The histological influence to periosteum under the tibial tuberosity by increase of mechanical load with aging in rats

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【Summary】

The quadriceps are embedded in the tibial tuberosity, and tibial tuberosity is pulled strong when there is contraction of quadriceps. Therefore, it is thought that the increase of mechanical stress with aging is not only structure for enthesis, but also the influence to the periosteum. Here we were aimed to examine that the increase of mechanical stress with aging influences the periosteum under the tibial tuberosity in rats from the viewpoint of histology. This study used to 3, 7 and 13 weeks-old rats (3W, 7W and 13W, respectively). In each group, calcification of the shallow area in tibial tuberosity was observed, and was confirmed under its tissue. Furthermore, the structure of the lower portion in tibial tuberosity was smooth for 3W. In addition, the connection zone in the lower portion of tibial tuberosity to the periosteum was rough with aging. In the previous

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study, the structure of enthesis was changed an increase or decrease of mechanical stress, and patella tendon fiber was embedded in the periosteum. Therefore, it is thought that in the contraction of quadriceps to the periosteum, mechanical loading with aging is influences the aging of the tibial tuberosity and periosteum connective zone. In conclusion, it is thought that the increase of mechanical loading with aging changes the structure of the connective zone because of resistance by quadriceps contraction.

Keywords: Tibial tuberosity, Periosteum, Enthesis

【Background and purpose】

Osgood-Schlatter disease is known as the sports injury of the tibial tuberosity during theof growing period[1]. The other theories reported that Osgood-Schlatter disease mostly occurs by the movement of the knee joint with sports activity. Moreover, it is thought that Osgood-Schlatter disease can occur, by the overuse of repetitive movement at the knee joint[2-5].

The tibial tuberosity is embedded through the patella tendon from the quadriceps for the extension of the knee joint. In the previous report, it was reported that for the tibial tuberosity constructed by fibrocartilage and hyaline cartilage[6]. In addition, we are shown that the tibial tuberosity was embedded in patella tendon fibers, its fibers calcified area (shallow area) and the hyaline cartilage of non-calcification area (deep area) can discerned. Furthermore, the tibial tuberosity in rats has clearly shown that its tissue is calcified and ossified with aging. Most importantly, the chondrocyte of the deep are in a growth period rat has shown the small type of chondrocyte, so its cell has proliferation potential. From this fact, it is guessed that the deep area of the tibial tuberosity increases its size with aging. From these reports, the histological function of the deep area in the tibial tuberosity has already been made clear. However, its function in the shallow area is not clear.

The fibrocartilage is characterized by the fibers embedded in hyaline cartilage[7], which are calcified around the cartilage matrix [8]. Moreover, plenty of proteoglycan existed in the cartilage matrix around theby chondrocyte plentifully existed in the for proteoglycan, but the fibrocartilage is mostly not contained[9]. On the other hand, the calcification fibers in the shallow area are pierced to the periosteum under the its portion. Furthermore, the rule of muscles-tendon insertions (enthesis) has been known to be broken for mechanical stress[10]. Therefore, it is thought that the increase of mechanical stress with aging is not

only structure for enthesis, but also the influence to the periosteum. However, no one knows whether histological changes in enthesis and periosteum by increase of mechanical stress.

Here we were aimed to examine that the increase of mechanical stress with aging is influenced to the periosteum under the tibial tuberosity in rats from viewpoint to histology.

【Materials and Methods】

・Animals

In this study used to 3, 7 and 13 weeks-old rats (3W, 7W and 13W, respectively), these rats were made by euthanasia. Thereafter, we were made a variety of specimens.

・Non-decalcification grinding specimen in GMA resin

The tibial tuberosities were sectioned for 3 μ after embedding in GMA resin, and specimens were stained by toluidine blue.

【Results】

Each group was observed to shallow area in tibial tuberosity, and under the its tissue was confirmed at the periosteum. (Fig.1) Furthermore, the structure of lower portion in tibial tuberosity was smooth for 3W. in addition, the lower portion in tibial tuberosity to periosteum connective zone was rough with aging.

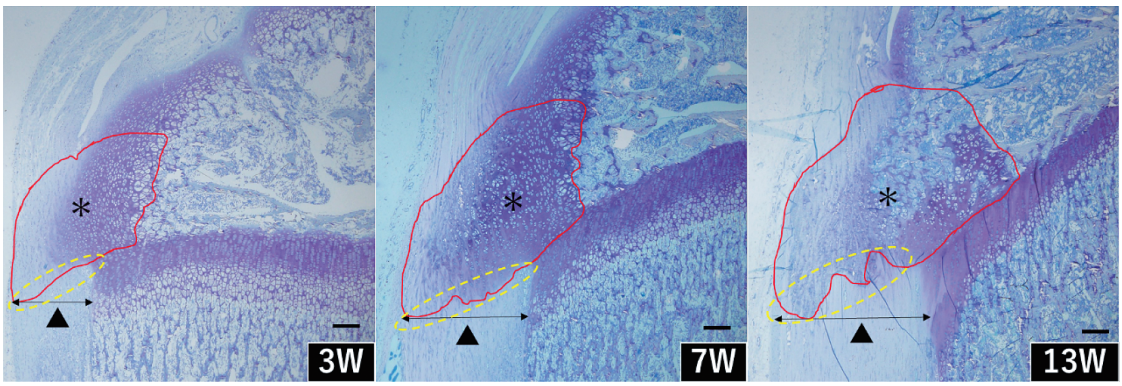

Fig.1 The different of tibial tuberosity to periosteum connective zone in each group
＊…tibial tuberosity ▲…Periosteum yellow circle…connective zone

