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Modified Fulkerson osteotomy in recurrent patellofemoral dislocations

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Objectives: We evaluated the results of a modified Fulkerson technique performed for the treatment of recurrent patellofemoral dislocations.

Methods: The study included 17 knees of 16 patients (11 males, 5 females; mean age 25 years; range 15 to 43 years) who were operated on by the same surgeon for patellofemoral alignment disorders. The mean duration of complaints was 3.4 years (range 1 to 12 years). Preoperatively, the number of recurring dislocations were 1 to 5 in three knees, 6 to 10 in five knees, and more than 10 in nine knees, and all the patients had a positive apprehension test and a Q angle exceeding 15 degrees. All the knees were assessed by preoperative and postoperative radiographs and computed tomography, which showed both subluxation and patellar tilt in all the knees, and trochlear dysplasia in two knees preoperatively. During surgery, diagnostic arthroscopy was performed in all the patients. The skin incision consisted of two horizontal incisions for cosmetic reasons. Surgical treatment was comprised of lateral patellar release to correct patellar tilt, and a modified Fulkerson osteotomy to correct patellofemoral malalignment, and medial plication in three knees. The patellofemoral congruity following lateral release, and the position of the patella following osteotomy and anteromedialization of the tibial tuberosity were checked arthroscopically. On control examinations, the patients were administered functional scoring questionnaires developed by Kujala et al. and Crosby and Insall. Radiographic grading of osteoarthritis was made according to the classification developed by Iwano et al. and modified by Palmer et al. The mean follow-up period was 2.6 years (range 24 to 53 months).

Results: During arthroscopy, eight knees had severe (Outerbridge grade III-IV) and nine knees had moderate (grade I-II) retropatellar cartilage damage. Follow-up evaluations showed effusion in two knees, subluxation in two knees, and a positive apprehension test in three knees. The mean flexion loss was 8° (range 0° to 20°). One patient who had an extension loss of 10° regained full extension following a six-week physical therapy program. Postoperative computed tomography scans showed that patellar tilt and subluxation were corrected in all but two knees. Preoperative radiographies showed degenerative arthritis in the tibiofemoral joint in one knee (5.9%), and in the patellofemoral joint in seven knees (41.2%). The number of knees with degenerative changes increased postoperatively to three knees (17.3%) in the tibiofemoral joint, and to 11 knees (64.7%) in the patellofemoral joint. According to the Crosby-Insall scoring system, five knees had excellent, seven knees had good, and five knees had moderate scores. The mean Kujala score was 82.6 (range 44 to 100) postoperatively.

Conclusion: Our results show that, with appropriate indications, the modified Fulkerson method is associated with successful results in the treatment of recurrent patellofemoral dislocations.

Key words: Bone malalignment/surgery; femur/surgery; knee dislocation/pathology/surgery; osteoarthritis, knee/pathology; osteotomy/methods; patella/surgery.

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Patellofemoral joint disorders are an important source of complaints of the knee region. The severity of the complaints hassle the clinician when they do not overlap with objective symptoms.[1] Most of the complaints about the knee arise from patellofemoral alignment disorders, which have good response to conservative treatment. Patellofemoral alignment disorders present as multifactorial patellofemoral instability, whose orthopedic manifestations include recurrent subluxation or dislocation, permanent dislocation, anterior knee pain with or without malalignment, or patellofemoral joint osteoarthritis.[2] Among these, patellofemoral dislocations are the most frequent patellofemoral joint disorder affecting daily activities. The etiologic factors of patellofemoral dislocations other than trauma are skeletal disorders (genu valgum, femoral or tibial torsional disorders, dysplasia of the patella, dysplasia of the femoral trochlea), soft tissue disorders (inadequate medial structures, increased Q angle, tight lateral structures, general joint laxity, patella alta), and there may be more than one factor in individuals.[3]

The main object of treatment of patellofemoral disorders is to determine patient-specific pathological factors and implement the most appropriate treatment strategy that will enable the patients to return to their predisease activity levels, with minimal damage to the affected structures. The most striking indicator for still not having an ideal surgical procedure to achieve ideal results is the existence of numerous surgical procedures defined for the patellofemoral joint. We believe that the ideal treatment approach to patellofemoral dislocations would be a procedure allowing minor adjustments within the scope of a basic approach, rather than performing a single surgical procedure in all patients. In this study, we evaluated the results of a modified Fulkerson technique[4] performed as a basic treatment procedure.

