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ACL Length Pattern Changes as a Result of Differences in the Femoral Footprint

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Summary:
The image matching study of the ACL length pattern showed that the lower direction of ACL femoral footprint leads to stronger tension during extension, the higher and shallower direction leads to isometric during flexion, whereas the deeper direction leads to laxity during flexion under normal load and movement conditions

Abstract:
INTRODUCTION
There are many reports on the location of the anterior cruciate ligament(ACL) femoral footprint. However, a clear consensus has not been reached. During ACL reconstruction, determination of the bone tunnel position is based on the surgeon's opinions and judgment.

Our objectives are to measure the distance between femoral and tibial footprint of the ACL during flexion in normal knees under normal loading condition using the biometric image matching technique and to investigate the length pattern of these distances. Additionally, we investigated length pattern changes as a result of differences in the femoral footprint.

METHODS
The subjects were five healthy knees. The movement studied was a squat movement from full knee extension to a deep flexion.

The images used for matching were created as previously reported by our group; we were based on three-dimensional bone models obtained by CT, and matching was accomplished by correlation of images obtained by flat panel equipment.

When defining the femoral and tibial footprint, we referred to reports using as similar measurement methods. We divided the ACL into AM and PL bundles and defined the femoral footprint using Bernard's quadrant method. Tibial footprint was defined by the Amis and Jakob line in the AP direction and by the quadrant method in the ML direction.

In addition, we also measured the footprint distances after changing the femoral footprint to be +10% lower, +10% shallower, and both +10% lower + shallower than the defined anatomical femoral footprint; this was to evaluate changes in the length patterns due to differences in the femoral footprint.

RESULTS
When the AM bundle femoral footprint, we observed a length change of approximately 10 mm from extension to flexion.

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Meanwhile, we observed a change of approximately 13.7 mm in the PL, which was larger than the change in the AM. In both cases, the maximum length was during extension, while the minimum was during 110 to 120° flexion.

When AMB footprint were defined 10% lower, we observed a change in length of approximately 2.5 mm greater than the defined value up to 120° flexion. Similar changes were observed with the PL. The difference in length during extension became larger in +10 lower position.

When footprint were defined 10% shallower, the length pattern of AMB was more isometric compared the defined values up to roughly 120° degrees, while the length patterns were similar during deeper flexion. Although there was little change up to 110°, the length pattern of PL elongated during deep flexion. The difference in length during flexion became smaller in +10 shallower position.

DISCUSSION
In the present investigation, we evaluated ACL length patterns accompanying changes in ACL femoral footprint under normal load conditions.

It may also be possible to estimate the tension pattern of the ligaments based on the length patterns. From these results, defining the site in the lower direction of ACL femoral footprint leads to stronger tension during extension, the higher and shallower direction leads to isometric during flexion, whereas the deeper direction leads to laxity during flexion.