Effects in the Q angle measurement with maximal voluntary isometric contraction of the quadriceps muscle

Belchior A.C.G. 1, Arakaki J.C. 1,2, Bevilaqua-Grossi D. 2, Reis F.A. 1 and Carvalho P.T.C. 1

ABSTRACT

The purpose of this study was to analyze the difference between the angle of the quadriceps in symptomatic and asymptomatic individuals in two different examination situations, having the quadriceps relaxed and in a maximal voluntary isometric contraction (MVIC) through radiographic measurement, aiming to contribute to the assessment and treatment of patients with patellofemoral disorder (PFD). Through the standard radiological method twenty 21 years old mean women (40 knees) were assessed. All individuals were positioned supine using a U-podalic stabilizer, having their lower limbs relaxed, using a plumb film on the anterior or tuberosity of the tibia. For the statistical analysis, the averages for the asymptomatic and symptomatic groups in a relaxed and MVIC status, as well as the Student's t-test with p < 0.05 significance level were used. The mean values to the Q angle compared to the asymptomatic group were 17.15° on relaxation, and 14.5° on MVIC, while the asymptomatic group presented 21.45° and 15.8°, respectively. The results in the equality analysis between the asymptomatic and symptomatic groups on the relaxed status attained a p = 0.004, and to the maximal voluntary isometric contraction (MVIC), while the asymptomatic group presented 21.45° and 15.8°, respectively. The results in the equality analysis between the Q angle among symptomatic and asymptomatic individuals, being found a higher value in the FPD group, representing a shared complaint in 20% of the population, affecting mainly young 15-25 years old females (1,6,7).

INTRODUCTION

The knee joint is involved in about 50% of the musculoskeletal injuries, and the most common of these injuries is the patellofemoral disorder(1-3). The PFD is an articular disorder manifested by pain in the anterior portion of the knee and a functional deficit that compromises the daily activities(4,5). It constitutes 25% of the injuries compromising the knee and 5% of every sportive injury, representing a shared complaint in 20% of the population, affecting mainly young 15-25 years old females(1,6,7).

The most frequent symptoms are pain in the anterior knee, peripatellar edema, blockage, and patellofemoral articular crepitation(6,8,9). Generally, they are bilateral, and presenting exacerbation periods related to long period in the seat position with the knees flexed, when standing up after being seat, while ascending and descending stairs or walking on inclined surfaces, running, training using weights, and kneeling(5,6,10).

There are several etiologic factors that can generate the PFD, such as neuromuscular imbalances of the oblique vastus medialis (OVM) and vastus lateralis (VL); the shortening of the lateral retinaculum, the ischiotiabils, the iliotibial tract, and the gastrocnemius; the excessive pronation of the subtalar joint; the loosening, or the ligamentous or capsular shortening; bone abnormalities; the excessive anteversion of the femoral cervix; the external torsion of the tibia; enlargement of the pelvis and the high patella(6,10-13).

Related to the active strength exerted on the patella, the main structure responsible by such activity is the quadriceps muscle of the thigh that controls the position of the patella related to the trochlea by means of the oblique fibers of its medialis and lateral portions – the vastus medialis (VM) and the vastus lateralis (VL)(11).

The VM muscle is divided in two portions: the vastus medialis (VML) a muscle that it is inserted in a 15° related to the longitudinal axle of the femur, and that exerts few or no traction to the adequate positioning of the patella, and the oblique vastus medialis (OVM) that is inserted mainly in a 50-55° on the longitudinal axle of the femur, and it is considered the medial dynamic stabilizer of the patellofemoral joint (PFJ). Likewise, the VL muscle is also divided in two portions: the proximal fibers that are originated in the femur, and that are inserted in the medial third of the quadriceps’ tendon of the thigh, constituting the vastus lateralis longus (VLL), and the posterolateral fibers are originated in the iliotibial tract, being more oblique towards its direction, and they are inserted on the base and the lateral edge of the patella, representing the oblique vastus lateralis (OVL) muscle. Taking into account the origins and insertions of these muscles, especially the oblique portions, it is observed its opposite actions, and their importance to the function for the patellar stability(14,15).

Considering the direction of the muscular fibers, the oblique vastus medialis (OVM) is the first muscle that contributes to the medial strength vector, same as the vastus lateralis (VL) is for the lateral strength(6,10).

