

学位論文の要旨

氏名 深澤郁雄

学位論文名 Development of the Meniscus of Knee Joint in Human Fetuses

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著者名 Ikuo Fukazawa, Toshihisa Hatta, Yuji Uchio,
Hiroki Otani

論文内容の要旨

INTRODUCTION

The meniscus of knee joint is composed of fibrous cartilage and contributes to the static stability of the knee joint in the standing position as well as to the dynamic stability during the extension and flexion of the knee joint. Given the important roles of the meniscus in the joint stability, resection area in the surgical treatment should be determined carefully. Among the knee joint abnormalities, discoid meniscus, which induces snapping and/or locking of the knee joint in young ages sometimes with indications for surgical treatments, is diagnosed by the characteristic morphology. It has been known that the incidence of discoid meniscus is higher in the lateral meniscus than in the medial meniscus. The shape of the lateral meniscus varies more widely than that of the medial meniscus, which may be involved in the pathogenesis of discoid meniscus.

To clarify the possible developmental origin of the etiology, sequential observations and quantitative analyses of normal development of the knee joint morphology in the

prenatal periods are thus necessary, however, such studies have been limited in human fetuses. In the present study, we analyzed the morphological changes of meniscus and tibial plateau quantitatively and histologically in human fetuses and adults.

MATERIALS AND METHODS

Forty-one externally normal human fetuses were used in the present study. They range from 14 to 30 weeks of gestation (88 to 249 mm in the crown-rump length (CRL)). The smallest fetus of CRL 88 mm (14 weeks of gestation) was used only for histological analyses. Fourteen adult specimens ranging from 56 to 91 years old were collected from the cadavers used in the dissection practice of anatomy for medical students in Shimane University. The fetuses were fixed in 10% formalin by immersion. Adult specimens were fixed with 10% formalin by perfusion for several hours, then by immersion.

The left knee joint cavities were opened by making the incision of capsule along the medial margin of patella for the macroscopic observation and quantitative analyses. The articular surface of tibia and menisci were photographed, and each area was measured by Scion Image. We applied the circularity analysis to access the discoid-shape of the meniscus, and the circularity index was expressed by the following formula.

$$\text{Circularity} = 4 \pi (\text{area/perimeter}^2)$$

Bivariate scattgrams were created for measured parameters and correlations between parameters were analyzed by Fisher's r to z analysis with fitting the simple regressions.

The right knee joints of seven fetuses were dissected out without opening the joint cavities and embedded in paraffin. Serial 10- μ m-thick coronal sections were prepared, stained by hematoxylin-eosin, and observed under the light microscope.

RESULTS AND DISCUSSION

The lateral meniscus was oval-shaped and covered the most part of the lateral tibial plateau in all fetuses. The occupied area of the lateral tibial plateau was remarkably larger in proportion in all fetuses than in adults, suggesting that the lateral meniscus in fetuses is more rounded than that in adults. In contrast, the medial meniscus was located marginally in the tibial plateau, and the shape was longer and more slender in fetuses than in adults.

The bivariate scattgram revealed that ratio of the area of meniscus to that of plateau was constitutively higher in the lateral side than in the medial side in the fetal range examined in the present study ($p < 0.01$).

When the circularity of meniscus was compared between fetuses and adults, the circularity index of the lateral meniscus was significantly higher in fetuses (mean \pm SD: 0.448 ± 0.049) than in adults (0.398 ± 0.049) in the lateral side ($p < 0.01$), whereas it was not significantly different in the medial side (fetuses: 0.340 ± 0.044 vs. adult: 0.333 ± 0.048).

The present study revealed that the proportion of covered area by meniscus in the tibial plateau is significantly larger in fetuses than in adults, suggesting that the incomplete type of discoid meniscus possibly originates from the fetal morphology of meniscus. While the areas of medial meniscus and tibial plateau increased more rapidly than those of the lateral meniscus and tibial plateau, the ratio of meniscus area to plateau in the lateral side was constitutively larger than that in the medial side. This indicates that the covered area of tibial plateau by the meniscus during the fetal period is larger in the lateral side than medial side, which may contribute to the higher incidence of discoid menisci in the lateral side. The present circularity analysis also supports this idea.

Histological changes following development in the lateral and medial menisci were determined in the anterior portion of the meniscus. The layered structure develops earlier in the lateral meniscus than in the medial in fetuses. This finding suggests that the histogenesis occurs earlier in the lateral than in medial menisci, corresponding to findings demonstrated by the present morphometric analyses of the meniscus.

CONCLUSION

Morphometric analyses revealed that the proportion of the area of meniscus to that of the plateau was continuously higher in the lateral side than in the medial side. Histological observation of the knee joint showed that the layered structure of fibers developed earlier in the lateral meniscus than in the medial in fetuses. The observed differential development of lateral and medial sides of the meniscus may be involved in the etiology of discoid meniscus.