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Dorsal cutaneous innervation of the hand with respect to anatomical landmarks: is there a safe zone?

Anatomik oluşumlara göre elin dorsal kütanöz inervasyonu: Güvenli bir bölge var mı?

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Objectives: In this study, we aimed to define the borders of the triangular area between the radial and dorsal nerves on the dorsum of the hand and to determine its dimensions using measurements between anatomic landmarks.

Materials and methods: We statistically analyzed the relation between the distance from Lister's tubercle to the blending point of the central branches of radial and ulnar nerves and the distance between styloids on 14 hands of seven adult human cadavers (5 males, 2 females). The distances of nerve branches to vertical lines drown distally from both styloid processes were also compared with interstyloid distances to help in presuming the course of these nerves.

Results: No statistical constant correlation was determined between the measurements. Neither the height of the triangular area nor the courses of both nerves seemed to be quantitatively related to any measurements between the anatomical landmarks.

Conclusion: Variability in these measurements in our study indicates that there is no surgical safe zone on the dorsum of the hand.

Key words: Anatomy; cadaver; dorsal hand; nerve tissue; variations.

Amaç: Bu çalışmada, el sırtında radial ve ulnar sinirler arasında bulunan üçgen alanın sınırlarının tanımlanması ve anatomik oluşumlar arasındaki ölçümleri kullanılarak bu alanın boyutlarının belirlenmesi amaçlandı.

Gereç ve yöntemler: Bu çalışmada yedi yetişkin insan kadavrasının (5 erkek, 2 kadın) 14 eli üzerinde, Lister tüberkülü ile radial ve ulnar sinirlerin santral dallarının birleşme noktaları arasındaki mesafe ile stiloidler arası mesafe arasındaki ilişki istatistiksel olarak analiz edildi. Bu sinirlerin seyrini tahmin edebilmek için, sinir dalları ile her iki stiloid çıkıntıdan distale çizilen dikey çizgiler arasındaki mesafe de stiloid çıkıntılar arası mesafe ile karşılaştırıldı.

Bulgular: İstatistiksel olarak ölçümler arasında sabit bir ilişki tespit edilemedi. Ne üçgensel alanın yüksekliği ne de her iki sinirin seyri kantitatif olarak anatomik oluşumlar arası herhangi bir ölçüm ile ilişkili görüldü.

Sonuç: Çalışmamızdaki ölçümlerde ortaya konan değişkenlik el sırtında cerrahi bir güvenli bölge olmadığını göstermektedir.

Anahtar sözcükler: Anatomi; kadavra; el sırtı; sinir dokusu; varyasyon.

The dorsum of the hand and wrist are innervated by the superficial branch of the radial nerve (RNsb) and the dorsal branch of the ulnar nerve (UNdb). The great variability in branching patterns of both nerves causes unexpected nerve injury during open and arthroscopic surgery.[1-5] The best way to protect a sensory nerve is by surgical identification and protection of the nerve. In addition, for arthroscopic surgery, confirmation of each surgical tool and insertion of cutting devices with their blades parallel to neurovascular structures is advised for prevention of such complications.[6] However, description of the course and the topographic anatomy of these cutaneous nerves especially with objective mathematical values in respect of proven anatomical landmarks can serve as a guideline for the surgical approach.

On the dorsum of the hand, most ulnar branches of the RNsb (RNmub) and most radial branches of the UNdb (UNmrb) seem to communicate or approximate and travel distally parallel down to about the midline

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of the fourth metacarpal. Other branches of both nerves branch out on the dorsum of the hand and fingers radially and ulnarly. On anatomic illustrations and drawings there seems to be a triangular-quadrangular area free of any nerves originating from these two branches.[1,7,8] The line between the radial and ulnar styloids forms the base and the intersection point of the RNmub and UNmrb forms the apex of this internervous zone (Figure 1).

