ANATOMICAL STUDY FOR THE EXPRESSION OF THE ANTERIOR CRUCIATE LIGAMENT FEMORAL AND TIBIAL FOOTPRINTS FOR DOUBLE-BUNDLE RECONSTRUCTION

INTRODUCTION
Recently, various biomechanical studies for anterior cruciate ligament (ACL) reconstruction have reported that the posterolateral bundle (PLB) of the ACL plays a role in restraint of rotational instability of the knee and the conventional single-bundle ACL reconstruction insufficiency restrains rotatory loads. Therefore, the current trend of ACL reconstruction has shifted to the anatomical double-bundle (DB) ACL reconstruction which reproduce both the anteromedial bundle (AMB) and PLB of the ACL. The successful outcome of the DB ACL reconstruction particularly depends on the tibial and femoral tunnel positions of both the AMB and PLB. The quadrant method described by Bernard (1) that was a useful postoperative evaluation of the tibial and femoral tunnel positions, however, this method was not adequate to the intraoperative evaluation during arthroscopic surgery. The traditional clock wise method as an arthroscopic representation was rough, inaccurate and subjective. Therefore, arthroscopic representation for the tibial and femoral tunnel positions has not been established. Therefore, the purpose of this study was to evaluate the anatomical footprints of both the AMB and PLB as the basis for the reference points to obtain under arthroscopic view, and to assess adequacy for application of this evaluation method to DB-ACL reconstruction.

MATERIALS AND METHODS
Thirty-six embalmed cadaveric knees (average age 78.0 years old) were used for anatomical evaluation. The ethical approval of this study was obtained from the Ethics Committee of Hirosaki University School of Medicine. The femur was split in the sagittal plane to expose the femoral attachment of the ACL. After the AMB and PLB were detached, the central points of the footprints of the AMB and PLB on the femoral and tibial sides were marked and digital photographs were taken. The digital photographs were introduced to a PC and used for analysis with image analysis software.

Analysis of the ACL tibial footprint
In the tibial side, the central points of the tibial footprints of each bundle were also measured from the anterior edge and the medial edge of the tibial plateau, and expressed as a percentage in longitudinal (sagittal plane) and transverse distance (coronal plane) of the tibial plateau (Fig.1A).

Analysis of the ACL femoral footprint
In the femoral side, the analysis was performed according to the evaluation system described by Watanabe et al. (2). The first reference point was the “over-the-top-position” (point O), the second point was the anterior notch outlet point (point A), and the third point was the most inferior point of the interface between bone and cartilage (point I). In the sagittal plane (shallow/deep), the distance a was defined as the distance between the central points of each bundle and point O; and the distance b was defined as the distance between point A and point O along the femoral axis. The central points were measured for the distance from the point O (from “deep”) and expressed as a percentage (a/b %) along the femoral axis. In the axial plane (“superior”/“inferior”), the distance c was defined as the distance between the central points and point O, and the distance d was defined as the distance between point l and point O. The central points were measured for the distance from point O (from “superior”) and expressed as a percentage (c/d %) (Fig.1B).

The evaluation of the validity of the ACL femoral footprint
To assess of the validity of the central point of the ACL femoral footprint, the central point of the femoral footprint was evaluated using the quadrant method (Fig. 2A), Mochizuki’s method (3) (Fig. 2B), and Takahashi’s method (4)(Fig.2C).

RESULTS
The ACL tibial footprint
In the tibial side, the central point of the AMB was located at the 37.6 ± 3.6 % position from the anterior edge of the tibial plateau in the sagittal plane, and at the 46.5± 3.2 % position from the medial edge of the tibial plateau in the coronal plane. The central point of the PLB was located at 50.1 ± 5.0 % position from the anterior edge, and at the 51.2± 2.4 % position from the medial edge (Table 1).

The ACL femoral footprint
In the femoral side, the central point of the AMB was located at the 23.7 ± 3.1 % position from “deep” in the sagittal plane, and at the 21.9± 5.1 % position from “superior” in the axial plane. The central point of the PLB was located at the 48.4± 4.8 % position from “deep”, and at the 40.8± 5.3 % position from “superior” (Table 1).

The evaluation of the ACL femoral footprint using other methods
In the quadrant method, the central point of the AMB was located at the 25.9± 2.9 % position from the “deep” margin, and at the 17.8± 5.1 % position from the Blumensaat’s line. And the central point of PLB was located at the 34.8± 2.0 % / 42.1± 3.9 % position. In the Mochizuki’s method, the central point of the AMB was expressed as the 25.0± 3.9 % position from the “deep” border between the bony wall and articular surface, the central point of the PLB was expressed as the 45.4± 5.5 % position. And in the Takahashi’s method, the central point of the AMB was expressed as the 23.7± 3.5 % position from the “deep” margin of the articular surface, the central point of the PLB was expressed as the 22.4± 3.6 % position (Table 2).

DISCUSSION
The present study described the anatomical data as the basis for the reference points to obtain easily during arthroscopic surgery. The central points of the ACL footprints was expressed almost constantly, furthermore, the present data is in accordance with previous measurement data (Table 2). Recently, navigation systems have been useful for ACL reconstruction (6). As these anatomical data will be introduced to navigation systems, and these reference points will be inputted to the navigation system during the arthroscopic procedure, the navigation system will show the more precise target area of the tunnel positions of the AMB and PLB to orthopaedic surgeons. Therefore, these anatomical data and reference points will contribute to DB-ACL reconstruction using navigation systems.

REFERENCES
2) Watanabe: J Jpn Knee Soc.: 253-6, 2005
6) Ishibashi: Orthopedics: 1277-82, 2005