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## ORIGINAL COMMUNICATION

# Applied Anatomy of the Superficial Branch of the Radial Nerve

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The superficial branch of the radial nerve (SBRN) is highly vulnerable to trauma and iatrogenic injury. This study aimed to map the course of the SBRN in the context of surgical approaches and identify a safe area of incision for de Quervain's tenosynovitis. Twenty-five forearms were dissected. The SBRN emerged from under brachioradialis by a mean of 8.31 cm proximal to the radial styloid (RS), and remained radial to the dorsal tubercle of the radius by a mean of 1.49 cm. The nerve divided into a median of four branches. The first branch arose a mean of 4.92 cm proximal to the RS, traveling 0.49 cm radial to the first compartment of the extensor retinaculum, while the main nerve remained ulnar to it by 0.64 cm. All specimens had branches underlying the traditional transverse incision for de Quervain's release. A 2.5-cm longitudinal incision proximal from the RS avoided the SBRN in 17/25 cases (68%). In 20/25 specimens (80%), the SBRN underlay the cephalic vein. In 18/25 (72%), the radial artery was closely associated with a sensory nerve branch near the level of the RS (SBRN 12/25, lateral cutaneous nerve of the forearm (LCNF) 6/25.) A longitudinal incision in de Quervain's surgery may be preferable. Cannulation of the cephalic vein in the distal third of the forearm is best avoided. The close association between the radial artery and first branch of the SBRN or the LCNF may explain the pain often experienced during arterial puncture. Particular care should be taken during radial artery harvest to avoid nerve injury. Clin. Anat. 21:38–45, 2008. 

**Key words: radial nerve; de Quervain's; antebrachial; cephalic vein; artery; cannulation; Kirschner; fracture; wrist block; radial artery puncture**

## INTRODUCTION

The superficial branch of the radial nerve (SBRN) is the third most commonly damaged peripheral nerve, after the spinal accessory and common peroneal nerves, and is readily amenable to repair (Kim et al., 2001; Kretschmer et al., 2001). Injury may result from fractures, lacerations, sustained pressure (e.g., handcuffs in a study by Grant and Cook, 2000) or may be iatrogenic. Examples of the latter include cannulation of the cephalic vein (Boeson et al., 2000; Vialle et al., 2001), harvest of the radial artery (Denton et al., 2001), as a complication of percutaneous fracture fixation in up to 20% of cases (Singh et al., 2005), during wrist arthroscopy (Steinberg et al., 1995) and surgery for de Quervain's tenosynovitis (Belsole, 1981).

De Quervain's tenosynovitis is an inflammatory condition of the first compartment of the extensor retinaculum (containing the tendons of extensor pol-

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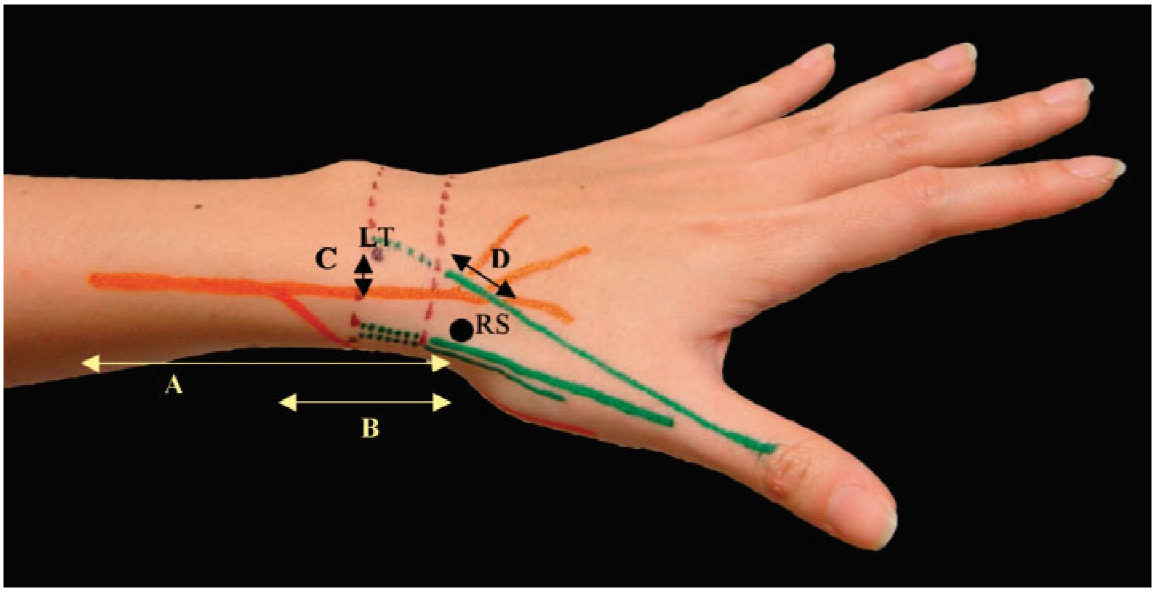


