

# Optimal Surgical Approach for First Metacarpal Base Fractures; A Surgical-Anatomical Study

*J Hand Surg Eur Vol. 2020 Feb;45(2):136-139.*

A.P.A. Greeven

J. Van Groningen

A. Poublon

E.M.M. Van Lieshout

G.J. Kleinrensink

M.H.J. Verhofstad

## Abstract

The aim of this study was to define a possible safe zone for a (minimally invasive) surgical approach of first metacarpal fractures in relation to the superficial branch of the radial nerve (SBRN) and the Dorsal Branch of the Radial Artery (DBRA).

Twenty embalmed arms were dissected and the course of the SBRN and the DBRA in each individual arm was marked. With Computed Assisted Surgical Anatomy Mapping (CASAM) a large diversity in anatomical pattern for the SBRN and a consistent pattern for the DBRA was found. Combining these findings, a safe zone could be defined for future surgical fixation. Preferably, a percutaneous or minimally invasive trans-metacarpal fixation technique should be used treating first metacarpal fractures, with K-wire positioned on the radial border of the first metacarpal, in the distal 75% of the first and second metacarpal to prevent iatrogenic damage to SBRN and DBRA.

***Level of Evidence: Anatomical Study***

## Introduction

Long-term complications after percutaneous and open surgery of the first metacarpal have recently been reported, describing pain and loss of sensation of the thumb [108-111]. The SBRN is known for its involvement in pain syndromes which are very difficult to treat [112]. Therefore, it is generally assumed that preventing iatrogenic damage to the SBRN is of clinical importance.

Injury to the superficial branch of the radial nerve (SBRN) has been reported after various types of operations, e.g. external fixation of distal radial fractures [113-116]. Suggestions have been made to adjust pin positioning, from the radial side to the dorsal side of the radius while applying an external fixator to prevent damage of the SBRN [111]. Similar iatrogenic injuries have been described for K-wire fixation according to Kapanji. Semi-open procedures; i.e. surgical approach, blunt dissection and the use of a tissue guard; have also been suggested with direct vision to approach the distal radius. Iatrogenic injury of the radial artery has also been reported in hand surgery [117, 118]. The dorsal branch of the radial artery (DBRA) can be damaged during inter-metacarpal Kirschner wire fixation [50, 119, 120].

The anatomical technique called Computer Assisted Surgical Anatomy Mapping (CASAM) has been successfully used to define anatomical variance in a diversity of anatomical studies [121-124]. Based on these anatomical studies clinically important suggestions have been made to optimize surgical approaches [123, 125].

The current anatomical study uses CASAM to focus on the branching pattern of the SBRN and the DBRA in relation to the first and second metacarpal. The hypothesis was that based on the anatomical position of the SBRN and the DBRA a possible safe zone could be described for minimally invasive or even percutaneous surgery to approach of first metacarpal fractures preventing iatrogenic damage to the SBRN and DBRA.

## Materials and methods

### *Preparation of the specimen*

Twenty arms were flushed with anubifix® ([www.anubifix.com](http://www.anubifix.com)) to regain flexion after rigor mortis and embalmed with a 4.4% formalin solution. None of these arms showed macroscopic signs of disease or previous surgery. All dissections were performed by two researchers (AG and JvG, Level of experience Level IV and III respectively) [76].

### *Dissection*

A standardized dissection technique was used. A semi-circular incision was made on the radial side of the forearm, approximately 10 cm distally from the elbow. On the volar side of the forearm a longitudinal incision was made towards the thenar muscle. Another incision was made on the dorsal side over Lister's tubercle towards the second Metacarpal Phalangeal joint (MCP II). The two longitudinal incisions were connected via a semi-circular incision over the dorsal

side of the Interphalangeal joint (IP) and the MCP II joint. The skin flap was then dissected from cranial to distal after identifying the SBRN submerging between Brachioradialis muscle (BR) and Extensor Carpi Radialis Longus (ECRL).

