Detailed anatomy of the extensor mechanism at the proximal aspect of the finger

To explain the unique action of the lateral bands during flexion and extension of the finger, a study was undertaken to examine the extensor mechanism at the level of the proximal interphalangeal joint. The study was carried out in three stages—histologic, anatomic, and dynamic. The histologic sections showed no elastic tissue present to account for the expansile and contractile movement of the lateral bands. The anatomic and dynamic studies showed that the extensor mechanism at the level of the proximal aspect of the finger was composed of an intricate, layered, crisscross fiber pattern which altered its geometric arrangement as the finger was flexed and extended. It is our opinion that the action of the crisscross fibers may govern both the action and degree of displacement of the lateral bands during flexion and extension of the finger.

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The proximal interphalangeal (PIP) joint of the finger contains a unique extensor apparatus which is not duplicated in any other major joint of the body, with the exception of the PIP joint of the toe.1, 2 It is generally accepted that this extensor apparatus consists of a well-defined central tendon and two lateral bands, the latter of which are displaced volarly in flexion and return to the dorsum of the finger in extension.3-6 This action of the extensor mechanism may be likened to two strings fixed at a central point. When a longitudinal force is applied to the ends of the strings, they will come to the center. We realize this oversimplification does not exist over the PIP joint. The string model does not have a central mechanism as does the extensor apparatus of the finger, a deficiency which will not allow the lateral bands to return to the midline when a proximally directed longitudinal force is applied (Fig. 1).

We believe that insufficient attention has been given to the interconnecting tissue that binds together the central tendon and the lateral bands. Past reports have illustrated this interconnecting tissue occurring in a transverse pattern or in force diagrams where the fiber pattern has been omitted entirely (Fig. 2).4, 6-9

In a preliminary report,10 we described this interconnecting tissue as a specific fiber pattern arrangement between the central tendons and the lateral bands.

The existence of such an intricate mechanism raises both anatomic and biomechanical questions. Anatomically, what is the makeup of the interstitial tissue which expands and contracts when the lateral bands displace from the midline and return during flexion and extension of the finger? Do the tissues exhibit an elastic quality, as has been described by Littler and Eaton?9 Biomechanically, what mechanism permits the lateral bands to be displaced volarly and then return?

To answer these questions and explain this unique action, a study of the anatomy on a gross, microscopic, and histologic level was done to define the anatomy and dynamics of the extensor mechanism overlying the PIP joint. The biomechanical aspects will be the subject of a future report.

Material and methods

The study was carried out in three stages.

Histologic. Multiple sections of the extensor mechanism overlying the PIP joint were prepared and studied utilizing hematoxylin and eosin stain and elastic tissue stain. These sections included the central tendon and the lateral bands, as well as their interconnecting tissue.

Gross anatomic. Filleted specimens of the extensor mechanism were studied under magnification utilizing a dissecting microscope. This permitted greater detail visualization of the fiber pattern between the central tendon and the lateral bands.

Dynamic. Using fresh cadaver hands, the fiber pattern was studied under magnification to observe its action during flexion and extension of the finger.

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The specimens used for the study consisted of fresh, fresh-frozen, and preserved cadaver hands. Preliminary dissection consisted of the removal of the skin and subcutaneous tissue overlying the extensor apparatus with 3.5 power Loupes. Following this, the digit was placed in a water bath, and water was allowed to drip slowly over the dorsum of the finger for 12 hours. This acted as a blunt dissection to remove any extraneous tissue from the extensor apparatus. The specimen was then placed under the dissecting microscope, and a fine dissection removed the loosely attached superficial tissue. If needed, the finger was again placed under constant water flow, and the process was repeated until all extraneous tissue had been removed from the extensor mechanism. The fiber pattern was the same in both the fresh and the preserved specimens.

For stage one, multiple sections of the extensor mechanism—including the central tendon, lateral bands, and interconnecting tissue at the level of the PIP joint—were prepared using standard techniques with hematoxylin and eosin stain and elastic tissue stain. Specimens were then studied with a light microscope.

For stage two, preserved cadaver fingers were used. The extensor mechanism—including the central tendon and lateral bands—were filleted and prepared as noted above, removing all extraneous debris. The specimens were secured between glass slides and studied through the dissecting microscope to demonstrate the fiber pattern.

For stage three, fresh cadaver specimens were used. The extensor mechanism was again prepared as previously described. However, this time it was left with its bony attachments. The flexor tendons were also prepared so that traction could be applied. Thus active PIP joint motion could be obtained by pulling on the flexor and extensor tendons.

The proximal phalanx was transfixed in a rigid clamp, and the interphalangeal joints were passively flexed and extended using the tendons. The action of the fiber pattern was observed under $\times 15$ to $\times 20$ magnification during flexion and extension of the finger and was recorded using a 16 mm movie camera attached to the operating microscope.

**Results**

**Stage one.** The microscopic sections were prepared to determine whether the expansile and contractile nature of the interstitial tissue, permitting displacement and return of the lateral bands, was based on histologic
Fig. 3. Histologic section of extensor mechanism overlying PIP joint. Multiple sections stained with hematoxyline and eosin stain and elastic stain did not demonstrate any evidence of elastic tissue.

Fig. 4. A, Magnified filleted specimen demonstrating crisscross fiber pattern between central tendon and lateral bands. B, Closeup of extensor mechanism. Note that central fibers do not proceed in toto directly to central insertion as isolated single structure but that more peripheral fibers flare out, gently curving laterally in fan-shaped pattern to join lateral bands. Fibers arising from intrinsic tendons on other hand demonstrate lateral fibers to continue straight, while more dorsally situated fibers curve gently towards midline, crossing fibers from extensor communis.
properties. When compared to a standard for elastic tissue, neither the hematoxylin and eosin stain nor the elastic tissue stain demonstrated the presence of elastic fibers in the tendon or the interconnecting tissue (Fig. 3).