**Fig. 1.** Course of SBRN relative to the extensor retinaculum, extensor tendons, and bony landmarks. LT, dorsal tubercle of the radius; RS, radial styloid process; A, length of SBRN from emergence (between ECRL and BR muscles) to RS: 8.31 ($\pm$1.14) cm; B, first branch of SBRN distance from RS: 4.92 ($\pm$1.44) cm; C, main trunk of SBRN distance from LT: 1.49 ($\pm$0.53) cm; D, distance from extensor retinaculum that all distal branches crossed EPL tendon: 2.69 ($\pm$0.87) cm; all branches crossed in the proximal 39.4% ($\pm$13.5%) of EPL tendon length between the extensor retinaculum and tendon insertion. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

licis brevis (EPB) and abductor pollicis longus (APL)) that results in a functional narrowing of the compartment and pain on movement of the tendons. The condition affects women 10 times more frequently than men, with the commonest cause appearing to be overuse of the hand at home or work (Canale, 1998). Associations include rheumatoid arthritis and pregnancy (Avci et al., 2002). Anatomical variations within the first extensor compartment are frequent. Jackson et al. (1986) carried out a cadaveric study in which the number of tendons within the first extensor compartment differed from the standard description in 75% of cases. Furthermore, there was complete or partial septation of the compartment in 40% of specimens. This was in keeping with the intraoperative findings of a series of patients who underwent surgical treatment for de Quervain's tenosynovitis. Treatment for de Quervain's tenosynovitis ranges from conservative splinting and steroid injection into the affected compartment to surgical decompression of the first extensor compartment in refractory cases (Canale, 1998).

Injury to the SBRN typically produces an area of paresthesia over the dorsum of the first web space or, more seriously, results in the formation of a painful and debilitating neuroma. Understanding the course of this sensory nerve should minimize the risk of iatrogenic injury and aid the recognition of accidental injury.

This study aimed to describe and clinically apply the anatomy of the SBRN relative to the first compartment of the extensor retinaculum, the cephalic vein, and the radial artery.

## MATERIALS AND METHODS

Twenty-five upper limbs from 16 (8 males and 8 females) UK Caucasian, formalin-preserved cadavers were studied (13 left and 12 right limbs). The mean age of the subjects was 79.5 years (range 67–91 years; SD = 7.0 years). Dissection of the limbs from the humeral epicondyles to the metacarpophalangeal joints was carried out. Skin and subcutaneous tissue were removed from the limbs. Nerve trunks, veins, and arteries were identified and preserved. The location of the SBRN was measured relative to the radial styloid (RS) process (from which measurements were taken in a longitudinal direction) and the dorsal tubercle of the radius (from which measurements were taken in a transverse plane). All measurements were made using Vernier calipers accurate to 0.1 mm and are presented as mean values $\pm$ standard deviation. In addition, measurements were taken relative to the distal edge of the extensor retinaculum, defined as the point where transverse fibers of the retinaculum blended with the fascia and where the septae of the compartments ended distally. This landmark was chosen as it is identified readily at operation. All measurements involving soft tissue structures (such as nerve trunks) were taken from their edges to give clinically relevant distances between structures. Close association between structures was defined as a separation distance of less than 2 mm. Measurements were expressed as both absolute distances and as relative lengths compared to the cadavers' forearm lengths. Forearm length was measured as the distance between the olecra-

