

Quantitative Differences in Fibrocartilage at the Epiphyseal Attachment of Quadriceps Tendon and Semimembranosus Tendon of Man

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Abstract

Objective: To determine the width of zone of fibrocartilage at the epiphysal insertion of tendons of quadriceps and semimembranosus muscles to facilitate in the understanding of arthro-mechanics of knee joint. **Study Design:** It was cross-sectional comparative study. **Place and duration of study:** The study was conducted in the Anatomy department at Rawalpindi medical college Rawalpindi from January 2011 to July 2011. **Results:** All tendons were obtained from autopsy room of DHQ hospital Rawalpindi. The specimens were taken from deceased not beyond 40 years of age. The study was divided into two major groups. Group A included 15 sets of quadriceps tendon. Group B included 15 sets of semimembranosus tendon. The groups were studied for width of zones

of fibro cartilage. There were pronounced quantitative differences between the attachments of these two tendons. There was significantly more fibro cartilage at the attachment of quadriceps tendon than at semimembranosus. **Conclusion:** The present study suggested that there was striking differences in the width of zone of fibrocartilage at the distal epiphysal attachment sites of quadriceps tendon and semimembranosus tendon. Fibrocartilage is comprised of uncalcified and calcified fibrocartilage. Both are separated by tidemark. Uncalcified fibrocartilage is greater in quadriceps tendon than semimembranosus reflecting the greater range of movement at this site. The amount of calcified fibrocartilage in quadriceps tendon exceed than semimembranosus due to maximum force and greater cross-sectional area.

INTRODUCTION

Enthesis is the point of insertion of tendon, ligament, joint capsule and fascia to the bone.¹ Enthesis are either fibrous or fibrocartilage-nous.^{2,3} In fibrous enthuses, dense connective tissue links the tendon or ligament to the bone. These are common at the diaphysis of bone. Fibrocartilaginous entheses predominate at the epiphyses of the long bone.^{4,5} There is transitional zone of fibrocartilage at bone tendon interface. Much of literature on the histology of epiphyseal tendon attachment is provided by Germans. They mentioned its four zones (1) tendon, (2) uncalcified fibrocartilage, (3) calcified fibrocartilage; and (4) bone.^{6,7} Later on it was shown that each of the zones has different characteristics.^{8,9} It has been also found that where more movement permitted at soft / hard tissue interface, there is more uncalcified fibrocartilage.^{10,11} And where more force is transmitted to

bone, there is more calcified fibrocartilage.^{12,13} The layers of calcified and uncalcified fibrocartilages at an entheses are separated by a calcification front that is more commonly called tidemark,¹⁴ although a tidemark separates calcified from uncalcified fibro-cartilage, collagen fibers in two regions are continuous.^{15,16} The enthuses fibrocartilage is also a site of pathological changes during ankylosis spondylitis and spondyloarthropathies.

In the present study we compared the fibrocartilage at the insertion of tendon of quadriceps and semimembranosus on mobility and force transmitted to the bone. The mobility of soft / hard tissue interface is greatest at the insertion of quadriceps tendon as this muscle is sole extensor of the knee joint. The force transmitted by quadriceps tendon also exceeds than semimembranosus tendon, which is one of many flexor

of knee joint. The relevant literature especially regarding the mechanisms of semimembranosus muscle is scarcely available.

MATERIAL AND METHODS

The right sided distal attachment of quadriceps tendon on patella and semimembranosus tendon into tibia were removed from 15 male cadavers at autopsy room DHQ hospital within 24 hours of death. Only the specimens with all the structure in and around the knee joint exhibiting absence of gross pathological changes were included. Each specimen was comprised of portion of both tendon and bone. Tissues of approximately 3mm thick were cut from central portion of attachment zone of quadriceps tendon and semimembranosus tendon. These were grouped as A & B respectively. Tissues were fixed in 10% neutral buffered formalin, decalcified in 2% nitric acid, dehydrated with graded alcohols, cleared in inhibisol and embedded in paramat. Three sections were cut after every 500µm distance along the long axis of tendon throughout the block and stained with hematoxylin and eosin. The width of uncalcified fibrocartilage, calcified fibrocartilage and total fibrocartilage was measured. The ratio of uncalcified fibrocartilage and calcified fibrocartilage was determined. Statistical comparisons were made with ANOVA and Tukey's HSD Test.

RESULTS

There were striking differences between the quantities of uncalcified fibrocartilage, calcified fibrocartilage and total fibrocartilage at insertion of quadriceps tendon and semimembranosus tendon (Table 1).

Table-1
Average width of zones of fibrocartilage with standard deviation in Groups A & B.

