Relationship between the Q Angle and the Gliding Resistance of Patella
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Introduction: Patellofemoral pain syndrome (PFPS) is a common knee problem among young, active individuals [1, 2]. Although predisposing factors have been identified [3], the mechanism of PFPS is not well understood. The quadriceps angle (Q angle) is a measurement of patellofemoral (PF) joint mechanics regularly used in musculoskeletal medicine. The Q angle has been considered as a major factor associated with various knee pathologies. The gliding resistance of the patella (GRP) is generated when the patella moves against the femoral condyle during knee flexion and extension. The GRP is limited when limb alignment is normal. An abnormal Q angle alters the contact pressure between PF and femoral-tibia (FT) joints, but the effect on the GRP is unknown.

The purpose of this study was to investigate the correlation between the Q angle and the gliding resistance of the patella in the PF joint using canine cadavers.

Materials and Methods: Materials and Preparation: Eight canine knees were used to measure the GRP. The specimens were obtained from the canines that were sacrificed for other purpose of the study that has been approved by Mayo Institutional Animal Care and Use Committee. The proximal portion of the rectus femoris and vastus intermedius were exposed and attached to a custom-made ring load transducers to measure the proximal force (F1). The distal portion of the patella tendon (PT) was detached from its tibia insertion site. The second load transducer was connected the distal end of PT after resecting a 1.5 cm of the distal PT to accommodate the initial length of the PT. Then this transducer was reattached to the tibial insertion without altering the patella original position. This load transducer was used to measure the distal force (F2) of the PT. The specimen was mounted on to the testing apparatus.

GRP Measurement: The static loads (4.9 and 9.8 N) were applied to the quadriceps tendon by hanging dead weights. The knee was passively flexed first by the motor (10 degree/sec) driving the tibia against the dead weights applied to the quadriceps tendon. Then the motor reversed and the knee was passively extended due to the dead weights. Two-dimensional kinematics of the FT and PF were monitored with motion analysis system (Motion Analysis Corp, Santa Rosa, CA). Each specimen was tested in following conditions: Q angle is -20, -10, normal, 10, and 20 degrees. After measuring GRP with knee as the normal alignment, the malalignment of the knee was created with tibial dome osteotomy at the proximal to the tibial tuberosity with bone saw. The tibia was fixed with the external fixator and Q angle was changed with the distal tibia moving laterally or medially. Data was collected during the knee motion.

Data Analysis: The GRP was calculated from the absolute difference between the load transducers. During knee flexion, as the GRP was against F2, the GRP in flexion can be calculated with F2f - F1f (Fig 1). During knee extension, as the GRP was against dead weights, the GRP was calculated by F1eF2e (Fig 1) - F2eF1e. By averaging GRP in flexion and extension motion, the formula will be [(F2f - F1f) + (F1e - F2e)]/2. Since F1 remains constant during the test (equal to dead weights), the GRP was calculated as the (1/2)*(F2f - F2e). The data of GRP was analyzed by one-way ANOVA. Tuckey-Kramer multiple-comparison procedure was used as a post-hoc. A p-value of less than 0.05 was considered to indicate statistical significance.

Results: The mean normal Q angle of canine was 2 ± 0.2 degree. The normal FT range of motion was from 23 ± 5 degree to 124 ± 6 degree. The GRP at Q angle 20 degree (0.191 ± 0.031 N) was significantly larger than that at normal (0.155 ± 0.022 N) and Q angle 10 degree (0.160 ± 0.015 N) with dead weights 4.9 N (p<0.05) (Fig 1). The GRP at Q angle 20 degree (0.280 ± 0.064 N) was significantly larger than that at normal (0.224 ± 0.046 N) and Q angle 10 degree (0.234 ± 0.028 N) with dead weights 9.8 N (p<0.05). The GRP with dead weights 9.8 N was significantly larger than that with the dead weights 4.9 N at all data point (p<0.01) (Fig 1).

Discussion: The Q angle is considered a major factor in various knee pathologies. When the Q angle exceeds 15-20 degree it is thought to contribute to knee extensor mechanism dysfunction and PF pain by increasing the tendency for lateral patella malposition [4]. Abnormally low values have also been linked with pathologies [5]. In this study, the gliding resistance of the patella at normal Q angle was smallest in the all Q angle conditions. The graph of relationship between the Q angle and the gliding resistance of the patella showed the U shape (Fig. 1). The loading applied to the patella is also a factor that influences the gliding resistance of the patella. However, this influence seems independent of the Q angle changes. The current study showed that an abnormal Q angle leads to an increase in the gliding resistance of the patella which may be associated with PFPS and accelerated patellofemoral articular cartilage degeneration.

Figure 1. The relationship of Q angle and the gliding resistance of the patella (GRP). (*p<0.05, **p<0.01).