SCIENTIFIC ARTICLE

# Mechanics of Metacarpophalangeal Joint Extension

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**Purpose** It is a common belief that extension of the metacarpophalangeal (MCP) joint of the finger is achieved via the sagittal bands acting as a sling or lasso to attach the extensor tendon to the base of the proximal phalanx. The aim of this study was to test the hypotheses that (1) division of the sagittal bands reduces extension force or torque of the MCP joint, and (2) division of the extensor tendon distal to the sagittal band will not affect the extension force or torque of the MCP joint.

**Methods** Ten cadaver limbs were secured to a jig to allow for testing of the extension force of the MCP joints of the index, middle, and ring fingers. A 1-kg load was applied to the forearm extensor digitorum communis tendon and the extension force was measured with the MCP joint positioned at 0° (neutral extension) and again at 45° flexion. These measurements were repeated after the sagittal bands were divided in 15 specimens; in the other 15 specimens, the extensor tendon was divided just distal to the sagittal bands.

**Results** After sagittal band division, extension force was similar in the 2 groups (0.11 N reduction after division with the MCP joints in neutral and 0.14 N in 45° flexion). There was significantly less extension force after division of the extensor tendon in both joint positions (0.95 N reduction after division in neutral extension and 0.66 N in 45° flexion).

**Conclusions** The sagittal bands do not primarily extend the MCP as a sling or lasso. The extensor tendon continuation to the extensor hood and middle phalanx is the major extension motor. The MCP joint is extended by the torque generated by the extensor tendon passing the joint carrying a force and possessing an extension moment arm.

**Clinical relevance** This principle should be correctly understood in the literature to ensure that clinical decisions related to injury and/or repair of the extensor tendon and sagittal bands are based on a sound understanding of their mechanics. *(J Hand Surg Am. 2017;■(■):1.e1-e5. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

**Key words** Extension, extensor tendon, metacarpophalangeal joint, sagittal band.

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## INTRODUCTION

"Metacarpophalangeal joint extension is accomplished via fibers of the sagittal band that extend from the extensor hood to the palmar plate." This unreferenced statement first appeared in the fifth edition of *Green's Operative Hand Surgery* and has been repeated and expanded in the sixth edition and restated again in the seventh edition as "Extension of the MP joint is transmitted by the pull of the EDC through the sagittal bands."[1–3] No reference is given, much in the way of an accepted wisdom. Searching the literature supplies some clues regarding the origin of this idea.[4–13]

The concept seems to arise to satisfy the question of how the metacarpophalangeal (MCP) joint extends without a direct insertion of extensor digitorum communis (EDC) into the base of the proximal phalanx. The sagittal band (SB) passes from the EDC to the volar plate, and hence indirectly to the volar base of the proximal phalanx.

One origin of this theory appears in the work of Zancolli and Cozzi.[4] Their concept seems to apply only to the posture of hyperextension, such as in a claw hand, and not physiologic extension through the normal MCP joint arc of motion. Zancolli and Cozzi referenced an 18th-century anatomy text by Winslow,[5,6] who stated that "each (extensor) tendon having reached the bases of the first phalanx, is slightly inserted therein by some lateral expansions fixed in each side of the bases,"[5] and "The lateral Expansions extend the first Phalanx."[6] It is not clear whether Winslow was referring to the SBs or the lateral aponeurotic expansions of the extensor hood distal to the SB.

Smith[7] also conceptualized that the primary extensor of the MCP joint is the encircling fibers connecting the extensor mechanism to the flexor sheath, volar plate, and the periosteum of the proximal phalanx, and that "the principle function of the sagittal bands is to extend the proximal phalanx." Other authors stated a role for the SB in MCP joint extension,[8–11] but many cited no reference. Thompson and Wehbe[12] called this the lasso effect but provided no reference. Some authors referenced an article by Harris and Rutledge,[13] which infers the lateral expansion as the indirect connection rather than the SB. However, the article anecdotally notes full extension of the MCP joint after division of the EDC at the distal margin of the SB.

The purpose of this study was to test empirically the extension effect in a cadaver model of (1) the SBs and (2) the extensor tendon beyond the SBs. The hypotheses were that (1) division of the SB would weaken MCP extension force or torque, and (2) division of the extensor tendon distal to the SB would not.

## MATERIALS AND METHODS

After obtaining approval from the institutional human research ethics committee, a sample of convenience composed of 10 fresh-frozen cadaver forearms amputated distal to the elbow were prepared for testing. All cadavers had a full passive range of motion at the MCP and interphalangeal (IP) joints. The EDC tendons to the index, middle, and ring fingers were dissected proximal to the extensor retinaculum and a whipstitch with a large-caliber, nonabsorbable suture was placed at the musculotendinous junction to apply traction. The extensor apparatus overlying the proximal phalanges of the digits was exposed. The length of each proximal phalanx was measured using calipers and an indelible mark was placed at the three-quarter length position from the MCP joint. The limbs were then allocated into 1 of 2 groups: (1) those in which the SBs were to be divided; and (2) those in which the extensor tendon at the level of the MCP joint, at the distal margin of the SB, was to be divided. Each group contained 15 digits that were assumed to be independent specimens for purposes of the statistical analyses.

Each forearm was positioned on a wooden frame with the metacarpal heads placed just distal to the edge of a longitudinal wooden block. The forearms were pinned to the block in a position of neutral rotation and with the wrist neutral by one 1.6-mm K-wire passing through the radial and ulnar shafts and another through the midshaft of all metacarpals. A height-adjustable load cell frame was secured in place to the underlying plinth (Fig. 1).

The load cell was aligned (perpendicular to it and at the correct height) with the three-quarter mark on the proximal phalanx of each digit. The MCP joint was placed at 0° flexion. Force exerted with no tendon load was measured as 0 for the load cell. A 1-kg weight was then attached to the tendon via the proximal suture and a pulley. After a delay of 1 minute to allow for stress relaxation, the force exerted under load was recorded. These measurements were repeated with the MCP joint in 45° flexion (the limit of flexion before extensor tendon subluxation occurred after division of the SBs) by moving the wooden frame on the underlying plinth.

After this, the relevant structure (either both SBs at the margins of the extensor tendon or the extensor tendon at the distal extent of the SB) was completely divided. Force exerted on the load cell was remeasured both at rest and with weight attached at 0° and 45° flexion. This process was repeated through the index, middle, and ring digits of the 10 hands.

The results were recorded by an independent observer and paired *t* tests were applied for statistical analysis.

## RESULTS

A total of 30 digits were prepared from 10 cadaveric forearms, with 10 each of index, middle, and ring