

Dorsal Digital Expansion Of Thumb – A Cadaveric Study and Its Clinical Significance

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ABSTRACT

Background: Human hand is a prehensile organ & is endowed with grasping, precision movements for skilled work. Broad representation of thumb in the brain reflects the functional importance & complexity of movements of thumb. A succession of activity occurs among the extensor tendons & the thenar muscles during opposition. Dorsal digital expansion has been reported in our study & contribution made by muscular elements which go into its formation has been described. Many authors are not in consensus regarding its anatomy, hence the study was undertaken.

Methodology: An observational descriptive study, using 50 free upper limbs, in the department of Anatomy was carried out. Dissection was performed following instructions from the standard practical manual. Observations were described, photographed & tabulated.

Results: The DDE (Dorsal Digital Expansion) of thumb, a pearly white translucent triangular expansion on dorsum of its proximal phalanx, is the tendinous fibers of the EPL (Extensor Pollicis Longus) & EPB (Extensor Pollicis Brevis) was found in all specimens. Medial margin being more prominent, in addition to EPL & EPB received fibers from Adductor pollicis & first palmar interossei (if present). The lateral margin received contribution from APB (Abductor Pollicis Brevis) & FPB (Flexor Pollicis Brevis). The percentage of each tendon contribution towards DDE has been tabulated & variations in the insertion of extensor tendons to the phalanges are also discussed.

Conclusion: Human thumb plays a crucial role in the smooth functioning of hand. The knowledge of DDE adds to analyze the biomechanics of thumb & in the management of de Quervain's Tenosynovitis (DQT). Multiple tendons may attribute to disturbance in joint movements.

KEY WORDS: Dorsal digital expansion, Extensor pollicis longus, Extensor pollicis brevis, Adductor pollicis, Abductor pollicis brevis, Flexor pollicis brevis, de Quervain's Tenosynovitis, proximal phalanx, distal phalanx.

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INTRODUCTION

Human hand represents "Revolution in Evolution". The opposition of thumb to the

index finger & other digits highly evolved in mankind for grasping & finer movements. This is accountable to the high degree of

neuromuscular co-ordination & larger cortical representation of thumb in sensory-motor cortex of the brain. Opposition is a composite position of thumb achieved by circumduction of the 1st metacarpal, internal rotation of thumb ray and maximal extension of the metacarpophalangeal joint & interphalangeal joint. A succession of activity occurs among the extensor tendons & the thenar muscles during the movement of opposition. A meticulous study was undertaken to unveil the presence, formation & contribution made by various elements which go into the formation of DDE of thumb [1, 2].

A fibrous triangular expansion on the dorsum of proximal phalanx of thumb is formed by Extensor pollicis longus(EPL), Extensor pollicis brevis(EPB) & most of the intrinsic muscles of thumb. DDE of thumb presents structural difference when compared with that of other digits. Unlike other digits that possess 3 slips, DDE of thumb has a single triangular expansion [1].

METHODOLOGY

An observational descriptive study included 50 free upper limbs of unknown sex & age, in the department of Anatomy, Chikkaballapur Institute of Medical Sciences, Chikkaballapura. **Exclusion criteria:** Upper limbs with hand deformities, marks of gross soft tissue injuries & fractures were excluded. Standard dissection procedures as described in Cunningham Manual Volume I was carried out [3]. First & third extensor compartments were exposed by vertically splitting the extensor retinaculum. Extensor tendons & DDE were delineated over the dorsum of thumb. The contribution of EPL & EPB to the formation of DDE was observed. The margins & attachments of DDE were discerned. The phalangeal attachments of EPL & EPB were noted & photographed. The contribution of intrinsic muscles of thumb such as Abductor pollicis brevis(APB), Flexor pollicis brevis(FPB) on radial side & Adductor pollicis(AP), 1st palmar interossei (if present) on ulnar side were looked for & photographed. The tendinous fibres of muscle elements contributing to DDE and the phalangeal attachment of EPL & EPB were

expressed as percentage & compared with other studies.



Fig 1A



Fig 1B

Fig 1A & Fig 1B: DDE on dorsum of proximal phalanx of thumb.

DDE – Dorsal Digital Expansion, EPL – Extensor Pollicis Longus, EPB- Extensor Pollicis Brevis, APB- Abductor Pollicis Brevis, FPB- Flexor Pollicis Brevis, AP- Adductor Pollicis, PI – Palmar Interossei.