We hypothesized that the predefined safe distances for both arthroscopic and surgical interventions on the dorsum of the hand are variable between individuals and depend on some measurements between anatomic landmarks. The determination of a mathematical relationship between these measurements can introduce a guideline to presume the borders of the safe internervous zone.

The purpose of this study was to determine if there is a safe internervous zone for the dorsum of the hand. We also aim to define objective criteria to predict the course of these nerves distal to the radiocarpal joint line, which will help avoiding injury of these nerves during surgery.

MATERIALS AND METHODS

Fourteen forearms and hands of seven embalmed adult human cadavers (5 male, 2 female) were dissected for this study with the approval of the local ethics committee (Number 2010/095, dated 27.12.2010). A single dissector performed all dissections and all of the measurements were performed with a digital caliper. The skin over the hand and wrist was removed. The radial and ulnar styloid processes (RS and US), Lister's tubercle (LT) and lateral epicondyles (LE) were marked out with needles as landmarks. The intersection point of RNmub and UNmrb or the point they come closest is defined as the blend point (BP). The distance between BP and LT is defined as the height of the assumed internervous zone. In order to find out if there is a constant proportion between the above mentioned distances and the height of the internervous zone, we performed some statistical analysis; the relation between the US-RS distance and LT-BP distance and the relation between the LE-LT distance and LT-BP distances were statistically investigated with linear regression analysis.

In addition, to help in predicting the course of the RNmub and UNmrb during surgical dissection on the midline of the hand, the distance of these branches to vertical lines drawn distally from both styloid processes were measured at radiocarpal and midcarpal joint levels, and the correlation between these measurements and the distance of RS-US was statistically evaluated with regression analysis (Figure 2). The significance level was set to $p<0.05$.

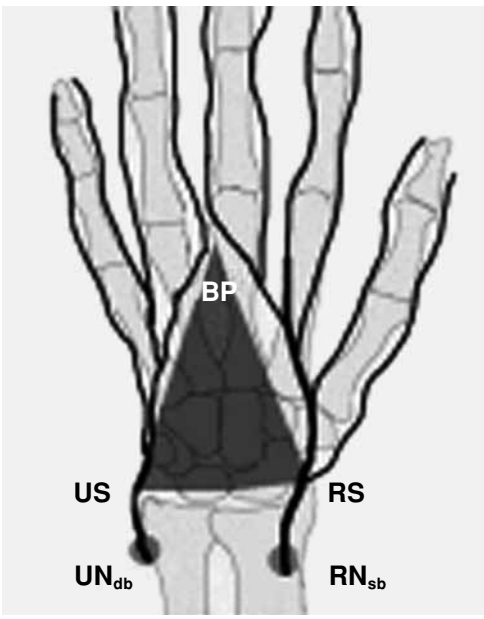

Figure 1. The demonstration of the triangular zone between the central branches of ulnar and radial nerves on the dorsum of the hand. BP: Blend point; US: Ulnar styloid; RS: Radial styloid; UNdb: Dorsal branch of the ulnar nerve; RNsb: Superficial branch of the radial nerve.

RESULTS

The dimensions of the internervous zone

The exact location of the BP was variable. In one cadaver, it was located at the metacarpophalangeal (MCP) joint level in the second web space whereas it was located at the third web space in others. In another

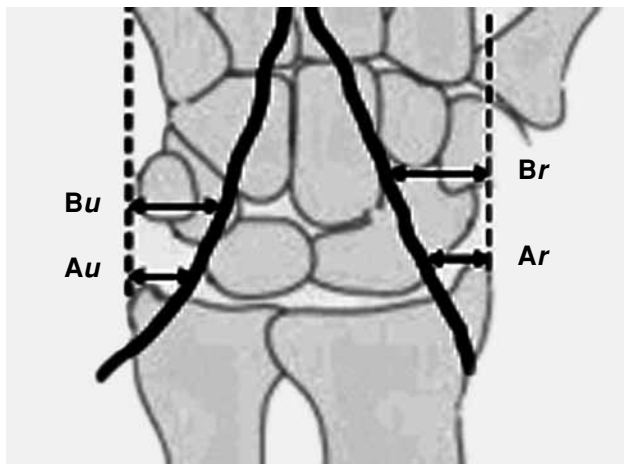

Figure 2. The measurements performed between the central branches of ulnar and radial nerves and the lines drawn vertically from both styloid processes at the levels of radiocarpal (A*u* and A*r*) and mid-carpal (B*u* and B*r*) levels.

