Anatomical and Computed Tomographic analysis of Femoral Attachment of Anterior Cruciate Ligament

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Introduction: Accurate and anatomic tunnel placements are essential to success the reconstruction of the anterior cruciate ligament (ACL). In 1990’s, The tunnel of femoral side was located commonly between the 1- and 2-o’clock positions or the 10- and11-o’clock positions in the colonal plane and over the top position in saggital plane referring the “resident’s ridge”. The anatomy of “resident’s ridge,” was described the raised bony landmark commonly visualized just anterior to the femoral attachment of the ACL. Recently, many of anatomical ACL insertion studies were published that ACL consist of 2 major bundle, anteromedial bundle (AMB) and posterolateral bundle (PLB). Biomechanically, anatomical ACL reconstruction was better results than isometric ACL reconstruction in cadaver study. In performing an “anatomic” ACL reconstruction, the location of the anatomy of these fiber bundles is critical. Arthroscopic surgeons may have difficulty in accurately placing the drill holes for 2-bundle reconstruction. The objective of this study was to define the morphology of the femoral attachment areas of ACL in cadaveric knees.

To define the bony landmarks, we prepare the slices vertically to ACL insertion and analyzed by radiograph and microscopy. Because resident’s ridge appeared to be harder than the bone of the lateral wall of the condyle anterior or posterior to it, we examine the Computed Tomography (CT) scan and the value of CT were measured.

Materials and Methods: 8 cadavers from the anatomical course of medical students at Osaka city university medical school of medicine, Osaka, Japan were used. The cadaver’s knee had slightly cartilage damages but ACL intact. The age range was 73-98 years. Distal femur was extract and all tissue except the ACL was removed. CT examination of the all distal femur was performed with a helical CT machine. Images of 1mm slice thickness were reconstructed using three-dimensional (3D) reconstruction software (Axe Ltd., Japan).

Cross-sections 3-mm thick was made using an bone trimmer with diamond band-saw blade (1-mm thick) vertical to the ACL attachment. Four slices were prepared and named group1, 2, 3 and 4 from deep to shallow.

The each cut specimens were radiographed with soft X-ray and magnified with microscope to identify the insertion of the ligament and bone. We examined the type of the bone morphology at the insertion, the height of the ridge and the location of insertion site.

At CT analysis, six zone (AM bundle-shallow (AS), AM bundle-ridge (AR), AM bundle-deep (AD), PL bundle-shallow (PS), PL bundle-ridge (PR), PL bundle-deep (PD)) were defined and 10 point of CT value in each area were measured and analysed.

Results: In radiograph, three types of the shape at the lateral wall of ACL attachment were identified, that is one ridge type, two ridges type and flat type. One ridge type were 50%, 100 %, 37.5 % and 37.5 % in group 1,2,3 and 4. Two ridges were 0 %, 0 %, 50% and 0% and flat were 50 %, 0%, 12.5% and 37.5% in group 1,2,3 and 4. The average height of the ridge were 0.7+/-0.6 mm, 1.1+/-0.7 mm, 0.7 +/-0.6mm, and 0.3+/-0.5mm in group 1,2,3 and 4. The location of the ACL insertion was mainly on the ridge (64%) and deeply to the ridge (28%). The CT values were 580+/-234, 882+/-104, 506+/-154, 552+/-214, 656+/-221 and 366+/-132 at AS, AR, AD, PS, PR and PD, respectively. The CT values of AR and PR were higher value than other zones.

Discussion: It is famous that resident’s ridge is the important bony landmark in performing an “isometric” ACL reconstruction. The classical resident’s ridge was located commonly between the 1- and 2-o’clock or the 10- and11-o’clock positions in the coronal plane. Recently, many studies were reported that ACL consist of 2 major bundle, AM bundle and PL bundle and its insertion was found at deeper and lower position than isometric point. In this study, we showed the bony ridge continued from the resident’s ridge to the lateral wall where ACL was inserted and the location of the ACL insertion was mainly on the ridge and deeply to the ridge.

Mark R et al were reported that cortical thickness was found at ACL insertion deeply to the ridge. In this study, The CT value of the bony ridge was higher value than the other zone. This is indicated that ACL attachment was easily visualized using 3D reconstruction software and the difference of the bone quality may be the response of the continuous stretch loading.

Fig 1, upper; the slices of ACL attachment. lower; CT of femur and six zone of ACL attachment.

fig2; three types of the bony ridge.

fig3; results of the CT values of lateral wall around ACL attachment.