

Concordance in the measurement of the distance between the anterior tibial tuberosity to the trochlear groove in axial tomography of the patella at 20 degrees of flexion with respect to 0 degrees

Concordancia en la medida de la distancia entre la tuberosidad anterior de la tibia y el surco troclear en la tomografía axial de rótulas a 20 grados de flexión con respecto a 0 grados

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Summary

Background: Patellofemoral malalignment is a frequent pathology in young people. With an early diagnosis, a timely intervention can be made, so the distance between the intertrochlear groove and the anterior tibial tuberosity (ICG-ATT) is essential to indicate which patients need surgery. Currently patellar axial tomography is taken with cuts at 0, 20 and 45 degrees of flexion, although there is not enough information in the literature that specifies and justifies which degrees of flexion should be used, the purpose of the study is to establish the protocol for patellar axial tomography. ***Objective:*** To establish whether there is agreement between the ICG-ATT measurement performed at 20 and 0 degrees of flexion. ***Methods:*** A concordance study was carried out, 90 patients were taken for a total of 180 knees, and ICG-ATT measurement performed on these images, interposing cuts at 0 degrees and 20 degrees of flexion, to evaluate if there is agreement between the two measurements. ***Results:*** There is an almost perfect agreement of 0.909 between the measurement at 0 and 20 degrees of flexion on the left side and an almost perfect agreement of 0.8872 between the measurement at 0 and 20 degrees of flexion on the right side of the images. evaluated. ***Conclusions:*** Near perfect agreement was found between the ICG-ATT measurement performed at 0 and 20 degrees of flexion, meaning that there is no difference in taking the measurement at these degrees. We propose that patellar CT protocols should be taken at 20 degrees, supported by the biomechanics of the knee, because the stability of flexion at 20 degrees is based primarily on bone restriction as well as decreased radiation dose. We suggest future research with standardized protocols at 20 degrees of flexion.

Resumen

Antecedentes: El mal alineamiento patelofemoral es una patología frecuente en jóvenes. Con un diagnóstico temprano se puede hacer una intervención oportuna, por lo que la distancia entre el surco intertroclear y la tuberosidad anterior tibial (SIT-TAT) es fundamental para indicar qué pacientes necesitan cirugía. Actualmente, la tomografía axial de rótulas se toma con cortes a 0, 20 y 45 grados de flexión; aunque en la literatura no existe suficiente información que especifique y justifique los grados de flexión que se deben usar. ***Objetivo:*** Establecer si existe concordancia entre las medidas de SIT-TAT realizadas a 20 y 0 grados de flexión. ***Metodología:*** Se realizó un estudio de concordancia, incluyendo 90 pacientes para un total de 180 rodillas. A estas imágenes se les realizó la medida SIT-TAT interponiendo cortes a 0 grados y a 20 grados, para evaluar si existe concordancia entre estas dos medidas. ***Resultados:*** Se observó una concordancia de 0,909, casi perfecta, entre la medición a 0 y 20 grados de flexión en el lado izquierdo y una concordancia de 0,8872, casi perfecta, entre la medición a 0 y 20 grados de flexión en el lado derecho de las imágenes evaluadas. ***Conclusiones:*** Se encontró una concordancia casi perfecta entre las medidas de SIT-TAT realizadas a 0 y 20 grados de flexión, lo que quiere decir que no hay diferencia en la toma de la medida a estos grados. Los autores proponen que los protocolos de TAC de rótulas se tomen a 20 grados, soportados por la biomecánica de la rodilla, debido a que la estabilidad de la flexión a 20 grados se basa principalmente en la restricción ósea, así como también por la disminución en la dosis de radiación. Se sugieren futuras investigaciones con protocolos estandarizados a 20 grados de flexión.

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Introduction

Patellofemoral malalignment manifests as pain in the anterior region of the knee, the diagnosis is made through the union between physical examination, clinical history and diagnostic images (1). The images evaluate other causes of pain in the knee. Among the diagnostic methods are computed tomography (CT) of the patella, which is more cost-effective than magnetic resonance imaging (MRI) and more specific than radiography (2). The distance between the intertrochlear groove and the anterior tibial tuberosity (ICG-ATT) has a high sensitivity for femoral alignment and femorotibial rotation, its normal value ranges between 9-20 mm and if it is greater than 20 mm, the patient requires surgical intervention; this measurement is taken in axial reconstructions of the knee. Gulati et al. explain the biomechanics of the knee joint, which consists of the fact that from 30 degrees of flexion, stability is based mainly on the bone component and not on the ligaments, muscles or tendons (3); for this reason, most of the time measurements are taken in flexion.

