# TENDON HEALING

ESSAY SUBMITTED FOR PARTIAL FULFILMENT

OF M.Sc. IN ORTHOPAEDIC SURGERY

BY

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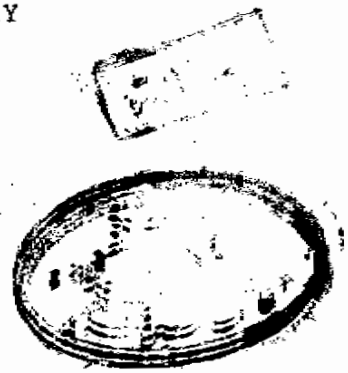



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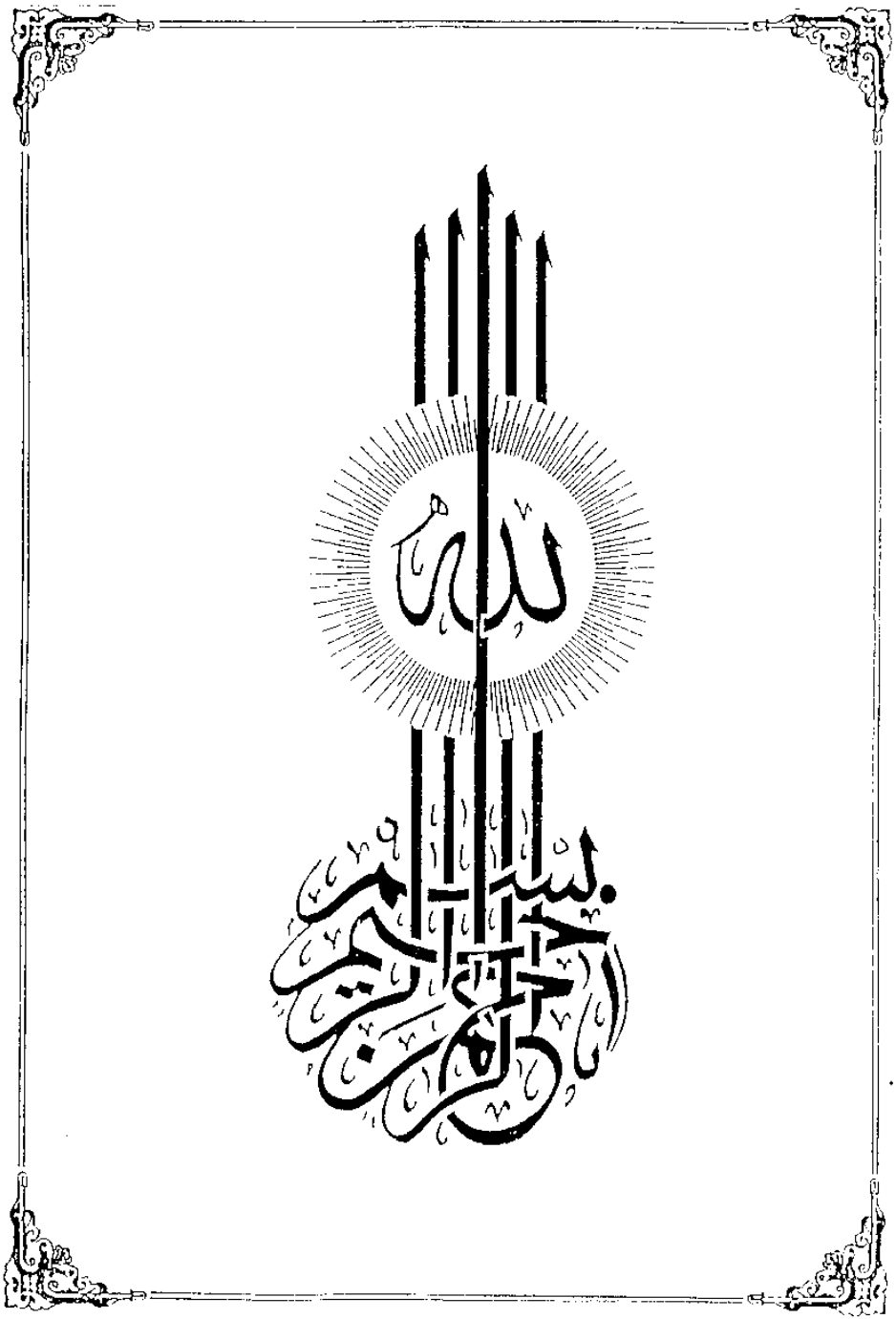

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# Introduction and aim of the work

Tendons are specialized structures of connective tissue which enable muscles to concentrate or extend their action . The Achilles tendon is a good example of a tendon which concentrates the power of several bulky muscles to one limited area of insertion , the long tendons of the hands and feet exemplify the function of extending the effect of distant muscles . Many muscles have no tendinous insertions , for example the paravertebral and the gluteal muscles have short fan shaped fibrous insertions which hardly justify their description as tendons ( C semple , 1981 )

The human flexor tendon system is a wonderfully comlex mechanism that permits strong muscle contraction in the forearm to translate into the powerful digital motion necessary for a wide array of hand functions .

