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Radiological evaluation of the quadriceps angle (Q angle) in German Shepherd Dogs

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Summary

The research was conducted on a selected group of 65 healthy German Shepherd Dogs to determine Q angle values. The animals were tranquilized, positioned in ventrodorsal recumbency, and examined radiologically. The radiographs were converted into digital form and analyzed by specialized software to determine the lines and to make measurements.

The Q angle assessment was based on the determination of two lines according to Kaiser and Miles in previous research. The first line was drawn from the cranial lip of the acetabulum of the hip joint to the centre of the femoral intercondylar notch. The second line was drawn from the femoral intercondylar notch to the tibial tuberosity. The angle between these two lines was the Q angle. The results were statistically analyzed, and basic statistical parameters were calculated, such as statistical mean (Me), standard deviation (SD), as well as minimum (Min) and maximum (Max) values.

In our study the mean of the results was 17 with a standard deviation of 7.38. These results are are in agreement with the results of studies carried out on foxes, which suggests that the selection of patients of the same breed, size and similar body weight does not significantly reduce the standard deviation in determining the reference values. The differences between the right and left hind limbs were also observed in our study.

Keywords: Q angle, quadricpes femoris muscle, radiographic measurements, patella alta, patella baja

Malfunction of the patellofemoral joint is a serious problem, widely discussed in medical and veterinary literature (16). In some small breed dogs, the incidence of patellar luxation reaches 50%, and similar cases are increasingly frequent in large breed dogs (1, 5, 6, 8, 9, 15, 16, 18, 21, 23). The risk of luxation greatly depends on numerous anatomical abnormalities of the musculoskeletal system. They are diagnosed in up to 95% of animals with patellar luxation (6, 28, 31, 38, 39, 41, 44). The pathological changes occur mainly in the femoral trochlea, patella, patellar ligament, and tibial tuberosity, as well as other parts of the skeletal system, including the hip joint. Particularly important is the conformation of the entire pelvic limb, including femoral and tibial torsion and angulation, the origin of which has not been clearly established (4, 45). Patellar luxations are therefore considered to be the effect of complex morphological abnormalities of the hind limb (7, 11, 12, 17, 23, 27, 30-33, 37, 41-44, 47, 48-50).

The dominant role in the pathogenesis of patellar luxation is played by an abnormal development (dysplasia) of the femoral trochlea, a high-riding and a low-riding patella (*patela alta* and *patella baja*, respectively), as well as deviation in the direction of the force of the quadriceps muscle group (*m. rectus femoris*, *m. vastus intermedius*, *lateralis et medialis*), which usually results from the displacement of the tibial tuberosity. A slight displacement of the tibial tuberosity to the lateral or medial side with laxity in lateral retinacular structures is often observed in grades I and II of luxating patella according to Putnam and Singleton's scale. It is often the only diagnosed abnormality of the musculoskeletal system at this stage of the disease (1, 17, 32).

The direction of the force of the quadriceps muscle group is expressed by the value of the Q angle, between the long axis of the muscle rectus femoris and the patellar ligament (16, 17, 34, 39, 40).

In medicine, the Q angle is measured with the goniometer, whose one arm is placed along the long axis of the femur (from the anterior superior iliac spine, which is the site of attachment of the rectus femoris muscle to the centre of the patella) and the other arm is set along the patellar ligament (2, 13, 22, 25, 29, 34, 39, 47). In dogs, the site of attachment of the rectus femoris muscle is not available for clinical examination. Therefore, the most reliable method of measuring the Q angle is diagnostic imaging, which is commonly used in humans (29, 30, 39, 41, 49). For the radiological determination of the Q angle, the patient is positioned in ventrodorsal recumbency, which is the standard posture to assess hip dysplasia (39, 41, 48). After determining the line consistent with the axis of the femur and the other line, drawn from the central patella to the tibial tuberosity, the Q angle is obtained, in which both lines intersect at the geometric centre of the patella (39, 40, 48). Over time, these methods have been modified and are used to measure not only the patella as a landmark, but also the femoral trochlea, and the intercondylar notch (3, 28, 39).

The top of the Q angle, regardless of the measurement method, is directed medially, and its size determines the degree of knee valgus (40). Angle reduction is observed in the varus deformity of knees, whereas its increase occurs in the valgus deformity, dislocation of the tibial tuberosity, and patellar maltracking (12, 29, 32, 40).

