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Pigmented border as a new surface landmark for digital nerve blocks: a cross sectional anatomical study

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Abstract

The purpose of this study was to identify surface anatomy of digital nerves in relation to the pigmented border of digits. Three-hundred and sixty digital nerves in 36 preserved adult cadaveric hands were dissected under magnification. The digital nerves were constantly located anterior to the pigmented border. The median curvilinear distance along the skin from the pigmented border to the digital nerves of the index, middle, ring and little fingers was 1.4 mm. In the thumb, this distance was 2.4 and 3.7 mm on the radial and ulnar sides, respectively. The digital nerve was located 2.4 mm deep to the skin in all fingers. The median angle to the nerve from the skin at the pigmented border was 30°. These dimensions differed in the thumb compared with the rest of the fingers. We conclude that the pigmented border of digits is a reliable anatomical landmark to locate digital nerves.

Keywords

Ring block, digital nerve block, digital nerve, pigmented border, anaesthesia

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Introduction

Anaesthesia for surgery involving the fingers can be achieved by infiltrating local anaesthetic agents around the digital nerves. Regional anaesthesia to a single digit is achieved by two main approaches; volar and dorsal (Brutus et al., 2002; Kasmaei et al., 2013). Braun (Braun, 1914; Braun and Harris, 1924) first described the two-injection dorsal digital nerve block. In this method, the needle is inserted dorsally at the base of the digit into the areas surrounding the two digital nerves on radial and ulnar sides successively. The needle is advanced until the tenting of the skin is felt in the palmar surface. The anaesthetic agent is then injected while withdrawing the needle (Braun, 1914; Braun and Harris, 1924). An advantage of this technique is that the dorsal approach is less painful than the volar needle puncture (Ahmad, 2017). Volar block include a single or two injection punctures subcutaneously at the palmar digital crease of the digit (Ahmad, 2017). The aim of this method is to anaesthetize the finger by delivering anaesthetic agent close to the digital nerves (Miller et al., 2010). In dorsal digital block, clinicians use the feel of needle advancement inside the finger as a guide to the site of infiltration (Ahmad, 2017). Thus, there is a risk of needle puncture injuries to the clinician.

Standard anatomical publications describe the nerve in relation to deep structures of the digit (Standring, 2015; Zenn et al., 1992). Previous studies concentrated on identifying the digital nerves in pulley release procedures and reconstructive surgery (Carrozzella et al., 1989; Pope and Wolfe, 1995; Zenn et al., 1992). None of the available studies indicate the exact anatomical location of the digital nerves or the distance of the advancement and the angle of needle puncture. This highlights the need for a fixed surface landmark for the digital nerves during local anaesthetic

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delivery. Thus, the objective of this study was to assess the validity of the pigmented border of the digit (Figure 1) as a surface landmark to locate the digital nerves.

Methods

A descriptive anatomical study was conducted on self-donated cadavers of Sri Lankan ethnicity. Ethical clearance was obtained from the institutional Ethics Review Committee [EC/15/149] and the study was conducted in accordance with the guidelines set out in the Declaration of Helsinki.

Thirty-six preserved adult cadaveric hands were selected using a simple random sampling method. A power analysis was conducted to calculate the sample size for the measurements of distances following a pilot study (Faul et al., 2007; Meurs, 2016). A sample size of 22 was obtained when the significance level and statistical power were set at 0.05 and 0.80, respectively, at a mean effect size of 0.46. Cadavers with vitiligo or deformed fingers were excluded from the study.

Phenoxyethanol mix was used as the preservative (Nicholson et al., 2005). The solution contained 95% ethanol (60.16%), glycerine (15.10%), water (15.10%), 90% phenoxyethanol (7.65%) and 37% formalin (1.99%). Eight litres of the solution was injected via the femoral artery over 3–4 h. Extremities were not injected separately to preserve the original soft tissue arrangement. The bodies were kept in body bags for 3 months to ensure required quality of fixation before dissections. We used this method because it did not discolour, and the tissue texture was maintained. Furthermore, it produced good definition between different types of tissues.