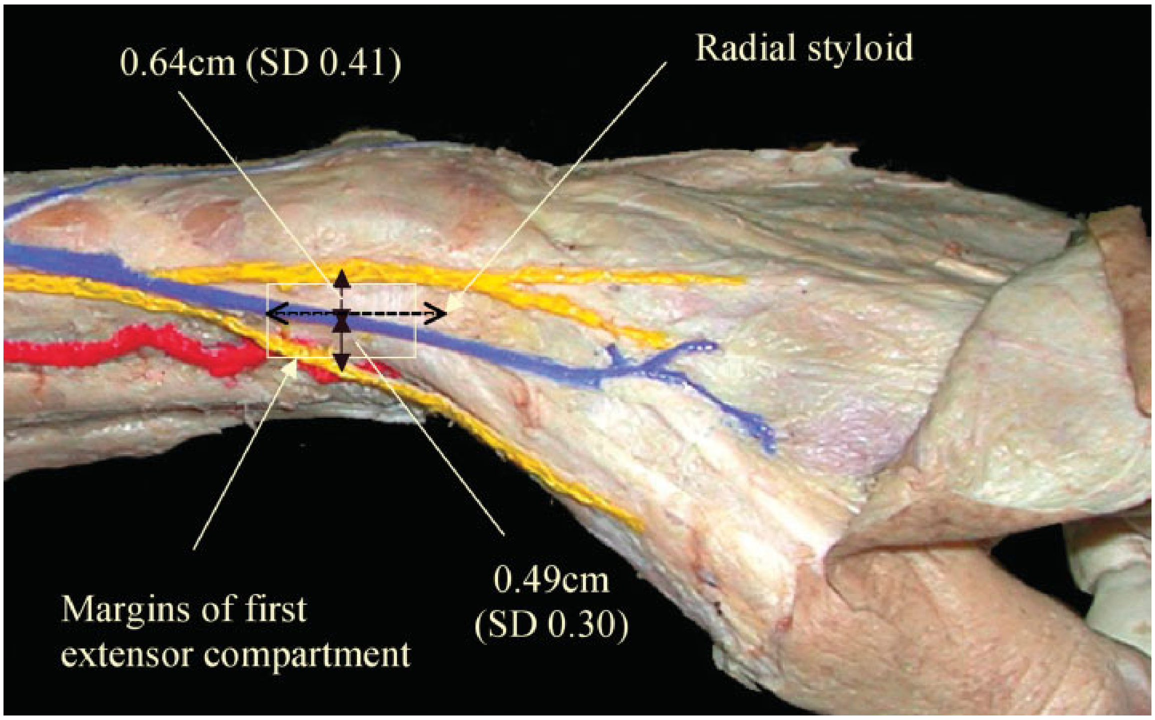


**Fig. 2.** Relationship between the SBRN and the first compartment of the extensor retinaculum. Dotted arrow, 2.5-cm longitudinal incision from RS over first compartment, avoiding nerves in 17/25 (68%) cases. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

non process and ulnar styloid process. Additionally, standard incision patterns for de Quervain's tenosynovitis (overlying the first compartment of the extensor retinaculum) were assessed for the frequency with which they would abut or cross underlying nerve trunks. A specific 2.5-cm longitudinal incision commencing at the RS and running proximally, overlying the first dorsal compartment, was also assessed in the same fashion. Sketches and photographs were taken during data acquisition. For the purposes of data presentation, the SBRN, the lateral cutaneous nerve of the forearm (LCNF), the cephalic vein, and its tributaries together with the radial artery were highlighted with water-soluble paint to illustrate their relative courses. The findings were compared with those in previous publications.

