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CT Patellar Cortex Tilt Angle: A Radiological Method to Measure Patellar Tilt

Background/Objectives: The role of patellar tilt in the anterior knee pain is indisputable. Traditionally, the lateral patellofemoral angle of Laurin has been defined in both the axial view and CT images for measuring the tilt of patella. We present a new angle, which is independent of the morphology of patella and directly relates to clinical assessment of the tilt, which is appreciated from palpation of the edges of the patella.

Patients and Methods: 38 patients with anterior knee pain and forty normal control subjects were examined using CT scan of patellofemoral joint in 15 degrees of knee flexion. The amount of lateral patellar tilt was quantitatively assessed using the lateral patellofemoral angle, as described by Laurin et al, and the newly defined patellar cortex tilt angle. This angle is subtended by the line drawn along the posterior femoral condyles and the one parallel to the subchondral bone of patellar cortex. The fifteen-degree tilt was taken as normal cut-off point for patellar cortex tilt angle in the control group.

Results: In patients, the average tilt of patella, using the patellar cortex tilt angle was 15.26 versus 7.05 in the control group. Using Student's t test, the difference between the two means was significant (P<0.001). The sensitivity and specificity of patellar cortex tilt angle were 40 and 90 percent, respectively There was a moderate agreement between our presented test and the lateral tilt angle test (kappa=0.40, P<0.001).

Conclusion: Our results indicate that patellar tilt can also be detected using patellar cortex tilt angle. We need more specific studies to determine the validity of the test.

Keywords: knee, patella, pain

Introduction

The role of patellofemoral malalignment in anterior knee pain has been shown by many investigators. [1-3] Detection of lateral displacement was the sole purpose of earlier studies until Laurin et al. introduced the concept of patellar tilt as a form of malalignment. This tilt could be observed even with the patella completely reduced in the femoral groove, and was therefore independent of the mediolateral position of the patella. The patella, however, needs to be severely tilted before the lateral patellofemoral angle becomes abnormal, and the method cannot detect minor degrees of tilt.

Tangential (axial) views of the patellofemoral joint provide good basic information regarding the condition of this joint.[4] However, subtle patellar tracking abnormalities in the first 20 to 30 degrees of knee flexion are difficult or impossible to detect with tangential radiographs of the patella, because it is technically difficult to capture the patella on a radiography cassette in this range of minimal knee flexion. [5-8] To define patellar tracking accurately, CT offers sequential images at any degree of knee flexion using the mid-transverse patella as a stable plane of reference. [9] The lateral patellofemoral angle of Laurin and the congruence angle are currently used by many investigators to define patellar maltracking. Both of these measurements use the lateral facet of patella as a reference point.

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Little attention has been paid to the morphology of the lateral facet. This facet of patella is subject to various developmental pathologic changes, which in turn, can affect the morphology of the lateral facet and make it difficult to draw and measure the lateral patellofemoral tilt angle.

Accepting the lateral patellofemoral angle of Laurin as an effective and useful method for determining patellar tilt, we sought a simple and reproducible measure of patellar tilt on CT scan. We defined a new angle that addresses the anterior cortex of patella instead of the lateral patellar facet to reflect the assessment of the tilt on physical examination (Figure 1). We assume this angle may prove useful in the evaluation of tilt when lateral facet of patella is defective.

Patients and Methods

In this study, 38 patients with anterior knee pain were examined using computed tomography with the knee in 15 degrees of flexion. Twenty-six patients were female and 12 male. The inclusion criteria for patients were an age of 15-30 years, gross patellar tilt in physical exam, and anterior knee pain for at least one year. The clinical diagnosis of patellar malalignment was based strictly on the description by Fulkerson et al.[10] Patients who had ligamentous instability, meniscal injury, medial plica syndrome, patellofemoral osteoarthrosis, reflex sympathetic dystrophy, overuse syndrome, rheumatoid arthritis, or a tumor adjacent to the knee joint were excluded from the study.

Twenty-five out of 38 patients had bilateral symptoms. Nine patients had positive apprehension test. Patellar grinding test was positive in 34 patients. We assessed the lateral patellar tilt by pushing posteriorly on the medial border of the patella. If the patellar tilt was not corrected to neutral or beyond, we considered that a significant patellar mobility restriction. This test was positive in ten patients.

A control group of forty volunteers were also examined. The hazards of x-ray were completely described for all of them and a written consent was taken from the Ethics Committee of Urmia University of Medical Sciences. Eighteen controls were male and 22 were female. The mean age was 22 years. None of these individuals had signs or symptoms related to the patellofemoral joint.

To exclude the pairing effect on the distribution of data, we randomly selected either the right or the left knee of each control individual and the patient with bilateral involvement.

