



## Fulkerson osteotomy for the treatment of chronic patellofemoral malalignment

### *Kronik patellofemoral dizilim bozukluğu tedavisinde Fulkerson osteotomisinin yeri*

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**Amaç:** Kronik patellofemoral dizilim bozukluğu olan olgularda uygulanan Fulkerson osteotomisi ve sonuçları değerlendirildi.

**Çalışma planı:** On sekiz hastanın (10 kadın, 8 erkek; ort. yaş 28.6; dağılım 21-42) 21 dizine tibia tüberkülünün anteromedial transferi (Fulkerson osteotomisi) yapıldı. Ameliyat öncesi ve sonrası tüm hastaların 45° fleksiyonda tanjansiyel grafilerinde patellofemoral uyum açısı, lateral patellofemoral açı ve patellofemoral indeks ölçüldü. Bilgisayarlı tomografi de 12 dizde lateral patellar tilt, dört dizde lateral patellar subluksasyon, beş dizde her iki türde dizilim bozukluğu belirlendi. Cerrahi girişim öncesinde artroskopik değerlendirme yapıldı. Tüm dizlerde patella eklem yüzeyindeki osteoartroz ileri derecedeydi (Outerbridge tip III-IV). Ortalama 10.5 mm (dağılım 7-15 mm) anteriorizasyon yapıldı. Ydi olguda ayrıca vastus medialis kası ilerletmesi uygulandı. Objektif değerlendirme ameliyat öncesi ve sonrasında Fulkerson ve ark.nın ölçütlerine göre yapıldı. Ortalama izlem süresi 28 ay (dağılım 20-60 ay) idi.

**Sonuçlar:** Fulkerson ve ark.nın ölçütlerine göre, 18 dizde (%85.7) mükemmel, çok iyi veya iyi sonuç alındı. İki dizde (%9.5) orta, bir dizde (%4.8) kötü sonuç elde edildi. Ameliyat sonrası ağrı ve instabilite skorlarında anlamlı düzelme saptandı ( $p<0.05$ ). Son radyografik ölçümlerde patellofemoral uyum açısı ortalama  $-6.8^\circ$  (dağılım  $-26^\circ$  ve  $+10^\circ$ ), patellofemoral indeks 1.4 (dağılım 0.8-1.69) bulundu ( $p<0.05$ ). Bütün olgularda lateral patellofemoral açı laterale bakıyordu. Komplikasyon olarak bir dizde tibia tüberkülü avulsiyonu, bir dizde derin ven trombozu, dört dizde hafif hareket kısıtlılığı saptandı. Hiçbir olguda yara sorunu, kompartman sendromu ve peroneal sinir felci oluşmadı, tibia proksimalinde kırık gelişmedi.

**Çıkarımlar:** Patella eklem yüzeyinin özellikle lateral ve distalinde ileri derecede dejenerasyon (Outerbridge tip III-IV) oluşmuş kronik patellofemoral dizilim bozukluğunda Fulkerson osteotomisiyle başarılı sonuçlar alınmaktadır

**Anahtar sözcükler:** Kemik dizilim bozukluğu/cerrahi; diz/cerrahi; osteoartrit; osteotomi/yöntem; patella/cerrahi.

**Objectives:** We evaluated the results of Fulkerson osteotomy in patients with chronic patellofemoral malalignment.

**Methods:** Fulkerson osteotomy (anteromedial tibial tubercle transfer) was performed in 21 knees of 18 patients (10 females, 8 males; mean age 28.6 years; range 21 to 42 years). The patellofemoral congruence angle, lateral patellofemoral angle, and patellofemoral index were measured pre- and postoperatively on tangential radiograms obtained at 45° knee flexion. Malalignment patterns were determined by computed tomography as lateral tilt (n=12), lateral patellar subluxation (n=4), and both (n=5). All the patients underwent arthroscopic examination preoperatively and all had severe osteoarthritis in the patellar articular surfaces (Outerbridge type III-IV). The mean anteriorization was 10.5 mm (range 7 to 15 mm). The vastus medialis oblique muscle was advanced in seven knees. The patients were assessed according to the criteria of Fulkerson et al. pre- and postoperatively. The mean follow-up was 28 months (range 20 to 60 months).