## RESULTS

The SBRN emerged from under brachioradialis (BR), between the heads of the extensor carpi radialis longus (ECRL) and the BR muscles, at a mean distance of 8.31 cm (±1.14 cm standard deviation) proximal to the RS process (Fig. 1, arrow A). This represented 32.8% (±4.1%) of the length of the forearm. The forearms in the study were 25.32 (±1.81) cm long. The first branch, which came off in a radial direction and continued on to the volar aspect of the forearm, innervated the radial aspect of the thumb. This branch formed 4.92 (±1.44) cm proximal to the RS (19.5% [±5.9%] of the forearm length) (Fig. 1, arrow B). The main trunk of the SBRN continued distally, passing 1.49 (±0.53) cm radial to the dorsal tubercle of the radius (SD) (Fig. 1, arrow C). Three to five branches were then given off from the SBRN which passed over the tendon of extensor pollicis longus (EPL). This arborization occurred 0.29 (±0.84) cm distal to the level of the RS (1.2% [±3.4%] of the forearm length) and the nerves travelled in an ulnar direction over the dorsum of the hand supplying the radial three digits (thumb, index, and middle fingers). All branches crossed the tendon of EPL within 2.69 (±0.87) cm of the distal edge of the extensor retinaculum (Fig. 1, arrow D). This represented 39.4% (±13.5%) of the length of the tendon between the extensor retinaculum and the insertion into the distal phalanx of the thumb.

The first compartment of the extensor retinaculum contains the tendons of EPB and APL. The fork created by the main trunk of the SBRN and its first branch overlay the extensor retinaculum on the radial aspect of the wrist (Fig. 2). When measured in a transverse direction, the main trunk was sited 0.64 (±0.41) cm ulnar to the center point of the first extensor compartment and the first branch was sited 0.49 (±0.30) cm radial to the center point. In all cases, the main trunk was ulnar and the first branch was radial to the center point of the first extensor compartment. The transverse and Z incisions for de Quervain's release would cross these nerves in all observed cases. In this study, a 2.5-cm longitudinal

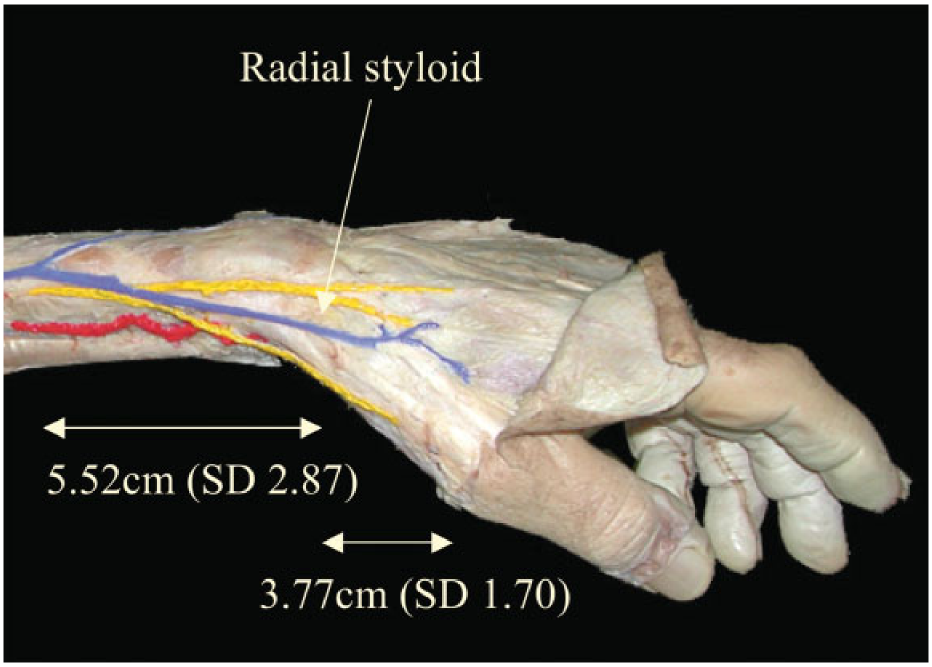


**Fig. 3.** Length of close association (<2 mm) between cephalic vein and SBRN. Close association between SBRN and cephalic vein proximal to RS in 20/25 (80%) specimens and distal to RS in 19/25 (76%) cases. Measurements show length of close association between structures. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

