

The arterial blood supply for the synovial tendon sheaths of the hand

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ABSTRACT

The blood supply for the synovial tendon sheaths of the hand was carefully investigated. We show that the origin of those arteries, supplying the synovial tendon-sheaths of the Mm. flexor pollicis longus, flexor digitorum superficialis and profundus, lies in the Canalis carpi. We also describe that the branches of the Aa. digitales palmares propriae arise independently. We emphasize that the terminal branches of the A. interossea posterior and the Rete carpi dorsalis form an arterial network on the synovial tendon sheaths of the Dorsum manus. The synovial membranes of the proximal joints of the fingers receive an ample blood supply from the Rami ascendentes of the Aa. metacarpeae palmares and the Aa. digitales palmares propriae (Aa. recurrentes).

Key words. Human. Hand. Arteries. Arterial anastomoses. Hand arteries.

INTRODUCTION

The digital sheath is the fibrous and synovial structure which wraps around the flexor tendons on the palmar side of the metacarpophalangeal joints and fingers. This sheath plays a major role in the mechanics of the digital flexor tendons and influences their blood supply. This structure is essential for digital flexion. The fibrous layer is attached to the periostium of the phalanges; its main parts are the pulleys. The synovial layer consists of two components, a parietal and a visceral.¹

Angiography may be used to demonstrate the arteries of the fingers and those arteries of the hand which

La llegada de sangre arterial para las capas del tendón sinovial de la mano

RESUMEN

El presente estudio investiga en forma minuciosa la irrigación sanguínea de las vainas sinoviales tendinosas. Describe el origen arterial que abastece las vainas sinoviales tendinosas de los músculos flexores de los dedos superficial, profundo y del pulgar localizados en el túnel del carpo. También demuestra que los ramos de las arterias colaterales de los dedos se originan independientemente una de otra. Además los ramos terminales de la arteria interósea posterior y el arco dorsal del carpo forman una red arterial en las vainas sinoviales tendinosas del dorso de la mano. La membrana sinovial de las articulaciones metacarpofalángicas obtiene un rico riego sanguíneo a través de los ramos ascendentes de las arterias colaterales de los dedos (arterias recurrentes).

Palabras clave. Humano. Mano. Arterias. Anastomosis arterial. Arterias de la mano.

form the various variations of the *Rete carpi dorsale* i.e. the A. *radialis*, the A. *interossea posterior* and the A. *ulnaris*.² The most commonly observed artery of the *Rete dorsale* is the *Ramus carpeus dorsalis* of the A. *radialis*, which begins 10 to 15 mm distally from the *Processus styloideus* radii with variations of its caliber and its area of supply.³ The A. *dorsalis pollicis* can also be demonstrated in a high percentage of the cases.⁴ The type of variation in the *Rete carpi dorsale* is determined by the arteries from which it originates ranging from the complete absence of the *Rete* to its formation by all three of the blood vessels.⁵

Kenesi and Droide⁶ have reported that the dorsal part of the synovial membrane of the metacarpophal-

langeal joints represents two thirds of this synovial membrane and that the surrounding ligaments and the capsule of the joints permit only the dorsal parts of the joint to be affected by rheumatoid inflammations of the synovial. Therefore it is recommended to perform synovectomies of the metacarpophalangeal joints from the dorsal side.⁶ In this report we describe the pattern and the origins of the arteries supplying the synovial membrane of the proximal *radiocarpea* and the metacarpophalangeal joints, and the synovial tendon sheaths and suggest improvements of the surgical treatment in this region.

MATERIAL AND METHODS

In this study we investigated 22 hands of post-mortem cases from both sexes, with no previous fixation, whose axillary arteries were perfused with 200 mL Silicosehl® (registered trademark) silicone rubber prepared with 10% cross-linker (catalyst). Silicosehl® silicone rubber has a low viscosity and according to the degree of catalyzation becomes a rubber of great consistency. For this processes the catalysts K11 and K14 from Silicosehl® are used. The silicone rubber solution was injected by hand using a 500 mL threaded syringe, avoiding rupture of small blood vessels. The threaded syringe allows for delivery of more viscous fluids with less force and/or allows more controlled delivery of fluids. As vascular resistance gave way the solution was perfused with manual pressure until it was observed returning through the venous system. It was not necessary to use a pressure pump since all specimens had no previous fixation for conservation, and perfusion of the solution displaced intravascular material. Following this the specimens were fixed in Jores' solution (formaldehyde, alcohol and glycerin) for their conservation for six months, and a delicate preparation of the arteries in the hand region was carried out through stereomicroscope with a Carl-Zeiss OPMI 1 with a 250 mm objective at 4X. Subsequently, the course of the arteries was photographically documented with a Canon EOS 1000F camera with a 35-80 mm lens.

