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Kinematic and dynamic axial computerized tomography of the patellofemoral joint in patients with anterior knee pain

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Anterior diz ağrısı olan hastaların patellofemoral eklem kinematik ve dinamik aksiyel bilgisayarlı tomografisi

Bu çalışmaya 26 hastanın 38 dizi (12'si çift taraflı) dahil edildi. Çalışmada 22 kadın, 4 erkek hasta vardı. (ortalama yaş 29). Her iki dizin kas kontraksiyonu ile ve olmaksızın 0°, 10°, 20°, 30°, 40° ve 60° fleksiyonda aksiyel BT incelemesi yapıldı. Görüntüler daima midpateller seviyeden alındı. Her iki diz pozisyonda Pateller tilt açısı (PTA). Kongruans (Uyum) açısı (CA) ve sulkus açısı (SA) ölçüldü. Böylece her diz pozisyonda patellofemoral uyumsuzluk tipi belirlenip, tabloda belirtildi. Sonra dizler için uyumsuzluk tipi not edildi. Patellofemoral uyumsuzluk tipleri şöyleydi; 1) Tilt-lateralizasyon (TL: 12 diz), 2) Lateralizasyon (L: 4 diz), 3) Medializasyon (M:5 diz), 4) Lateral-medial instabilite (LM: 1 diz). 5) Tilt (T: 1 diz). 15 diz normal olarak sınıflandırıldı. Gruplar ayrı ayrı analiz edildi. TL grupta, eğer görüntüler sadece 30° veya ilk 30° fleksiyonda alınmış ise 9 vakada (T) veya (L) komponenti kaydedilebildi. L grubunda, 2 patella 30°'de redükte oldu. (M) grubunda 3 dizde medializasyon 10°, 20° ve 30°'de başladı. 1 patella 40°'de redükte oldu. (LM) grubunda patella 0°, 20°'de lateralize ve 30° ve 40°'de medialize oldu. (T) grubunda patella sadece 20°, 40° ve 60°'de tilt yaptı. Bu çalışma gösterdi ki sadece 30°'de alınan görüntülerde önemli bilgiler gözden kaçmaktadır. Ayrıca ilk 30° fleksiyonda alınınan görüntüler doğru olarak instabilite tipini göstermeyecektir. Doğru teşhis için bütün fleksiyon derecelerinden alınan görüntüler gereklidir. Değişik diz pozisyonlarındaki uyumsuzluk tiplerinin belirlenmesi yeni bir kavramdır. Bu metodoloji ile, medial ve medial-lateral instabilitelerin varlığı verifiye edilir. Böylece sadece lateral instabiliteyi içeren sınıflandırma sistemleri tartışılır.

Anahtar kelimeler: *Ön diz ağrısı, patellofemoral eklem, bilgisayarlı tomografi*

Kinematic and dynamic axial computerized tomography of the patellofemoral joint in patients with anterior knee pain

38 knee of 26 patients with anterior knee pain (12 bilateral) were included in the study. There were 22 women and 4 men (av. age: 29). Axial CT examination of both knees were done at 0°, 10°, 30°, 40° and 60° of flexion with and without muscle contraction. Images were always taken at midpatellar level. Patellar tilt angle (PTA), congruence angle (CA) and angle (SA) were measured at each knee position. Normal values were also obtainedfrom 14 normal volunteers (28 knees). Thus, types of patellofemoral incongruence for the knees were noted. Types of patellofemoral incongruence were as follows: 1) Tilt+lateralization (TL: 12 knees), 2), lateralization (L: 4 knees), 3) medialization (M: 5 knees), 4) lateral to medial instability (LM: 1 knee). 15 knees were classified as normal. When the groups were analyzed seperately, in the TL group, (T) or (L) component would have been missed in 9 cases if the images were taken only at 30° or only in the first 30° of flexion. In the (L) group 2 patellae were reduced at 30°. In 3 knees in the (M) groupmedialization began at 10°, 20°, and 30°. 1 patella was reduced at 40°. In the (T) case, the patella was tilted only at 20°, 40°, and 60°. This study showed that axial images taken only at 30° will miss important information. Imaging in the first 30° of flexion will not reveal the correct type of instability either. Serial imaging in a wider range of flexion is necessary for correct diagnosis. Determination of the type of incongruence at different knee positions is a new concept. Hence, the classification systems including only the lateral instability should be questioned.

