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Grayson Ligament: A Revised Description of its Anatomy and Function

Rinze L. Zwanenburg, MD,* Duncan A. McGrouther, MD, PhD,† Paul M. N. Werker, MD, PhD*

Purpose Grayson ligament has been described as a common pathway for digital contracture in Dupuytren disease. Its anatomical descriptions in the literature are, however, inconsistent.

Methods We have performed a microsurgical dissection study in 20 fresh-frozen and thawed digits to revisit the anatomy of Grayson ligaments. We also performed dissections in Thiel-preserved hands to be able to study the changes in tension of the ligaments during flexion and extension of the finger.

Results We found the ligaments originally described by Grayson to be the best developed part of a trabecular network of fibers, originating in continuity with the outer adventitial layer of the flexor tendon sheath and running toward their insertions into the skin in multiple planes, all volar to the neurovascular bundle. The most dorsal fibers, which cover the neurovascular bundles, form a chevron shape with its midline apex pointing distally in an extended finger. During flexion, the fibers become more transversely oriented.

Conclusions We found Grayson ligament comprises a trabecular network of fibers, instead of a ligament, with a dynamic fiber orientation on the volar side of the finger. The main function of this network of fibers seems to be the stabilization of the skin and fat pad in digit extension while the relaxation in flexion allows the skin and volar fat pad to adapt optimally to the form of the object that is held.

Clinical relevance The new insights in the anatomy of Grayson trabecular network of fibers may be of importance in the understanding of the pathological anatomy of Dupuytren disease. *(J Hand Surg Am. 2019;44(4):341.e1-e6. Copyright © 2019 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Grayson ligament, Cleland ligament, Dupuytren disease, Dupuytren contracture, cutaneous ligaments.

Online Exclusive

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The components of the cutaneous ligament system originally described by Grayson are of importance because of their involvement in Dupuytren disease.[1,2] However, since the original description in 1941, their anatomy and function have been reported in a variety of ways by various authors. The purpose of this study was to clarify existing uncertainties and investigate the dynamic function of this structure.

Grayson[3] described a "fibrous septum volar to the digital nerves and vessels" in 1941. This septum was described as being present in pairs and having "precisely

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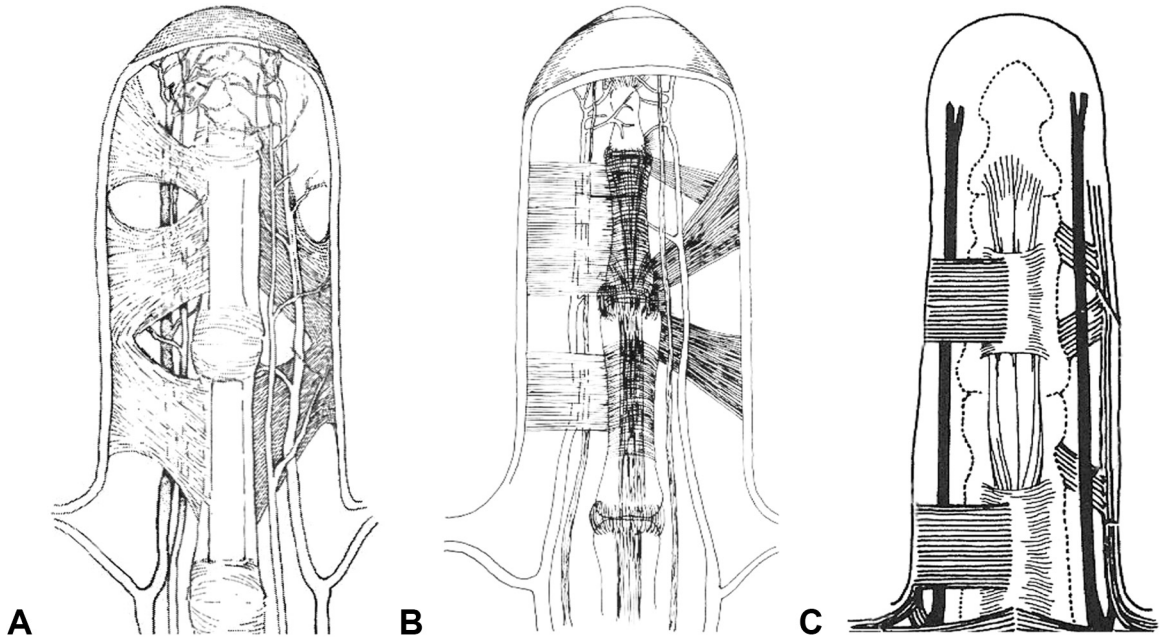

