New insights into the anatomy at the palmodigital junction in Dupuytren's disease

Malsagova, Asja T; Zwanenburg, Rinze L; Werker, Paul M N

Published in:
Journal of Hand Surgery (European volume)

DOI:
10.1177/1753193419863418

Full Length Article

JHS(E)

Journal of Hand Surgery
(European Volume)
2019, Vol. 44(9) 972–978

DOI: 10.1177/1753193419863418
journals.sagepub.com/home/jhs
SAGE

New insights into the anatomy at the palmodigital junction in Dupuytren's disease: the palmodigital spiralling sheet

Asja T. Malsagova, Rinze L. Zwanenburg and Paul M. N. Werker

Abstract

The anatomy in the region of the palmodigital junction has been relatively little studied, but it is very relevant for the surgical treatment of Dupuytren's disease. To study the microanatomy of the palmodigital junction, we dissected 26 cadaveric digits from 13 human cadaveric hands using microsurgical techniques. The dynamics of the different ligaments were studied in three hands preserved by Thiel's method. We found a structure, which we propose to name the 'palmodigital spiralling sheet' (PSS), which has not been described before. It has a spiralling course around the neurovascular bundle giving rise to a neurovascular tunnel distally in the palm of the hand. It is formed proximally by fibres from the pretendinous band and the intrinsic muscle fascias and distally is in continuity with Cleland's and Grayson's ligaments. As such it connects the palmar and digital fascias. Its spiralling course stabilizes the neurovascular bundle in the healthy hand, but can displace it in Dupuytren's disease, which may contribute to the development of spiral cords.

Keywords

Dupuytren's disease, spiral band, cutaneous ligaments, Cleland's ligament, Grayson's ligament

Date received: 21st November 2018; revised: 20th June 2019; accepted: 24th June 2019

Introduction

Dupuytren's disease (DD) has been found to develop in and follow the normal anatomical pathways of the fascial structures in the hand, giving rise to nodules, and transforming 'bands' into 'cords' (McFarlane, 1974; McGrouther, 1982). Many descriptions have been made of this 'normal' anatomy, but in our opinion the fascial relationships at the palmodigital junction are not completely clear.

The description of McGrouther (1982) of the palmodigital junction is one of the few that has attempted to explain the complex anatomy in this area of transition. He focused on the division of the pretendinous band distal to the transverse ligament of the palmar aponeurosis into three layers (Figure 1). The first and most superficial layer of these pretendinous extensions inserts into the palmar skin. The second layer originates in the bifurcation of the pretendinous band just distal to the transverse ligament of the palmar aponeurosis (TLPA). Thereafter, these bands pass in his description dorsally to the neurovascular bundle and the natatory ligament (NL) into the finger where they join the lateral digital sheet. This second layer is also called the spiral band, since it spirals around the neurovascular bundle. The third layer is the deepest and consists of fibres that dive deep on both sides of the metacarpophalangeal (MCP) joint and insert dorsally into the extensor sheet. These are also known as the perforating fibres.

During fasciectomy we have observed patterns of pathology that cannot be explained solely by what has been described previously. Therefore, the aim of this study was to provide a more comprehensive description of the relations between the various fascial structures at the palmodigital junction and translate this to the clinical situation in DD. For this purpose,

Department of Plastic Surgery, University of Groningen and University Medical Center Groningen, Groningen, The Netherlands

Corresponding Author:
Paul M. N. Werker, Department of Plastic Surgery BB81 University of Groningen, University Medical Center Groningen, Postbus 30.001, 9700 RB Groningen, The Netherlands.
Email: p.m.n.werker@umcg.nl