RESULTS

The palmar aspect of the hand

In the region of the *Carpus*, the *A. radialis* and the *A. ulnaris* form the *A. transversalis superficialis* which supplies the proximal area of the superficial part of the synovial tendon sheaths of the *M. flexor*

digitorum superficialis, *M. flexor digitorum profundus* and *M. flexor pollicis longus* (Figure 1). Branches from the *A. transversalis superficialis* also supply the *Nervus medianus* with blood. The medial parts of the carpal synovial tendon sheaths are supplied by the *Ramus palmaris superficialis* of the *A. radialis* and by a branch from the *A. ulnaris*. The *Arcus palmaris superficialis* provides the blood supply for the distal parts of the synovial tendon sheaths of the *M. flexor pollicis longus*, *Mm. flexor digitorum superficialis* and *profundus*.

The synovial tendon sheath of the fifth finger is connected with the carpal *Vagina synovialis communis*. Thus, these structures form a topographical entity which is supplied with blood by the first and second *A. digitalis palmaris communis*.

The deep leaf of the carpal synovial tendon sheaths is supplied with blood by the *A. transversalis profunda*, which stems from the *A. ulnaris*, the *A. interossea anterior* and a *Ramus profundus* of the

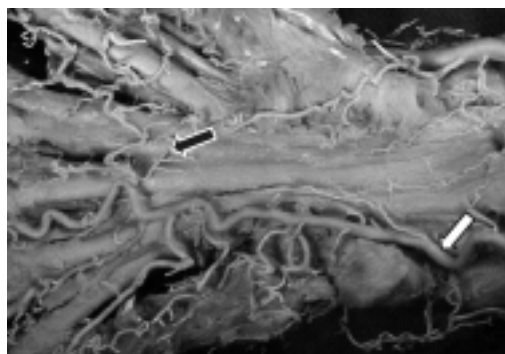


Figure 1. In the palmar aspect of a right hand the *A. ulnaris* (white arrow) form the *A. transversalis superficialis* which supplies the proximal area of the superficial part of the synovial tendon sheaths of the *M. flexor digitorum superficialis* (black arrow).

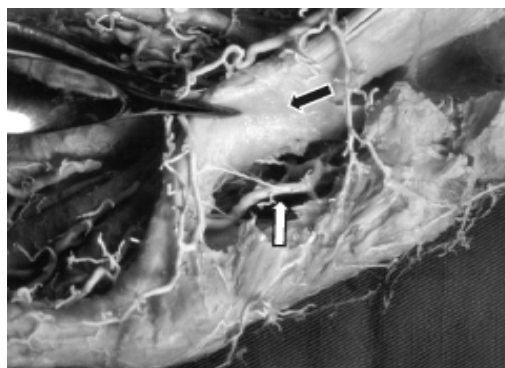


Figure 2. The deep leaf of the carpal synovial tendon sheaths (black arrow) of a right hand is supplied with blood by the *A. transversalis profunda* (white arrow).



Figure 3. Blood supply of the Vincula tendinum longum (black arrow) and breve (white arrow) of a left hand.



Figure 4. In the dorsal aspect of the hand the Rete carpi dorsale sends branches to the synovial tendon sheath of the M. extensor digitorum communis.

A. radialis (Figure 2). The *Arcus palmaris profundus* provides the blood supply for the palmar parts of the synovial tendon sheaths of the *M. flexor pollicis longus*, *M. flexor digitorum superficialis* and *profundus* and also forms an anastomosis with branches of the *A. transversalis profunda*. These branches supply the synovial membrane of the carpal joint.

The distal end of the synovial tendon sheath of the *M. flexor pollicis longus* reaches up to the base of the distal phalanx of the thumb. This digital tendon sheath is supplied by the *A. princeps pollicis* and its two *Aa. digitales palmares propriae*, for the radial and the ulnar edge of the thumb.

On the palmar aspect of the fingers, the tendons of the long flexor muscles are enclosed by a double sheath. One is a fibrous sheath, designed to direct the movements of the tendons, the other is a synovial sheath, which ensures the smooth gliding within the structure of the sheath.