Keywords: *Anterior knee pain, patellofemoral joint, computerized tomography*

Patellofemoral malalignment is a common cause of knee pain which has been usually callad as patellofemoral pain or anterior knee pain (4, 5, 12). The condition has been claimed to predispose to chondromalacia and arthrosis (4, 11, 14).

Patellofemoral disorders may minic internal derangements as well as the extraarticular disorders of the knee. Patellofemoral incongruence may not be present in all the patients with anterior knee pain. In fact, the documentation of patellofemoral incongruence as well as its type, if present, is of utmost importance for proper treatment.

Many axial radiographic techniques in varision knee positions have been devised to evaluate patellofemoral relationship (1, 7, 13, 15, 17, 19). Both technical and interpretive problems have been encountered with most of these technipues (2, 16, 18, 21). Axial plain radiographic evaluation of the patellofemoral

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joint requires knee flexion of at least 30° (3, 10, 13, 16, 18, 21). It has recently been emphasized that imaging within the unstable range of motion, that is the first 20°, 30° of flexion, is of prime importance (4, 13, 16, 21, 22, 23). In addition, imaging under static conditation can be misleading (13).

The above-mentitation difficulties led us to evaluate the patellofemoral relationship in a wider range of knee flexion in patient with anterior knee pain. We also attempted to find out if contaction of the thigh muscles had any influence on patellofemoral relationship.

Materials and methods

Forty consective patients with anterior knee pain underwent axial computerized tomography of both patellofemoral joints. The firs fourteen patients were excluded because of technical problems. 26 patients were included in this prospective study. There were 22 females and 4 males whose ages averaged 29 years (range, 16-57 years). Symptoms were bilateral in 12, and unilateral in 14 (right: 10, left:4) patients. Thus, the study consisted of 38 symptomatic knees. Pain with ascending and descending stairs, anteriorly localized pain and 'movie sing' were the most prominent symptoms.

The patients underwent clinical examination of the patellofemoral joint as well as routine examination of the knee. Six patients underwent computerized tomography and/or magnetic resonance imaging for possible meniscus lesion. None had any meniscus lesion with these imaging techniques. Two other patients underwent arthroscopy which revealed grade 1 and grade 4 lesions of the patellar articular cartilage. None of the knee showed laxity on clinical examination.

CT scans were obtained at 0°, 10°, 20°, 30°, 40°, and 60° of flexion with and without contraction of the thigh muscles. Simple wedges were used to obtain the desired angle of knee flexion. The CT scanner was focused at midpatellar level prior to each image. Thus, twelve images were obtained for each patients. In other words, measurements were made on twenty-four images for each individual.

Fourteen normal volunteers (28 knees) with no history of previous or current knee problems olso underwent CT scanning with the same technique.

Three angles were measured:1) patellar tilt angle (PTA), an angle subtended by a line parallel with the lateral patellar facet and the posterior condylar reference line, 2) sulcus angle (SA), formed by the crossing of lines drawn parallel to medial and lateral trochlear facets, 3) congruence angle (CA), obtained by bisecting the SA and then drawing a second line from the apex of the trochlea to the deepest portion of the median groove of the patella.

Mean values and standard deviations were calculated on normal knees for each knee position. Based on the normal values, types of incongruence were noted for each knee position separately and plotted on a table. Then, the type of malalignment was determined.

Results

The types of patellofemoral malaligment are given on Table 1.