Definition: Patellar cortex tilt angle was subtended by the line drawing from one corner of the patella to the other and was measured as the deviation of this line from the posterior femoral condyles (Figures 1 and 2). The lateral tilt was termed positive to correlate with similar measurements described in the literature on biomechanics of the patella. When the two edges of the patella were not readily visible, a

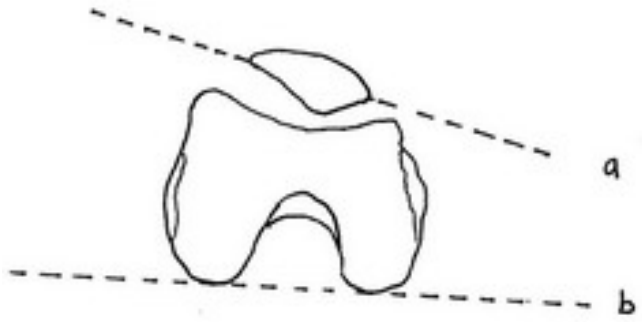

Fig 1. Radiological tilt of patella can be appreciated from clinical tilt assessment using CT patellar cortex tilt angle (i.e. the angle between lines a and b).

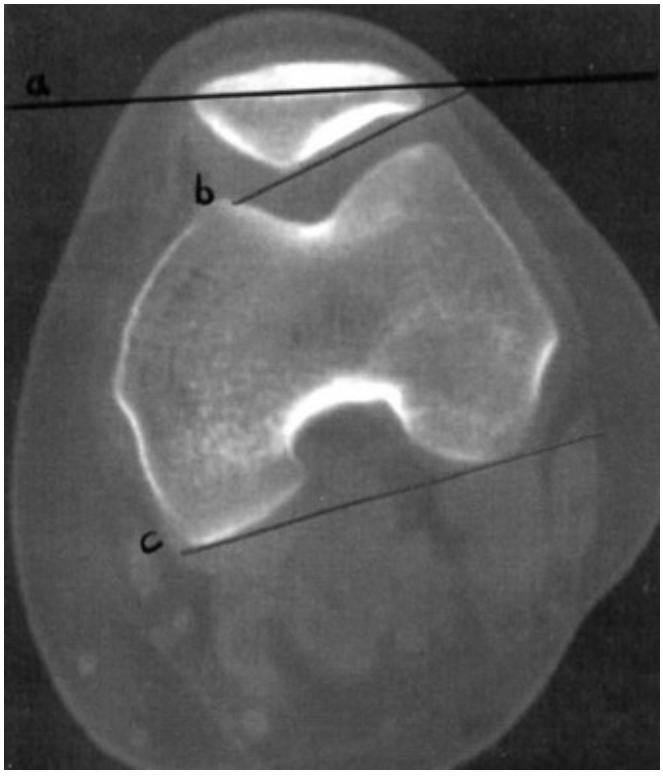

Fig 2. The angle between a and c is the patellar cortex tilt angle and the angle that is subtended by b and c is the conventional lateral patellofemoral angle

line was drawn along the anterior patellar cortex (anterior cortical line) parallel to the edge-to-edge line.

Radiological assessment

For all patients, anteroposterior, lateral and Merchant tangential radiography of the knee and computed tomography scan were done. The computed tomographic examination consisted of imaging at the mid-patellar level, with the patient supine on the table and the knee in 15 degrees flexion. The individual was told to relax the muscles of the thigh.

Computed tomography was also done for all individuals of the control group with the same technique. For computed tomography imaging, the amount of tilt was recorded as the patellar cortex tilt angle. The lateral patellofemoral angle of Laurin was also measured in both the case and the control groups. The congruence angle was used for quantifying patellar subluxation.

Data analysis: The agreement between the presented test and the lateral tilt angle test (the routine test) was measured by kappa. We used Student's t test to determine the mean difference of patellar tilt angle between the cases and controls. According to the, observed difference, the cut-off point value was determined, based on which sensitivity, specificity and predictive values were calculated.

Results

Calculating kappa statistics showed that there was a moderate agreement between our presented test and the lateral tilt angle test (kappa=0.40, P<0.001).

Analysis of data showed that in the control group, the 95th percentile was at 15 degrees of tilt. It meants that 95 percent of normal subjects had less than 15 degrees of patellar tilt angle. The authors, therefore, used 15 degrees as the cut-off point between normal and the tilt. The mean patellar cortex tilt angle in the case group was 15.26 (95% CI: 11.78-18.75) and 7.05 (95% CI: 5.65-8.45) in the control group. The P value was significant (t test P <0.001).

If applied to the case group, 15 patients would be out of the normal range, but only 2 cases would be in control group.

The bar chart (Figure 3) shows that patient with anterior knee pain were more likely than the normal ones to have a patellar tilt.

Considering the point of 15 degrees as the cut-off point, the sensitivity and specificity of this angle would be 39.5% and 95%, respectively. The positive and negative predictive values would also be 88% and 62%, respectively. By these values, the positive likelihood ratio is 7.89 and the negative likelihood ratio is 62.29.

Using Merchant radiological criteria for defining patellar subluxation, 17 cases in the control group and 20 patients in the case group had subluxation. The difference was significant (P<0.005).

Accepting the lateral patellofemoral angle as a valid test, 23 were normal angles and 15 were tilted in the case group. In the control group, there were 4 tilts and 36 normal angles. Kappa test showed a moderate agreement between the positive values for the lateral patellofemoral tilt angle and patellar cortex tilt angle. However, there was a strong agreement between negative values.