FIGURE 1: Overview of historical drawings of the orientation of Grayson ligaments in the finger. Grayson ligament is shown on the left side in each drawing and situated volar to the neurovascular bundle. Cleland ligament is shown on the right, dorsal to the neurovascular bundle. **A** Grayson's findings as drawn by Wood-Jones.[3] **B** Milford's[6] description of the cutaneous ligaments. **C** The currently most widely used figure based on McFarlane's[1] drawing, which is based on Milford.

the same function as their deeper fellows"[3] (eg, Cleland's ligament[7]). They were stated to run toward their insertions into the skin more distally at the level of the proximal phalanx and more proximally at the middle phalanx (Fig. 1A).[3] In Grayson's opinion, the main function of the ligament was "to protect the skin from bagging."[3] Since its earliest description, descriptions of the anatomy of Grayson ligament have been revised a few times. The drawings made by McFarlane in 1974[4] have been widely accepted and are used in almost all textbooks. Notwithstanding this, during anatomical dissections, we noted inconsistencies that motivated us to conduct a microsurgical dissection study.

The descriptions under debate are the overall arrangement of the ligament as a sheet or as solitary fibers, the fiber orientation, and whether the function is more than maintaining the neurovascular bundle in place. To clarify these inconsistencies, we studied the hands of cadavers that had been preserved using Thiel's method.[5] This embalming technique preserves the normal consistency of tissues and allows for movement of the joints without disrupting the fibrous skeleton of the soft tissues. As such, it enables study of the function of these fibrous tissues.

MATERIALS

This study consisted of 2 parts. In part 1, dissections were performed in fresh-frozen and thawed human adult cadaveric hands (frozen to −24°C, and thawed for 16 hours at +3°C). The hands had been frozen with the fingers in extension. Twenty cadaveric digits (from 12 male and 8 female hands) were dissected. The mean age of the cadavers at time of death was 76 years (range, 56−95 years). Six little, 8 ring, and 6 middle fingers were dissected. There were no signs of previous injury, surgery, or illness in any of the fingers used. In part 2, 4 hands from cadavers preserved by Thiel's method[5] were used to study the function of Grayson ligament during passive digit movement.

All dissections were performed using microsurgical instruments at 12.5 times magnification, using a ZEISS universal S2 surgical microscope (Zeiss, Oberkochen, Germany). Detailed images were made during dissection with a Canon EOS 500D photographic camera with macro lens (Canon, Oita, Japan). During all dissections, drawings were made by the dissector.

Dissection started using a longitudinal midline skin incision on the palmar aspect of the digit from the proximal digital crease to the hyponychium. In addition, transverse incisions were made at the flexor creases of each joint from one midlateral line to the other. In each segment, the skin was sharply elevated at a level leaving intact the deepest fibers of the dermis. The dissection was then slightly deepened at the midline and continued toward the sides of the