The study comprised two parts. In Part A, using 14 cadavers, anatomical variations of the digital nerves between the distal palmar crease and the distal interphalangeal crease of all the fingers were studied. Cadaveric hands were positioned supine and skin incisions were made along the pigmented border of the digits on ulnar and radial sides. The digital nerves were identified with dissection under magnification and traced proximally and distally to describe the anatomical variations. In Part B, cross sectional anatomy of the digital nerves with their relations were studied. Twenty-two formalin preserved cadaveric upper limbs were frozen in minus 20°C for 48 h. The soft tissue was sectioned using a size 24 carbon steel scalpel blade (REF 0211, Swann-Morton, Sheffield, UK), at the level of the palmar digital crease down to the bony surface. The bone was sectioned proximal to this incision using a hand saw (Swann-Morton). This method was used to avoid distortion of the anatomical relations of the nerve by the saw. Digital nerve and vessels were identified.

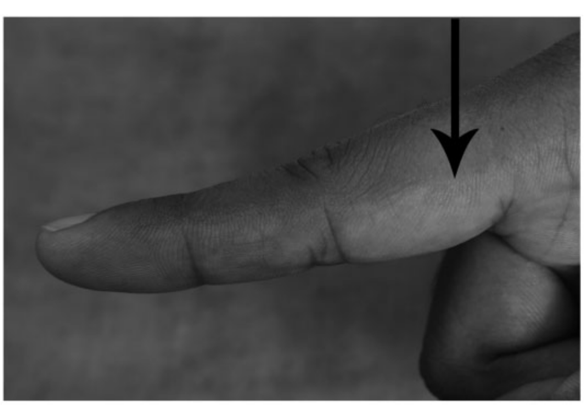

Figure 1. Radial surface of index finger of the right hand showing the pigmented border (arrow).

The following measurements were obtained on cross sections of digits at the level of palmar digital crease (Figure 2). A perpendicular line was drawn from the centre of the cross section of the digital nerve to the closest overlying skin surface. This distance was defined as D. The curvilinear distance along the skin from the pigmented border to where the aforementioned line touches the skin was defined as C. The direct distance from the skin surface at the pigmented border to the digital nerve was defined as X. Measurements were recorded with an accuracy to the nearest 0.1 mm using a Vernier calliper (Model No - 505-633-50, Mitutoyo, Kanagawa, Japan), set squares, divider and a fine thread. The angle of needle insertion from the dorsal side through the pigmented border towards the digital nerve was calculated (θ) with an accuracy to the nearest 5° (Figure 2). Mid-upper-arm circumference and the length of upper limb from the apex of the lesser tubercle of the humerus to the tip of the index finger were measured in centimetres using a standard measuring tape. Gender and the side of the hand were also recorded.

Non-parametric statistics were used to analyse and describe data. Mann-Whitney U and Kruskal Wallis tests were used to compare means of two and multiple sample means, respectively. Spearman's test was used to examine correlations between two continuous variables. All the analyses were conducted with a priori alpha of 0.05.

Results

Thirty-nine randomly selected cadavers were initially screened for the eligibility to be included in the study. Two cadavers with deformed fingers and one cadaver with vitiligo were excluded, leaving 36 cadavers for the study. All these cadavers had conspicuous pigmented borders on their digits. Of 14 cadaveric hands studied in Part A, the male: female ratio was 1:1. There were

