

# MIDTERM OUTCOMES OF TIBIAL TUBERCLE ANTEROMEDIALISATION (FULKERSON PROCEDURE) FOR PATELLOFEMORAL MALALIGNMENT

## PATELLOFEMORAL DİZİLİM BOZUKLUĞUNDA TİBİAL TÜBERKÜL ANTEROMEDİALİZASYON (FULKERSON) CERRAHİSİNİN ORTA DÖNEM SONUÇLARI

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### ABSTRACT

**Objective:** Patellofemoral malalignment is a known risk factor for instability, anterior knee pain, chondropathy and arthrosis. Patellofemoral malalignment with a laterally positioned tibial tubercle that results in symptoms of pain and/or instability can be effectively managed with a tibial tubercle osteotomy.

**Material and Method:** We present long term results of 50 knees of 45 patients with patellofemoral malalignment treated with Fulkerson osteotomy at our institution.

**Results:** The mean follow-up time was 116,9 months (60-204). Significant improvement was observed at all of the radiographic parameters when compared with the preoperative values of our cohort. We found that patients' postoperative quality of life increased significantly according to various pain and functional scales.

**Conclusion:** In conclusion, Fulkerson osteotomy is successful in the treatment of patients with lateral patellar instability and/or patellofemoral chondrosis/arthrosis owing to patellofemoral malalignment. We believe that careful patient selection is the most important factor determining the overall outcome.

**Keywords:** Patellofemoral malalignment, Tibial tubercle anteromedialisation, Fulkerson osteotomy

### ÖZET

**Amaç:** Patellofemoral dizilim bozukluğu instabilite, diz önu ağrısı, kondropati ve artroz için bilinen bir risk faktörüdür. Tibial tüberkülün lateral yerleşimli olduğu, ağrı ve/veya instabilite şikayeti olan patellofemoral dizilim bozukluğu tibial tüberkül osteotomisi ile etkin bir şekilde tedavi edilebilir.

**Gereç ve Yöntem:** Biz çalışmamızda patellofemoral dizilim bozukluğu olup kliniğimizde Fulkerson osteotomisi yapılmış olan 45 Hastanın toplam 50 dizinin uzun dönem sonuçlarını sunmaktayız. Ortalama takip zamanı 116,9 aydır (60-204).

**Bulgular:** Bizim kohortumuzda tüm radyolojik parametrelerde preoperatif değerlere göre anlamlı gelişme görülmüştür. Hastalarımızın çeşitli fonksiyonel ve ağrı skorlamalarına göre yaşam kaliteleri postoperatif anlamlı olarak artmıştır.

**Sonuç:** Sonuç olarak, Fukerson osteotomisi patellofemoral dizilim bozukluğu zemininde lateral patellar instabilite ve/veya patellofemoral kondroz/artrozu olan hastalarda tedavide başarılı bir yöntemdir. Dikkatli hasta seçiminin sonucu etkileyen en önemli faktör olduğuna inanıyoruz.

**Anahtar Kelimeler:** Patellofemoral dizilim bozukluğu, Tibial tüberkül anteromedializasyonu, Fulkerson osteotomisi

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## INTRODUCTION

Patellofemoral malalignment is a known risk factor for instability, anterior knee pain, chondropathy and arthrosis (1). Although initially managed conservatively, when conservative treatment methods fail, surgical interventions are considered.

Many surgical procedures have been described for the management of patellofemoral instability and chondropathy/arthrosis including lateral release (2), medial imbrications (3), medial patellofemoral ligament (MPFL) reconstruction (4), patellofemoral arthroplasty. Chondropathy or instability in the setting of an increased tibial tubercle-trochlear groove (TT-TG) distance can be effectively managed with a tibial tubercle osteotomy. With a single oblique osteotomy and without the need of a bone graft, Fulkerson procedure (5), which not only provides the patellar stabilizing effect through medialization of Elmslie-Trillat (6), one of the most popular tibial tubercle transfer methods, but also furnishes Maquet's effect of transferring the load onto healthy proximal cartilage on the patella through anteriorization (7), has become one of the most preferred surgical methods in solving patellofemoral problems resulting from malalignment. The aim of our study is to present the mid term outcomes of our patients who underwent tibial tubercle antero-medialisation (Fulkerson osteotomy) for patellofemoral malalignment/instability.

