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Brief communication (Original)

Comparing goniometric and radiographic measurement of Q angle of the knee

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Background: The Q angle is a relevant clinical diagnostic measurement to detect various disorders of the knee. The common method used to measure the Q angle in the routine clinical practice is by radiography. An alternative to radiographic measurement is goniometry, by which exposure to x-rays can be avoided.
Objectives: To compare and correlate the goniometric measurement of Q angle with radiographic measurement of the Q angle in patients with acute knee pain.
Methods: We selected 45 patient participants with a mean age of 32.5 years who satisfied the inclusion criteria for this study. All the patients underwent goniometric measurement of the Q angle followed by x-ray imaging of the entire lower limb. Later the bony prominences were marked on the x-ray image and the Q angle formed was measured using a protractor. The Pearson correlation coefficient between the goniometric and radiographic measurements was determined.
Results: We found a significant relationship between Q angles obtained using a goniometer and x-ray imaging in the supine position ($r = 0.91$, $P = 0.001$). The mean difference between the goniometric measurement of Q angle and the radiographic measurement was 0.1°, which is not significant.
Conclusions: Goniometry can be used to measure Q angle as accurately as radiography, and can be used as an inexpensive and radiation free alternative.

Keywords: Goniometry, Q angle, x-ray imaging, radiography, quadriceps angle

The quadriceps or Q angle is formed by an imaginary line passing from anterior superior iliac spine (ASIS) to the patellar center intersecting with the line from patellar center through to the tibial tubercle. The angle reflects the mechanism of quadriceps effects on the knee and depicts the overall alignment of patella. When assessed properly, it indicates the biomechanical function of the lower extremity, especially the alignment of foot, leg, and pelvis. Assessment of the Q angle plays an important role in sports medicine. It is important to measure the angle in women who go jogging or do stepping activities as part of their fitness program. Excessive pronation of foot can have an effect on Q angle, which if corrected, can often reduce the ill effects of an abnormal Q angle [1].

Brattstrom defined and described the Q angle as the angle that is formed between the patellar ligament and the quadriceps muscle resultant force line extension with its apex at the patella [2]. The Q angle is formed between the patellar tendon and the quadriceps muscle, especially the rectus femoris [3]. The Q angle provides important information about the knee alignment in the frontal plane. Because forces are passed through the patella during extension, malalignment may lead to pathological problems in knee function [4].

The approximate tracking of the patella can be determined through Q angle measurement. This

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measurement is performed in knee extension. The normal Q angle in knee extension is 13° in men and 18° in women. Increased Q angle can result in increased force placed on the patellar lateral facet, medial part of the retinaculum of patella, and lateral border of trochlea of the femur, secondary to an increased lateral glide of the patella [5]. An increased Q angle can reflect a greater valgus angle in the knee joint, which may lead to a high incidence of lateral pull on the patella. This can cause increased pressure in the patellar lateral facet, and may lead to subluxation of patella and articular softening, which collectively can cause patellofemoral disorders (PFD) [6, 7]. An abnormally high Q angle is one of the main causes of PFD. The knee joint is one of the major weight bearing joints, is injured almost in 50% of all musculoskeletal injuries, and the most common of all these injuries are PFD [8, 9]. PFD affects the articular cartilage, which can result in anterior knee pain and deficits in function [10, 11]. PFD is most commonly seen in young athletes 15-30 years old [12-15]. The increased incidence in patellofemoral pain among women has been attributed to sex differences in muscle strength, conditioning and anatomic structure; and especially an increased Q angle [16, 17].

Various methods have been adopted to measure the Q angle, including the radiographic method [6, 7] and the goniometric method [7]. The Q angle is measured in various positions, including supine with full extension of knee and relaxed quadriceps [18], contracted [19], or orthostatic [7, 10, 11], seated with the knees in 90° flexion, or in 20-30 flexion with the maximal lateral, medial rotation, or in a position where the tibia is in a neutral position [11]. There are many studies focused on measurement of the Q angle using a goniometer or with x-ray imaging alone. Although radiographic methods have advantages in accuracy and precision, they also involve health-related hazards because of x-ray exposure; they are relatively expensive and time consuming, and not always available. They are now less used for research and clinical purposes [20]. Goniometry is a clinical method, is easy to administer, and does not involve any radiation exposure. Although there are reports stating that goniometry and radiographs can be used to determine the Q angle, there are few studies of whether these techniques are equally effective in determining the true Q angle, and thus whether they can be used interchangeably.