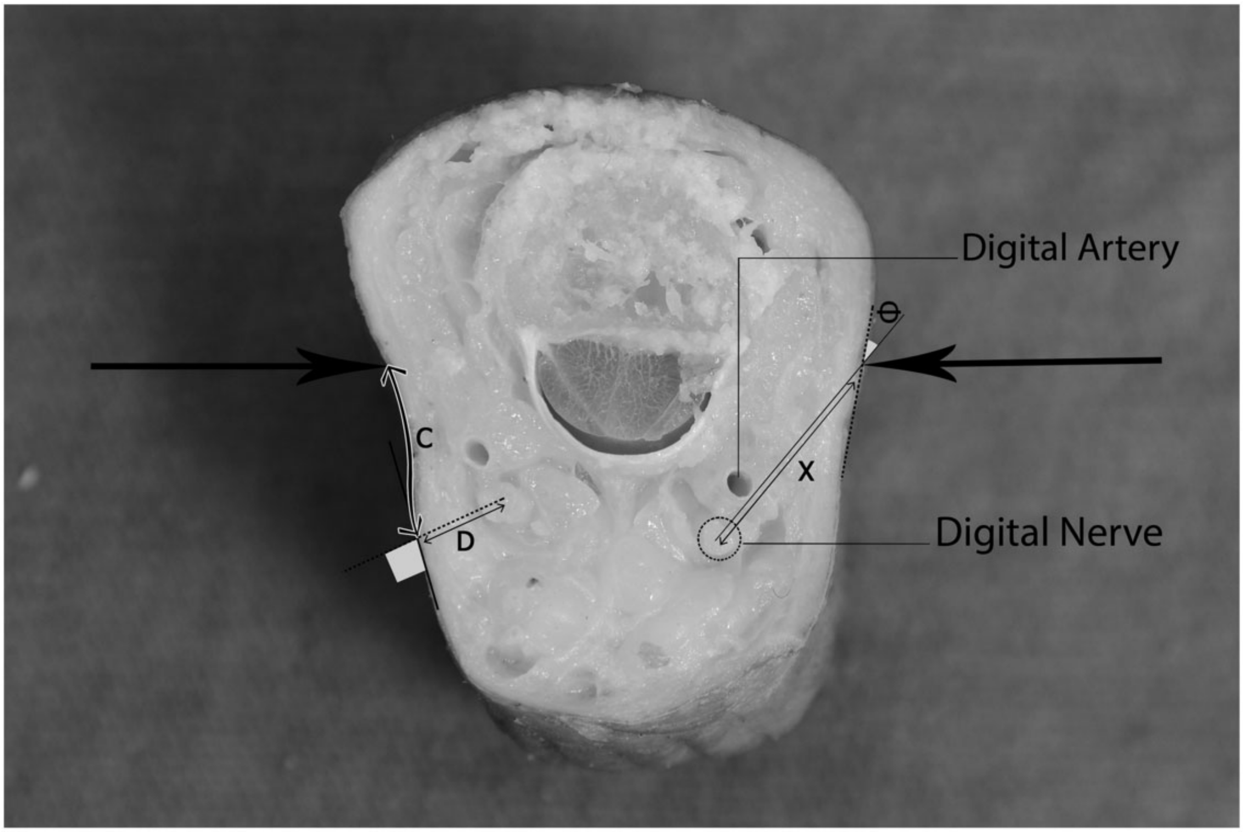

Figure 2. A cross section of a ring finger at the level of the palmar digital crease showing the digital nerves in relation to the pigmented border (marked by an arrow). C, curvilinear distance along the skin from the pigmented border of digits to a perpendicular line joining the nerve and the nearest overlying skin measured at the palmer digital crease; D, distance from the digital nerve to a line that touches the closest overlying skin surface; θ, angle of needle insertion from the dorsal side through the pigmented border towards the digital nerve; X, direct distance from the skin surface at the pigmented border to the digital nerve.

equal numbers of right and left hands. The digital nerves were constantly located anterior to the pigmented border. All the proper digital nerves originated in the distal palm before the palmar digital crease. The dorsal cutaneous branch was given off proximal to the palmar digital crease in all cases. After passing between superficial and deep transverse ligaments, the digital nerves were found on either side of the fibrous flexor sheath. The digital artery was dorsolateral to the digital nerve on the radial aspect, and dorsomedial to the digital nerve on the ulnar aspect in all digits. Only one main nerve trunk was found between the palmar digital crease and proximal interphalangeal crease. There were two to three branches distal to the proximal interphalangeal crease.

In Part B, 22 cadaveric hands (right:left = 13:9) were studied to obtain cross sections of 110 digits. The male to female ratio was 1:1. Visual observations and Shapiro-Wilk tests of the variables C, X, D and θ rejected the hypotheses of normal distribution ($P < 0.01$). The median X and D were 2.9 mm (IQR = 2.4–4.0 mm) and 2.4 mm (IQR = 1.8–2.9), respectively. The median angle (θ) was 30° (IQR = 20°–45°). The above measurements on radial and ulnar aspects of each digit are summarized in Table 1. The statistical tests comparing the medians of variables C, X, D and θ are given in Table S1 and summarized in the following text.