Groups	Group A		Group B	
	Mean (µm)	SD	Mean (µm)	SD
Uncalcified Fibrocartilage	2.252	0.22240	0.856	0.156
Calcified fibrocartilage	1.77	0.4556	0.503	0.166
Total fibrocartilage	3.80	0.81	1.35	0.307
Mean ± SD	2.606	1.005	0.906	0.41546

Figure-1
Photomicrograph of epiphysis at quadriceps tendon insertion into patella, showing four zones: X100, H&E stain.

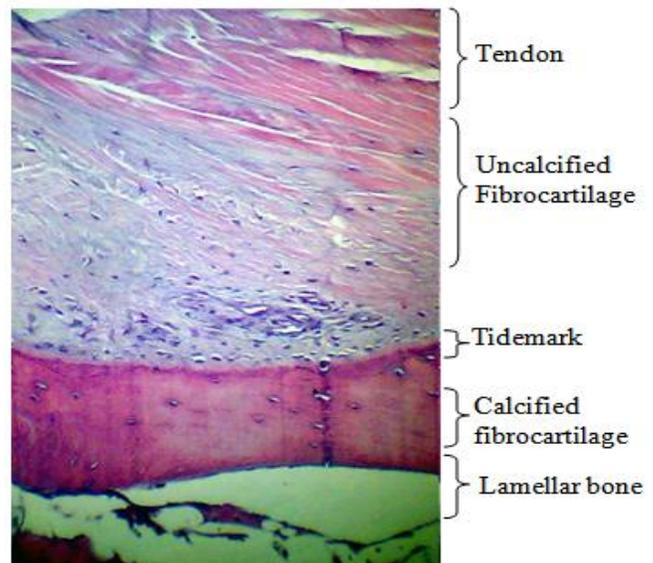
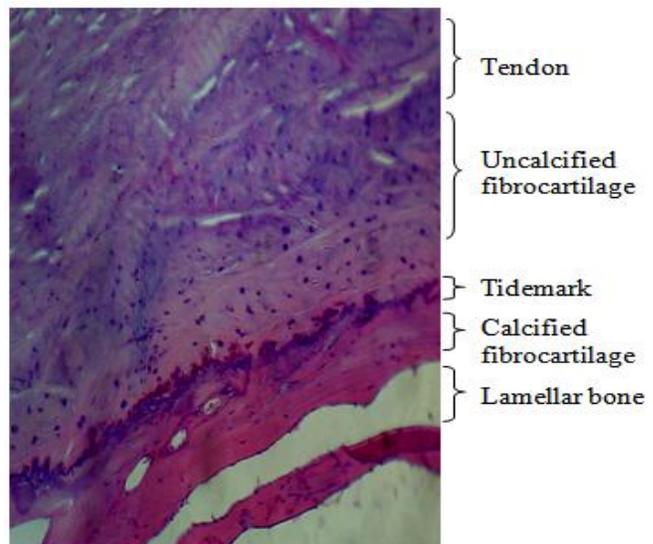


Figure-2
Photomicrograph of epiphysis at semimembranosus insertion into tibia showing four zones, X100, H&E stain



The width of zone of uncalcified fibrocartilage was significantly greater in quadriceps, (Mean value $2.25 \pm 0.22 \mu\text{m}$) than semimembranosus tendon (Mean value $0.856 \pm 0.156 \mu\text{m}$) as shown in figure 3. The width of zone of calcified fibrocartilage was greater in

quadriceps tendon (Mean value $1.77 \pm 0.455 \mu\text{m}$) than semimembranosus tendon ($0.503 \pm 0.166 \mu\text{m}$) as shown in figure 4. The total width of zone of fibrocartilage in quadriceps tendon (Mean value $2.606 \pm 1.005 \mu\text{m}$) was greater than semimembranosus (Mean value $0.906 \pm 0.415 \mu\text{m}$) as shown in figure 5. The ratio of uncalcified and calcified fibrocartilage was less (1.277) in quadriceps while it was more (1.77) in semimembranosus tendon as shown in table 2. This signifies that width of calcified fibrocartilage as compared to uncalcified has decreased in semimembranosus. This change is due to weak power and less range of movement of this tendon.

Figure-3
Figure showing the mean & standard deviation of uncalcified fibrocartilage in groups A & B.

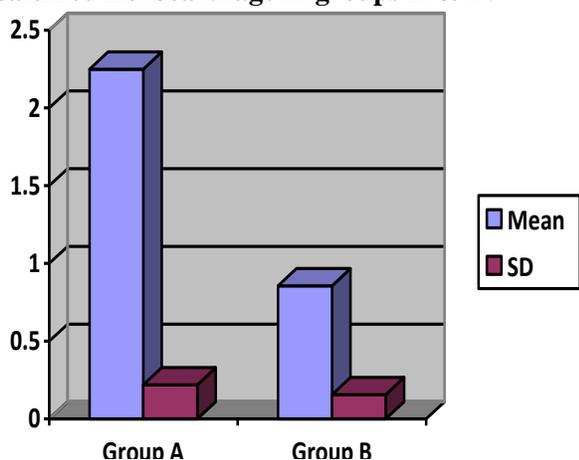


Figure-4
Figure showing the mean and standard deviation of calcified fibrocartilage in groups A & B.