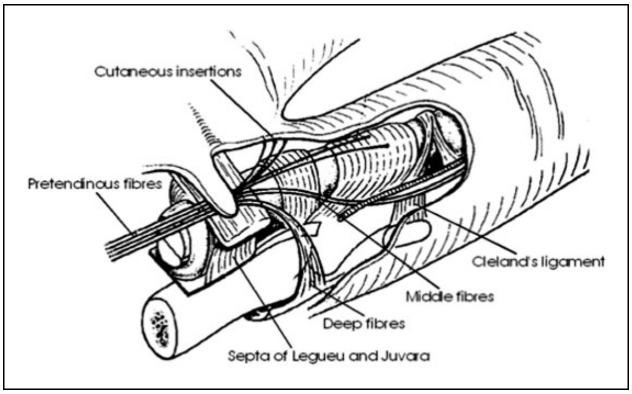

Figure 1. Illustration of McGrouther's three layers of the pretendinous extensions distal to the transverse ligament of the palmar aponeurosis. The left side of the illustration is proximal and right is distal. McGrouther's first cutaneous layer is the superficial fibres that insert into the skin, the middle layer is the fibres that are continuous with fibres in the finger and are the most important for the palmodigital spiralling sheet. McGrouther's deep layer is the fibres that run deep on each side of the metacarpophalangeal joint, also known as the perforating fibres.
(Reprinted by the permission of the publisher, Elsevier, from McFarlane RM. The finger. In: McFarlane RM, McGrouther DA, Flint M (Eds.) *Dupuytren's disease.* Edinburgh, Churchill Livingstone, 1990.)

microanatomical dissections were carried out in human cadaveric material and the findings were compared with clinical dissections during fasciectomy for DD.

Methods

Cadaveric study

The dissections in this study were done on human cadaveric hands. The material was used in full agreement with the regulations on working with human cadaveric tissue. The hands were obtained from adult cadavers fresh frozen at a temperature of $-24^{\circ}C$ and thawed at $+3^{\circ}C$ for 16 hours. In all, 26 cadaveric rays were dissected from 13 cadaveric hands, 13 middle fingers and 13 ring fingers. The ages of the cadavers ranged between 59 and 91 years with a mean age of 79 years; ten were female and three male. The hands showed no signs of injury, disease, or previous surgery. None of the specimens had signs of DD. Additionally, three dissections were done on cadavers conserved using Thiel's embalming method (Thiel, 1992). Because of the preservation of tissue flexibility in Thiel-embalmed cadavers, these dissections were particularly suitable to study the dynamics of the ligaments in question.

The dissections were done with microsurgical instruments using $20\times$ magnification obtained from a ZEISS universal S2 surgical microscope (Zeiss, Oberkochen, Germany). Photographs and video recordings were taken using a Canon EOS 500 D photo camera with macro lens (Canon, Oita, Japan), and drawings were made by the dissector (AM) throughout the dissections to record the anatomical findings.

Dissection procedure

A longitudinal midline incision was made through the palmar skin of the digit, running from the midpalm to just distal to the proximal interphalangeal (PIP) joint crease. The skin was released and the fatty tissue was removed by blunt dissection preserving the underlying fibrous condensations. In doing so, the palmar fascia with its pretendinous bands and the natatory and Grayson's ligaments became visible. In the distal palm, removal of all adipose tissue disclosed the neurovascular bundle and specifically the bifurcation of the common digital artery. The neurovascular bundle was followed distally into the finger underneath the natatory and Grayson's ligaments. The fascial structures were thereafter divided in the midline of the finger, sharply released from the flexor tendon sheath, and reflected laterally, exposing the proper digital nerve and artery. Subsequently, the neurovascular bundle was also freed from the underlying fascial structures.

The positions of the neurovascular bundle and arterial bifurcation at the palmodigital junction and their relation to the underlying and adjacent structures were studied. Subsequently, the neurovascular bundle was cut just distal to the arterial bifurcation and reflected distally. In doing so, the fibrous condensations at the level of the palmodigital junction and dorsally to the neurovascular bundle could be visualized and studied in more detail. Their origins, insertions, and course were recorded. All dissections were carried out on each side of the dissected fingers.