The digital nerve location on radial and ulnar sides was similar in all fingers apart from the thumb (see post-hoc Mann-Whitney tests in Table S2). The median distance C on radial side of the thumb 2.4 mm (IQR = 1.8–3.8 mm) was significantly lower than that of the ulnar side of the thumb 3.7 mm (IQR = 2.4–5.7 mm) ($U = 144.5$, $P = 0.022$). However, there was no significant difference in the median C in the rest of the fingers (1.4 mm, IQR = 1.0–2.0 mm). The median X of all four digits excluding the thumb was 2.9 mm (IQR = 2.3–3.6 mm). The median X on radial side of the thumb (3.6 mm, IQR = 2.4–4.6 mm) was significantly lower than that of the ulnar side (4.9 mm, IQR = 3.4–5.8 mm). The measurements C and X on either side of each finger are summarized in boxplots (Figures S1 and S2,

Table 1. A comparison of median (interquartile range) curvilinear distance (C), depth from the skin (D) and angle (θ) and direct distance from the pigmented border (X) in either side of each digit.

Digit	Side of the digit	Curvilinear distance: C (mm)	Depth from the skin: D (mm)	Angle: θ (degrees)	Direct distance from the pigmented border: X (mm)
Thumb	Ulnar	3.7 (2.4–5.7)	2.7 (1.5–4.6)	35 (10–70)	4.9 (2.5–9.0)
	Radial	2.4 (1.8–3.8)	2.6 (1.3–5.3)	30 (10–60)	3.6 (1.4–7.9)
Index	Ulnar	1.3 (0.8–1.6)	2.6 (0.7–4.6)	25 (10–50)	3.1 (0.8–6.3)
	Radial	1.5 (1.1–2.4)	2.8 (1.0–5.1)	35 (0–60)	3.3 (1.6–8.0)
Middle	Ulnar	1.4 (1.1–2.4)	2.3 (1.0–4.7)	35 (10–75)	2.8 (1.1–4.8)
	Radial	1.4 (1.0–2.0)	2.6 (1.3–5.3)	40 (10–70)	3.1 (1.5–6.0)
Ring	Ulnar	1.5 (1.3–2.1)	2.4 (1.0–4.3)	35 (10–70)	2.8 (1.2–6.8)
	Radial	1.2 (0.8–1.9)	2.8 (1.1–4.5)	35 (10–65)	3.1 (1.8–5.1)
Small	Ulnar	1.6 (1.0–2.5)	2.1 (0.6–4.4)	30 (10–70)	2.8 (1.0–5.3)
	Radial	1.9 (1.2–2.0)	2.1 (1.0–3.8)	35 (5–75)	3.1 (1.3–7.8)

D: distance from the centre of the digital nerve to the closest overlying skin surface.
C: curvilinear distance along the skin from the pigmented border to where a line joining the centre of the digital nerve touches the overlying skin.
X: direct distance from the skin surface at the pigmented border to the digital nerve
θ: angle of needle insertion from the dorsal side through the pigmented border towards the digital nerve (see Figure 2).

respectively). The median D of all four digits excluding the thumb was 2.4 mm (IQR = 1.7–2.9) mm. The median D of the thumb was 2.6 mm (IQR = 2.2–2.8 mm) and was similar in ulnar and radial sides. Males had a higher median distance of X (3.0 mm, IQR = 2.6 – 4.4 mm) than females (2.8 mm, IQR = 2.2 – 3.6 mm). The rest of the measurements were comparable between the two genders. The location of the nerves did not differ according to upper arm circumference, or side of the hand. The greater the length of the upper limb, higher the angle (θ).