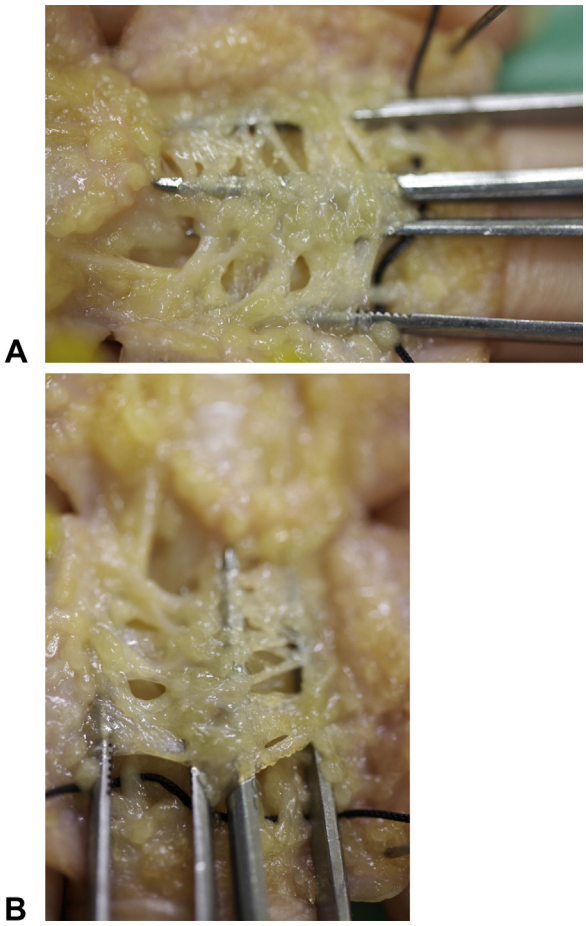

FIGURE 2: A A dissected proximal phalanx from a volar view, right is distal and left is proximal. The characteristic chevron shape with its apex pointing distally can been seen clearly; forceps are placed in both neurovascular tunnels with a nerve visible dorsal to Grayson fibers. It also resembles the origin of the fibers from the flexor tendon sheath; the forceps are held apart from each other by Grayson's origin in the midline. **B** The same finger as in **A** but now a photograph is taken from distal to proximal by which we can see into the neurovascular tunnel. Both the neurovascular bundles are visible dorsal to Grayson fibers and volar to a black thread that lies over Cleland ligament.

finger leaving all fascial structures intact and exposing the underlying fibrofatty tissue. Fatty tissue was removed from pockets between fibrous condensations by delicate blunt dissection using 2 microforceps to disclose the detailed anatomy of the fibrous tissue.

RESULTS

Part 1: the anatomy of the palmar digital ligaments

We found fibrous structures situated volar to the neurovascular bundles (Fig. 2) in all 20 digits dissected, but only at the proximal and middle phalangeal levels. Two well-defined parts could be distinguished. The first and proximal part was limited proximally by the natatory ligament and distally by the first transverse digital skin crease over the proximal interphalangeal (PIP) joint. Because this ligament showed a resemblance to the structure Grayson described, we named this part Grayson proximal phalanx ligament. The second part was limited by the transverse digital skin creases at the PIP and distal interphalangeal joints and covered the middle

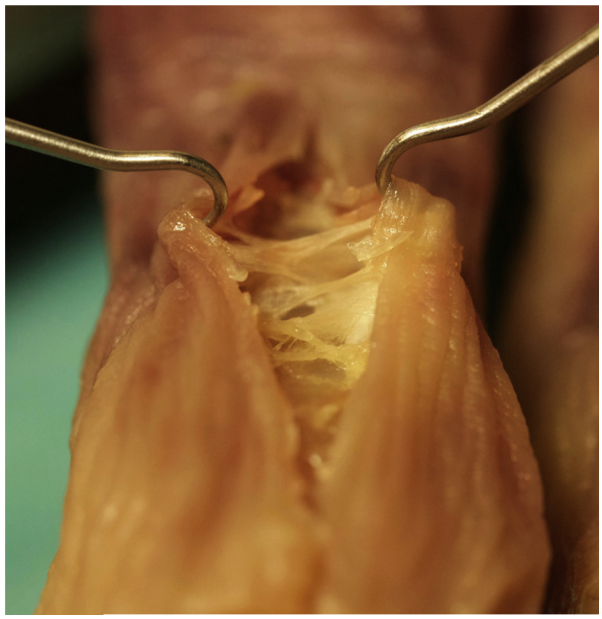

FIGURE 3: Grayson fibers are dissected at the proximal phalangeal level and seen from distal below to proximal. It shows the fibers crossing the midline toward its insertion into the skin on the contralateral side of its origin from the flexor tendon sheath (not shown).