The specimens preserved with Thiel's embalming method were dissected in the same way and specifically used to study changes in arrangement and the degree of tension of these fascial structures during motion of the MCP and PIP joints.

After completion of the anatomical dissections on cadaveric material, our findings were further studied at fasciectomies for DD. All operations were done by the senior author (PW). Photographs were taken during the operations.

Results

At the palmodigital junction we found a structure that has a spiralling course around the neurovascular bundle, and which is formed by more elements than the previously described spiral band. We propose calling it the 'palmodigital spiralling sheet' (PSS). The anatomy of the PSS was found to be constant, having the same origins and insertions in all the dissected ring and middle fingers.

Origins and insertions

We found that proximally the PSS is formed by the blending of fibres of the second layer of the pretendinous band described by McGrouther (1982), fibres originating from the fascia of the intrinsic muscles, and fibres originating from the lateral side of the flexor tendon sheath at the level of the A1 pulley and the proximal part of the A2 pulley.

The PSS can be artificially subdivided into proximal, intermediate, and distal parts, each with its specific origins and insertions (Figure 2). The proximal border fibres correspond with the previously described layer of the pretendinous extensions and originate from the pretendinous band. They bypass the A1 pulley on either side where they merge with fibres originating from the fascia of the lumbrical muscle on the radial side of the fingers and the palmar interossei muscles on the ulnar side (Figures 2 and 3). These fibres were found to blend with the transverse fibres on the dorsal aspect of the NL, ending in the insertion of the NL on the flexor tendon sheath after making a 360° spiral during their course. There is a triangular-shaped space between the pretendinous fibres that feed the PSS and the fibres originating from the intrinsic muscles (Figure 3).

The fibres that form the distal border of the PSS have their origin at the proximal part of the A2 pulley and remain dorsal to the neurovascular bundle during their entire course. Distally they blend with the fibres of that part of Cleland's ligament that has its origin at the PIP joint and runs proximally and which has recently been named by us as 'Cleland's PIP-proximal ligament' (Zwanenburg et al., 2014). In this way, they contribute to the dorsal part of the neurovascular tunnel between the level of the NL and Cleland's PIP-proximal ligament (Figures 2 and 3).

Between the proximal and distal borders of the PSS, we found fibres that we call the intermediate fibres. They have their origin on the flexor tendon sheath at the level of the distal part of the A1 and the proximal part of the A2 pulley, dorsal to the neurovascular bundle (Figure 3). These fibres were found to end anteriorly as Grayson's fibres after having spiralled 180° around the neurovascular bundle, via what hitherto has been described as the lateral digital sheet (Figure 3).