Discussion

In evaluating patients with anterior knee pain, the diagnosis of patellar tilt cannot always be made with certainty on a clinical basis. Moreover, the current inability of the orthopedic community to agree on a surgical protocol for this condition does not detract the necessity to recognize it.

Since the patellar tilt is no more than a subtle tilt on

Fig 3. Bar chart comparing patellar cortex tilt angle in the case and control groups.

clinical examination, it should be measured roentgenographically.

Laurin et al. recognized that the normally tracking patella is centered within the trochlea by 20 degrees of knee flexion. We performed CT scans at 15 degrees of knee flexion to guarantee the centralization of patella within the trochlear groove. The posterior condyle reference line in CT scan is symmetric and reproducible for determining the patellar cortex tilt angle. Many investigators have shown that the lateral patellofemoral tilt angle is a reliable indicator for determining the patellar tilt [11, 12], but it has its own drawbacks one of which has received little attention: the angle lacks sensitivity to patellar morphology.

Unusual patellar shapes can lead to misleading values. In addition, the lateral facet of patella, which is necessary for the measurement of the lateral patellofemoral tilt angle, is often difficult to define. Wiberg classification was based on this variable morphology. The concavity of the lateral facet is not consistent. It is difficult to outline the lateral facet in pebble and the Alpine hunter's cap deformities of patella. In patients with patellofemoral osteoarthrosis, large osteophytes and bone erosion may interfere with the actual measurement of the lateral tilt angle (Figure 4). The patellar cortex tilt angle is independent of these variables and it seems to be well suited for detecting patellar tilt. It is usually easy to draw, and when it is not, a line parallel to the subchondral bone of anterior patella will suffice.

Nonetheless, the patellar cortex tilt angle has its own drawbacks. On the femoral side, the condyles are not subject to dysplasia, but the position of one condyle relative to the other varies with the level of section. In addition, femoral torsion can cause rotation of the distal femur, and CT imaging is too expensive for routine screening.

Our purpose in this paper is not to show superiority of this radiological measurement to other well-documented indices, but we think it is a useful and accurate method that can be helpful in cases where dysplasias and joint defects interfere with patellofemoral tilt measurements.

It is clear, however, that patellar cortex tilt angle cannot evaluate subluxation. The prevalence of patellar tilt in the absence of subluxation and vice versa is open to discussion. Schutzer et al found that only 19 of 45 patients had the tilt without subluxation with the knee at neutral extension.[9] In our study, carried out at 15-degree flexion, 52% of patients had the tilt without subluxation and 42% had subluxation without tilt. Combining Merchant criteria, we found that the lateral patellofemoral tilt and the patellar cortex tilt angles can help the surgeon to better understand the alignment pattern of a given patient's knee and assist in determining how to proceed with further diagnostic testing or treatment planning.

Conclusion

The aim of this study was to assess the diagnostic usefulness of the proposed method in a group of patients in comparison to normal controls. The level of agreement between the new method and the routine method of lateral tilt angle shows the reliability of the former. The calculated sensitivity and specificity of the new method is not for its validation but to explain the difference in the results of the case and control groups. Kappa statistics indicate the moderate agreement of the two methods. The findings can be soundly interpreted once the new method is validated and the results are compared with a diagnostic

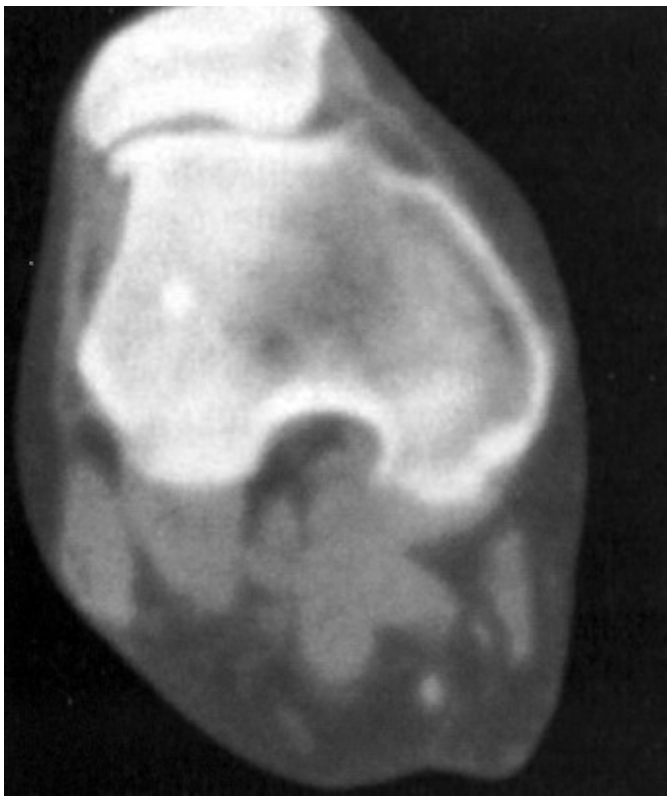

Fig 4. The lateral patellar tilt angle could not be delineated in this patient with degenerative changes of patellofemoral joint.

gold standard.

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