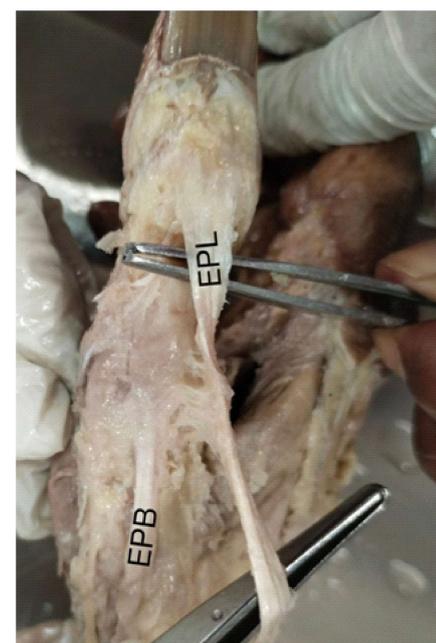


Fig 2: EPL attached to both proximal phalanx & distal phalanx.

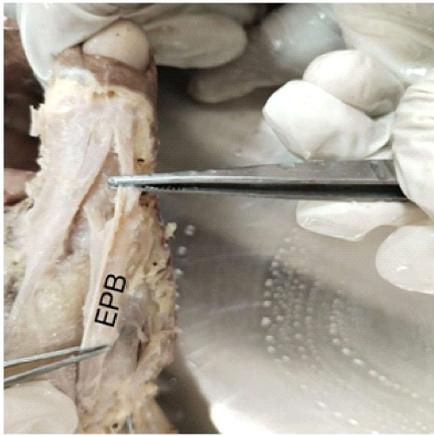


Fig 3: EPB attached to both proximal & distal phalanx.



Fig 5: Absence of tendon of EPB.

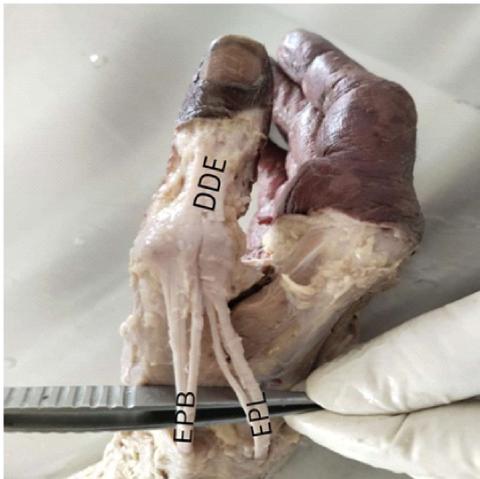


Fig 4: Splitting of tendons of EPL & EPB.

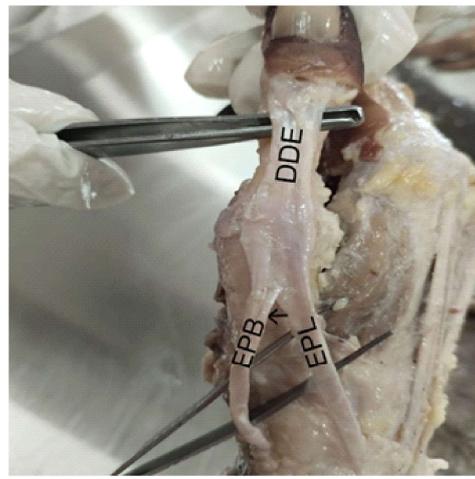


Fig 6: EPB sharing tendinous fibres to EPL, both merge & fuse forming DDE.

RESULTS

Table1: Comparison of contribution of various tendons of thumb.

Muscle contributing	Joshi et al [4]	Michael et al [5]	Present study
EPL	All specimens	All specimens	100%
EPB	All specimens	All specimens	98%
APB	68.20%	100%	96%
FPB	3.60%	41.20%	82%
AP	98.10%	100%	100%
1 st Palmar interossei	62.70%	50%	36%

Table2: Comparison of Insertion of EPL.

Study	To proximal phalanx	To distal phalanx	Both proximal phalanx & distal phalanx
Joshi et al 2008 [4]	Nil	98.20%	1.80%
Abdel-Hamed et al 2013[6]	Nil	5.30%	94.70%
Esther Yamuna et al 2017 [7]	+	-	-
Sabnis 2013[8]	Nil	98%	2%
Michael et al 2020 [5]	Nil	45%	55%
Present study 2024	Nil	66%	34%

Table3: Comparison of Insertion of EPB.