**Results:** According to the criteria of Fulkerson et al., the results were excellent, very good, or good in 18 knees (85.7%), fair in two knees (9.5%), and poor in one knee (4.8%). Pain and instability scores showed significant improvement ( $p<0.05$ ). On final radiographic assessment, the mean patellofemoral congruence angle and patellofemoral index were  $-6.8$  (range  $-26^\circ$  to  $10^\circ$ ) and 1.4 (range 0.8 to 1.6), respectively ( $p<0.05$ ). The lateral patellofemoral angle had a lateral orientation in all the knees. Complications included tibial tubercle avulsion (n=1), deep vein thrombosis (n=1), and slight knee flexion contractures (n=4). Wound-related problems, compartment syndrome, peroneal nerve palsy, or proximal tibial fracture were not encountered.

**Conclusion:** Successful results are obtained by Fulkerson osteotomy in the treatment of chronic patellofemoral malalignment with severe articular degeneration (Outerbridge type III-IV) particularly in the lateral and distal regions of the patella.

**Key words:** Bone malalignment/surgery; knee/surgery; osteoarthritis; osteotomy/methods; patella/surgery.

Anterior knee pain is a frequent cause of patients who visit orthopaedic surgeons. There are six major anatomical sources of patellofemoral pain; subchondral bone, synovium, retinaculum, skin, muscle and nerve. These structures may be affected by many factors, including systemic disease. However, trauma, overuse and patellofemoral malalignment are more common causes of anterior knee pain in young adults and middle-aged patients.<sup>[1-7]</sup>

Nontraumatic anterior knee pain was attributed to chondromalacia patella and often believed to be idiopathic before. It was treated with the use of conservative methods. After the failure of conservative methods to remove the anterior knee pain, patellar malalignment was accepted as a source of this pain by many orthopaedic surgeons. For treatment of patients with patellofemoral instability, or pain, more than 100 procedures have been described. These procedures include shaving or excision of abnormal cartilage, osteotomy of the patella, spongiolization, lateral release, anterior advancement of the tibial tubercle, proximal and distal realignment. After discovering the cause of chronic pain as damage of articular cartilage of patella and tightness of retinaculum around the patella, surgical interventions which alter the patella femoral joint contact forces became more important and effective in orthopaedic surgery. Fulkerson<sup>[8]</sup> osteotomy is preferred mostly by many surgeons. It is a distal realignment procedure which permits the anteriorization and medialization of the tibial tubercle at the same operation.

The purpose of this study is to report the results of anteromedial tubercle transfer for chronic patellofemoral malalignment with severe articular degeneration of the patella.

## Patients and methods

Fulkerson osteotomy (anteromedial tibial tubercle transfer) was performed in 21 knees of 18 patients (10 females, 8 males, mean age 28,6 years; range 21 to 42 years) between 1999 and 2004. Nine patients had surgery on the right knee, six on the left, and three on both knees. All the patients had anterior knee. The movie sign, pain due to passive 90° knee flexion of long duration was present in all of them. Complaints of swelling after activity occurred in some patients and also some of them defined retropatellar crepitus occurring while ascend-

ing stairs. All patients had pain for more than 1 year. Rehabilitation program that consists of stretching the retinaculum, the hamstring and the iliotibial band was considered for all patients with antiinflammatory medication at the same time. The patients were also advised to modify their activities. The pain of all the patients did not respond to conservative management. Six knees (28,6%) had lateral release before and three of them (14,3%) had also proximal alignment procedures.

All patients were evaluated with clinical and radiological findings. Anteroposterior, lateral and axial radiographs at 30 or 45° of knee flexion were used for direct radiographic assessment. (Figure 1a-c, 2a-c). Anteroposterior and lateral views were useful in finding arthritic changes. Patellar height was evaluated with the use of Insall and Salvati method.<sup>[9]</sup> The relationship of the patella to the femoral sulcus were investigated on axial graphs. The patellofemoral congruence angle, lateral patellofemoral index were measured to evaluate the functional relationship of the patella and trochlea on tangential radiograms obtained at 45° knee flexion. Pre- and postoperative radiograms are taken on the same positions for evaluations. Computerized tomography (CT) is used for precise malalignment interpretation (Figure 3). Our study group included patients with malalignment who were diagnosed by clinical and radiological findings and who had pain symptoms at first. Patellar malalignment was defined according to Grelsamer's<sup>[10]</sup> description. It was the abnormal positioning of the patella in any plane and there was a contact between the articular surface of the trochlea and that of the patella. Fulkerson and Shea's<sup>[2]</sup> classification was used. All the patients had patellofemoral malalignment and osteoarthritis (Outerbridge<sup>[11]</sup> type III, IV). So they were classified as type 1, 2, 3. CT was used in patients with axial radiographs in whom it was difficult to interpret the tilt or subluxation.