So far, there have been few veterinary publications on normal values of the Q angle in dogs and foxes. Most such studies are based on small and heterogeneous groups of animals. Various methods of measurement have been used, involving the identification of the geometric centre of the patella, the femoral trochlea, or the intercondylar notch of the femur. The last technique is considered to be the least error-prone (39).

In the present study, Q angle values were determined for a selected breed of German Shepherd Dogs on the basis of the intercondylar notch of the femur and the tibial tuberosity as landmarks.

Material and methods

The research was conducted on a group of 65 clinically healthy German Shepherd Dogs (58 males and 7 females) weighing 22-44 kg and aged 2-12 years (Tab. 1). Before the examination, the dogs were fasted for 24 hour. A detailed interview was carried out with the owners of each animal to obtain information about the general health of the patients, as well as about past and present injuries or other problems with the musculoskeletal system, which could cause signs of lameness. If such problems had appeared in the past, the owners were asked for information about the location of lameness, the beginning and changes in the course of the disease, as well as medical diagnosis and treatment. Next, the clinical and orthopedic examination was performed.

To tranquilize the animals, prior to radiographic examination, they were given an intramuscular injection of xylazine (2 mg/kg bw), diazepam (0.25 mg/kg bw), and atropine (0.1 mg/kg bw). The animals were placed in ventrodorsal recumbency, with limbs positioned caudally, parallel to each other and to the table. Stifle joints were straightened and slightly rotated medially to obtain a medial position of the patella between the femoral condyles. The range of the X-ray beam included sacroiliac joints, hip joints, and stifle joints. The radiographs were considered properly made if the vertebral column was visible in the midline of the body, the pelvis, hip joints and femurs were located symmetrically to the vertebral column, the obturator foramens and the surface of the ilium bones were the same size, the femora were the same length, and the patellas were located centrally between the femoral condyles. Moreover, each radiograph included the proximal part of the tibia bones with the tibial tuberosity. X-ray images that did not meet the above requirements were rejected and repeated.

Tab. 1. Characteristics of the animals examined

	Me	SD	Min	Max
Age of animals	5.046	2.101	2	12
Weight of animals	35.831	4.422	22	44

Explanations: Me – mean, average; SD – standard deviation; min – minimum values; max – maximum values

Tab. 2. The values of quadriceps angle (Q) in own observations

Parameter	Me	SD	Min	Max
Q angle	17	7.388	–5.91	31.61

Explanations: as in tab 1.

Fig. 1. Method of determining the Q angle

Next, the radiographs were converted into digital form using a scanner Microtek ScanMaker 9800XL with a transparent materials adapter TMA 1600, and were analyzed by specialized software, Iris Laboratory (Medicom), which is used for imaging diagnosis and documentation. This program was used to determine all lines and to make measurements.

The Q angle assessment was based on the determination of two lines according to research by Kaiser and Miles (29, 39). The first line was drawn from the cranial lip of the acetabulum of the hip joint to the centre of the femoral intercondylar notch. The second line was drawn from the femoral intercondylar notch to the tibial tuberosity. The angle between these two lines was the Q angle (Fig. 1).

The results were statistically analyzed. Basic statistical parameters were calculated, such as statistical mean (Me), standard deviation (SD), minimum (Min) and maximum (Max) values (Tab. 2).

Results and discussion

Under physiological conditions, the Q angle value is the highest in the full extension of the knee joint as a result of external tibial rotation and the lateral shift of the tibial tuberosity (12). The greater the angle, the greater the forces shifting the patella from the correct tract, and the bigger the risk of its luxation. Medial displacement of the quadriceps femoris and the co-occurrence of a high-riding patella (*patella alta*) and a long patellar tendon are responsible for medial patellar luxations. Lateral dislocation with a simultaneous low-riding patella (*patella baja*) results in lateral patellar luxations (2, 12, 15, 17, 18, 29, 39, 41, 42). Numerous anatomic abnormalities of bones and soft tissues, including an abnormal anteversion angle, additionally increase the forces of the quadriceps femoris muscle group and change their direction (29, 38). This may result in an increased pressure of the patella on the articular cartilage of the femoral condyles, leading to the formation of chondromalacia and the development of the knee pain syndrome (16, 19, 20, 24, 26, 29, 35).

