Fibrocartilage in Extensor Tendon and in Ligament of Human Knee Joint

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Abstract
Background: To compare distal epiphyseal attachments of quadriceps tendon and patellar ligament by routine histology in view of their role as mechanical barrier and primary pathological site for spondyloarthopathies.

Methods: Twenty autopsy specimens were collected. Strips were taken from central portion of attachment zones of quadriceps tendon and patellar ligament. It was confirmed in all cases that knee joints were devoid of gross pathological changes. After fixation, dehydration and processing sections were cut at 500µm interval along the long axis of the tendon and ligament. The widths of zones of uncalfied, calcified and total fibrocartilages were calculated.

Results: There were four zones at the attachment sites. These included tendon, uncalfied fibrocartilage, calcified fibrocartilage and bone. There were marked differences in quantities of fibrocartilage between quadriceps tendon and patellar ligament insertion.

Conclusion: The width of zone of fibrocartilage was greater in quadriceps tendon than patellar ligament. As quadriceps tendon is strong extensor with greater mobility and patellar ligament is also extensor of knee joint, so fibrocartilage is more in quadriceps tendon than patellar ligament.

Key Words: Epiphysis, quadriceps tendon patellar ligament.

Introduction
General features of attachment zones of tendons, ligaments and related structures are well known. These include pure ligament or tendon, uncalfied fibrocartilage, calcified fibrocartilage and bone. Zones of uncalfied fibrocartilage and calcified fibrocartilage are collectively called enthesis fibrocartilage that was observed to be most conspicuous where tendons/ligament pressed predominantly against the epiphysis of bone. Such fibrocartilage has mechanical role to diffuse the forces over the entire attachment zone. It was also stated that during joint movements, there was more change in the angle at the insertion of tendons and ligaments. This enthesis fibro-cartilage is also the site of pathological changes in ankylosing spondylitis and spondyloarthopathies. Zone of fibrocartilage is also a characteristic feature of ligaments and tendons crossing the joint. Enthesis fibrocartilage reduces wear and tear and forms one of the protective devices. The zones of uncalfied fibrocartilage and calcified fibrocartilage are separated by basophilic line that is called tidemark. This tidemark is smooth at sites with much uncalfied fibrocartilage. In the present study we compared the fibrocartilage at the insertions of quadriceps and patellar ligament depending on mobility and force transmitted by these to bone. As quadriceps tendon is strong extensor, it transmits more force and has more mobility compared with the patellar ligament.

Material and Methods
The specimens of distal attachment of quadriceps tendon on patella and patellar ligament on tibia were collected from twenty cadavers of adult males but not beyond 40 years from DHQ Hospital, Rawalpindi. The specimens were collected within 24 hours of death. Only the specimens with all the structures in and around the knee joint exhibiting absence of gross pathological changes were included in this study. Each specimen was composed of portion of both tendon and bone. Pieces of approximately 3mm thick were cut from central portion of the attachments zone of quadriceps tendon and patellar ligament. These were grouped as A and B respectively. The tissues of both groups were fixed in 10% neutral buffered formalin saline for 36 hours and decalcified in 2% nitric acid till the decalcification is completed. The end point of decalcification was determined by palpation method. Tissues were dehydrated in graded alcohol, cleared in inhibisol and embedded in paramat. Sections were cut at every 500µm interval along the axis of the tendon and stained with hematoxylin and eosin. The width of uncalfied fibrocartilage and calcified fibrocartilage was measured with the help of ocular micrometer. The arithmetic mean of observations and standard error of the means were calculated. The two ways analysis of
variance (ANOVA) was used to analyse the significant difference between two groups A & B and the two types 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 two groups for total fibrocartilage, uncalcified fibrocartilage and calcified fibrocartilage.

**Results**

There were marked histological differences in the widths of zone of total fibrocartilage, uncalcified fibrocartilage and calcified fibrocartilage at the distal attachment of quadriceps tendon and patellar ligament(Table I,Figure 1&2). The width of zones of uncalcified fibrocartilage was maximum in quadriceps tendon (mean value $2.252 \pm 0.22240 \mu m$. The p value was less than 0.05. It exceeded the width of zone of uncalcified fibrocartilage in patellar ligament (mean value $1.408 \pm 0.149 \mu m$(Table 2).