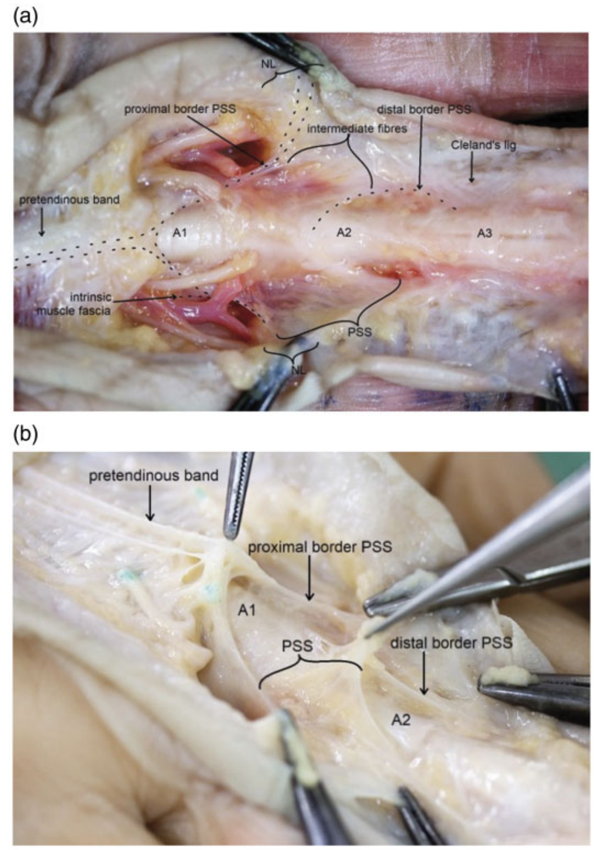

Figure 2. (a) Left is proximal and right is distal. This image gives an overview of the palmodigital spiralling sheet (PSS) seen from above after the natatory ligament (NL) has been divided in the midline and reflected bilaterally. Proximal border fibres are seen to originate from the pretendinous band (indicated by the dashed line) and insert into the divided and reflected natatory ligament, held by the most proximal clamps on both sides of the finger. The intrinsic muscle fascia is indicated, contributing fibres to the proximal border of the PSS. The intermediate fibres originate from the flexor tendon sheath mostly over the A1 pulley and continue into Grayson's ligament (not shown in this photograph). The distal border fibres originate from the flexor tendon sheath just distal to the proximal border of the A2 pulley and arch into Cleland's PIP-proximal ligament. (b) Left is proximal and right is distal. In this image the PSS is visualized from an ulnar angle. When lifting the proximal and distal borders of the PSS with the forceps in the midline of the digit, tent-like formations appear, clearly marking these borders bilaterally. The NL is held by the middle clamps. The proximal part of Grayson's ligament is held by the most distal clamps.

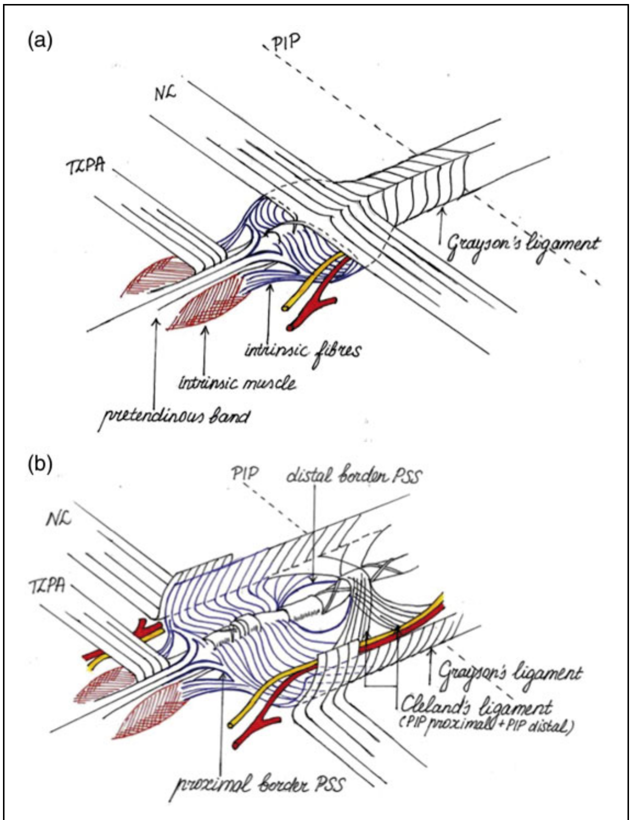

Figure 3. (a) This is a schematic drawing of the microanatomy of the palmodigital junction with the palmodigital spiralling sheet (PSS) as it would be in the undissected state. On the right the neurovascular bundle has been visualized as it enters the neurovascular tunnel in relation to the PSS, which is marked in blue. On the left the neurovascular bundle and on the right the transverse ligament of the palmar aponeurosis (TLPA) have been left out for clarity. (b) This is a schematic drawing of the palmodigital spiralling sheet (PSS) after it has been released from the midline of the flexor tendon sheath and reflected bilaterally (as also shown in Figure 2(a) and (b)). Note the proximal border fibres blending with the fibres from the intrinsic muscle fascia, with a triangularly shaped space in between. The natatory ligament (NL) covers the PSS and takes up fibres from it. The original attachment of the NL on the A1 pulley has been left as an orientation point.