Discussion

The pigmented border of the finger was used as a guide to locate the digital nerve in our study. Having a single nerve trunk without branching between the palmar digital crease and the proximal interphalangeal crease, and having a fairly constant location irrespective of gender and build, makes our technique of locating the nerve for the digital block more appropriate. A common infiltration depth and curvilinear distance can be adopted for all the fingers except the thumb. In the thumb, the curvilinear distance (C) from the pigmented margin to the nerve was more on the ulnar side than on the radial side. This correlated with the author's clinical experience, where effectiveness of local anaesthetics was better when anaesthetic agent was infiltrated at a greater distance anteriorly from the pigmented border on the ulnar compared with the radial side of the thumb.

The findings of Wallace and Coupland (1975) were supportive of our observation of only one main nerve trunk without branching at the palmar digital crease. The dorsal branch was absent in 5 out of 25 digits in Wallace's study. In contrast, Part A of our study showed the dorsal branches in all the specimens. Similarly, a cadaveric study on 40 fingers showed that there was a constant dorsal digital branch arising from the digital nerve at the base of the proximal phalanx (Tellioglu and Sensoz, 1998). Lourie et al. (1998) described a method to locate the radial digital nerve of the index finger based on 15 unpaired cadaveric hand dissections. In 13 out of 15 dissections, the radial digital nerve crossed deep to a point where a line drawn from the midline of the index finger crossed the proximal palmar crease. Zenn et al. (1992) studied the course of the radial digital nerve of the thumb using cross sections at the metacarpophalangeal joint in five cadavers. They found the radial digital nerve 2.2 mm (range 1.3–2.9 mm) deep to the dermis and 1.2 mm anterior to the radial sesamoid bone. This finding is comparable to our study as we found the radial digital nerve of the thumb was 2.4 mm deep to the skin. Both Lourie's and Zenn's studies were individualized for a particular nerve that might be relevant to operations such as pulley release. We found that the digital artery had a dorsolateral (on the radial aspect of the digit) or dorsomedial (on the ulnar aspect of the digit) relationship with the digital nerve as opposed to a direct dorsal relationship stated by Wallace and Coupland (1975).

Kasmaei et al. (2013) stated that the volar approach is more suited for local anaesthetic block because the nerve is situated towards the palmar aspect of the hand. In contrast, Thompson and Malchow (2002) preferred the dorsal approach as the palmar skin is thicker than dorsal and difficult to penetrate with a needle. Another study found the two techniques were equally acceptable in terms of effectiveness and pain (Ahmad, 2017). According to our study, if the dorsal approach is used, the needle should be inserted approximately 3 mm deep from the pigmented border at the palmar digital crease directing 30° from a tangent line at the pigmented border towards palmar aspect of the finger in all the fingers except the thumb. In the thumb, the needle should be advanced approximately 3.5 mm and 5 mm in the radial and the ulnar sides, respectively, with the same angle. If a volar approach is used, the needle should be inserted approximately 2.5 mm, at a 90° angle to the skin surface, 1.4 mm anterior to the pigmented border of any digit except the thumb. In the thumb, the needle should be advanced to a similar depth, 2.4 mm and 3.7 mm anterior to the pigmented border on the radial and the ulnar sides, respectively.

Since this study was based on preserved cadavers, subtle distortions of anatomy due to post-mortem changes cannot be ruled out. However, meticulous techniques were used for the preservation and fixation of the fresh cadavers to ensure normal dimensions. Future studies should involve clinical correlations of these findings. The pigmented border can be appreciated in people from the ethnicities with dark or tan skin colour spanning from Latin American, Mexican, Southern European, Middle East and most of the Asian populations. Since the pigmented border may be inconspicuous in Caucasian populations, the results may not be reproducible in them. Therefore, further studies to see whether mid-axial line of the digits or dermatoglyphics can be used to surface mark the digital nerve can be recommended. In our study, we assessed the anatomical basis of both volar and dorsal injection techniques. Therefore, it is possible for clinicians to adopt these findings according to their desired method of digital block. Clinical studies can be conducted to assess the pain scores while injecting local anaesthetic agents using different techniques according to the present findings.

We conclude that the pigmented border of digits is a reliable anatomical landmark to locate the digital nerves. Hence, this landmark can be used as a guide for clinicians when injecting local anaesthetic agents for ring blocks using both volar and dorsal approaches.

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Data sharing statement The data are available from the corresponding author upon reasonable request.

Supplementary material Supplemental material for this article is available online.

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