**Table 1:** Patients according to their diagnoses

Diagnosis	Total number
Patellofemoral chondropathy/ arthrosis	
Post-traumatic	1
Patellofemoral malalignment	
Chronic subluxation +/- history of dislocation	13
Anterolateral compression syndrome	10
Patellofemoral instability	
Subluxation	
Tilt (+)	1
Tilt (-)	5
Dislocation	
Recurrent	11
Habitual	6
Post-traumatic	3
Total	50
	(45 patients)

## MATERIAL AND METHOD

Institutional Review Board (IRB) approval was obtained for the study. Patient consents were obtained retrospectively. We evaluated 50 knees of 45 patients (13 males, 32 females) who had the diagnoses of lateral patellar instability and/or patellofemoral chondropathy/arthrosis due to patellofemoral malalignment, who did not respond to conservative treatment for at least 6 months and who were treated with Fulkerson osteotomy between March 1995 and March 2007 at our institution. Patients with open growth plates and previous knee surgery were excluded from the study. Patients' diagnoses are summarized in Table 1.

The demographic information of the patients, including age at the time of surgery as well as gender, was collected along with relevant operative data such as surgical procedures and intraoperative complications. For radiographic evaluation, patellofemoral congruence angle and lateral patellofemoral angle were measured on the Merchant axial radiographs taken at 30° knee flexion, and on the lateral radiographs taken while weight-bearing at 30° knee flexion. Modified Insall-Salvati and Caton indices were calculated. The tibial tubercle-trochlear groove (TT-TG) distances and patellar tilt angles were measured via axial computed tomography (CT) scans at 20° of knee flexion. All radiographic measurements were performed pre- and post-operatively, and the final post-operative follow up took place within a minimum of five years.

For objective evaluation, both before and after the operation, IKDC subjective knee evaluation form, HSS knee score, Oxford knee score, Knee Outcome Survey-Activities of Daily Living scale, modified Lysholm knee score, Tegner activity scale, Kujala patellofemoral scoring and Fulkerson patellofemoral scoring were applied to each patient.

Data was analyzed with SPSS (SPSS Inc. Chicago Illinois USA) 21.0 statistical software. The values of the preoperative and postoperative data were compared using the paired t-test. Statistical significance was set at  $p < 0.05$ .

### Surgical technique

Our surgical indications for Fulkerson osteotomy were complaints of anterior knee pain and / or patellofemoral instability which had occurred for at least 1 year and had not responded to at least 6 months of physical therapy and rehabilitation, patellofemoral brace and 3 weeks of oral non-steroidal anti-inflammatory drugs.

The patient is positioned supine on the operating table and tourniquet is applied on the upper thigh. The surgery begins with knee arthroscopy using standard portals in supine position with the knee flexed 90 degrees off the table when necessary. All three compartments of the knee are also inspected. Cartilage and menisci are exam-

ined. Cartilage changes of the patellofemoral joint, static and dynamic alignment (patellar tracking) are also examined and any pertinent findings are noted. After the arthroscopic examination, an oblique incision is made from the lateral of patella extending distally 7-8 cm to the tibial tubercle. The lateral retinaculum is evaluated and released. The patellar tendon and tibial tubercle are exposed. If patellar joint surface debridement has not been sufficiently performed before, the patella is rotated and the articular surface is examined. If needed, patellar drilling and shaving of the marginal osteophytes is performed. Later, the proximal anterior compartment muscle (tibialis anterior) is released from the tibia with sharp dissection and taken posteriorly with the aid of a periosteal elevator. The anteromedial tibial periosteum is marked distally and medially (Figure 1). Three K-wires are placed colinearly in a medial to lateral direction at the planned osteotomy angle. The angle of the osteotomy can now be visualized, and adjusted as needed. The ori-

entation of the osteotomy in the sagittal plane is towards anterior from proximal to distal at about 5-7 cm length from the tibial tubercle. The distal part of the osteotomy should be designed so that 2-3 mm bone thickness is left on the pedicle on the hinge part.

