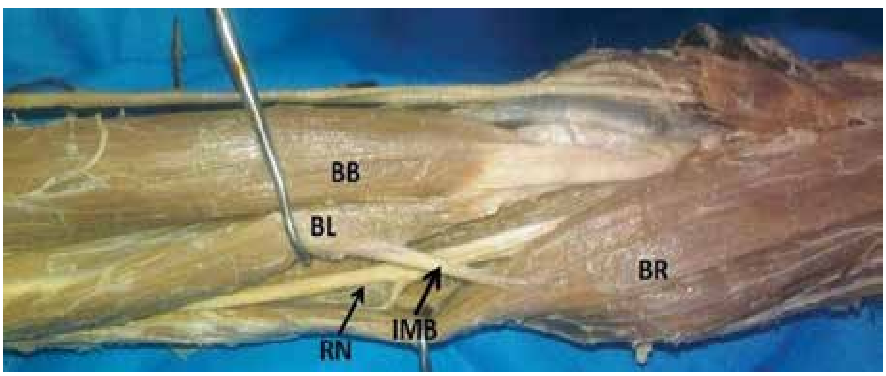

Figure 4. Right upper limb showing radial nerve entrapment by intermuscular bridge (tendinous type) connecting brachialis and brachioradialis (BB-biceps brachii; BL-brachialis; BR-brachioradialis; RN-radial nerve; IMB-intermuscular bridge).

tion and reasoning the aetiopathogenesis of neuropathy is often difficult for clinicians. There may be a dramatic improvement in the patient's condition following the surgical decompression of nerve entrapment. Therefore, it is a matter of great importance to diagnose these conditions and surgically treat them as quickly as possible (17). The anatomical variations should be kept in mind during the surgical procedures of the radial tunnel to prevent the postoperative complications (18).

Entrapment neuropathy of branches of RN at the level of the elbow joint is a rare entity as compared to the entrapment neuropathies of ulnar and median nerves (4,17). The reported incidence of RTS as quoted by Weitbrecht and Navickine was 1% (19). However, compression of radial nerve and its terminal branches should be considered as the diagnosis when symptoms like pain around the elbow joint, show no relief following the conservative treatment or whenever there is progressive weakness in wrist extension. These connecting muscular bands observed in this study and the fact that they cross the radial nerve, may compress the nerve, especially during movements of the elbow and radio-ulnar joints. In a clinical setup, electrophysiological evaluation may help in the identification of location of compression (20).

The nerve entrapment syndrome is a neuropathy, which can be due to structural abnormalities like anomalous muscles and tendons (21). The strength of the present study is that, it describes 3 different morphological intermuscular connections between BL and BR, which are entrapping the radial nerve. These observations will definitely have implications in clinical setting and radiologic interpretation including ultrasound diagnosis. The application of high-resolution ultrasound in peripheral nerve entrapment is becoming popular in western nations (22, 23). The portable ultrasound machines are less expensive in comparison to MRI machine and can be performed by non-radiologists as well (24), hence the cost is very economical to the patient. However it is a known fact that MRI gives better observation of the soft tissue. During the ultrasound, the nerve can be identified as honeycomb appearance, which differentiates it from the adjacent soft tissue. The nerve gives more echo to the adjacent muscle and less to the adjacent tendon (22). It is believed that if the radiologist has prior knowledge about the adjacent anomalous muscles and tendons, it will help in more accurate interpretation.

The present study has few limitations like the gender based analysis, which could not be done. Here we involved disarticulated upper extremities and the gender of the cadaver was not noted. Also, the measurements of the intermuscular connections and the radial nerve underneath them were not included. The further course of the radial nerve in relation to the supinator muscle is not studied. These details have implications in understanding the radial tunnel syndrome, where the nerve entrapment happens in the arcade of Frohse (22). The relation of radial nerve and supinator muscle is very important because the commonest structural entrapment neuropathy of radial nerve is compression by the superficial fibers of supinator. These can be considered as the potential limitations of the present study and opens up new avenues for further research.

CONCLUSIONS

The insight of such anatomical muscular variations is important for orthopaedic and plastic surgeons dealing with upper limb surgeries. Any operative procedure for RN entrapment should include a meticulous exploration of the RN and the structures around it where it crosses the elbow joint. Any aberrant muscular, tendinous or fibrous band found connecting the BL and BR muscles should be considered as the reason for compressing the nerve. The excision surgery should be carried out in these muscular variations to decompress the nerve. Caution has to be taken to avoid injuries to the underlying nerves.

CONFLICT OF INTERESTS

The authors declare they have no conflicts of interest.

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