Study	To proximal phalanx	To distal phalanx	Both proximal phalanx & distal phalanx
Joshi et al 2008 [4]	58.15%	27.50%	14.60%
Roy et al 2012 [9]	79%	14%	5%
Sabnis 2013 [8]	72%	6.80%	21.20%
Ravi et al 2019 [10]	58.70%	36.25%	0
Michael et al 2020 [5]	46.20%	25%	23.75%
Present study 2024	56%	20%	24%

The extensor tendons & intrinsic muscles sharing their tendon fibres for the DDE have been presented in percentage. The attachment of EPL & EPB to proximal & distal phalanx, also expressed. The present study results were also compared with previous studies & tabulated [Table1, 2&3].

DISCUSSION

The DDE of thumb is a flat fibrous, pearly white translucent triangular expansion on dorsum of its proximal phalanx is the tendinous fibers of the EPL & EPB, forming a movable hood that moves distally when the metacarpophalangeal joint is flexed & proximally when it is extended. The expansion is triangular, with its base being proximal at metacarpophalangeal joint & apex is distal at interphalangeal joint. DDE permits extension of interphalangeal joint, when metacarpophalangeal joint is flexed by flexors. The thumb enjoys a greater range of extension with presence of DDE, than if it was a single extensor tendon [1].

DDE of thumb presents structural difference when compared with that of other digits. One being the apex of expansion will directly attach to base of distal phalanx without splitting into 3 slips. The other one is the tendinous fibers of the expansion neither attaches with volar plate nor merges with fibrous flexor sheath of the thumb. Among the two margins of the expansion medial one was more prominent & well defined. Added to EPL & EPB contribution, the medial margin received extension of fibers from Adductor pollicis, the most powerful intrinsic muscle of hand that holds thumb adducted with the rest

of the digits. The lateral margin also receives contribution from APB & FPB [Figure 1A & 1B]. This can be equated with observations by Joshi et al & Michael et al [4, 5] [Table 1].

The tendon of EPL was traced up to the base of distal phalanx, where it widens before attachment. In 66% of specimens EPL attached to distal phalanx, whereas in 34% of upper limbs the tendon gave a small slender tough slip that attaches to the base of proximal phalanx & then extends further distally to attach to base of distal phalanx [Table 2][Figure 2]. Our observation is in line with Joshi et al [4] who also stated the attachment to distal phalanx is more frequent compared to both phalanges. Literature by Esther Yamuna et al [7], have stated the attachment of EPL to proximal phalanx alone, but this was not noticed in our study.

In two specimens the tendon of EPL splits into two [Figure 4], & in one specimen it triples. Joshi et al [4] reported out of 110 upper limbs, in 6 the tendon of EPL splits into 3 & in 27 cases divided into two before inserting into distal phalanx.

Lamb et al [11] have explained varying range of extension on all joints of thumb by EPL & simultaneous rotation of first metacarpal laterally. Romanes [12] & Spinner [13] have stated that dorsal part of capsule of metacarpophalangeal joint is replaced by tendon of EPL. The tendon later forms a triangular expansion that is joined by tendinous fibers of APB on radial side & AP on the ulnar side.

The EPB emerges out from the first extensor compartment of the wrist, crosses carpometacarpal joint & courses distally on dorsum of 1st metacarpal, to gain attachment to the base of

proximal phalanx. In 56% we observed the attachment to base of proximal phalanx. In 20%, it coursed further distally to gain attachment to base of distal phalanx. In 24% of specimens it presented with attachment to both proximal phalanx & distal phalanx [Figure 3][Table 3].

In one of the specimens EPB was absent [Figure 5]. 3 specimens presented with, EPB splits into 2 tendons on dorsum of 1st metacarpal. At the formation of DDE in one of the specimens, we could observe the tendinous fibers of EPL & EPB merged at metacarpophalangeal joint, crisscross with each other & fuse. The EPB sends tendinous fibers to EPL & fuse with it & finally inserted to both phalanges. The additional attachment of tendon of EPB to base of distal phalanx is through a fasciculus that joins the tendon of EPL [Figure 6].

Nayak et al [14] have reported in 24 specimens EPB fused with EPL tendon prior to insertion into distal phalanx, 3 specimens showed direct attachment to distal phalanx & have reported a case of absence of EPB.

Lamb et al [11] have discussed in their literature that EPB may be absent in 5% of people or may have multiple tendons and at times it may be fused with APL (Abductor Pollicis Longus). Hollinshed also states that EPB often shows doubling; either at wrist or on dorsum of thumb & in 72% EPB is inserted into proximal phalanx, 6.8% directly on to distal phalanx & in 21.2 % to both the phalanges [15].