At the level of the palmodigital crease, the two adjacent PSSs of neighbouring fingers converge, run together for a short distance, and diverge again to attach into the dorsal aspect of the homodigital NL as shown in Figure 4. This point of convergence lies just distal to the bifurcation point of the common digital artery, with the two proper digital arteries bordering it.

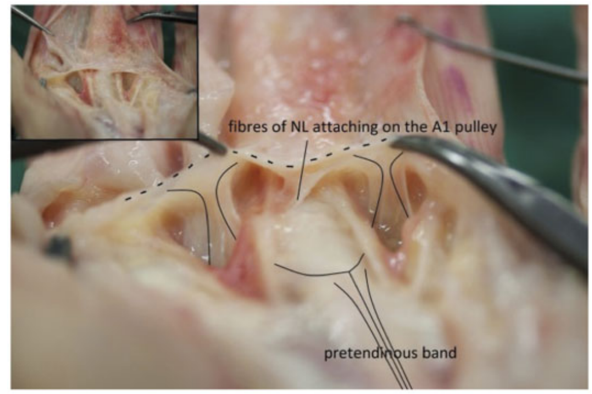

Figure 4. The bottom of the image is proximal and the top is distal. This image focuses on the proximal border of the neurovascular tunnels of a middle finger as it appears when elevating the natatory ligament (NL) by its proximal border (indicated by the dashed line) from its natural position as shown in the inset in the top left corner. The neurovascular bundles can be seen to pass into their corresponding neurovascular tunnels. In the interdigital space, palmodigital spiralling sheet (PSS) (indicated by the continuous line) from neighbouring digits can be seen to merge, diverge, curve, and blend with the homodigital NL.

Dynamics of the PSS

Tension on the PSS was not found to change much during flexion and extension of the finger in the PIP joint, but was found to diminish somewhat during MCP joint flexion. This may accommodate for some movement of the neurovascular bundle as the finger is bent. A continuous structure, such as the PSS, encircling the neurovascular bundle seems able to stabilize the neurovascular bundle during various finger movements at the level of the MCP joint.

Operative findings

During clinical dissections in patients with DD, we have found several examples of pathologically affected structures at the palmodigital junction following the described anatomical course of the PSS. Examples of these are shown in Figures 5 to 8.

Discussion

At the palmodigital junction, we identified a structure that is a coalescence of already known and newly described fibres that connect the palmar and digital

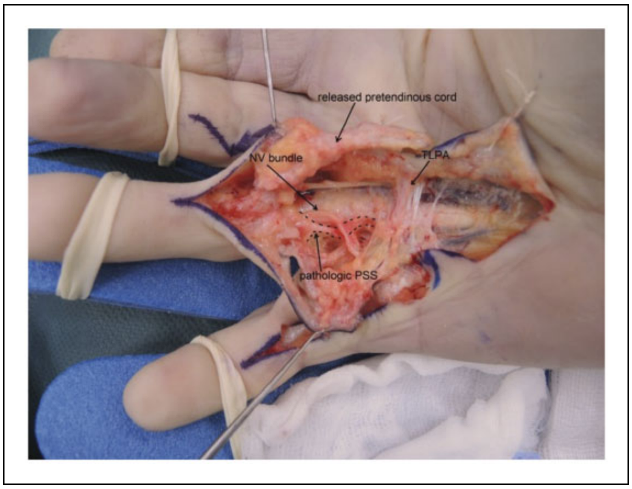

Figure 5. This image shows a pathologically affected palmodigital spiralling sheet (PSS) on the ulnar side of a left ring finger. The PSS is outlined with the dashed lines, starting distally from the transverse ligament of the palmar aponeurosis (TLPA) and ending anterior to the neurovascular bundle distal to the palmodigital joint crease. Note the neurovascular bundle spiralling around the pathologically changed PSS fibres.