The digital tendon sheaths are supplied with blood by the *Aa. digitales palmares propriae*. From these arteries originate superficial, deep and dorsal branches. The deep branches are the most important, since they pass all joints of the finger and ensure a rich blood supply for the lower leaf of the digital tendon sheath.

Thus, the deep branches supply for the digital tendons and the *Vincula tendinum (longum et breve)* as well as for the synovial membrane of each joint (Figure 3). The superficial branches supply for the digital tendon sheaths and the dorsal branches for the dorsal aspect of the fingers.

The dorsal aspect of the hand

The *A. interossea posterior* contributes to the blood supply for the extensor muscles of the forearm. It lies on the *membrana interossea* in a ra-

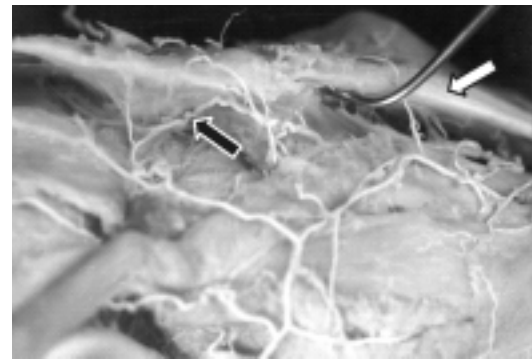


Figure 5. Dorsal site of a right hand. The radial branch of the *A. interossea posterior* runs through the deep leaf of the synovial tendon sheath (black arrow) of the *M. extensor digitorum communis* (white arrow).

ther fixed position. It terminates into a radial and ulnar branch which proceed towards the *Rete carpi dorsale*. Before its termination there, it sends off branches to the synovial tendon sheath of the *M. extensor digitorum communis* (Figure 4). These branches surround the broad synovial tendon sheath and form artero-arterial anastomoses on its dorsal and palmar plane (Figure 5). Other contributions to the *Rete carpi dorsalis* are the *Ramus carpeus dorsalis* of the *A. radialis* and the *Ramus carpeus dorsalis* of the *A. ulnaris*.

The main orientation of the bigger branches in the *Rete carpi dorsalis* is a longitudinal one. These main branches have smaller side branches at various angles which hardly form anastomoses. The mainly longitudinal orientation of the branches causes some areas to have a relative lack of blood supply. While the articular chambers of the *Carpus* are mostly in a transversal orientation, the *Rete carpi dorsale* is mainly longitudinally structured. Some branches leave the *Rete carpi dorsalis* to go to the underside of the *Pars medialis* of the synovial

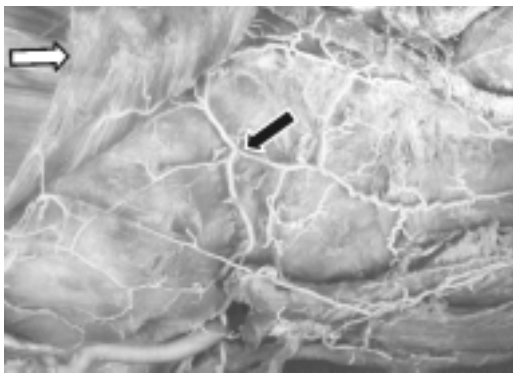


Figure 6. Dorsal site of a right hand. The Rete carpi dorsale sends an artery (black arrow) to the underside of the synovial tendon sheaths of the *M. extensor digitorum communis*, displaced (white arrow).

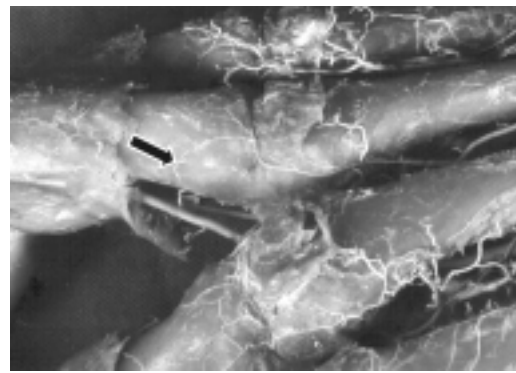


Figure 8. Dorsal site of a left hand. The blood supply of the synovial membrane of the proximal joints of the fingers from the *Aa. recurrentes* (black arrow).