**Table 1: Fibrocartilage width of the distal attachment of quadriceps tendon and patellar ligament**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Uncalcified Fibrocartilage</td>
<td>2.252</td>
<td>0.222</td>
</tr>
<tr>
<td>Calcified fibrocartilage</td>
<td>1.77</td>
<td>0.455</td>
</tr>
<tr>
<td>Total fibrocartilage</td>
<td>4.002</td>
<td>0.677</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>2.011</td>
<td>0.338</td>
</tr>
</tbody>
</table>

**Table 2: Mean width of zones of fibrocartilage in group A and B**

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncalcified fibrocartilage</td>
<td>2.252±0.22</td>
<td>1.408±0.149</td>
</tr>
<tr>
<td>Calcified fibrocartilage</td>
<td>1.77±0.455</td>
<td>1.090±0.139</td>
</tr>
<tr>
<td>Total fibrocartilage</td>
<td>4.002±0.677</td>
<td>2.498±0.288</td>
</tr>
</tbody>
</table>

**Table 3: Multiple comparison test i.e Tukey's HSD on Total fibrocartilage**

<table>
<thead>
<tr>
<th>Source</th>
<th>Groups comparison</th>
<th>Mean difference</th>
<th>Std. error</th>
<th>p.value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncalcified Fibrocartilage</td>
<td>Group A</td>
<td>1.39533</td>
<td>0.06549</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>0.55133</td>
<td>0.06549</td>
<td>.000</td>
</tr>
<tr>
<td>Calcified fibrocartilage</td>
<td>Group A</td>
<td>1.26667</td>
<td>0.06908</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>0.58733</td>
<td>0.06908</td>
<td>.000</td>
</tr>
<tr>
<td>Total Fibrocartilage</td>
<td>Group A</td>
<td>1.33100</td>
<td>0.06941</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>0.56933</td>
<td>0.06941</td>
<td>.000</td>
</tr>
</tbody>
</table>

The mean difference is significant at the 0.05 level.
The width of zone of calcified fibrocartilage in patellar ligament (1.0901 ± 0.139) μm was less than quadriceps tendon (1.77 ± 0.455) μm. The total width of zone of fibrocartilage was greater in quadriceps tendon (4.002 ± 0.677) μm than patellar ligament 2.498 μm ± 0.288 (Table 2). The mean difference was significant at 0.05 level (applying ANOVA and Tukey’s HSD test) (Table 3).

Discussion

The word enthesis has been in use since 19th century. It is also called insertional complex. It is regarded enthesis as being either fibrous or fibrocartilagenous depending upon the nature of tissue at the tendon-ligament bone interface. The fibrous enthesis are usually present where tendon-ligament attachment to diaphysis or metaphysis of a long bone. It equates to diaphyseal-periosteal attachment of Beirman. The fibrous enthesis can be further subclassified into bony or periosteal, to indicate whether the tendon inserts directly into the bone or indirectly into it via periosteum. Fibrocartilagenous enthesis are more common than the fibrous. This insertional complex includes four zones: tendon, uncalcified fibrocartilage, calcified fibrocartilage and bone itself. The chondral insertions are common at the epiphysis of bone.

The present study suggested that there were striking differences in the width of zone of fibrocartilage at the epiphyseal attachment sites of quadriceps tendon and patellar ligament. The fibrocartilage has characteristic of sites where the angle of attachment changes through the range of joint movement and it reduces wear and tear by dissipating stress concentration at bone-tendon interface.

Fibrocartilage comprised of both un-calciﬁed and calcified zone. Both were separated by tidemark. The uncalcified fibrocartilage was greater in quadriceps tendon than patellar ligament as more movement was permitted here. The amount of fibrocartilage in quadriceps tendon exceeded than patellar ligament due to maximum force and great cross sectional area required at this insertion site. There was good correlation between the distribution of fibrocartilage within an enthesis, movement and force.

Conclusion

1. The width of zone of fibrocartilage was greater in quadriceps tendon than patellar ligament.
2. As quadriceps tendon is strong extensor with greater mobility and patellar ligament is also extensor of knee joint, so fibrocartilage is more in quadriceps tendon than patellar ligament.

References

3. Lane LB and Bullough PG. Age-related changes in the thickness of the calcified zone and the number of tidemarks in adult human cartilage. J Bone Jt Surg 1980;62B:372-75.

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