Methods

Source of data

The study included 45 male participants between the ages of 20 and 40 years. They complained of acute knee pain on their right side. Approval for the study was obtained from the central ethical clearance committee of our institution (KAU/ FAMS/ PT/ EC/ 113/2014 dated 20/03/2014). We explained the experimental procedures and outcome measures to the patient participants. Formal written informed consent was obtained from each participant before they took part in this study. Exclusion criteria were limb length discrepancy, dislocation of the knee, chronic degenerative disorder of the knee and rheumatoid arthritis, recent history of surgery on the knees (less than three months before), pain radiating from the columna vertebralis. Written informed consent for publication of clinical photographs was obtained.

Q angle measurement by goniometry

The Q angle measurement was made on the patient's dominant side, which was on the right in each case. Each patient was asked to lie supine with completely relaxed quadriceps muscles. To measure the Q angle, a universal goniometer with one degree of precision was used. Knee and hip joints were kept in neutral rotation while the patella was pointing upwards. A mark was made with ink over the ASIS, the center of the patella, and tibial tuberosity, and these three points were later joined by lines before each measurement **(Figure 1)**.

Figure 1. Procedure for marking the bony prominence for the measurement of the Q angle (photograph with permission)

Because the goniometer had sufficient length to span the area encompassed by the Q angle, there was no need to project the proximal part of the goniometer up to the ASIS visually as would be the case for a standard protractor. Measurements were made to the nearest degree **(Figure 2)** [21, 22].

Q angle measurement by radiography

The subject was asked to lie supine, while maintaining full extension of their knees along with a wooden block stabilizer, and each subject was asked to keep their lower extremities completely relaxed. The same x-ray technician took all radiographs with the patients in an anteroposterior position using radiological overlapping 36 cm × 42 cm films of the hip, femur, and knee **(Figure 3)**.

The tibial tuberosity was marked with the aid of lead marker for the bony reference. The bony prominences were marked on the x-ray film using a pen marker and a connecting line was drawn through the ASIS to the midpoint of the patella and from tibial tuberosity to midpoint of patella, the intersecting angle was measured using a protractor **(Figure 4)** [21].

Statistical analyses

The data were analyzed using IBM SPSS Statistics for Windows, version 19.0. The level of significance was set at $P < 0.05$. The Pearson correlation coefficient between the goniometric measurement and x-ray imaging measurement was determined.

Results

There was a significant correlation between the Q angles obtained using the goniometer and x-ray imaging in the supine position ($r = 0.91$, $P = 0.001$) as shown on the scatter plot **(Figure 5)**.

Figure 2. Procedure for the measurement of Q angle with the goniometer (photograph with permission).

Figure 3. Procedure for x-ray imaging of the lower limb (photograph with permission)

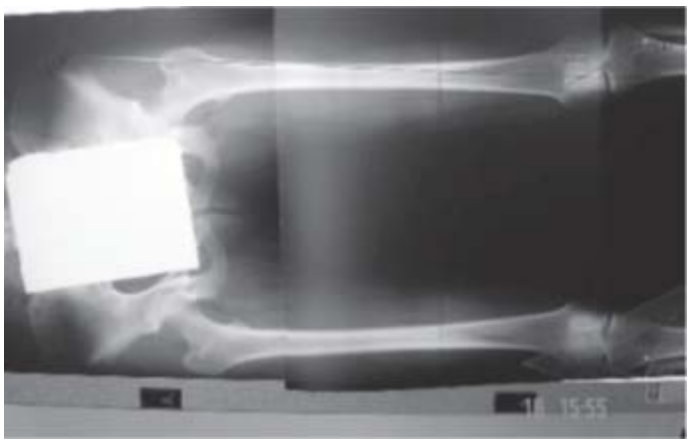

Figure 4. Procedure for measurement of the Q angle on an x-ray film by intersecting the line between the bony prominence