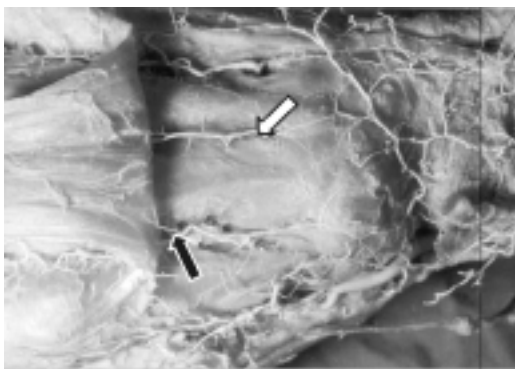


Figure 7. Dorsal site of a right hand. The *Aa. metacarpeae dorsales* (white arrow) provide the blood supply for the synovial tendon sheath of the *M. extensor digitorum communis* at the lower side and with their *Aa. perforantes* (black arrow) also the upper side.

tendon sheath of the *M. extensor digitorum communis* (Figure 6). These stronger branches give rise to smaller ones for each tendon. The terminal *Aa. perforantes* penetrate the top side of the synovial membrane and the tendons of the extensor muscles of the fingers.

The *Rete carpi dorsalis* is interconnected with parallel branches of the *Aa. metacarpeae dorsales*, which supply for the distal parts of the synovial tendon sheath of the *M. extensor digitorum communis* (Figure 7). They enter the tendon from below and run parallel to the tendon's fibers. *Aa. perforantes* penetrate the tendons and reach their surfaces.

A rather strong branch of the *A. interossea posterior* proceeds towards the underside of the tendon of the *M. extensor pollicis longus*, the *Mm. extensor carpi radialis longus* and *brevis*. This branch forms an anastomosis with the *A. radialis* which itself supplies blood to these tendons.

The synovial tendon sheaths of the *M. extensor carpi ulnaris* and the *M. extensor digiti minimi* obtain their blood supply from the ulnar terminal branch of the *A. interossea posterior* and the *Ramus carpi dorsalis* of the *A. ulnaris*.

Branches from the *Aa. metacarpeae dorsales* provide the blood supply for the proximal joints of the fingers and the tendons of the *M. extensor digitorum communis*.

These branches form anastomoses at the bifurcation of the *Aa. digitales palmares communes*. The *Aa. metacarpeae dorsales* have anastomoses with the *Arcus palmaris profundus*, which lies on the palmar aponeurosis, and this provides blood via the *Aa. metacarpeae palmares* for the *M. interossei palmares*. From the *Aa. metacarpeae palmares* branch off the *Rami ascendentes radialis et ulnaris*, which supply blood for the capsule and the synovial membrane of the proximal finger joints (Figure 8) and form anastomoses with the *Aa. digitales palmares propriae (Aa. recurrentes)*. The radial and the ulnar branch pass by the radial and the ulnar side (resp.) of the *Capita ossium metacarpalium* II, III, IV and V.

DISCUSSION

The synovial tendon sheath has in the past been accorded little attention, and in the literature on hand surgery it has often been recognized as a structure which should be resected in association with tendon grafting and tendon repair.⁷ Problems in the surgical management after flexor digital tendon injury may be related to the blood supply of the tendon. The reports of the blood supply of the tendon are not sufficient for clinical requirements.⁸

In surgery, the carpal region is of ever increasing importance, considering that synovectomies are now being performed as a treatment for polyarthritis. The surgeon has to know the organization of the arterial blood supply, since extended interruptions of blood flow will impair the process of healing.

According to Zbrodowski,⁹ the top leaf of the synovial sheaths of the tendon of the *Mm. flexor digitorum superficialis*, *flexor digitorum profundus* and *flexor pollicis longus* is provided with blood from the "carpal mesotendineal arteries". The *Arcus palmaris profundus* and the metacarpal arteries, "peritendineal arteries", provide for the metacarpal part of the synovial sheaths.

We found that the blood supply for the *Pars proximalis* of the synovial tendon sheaths is cared for by the *Aa. transversalis superficialis* and *profunda* at the level of the *Canalis carpi*. The *Arcus palmaris superficialis* as well as *profundus* send branches to the distal part of the synovial tendon sheaths of the *Mm. flexor pollicis longus*, *flexor digitorum superficialis* and *flexor digitorum profundus*. There is an anastomosis of the *A. transversalis profunda* and the *Arcus palmaris profundus* from which originate branches to supply the synovial membrane of the *Carpus*.