cadaver, there was a transverse branch from the UNdb coursing transversely to the radial side at the level of the distal end of extensor retinaculum (Figure 3). The BP was located at the intercarpal joint level in line with the shaft of the third metacarpal in a third cadaver. In all of the other cadavers, the BPs were located at the third web space at the level of the MCP joint. In addition to this variability, the BP was in a different localization between two hands of another cadaver. In this cadaver the distance between the BP and LT was 48.27 mm on the right hand and 97.28 mm on the left.

The mean distance between the RS and US was 50.02 mm (range, 46.08-54.09 mm) on right hands and 51.55 mm (range, 48.13-54.02 mm) on left hands. The mean distance between LT and the BP was 71.53 mm (range, 48.27-93.01 mm) on right hands and 78.46 mm (range, 55.21-97.28 mm) on left hands. With regression analysis, no constant correlation between the distance of RS-US and BP-LT was determined (p=0.406).

The mean distance between LT and LE was 260.42 mm (range, 283-197 mm) on the right, and 260.28 mm (range, 280-205 mm) on the left. With regression analysis, no correlation between the distances of LT-LE and LT-BP was determined (p=0.755).

The courses of RNumb

The mean distance between the vertical line drawn from the radial styloid and the RNumb was 6.22 mm (range, 1.73-20.34 mm) at the level of the radiocarpal joint and 9.54 mm (range, 2.62-28.53 mm) at the level of the midcarpal joint. Linear regression analysis showed no correlation between RS-US distance and these measurements (p=0.939 and 0.944 respectively).

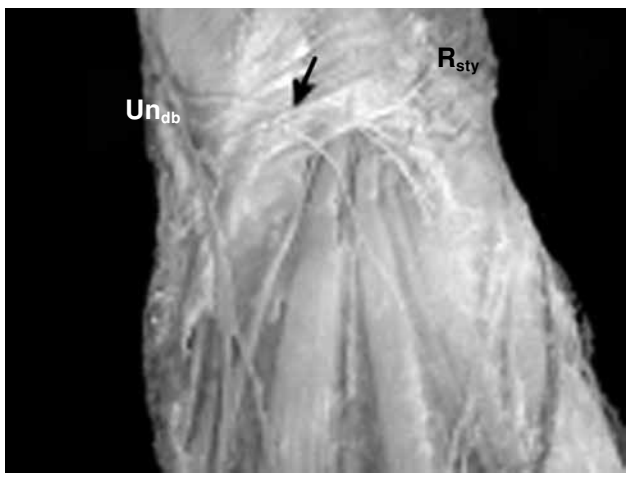

Figure 3. Transverse dorsal branch (black arrow) from the ulnar nerve to the radial side of the wrist at the distal border of the extensor retinaculum. Undb: Dorsal branch of the ulnar nerve; Rsty: Radial styloid process.

This finding indicates that the course of the nerve is not predictable. For both of these measurements, the difference between the minimum and maximum values underlines the variability of the course of the radial nerve on the dorsum of the hand. For cadavers having a distance of 20.34 mm at the level of radiocarpal joint and a distance of 28.53 mm at midcarpal joint levels, there seem to be a very narrow zone free of any nerve on the midline of the dorsal hand. The nerve gives almost transversal branches to the ulnar side of the hand.

