SCIENTIFIC ARTICLE

Comparison of Transverse Carpal Ligament and Flexor Retinaculum Terminology for the Wrist

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Purpose To investigate the macroscopic anatomy and histological characteristics of the transverse carpal ligament and the flexor retinaculum of the wrist and to investigate their anatomical relationships and define appropriate terminology.

Methods The volar regions of the wrists of 30 unembalmed subjects were examined by dissection and by histological and immunohistochemical staining. *In vivo* magnetic resonance imaging studies were also carried out on 10 subjects.

Results The dissection study showed that the antebrachial fascia at the volar aspect of the wrist presents a reinforcement. From a histological point of view, it is composed of 3 layers of undulated collagen fiber bundles. Adjacent layers show different orientations of the collagen fibers. Many nerve fibers and Pacini and Ruffini corpuscles were found in all specimens. Under this fibrous plane is another fibrous structure, placed transversely between the ulnar-sided hamate and pisiform bones, and the radial-sided scaphoid and trapezium bones. The deeper fibrous structure shows completely different histological characteristics, having parallel, thicker collagen fiber bundles and few nerve fibers. Magnetic resonance images confirm the presence of 2 clearly distinguished fibrous structures in the wrist, the first in continuity with the antebrachial fascia and the second located in a deeper plane between the hamate and scaphoid.

Conclusions Two different fibrous structures with different histological characteristics are present in the volar wrist: the more superficial one is in continuity with the antebrachial fascia and could be considered its reinforcement; the deeper one is composed of strong lamina, with histological features similar to those of a ligament. For these reasons, we suggest that the term *transverse carpal ligament* should be used to indicate the fibrous lamina connecting the hamate and pisiform to the scaphoid and trapezium and that the term *flexor retinaculum of the wrist* should be abandoned because it does not correspond to any specific, autonomous structure. *(J Hand Surg 2010;35A:746–753. Copyright © 2010 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Antebrachial fascia, flexor retinaculum, palmar aponeurosis, transverse carpal ligament, wrist.

According to Testut and Jacob,[1] the antebrachial fascia at the volar aspect of the wrist becomes thicker, forming the anterior annular ligament, or *transverse carpal ligament*, which represents the roof of the carpal tunnel, whereas Platzer[2] uses the term *flexor retinaculum carpi* to indicate the same structure. Chiarugi[3] and, successively, Rotman and Donovan[4] described 2 different structures: the *carpal*

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palmar ligament (ie, a reinforcement of the antebrachial fascia) and the *transverse carpal ligament* (ie, the fibrous lamina placed between the carpal bones, forming the roof of the carpal tunnel). Denman[5] gave the most accurate description of the fibrous structures overlying the carpal tunnel, with an analysis in terms of single fibers as visualized with the operating microscope. Denman's study emphasizes the role of the mechanical forces acting on the fascia in determining the fiber arrangement of the volar carpal ligament, although the extreme attention to detail makes it difficult to integrate observations in an overall perspective.

The description of the fascial and ligamentous structures most commonly accepted today in specialized textbooks is that of Cobb et al.,[6] who proposed a *flexor retinaculum* composed of 3 parts. The first is proximal, continuous with the deep investing fascia of the forearm; the second is intermediate, identified as the proper *transverse carpal ligament* and corresponding to the *flexor retinaculum* of standard anatomy textbooks; and the third is distal, corresponding to the transverse fibrous structure placed between the bases of the thenar and hypothenar eminences, deep to the proximal apex of the longitudinal layer of the palmar aponeurosis. At all levels, they identified an antebrachial fascia superficial to the flexor retinaculum, clearly separated from it at the ulnar and radial sides and closely sticking in the middle. For those reasons, in the last few years, the term *flexor retinaculum* has been introduced. Putz and Pabst,[7] Rohen et al.,[8] and Martini et al.[9] use only this term to indicate the fibrous formation between the scaphoid and the hamate. In the last edition of *Terminologia Anatomica*[10] the term *transverse carpal ligament* was abandoned and replaced by *flexor retinaculum*. In fact the various terms (flexor retinaculum, transverse carpal ligament, and volar or anterior annular ligament) still co-exist in textbooks and are used by specialists with synonymous or complementary meanings, leading to confusion. For example, in Netter and Colacino[11] and the last edition of Schünke et al.[12] atlases, both terms—*flexor retinaculum* and *transverse carpal ligament*—are used as synonyms, but Netter and Colacino[11] also recognize another, independent anatomical structure, called the *palmar carpal ligament* or *transverse fibers of the palmar aponeurosis*. In the last edition of Moore and Dalley,[13] the term *flexor retinaculum* is used, but the authors provide a footnote, stating that the structure called *flexor retinaculum* does not correspond in position and characteristics to the extensor retinaculum. At the same time, in the last textbook edition of *Gray's Anatomy*,[14] the term *flexor retinaculum* is used together with *extensor retinaculum* to indicate a reinforcement of the antebrachial fascia, but at the same time, in another paragraph, it is described as a "strong, fibrous band [that] crosses the front of the carpus and converts its anterior concavity into the carpal tunnel."

The aim of the present study was to investigate the macroscopic anatomy and histologic characteristics of the fascial layers of the wrist region and to clarify their anatomical relationships and define appropriate terminology.

MATERIALS AND METHODS

Thirty upper limbs of 19 cadavers (15 male, 4 female, mean age 78.3 y) were examined, of which 17 were unembalmed and 2 were embalmed according the method of Thiel.[15]

Macroscopic study

Twenty upper limbs were evaluated by macroscopic dissection. A longitudinal, cutaneous incision was made, in line with the ring finger, from the medial aspect of the elbow region to the palm. Initially, only the skin was dissected and raised medially and laterally to show the subcutaneous tissue and superficial fascia. The subcutaneous tissue was then carefully removed to expose the deep fascia and, in the hand, the palmar aponeurosis. Evaluation of the relationship of the antebrachial fascia with the deeper fascial structures was carried out with the aid of a surgical microscope (Olympus OME, Olympus, Japan). The antebrachial fascia was dissected along an incision, in line with the index finger, and reflected laterally and medially to explore the transverse carpal ligament and the relationship between these 2 structures and with the palmar aponeurosis.

Histological study

From 10 upper limbs, full-thickness specimens that included all tissue superficial to the flexor digitorum superficialis tendons were obtained for histological analysis. In particular, serial transverse sections were taken every centimeter from 5 cm proximal to the bistyloid line to the mid-palm (Fig. 1). The specimens were oriented, mounted on cardboard to avoid deformation artifacts, fixed in 10% formalin solution, and embedded in paraffin. Sections of 10 μm thickness were cut and stained with hematoxylin-eosin, van Gieson for elastic fibers, and azan-Mallory for collagen fibers. An immunohistochemical stain (anti-S100 antibody) for nerve structures was also applied, according