Despite recent advances in our understanding of the anatomy , biomechanics , nutrition , and healing of flexor tendons , the return of satisfactory digital performance following tendon interruption remains as one of the most difficult and challenging problems for the hand surgeon . ( James W. Strickland , 1983).

Any treatment protocol for flexor tendon injuries should be based on an understanding of how flexor tendons heal , how they react to specific trauma , how trauma to contiguous structures affects their healing . ( A.D.Potenza , 1986).

Our main concern with tendon repairs will always be to get them moving , for an adherent tendon repair is a total failure . This state of affairs may be considered sometimes as a temporary stage , to be followed by a subsequent tenolysis , but , as a rule , our aim will be to obtain not merely a solid tendon , but a gliding one The gliding apparatus , which plays so essential part in every planning of repairing methods varies at different levels , depending on the amplitude , the direction and the situation of each tendon in relationship to bones and joints in the various anatomical arrangement of the forearm and hand .

Anatomical and Physiological considerations including electron microscopic studies and vascular supply .

# ANATOMY OF FLEXOR TENDONS

The anatomy of the flexor digitorum profundus , flexor digitorum superficialis and flexor pollicis longus muscle-tendon units is an essential prelude to all hand surgeons .

Several tendon zone systems have been described in an effort to clarify and classify flexor tendon injuries based on anatomic and clinical considerations

A modification of Verdan's zone system will be utilized in this article ( Figure 1) , (James W. Strickland )

The flexor digitorum profundus and the flexor digitorum superficialis muscles both give rise to long slim tendons , up to 280 mm in length and from 2- 5 mm in diameter . The tendons in general arise from the muscle mass in multipennate fashion . (C. semple )

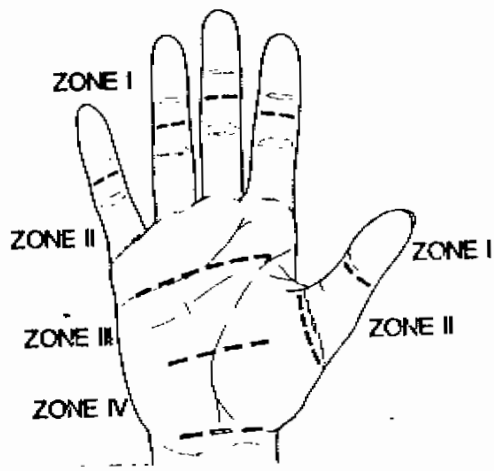


Figure 1. Verdan's zone system for flexor tendon injuries as illustrated . Injuries in Zone II from the proximal edge of the fibrosseous flexor tendon canal to the insertion of the flexor digitorum superficialis have been the most clinically difficult to return to function following flexor tendon interruption .(James W. Strickland , 1983 )

Verdan's zone system :

- Zone 1 is that area of flexor sheath which extends distally from the distal - most termination of the superficialis tendon of insertion on the middle third of the middle phalanx past the insertion of the flexor digitorum profundus tendon on the distal phalanx .

- Zone 2 includes the area commonly reffered to as "no man's land" which extends from the beginning of the fibrous flexor sheath in the area of the distal palmar flexion crease distally to the distal-most termination of the superficialis tendon on the middle third of middle phalanx.

- Zone 3 includes the palm from the distal end of the transverse carpal ligament distally to the commencement of the flexor sheaths at the distal palmar flexion crease .

- Zone 4 encampasses the area of the wrist beneath the transverse carpal ligament contained within the carpal tunnel .

- Zone 5 includes the distal forearm from the musclotendinous junction of the forearm distally to the proximal boundary of the transverse carpal ligement . (J.P.Leddy )(1982).

This zone classification has an important implication in dealing with tendon injuries and dictates the line of management .

The flexor tendons originate from their respective muscle groups in approximately the distal third of the forearm . At this point ,

the more independent superficialis tendons lie anterior to the combined profundus tendon group . A predictable tendon arrangement exists at the wrist where the long and ring finger superficialis tendons lie superficial to those of the index and small fingers , with the profundi oriented posteriorly . The tendons then pair off in the carpal tunnel with the superficialis tendons covering the profundi as they proceed towards their respective digits . In the distal palm , the lumbrical muscles originate from the flexor digitorum profundus tendons , and the tendons then enter the flexor synovial sheath at the level of the neck of the metacarpals .

The amount of flexor tendon motion necessary to produce full flexion at all distal joints is depicted in figure 2.

An understanding of these requirements in achieving functional recovery following tendon interruption . (James W. Strickland ) (1983).