The radiological evaluation of the Q angle in the present study was performed on the basis of two lines: the first line was drawn from the cranial lip of the acetabulum of the hip joint to the centre of the femoral intercondylar notch, and the second line was traced from the femoral intercondylar notch to the tibial tuberosity. This method of measurement, in which the cranial lip of the acetabulum is regarded as the attachment site of the rectus femoris, was proposed by Kaiser and Miles in previous studies (29, 39). The use of the intercondylar notch as a landmark was first described in animals at the beginning of 2012 (39). This method was compared to the technique proposed by Kaiser et al, which determines the Q angle from the femoral trochlea (29, 39). Although Kaiser's method was considered more sensitive, it is inappropriate in the cases of patellar instability, as it may produce false results (39, 48). In humans, the use of the modified method has resulted in a smaller number of errors because of reduced susceptibility of measurement results to the rotation of the pelvic limb (3). The examination of animals in the standard position to assess hip dysplasia requires internal rotation in the stifle joints, which can affect Q angle values and contribute to patellar instability (29, 32, 37, 44). To prevent this, the twisting force of limbs in the knee joints should be unified for each patient, which is almost impossible to achieve in everyday clinical practice (39). Therefore, the examination method involving the use of the intercondylar notch seems to be the most appropriate.

Because of the potential connection of the Q angle with numerous pathological states of the musculoskeletal system, the measurements are an important part of clinical examination to evaluate the geometry of the patella. In the present study, the average of the results was 17° with a standard deviation of 7.38°. Interestingly, these findings largely agree with the results of Miles's research on foxes, in which the average was 16.7° with a standard deviation of 7.5°. These values cannot be compared with the results of Kaiser (10.5°; SD 5.6°) because the centre of the intercondylar notch is located closer to the tibial tuberosity than the centre of the femoral trochlea, which results in higher values of the Q angle (39).

In comparative studies, using the measuring technique proposed by Kaiser, it was observed that the selection of patients of the same breed, size and similar body weight does not significantly reduce the standard deviation in determining the reference values (–0.7° to 21.7°) (29, 39). The results of Miles's studies, the average of 15.5° with a standard deviation of 3.6°, were in the same range as the results of the first author (the average 10.5°, SD 5.6°). Therefore, Miles concludes that the breed and size of animals have little effect on the results of Q angle measurements. The comparison of our results with those obtained by Miles suggests similar conclusions. The morphology of the fox's limb is similar to that of the dog's limb. However, in Miles's study, the average weight of foxes was 8.2 kg (SD 1.7 kg), which differs considerably from the average weight of German Shepherd Dogs, amounting to 35.83 kg (SD 4.42) (39, 51). It is particularly important in the light of medical studies suggesting that the Q angle value is variable depending on the patient's height (14, 20, 39). Similarly, in animals no differences of angles have been found between males and females, although it is hypothesized that some differences might occur because of sexual dimorphism (39). The results obtained in the present study contradict these assumptions.

In the available medical and veterinary literature, the results of studies by different authors demonstrate either the presence or the absence of differences in Q angle values between individual limbs, and most of the studies consider them as statistically irrelevant (19, 24, 34-36, 39). Some differences were also observed in the present study, but it should be borne in mind that the methods of Q angle measurement are highly prone to error (19, 24, 34, 35, 39). In humans, the error may result from the improper identification of anatomical landmarks, such as the geometric centre of the patella, the intercondylar notch, the centre of the tibial tuberosity and the iliac spine, the last of which is the most reliable in determining the Q angle during clinical examination (19, 39). Because of the difficulties in identifying the anatomical landmarks, a certain margin of error has been adopted in medicine in evaluating the Q angle. It is reported that in order to reduce the measurement error for the Q angle to below ± 5°, a location error of the centre of the patella and the tibial tuberosity should be less than 2 mm (19, 39). According to examinations conducted on foxes with the use of imaging diagnostic methods, the location error for all landmarks need to be defined within 1.3 mm for the calculation method using the centre of the patella, and 0.8 mm for the method based on the intercondylar notch, and it is reported to depend on the size of the patient (39). The Q angle value also depends on the degree of knee joint rotation, as well as on other factors, such as quadriceps femoris muscle tension, the flexion of the stifle joint, or the positioning of the distal parts of pelvic limbs (24, 34, 35, 39). To avoid errors, computed tomography and magnetic resonance are used, as well as other methods of measuring the Q angle than those with the use of the geometric centre of the patella (3, 29, 39). Additional factors affecting the value of the Q angle are anatomical variants, such as a lateral displacement of the tibial tuberosity, variation in the size of the pelvic girdle, and a medial displacement of the femoral trochlea, which, however, has not been examined in animals yet (2, 3, 34, 37).

The results of the present study should be compared with those obtained in the examinations of other large dog breeds in order to determine common reference values and detect even small orthopedic abnormalities affecting patellar maltracking disorders.

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