The insufficiency or hypotrophy of the VMO muscle can generate a patellar malalignment, especially in the last extension grades (0-15° flexion) of the knee joint, where it occurs a major instability in the joint due to a lower bone congruence, but it does not present an efficiency to restrain the lateral traction of the patella(16).

Another factor that may contribute to the pain development or worsening, with a consequent generation of instability in the knee is the malalignment of the patellofemoral joint, whose measurement can be performed through the quadriceps angle (Q)(4,18).

The Q angle is formed by the crossing of two imaginary lines: the first line is formed by the anterosuperior iliac spine up to the medium patellar spot, and the second line is formed by the anterior or tuberosity of the tibia up to the medium patellar spot, and its mean normal value is 13° in men, and 18° in women(2,5,7,11,19).

The increase in the Q angle creates a higher valgus vector and increases the lateral traction of the patella as well, causing a higher pressure in the patellar lateral facet that may lead to a patellar...
subluxation, causing a softening of the cartilage and a stress on the retinaculum, besides of contributing to a spread in the PFD.

The measurement of that angle can be performed using different methods, such as the radiographic method or clinically through the goniometer, and in different ways, having the patient in supine with his knees in total extension of the knee and relaxed quadriceps, or contracted, in orthostatism, seat with the knees in a 90° flexion, or in a or 20-30° with the maximal medial, lateral rotation or in a neutral position of the tibia.

Thus, the aim of this study was to search the difference between the quadriceps angle in symptomatic and asymptomatic individuals in two different examination situations, having the quadriceps relaxed and in maximal voluntary isometric contraction using the radiographic measurement, in order to contribute to the assessment and treatment of patients with PFD.

CASUISTIC AND METHODS

Sampling

It was recruited through oral invitation twenty 15 to 30 years old (mean 21 years) female volunteers (n = 40 knees) during the period from May to July, 2003.

Ten individuals (n = 20 knees) did not present any complaint of pain in the knees; traumatic or surgical records or any pathology involving any of the joints of the lower limbs; vascular, peripheral or central neurological disorder, constituting the group of knees considered normal, that means, asymptomatic.

The remaining persons (n = 20 knees) were diagnosed with PFD, presenting bilateral pain, according to the Cowan et al. criteria that have the following inclusion factors: 1) anterior or retropatellar pain when performing at least two of the following activities: ascending stairs, be seat for long periods, upon squatting, kneeling, or jumping; 2) pain on the patellar palpation; 3) symptoms for more than one month whose onset is not related to any trauma.

As exclusion factors it was considered the following: 1) signs or symptoms of another pathology; 2) recent history (less than three months) of surgery in the knees; 3) patellar luxation or subluxation; 4) clinical evidence of meniscal injury; 5) ligamentous instability; 6) patellar tendinitis; 7) osteoarthrosis or pain irradiated from the columna vertebralis; 8) pregnancy or another condition that may interfere in the data collection.

Before performing the assessments, all volunteers were clarified on the procedure used in the research, and they signed a Free Formal and Clarified Consent Term according to the Federal Regulations for Human Subjects Research referred in the Resolution 196/96 of the National Health Council.

Instruments

U-podalic stabilizer: U formatted metallic plate with two mobile arms, upon which the regions of the heels were positioned. The gap of the arms impeded the lateral rotation of the lower limbs, and such gap corresponded to the distance between the feet after the knees were aligned to the hips.

Radiological device: A 500 mA G3 Model. The distance from the ampoule to the 35 x 91 cm cassette was 1.70 m, a Kodak® film and automatic revelation (Macrotec®).

Procedures

The patient was positioned supine, with their knees in total extension along with the U-podalic stabilizer, and each patient was asked to keep her lower limbs in a relaxing status (figure 1).

Afterwards, the same technician took radiographies in anteroposterior positioning using radiological 35 x 91 cm film, comprising a portion of the hip 15 cm below the previously market TAT using a lead film (4 cm²) fixed on the skin with adhesive tape, in order to facilitate the visualization of the TAT after revealing the film, when the Q angle was traced by the researcher using a conventional rule, a pen, and protractor (figure 2).

A similar procedure was performed along with the request for a maximal voluntary isometric contraction of the quadriceps muscle.