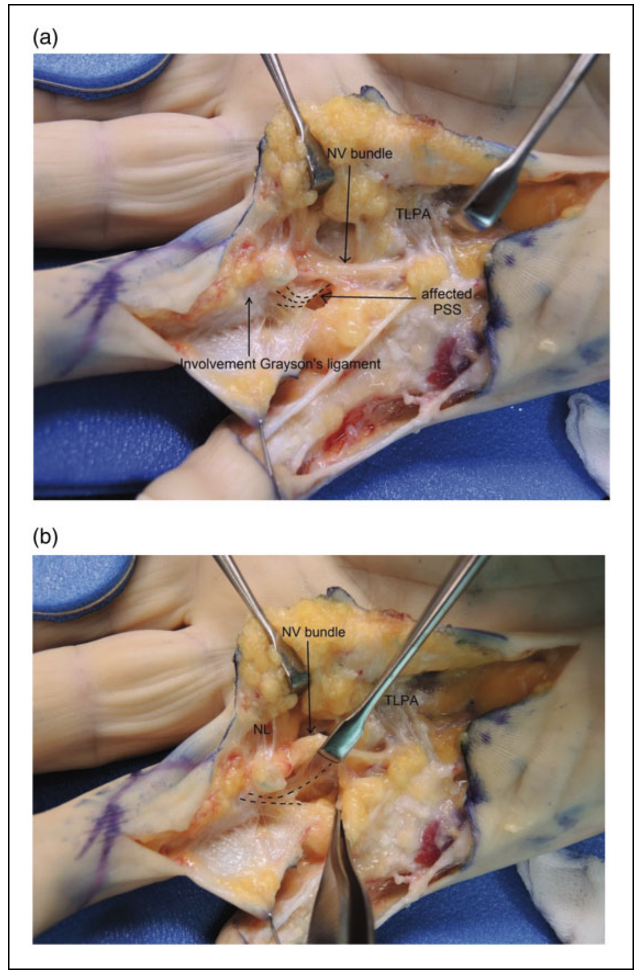

Figure 6. (a) This image shows an affected palmodigital spiralling sheet (PSS) on the ulnar side of another ring finger, indicated with the dashed line, spiralling around the neurovascular bundle (NV bundle). (b) When lifting up the neurovascular bundle, intrinsic fibres originating in the intrinsic muscle fascia are visualized, feeding into the affected palmodigital spiralling sheet (PSS).

fascias: the PSS. This description has several new features.

- Blending of the spiral band with fibres that originate from the fascia of the intrinsic muscles to form the proximal border of the PSS and their insertion on the dorsal surface of the NL.
- The contribution of the intermediate fibres that run via the lateral digital sheet into Grayson's ligament.
- The continuation of the distal part of the PSS into the Cleland PIP-proximal ligament.
- The convergence of the spiralling fibres of adjacent fingers just distal to the bifurcation of the common digital artery.

Since all these components are possible routes for cord development, we now routinely remove them during fasciectomy together with the natatory, Cleland's, and Grayson's ligaments in an effort to try and prevent recurrence.

The term spiral band was proposed by Gosset (1967) and it was McGrouther (1982) who described the different fascial layers that are the continuation of the pretendinous band at the palmodigital junction. His description of the second layer, which corresponds to Gosset's spiral band, is of importance for this work: it is part of the proximal fibres that form the PSS (Figures 1 and 3). This is also in agreement with the description of the bifurcating fibres of Zancolli and Cozzi (1992). Their description resembled this aspect of the PSS, but did not fully appreciate the 360° spiralling motion of the proximal fibres around the neurovascular bundle that we found during dissections. This is the reason why a spiral nerve in the distal palm always lies proximal to the NL (Figures 3 and 4).