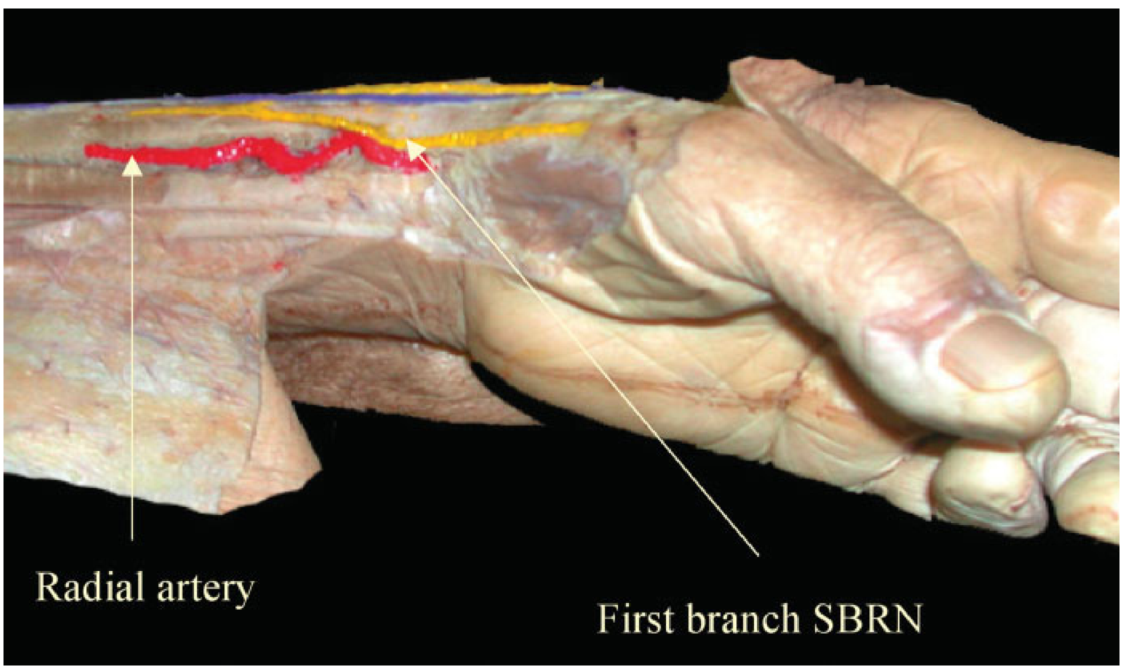


**Fig. 4.** Close association between SBRN and radial artery near the level of the radial styloid process. The radial artery and SBRN were closely associated (<2 mm) near the level of the radial styloid process in 12/25 cases (48%). [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

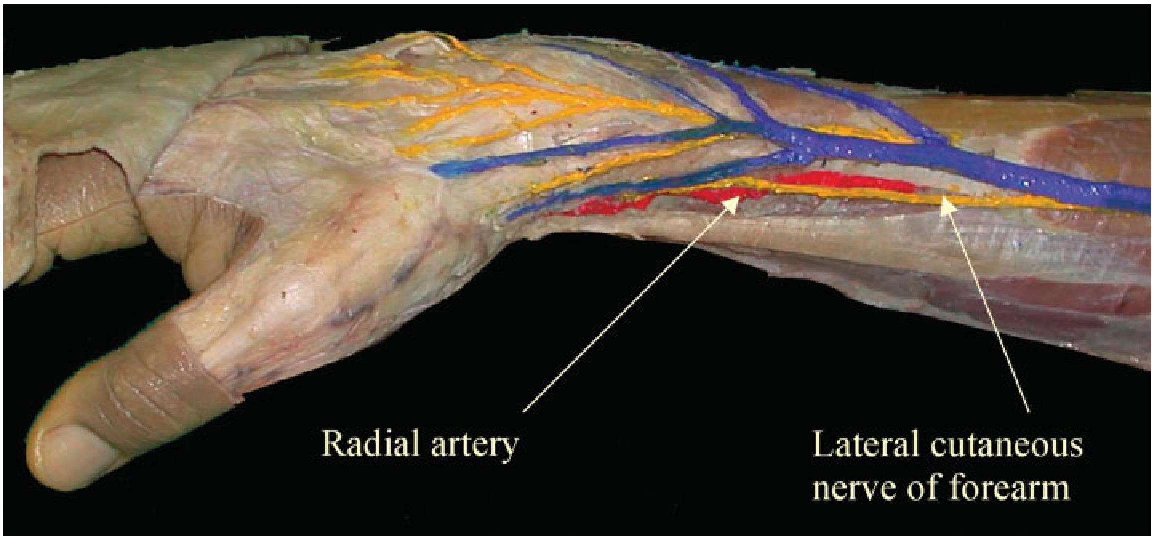


**Fig. 5.** Close association between the radial artery and the LCNF near the level of the radial styloid process. The radial artery and LCNF were closely associated (<2 mm) near the level of the radial styloid process in 6/25 cases (24%). [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

incision commencing at the RS and running proximally, overlying the first dorsal compartment, would avoid the nerves in 17/25 cases (68%). In the remaining 8/25 cases (32%), the longitudinal incision would have at least partially crossed the SBRN.