RESULTS

First, it was calculated the means of the Q angle presented in the relaxing status and in the maximal voluntary isometric contraction of asymptomatic and symptomatic patients both in the group of asymptomatic and in the symptomatic group of patients (table 1).
Next, it was performed the statistical analysis using the t-Stu-
dent test to analyze the equality between symptomatic and asym-
tomatic groups (figures 3 and 4). In the relaxation status, it was
attained a p = 0.004, while the maximal voluntary contraction
presented p = 0.26.

![Fig. 3 - Graphic of the measurement of the Q angle attained in the relaxation status](image1)

![Fig. 4 - Graphic of the measurement of the Q angle attained in the maximal voluntary isometric Contraction](image2)

**DISCUSSION**

Following the analysis of the results, it is possible to view the
difference in the Q angle magnitude between symptomatic and asym-
tomatic individuals in the relaxation status (p = 0.004). The mean value found confirms the estimated values found in the lit-
erature, which are the following: 15° mean to asymptomatic indi-
viduals, and 20° to symptomatic individuals.

The reduction in the Q angle value in the maximal voluntary isometric contraction for asymptomatic individuals were also found in a similar study analyzing the Q angle in mean 22 years old healthy
women in the orthostatic position, where the expressed values
found were mean 13°(23).

Nevertheless, the value of the Q angle in symptomatic women
(p = 0.26) found in this study has also presented a reduction dur-
ing the maximal voluntary isometric contraction. As they were PFD
bearers, it was expected a change in the activation of the OVM
function(16), especially having the lower limb in total extension (0°)
where it occurs the major articular instability due to the lower bone
congruence(17,22), and it did not present any efficiency in restrain-
ing the lateral traction of the patella. Thus, with the request on the
maximal voluntary isometric contraction of the quadriceps muscle,
it was estimated that the patella would be lateralized, thus
generating an increase in the Q angle.

But the reduction of the Q angle which was seen can be justi-
fied in studies analyzing the activation of the oblique medial and
vastus lateralis muscles upon isometric exercises on the quadri-
ceps having the knees in total extension, where none of the mus-
cular portions presented preferential activation(24,25).

Other electromyographic studies has examined variables such as
the intensity and the time of the neuromuscular recruitment
between the OVM and VL muscles while performing functional
activities, such as ascending and descending stairs, and walking
in healthy and PFD bearer individuals, but it was found no satisfac-
tory results associated to the PFD(20,24,26).

Analyzing the patellar behavior in PFD bearer women through
computerized tomography, no conclusion was attained as to the
effect of the quadriceps muscle contraction on the patellar decli-
nation angles, but there was a significant increase in the congru-
ence angle, especially in the 0° and 20° flexion knee(27).

Therefore, the behavior in the reduction of the Q angle together
with the maximal voluntary isometric contraction of the quadri-
ceps muscle in PFD bearer individuals leads to a justification of
the use of treatment ways that use such kind of contraction.

The SLR, an exercise performed having the leg straight raised,
is a way of treatment much employed in the PFD rehabilitation(28-
31). Based on this study, we believe that if it is associated to the
maximal voluntary contraction during its execution, it can mini-
imize the bad patellar alignment.

Besides, the present treatment proposals emphasize the
strengthening of the abductor muscles of the hip(32,33) due to the
kinematical imbalance of the lower limbs, and thus, it is wise to
initiate a kinesiotherapeutic SLR exercising program associated to
the hip abduction.

But regardless the form chosen to perform the SLR, physical
exercises promote a sensorial reeducation through the motor ac-
tivity(34), and this is extremely benefic to PFD bearer individuals,
since in general they present proprioceptive abnormalities(3).

Despite this study presents significant data, it had some limita-
tions, such as the cost involved in acquiring radiological images,
as well as the positioning adopted to the procedure in supine,
which we believe that it does not reproduce the optimum func-
tional measurement.

**CONCLUSION**

Considering the data attained in the present study, it was veri-
ﬁed that in a relaxing status, there is signiﬁcant difference be-
tween the value of the Q angle between symptomatic and asym-
tomatic individuals, and such difference is not present in a maximal
isometric contraction of the quadriceps muscle, and there was a
reduction in the value of the angle in both individuals.

All the authors declared there is not any potential conﬂict of inter-
ests regarding this article.

**REFERENCES**

1. Cabral CM, Monteiro-Pedro V. Recuperação funcional de indivíduos com disfun-