After completing the proximal parts of the osteotomy, anteromedialization of the tubercle is achieved by sliding it medially (Figure 2). At this stage, osteotomy is temporarily fixed with a k-wire and patellar movement is checked with the flexion-extension of the knee for stable fixation of the osteotomy, two or three 4.5 mm cortical screws (or one 6.5 mm spongiosis and one 4.5 mm cortical screw) are used with lag screw technique (Figure 3). After the screws are inserted, the osteotomy and screws are checked by fluoroscopy and the appropriate length screws are placed. The skin is closed with interrupted sutures. The extremity is wrapped with an elastic bandage and immobilized in a hinged brace or immobilizer.



**Figure 1:** Exposure: Anterior compartment muscles are subperiosteally elevated with sharp dissection and the anteromedial tibial periosteum is marked medially and distally.



**Figure 2:** The osteotomized tubercle is anteromedialized.



**Figure 3:** Final control of screw sizes with C-arm.

### Postoperative protocol

After the surgery the knee is placed in a immobiliser or hinged knee brace. Exercises such as ankle pumping (dorsiflexion-plantarflexion), isometric quadriceps strengthening, and non-weightbearing walking are performed as tolerated. Passive range of motion is begun on the 2<sup>nd</sup> day and 90 degrees are achieved on the 3<sup>rd</sup>-4<sup>th</sup> days after surgery. During the 8<sup>th</sup>-12<sup>th</sup> weeks, the brace is removed and full-weightbearing is allowed. On the 3<sup>rd</sup> month after surgery, mild jogging, proprioception exercises and partial sports activities are recommended.

### RESULTS

50 knees of 45 patients (13 males, 32 females) with a mean age of 31.18 (16-56) at the time of operation were evaluated. These patients had previously been diagnosed with lateral patellar instability (22 patients (49%), 4 bilateral) and/or patellofemoral chondropathy/arthrosis (23 patients (51%), 1 bilateral) due to patellofemoral malalignment and had been treated with Fulkerson osteotomy. Thirteen patients had surgery on the right knee, twenty-seven on the left, and 5 patients had bilateral procedures at different stages. The mean follow-up time was 116.9 months (60-204). All the patients had anterior knee pain preoperatively. The movie-theatre sign; which is pain due to passive 90° knee flexion of long duration, was present in 43 (97%) of 45 patients. "Fair-bank's apprehension test" was recorded as positive in twenty-four of the 26 knees which had been diagnosed with patellar instability (92%) on a pre-operative physical examination. Post-operatively the same examination was repeated and was negative in 22 of these 24 patients (91.66%). As additional surgical interventions, the following treatment was administered: in 11 knees medial plication/imbrication and VMO advancement, in 15 knees conventional cartilage resurfacing procedures, in 9 knees OATS and in 7 knees patellar denervation. These are summarized in Table 2.

20 of the 26 patients who had surgery for patellofemoral joint instability had a history of lateral patellar dislocation. In the postoperative follow-up period, patellar dislocation did not recur in any patient. The remaining six patients who had a chief complaint of chronic recurrent lateral subluxation did not experience any giving way in their knees during the postoperative period.