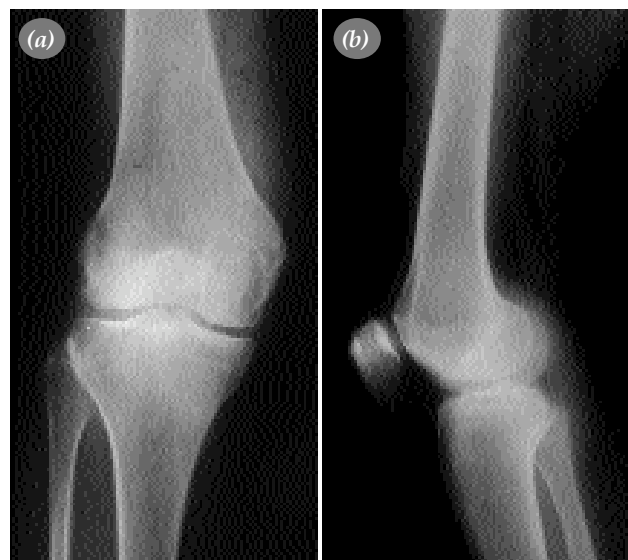
According to these findings, there were 12 knees with lateral patellar tilt, four with lateral patellar subluxation and five with both. Predisposing factors were also evaluated. Femoral dysplasia was observed in 3 knees (14,3%) of subluxation and planovalgus accompanying external tibial torsion was found in two (9,5%) women. The Q-angle average measured in about 15° flexion of knee was 24,2

(range 18 to 34°). This average was 24.2° in males and 24.5° in female patients. Three patients with hypermobility of the patella had length of patella to length of tendon ratio below 0.8 (average 1.12). Atrophy of the vastus medialis muscle was observed in six knees (28.6%). Five knees (23.8%) had effu-

sion. Apprehension test was positive in all patients with subluxation.

All patients were assessed with the use of arthroscopy before the operation. Three different surgeons did the arthroscopic evaluations; arthroscopic findings, intraarticular pathologies and type of treatment methods were registered with details. Patellofemoral joint relationship was observed dynamically. Dynamic patellar position was tested at 0, 30, 45 and 60° of knee flexion and the other intraarticular pathologies were examined. Articular degeneration of patellar articular surface was evaluated according to Outerbridge<sup>[11]</sup> classification. Anteromedialization of the tibial tubercle was arranged for patients with articular degeneration of Outerbridge<sup>[11]</sup> type III-IV particularly in the lateral and distal regions of the patella. Fulkerson osteotomy was planned as a further procedure in 19 knees (90,5%) where it was performed just after the arthroscopic examination. None of the patients had Outerbridge<sup>[11]</sup> type III-IV chondral lesions.

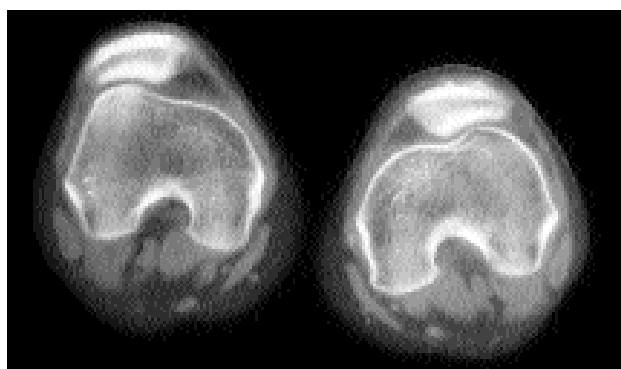
The surgical procedure was performed according to the standart technique of Fulkerson.<sup>[8]</sup> Under tourniquet a straight incision was made from the lateral of patella extending distally 5-8 cm to the tibial tubercle. A lateral retinacular release is accomplished and than the posterolateral edge of the tibia is exposed by a sharp dissection of the anterior muscle belly. In patients in whom the arthroscopic joint surface debridement of the patella was not done enough before, the patella was rotated and the articular surface was examined. If needed, patellar drilling and shaving of the marginal osteophytes was performed (Figure 4).



**Figure 1.** (a) Anteroposterior and (b) lateral radiographs of a 32 years old woman. (c) patellar tilt and subluxation was seen on the tangential radiograph of the right knee.



**Figure 2.** (a) Anteroposterior and (b) lateral radiographs of the same patient's left knee. (c) patellar tilt was found on tangential radiograph.



**Figure 3.** The patellofemoral malalignment of this patient's knees was evaluated with the use of computerized tomography.



**Figure 4.** Severe articular degeneration of the distal articular surface of the patella which was first identified by arthroscopy.