The cephalic vein was closely associated (<2 mm) with the SBRN in 20 of 25 dissections. Measurements were taken to assess whether this was typically above or below the wrist (Fig. 3). This relationship between the SBRN and cephalic vein was noted to be both proximal and distal to the RS in 16/25 (64%) cases. In 4/25 (16%) cases the relationship was proximal to the RS only, in 3/25 (12%) the relationship was distal to the RS only, and in 2/25 (8%) cadavers there was no close association between the vein and SBRN at any point. Proximal to the RS, close association was typically along a length of 5.52 (±2.87) cm, 21.0% (±11.3%) of the length of the forearm: distal to the RS, there was close association for 3.77 (±1.70) cm, 15.2% (±6.8%) of the forearm length. No consistent pattern was noted as to whether the cephalic vein was sited radial or ulnar to the underlying nerve. In two of the cadavers, both the LCNF and the SBRN ran in close association

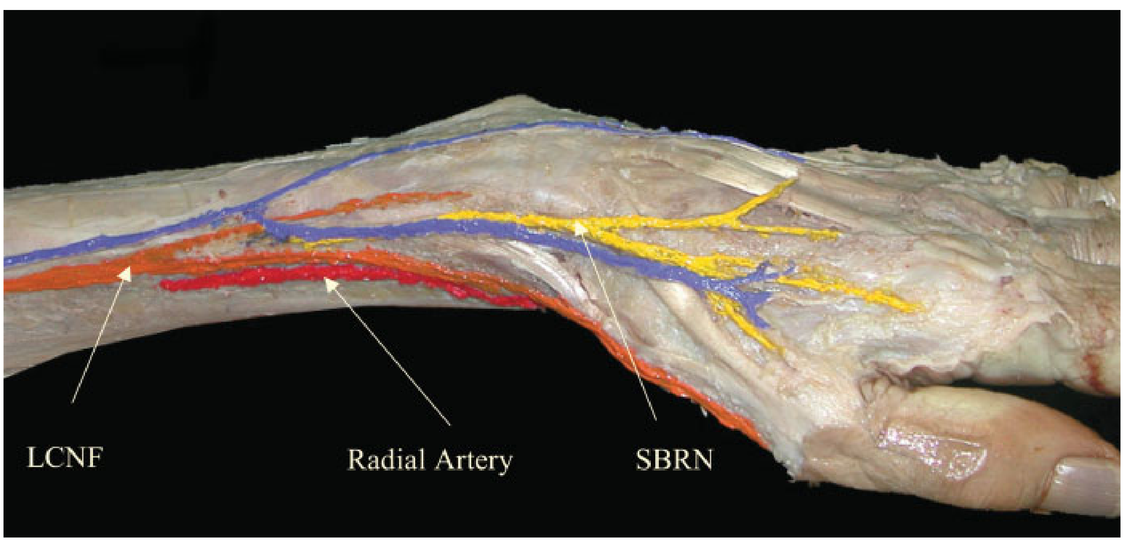


**Fig. 6.** Anomalous distribution of LCNF and SBRN in two specimens (one cadaver). The LCNF overlies the radial artery and innervates the radial aspect of the thumb. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

(<2 mm) to the vein (LCNF on the ulnar side, SBRN deep to the cephalic vein.) In the other cadavers, only the SBRN related closely to the cephalic vein.

The radial artery was found to be closely associated (<2 mm) with the SBRN in 12/25 (48%) cases for at least a part of its length near the level of the RS. This association occurred 1.47 (±0.97) cm proximal to the RS (5.8% [±3.9%] of forearm length) (Fig. 4). Furthermore, it was noted that the artery was closely associated with the LCNF rather than the SBRN in 6/25 (24%) cadavers (Fig. 5). In all cases, the sensory nerve branches either overlay the artery or were sited on the radial aspect. There were no instances of nerve branches sited on the ulnar aspect of the radial artery.