**Stage two.** The magnified filleted specimens permitted the anatomy of the fiber pattern to be visualized in greater detail and allowed one to appreciate the crisscross fiber pattern between the central tendon and the lateral bands. Fig. 4 demonstrates that (1) the fiber structure linking the central tendon to the lateral bands forms a crisscross pattern and (2) the fibers of the central tendon arising from the extensor digitorum communis were found not to proceed in toto directly to the central insertion as a single isolated structure. Proximally, the fibers are centrally arranged in a longitudinal pattern. Continuing distally, the central fibers proceed to the central insertion; the more peripheral fibers flare out gently, curving laterally and volarly in a fan-shaped pattern to join the lateral bands. The fibers arising from the intrinsic muscles display a separate pattern. The volar fibers continue straight, whereas those more dorsally situated curve gently toward the midline medially and dorsally to cross the fibers from the extensor communis. The fibers do not interdigitate but occur in two separate layers (Fig. 5).

**Stage three.** To gain insight into whether or not this fiber pattern had association with the action of the lateral bands, the dynamics of the fiber pattern were studied using the fresh cadaver specimens in which the prepared extensor and flexor mechanisms were left to their bony attachments.

The PIP joint was passively moved in flexion and extension and the fiber pattern observed. During flexion and extension of the PIP joints, the angles formed by the crisscross arrangement of the overlapping fibers changed. As the PIP joint passed from flexion to extension, the longitudinal angle between the individual crossed fibers decreased with the configuration, assuming a diamond shape aligned along the long axis of the finger. (Fig. 6).

As the PIP joint moved from extension to flexion, the angle formed between the individual crossed fibers increased, and the fiber pattern assumed a somewhat square configuration. (Fig. 7).

**Discussion and conclusions**

The anatomy of the extensor mechanism has been previously described by several authors, including Haines, Kaplan, Littler, Tubiana and Valentin, and Landsmeer. The physiology and function of the extensor apparatus has also been detailed by Tubiana and Valentin, Landsmeer, and Littler and Eaton. The one aspect of the extensor mechanism which seems to have been given scant attention by previous authors is the anatomy and functional significance of the interconnecting tissues between the central tendon and the lateral bands, which allow the lateral bands to be displaced volarly in flexion and return to the dorsum of the finger in extension. Littler and Eaton have described the attachment of the central tendon to the lateral bands as having “a unique, elastic property permitting their (lateral bands) volar displacement as the finger flexes.”

Several conclusions about the anatomy and possibly its functional significance in contributing to the unique action of the lateral bands in the extensor apparatus overlying the PIP joint may be drawn.
In stage one, the microscopic sections of the central tendon, the lateral bands, and the interconnecting tissue showed only the normal fibrocollagenous tissue with no elastic fibers noted in either the tendons or the interconnecting tissue. An elastic fiber microstructure, therefore, does not exist in the extensor mechanism at the level of the PIP joint and cannot be used to explain the motion of the lateral bands in flexion and extension.

In stage two, the filleted specimens of the extensor mechanism showed a crisscross arrangement of fibers which can be separated from each other in two layers. As the tendon of the extensor digitorum communis passes over the dorsum of the proximal phalanx to contribute to the extensor hood, it loses its definition as a distinct tendon and begins to give rise to the fiber pattern arrangement of the extensor mechanism. The fibers arising from the central aspect of the tendon proceed in a straight line to insert directly into the dorsal aspect of the base of the middle phalanx, thus contributing to the central insertion. The fibers on either side of the central fibers flare out, curving gently laterally and volarly to attach to the lateral bands and giving a fan-shaped appearance when viewed from above. The second, deeper layer fibers are composed of those arising from the intrinsic tendons on either side of the finger. The fibers on the most volar or lateral aspect proceed straight to insert on the dorsal aspect of the distal phalanx. Those fibers arising more dorsally or medially from the intrinsic tendons curve distally and dorsally to cross the central tendon. It is this arrangement that gives the fiber pattern its crisscross arrangement.

In stage three, the crisscross fiber pattern expanded and contracted as the PIP joint was flexed and extended. With the finger extended, the longitudinal angle between two adjacent fibers was 30°, and the fiber pattern was diamond-shaped in appearance. When the finger was flexed, the longitudinal angle between two adjacent fibers was 50°, and the fiber pattern assumed a more square configuration. This action of the crisscross fiber pattern, by altering the geometric arrangement, may govern both the action and the degree of displacement of the lateral bands.
Fig. 7. A, As PIP joint is moved from extension to flexion, angle between individual crossed fibers increases. Note that at approximately 90° of joint flexion angle between crossing fibers increased to 50°. B, Diagrammatic representation of fiber pattern in flexion, demonstrating widening of diamond-shaped configuration, assuming somewhat square pattern.

Summary

The extensor mechanism at the level of the PIP joint is not made of separate and distinct tendons.

There is no elastic tissue in the central mechanism, the lateral bands or the interconnecting tissue at the level of the PIP joint.

The extensor mechanism at the level of the PIP joint is composed of a unique crisscross fiber pattern that interconnects the central mechanism with the two lateral bands.

The fiber pattern exists in two separate layers—the superficial layer from the extensor digitorum communis tendon and the deep layer from the intrinsic muscles.

The layers move, one upon the other, as the finger is flexed and extended.

The action of the crisscross fiber pattern may govern both the action and the degree of displacement of the lateral bands by altering their geometric arrangement.

REFERENCES