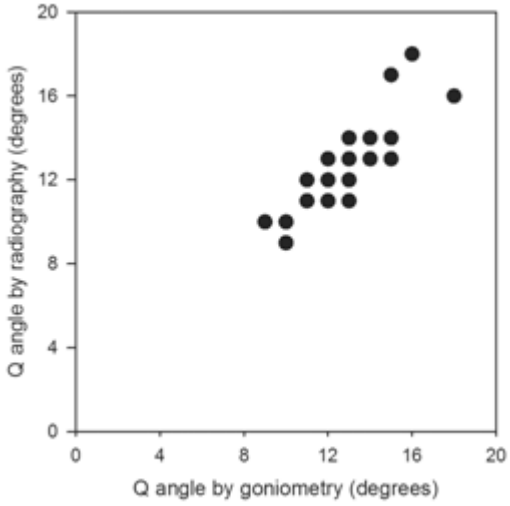

Figure 5. Correlation between goniometric and radiographic measurement of the Q angle

The result shows that both tools are equally effective, such that either method can be used for the Q angle measurement.

The mean and standard deviation of the Q angle calculated through radiographic method and goniometer method shows that, the mean value of goniometric measurement of the Q angle is 12.7 degrees (SD 1.72), whereas, the mean value of radiographic measurement of the Q angle is 12.6 degrees (SD 1.77). The results show that the mean difference between the two methods is 0.1 degrees, which is acceptable.

Discussion

The results of our present study show a strong correlation between the goniometric Q angle measurement and the radiographic Q angle measurement, supporting the hypothesis that goniometric measurement of Q angle can be used as an alternative to radiographic measurement.

Although Belchior et al. stated that the Q angle can be measured by various means, such as with a goniometer or by radiography [21], they did not conclude that goniometry can be used as an alternative, or method of choice because it does not entail radiation exposure and is inexpensive. Goniometry could be adopted for measuring the joint angulations in other pathological conditions of the knee such as genu varum or genu valgum.

The methodology we adopted for measuring the Q angle by goniometry was suggested by previous authors [23, 24] describing that, while measuring the

Q angle, the goniometer's proximal arm must be aligned to the ASIS, the distal arm with the tibial tubercle, and fulcrum is positioned over patellar midpoint [25]. Similarly, another report stated that, the Q angle measurement can be made by keeping the knee in extension, which results in high interexaminer reliability [26]. Grelsamer et al. concluded that an ink mark needs to be made over the tuberosity of tibia, the patellar midpoint and the ASIS before each measurement as the reference points for measuring the Q angle [22]. Similarly, the correct determination is conducted with a goniometer by having the subject in a supine position with full extension of the knees. The Q angle determination can be biased if it is measured in a standing position with quadriceps contraction, which can increase the Q angle; by contrast, knee flexion can reduce it [27].

To measure the Q angle radiographically, we adopted the method described by Belchior et al. [21]. Another report stated that radiography can be used for measurement of the Q angle [7]. A study conducted on chondromalacia patellae, stated that the Q angle is usually measured with the knee in extension, because excessive lateral force may be more of a problem when the knee is flexed, the Q angle will reduce as the tibia rotates medially relative to the femur [28]. Olerud and Berg stated that the Q angle decreases as the foot shifts from pronation to supination, and increases as the foot shifts from outward to inward, and concluded that a standard foot position should be maintained for measurement of the Q angle [29].

In the present study we only included patients between the age of 20 and 40 years to avoid any bias on the data, because it may be highly variable if data from an elderly population who have degenerative joint diseases is included. We have included data from subjects whose dominant side was right for the normality of data and to avoid any bias if dominance is a confounder. A limitation of our study is that we have included only male patients, because the Q angle in women is slightly greater than in men, which may have an impact on the outcome [30].

Conclusion

Goniometry and radiography are already widely used for Q angle measurement. Our findings showed that goniometric measurement of the Q angle is as effective and accurate as radiographic measurement of Q angle without exposing patients to radiation.

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Conflicts of interest statement

The authors statement have no conflicts of interest to declare.

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