In both limbs of one cadaver an anomalous nerve distribution was noted (Fig. 6). The LCNF crossed directly over the emergence of the SBRN from between the heads of the BR and the ECRL muscles, and subsequently formed a branch that innervated the dorsum of the hand and another branch that passed in a volar direction to overlie the radial artery to innervate the radial aspect of the thumb. The SBRN innervated the ulnar aspect of the thumb and dorsum of the hand, overlapping with the LCNF distribution.

## DISCUSSION

The radial aspect of the wrist is a frequent site of operation. Fractures of the wrist are very common, the radial artery represents a popular harvesting source for coronary artery bypass (CABG) surgery, radial free forearm flaps are used in reconstructive surgery and arterial blood gas analysis and venous cannulation are routinely performed at the wrist. Furthermore, surgery for soft tissue pathology such as de Quervain's tenosynovitis is common.

With regard to first extensor compartment release for de Quervain's tenosynovitis, there is no clear consensus on the optimal skin incision with different authors advocating transverse (Canale, 1998), longitudinal (Adams and Stossel, 1992; Gundes and Tosun, 2005), and Z incisions (Arons, 1987). The incidence of operative damage to the SBRN ranges from 2% in large volume centers (Ta et al., 1999) to 27% in smaller units (Mellor and Ferris, 2000). In this cadaveric study, transverse and Z incisions would have invariably crossed nerves in all cases while 68% of longitudinal incisions (if taken at 2.5 cm proximal to the RS as described above) would have avoided nerve branches and run in parallel with the underlying cephalic vein rather than crossing it. Of note, the longitudinal incision does not obviate the need for care in dissection down to the extensor retinaculum since in 8/25 (32%) cases the longitudinal incision did abut or cross underlying nerve branches. Meticulous intraoperative dissection, regardless of incision type, must be emphasized and care taken to identify nerve branches within the surgical wound. From the present results, it would be reasonable to suggest that the best anatomical approach to the first extensor compartment would be via a longitudinal incision. This would require investigation with clinical trials of actual surgical procedures to find a balance between the incidence of complications and cosmetic outcome. Canale (1998) argues that a transverse incision produces the most favorable cosmetic outcome.

There are several reports of injury to the SBRN as a result of cephalic vein cannulation, with slow recovery and occasional painful neuroma formation (reviewed in Boeson et al., 2000). A cadaveric study has identified randomly located nerve and vein crossing zones (Vialle et al., 2001). In our study, there was a close association (<2 mm) between the SBRN and the cephalic vein in 20/25 cases (80%), for most of the length of the SBRN. The cephalic vein is one of the most likely of all peripheral veins to be associated with neurological injury as a result of cannulation. For this reason, cannulation should be avoided in the region of the SBRN (distal third of the forearm) but is safe proximal to the emergence of the nerve—for practical purposes 10 cm proximal to the RS. If it must be attempted, the presence of tingling, numbness, or patient discomfort should prompt the operator to select an alternative site.

Radial artery puncture for arterial blood gas sampling and the siting of arterial lines is characteristically painful. There is evidence from randomized controlled trials that the pain is significantly reduced by infiltration of local anesthetic but not topical anesthetic creams (Lightowler and Elliott, 1997; Aaron et al., 2003). It may be that the pain of radial artery cannulation is caused by trauma to the first branch of the SBRN, which was closely associated to the artery in 12/25 (48%) of our cases, or the LCNF, which was closely associated to the artery in 6/25 (24%) cases. This neurovascular relationship centers over the area where arterial cannulation is most frequently attempted—approximately 1.5 cm proximal to the RS. This study suggests that SBRN injury could be minimized by approaching the artery from the ulnar side or confining exploratory needle passage to the ulnar aspect of the artery during puncture.

Postoperative sensory abnormalities in the distribution of the radial nerve have been reported in 10–18% patients undergoing radial artery harvesting (Denton et al., 2001; Greene and Malias, 2001) for CABG surgery. From this study, particular care should be taken in dissecting the distal portion of the artery, where nerve trunks are closely associated with the vessel in 72% of cases.