Type		no no knees
Tilt+lateralizasyon	(TL)	12
Lateralization	(L)	4
Medialization	(M)	5
Lateral to medial instability	(LM)	1
Tilt	(T)	1
Normal		15
Total		38

Table 1: Types of patellofemoral malaignment

Some of the cases in the (TL) group demonstrated only (T) or (L) at some knee positions. (TL) was present at all knee positions in only 3 knees. (T) component in 2 knees and (L) component in other 2 knees would have been missed if only the sections 30° of flexion were taken into consideration. (L) component in 3 knee, and (T) component in 2 knees appeared only after 20° to 30° of flexion. (T) component disappeared after 30° to 40° in 3 cases. At 60° of flexion, the position of the patellae were as follows: 4(L), 1(M), 1 normal, and 6 (TL).

2 patellae in the (L) group were reduced at 30°. 1 patella was lateralized at all knee positions, and another one was medialized at 60°.

3 patellae from the (M) group became medialized at 10°, 20°, and 30°. One patella was reduced at 40°. In another case, patella was centralized at 10° and 30° and medialized in other knee position.

In the case with lateral to mmedial instability, the patella was lateralized in the first 20° of flexion, medialized at 30° and 40°, and centralized at 60°.

In the (T) case, the patella was tilted at 20°, 40°, and centralized at 0°, 10°, 30°, 39% of the symptomatic knees exhibited normal patellofemoral alignment on serial CT scans. Patellofemoral incongruence was demonstrated in 7 of 14 unilaterally symptomotic knees. The asymptomatic contralateral knees exhibited similar incongruence in these knees.

The sulcus angle was highner than the normal values at all knee positions in nine cases. Six of these cases were in the (TL) group, and two were in the (L) group. One was in the normally tracking group.

No conclusion could be drawn on the effect of muscle contraction on the patellar tilt angle and the congruence angle in symptomatic knees. Muscle contraction increased the angles in some cases and decresed in others.

Discussion

The imroptance of computerized tomograpy and magnetic resonance imaging in the evaluation of patellofemoral relationship in the first 20°-30° of flexion

has been recently emphasezed (20-23). The images have usually been taken with 5° or 10° increments between 0° and 30° of flexion. More recently, Fulkerson (6), recommended CT imaging in the first 60° of flexion but did not report his findings. This study, confirmed the importance of axial imaging in the early degrees of knee flexion. an even more important observation is that imaging only in early flexion is not sufficient. This study clearly showed that imaging in a wider range of motion is needed, otherwise important information will be missed. Among the (TL) cases, three would be classified as (L) and two would be classified as (T) if only the images at 30° were considered. Moreover, two (L) and one (M) case would be missed. The (TL) cases comprised the largest group of abnormal patellar tracking in the first 20°-30° and either the (T) or (L) component dissappeared thenafter. In other cases, the pattern was (T) or (L) near extension, and changed to (TL) after 20°-30° of flexion. Only three patellae showed the (TL) pattern at all knee position. Medial subluxation of the patella has gone unrecognized until recently. It seems that it still has not achieved wide acceptance. Hughston and Deese (8), using physical examination criteria, drew attention to medial subluxation of the patella which occured in a high percentage of patients with persistent symptoms following arthroscopic lateral retinacular release. an important finding of our study was the hing frequency medial subluxation of the patella in patients that had not undergone prior surgery. Its frequency was even higner than the well-known lateral subluxation. To our knowledge, this particular type of instability without prior surgery has only been reported by Shellock et al. (23). That study which was done in the first 30° of flexion as well as ours suggest that medialization usually begins in the early degrees of flexion. Since Schutzer et al. (21) also used CT in the early increments of knee flexion, one wonders why medial subluxation of the patellar was not observed in their study. As suggested by Shellock et al. (23), the reason may be the difference in their patient positioning. We strongly emphasize the importance of identifying the medial subluxation of the patellar because the classical realignment techniques can further increase medialization and vorsen the patients symptoms. The authors of the present study think tah medial subluxation may rot be a frequent complication of the well-known realignment procedures, and that some of those patellae were indeed medialized prior to surgery.