**Table 2:** Additional procedures during Fulkerson osteotomy

Procedure	Number of patients
<b>Realignment procedures*</b>	
Medial plication/imbrication	9
VMO advancement	2
Medial retinacular release	1
<b>Chondral procedures</b>	
Patellar Drilling	7
Microfracture	3
Chondral shaving	4
Thermal chondroplasty	1
OATS	
Patella	7
Trochlea	2
<b>Patellofemoral joint procedures</b>	
Patellar denervation	7
Patellar cyst excision	1
Hoffa resection	1
Plica excision	2
<b>Tibiofemoral joint and capsular procedures</b>	
Partial medial meniscectomy	3
Baker cyst excision	1
Posterior capsular release	1

\*Lateral retinacular release as described by Fulkerson in his original technique was performed in all cases and therefore is not included in the table

According to modified Lysholm knee score, 41 knees (84%) were rated as excellent-good, 5 knees (10%) as fair and 4 knees (8%) as poor. According to Kujala patellofemoral scoring, 35 knees (70%) were rated as excellent-very good-good, 4 knees (8%) as fair and 11 knees (22%) as poor; and according to Fulkerson patellofemoral scoring, 38 knees (76%) were rated as excellent-very good-good, 7 knees (14%) as fair and 5 knees (10%) as poor. According to Tegner activity scale, the mean activity level increased from 3.84 to 4.78 ( $p < 0.001$ ). According to all other four knee evaluation scales, statistically significant increases were achieved in the mean values. The changes in the preoperative mean values of the radiographic parameters after the operation were as follows: congruence angle from 24.48 [(+2)-(+81)] to -1.54 [(-28)-(+47)], modified Insall-Salvati index from 2.09 (1.28-3.15) to 1.90 (1.01-2.42), Caton index from 1.20 (0.52-1.57) to 1.05 (0.25-1.70) ( $p < 0.001$ ). All but one (97.7%) of the lateral patellofemoral angles were opening laterally after the operation.

Post-operative complications included proximal metaphyseal fracture of the tibia in one patient which required surgical treatment, arthrofibrosis of the knee in four patients, three of which were treated with arthroscopic surgery, reflex sympathetic dystrophy mild-to-moderate in severity in three patients who were then treated with NSAIDs and physical therapy, and deep vein thrombosis in one patient. The latter condition did not cause massive pulmonary thromboembolism and was treated medically. Neurovascular injury, deep surgical wound infection, compartment syndrome or nonunion of the osteotomy did not occur in any patient.

## DISCUSSION

Anteromedialization of the tibial tubercle along an oblique osteotomy line for the patients with symptomatic patellofemoral malalignment and patellofemoral pain can be understood more easily when considered as an alternative to the Maquet process. Fulkerson (5) reported that this procedure is a good treatment option for patellofemoral chondropathy /arthrosis secondary to patellofemoral malalignment.

The effect of lateralized tibial tubercle on the static patellar position and patellar tracking can result in an increase in the lateral force vector of quadriceps, so Fulkerson procedure may be used successfully in the treatment of lateral patellar instability (subluxation / dislocation).

In our study, despite the improvement of postoperative radiological parameters, 4 patients who had the worst scores on pain-related assessment scales and who underwent OATS for severe cartilage damage in the same session as anteromedialization, were not satisfied postoperatively. During follow-up, patients indicated that their pain intensity decreased but 'not as much as they would like'.

Although their complaints related to instability did not continue, the absence of obvious improvement of pain levels was also in agreement with Pidorianno's study (8).

Carafino et al. (9), reported satisfactory results of the patients who had undergone surgery with Fulkerson procedure for isolated patellofemoral arthrosis at the age of 50 and further. All patients in this study had patellofemoral malalignment and they showed that satisfactory results can be achieved in patients with patellofemoral arthrosis. In our patient cohort, a minimum of 6 months of physical rehabilitation was tried before deciding operative treatment.

Three of the patients were over 50 years of age when they were operated on. One of them had severe patellofemoral pain at the 124<sup>th</sup> month follow-up, and the Kujala and Fulkerson scores were considered to be poor. The other two patients were evaluated as excellent. Our results in elderly patients is compatible with that of Carafino and Fulkerson's work (9). Our results indicate that if patellofemoral chondral surface in proximal and medial facet is healthy, Fulkerson osteotomy gets proper results for patients suffering with patellofemoral arthrosis secondary to patellofemoral malalignment or in association with patellofemoral malalignment.

