A cadaveric study on the anatomical variation of the Flexor Digitorum Profundus; the biomechanical effect of the Quadriga Phenomenon and potential methods of examination.

K. T. M. Oo [1] & P. B. M. Thomas [2]

NHS University Hospitals of North Midlands NHS Trust

Keele University

AIMS

To carry out a cadaveric study on the anatomical variation of the Flexor Digitorum Profundus (FDP), the biomechanical effect of the Quadriga Phenomenon and potential methods of clinical examination, with relevance to deep flexor tendon injuries.

BACKGROUND

The action of the FDP leads to flexion of the distal interphalangeal joint (DIPJ). The FDP is classically described as being conjoined at the muscle belly within the forearm, before individual tendons diverge beyond the carpal tunnel to insert into their respective distal phalanges. The conjoined nature of the FDP results in the Quadriga Phenomenon (QP). This describes the manner in which active flexion of one digit at the DIPJ leads to passive flexion of the neighbouring digital joints at various degrees. Hence the reference to the Roman Quadriga, a chariot drawn by four horses[1]. The extent to which this occurs depends on the variability of interconnections at four specific locations: the muscle belly, common tendinous intersection, synovial sheaths and lastly, the extent to which the lumbricals adhere to the FDP tendons within the hand[2]. Deep forearm lacerations are likely to damage the FDP tendons. This would result in an inability to flex the DIPJ. Thus, it is vital to determine the integrity of the FDP on examination. Having an understanding of the QP and its impact on individual DIPJ flexion, in combination with clinical examinations can allow surgeons to determine the severity of injury and likely post-operative outcome. Due to COVID, we are unable to provide cadaveric photographs, nevertheless, illustrations have been provided[4].

REFERENCES

1) Verdan, C. E. (1960). Syndrome of the Quadriga. Surgical Clinics of North America; 40(2), pp. 425-426.
2) Schreuders, T. (2011). The Quadriga phenomenon: a review and clinical relevance. Journal of Hand Surgery (European Volume); 37(6), pp. 513-522.
3) Tubiana, R., Thomine, J., Mackin, E. (1996). Examination of the hand and wrist. New York: Informa Healthcare USA Inc.
4) 3d4medical.com. (2020). Complete Anatomy 2020 | Complete Anatomy. [online] Available at: <https://3d4medical.com/press-category/complete-anatomy> [Accessed 12 June 2020].
5) Warwick, D., Dunn, R., Melikyan, E. and Vadher, J. (2009). Hand Surgery (Oxford Specialist Handbooks in Surgery). Oxford University Press.

METHODS

Dissection:

Four fresh frozen cadaveric forearms were dissected to study the underlying anatomy and biomechanical arrangement of the FDP. The apparent length of the FDP was measured from the medial epicondyle (ME) of the humerus to the proximal mouth of the carpal tunnel (PMCT). Secondly, from the ME, the PTMJ was then identified as the most proximal point at which tendon and muscle began to merge (Fig. 1). Other measurements include: average tendon width and the number of Oo-Thomas tendonelles within each FDP tendon.

Measurement of tendon excursion:

Excursion of the FDP tendons was measured using a custom-built apparatus (Fig. 2). A suture was placed in each PTMJ and its starting position was noted. Tension was then exerted through rubber bands in order to position each digit in the resting hand cascade (RHC). This describes the natural flexed position of the fingers resulting from normal muscle tone. Each digit was then fully extended and the excursion was measured using electronic callipers as the change in distance of the suture.

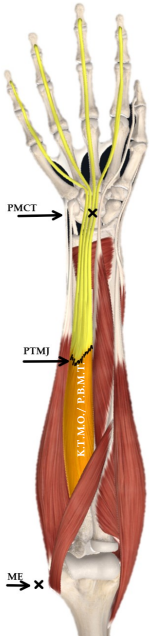

Fig. 1 (Above): Figure illustrating the landmarks used for measurements.

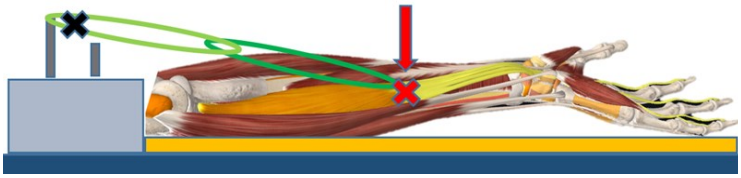

Fig. 2 (Left): Establishing the RHC using two interlinked rubber bands (green), which were attached to a loop within the suture at the PTMJ (red cross) and then onto the pins atop the raised stage (black cross); the cadaver is positioned on the lead hand (yellow). The custom built apparatus is shown in blue and grey.

RESULTS

Both qualitative and quantitative data was obtained. Upon dissection, variation within the FDP tenomusculature was documented. Overall, all cadavers displayed the classic anatomical layout whereby an individual muscle belly was present for index FDP tendon, whilst the 3rd, 4th and 5th FDP tendons shared a conjoined muscle belly. Although, minor variation was also noted within each cadaver. Biomechanically, the index FDP tendon was most independent and resulted in the least amount of excursion within neighbouring tendons. Whereas, extension of the 5th digit resulted in the greatest amount of excursion in the neighbouring three tendons, as follows: 4th: 1.3 mm, 3rd: 1 mm and 2nd: 0.9 mm.

DISCUSSION

The FDP is affected by the QP whereby flexion of one digit at the DIPJ, leads to passive flexion of the neighbouring three digital joints at various degrees. This study demonstrates the QP as being most prominent in the 4th and 5th FDP tendons. Thus, deep flexor tendon injuries of these digits is most likely to result in post-operative contracture deformities. Therefore, upon surgical repair, it is imperative to restore as much normal tendon excursion as possible.