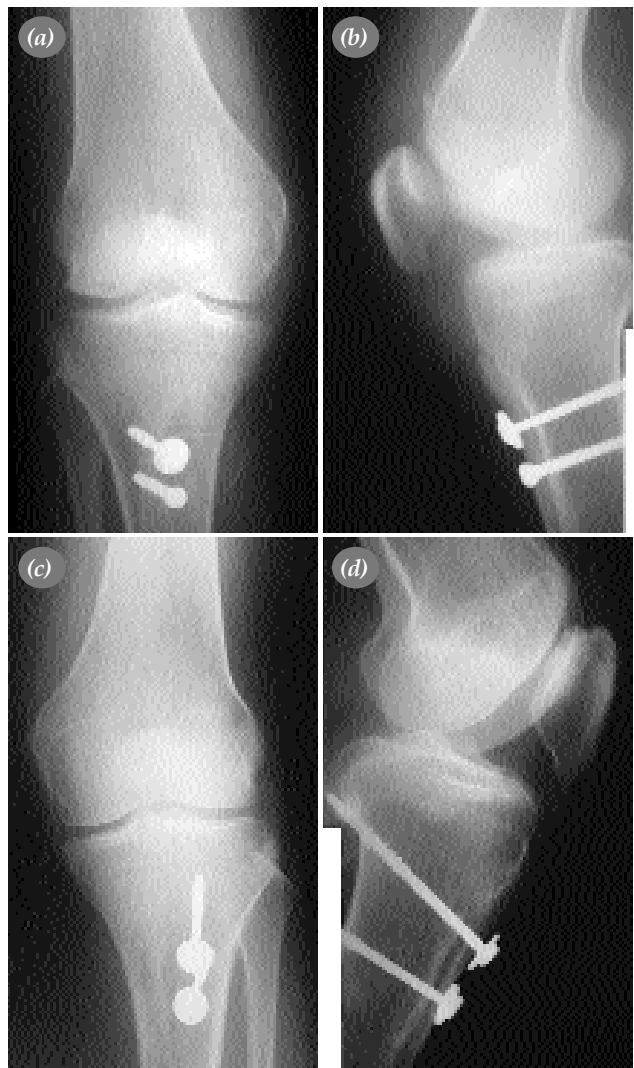


**Figure 5.** An extensile approach was used for anteromedial tibial tubercle osteotomy transfer together with advancement of the vastus medialis obliquus muscle. This procedure was performed to this patient who had a proximal realignment operation before. Bicortical fixation was done after the osteotomy. The status of the patella to the femoral trochlea during the extension –flexion motion of the knee was evaluated. The same procedures were performed for the other knee, too.

A 45° oblique osteotomy on coronal and longitudinal planes for a length of approximately 6-7 cm was done. The osteotomy is also tapered 2 to 3 mm anteriorly towards its most distal extent. The tibial pedicle is mobilized and the relationship of patellar and trochlear sulcus was detected at flexion. Once the ideal position was determined, after enough anteromedialization a bicortical fixation with two screws was made. In seven knees, to accomplish the

most appropriate position, the vastus medialis oblique muscle was also advanced ( Figure 5). In none of the patients bone graft was used for anteriorization. The mean anteriorization was 10.5 mm (range 7 to 15 mm)

In all patients, the operated leg was placed in a plaster cast and kept at rest until the third postoperative day. Then the patient was allowed to walk with partial weightbearing. Cast immobilization was usually maintained for four weeks (range 3 to 6 weeks). After control roentgenograms, flexion and extension exercises were initiated. The patient was allowed to walk with crutches until the knee gained 90° flexion.



**Figure 6.** (a) anteroposterior (b) lateral views taken on the 12<sup>th</sup> month of a patient's right knee who was allowed for full weight-bearing on the sixth postoperative week; the left knee's (c) anteroposterior and (d) lateral views are taken on the 14<sup>th</sup> postoperative month.

**Table 1.** Evaluation criteria of Fulkerson et al.<sup>[12]</sup>

Pain /Instability	Score
Limp	
None	10
Slight	5
Severe	0
Support	
Full	10
Cane or crutch necessary at times	3
Weightbearing impossible	0
Stair climbing	
No problem	10
Slightly impaired	6
One step at a time	2
Unable	0
Squatting	
No problem	5
Slightly impaired	4
No past 90° of knee flexion	2
Unable	0
Pain	
None	45
Slight during vigorous exercise only	40
Moderate with vigorous exercise	35
Severe after vigorous exercise	25
Severe after walking less than 1 mile	20
Severe after walking less than 1/2 mile	10
Constant and severe	2
Swelling	
None	10
With giving way	7
On severe exertion	5
On mild exertion	2
Constant	0
Instability	
Never gives way	10
With vigorous activity	5
Occasionally in daily activities	5
Often in daily activities	3
Everyday	0

## Scoring of overall surgical results

95-100 excellent; 90-94 very good;  
80-89 good; 70-79 fair; <70 poor.