The courses of UNmrb

The mean distance between the vertical lines drawn from the ulnar styloid and the UNmrb at the level of radiocarpal joint was 9.43 mm (range, 1.45-34.92 mm). The mean distance for this nerve at midcarpal joint level was 11.57 mm (range, 3.36-30.16 mm). Linear regression analysis showed no correlation between RS-US distance and these measurements (p=0.641 and 0.542 respectively). As with the course of the radial nerve, that of the ulnar nerve also seems to have great variability, sometimes giving transverse branches like the radial nerve that may be vulnerable to injury during surgery.

DISCUSSION

Two nerves (the dorsal branch of the ulnar nerve and the superficial branch of the radial nerve) innervate the dorsum of the hand. Great variability in the anatomic course of these two nerves seems to be a rule, and makes them vulnerable to injury during both arthroscopic and open surgery[9-12] ending with painful neuromas.[13] Prediction of the course and branching patterns of the nerves and the limits of internervous area could prevent neural injury. In this study, we aimed to define a safe zone for the dorsum of the hand similar to those defined for the axillary or the superior gluteal nerves.[14,15] We also worked to define the course of these sensory nerves with regard to some proven measurements.

When we compared the dimensions of the nerve free zone with distances between anatomical landmarks, we couldn't determine any mathematical relationship. The results of this study reveal that there is no nerve free zone on the dorsum of the hand whose dimensions are invariable, and it cannot be predicted using anatomical landmarks. Neither the height of the triangular/quadrangular area, nor the courses of both nerves seem to be quantitatively related to any measurements between these anatomical landmarks.

Two main groups of variability seem to affect the results in our study. First, the exact localization of the BP differs between individuals. In addition, an

interesting situation for localization of the BP was the difference between two hands of the same cadaver. In clinical practice, the variations in the localization of this point prevent surgeons from making a decision about the distal extension of a longitudinal incision. A transverse branch from radial or ulnar nerve branch to the other side as in one of our cadavers also makes these nerves susceptible to injury during surgery. The second group of variability affecting the results of the study was the difference in branching patterns and communications of these two nerves, in conjunction with the findings of Loukas et.al.[7] who defined a classification scheme for this variability. Tryfonidis et al.[16] and Kılıç et al.[17] also try to introduce a guideline for arthroscopic portal placement and define mean values for distances between dorsal wrist arthroscopy portals and sensory nerves. The transverse branching between the nerves frustrates the value of these measurements, because it can be at any level and lie down near a radiocarpal or a midcarpal portal. Here, we also tried to define a guideline for safe surgical and arthroscopic intervention, but no proportion between constant measurements and the courses of nerves was determined. Although we give mean values between landmarks and most central branches of dorsal sensory nerves, the difference between minimum and maximum values for these measurements is great; sometimes up to a 34-times difference between two individuals.

Rather than defining a whole area free of any cutaneous nerve, Tindall et al.[18] in a cadaveric study, define a safe zone for positioning of 6R portal for wrist arthroscopy. In this study, the dorsal branch of the ulnar nerve is determined to be safe if this portal is placed in a range of 19-27% of the distance between the ulnar styloid and the fourth web space. However, the transverse branches traversing the wrist joint may affect and change the range of the safe zone described by them. In addition, the topographical localization of the incisions when working in the hand becomes more important due to these unexpected alterations as underlined by Bilgin[19] for the volar region of the hand. Thus, during any surgical exposure the classification defined by Loukas et al.[7] must be always kept in mind.

The branching patterns and the courses of the UNdb and RNsb and the communications between them could not be standardized because of the great variability they are inheriting. In addition, this variability can be seen between two hands of an individual as we demonstrated on one of our cadavers.

In conclusion, the innervation pattern of the dorsum of the hand shows great variability. It is not possible to define a safe zone or a guideline for secure surgical intervention. We don't have any objective criteria to predict the courses of sensory nerves of the dorsal hand and wrist. Meticulous dissection during open surgery and blunt dissection after incision for portal placement seem to be the indispensable principles for dorsal hand surgery. We don't recommend placement of a wrist portal using a number 11 spiky blades and making a deep incision up to the joint capsule, as it is performed in knee arthroscopy.

Declaration of conflicting interests

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