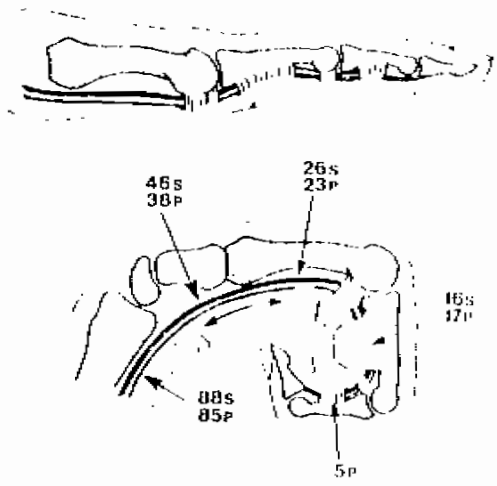


Fig. 2. The flexor tendon motion necessary to produce full flexation of distal joints at the levels of the forearm , wrist , hand , and digit is schematically depicted . Measurements are in mm . p = profundus , s = superficialis (Modified from Verdan.)

Whithin the flexor digital sheath , the flexor digitorum superficialis and flexor digitorum profundus lie juxtaposed as they passed through the fibroosseous canal separated from each other and surrounding canal by a film of synovial fluid . The fibroosseous canal is a closely applied semi-rigid tunnel through which the tendon pass . The fibrous portion of the canal is basically composed of three annular pulleys . The first is at the metacarpophalangeal joint level . It attaches to the junction of the volar plate and the deep transverse intermetacarpal ligament . The second and third pulleys are at the mid portions of the proximal and middle phalanges . Between each annular pulley is a cruciform portion which is more filmy , flexible and overlies each joint . The second and third pulleys are the most important elements of the system . The floor of the fibro-osseous canal is the volar aspect of the phalanges and volar plates of the metacarpals and interphalangeal joints .

The flexor digitorum superficialis enters the fibro-osseous canal volar to the profundus and splits just beyond the first pulley . Each slip rotates 180 degrees as it passes lateral and then dorsal to the profundus . Once dorsal to the profundus , the two slips rejoin and decussate forming Camper's Chiasma , before passing distally to insert at the mid-shaft of the middle phalanx . This creats a sloping ring aperture through which the profundus passes to become superficial to the decussation ( Verdan 1979 ).

Detailed description of the flexor pulley system in the digits and thumb have been provided by Doyle and Blythe (1975) and are probably the most important recent anatomic contribution to the understanding of flexor tendon function . With the exception of the small finger , where a continuous proximal synovial extension exists , the flexor synovial sheath begin at the level of the metacarpal neck and continue as double - walled , hollow synovial tubes with a series of annular and cruciate fibers forming the restraining cylinders that ensure tendon gliding and efficiency . ( James W. Strickland , 1983) (fig. 3).

The clasical description of the sheath is that of Doyle and Blythe (1975) who established the nomenclature of annular and cruciate pulleys .

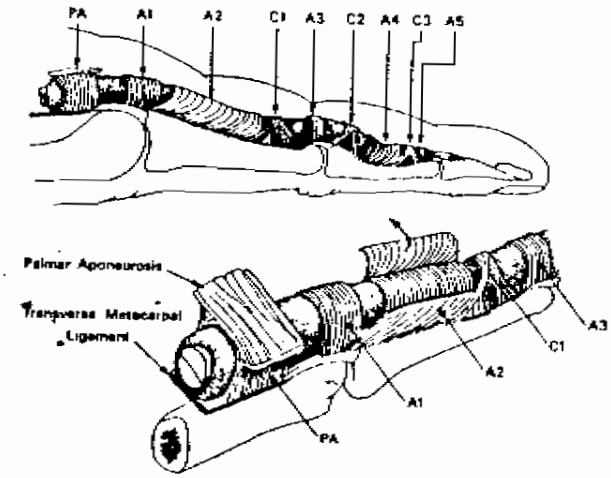


Fig. 3 Composite depiction of the flexor tendon synovial shearth and pulleys including the palmar aponeurosis pulley , five annular pulleys , and three cruciform pulleys .

Anatomical texts (William and Warick 1980 ; Romans 1981) describe a simillar configuration , but emphasis that the fibrous sheath is a continuous structure , which has localised thickening and a synovial lining , rather than a system of discrete pulleys linked by a synovial sheath . Instead of a continuous tube through the interior of the pulleys , the inner aspect of the opened sheath shows that in fact the pulleys are formed within the thin synovial parts and that their thickness causes them to stand proud of their surroundings . These thin parts are not attached to the edges of the pulleys but to their superficial surfaces, thus forming pockets The structural arrangement caused the sheath to fold in a specific manner , so that the thin parts of the sheath moved away from the tendon to avoid interference during flexion . At the proximal interphalangeal joint A3 pulley is at the joint line and the thin part of the sheath runs from the superficial aspect of C1 , A3 and C2 pulleys . There are potential spaces superficial to the thin parts of the sheath which are occupied by the bulging sheath during flexion .

There is a similar mechanism at the metacarpophalangeal joint , the thin parts of the sheath between the A1 and A2 pulley bulges during flexion . The thin parts of the sheath don't bear loads imposed by the tendons , because during flexion , the series of pulleys become approximated to form a continuous surface composed of strong fibrous tissue band. ( A.A.Amis , Marilyn M. Jones, 1988)