Since the PSS links the palmar and digital fascias, it contributes to the development of MCP joint contractures as shown in Figures 5 to 8. Since part the origin of the PSS comes from deep to the neurovascular bundle, it is conceivable that a cord that causes

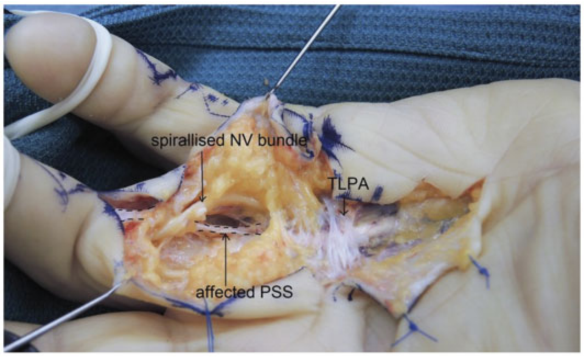

Figure 7. This image shows a pathologically affected palmodigital spiralling sheet (PSS) on the ulnar side of a ring finger. The straightening of the PSS (indicated with the dashed line) is especially noteworthy. It continues into a digital cord and the neurovascular bundle is spiralling around it.

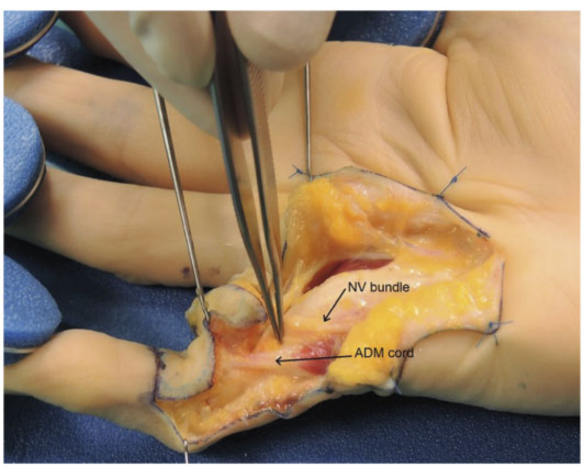

Figure 8. This image shows a neurovascular bundle (NV) spiralling around an abductor digiti minimi (ADM) cord.

an MCP contracture would be difficult to reach during needle fasciotomy. This explains the persistence of such a contracture, even though more superficial cords may have been released percutaneously.

Apart from this, and because of its connection to the similar structure of the adjacent finger just distal to the arterial bifurcation as previously described by Gosset (1967) and Strickland and Leibovic (1991), the PSS also contributes to the development of cords crossing from one digit into the next. Clinically, this explains the development of the so called 'Y' cords (Badalamente and Hurst, 2000; Warwick et al., 2016). Rupture of these cords at their base by collagenase or needle fasciotomy may result in a release of a contracture of both affected fingers.

The involvement of intrinsic fibres in DD has been described several times before. The most recent description is from Thoma and Karpinski (2017). They described the involvement of a muscle tendon unit in relation with the dorsal interosseous muscle in three cases. We consistently found distinct fibres originating in the fascia of the anteriorly located intrinsic muscles that merged with the PSS fibres originating from the spiral band (Figure 3). Since these fibres have been found to change pathologically into cords, we agree with Thoma and Karpinski that they should be resected as closely as possible to their origin on the intrinsic muscle in order to remove all potentially affected intrinsic fibres.

The NL has a three-dimensional structure that consists of a combination of transverse fibres and longitudinal fibres. The superficial longitudinal fibres that extend into the finger are in continuation with Grayson's ligaments and form part of what has been called the lateral digital sheet (Gosset, 1967; Thomine, 1965; Zancolli and Cozzi, 1992). The same goes for the middle fibres of the PSS, that originate dorsally and course anteriorly, whereas the distal fibres of the PSS that lie deep to the neurovascular bundle stay dorsal and are in continuation with Cleland's ligament. We consider these longitudinal fibres to be a part of the PSS.