In each arm the SBRN was located directly where it emerges between the BR and the ECRL. The course of the SBRN was then dissected distally to the Interphalangeal joint (IP) and Second Metacarpal Phalangeal joint (MCP II). At each location where the nerve branched a yellow pin was placed.

The Radial Artery was identified at the styloid process of the radius. The Dorsal Branch of the Radial Artery was marked with a red pin. The dorsal branch was identified within the anatomical snuff box and web space I. Both locations were again marked with a red pin.

### **CASAM**

Using CASAM enables comparison of anatomical routes or anatomical relationships between different anatomical specimen which are different in size and dimension [121, 123-125]. CASAM is based on the fact that bony landmarks (BL), such as Lister's tubercle, have a relatively constant position in each arm. From these "bony landmarks" so called "shape defining landmarks" (SDL) are calculated, to mark the outline of each arm, by equally dividing the space between two BL's. The BL's and SDL's were used to define the shape of each arm and the locations for these landmarks were computed. A digital program called Magic Morph (Publisher eTinysoft, version Nov 2007) was used to merge all twenty arms into one "average" arm. Each separate arm was then transformed into the shape of this "average" arm using the "average" arm as a model, a process called warping.

The result is that all twenty arms now have the dimensions of the "average" arm making it possible to compare the arms and the course of the SBRN and the DBRA in each arm individually.

### **Photoshop processing**

Each arm was photographed using a Nikon 60D camera with a Sigma 50mm 1:2.8 DG MACRO lens. These photographs were made using a standardized set-up [124]. The camera was positioned perpendicular to the specimen at a fixed distance and the arms were placed in specially designed clamps to ensure standard alignment [125].

The photographs of each are is then used for CASAM. After morphing of the twenty arms on these photographs, each arm is given the dimensions of the "average arm". On each of these twenty photographs the course of the SBRN and DBRA are traced using Photoshop CS4.

The photoshop layers marking the twenty routes of the SBRN are then compiled into one picture for further analysis. The same is done for the twenty routes of the DBRA.

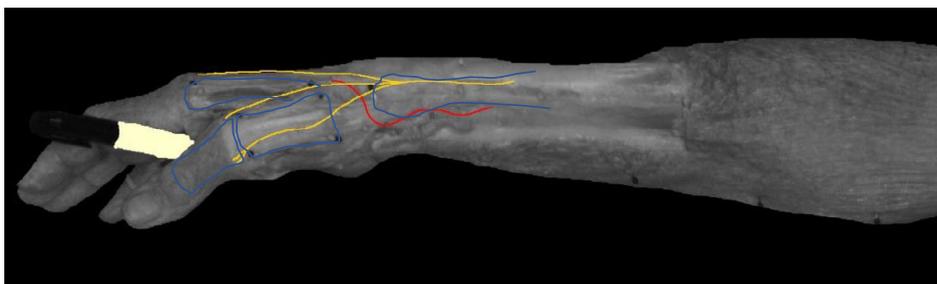
### **Safe zone identification**

A low-density area of the SBRN is defined for the branching pattern of the SBRN. The same was done for the branching pattern of the DBRA. The photoshop layers marking the SBRN and the

DBRA were than combined. The overlap between the low-density squares for the SBRN and the DBRA define the possible Safe Zone. The safe-zone is then related to bony landmarks for clinical reference.

## Results

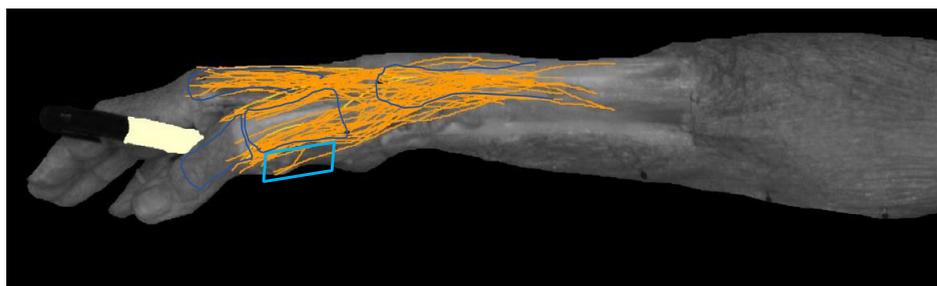
In all twenty arms the SBRN and DBRA could be identified and the anatomical course defined. Standardized photographs of all twenty arms could be made. Using CASAM it was possible to process all twenty arms. The course of the SBRN and DBRA were traced in all twenty arms and marked with yellow and red lines using Photoshop CS4 (**Figure 1**).