Preoperative planning must include calculating the amount of anteriorization and medialization. As a general rule, medialization is prioritized in patients with true lateral patellar instability and anteriorization is prioritized in patients with pain secondary to chondropathy and arthrosis. Nevertheless, patients who have complaints due to both conditions in varying amounts comprise the majority (10). Molina et al. (11) declared in their biomechanical study that anteromedialization is necessary to reduce pressure on the patellofemoral contact area rather than isolated anteriorization or medialization. Also an anteriorization of 0.5-1 cm combined with 1 cm medialization achieves most effective and optimal results (12).

Fulkerson et al. showed 93% excellent / good subjective result after tibial tubercle anteromedialisation surgery performed in 30 knees with patellofemoral pain and moderate joint degeneration and malalignment. The ratio of excellent / good results was 83% and no worsening was noted in the results of 12 patients who were followed for more than 5 years (13).

Morshuis and Pavlov (14), published 84% good / excellent results in 25 cases of anteromedialization series at short term follow up. The amount of anteriorization was less than 10 mm, and the best the results were obtained in patients with mild joint degeneration.

Pidorianno and Weinstein (8) studied the relationship between joint degeneration pattern and the results of an-

teromedialization, proposed in theory and supported with laboratory results. They confirmed the opinion that distal and lateral lesions will give the best response to anteromedialization. Good / excellent functional results were obtained in 87% of various distal and lateral facet chondral lesions. But good / excellent functional results were achieved in only 55% of medial facet lesions. 8% poor results were recorded in common or proximal patellar lesions. The results of patients with severe central trochlear lesions were also poor. An interesting finding was that the relationship of the results with the location of the lesions was stronger than the relation with its size and the depth of the lesions.

Wang et al. (15) reported their results of Fulkerson surgery performed in 35 knees of 30 patients at the end of a 40 month (12-72) follow-up period. More recent literature also reports excellent results when the indications are correct (16,17). Patients suffering patellofemoral malalignment coexisting patellofemoral pain, arthrosis and patellar instability achieved 73% excellent-good results on the Lysholm Score. Dantas et al. (18) applied Fulkerson osteotomy for patellofemoral instability to 24 knees of 19 patients. No recurrent dislocation was observed in any of the 22 knees at the end of a mean follow-up period of 52 months (16-86). 14 of the 15 patients who had patellofemoral pain before surgery (93.3%) had no pain in the postoperative period. Average Lysholm score increased from 63.3 to 98. The Blackburn-Peel index did not change with surgery. The subjective interpretation of the patients was excellent for 19 knees and good for 5 knees. Pritsch et al. (19) reported 72.5% excellent and good results according to Lysholm and Karlsson scores of operated knees in their study, including Fulkerson osteotomy of 55 patients in 69 knees. They emphasized that male patients with a healthy patellar cartilage surface had better results.

Significant improvement was observed at all of the radiographic parameters when compared to preoperative values in 50 knees of 45 patients who underwent Fulkerson surgery for patellofemoral malalignment in our cohort. We found that patients' postoperative quality of life increased significantly according to scales which measure the daily life activities of knee related health problems, quality of life and activity level. When our results are evaluated in terms of clinical findings, there was no recurrence with patients whose main problem had been instability, movie - theatre sign disappeared in 41 patients (95.34%), and apprehension sign disappeared in 22 of these 24 patients (91.66%). These results point to our high clinical success with Fulkerson surgery in our series. A follow-up time of minimum 5 years is the major strength of our study, whereas the retrospective design and small number of patients are the major limitations.

## CONCLUSION

In conclusion, Fulkerson osteotomy is successful in the treatment of patients with lateral patellar instability and/or patellofemoral chondrosis/artrosis owing to patellofemoral malalignment. We believe that careful patient selection is the most important factor determining the overall outcome.

**Ethics Committee Approval:** Ethics committee approval was received for this study.

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