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CASE REPORT

Variation of Myotendinous Junction with Muscle's Tensile Strength: A Case Report

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Abstract

Myotendinous Junction is the transition zone between the muscle and its tendon. Hence, it is subjected to immense stress within the muscle. It is hypothesized that muscles used for more stressful actions should have a more arranged myotendinous junction compared to muscles which are used less. Cadaveric specimens of MTJ from Plantaris, Gastrocnemius, Soleus muscles have been observed under the microscope and compared, the results were found to be consistent with the hypothesis.

Key Words: *Myotendinous junction; Gastrocnemius; Plantaris; Soleus*

Introduction

The myotendinous junction (MTJ) is a complex specialized region located at the muscle-tendon interface that represents the primary site of force transmission. It is the region responsible for transmission of contractile force from muscle to tendon. The structural relationship between the cytoskeleton proteins and components of the extracellular matrix is responsible for the transmission of contractile force between the intracellular and extracellular muscle [1]. It consists of muscles and tendons which help in force generation and energetics during human movement [2]. The interaction between muscles and tendons allows effective force utilization and tendon elasticity in performing specific movements [3,4].

In the present study it is thought that the arrangement of the myotendinous junction will depend on the tension generated (on day-to-day basis). MTJ is a discontinuous, heterogeneous area. It is prone to ruptures, MTJ should be made extremely strong and resistant to stress. Aim of the present study is that the MTJ of a highly stressed muscle will be sharper, organized and defined. This should be logical, because as discussed, the muscles undergoing regular tensile stress will have to be more defined to prevent themselves from getting ruptured. Thus, we expect to see a sharp MTJ in a highly used muscle. Whereas the muscles that are more of an accessory in function like Plantaris need not have that much morphological organization. And thus, we expect to see a diffused MTJ in an accessory muscle.

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Methodology

This study was performed in Anatomy Department, AIIMS Rishikesh, India.

The lower limb of a cadaver was dissected and MTJ of three muscles namely- Gastrocnemius (Figure 1a), Plantaris (Figure 1b) and Soleus (Figure 1c) was taken out.

Figure 1) *(a) Gross MTJ of Gastrocnemius, (b) Gross MTJ of Plantaris, (c) Gross MTJ of Soleus.*

The MTJs of each of the muscles were dissected out, processed [5] and stained with both the H and E stain and the Mason Trichrome stain and observed under the microscope.

Results

On examination under the microscope the following results were observed. MF stands for Muscle fiber, T stands for Tendon.

In figure 2, the ends of muscle fibers and tendon were appreciated distinctly. Also, MTJ was clearly demarcated in region between MF and T. The observations were consistent with both the stains. (H and E-Figure 2a; Mason Trichrome-Figure 2b)

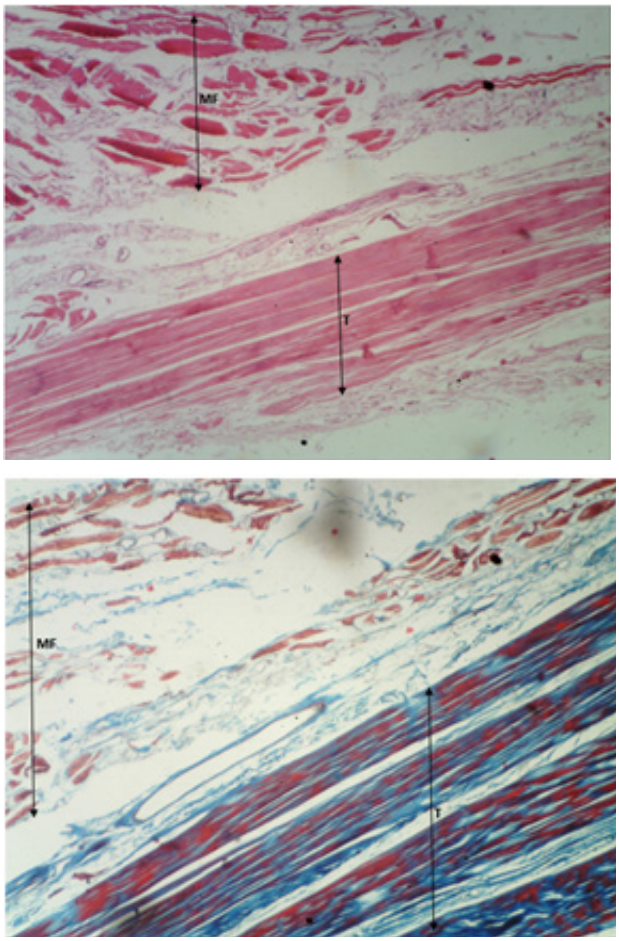


Figure 2) *Soleus - (a) H and E staining of MTJ of Soleus, (b) Mason Trichome staining of MTJ of Soleus.*