It has long been known that the arteries reach the tendons in their *Vaginae fibrosae* via the *Vincula tendinum*.^{10,11} These extend quite variably and may be interpreted as the remainders of the *fetal mesotendinium* which used to be complete earlier in ontogeny. The tendon of the long flexor muscle of the thumb has two *Vincula* at the phalangeal level and is provided with blood by the *A. princeps pollicis* and its two *Aa. digitales palmares propriae*.¹² For Zhang ZZ, *et al.*⁸ each tendon had a synovial and a non-synovial region. At the synovial region the extratendinous blood through the mesotendon, long and short *vincula* provided the nutrition of the tendon. At the carpal level the blood supply came from the mesotendons which attached the dorsal side of the tendons to the bottom of the synovial bursa. In the fingers there were many blood sources, but the number of intratendinous blood vessel was small.

Brockis¹³ and Zbrodowski¹⁴ describe the blood supply of the synovial sheaths and tendons of the fingers via the digito-palmar arcus, which splits into three branches, one each for the tendons, the synovial membranes and the dorsal side of the finger. Gajisin S, *et al.*¹ in their study concerning the digital sheaths of the fingers index, middle and ring fingers describe that the digitopalmar arches are the main source of blood supply to the digital sheath as

well as to the flexor tendons, and also supply the arteries of the lateral wall of the sheath. The fibrous layer of the sheath has its own vascular network formed by branches of the proper palmar digital arteries. The synovial layer is supplied by arteries originating in the digitopalmar arches. These branches reach the tendons and inner surface of the synovial sheath via synovial structures such as *vincula* and *mestendons* and upon entering the tendon they divide into two ascending and descending branches. Our work demonstrates that the formation of a digito-palmar arcus is not frequent and that the branches for the synovial sheaths, the tendons and the dorsal side of the fingers originate directly from the *Aa. digitales palmares propriae*.

We dissected the *Rete carpi dorsalis* on the dorsal aspect of the hand. It is formed by the *Ramus carpi dorsalis* of the *A. radialis*, the *Ramus carpi dorsalis* of the *A. ulnaris* and terminal branches of the *A. interossea posterior*. The *Rete carpi dorsale* lies on the dorsal side of the *Carpus* underneath the *Retinaculum musculorum extensorum*.

Zbrodowski¹⁵ reported that the tendons of the extensor muscles of the distal forearm receive their blood supply from the *A. interossea* anterior with contributions from the *A. radialis* and the *A. ulnaris*. The *Rete carpi dorsalis* sends branches to the tendons and synovial tendon sheaths at the radiocarpal joint. Our results confirm that the *A. interossea posterior* is the main supplier of blood to the extensor muscles of the forearm. It divides into two terminal branches, which supply the proximal part of the synovial tendon sheath of the *M. extensor digitorum communis*. The *Rete carpi dorsalis* sends branches to the medial part of the synovial tendon sheaths. The *Aa. metacarpeae dorsales* supply underside of the distal part of the synovial tendon sheath of the *M. extensor digitorum comunis* directly and the top side via its branches, the *Aa. perforantes*.

Lippert⁵ ascribed a much lesser importance to the arteries of the *Dorsum manus* than to the arteries of the *Palma manus*. Their region of supply is less wide with respect to surface and depth. According to Gajisin, *et al.*¹ the best vascularized area is the floor of the sheath, while the pulleys and the palmar surface are less well vascularized. Zbrodowski, *et al.*¹⁴ suggest that the ideal location for incision into the digital sheath is the midline of the palmar surface, a zone which is only slightly vascularized. Zhang, *et al.*⁸ found that in the synovial sheath the blood vessels were distributed only in the dorsal side, while the volar side was devoid of vessels. The *profundus*

and *superficialis* tendons had an avascular zone at the proximal interphalangeal and metacarpophalangeal joints respectively. However, our results agree with Kuhlmann¹⁶ in that the superficial and deep tissues receive an ample blood supply from the terminal branches of the *A. interossea posterior*, the *Rami carpi dorsales* of the *Aa. radialis* and *ulnaris* and from branches of the *Rete carpi dorsale*. In this way, non-invasive rehabilitation can be used to favor blood flow to these regions to prevent or control rheumatic illnesses.

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*Recibido el 29 de marzo de 2007.
Aceptado el 18 de febrero de 2008.*