At the institution, the patella CT protocol is taken at 0, 20 and 45 degrees of flexion. At the moment, there is no consensus protocol. In the literature review, images are taken at different degrees of flexion and insist on the implementation of a standardized protocol.

Theoretical framework

Patellofemoral pain is one of the most frequent consultations in orthopedics, occurring in approximately 22 out of every 1000 people per year (1), affecting up to 30% of adolescents (2). The affected population are young women, twice as many as men. The symptomatology is mainly based on pain in the anterior aspect of the knee or retropatellar, which may increase in certain situations such as going up and down stairs or when resuming activity after prolonged rest. It may also manifest with cramps, functional limitation or instability of the patella (1).

Several causes are attributed to this condition, one of the main ones is the abnormal alignment of the patella, which can be generated by alterations in periarticular soft tissues or by bone alterations such as femoral or tibial rotation, trochlear dysplasia or hypoplasia of the femoral condyle. This leads to wear and tear and progressive lesion of the patellofemoral joint, a mechanical problem that translates into irritation of innervated structures (subchondral bone, retinaculum, synovial membrane, among others) (2), which produces the described symptomatology and triggers the appearance of various pathologies such as patellofemoral pain syndrome, osteochondral lesions, osteoarthritis, primary and recurrent dislocation of the patella, alterations of the extensor mechanism.

Early diagnosis is achieved with an adequate clinical history, physical examination and diagnostic imaging. Dynamic studies consist of taking images in different degrees of flexion. To understand this, it is important to know the anatomy and biomechanics of the knee joint. The contact area with the patella increases with increasing degrees of flexion, the trochlea engages with the patella at 30 degrees of flexion. From 0-30 degrees of flexion the quadriceps, medial retinaculum, lateral retinaculum and patellar tendon act as static stabilizers, but at 30 degrees flexion stability is based primarily on bony restraint; in full extension patella contact with the trochlea is less, predisposing to instability (3, 4).

Diagnostic imaging includes anteroposterior and lateral knee radiography at 30 degrees and MRI, which is superior in the evaluation of soft tissues and in the identification of acute osteochondral lesions, degenerative cartilage lesions and medial patellofemoral ligament lesions that cannot be identified on CT or radiography. MRI also allows the determination of different measurements, including the TT TG (tibial tubercle-trochlear groove distance) and the height of the patella. The TT TG distance, translated as intertrochlear groove and tibial anterior tuberosity (ICG-ATT) indicates patellar lateralization, and the Insall-Salvati and Caton Deschamps indices are used to assess patella height. The disadvantages of MRI are the long acquisition times, its high cost and the relative contraindications, such as some ferromagnetic devices, and absolute contraindications, such as claustrophobia (3).

CT of the patella is a more sensitive and specific diagnostic method than radiography (5-7). But compared to MRI, it uses ionizing radiation. The effective dose refers to the absorbed dose and radiosensitivity relative to organ exposure. This measure represents a risk for the general population, in both sexes, at all ages and sizes (8), knee CT has an effective dose of 0.16 mSv (9).

The dynamic protocol consists of taking the study with different degrees of flexion: at 0, 20 and 45 degrees lets evaluate some measures and aspects such as lateralization of the patella, the angle of congruency, evaluation of the morphology of the trochlear sulcus and ICG-ATT (5, 7).

In a 2018 systematic review on the stratification of factors influencing patellofemoral joint stability, they conclude that ICG-ATT distance and sulcus angle in pediatric patients are the only two parameters that have statistical confidence in predicting the risk of patellar dislocation recurrence (10). In the last decade, it has been shown that increased ICG-ATT distance is related to increased incidence of patellofemoral instability, which quantifies the medial or lateral distance from two points: the deepest point of the trochlear groove and the most anterior point of the tibial tuberosity. The value of 20 mm has been used to define if the patient needs surgical intervention (11, 12).

Suomalainen et al. in 2018 evaluated 16 knee MRI studies in healthy adolescents with different degrees of flexion, from 0 to 30 degrees, and found that the ICG-ATT distance decreases 0.29 mm for each degree of flexion; they concluded that standardization of the knee flexion protocol for measuring ICG-ATT is necessary (13).

Materials and methods

This is a concordance study, performed in patients with suspected patellofemoral malalignment; images obtained from a repository of anonymized patella scans were used, the main inclusion criterion was patients with mature skeleton. Exclusion criteria were patients with open phthisis and with previous knee surgery (joint replacements or surgeries that generate bony changes evident in CT).