**Figure 1. The marked course of the Superficial Branch of the Radial Nerve and the Dorsal Branch of the Radial Artery on one arm**

*(Yellow = Superficial Branch of the Radial Nerve, Red = Dorsal Branch of the Radial Artery, Dark Blue line: identifies Distal Radius, First and Second Metacarpal and Proximal Phalanx)*

The marked courses of the SBRN of all twenty arms were than projected on one arm using photoshop (**Figure 2**). The course of the SBRN at the Carpo-Metacarpal joint and base of the first metacarpal was very diverse. A possible zone with low density of SBRN could be marked more distally from the CMC joint. The diversity pattern found of the SBRN considered a safe zone was marked with low density of the SBRN (**Figure 2; blue square**).

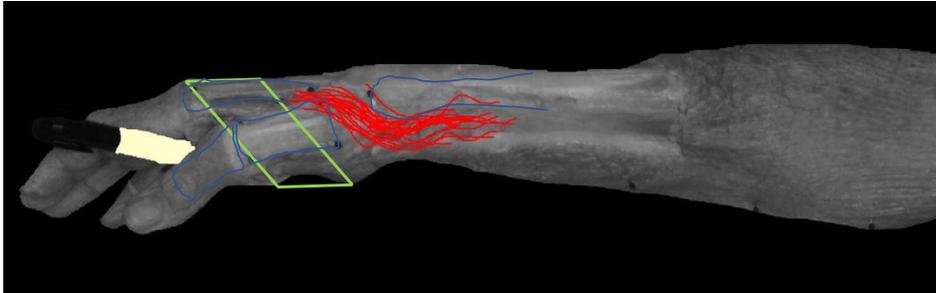


**Figure 2. The twenty routes of the Superficial Branch of the Radial Nerve**

*Bleu-Square: low density zone*

*Dark Blue line: identifies Distal Radius, First and Second Metacarpal and Proximal Phalanx*

The twenty courses of the DBRA were projected on one arm (**Figure 3**). The course of the DBRA was shown to be very similar in all twenty arms. A zone with low density of DBRA can be marked just distally from the base of the second metacarpal, this area corresponded with 25% of the total length of the second metacarpal (**Figure 3; green square**).

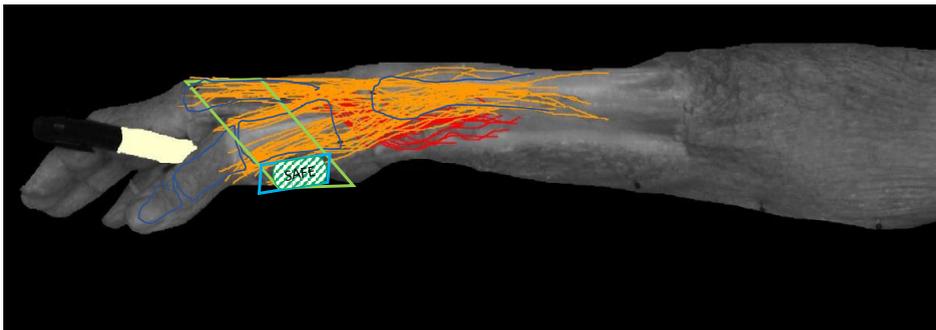


**Figure 3. The twenty routes of the Dorsal Branch of the Radial Artery**

*Green Square: low density zone*

*Dark Blue line: identifies Distal Radius, First and Second Metacarpal and Proximal Phalanx*

Combining the courses of the SBRN and DBRA shows overlap between the two squares resulted in a possible Safe Zone (**Figure 4**).