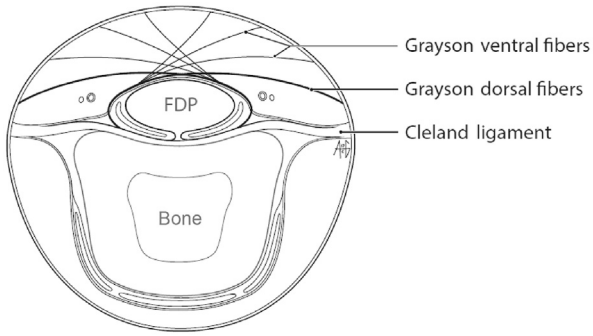

FIGURE 4: A schematic cross-section through the distal part of the proximal phalanx where the upper part is ventral and the lower part is the dorsal side of the finger. It shows Grayson ligament originating from the flexor tendon sheath. Fibers cross the midline of the flexor sheath and are directed toward the contralateral side to its various insertion into the skin on the palmar aspect of the finger. In addition, the trabecular network of fine fibers is shown. FDP, flexor digitorum profundus.

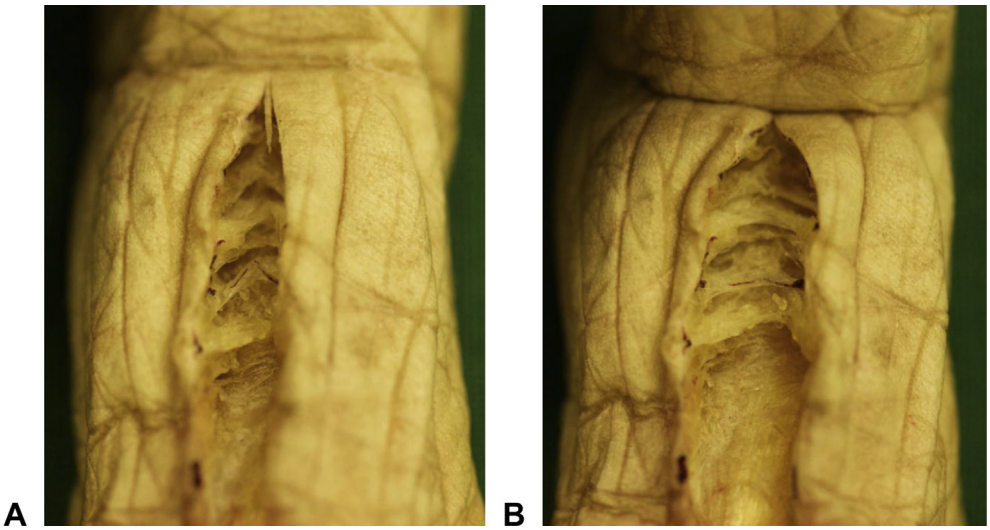

FIGURE 5: **A** Grayson trabecular network of fibers in an extended finger lying in a chevron shape with the apex pointing distally. One pair of Grayson fibers is marked in black. **B** The orientation of Grayson fibers are more transversely oriented in a flexed finger.

phalanx, and we called this part Grayson middle phalanx ligament. Transversely oriented fibers that seemed to be responsible for the digital skin creases were not part of these structures and were found to have their origin and insertion in the skin without having any connection with the flexor tendon sheath.

Close inspection of both Grayson proximal and middle phalangeal ligaments revealed a clear change in appearance over the length of the respective phalanx; the distal one-third was, in all cases, better defined than the proximal part. In addition to this, Grayson middle phalangeal ligament appeared better developed than Grayson proximal phalangeal ligament. The origin of these ligaments in all dissected digits was from, and blending with, the outer loose connective tissue adventitial layer of the volar surface of the flexor tendon sheath. From their origin, the fibers were found to cross the midline to course toward their insertion into the dermis on the contralateral side of the finger (Fig. 3).