Full weightbearing was allowed after the six postoperative week. Consolidation was achieved at the osteotomy site in all patients (Figure 6 a-d).

The patients were assessed according to the criteria of Fulkerson et al.<sup>[12]</sup> based on pain and instability scale pre- and postoperatively (Table 1). All of

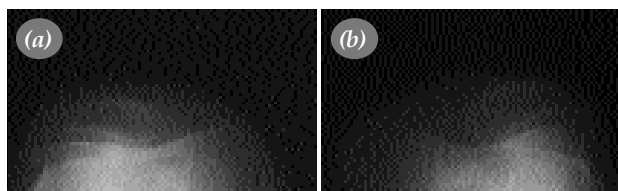
the preoperative scores were below 70. Patients were questioned about preoperative status, pain, limitation of activities and overall satisfaction. The mean follow-up was 28 months (range 20 to 60 months)

The mean preoperative patellofemoral congruence angle was 18.6° (range -2 to 46°) and the patellofemoral index was 2.1. The lateral patellofemoral angle had a parallel orientation in six knees and had a medial orientation in other knees.

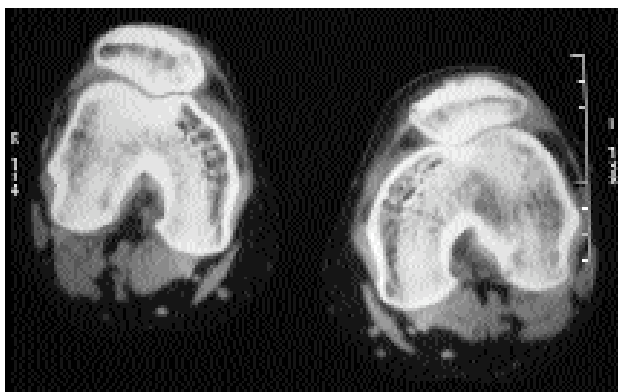
Statistical analysis were made with the use of the SPSS for Windows program for t-test comparisons;  $p < 0.005$  values were significant.

## Results

At the latest objective follow up excellent or good results were obtained in 18 knees (85.7%). According to criteria of Fulkerson et al.<sup>[12]</sup> the results were excellent, very good or good, fair and poor in 2 (35.5%), ten (47.6%), six (28.6%), two (9.5%) and one knee (4.8%) respectively. The patient with the poor result felt himself good so this result was evaluated as fair. All patients expressed improvement with surgery for pain and instability criteria. Based on Fulkerson<sup>[12]</sup> criteria the postoperative pain score improved from 24 to 45 and the mean instability



**Figure 7.** On tangential radiographs, it is seen that patellofemoral alignment was achieved on the (a) right and (b) left knee; the improvement of patellar tilt and subluxation of the right patella, and the tilt of left patella was obtained.



**Figure 8.** Cross sections of the right knee was taken on the 20<sup>th</sup> month and of the left knee on the 14<sup>th</sup> month with the use of a computerized tomography.

score improved from 5 to 1 ( $p < 0.05$ ). More anteriorization was advised for the patients with fair or poor scores, however they did not accept a new operation.

On final radiographic assesment the mean patellofemoral congruence angle and patellofemoral index were  $-6.8^\circ$  (range  $-26^\circ$  to  $10^\circ$ ) and 1.4 (range 0.8 to 1.6) respectively. The results were statistically significant. The lateral patellofemoral angle had a lateral orientation in all the knees. The mean Q angle was  $12.6^\circ$  (range  $6^\circ$  to  $15^\circ$ ); this value was  $9.8^\circ$  in males and  $13.8^\circ$  in female patients (Figure 7,8).

As a postoperative complication, there was one tibial tubercle avulsion which was recognized on the second postoperative day. In this case the screws were firmed with a new operation. A superficial infection responded to antibiotics therapy. Deep venos thrombososis developed in one patient. Slight knee motion limitation ( $10^\circ$  flexion,  $15^\circ$  extention) was observed in four knees, and quadriceps athropy of 1cm or below was observed in eight knees (38.1%). All patients complained of pain at the screw localization of the kness on squatting. Screws were removed off in fifteen (71,4%) knees. Loss of sense on the lateral side of tibial tubercle was defined on six knees (33.3%). Wound problems, compartment syndrome or peroneal nerve palsy developed in none of the patients. Fracture did not occur on the proximal end of the tibia in the early or late postoperative period.