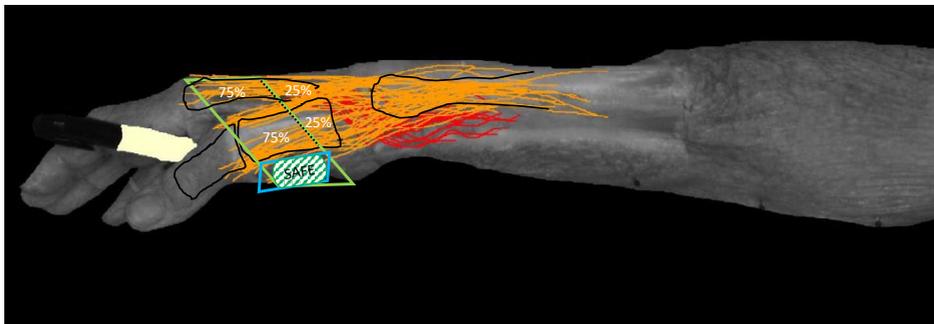


**Figure 4. Combining the routes of the SBRN and the DBRA resulting in a possible Safe Zone**

*Combined Square: Safe Zone*

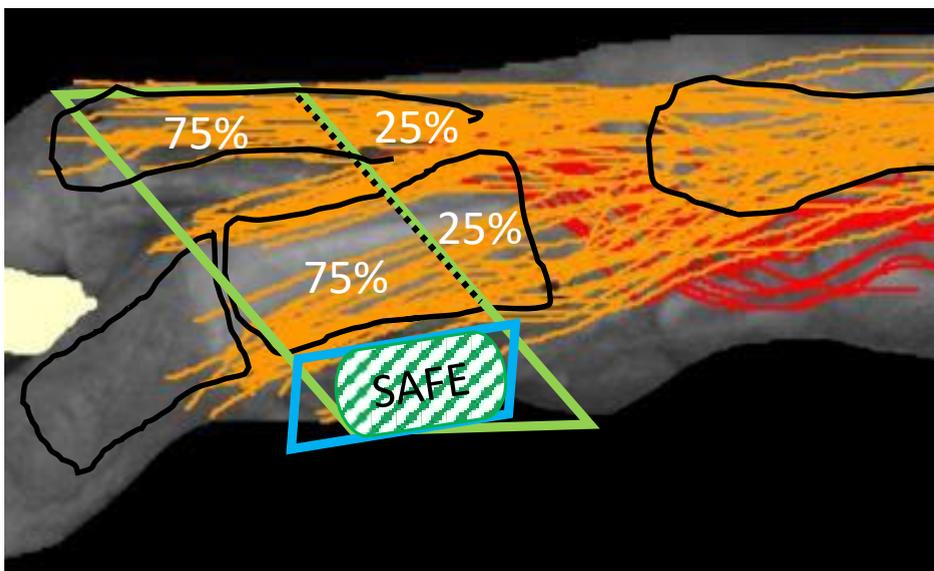
*Dark Blue line: identifies Distal Radius, First and Second Metacarpal and Proximal Phalanx*

Assessment of the Safe Zone in relationship with bony structures showed that at the base of the first metacarpal a large diversity of branching pattern could be found of the SBRN. This area corresponded with 25% of the total length of the first metacarpal (**Figure 5 and 6**).



**Figure 5. Safe Zone in relationship to bony structures**

*Black line: identifies Distal Radius, First and Second Metacarpal and Proximal Phalanx  
% (in white): branches of SBRN mostly seen in base 25% of metacarpals*



**Figure 6. Detail of base of First Metacarpal with the Identified Safe zone.**

*Black line: identifies Distal Radius, First and Second Metacarpal and Proximal Phalanx  
% (in white): branches of SBRN mostly seen in base 25% of metacarpals*

## Discussion

The most important finding of the current study is that a safe-zone for optimal surgical approach of first metacarpal fractures can be defined. This safe-zone for surgery of the first metacarpal is based on the diverse courses found for the SBRN and the very similar anatomical routes found for the DBRA.