In a transverse cross-section, the fibers were found to radiate from their origin toward their insertion in the contralateral palmar skin (Fig. 3), but to remain volar to the neurovascular bundle (Fig. 2). Together, they formed a 3-dimensional trabecular network that contained the volar fat lobules (Fig 4). The most dorsally located fibers, which actually form the layer that is generally recognized as Grayson ligament, were the best defined. This layer inserted on the lateral aspect of the finger just volar to the insertion of Cleland ligament in continuation with the distal edge of the natatory ligament at the volar aspect of the digital midlateral line.

With the digit fully extended, the insertion of each Grayson fiber into the skin was more proximal than its origin at the flexor tendon sheath. All fibers together were, therefore, oriented in a chevron shape with the apex pointing distally (Figs. 2, 5).

Part 2: The dynamics of Grayson ligament and the volar trabecular network

With all finger joints in extension, the fibers of Grayson ligament and the volar trabecular network were found to be mostly taut and obliquely oriented to form the previously mentioned chevron shape together with the fibers of the contralateral side of the finger. During flexion of the finger, the tension of the fibers was seen to gradually decrease and the fibers became more transversely oriented (Figs. 5, 6). The concertina-like movement of the flexor tendon sheath at the level of the cruciate pulleys made this change of tension and orientation during flexion possible. The differences in tightness and orientation of these fibers make the fat pad more deformable during flexion than during extension.

DISCUSSION

We found that the basic structure of the fibrous tissues palmar to the neurovascular network is that of a trabecular network. The term trabecular has been chosen to describe fine fascial bundles with interspersed material, in this case fat. Because of its 3-dimensional nature, trabecular seems to be a better description than a membranous sheet[3] or reticular network.[6]

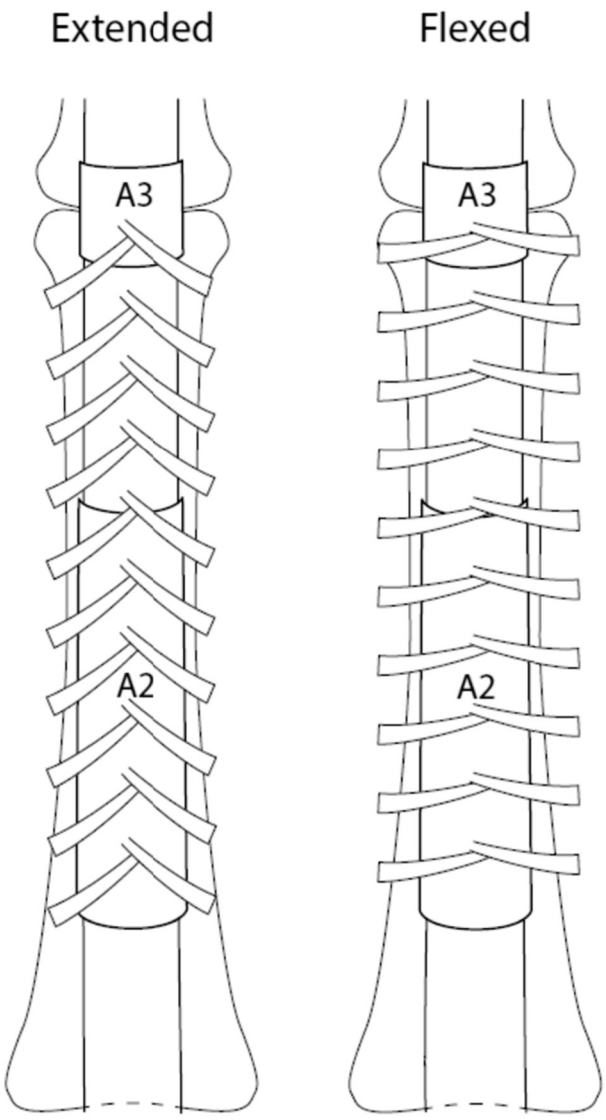

FIGURE 6: The dynamics of Grayson fibers over the proximal phalanx. Shown is a simplification of the observed anatomy: the fibers of Grayson are in extension obliquely oriented and become more transversely oriented during flexion of the finger. This mechanism provides the skin tension in extension and loosening during flexion.