## Discussion

Most of the time it is very hard to select the type of treatment method for patellofemoral arthrosis in young and middle aged patients. Even radical operations may be considered for patients in which conservative treatment and soft tissue procedures are ineffective for the intolerable pain.<sup>[13-20]</sup> These type of operations find absolute indications in young patients because there is no alternative treatment methods for these people. Patellofemoral anterior knee pain appears in young adults or middle-aged patients. Anterior knee pain accounts for almost 10 percent of all visits to orthopaedic surgeons for 20 to 40 percent of all knee problems.<sup>[21]</sup> Pain related to patellofemoral arthrosis may even occur in daily activities. Such as sitting, squatting and climbing stairs. These pain may be treated unless correct diagnosis and surgical intervention is considered. Patellofemoral malalignment

is a translational or rotational deviation of the patella relative to any axis and it is a major component of patellofemoral arthrosis. The traditional evaluation of the patellofemoral malalignment is focused on a story of patellar dislocation and abnormal Q angle, rotation of the lower extremity and positive apprehension test. However the type of pain occurrence or the first clinical examination is almost helpful.<sup>[1-4,7]</sup> The fist admission of the patients to us was due to the pain. Diagnosis was achieved by taking a detailed history, clinical examination and radiological investigations.

There is a very small amount of bony contact at any motion of the knee between trochlea and patella which is the most thickest articular surface of any bone in the human body. Patella is aganist the hoffa when the quadriceps muscle is contracted on extension, and there is no or very small patellofemoral contact. So the patellofemoral pain is not prominent when standing on a flat surface. However the first contact of articular surface of patella with femur is at the first 10 to  $20^\circ$  of knee flexion.<sup>[22]</sup> The patellofemoral contact surface changes from the lower pole of he patella to the upperside as the knee moves from extension to flexion. As the flexion increases the contact surface also increases regularly. The contact point changes towards the lateral side of patella as the extension changes to  $90^\circ$  flexion but never reaches the medial side.<sup>[22]</sup> Pain arising from long sittig and called as movie sign and also the pain arising from climbing the stairs can be explained with this physiological mechanism.

There are many symptoms which arouse suspicion of patellofemoral malalignment but none of them is specific to the malalignment. Positive apprehension test is a reflection of an extreme malalignment bu when this test is negative it does not exclude less malalignment. Radiological imaging can confirm a specific diagnosis of malalignment and moreover classification can be made easily. Patellofemoral malignment is diagnosed best at tangential radiograms obtained at  $30^\circ$  and  $45^\circ$  knee flexion. Minor malalignment can be misdiagnosed when the radiograms are obtained at less knee flexion. Imaging the tochlea at  $30^\circ$  knee flexion allows the malalignment more noticable and relevant however it is more easy to describe the  $45^\circ$  knee flexion to the technician.<sup>[23,24]</sup> We preferred this knee flexion in all patients. But tilt

and lateral patellar subluxation can be evaluated and measured better with CT. A major advantage of CT is that false measurement due to the uncontrolled hip rotations can be prevented by taking the posterior femoral condyles as a reference line. The anatomy of the trochlea changes on direct tangential radiographs depending on the motion of the patella however the line passing through the posterior condyles forms a stable reference point.<sup>[16,24]</sup> The malalignment was also evaluated with the use of CT in our patients, too. In studies, the evaluations done by CT was found more correct and valuable.<sup>[16,24]</sup>

Chronic pain with an instability indicates an articular damage. This usually occurs on the lateral facet or distal central patella. Crepitus on physical examination and radiological findings are not enough to determine the articular damage of patellar surface. In this condition, arthroscopy should be performed to determine the extent of damage to the articular cartilage. Arthroscopy has proved to be the most valuable method in choosing the type of surgical method. Soft tissue procedures as lateral release may be effective provided the articular cartilage degeneration is in the early stage (Outerbridge<sup>[11]</sup> type I and II); however procedures which relieve the contact stress on the defective parts of the articular surface are needed for the progressed lesions (Outerbridge<sup>[11]</sup> type III, IV).<sup>[1,2,4,5,25-32]</sup>