Knowledge of the distribution of the main trunk and branches of the SBRN is important when exploring lacerations of the forearm and dorsum of the hand, since the nerve is amenable to surgical repair. From this study, in addition to the main trunk and first branch of the SBRN, 3–5 branches are given off from the arborization of the first branch of the SBRN and care should be taken to identify injury to these small nerve branches on the dorsum of the hand so that prompt repair may be undertaken if necessary.

The radial forearm fasciocutaneous free flap is of considerable use to plastic and reconstructive surgeons. The procedure entails harvesting a fasciocutaneous paddle together with a length of radial artery and cephalic vein or venae comitantes. The SBRN may be damaged during raising of the flap.

Flap donor site morbidity of the SBRN has been documented by Grinsell and Thiele (2005) at between 9 and 18% depending on whether the venae comitantes or cephalic vein were utilized as part of the flap (raising the cephalic vein doubled the risk of SBRN injury). Anatomically this is in keeping with the present study as it is demonstrated that a close relationship occurs between the cephalic vein and SBRN in the majority of individuals. If harvest of the cephalic vein is undertaken by the surgeon during formation of the flap, an awareness of the precise anatomical location of the SBRN in relationship to both the radial artery and cephalic vein is essential.

Wrist local anesthetic blocks are routinely used in hand surgical procedures. It is necessary to anesthetize both the main trunk and first branch of the SBRN to provide full sensory blockade of the nerve. A wide variety of approaches are advocated by practicing anesthetists. For example, Wedel (2000) recommended infiltration of local anesthetic superficial to the EPL tendon at the base of the first metacarpal while Allman and Wilson (2006) preferred infiltration some two finger breadths proximal to the metacarpal base along the radial border. From this anatomical study, to achieve sensory blockade of the SBRN, the most efficient site for infiltration of local anesthetic would be between the point of emergence of the SBRN between the heads of BR and ECRL muscles and the formation of the first branch of the SBRN. Consequently, the preferred region for application of local anesthetic wrist block would be on the radial border between the distal 33% and the distal 20% of the length of the forearm.

Clearly the anatomy of the SBRN with regard to common orthopedic surgical approaches at the wrist is important. Examples of these are wrist arthroscopy and percutaneous fixation of fractures of bones such as the distal radius or carpus (e.g., scaphoid and perilunate fractures). These have been formally investigated elsewhere (Botte et al., 1989; Steinberg et al., 1995; Slutsky, 2002). This cadaveric study demonstrates that the course of the SBRN produces a safe-zone in the anatomical snuff-box in terms of potential nerve damage but does not consider the radial artery and cephalic vein, which pass through the base and roof of the snuffbox, respectively. Given the variability of the location of structures within the anatomical snuffbox region, some authors suggest that limited open procedures are preferable to exclusively percutaneous approaches to bony structures at the wrist (Steinberg et al., 1995; Hochwald et al., 1997). The data in this study support limited open approaches in orthopedic wrist surgery but we are not able to fully comment on them.

A limitation of this study of the SBRN is the relatively small number of cadavers in the dissection series. In the light of this, conclusions drawn here are tentative and emphasize surgical safety.

This dissection series confirms the findings of other studies that have examined the anatomical relationship between the SBRN, bony structures, and the extensor retinaculum (Abrams et al., 1992). Furthermore, using cadaveric dissection, it has been documented that, based on the anatomical distribution of nerve branches, there is at least partial anatomical overlap between the SBRN and LCNF in 75% of cases (Mackinnon and Dellon, 1985). Consequently, in injuries to the radial side of the wrist, there may be simultaneous injury to both the LCNF and the SBRN. As a result of this, denervation of the SBRN alone to treat neuroma-related pain at the dorsoradial side of the hand may be unsuccessful. In these instances, the potential involvement of the LCNF should be considered.

In summary, knowledge of the clinical anatomy of the SBRN may minimize nerve injury associated with several commonly performed hospital procedures. Specifically, a longitudinal rather than transverse or Z-incision for de Quervain's tenosynovitis may be less traumatic. This proposal merits further study in a clinical setting.

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