The current study is the first in which CASAM was used to suggest a possible safe zone for first metacarpal surgery. The current study has shown that this new anatomical technique, in which modern digital processing techniques are used to compare anatomical findings in separate anatomical specimen, can be successfully used in hand surgical research as well.

The reported large diversity in anatomical course of the SBRN over the first and second metacarpal might be explanatory for the iatrogenic injury which sometimes occur during surgery resulting in post-operative pain and loss of sensation [109].

A similar anatomical route of the DBRA in all twenty arms was found. This might explain why iatrogenic arterial injury occurs less frequently in metacarpal surgery than in scaphoid fixation [126]. Nonetheless, according to the current study the dorsal branch of the radial artery can be at risk when using a percutaneous inter-metacarpal technique for first metacarpal fractures, in which the cranial Kirschner wire is placed at the base of the second metacarpal (**Figure 5**).

For ORIF of first metacarpal base fractures a dorsal or latero-dorsal approach is often recommended [127]. These incisions use anatomical landmarks such as the Extensor Pollicis Longus tendon, Extensor Pollicis Brevis tendon and Abductor Pollicis Longus and bony landmarks such as Radial Styloid Process, First Carpo-Metacarpal Joint (CMC-I) and Metacarpal Phalangeal Joint to define the surgical approach. With the large variance in anatomical branching pattern of the Superficial Branch of the Radial Nerve as found in this study an open approach for first metacarpal base fractures can be a challenging operation and the diversity in branching pattern makes it very hard to predict where sensory branches can be found. It therefore can be debated if a dorsal or latero-dorsal approach could better not be used.

The modified Wagner approach projects through skin overlapping the base of the first metacarpal. Based on the current anatomical study it can be confirmed that the SBRN is at risk during this approach. This explains the results reported in a recent long-term clinical study reporting on the comparison between outcome after ORIF and CRIF after 10-year follow-up. A change of sensation of the thumb was reported in 13 patients, of which 11 had been treated using ORIF. Secondly, patients with high pain scores (VAS) were only seen in ORIF patients [109].

Several K-wire positioning for CRIF are described [25, 61, 128, 129]. The findings of the current study suggest that with Wagner's and Iselin's technique, in which the cranial K-wire transfixes the first metacarpal to the base of the second metacarpal, the DBRA might be at risk [24, 25, 128]. To prevent possible injury to the DBRA the K-wire position should be placed in the area where the DBRA is absent. When compared with bony landmarks this corresponds with distal 75% of the second metacarpal (**Figure 3**). Clinical studies have shown that a parallel trans-metacarpal fixation technique can be safely used in the treatment of extra-articular fractures

as well as intra-articular fractures at the base of the first metacarpal and result in good clinical and radiological outcome [11, 56].

Alternative K-wire placement is seen with pin fixation of the first metacarpal to the trapezium [129]. In order to prevent the SBRN from injury the skin overlying the base of the first metacarpal should be avoided. When compared with bony landmarks this corresponds with not placing K-wires in the proximal 25% of the first metacarpal (**Figure 5**). Therefore, this technique might be more difficult to perform when aiming to avoid the overlying skin of the proximal 25% of the first metacarpal.

Based on the current study an extra-focal pinning technique in which the K-wires are positioned more distally from trapezo-metacarpal joint and placed in the distal 75% of both the first and second metacarpal would be the safest option to prevent the DBRA and SBRN from injury.

Based on the current study the authors conclude that an open surgical approach of the base of the first metacarpal base might result in unintended damaging the sensory nerve of the radial nerve. A closed extra-focal pinning technique could prevent this complication from occurring, while using the defined safe-zone for K-wire positioning.