The best operative method to reduce the contact pressure on areas of deficient articular cartilage is to restore the patellofemoral alignment of extensor mechanism.<sup>[31]</sup> In the past, Maquet procedure was often done to provide a decrease in patellofemoral contact pressure by direct anteriorization of the tibial tubercle. The principle of Maquet procedure is to increase the lever arm of the patellar tendon in order to decrease the intraarticular joint forces and so the pain resolves when the force is distributed to the whole articular surface of the patella.<sup>[2,4,29,33]</sup> At first results were successful by pain relief, however high complication rates were noted later. Complication rates even up to 70 % were documented in some studies.<sup>[33]</sup> Wound problems were encountered in most patients. The high rate of patients who needed skin grafting or flap procedures due to the skin necrosis was a great problem to the surgeons. Also the long term results were not very successful. The morbidity for obtaining a bone graft from the iliac crest, skin

necrosis overlying an excessively advanced tubercle, non-union of the tibial tubercle and anterior compartment syndrome have caused many orthopaedic surgeons to abandon this procedure. The procedure is most effective when there is osteoarthritis of distal region of the patella because the decrease of forces is observed only in the distal part with this procedure.<sup>[1,2,4,33]</sup>

Elmslie-Trillat procedure is one of the distal realignment procedures for patellofemoral malalignment.<sup>[34]</sup> It is mostly considered for instability. Straight medial tibial tubercle transfer combined with lateral release is done in this procedure. This technique is indicated for patients having Insall index of less than 1.2. The technique is successful in all patients having low grade (Outerbridge<sup>[11]</sup> I, II) articular degeneration.<sup>[6,14,34]</sup>

The Fulkerson osteotomy which is adjusted for anteriorization and medialization at the same time has several advantages. Since distraction of the tibial tubercle is avoided with anteromedialization, no bone grafting is necessary. Because the cut surfaces of bone are not distracted from each other there is a better control of bleeding from the cut bony surfaces with tamponading of much of the surface. Fixation of the tibial tubercle bone pedicle is quite firm and early motion is tolerated well when the operation is done correctly. When medialization of the tibial tuberosity is accomplished accurately, considerable compression across the osteotomy site is possible due to the flat corticocancellous surfaces. And this prompts early healing. The procedure can also be adjusted by the surgeon for more anteriorization or medialization by changing the obliquity of the pedicle cut. Obvious disadvantages are the rather extensive consolidation time and the hypesthesia around the screws with kneeling.<sup>[8,12,19]</sup> Most of our patients had difficulty with kneeling. There was pain and hypesthesia around the scars of the screws. We removed most of the screws after consolidation.

Although the Fulkerson osteotomy has many advantages, a good surgical technique should be performed to be successful. The amount of the anterior-medialization should be carefully determined. In studies 10 mm anteriorization and 5 to 10 mm medialization is recommended.<sup>[12,16,20]</sup> The medial compartment is most affected by over medialization, howev-

er it is reported that there is anormal increase in all articular contact stress and knee pain is defined by the patients in flexion.<sup>[12,16]</sup> Vastus medialis obliquus and medial retinaculum should be distally and laterally transferred to the superomedial periosteum of the patella to achieve a good patellar tracking in trochlea.<sup>[4,12,14,15]</sup> We performed this technique in seven patients. The tibial tubercle osteotomy should be tapered anteriorly toward its most distal extent. If it is not done, occurrence of a fracture is reported even weeks later, too.<sup>[35,36]</sup> And also nonunion can be observed if enough cancellous bone is not spaced at the osteotomy site. Because of these problems partial lateral facetectomy is advised by some authors.<sup>[37]</sup> But this technique should be performed for patients with normal valgus vector. This technique is effective for pain but not for malalignment. We have advanced the vastus medialis obliquus for patients when patellar balance is not achieved in trochlear sulcus. In our study, our anteriorization and medialization amount was the same as the other authors in the literature.

Patellofemoral arthroplasty is also preferred for patients who have articular defects of patella nowadays. But patients who have severe degeneration lesion of patella (Outerbridge<sup>[11]</sup> type IV) on both knees are best treated with Fulkerson osteotomy at first. Patellofemoral arthroplasty is recommended in failure of this osteotomy. Age younger than 30 year is accepted as a relative contraindication for patellofemoral arthroplasty, however Fulkerson osteotomy can also be performed for these patients.<sup>[17,38]</sup> Fulkerson osteotomy makes it easy for knee arthroplasty in the future by correcting the patellofemoral malalignment. Patellectomy is only indicated for cases with severe articular degeneration as a salvage procedure but soft tissue augmentation operations should be added at the same time.<sup>[39]</sup> There is not a perfect procedure for defects of the articular surface today. Other procedures such as chondral transplantation is only experimental nowadays.<sup>[40]</sup> Fresh osteochondral allografts can be used only when other methods fail.<sup>[41]</sup>