Ninety patients were included, for a sample size of 180 knees. A one-sided hypothesis was evaluated for Lin's correlation coefficient of concordance between X and Y. Sample size calculation was obtained based on the following parameters:

Mean of X and Y measurement = 14.4 millimeters
Standard deviation of X and Y = 5.4 millimeters.
Correlation between X and Y (ρ0) under the null hypothesis = 0.9
Correlation between X and Y (ρ1) under the alternative hypothesis = 0.93
Significance level (α)= 0.05
Power (1 -Beta) = 0.8

For the study, the current protocol of the institution was followed, consisting of the acquisition of three volumes of images with 0, 20 and 45 degrees of flexion. The ICG-ATT distance measurement was performed as explained in Figure 1 (10, 14).

The principal investigator performed the measurements by interposing the slices as written by Schoettle and Fithian (8, 12, 15). With the superimposed images a numerical indicative was assigned to each one, subsequently the images were distributed to the radiology resident and the radiologist, who were masked with respect to the degrees of flexion and performed the ICG-ATT measurement.

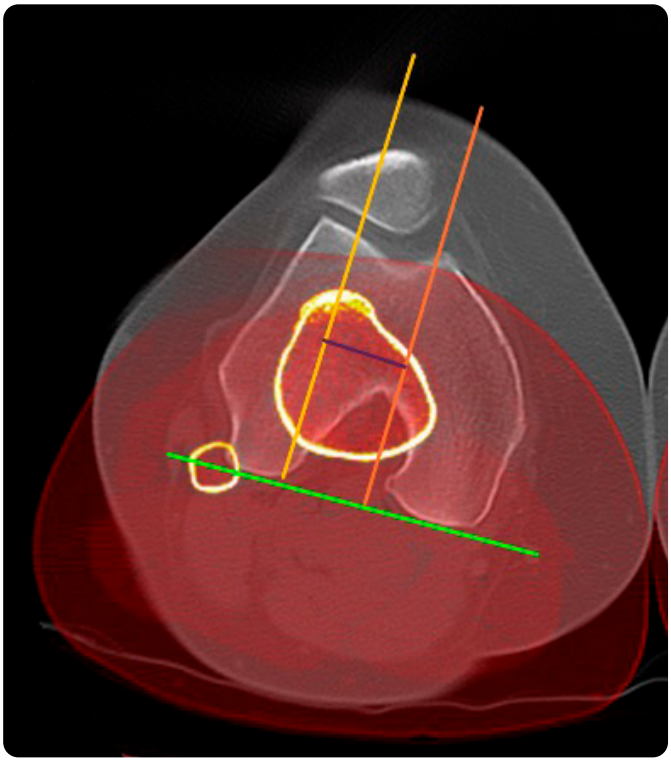


Figure 1. Method used to measure the ICG-ATT distance, according to the institutional protocol. The superposition of CT axial slices at the level of the trochlea and the tuberosity of the tibia is observed. For the measurement, a line is drawn along the posterior aspect of the femoral condyles (green line), then a line perpendicular to this passing through the femoral groove (orange line) and the distance (black line) is measured between the most anterior point of the tibial tuberosity (yellow line) and the trochlear groove.

Statistical analysis

The Shapiro-Wilk statistical test was performed to determine the type of distribution of the variables, finding that the variables sex, age and ICG-ATT distance are continuous with a nonparametric distribution. They were reported as quantitative measures such as median and interquartile range (IQR). Subsequently, the kappa index was analyzed to determine the concordance between the two degrees of flexion.

Results

In this study, 180 knees of 90 patients were analyzed, of which 83 % (n=75) were women and 16 % (n=15) men, in an age range between 18 and 68 years with an average of 37 years (Table 1). The variables sex, age and ICG-ATT distance were defined as nonparametric continuous. A kappa index of 0.909 was observed between the measurement at 0-0 and 20-20 degrees of flexion on the left side and a kappa index of 0.8872 between the measurement at 0-0 and 20-20 degrees of flexion on the right side of the patients evaluated (table 2).

In addition, the ICG-ATT distance at the right knee at 0 degrees of flexion was found to be 18 mm RIC (23-17), with a standard deviation (SD) of 4.53. At 20 degrees of flexion it is 18.5 mm RIC (2215), with a SD of 6.36. In the left knee at 0 degrees of flexion it is 18 mm, RIC (24-17) with an SD of 5.17 and at 20 degrees of flexion it is 18.5 mm RIC (23-15) with an SD of 6.47 (Table 3). The ICG-ATT distance was explored according to the "sex" category (Table 4).