Abdel – Hamid et al [6] have stated absence of EPB in 2.1%. They stated rupture of EPL at level of Lister's tubercle as in Colles' fracture results in major functional loss of extension at metacarpophalangeal joint. Extension at interphalangeal joint is by intrinsic muscles through their contribution to DDE of thumb.

Rupture of EPB leads to flexion of metacarpophalangeal joint which may worsen with displacement of EPL, this result in hyper extension at the interphalangeal joint[15].

EPB, a unique muscle known for variations; its tendon may be united with EPL & inserted with it, may be absent being fused with APL or may be duplicated. Multiple tendons may result in

clinical conditions like de Queverain's syndrome & may also attribute to disturbance in joint movements, may be one of the reasons for treatment failure & recurrence of the syndrome [16].

Nishimura R et al [17] have stated that the diversity of EPB tendon may reflect ongoing process of evolution. The literature also describes in some cases, all the EPB tendon fibers reached the distal phalanx without branching, while only small fiber bundles branched & reached the distal phalanx in other cases. Moreover, the fiber bundles branching from the main trunk of the EPB tendons were not uniform as they were inserted into aponeurosis, proximal phalanx or EPL tendon. EPB tendon fibers branch in varying proportions & stop at multiple sites & merge with EPL tendon. They also noticed in contrast to EPB tendon variations among EPL tendons are rare due to their stable structure. But in our study we have reported duplication of EPL. Added to this they speculated that the symptoms produced by a rupture of EPL tendon may vary according to EPB tendon variations.

Ravi et al [18] have speculated the ongoing process of evolution of EPB tendon by reporting a case, the EPB tendon's insertion into the 1st metacarpal in 3% of cases. But we have not reported the above variation in our study.

Sabnis et al [8] stated that EPL carries out extension of terminal phalanx of thumb. EPB causes extension of carpometacarpal & metacarpophalangeal joint. They also stated multiple tendons may alter the kinematics around the site of attachment to the phalanges. The number, thickness & length of such supernumerary tendons have a functional significance in the development of DQT

A thin slip from 1st palmar interossei joins DDE in 62.7% of specimens was described by Joshi et al & 50% by Michael. We could observe the same in 36% of specimens of upper limb.

The expansion from APB contributed to the DDE in 96% of specimens along the radial side & FPB contribution was 82%. Along the ulnarside the DDE received 100% from AP, whereas from 1st palmar interossei it was 36%. Joshi et al [4] while discussing APB, have

stated the contribution to DDE was seen in 68.2% of thumb examined & FPB in 3.6% cases only. Our findings are at variance from those reported by the above author. Michael et al [5] have explained in their literature the contribution of APB & FPB as 100% & 41.2% respectively.

Adductor pollicis plays a crucial role in keeping thumb in close approximation to other digits. Human thumb plays a crucial role in smooth functioning of hand especially for power, prehensile & precision work. Thumb primarily adducted by a powerful muscle AP. Hunter et al [19] have noted that AP is one of stabilizing factor to extensor tendons & shifts extensor forces to the interphalangeal joint. In the present study DDE received 100% contribution from AP along the ulnarside. Spinner[13] demonstrated the adduction with simultaneous extension of distal phalanx by stimulating this muscle.

CONCLUSION

The knowledge of DDE'S formation, its contributors & their variation in attachment to phalanges may yield new insights in understanding the biomechanics of thumb that is clinically important. The anatomical variations of extensor tendons of thumb contributing to DDE may aid in approach to the management of DQT. Presence of multiple tendons may be useful for hand surgeons for tendon transfer in reconstructive surgery without hampering the function of thumb.

Limitations: Our study was limited to gross features of DDE, the histological demonstration of tendon fibers of EPL & EPB i.e. when they fuse with each other at metacarpophalangeal joint, when each tendon splits, exchange the fibers & the replacement of dorsal part of capsule at metacarpophalangeal joint may provide comprehensive knowledge about formation of DDE which would aid to have better overview of the biomechanics of thumb.

ABBREVIATION

DDE- Dorsal digital expansion
EPL- Extensor pollicis longus
EPB- Extensor pollicis brevis
AP – Adductor pollicis

APB- Abductor pollicis brevis
FPB- Flexor pollicis brevis
DQT- de Queverain Tenosynovitis

Author Contributions

Jyothi S.R and Chaithra Rao B.R, contributed in article search, data collection and analysis, scripting the article. Vasudha T.K contributed in reviewing & editing.

Conflicts of Interests: None

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