The Connective zone in 3W was observed to smooth condition, and same portion was changed to rough with aging.

【Discussion】

We have already discovered that the tibial tuberosity can separated the shallow and deep area for condition of calcification [6]. Moreover, the tibial tuberosity has reported by Badi's theory that its tissue is structured the fibrocartilage and hyaline cartilage [11]. From the same structures also the tibial tuberosity in this study, we can lead to supported the previous study. On the other hand, like a shallow area of the tibial tuberosity, the embedding portion for muscles, tendons or ligaments in cartilage or bone tissue is called "enthesis" [12-15]. The enthesis has separated for two types from the function of histology, "Fibulous type" and "Fibrocartilaginous type" [10,16]. Bony type is observed the embedding portion by muscles or tendon fibers to diaphysis, and its fiber is embedded in bone tissue. In contrast, Fibrocartilaginous type is characterized by the insertion to epiphysis or cartilage, and the embedding in the order of non-calcification fibrocartilage portion, calcification fibrocartilage portion, bone tissue (for example, supraspinatus-greater tubercle). From these facts, the enthesis is different for enthesis type by interjacent tissues when the fibers insertion. The tibial tuberosity is confirmed by the calcification fibrocartilage portion upper the shallow area. In this fact, the enthesis type of tibial tuberosity makes it reasonable to suppose that the fibrocartilaginous type from structural insertion. The enthesis has proved that it area changes by increase or decrease of mechanical stress. On the other hand, the periosteum was connected the patella tendon fiber from the upper of tibial tuberosity, and the structure of connective portion was changed to rough condition from smooth condition with aging. Also this result, it may be deduced from the increase of mechanical stress. In fact, the connective portion of different tissues like a muscles-tendon portion was connected to the rough condition, its condition changing to smooth connective by decrease of mechanical stress.

The structural characteristic was suggested that the calcification of lower portion in tibial tuberosity occurred the same structural changes to the periosteum connective zone. Therefore, it was suggested that the lower portion of tibial tuberosity at the periosteum was influenced by the both connective portion by mechanical stress.

【Conclusion】

It was understood that tibial tuberosity to the periosteum connective cone was influenced the structure of connection by mechanical stress.

【Committee of Animal Experiment and Ethics】

This study was approved by Committee of Animal Experiment and Ethics for the research, Graduate School of Graduate School of Human Life Design, Toyo Univ.

【Acknowledgements】

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発育に伴うメカニカルストレスの増加が ラット脛骨粗面下方の骨膜に及ぼす組織学的な影響

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要旨

【背景】脛骨粗面には大腿四頭筋が埋入し、同筋の収縮は脛骨粗面を強く牽引する。また、脛骨粗面の下方には脛骨前縁の厚い骨膜があり、大腿四頭筋は脛骨粗面を貫き、骨膜にまで埋入していることから、大腿四頭筋の収縮によって脛骨粗面のみならず骨膜も牽引される。一方で、発育に伴う機械的刺激の増加は脛骨粗面の組織構造に影響を及ぼすことがすでに明らかにされている。しかし、その機械的刺激の増加が脛骨粗面下方にある骨膜の組織構造に及ぼす影響について明らかにされていない。

【目的】本研究は、発育に伴う荷重の増加がラット脛骨粗面の下方にある骨膜の組織構造に及ぼす影響について明らかにすることを目的とした。

【材料および方法】３週齢、７週齢、１３週齢のwistar系雄性ラットを用い、炭酸ガスによって安楽死させた後、脛骨を摘出し、その構造を観察した。

【結果】脛骨粗面と骨膜の結合部に着目すると、発育初期では平滑に結合していたが、発育後期ではその部位の結合様式が粗造に観察された。

【考察】硬組織の中に筋や腱の線維が埋入される構造は広義的にenthesisとして認知されている。この構造の特徴は、機械的刺激の増減に応答することである。骨膜には大腿四頭筋からなる膝蓋靭帯の線維が埋入している。したがって、発育に伴う荷重の増加によって脛骨粗面の結合部の接着面積を増やすようにその構造が粗く変化したと考えられる。

【結論】脛骨粗面結合部の組織構造は、発育に伴う荷重の増加に応答し、その組織構造を変化させることが理解された。

キーワード：脛骨粗面、骨膜、筋腱埋入部