Table 1. Demographic table and description of the population

Demographic variables	Total patients (*n*=90)	Porcentage (%)
Sex		
Female	75	83
Male	15	16
Age group		
18-30 years old	21	23
30-68 years old	69	76

Table 2. Concordance in ICG-ATT measurement at 0-0 and 20-20 degrees of flexion in the right and left knees

Point	% of agreement	Kappa
Left knee	95.56	0.909
Right Knee	94.44	0.8872

Table 3. Measures of central tendency of the ICG-ATT distance at 0 and 20 degrees of flexion

Variable	Median (mm)	RIC	SD
ICG-ATT 0 right	18.0	23-17	4.53
ICG-ATT 20 right	18.5	22-15	6.36
ICG-ATT 0 left	18.0	24-17	5.17

ICG-ATT 20 left	18.5	23-15	6.47

Table 4. Measures of central tendency of ICG-ATT distance at 0 and 20 degrees of flexion according to sex

Variable	Category	Median (mm)	Range RIC	SD
ICG-ATT 0 right	F	18	23-17	4.62
	M	18	22-16	4.13
ICG-ATT 20 right	F	19	22-15	6.40
	M	17	21-12	6.06
ICG-ATT 0 left	F	18	25-17	5.44
	M	18	21-17	3.52
ICG-ATT 20 left	F	19	23-15	6.59
	M	17	21-13	5.65

Discussion

In our analysis we found that there is an almost perfect agreement of 0.909 between the measurement at 0-0 and 20-20 degrees of flexion on the left side and an almost perfect agreement of 0.8872 on the right side of the patients evaluated, which means that there is no significant difference when measuring at 0 or 20 degrees of flexion. These results are contrary to those found by Dietrich et al. who evaluated 30 knees in asymptomatic patients in extension, 15 and 30 degrees of flexion, where the mean difference in extension vs. flexion at 30 degrees was 7 mm, plus or minus 3.4 mm, demonstrating that there is a statistically significant difference between the measurements (16-20).

In our analysis, the ICG-ATT distance was 18 mm at 0 degrees and 18.5 mm at 20 degrees, demonstrating an increase of 0.5 mm. This is contradictory to the results of the study by Suomalainen et al. who evaluated 26 adolescent knees, finding that the ICG-ATT distance decreased 0.29 mm for each degree of increase in flexion (p=0.001) (13). In another study by Marquez conducted in 2016 where they analyzed 12 adult knees, the ICG-ATT measurement decreased as flexion increased, so they propose using anatomical repairs dependent on posterior cruciate ligament and patellar tendon insertion, instead of the already known bony anatomical repairs (13,19). We also found differences in the age of presentation of patellofemoral malalignment with an average of 37 years and a range between 30-68 years, being reported in the literature a more frequent pathology in adolescents and young adults (1, 2).

The main limitation of our study lies in the lack of standardization of the patellar CT protocol, since many times the acquisition in flexion at 20 degrees is not accurate because the goniometer is not routinely used to measure 20 degrees, or because of the absence of parameterized cushions for this purpose. Several limitations are also noted in other studies, including sample size, type of population. The sample sizes are small, which limits determining an exponential effect of the value of the ICG-ATT measurement and the degrees of flexion. Likewise, most of the patients included are healthy individuals, leaving in doubt how this measure behaves during flexion in patients diagnosed with malalignment.

Our results support the need for a standardized protocol for patellar CT acquisition, and we suggest that a single acquisition at 20 degrees be performed for several reasons. First, the biomechanics of the knee in flexion allow the patella to be properly centered with respect to the trochlea, avoiding the external rotation of the tibia and abduction of the femur that occurs during extension (13, 19). Second, radiation tapering with the use of a specific protocol is one of the most widely used strategies to reduce the effective radiation dose in CT (20). Likewise, it would be further suggested to include the routine use of the goniometer.

Conclusion

An almost perfect concordance was found between ICG-ATT measurements taken at 0 and 20 degrees of flexion, this means that there is no difference in taking the measurement at these degrees. The authors of this work propose that patellar CT protocols should be taken at 20 degrees taking into account the biomechanics of the knee, due to the fact that the stability of flexion at 20 degrees is based mainly on bone restriction and also because of the decrease in radiation dose. Future research with standardized protocols at 20 degrees of flexion is suggested.

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