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REVIEW

Review of the vascularisation of the human Achilles tendon

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Summary A region of avascularity mid-way along the length of the Achilles tendon has long been associated with rupture. Whilst it is agreed that this region is the location most common to rupture, the exact vascular distribution appears unclear. Regions of avascularity identified within the tendon have included the origin and insertion, as well as the midsection.

This review aims to analyse critically and summarise all previous studies of the vascularisation of the healthy human Achilles tendon, in order to determine the most likely region of avascularity and, thereby establish whether a relationship exists between vascularisation and rupture.

Whilst no definitive conclusion was reached, it was concluded that the vascularisation does affect the tensile strength and so rupture vulnerability of the healthy Achilles tendon, although it is unlikely to be either the sole, or most significant, contributor. Other factors, such as thinning and twisting of the tendon at the midsection are mechanical influences that will increase the incidence of rupture by increasing the concentration of stress.

Contents

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Introduction

The Achilles tendon provides a connective tissue linkage between gastrocnemius and soleus muscles and the os calcis and is a common cause of complaint in athletes,[11,23,39] with injuries such as Achilles peritendinitis. Approximately 7 per 100,000 males experience Achilles tendon rupture[12,25]—typically at the midsection,[8,20,32] which is believed to coincide with a zone of avascularity.[1,9,19,36,40,45]

Whilst many studies have attempted to solve the relationship between the blood supply to the Achilles tendon and the location most vulnerable to rupture,[1,3,4,9,19,36,45] a range of possible theories and solutions has been reported.

Anatomy of the Achilles tendon

Fusing with the gastrocnemius muscle proximally, the Achilles tendon is of a broad, flat shape near its origin. The length of this attachment ranges from 11—26 cm, with the attachment formed by the fusion of the soleus muscle to the anterior surface of gastrocnemius being 3—11 cm in length.[13] The midsection of the tendon is thinner and rounder than its origin, before expanding and attaching to the calcaneus in a shape of a delta.[16]

The Achilles tendon comprises bundles of collagen fibrils, each wrapped in endotenon, which in turn are enveloped by an epitenon. Further protection and stability is provided to the Achilles tendon by the paratenon, a layer of thin, areolar tissue wrapped around the epitenon.[44]

In spanning between the muscle and bone, the fibres of the Achilles tendon spiral by up to 90°,[16,27,40] producing an area of concentrated stress[16]—the extent of this rotation is determined by the position of fusion between the two muscles, with a more distal fusion resulting in more rotation.[16] In twisting, the tendon is being wrung, causing constriction of the vascular networks. Twisting does, however, result in less fibre buckling when the tendon is lax and less deformation of individual strands when under tension, thereby reducing both fibre distortion and inter-fibre friction, so increasing strength.[1]

Stress concentrations are believed to cause avascularity,[31] which in turn is believed to be a factor in tendon rupture,[1,3,4,9,19,36,45] either due to a direct reduction in tendon strength,[10,14,19,24] or by indirectly triggering rupture through events such as degenerative change.[1,30,45] Other authors, however, suggest that there is no correlation between the two.[36]

The location at which rupture is likely to occur is in little doubt, with regions 2—6,[20] 4—7,[32] or 3—5 cm[8] proximal to the calcaneal insertion reported as the most frequent. The aetiology of rupture in this region, however, remains unclear,[5] although investigations suggest that a significant cause of rupture of the Achilles tendon may be repeated microtrauma.[2,26,32,44]

Anatomy of the blood supply

Supplying the length of the Achilles tendon are vessels of the anterior paratenon, deriving from the posterior tibial artery.[1,9,17,36] The peroneal artery, probably through anastomoses with the posterior tibial artery, makes small contributions; the anterior tibial artery appears not to be involved.[1]

Whilst the paratenon is known to be a highly vascular tissue,[9] disagreement exists as to whether the vessels are uniformly distributed throughout its length,[9] or allow for greater blood flow at the site of insertion.[36] It has been reported that the paratenon contributes only 35% of the total supply to the midsection of the rabbit Achilles tendon,[29] implying that the remaining 65% must be supplied through the additional sources that vascularise the tendon insertion and origin. This contrasts with the human Achilles tendon, however, which is thought to be vascularised primarily by the paratenon.

The proximal third of the tendon receives additional blood supply through vessels of the muscle bellies continuing into the endotenon, although this contribution is not believed to be significant.[1,19,21,24,35,45] The distal third of the tendon receives additional vascularisation, the majority of which is supplied by vessels of less than 300 μm in diameter[19] of the rete arteriosum calcaneare, fed by the fibular and posterior tibial arteries. This supply starts at the margin of the insertion, continuing proximally up the endotenon for approximately 2 cm.[1,17,19,24,35,45]

Vascular supply development

Whilst blood flow is known to decrease with age,[4] it has also been shown that the relative blood sup-