Patients with patellofemoral malalignment visit the orthopedic surgeons commonly for pain, their expectation is pain relief. Moreover some action on the part of the patient or a second person is required to reposition the patella in patellar dislocation. We have not observed patellar dislocation in our study

group. Malalignment was evaluated according to the description of Grelsamer.<sup>[10]</sup> There was no contact between the articular surface of the trochlea and that of the patella. Proximal realignment procedures are not effective in relieving pain of patellofemoral malalignment. Lateral release is only effective in patients who have subluxation without tilt and early stage articular degeneration. This procedure provides benefit in young patients, delaying the need for further radical surgical interventions. Lateral release should be preferred for good selected patients.<sup>[25-28]</sup> It appears to be of no value in patients with advanced articular lesions of the patella.

Our study results for pain relief were very successful. Only one patient had moderate pain after vigorous exercise and stair climbing capacity was slightly reduced after knee flexion of 90°. This patient had no instability and effusion. Objectively the patient was satisfied although the result was rated as poor. The patient was satisfied with his status, was working and did not want further treatment. Our patients returned to their activities especially after the relief of pain in ascending and descending the stairs. But however 13 patients(61%) complained of crepitus at the latest control. One patient required a crutch during the follow-up period. A great deal amount of patients had painful kneeling and screws were removed off in 15 knees (71%). None of the knees had effusion or instability during the follow-up period. The patients were satisfied within the follow-up period. In the literature, some authors reported a decline in the further satisfactory results.<sup>[19]</sup> So we are planning to evaluate the patients in the future again.

Knee stiffness after the anteromedial transfer and rigid bicortical fixation of the tibial tubercle can be prevented by early knee motion. For this, different types of rehabilitation programs are performed. Fulkerson<sup>[8]</sup> used a brace which limited knee flexion for four weeks postoperatively in his early experience with the technique, however he promoted early knee motion in his last experience. Morshius et al.<sup>[19]</sup> preferred cast immobilization for six weeks. Knee flexion and extension were initiated after the roentgenographic consolidation was ensured. Sakai et al.<sup>[20]</sup> started active knee motion 1 week after the operation and did not use any external immobilization device. The oblique osteotomy weakens this part of the tibia. When considering the sociocultural and



economic status of our patient group and also the difficulty in cooperation with them, we preferred the use of cast immobilization for four weeks in the postoperative time. One of our patients had an avulsion of the tibial tubercle on the second postoperative day. This experience also effected our decision for this immobilization period. Four of our patients (19%) had a slight knee flexion limitation in the last control time. Full weight bearing after six months was also the same with the literature.

Very successful results after the anteromedialization of the tibial tubercle was also obtained in other studies, too. Fulkerson et al.<sup>[12]</sup> reported 93% good and excellent results subjectively in 20 patients who were followed for 2-9 years. Morshuis et al.<sup>[19]</sup> evaluated the results for 20 knees as excellent or good at an average of 2-5 years follow-up. And also the results were satisfactory in 84% patients at the first year evaluation. This percentage decreased to 70% at the end of the study. Pidioriano et al.<sup>[32]</sup> followed 37 knees for a mean time of 2.5 years. Nine(90%) of ten knees with distal patellar lesions, 11(85%) of 13 knees with lateral facet patellar lesions had good to excellent results. They reported that knees with distal and lateral facet lesions were significantly more likely to have good or excellent results in 18 knees (85,7%). We have achieved improvement for patellofemoral pain and instability in our patients. And also there was a significant improvement in the radiographic measurements.

In conclusion pain is a major component of chronic patellofemoral malalignment. Surgery should be considered for patients with intolerable pain not responding to conservative treatment methods. Successful results can be achieved with many different realignment procedures for patellofemoral instability. However most of the time relief of pain associated with patellofemoral joint is not achieved. And the patients are not easily satisfied. Diagnose of the source of anterior knee pain depends on taking a good history. After the diagnose of the patellofemoral malalignment by a good physical examination and radiological investigations the extent of articular degeneration of the patellar joint surface should be identified by arthroscopy. And then after, the definitive operation procedure should be selected.

In the light of the literature and our experience we believe that Fulkerson osteotomy should be performed for the patients having severe articular degeneration (Outerbridge<sup>[11]</sup> type III-IV) particularly in the lateral and distal regions of the patella in order to change the patellofemoral contact surface stress.

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