In figure 3, the ends of muscle fibers and tendon were not appreciated distinctly. Also, very diffused MTJ was observed in region between to MF and T. The muscle fibers and tendons were visible between each other. The observations were consistent with both the stains. (H and E-figure 3b; Mason Trichrome-figure 3a)

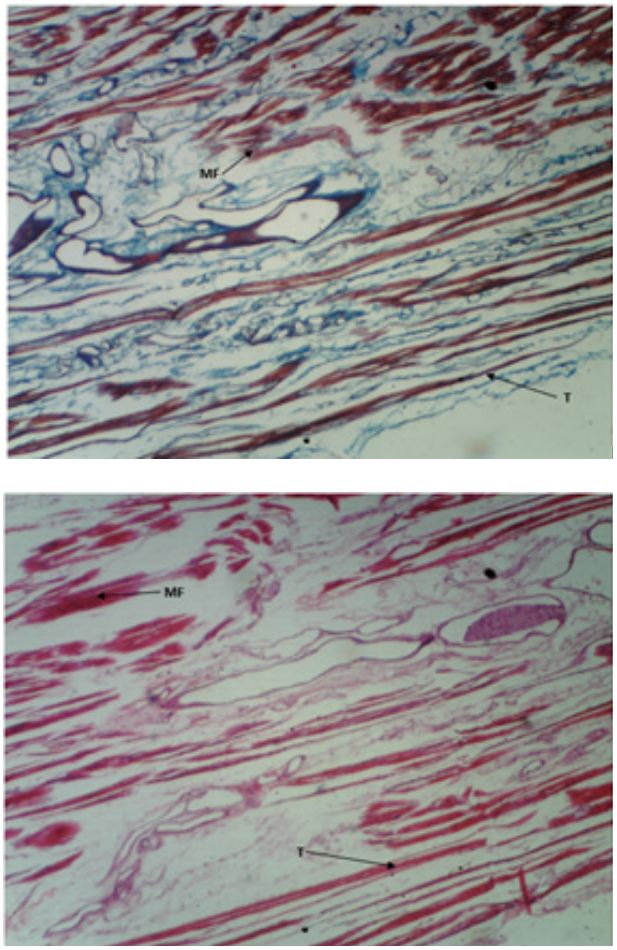
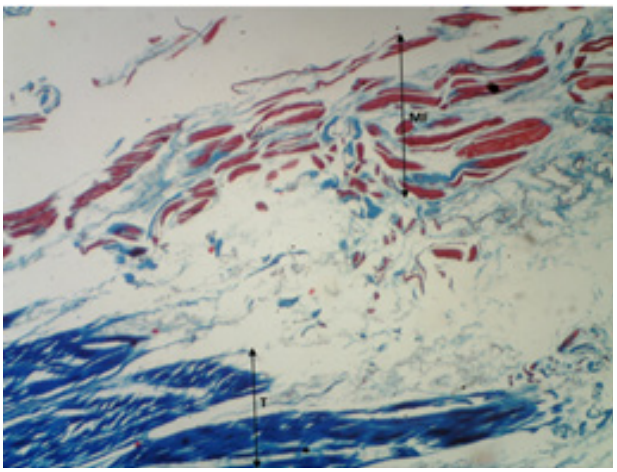


Figure 3) *Plantaris - (a) Mason Trichrome staining of MTJ of Plantaris, (b) H and E staining of MTJ of Plantaris.*

As seen in figure 4, the ends of muscle fibers and tendon were appreciated. Also, the MTJ was more diffused than Soleus but sharper than Plantaris in the region between MF and T.

Very few muscle fibers and collagenous fibers were visible between each other.