The authors once more agree with Shellock et al. (23) as regards the presence of lateral to medial instability in unoperated knees. The incidence is nearly 3% in the present study classified as (L) and two would be classified as (T) if only the images at 30° were considered. Moreover, two (L) and one (M) case would be missed. The (TL) cases comprized the largest group of abnormal patella tracking in this study. The variable patterns should be noted. In some cases, the pattern was (TL) in the first 20°-30° and either the (T) or (L) component dissappeared thenafter. In other cases, the pattern was (T) or (L) near extension, and changed to (TL) after 20°-30° of flexion. Only three patellae showed the (TL) pattern at knee position

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The authors once more agree with Shellock et al. (23) as regards the presence of lateral to medial instability in unoperated knees. The incidence is nearly 3% in the present study which is slightly less than that reported in their study. This unusual type of instability is characterized by lateralization near extension and medialization after 20-30. The measurements on normal volunteers showed that congruence angles as high as+39° in extension should be considered as normal. This means that when the serial CT images are evaluated only by 'eyeballing', the patella may be easily minister-preted as lateralized at 0° and 10° of flexion, and may be erroneously considered as the lateralization component of a lateral to medial instability. Indeed, such a case in only a medial instability. Following this example, we emphasize that the assessment of the type of patellar instability should be based on quantitative data. The cause of lateral to medial instability of the patella is unknown, however, the mechanism seems to be a complex peripatellar muscular imbalance. EMG studies added to dynamic and kinematic CT scanning may reveal useful data on the pathogenesis added of this and other types of patellar instability. In constant to Schutzer et al's study (21), pure tilting of the patella was found to be a rare form of patellofemoral incongruence. This observation supports the 8% incidense reported by Shollock et al (23). Patellar tilt was almost alwasy accompanied by abnormal lateralization in this study. Variable patterns of the (TL) group were mentionet. Imaging only in the first 30° of flexion seems to diagnose either the tilt or the lateralization component of this group and thus lead to a misdiagnosis. The congruence angle described by Merchant et al. (17) is the best indicator of lateral and/or medial instabilities. It should be measured at different knee positions

and compared to normal values. Merchant's classical congruence angle at 45° of flexion has no practical value. 30° axial radiograph with lateral rotation of the leg has been claimed to be useful in detecting lateral subluxation of the patella (15). This means that the technique may misdiagnose the medial and lateral to medial instabilities.

Seven of fourteen unilaterally symptomatic knees demonstrated patellofemoral incongruence. All of these patients had incongruence in the contralateral knee. This has been reported to occur in 68% and 100% of the patients in Schutzer et al's (21) and Inoue et al's (9) studies, respectively.

39% of the symptomatic knees did not show any incongruence on CT scans. Normal CT scan in patients was reported to be 20% in another study (21). This may point to the complexity of patellofemoral problems. Besides, it may be due to undiagnosed chondromalacia patella, plica syndrome or other internal derangements of the knee. The CT scanning technique described in this study is useful in ruling out patellofemoral malalignment, and thus avoids unnecessary realignment procedures.

When midpatellar sections are taken, it is not difficult to underslant the gradual decrease of the sulcus angle with knee flexion. as the knee is flexed, the patella moves distally and comes into contact with the deeper and more distal part of the trochlea. Thus, a very shallow sulcus angle near extension is an indirect sing of patello alta. It does not indicate trochlear dysplasia. Measuring the sulcus angle at midpatellar level at a wide range of flexion seems to be important in that it gives a profile of the femoral trochlea from proximal to distal. High sulcus angles in all sections may be the best indicator of trochlear dysplasia. This condition was present in nine cases in this study.

The auther cannot comment on the role of dynamic images on the diagnosis. A regular pattern could not be observed. EMG studies combined with dynamic imaging may provide useful information for selective strenghening of vastus medialis or vastus lateralis. Further research is needed in this area.

This study showed that axial computerized tomographic images taken at one knee position will miss important information. Imaging in the first 30° of flexion which has been recommended recently, may not reveal the corrent type of instabilit, either. Serial imaging in a wider range of flexion is necessary for correct diagnosis. Determination of the type of incongruence at different knee positions is a new concept. With this methodology, the presence of medial and lateral to medial instabilities is verified. Hence the classification systems including only the lateral instability should be questioned.

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