The anatomy of the PSS, artificially divided in its three components, makes it also possible to understand the 'double corkscrew' cord described by Hettiaratchy et al. (2010). The proximal component of the PSS is responsible for the classic spiral cord, proximal to the NL, and the intermediate part also makes a spiralling motion for almost 180° distal to the NL, owing to its continuation with Grayson's ligament.

Our anatomical findings were very consistent and we regard the limited number of dissected fingers only as a relative limitation. We are aware that these kind of dissection studies are prone to misinterpretations and unintended 'creation' of new structures. Therefore, dissections were done only after a meticulous study of the findings of former authors and using microsurgical techniques.

Acknowledgements Joint first authors Asja T. Malsagova and Rinze L. Zwanenburg contributed equally to this study.

Special thanks for Professor D. A. McGrouther for his inspiration and contribution to this project and employees at the Department of Anatomy and Neuroscience of UMCG, University of Groningen.

Declaration of conflicting interests The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Paul M. N. Werker is a member of Fidia Advisory Board and Fidia collagenase Phase 1 'Independent Safety and Efficacy Review Board'. Rinze L. Zwanenburg and Asja. T. Malsagova have nothing to disclose.

Funding The authors received no financial support for the research, authorship, and/or publication of this article.

Ethical approval Approval for this research project was given by the ethical committee considering scientific research with human cadaveric material from the laboratory of anatomy and neuroscience, Professor Dr J. B. M. Kuks, supervisor, University Medical Center Groningen.

References

Badalamente MA, Hurst LC. Enzyme injection as nonsurgical treatment of Dupuytren's disease. J Hand Surg Am. 2000, 25: 629–36.

Hettiaratchy S, Tonkin MA, Edmunds IA. Spiralling of the neurovascular bundle in Dupuytren's disease. J Hand Surg Eur. 2010, 35: 103–8.

Gosset J. Maladie de Dupuytren et anatomie des aponévroses palmo-digitales. Ann Chir. 1967, 21: 554–65.

McFarlane RM. Patterns of the diseased fascia in the fingers in Dupuytren's contracture. Displacement of the neurovascular bundle. Plast Reconstr Surg. 1974, 54: 31–44.

McFarlane RM. The finger. In: McFarlane RM, McGrouther DA, Flint M (Eds.) *Dupuytren's disease.* Edinburgh, Churchill Livingstone, 1990, 5: 155–67.

McGrouther DA. The microanatomy of Dupuytren's contracture. Hand. 1982, 14: 215–36.

Strickland JW, Leibovic SJ. Anatomy and pathogenesis of the digital cords and nodules. Hand Clin. 1991, 7: 645–57.

Thiel W. The preservation of the whole corpse with natural color. Ann Anat. 1992, 174: 185–95.

Thoma A, Karpinski M. Involvement of the interosseous and lumbrical muscle-tendon units in the lateral and spiral cords in Dupuytren's disease of the middle fingers. Plast Reconstr Surg. 2017, 140: 116–24.

Thomine JM. Conjonctif d'enveloppe des doigts et squelette fibreux des commissures inter-digitales. Ann Chir Plast. 1965, 10: 194–203.

Warwick D, Arandes-Renú JM, Pajardi G, Witthaut J, Hurst LC. Collagenase Clostridium histolyticum: emerging practice patterns and treatment advances. J Plast Surg Hand Surg. 2016, 50: 251–61.

Zancolli EA, Cozzi EP. The retinaculum cutis of the hand. In: *Atlas of the surgical anatomy of the hand.* Singapore, Churchill Livingstone, 1992: 1–18.

Zwanenburg RL, Werker PM, McGrouther DA. The anatomy and function of Cleland's ligaments. J Hand Surg Eur. 2014, 39: 482–90.