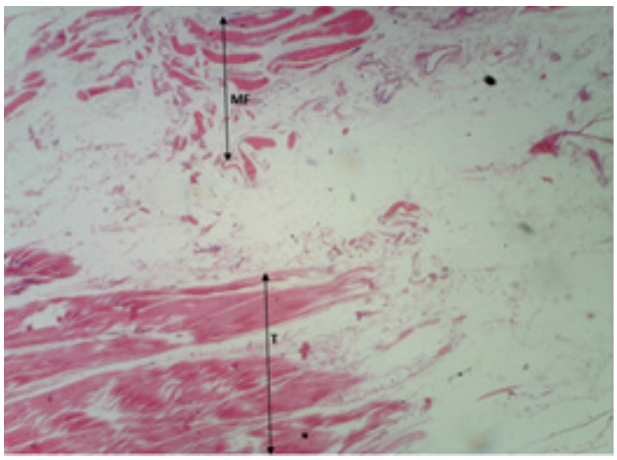


Figure 4) *Gastrocnemius - (a) Mason Trichrome staining of MTJ of Gastrocnemius, (b) H and E staining of MTJ of Gastrocnemius.*

Discussion

Exercise intensities lead to myotendinous junction undergoing certain morphological changes. These changes support the transfer of higher levels of tensile strength [6]. Automatic tracking of MTJ displacement can be seen in ultrasound images if sufficient knowledge about myotendinous junction and tendon tissue is present. The method targets the influence of non-tendinous components on the calculation of affine transform parameters over the effective MTJ region [7]. Chemical and signaling pathways involved in tissue differentiation and morphogenesis can be studied by studying the development of MTJ [8]. It has been concluded that the prevalence of supraspinatus myotendinous junction injuries were 0.47%, mostly in the anterior part of the supraspinatus muscle [9] and Taneja et al established that rotator cuff myotendinous junction injuries affect mostly the infraspinatus and supraspinatus muscles, usually in a strain pattern and not in the region of tendon attachment [10]. Muscle and tendon have different embryological origins, but morphogenesis occurs in close spatial and temporal associations [1].

For amplifying the interactions between muscle and tendon, the MTJ is arranged in a

fingerlike pattern where the tendon processes penetrate the muscle mass. The plasticity of the myotendinous junction, which appear at the morphological, structural, and functional levels, is due to different physiological and pathological stress [11]. Knudsen et al observed that the tendon made ridge-like protrusions, which interdigitated with groove-like indentations in the muscle cell [12]. Finger-like processes help in the transmission of muscle contraction force to the tendon. Intracellularly, muscle failure is seen just proximal to the structurally defined MTJ, in the muscle cell body and not in the MTJ [1]. The peak torque after static stretching is related to decrease in the muscle-tendon unit (MTU), muscle and tendon stiffness [13]. The ballistic stretching training program did not affect contractile elements and connective tissues (endomysium, perimysium, and epimysium). Also, the measurements of fascicle length and pennation angle during the range of motion (RoM) remained unchanged. A 6-wk ballistic stretching training program of the lower-leg muscle increases dorsiflexion RoM but does not affect muscle and tendon tissue [14]. During a concentric contraction, involvement of the tendon depends on the range of motion used for the analysis [15]. The pathological and clinical variability was found to accompany the same genetic mutation, hence having a significant role for modifier genes in distal myopathy (MPD1) pathogenesis [16]. MRI can detect infraspinatus tear at the level of MTJ. Isolated infraspinatus damage at the MTJ can be detected by ultrasound too. Ultrasound can detect rupture of the main tendon skeleton which is in the main body of the muscle. USG studies need to be considered in patients with rotator cuff tendon disease [17].

This case shows that the muscle-tendon junction arrangement is related to the tensile strength. Soleus, the muscle which is responsible for maximum tensile strength has a sharp and well-developed muscle-tendon junction. Whereas Plantaris, which is a spare muscle (lowest tensile strength) has a diffusely arranged muscle tendon junction. Gastrocnemius, which has intermediate tensile strength, has its level of muscle-tendon junction arrangement between the other two.

Conclusion

It can be stated that the proposed hypothesis and the results observed are congruent. Thus, we can establish the fact that the organization of the MTJ depends on the usage of a muscle. The more used muscle tensile strength will have a sharper MTJ, and the less used muscle will have a diffused MTJ. Thus, it can be concluded that arrangement of the muscle-tendon junction is dependent on the tensile strength it produces. This case will be useful to study sports injuries and normal muscle physiology.

Limitations

MTJ is a complete structure which needs electron microscope and other molecular level study for its complete analysis. This study is limited to the gross findings due to lack of higher technology and expertise available in the place of study. Also, very few studies were carried out in this field hence this study will stimulate much research work like similar study in athletes and non-athletes.

Clinical Significance

The study can be helpful for sports injuries and studying normal muscle physiology. This may also be helpful for further studies.

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