The most dorsal part of this trabecular network forms the volar part of the neurovascular tunnel and resembles a fibrous layer of ligament-like material and is probably the layer that has originally been described by Grayson.[3] The origin and insertion of these fibers, together with its dynamics in extension and flexion (eg, changing from a taut chevron shape to a more relaxed transverse oriented network caused by telescoping of the flexor tendon sheath at the level of the C-pulleys) might be a key factor in explaining the development of a flexion contracture in Dupuytren disease. We hypothesize that contraction of these fibers in a central cord moves these fibers into a more transverse or even reversed V-orientation making it impossible to extend the PIP joint.

The insertion of the best defined, most dorsal layer of the network, is at almost the same level as the insertion of Cleland PIP[7] ligament at the lateral side of the finger and in continuity with the lateral digital sheet. This may play a role in the formation of a structure recognized as the lateral digital cord, which, according to McFarlane,[4] is part of a spiral cord and may also be responsible for a PIP joint contracture.

Grayson's original description[3] differs from ours with respect to fiber orientation and the thickness and extent of the network. Milford's description[6] is more in concordance with what we have found, although we note that the orientation of the fibers depends on the position of the finger joints.

The origin of Grayson fibers, as we found it, corresponds, to some extent, with the findings of Mester et al.[8] However, in our dissections, the fibers ran more parallel than can be seen in the schematic drawing of Mester et al,[8] which suggested a more random pattern. In addition, the thickness of the fibers in our dissections was more diverse and ranged from thick dorsal and distal fibers to more delicate structures where the fibers are more volarly and proximally situated.

In contrast to the study presented by De-Ary-Pires et al,[9] we did not find any Grayson fibers distal to the distal interphalangeal joint, nor could we distinguish the fanning out of Grayson fibers that they described. In agreement with their findings, we found Grayson fibers to originate at different angles from the flexor tendon sheath running toward their insertion into the skin at the contralateral side.

Our findings suggest a stabilizing function of the volar fat pad by the trabecular network, which is a direct consequence of the course of its fibers and their relatively mobile origin on the surface of the flexor tendon sheath. This may explain the inconsistency in the previous descriptions of these fibers: as the finger flexes, the flexor tendon sheath shortens as the space between the annular pulleys becomes smaller.

The course of the fibers from one-half of the flexor tendon sheath to the contralateral skin may limit lateral shear of the skin and better accommodate grip when heavier forces are applied. In addition, the fibers run in various planes from their origin toward the palmar skin, stabilizing the fat lobules.

Grip depends upon the amount of surface friction. We hypothesize that the change from a taut, oblique orientation in extension to a more relaxed transverse orientation in flexion allows the fat pad to transform from a relatively more rigid cushion of subcutaneous

fat and skin to a more pliable fat pad and skin envelop. We think that this characteristic of the Grayson trabecular network of fibers allows for optimal adaptability of the skin and subcutaneous tissues during grip. The contraction of the insertions of Grayson fibers in cases of Dupuytren disease may explain dimpling or skin retraction at the volar side of affected phalanges.

We believe that our description of the dynamics in fiber orientation during joint movement explains many of the inconsistencies in previous reports. The use of fresh-frozen hands with fingers frozen in an extended position makes artifacts due to manipulation less likely. Our findings with regard to movement and function of Grayson fibers in digits preserved by the Thiel's method reveal a realistic flexibility of the tissues.[5]

A limitation of this study is the relatively small number of dissections. However, because the findings were consistent, we believe that our findings are generalizable. Another limitation is that we only dissected healthy hands and that the relation of these findings to a clinical condition like Dupuytren disease is not proven.

The new insights in the anatomy of Grayson trabecular network of fibers may be of importance in the understanding of the pathological anatomy of Dupuytren disease.

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