Introduction: Reconstruction of the cruciate ligaments in double bundle technique tends to restore the natural kinematics of the knee joint more closely, including rotational stability. Therefore this technique has become more common. Studies, concentrating on single bundle reconstruction, suggested that isometry is an important factor for tunnel placement. Only few studies examined the isometric behaviour of each individual anatomic bundle. This biomechanical study analysed the length change of the anteromedial and posterolateral bundle for the ACL and the anterolateral and posteromedial bundle for the PCL.

Materials and Methods: Seven cadaveric knees were measured with a special testing device, that allows six degrees of freedom. First all knees were registered in the testing device with the complete soft tissue and intact ligaments in 11 predefined flexion positions. After the registration process the complete soft-tissue was resected, the footprint of the functional bundles of the ACL and PCL marked and the center of gravity (COG) of these areas evaluated. Depending of the COG five predefined drill holes (Center, North, West, South, East) were placed within the femoral and tibial footprints of each bundle, except of the tibial insertion of the PCL, where only three drill holes were defined (Center, North, South). All possible combinations were connected by a wire and the changes of the tibiofemoral distance were measured in the 11 predefined flexion angles from 0° to 125°. Combinations of the different insertion points were compared to each other.

Results: In this study, no complete isometry was found for each bundle. Concerning the AM bundle of the ACL, the least change in distance of the different combinations was measured, when the Fiber-Wire® was connected to the N (1,23 cm ± 0,09) or W (1,23 cm ± 0,23) femoral drill holes. The results for N and W were significant (p<0,05) compared to E and the S. Therefore, the N-W corner of the anatomical origin of the anteromedial bundle seemed to be the best tunnel position. This area is located in the anterior proximal part of the footprint. The distance of the combinations with the femoral E of the AM bundle increased by 1,46 cm ± 0,12 the most.

The comparison of the femoral insertion tunnels of the PL bundle showed the same significant outcome (p<0,05). Connecting the N (1,62 cm ± 0,09) and W (1,63 cm ± 0,14) to all tibial drill holes, the least change of distance was measured. N and W are located in the anterior proximal corner of the anatomical attachment. The S was for the PL bundle the worst possible tunnel position (distance change: 2,12 cm ± 0,14).

Measurements of the AL bundle of the PCL demonstrated that all connections to the femoral W drill hole led to the least change in distance (1,12 cm ± 0,19). This result was highly significant (p<0,001). From the anatomic point of view, the W describes a posterior proximal site within the footprint. In contrast, fixations to the femoral E point resulted in a length change of 1,96 cm ± 0,02.

Again, the combinations with the femoral W (posterior proximal) of the PM bundle showed the least increase in distance (1,05 cm ± 0,12). Here the femoral S seemed to be the worst solution (1,65 cm ± 0,13). The significance of the W compared to the S was calculated with p<0,05.

The tibial drill holes showed neither for the ACL nor for the PCL significant differences.

An overview for favorable insertions of the functional bundles of the ACL and PCL shows Image 2.

Discussion: Regarding the results for the ACL and PCL, no complete isometric point inside the anatomical bundle origin was found, which is in agreement to previous researchers. For the analysis of the results, the differences of the extreme measurement results were calculated. The data in between had only minor influence on the statistics. Nevertheless, the results of this study are eminent and support the suggestions of previous authors, from a biomechanical point of view.

With the especially developed testing device, the experiments could be performed without any problems. It was possible to conduct a physiological knee flexion, from full extension to full flexion, reproducible for all measurements. Some of the previous studies concentrated on a flexion angle, only from 0° to 90°, whereas in this study the full flexion was conducted.

In literature, robotic devices were described, which made a continuous recording of length change behaviour possible, while this study was limited to a measurement in eleven different positions.

Ranging from 0° to 20°, the major changes in length were measured. Zavras, Race and Amis also described the biggest alteration in the same interval, measuring the graft tension.

What distinguishes this study from previous ones is the orientation only on the footprint. Therefore the individual anatomical properties were taken into account and the drill positions were described without the use of absolute distances to anatomical landmarks. Consequently, the results of this study respect the individual anatomic characteristics.