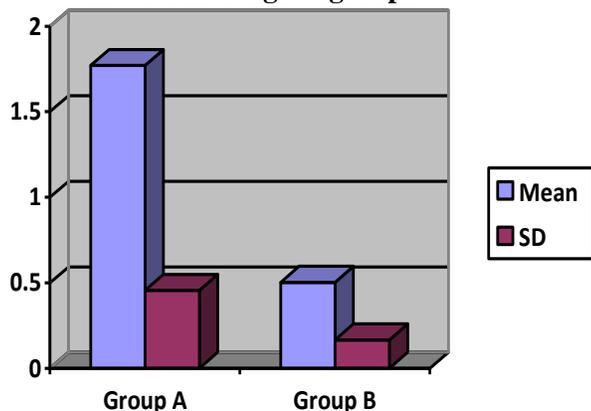


Figure-5
Figure showing the mean and standard deviation of total fibrocartilage in groups A & B.

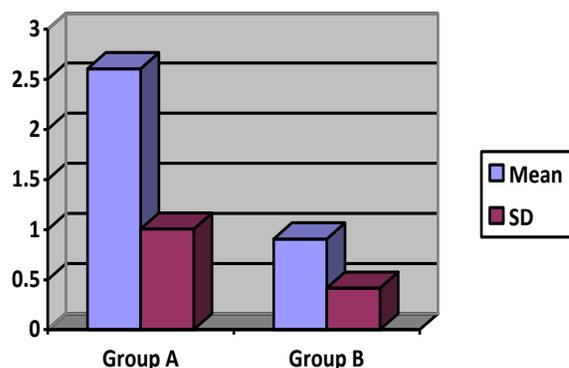


Table-2
Ratio of uncalcified and calcified fibrocartilage in groups A & B.

Groups	Mean width of Uncalcified fibrocartilage (μm)	Mean width of calcified fibrocartilage (μm)	Ratio of uncalcified and calcified fibrocartilage
A	2.252	1.77	1.27
B	0.85	0.5	1.7

STATISTICAL ANALYSIS

The statistical analysis was carried out using computer software, statistical package for social sciences (SPSS) version 16.0. The arithmetic mean of observations and standard error of the means were calculated. The two ways analysis of variance (ANOVA) was used to analyze the significant difference between two groups A & B and the two levels of total fibrocartilage i.e. calcified and uncalcified fibrocartilage. The difference was regarded significant if the p-value was equal to or less than 0.05.

The above test was followed by multiple comparison test i.e. Tukey's HSD test between each two groups for total fibrocartilage, uncalcified fibrocartilage and calcified fibrocartilage.

DISCUSSION

The present study clearly demonstrated that a zone of fibrocartilage was present in both quadriceps tendon

and semimembranosus tendon. The results showed striking differences in the width of zone of fibrocartilage at these insertional sites. The fibrocartilage comprised of both uncalcified and calcified zone^{3,5,6}. Both were separated by tidemark^{14,10}. The greatest quantity of uncalcified fibrocartilage was in quadriceps tendon as more movement was permitted here. The quadriceps tendon was sole extensor of knee joint. The insertion of semimembranosus has less uncalcified fibrocartilage as this tendon is one of many flexors of knee joint and less movement is permitted here. So, the width of zone of uncalcified has decreased in semimembranosus tendon. The greatest amount of calcified fibrocartilage was at the insertion of quadriceps tendon. It was this site which subjected to great force.

The present results suggested that the semimembranosus exerted less force (being weak flexor), so less calcified fibrocartilage was registered. The width of zone of calcified fibrocartilage was significantly greater in quadriceps tendon as large force is transmitted by this tendon. Thus, there was a good correlation between the distribution of fibrocartilage within an enthesis and levels of compressive stress.

CONCLUSION

The results of this study suggest that there are striking differences in the width of zone of fibrocartilage at the epiphyseal attachments sites of quadriceps and semimembranosus tendon. The fibrocartilage has characteristic features of sites where the angle of attachment changes throughout the range of joint movement and it reduces wear and tear by dissipating stress concentration at the bony interface.

The present work has also depicted histological differences in the width of zone of fibrocartilage between sole extensor quadriceps tendon and one of many flexors (semimembranosus) of knee joint. Finding in our study suggests that extensor has more fibrocartilage as compared to flexor, as they exert more force at bony interface.

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