Patients and methods

A retrospective review of 59 patients was made, who were operated on by the same surgeon for patellofemoral malalignment between January 1996 and 2000. Inclusion criteria were defined as the following: a follow-up of more than two years, a history of at least one complete dislocation, surgery with a modified Fulkerson osteotomy and by the same surgeon, and postoperative physical therapy performed in our clinic. Thus, 18 patients met these criteria, of which 16 patients (17 knees; 11 males, 5 females) were available for the final follow-up controls. The mean age of the patients at the time of surgery was 25 years (range 15 to 43 years). Eleven right knees and six left knees were operated. Two patients were engaged in amateur football and one was a climber; the remaining 13 patients had a low activity level.

The mean duration of preoperative complaints was 3.4 years (range 1 to 12 years). Preoperatively, the number of recurring dislocations were 1 to 5 in three knees, 6 to 10 in five knees, and more than 10 in nine knees. At the time the first knee symptoms appeared, only four patients had a history of trauma; complaints had a sudden onset or showed a gradual increase in severity in the remaining patients.

Two patients had a history of arthroscopic lateral release, and one patient had a history of lateral release and plication of the vastus medialis.

Preoperatively, all the patients had a positive apprehension test and a Q angle exceeding 15 degrees. Preoperative and postoperative radiographs (anteroposterior, lateral, tangential patellar images), and computed tomography images were analyzed in terms of patellofemoral discordance and development of patellofemoral and tibiofemoral osteoarthritis. For radiographic evaluation, 45° tangential patella views were preferred. In addition, preoperative and postoperative computed tomographies of all the patients with the knee in full extension were evaluated. Trochlear evaluation made according to the criteria defined by Dejour et al.[5] showed a positive crossing sign on the lateral radiographs and trochlear flattening on tomographic scans in two patients, suggesting trochlear dysplasia. Both subluxation and patellar tilt were observed on roentgenograms and tomographic scans of all the patients. Patellar tilt was assessed using the lateral patellofemoral angle described by Laurin et al.[6] and this angle was open medially (normally should be open laterally) in all the patients. For tilt evaluation, the angle of patellofemoral congruity was measured and was found in positive values in all the cases. According to the computed tomographic classification of patellofemoral malalignment defined by Schutzer et al.,[7] all the patients had type 2 patellofemoral malalignment (subluxation and accompanying patellar tilt). Based on these findings, surgical treatment was designed as lateral patellar release to correct patellar tilt, and a modified Fulkerson osteotomy to correct patellofemoral malalignment.

Surgical technique

After evaluation of patients for eligibility for anesthesia, surgeries were performed under general (8 knees)or epidural (9 knees) anesthesia. With the patient placed in the supine position, a tourniquet was placed around the thigh as proximal as possible. After application of an Esmarch bandage to force blood out of the limb, the tourniquet was inflated up to 300 mmHg. Diagnostic arthroscopy through the standard portals was performed in all the patients, regardless of the presence or absence of symptoms and, when necessary, intra-articular surgical procedures were added. Arthroscopic examination focused particularly on patellafemoral congruity and cartilage tissue quality. Arthroscopic debridement was performed for patellofemoral cartilage pathologies and arthroscopic microfracture was performed when necessary.

The skin incision consisted of two horizontal incisions for cosmetic reasons (Fig. 1). The proximal incision was made parallel to the Langer's lines, approximately 2 cm proximal to the insertion of the patellar tendon on the patella. In cases in which only lateral release was planned, the length of the skin incision was about 5 cm, with its midpoint at a slightly lateral position. If an additional medial plication was planned, the incision was made exactly in the middle of the knee, about 8 cm in length. Lateral retinacular vessels were cauterized leaving the synovial membrane intact. Lateral retinacular release was performed as distally as the skin incision allowed, and

Fig. 1. The appearance of two transverse skin incisions in the left knee at postoperative 30 months.

proximally up to the superior border of the patella. Following the lateral release, arthroscopic examination of the patellofemoral congruity was made, and in those in whom sufficient correction could not be obtained, a 10 x 1 cm-long strip was excised along the patellar insertion of the tendinous portion of the vastus medialis obliquus muscle, and the remaining parts were sutured opposingly.

The distal horizontal incision was about 5 cm in length, with its midpoint lying on the tibial tuberosity. Together with subcutaneous releases and with atten-

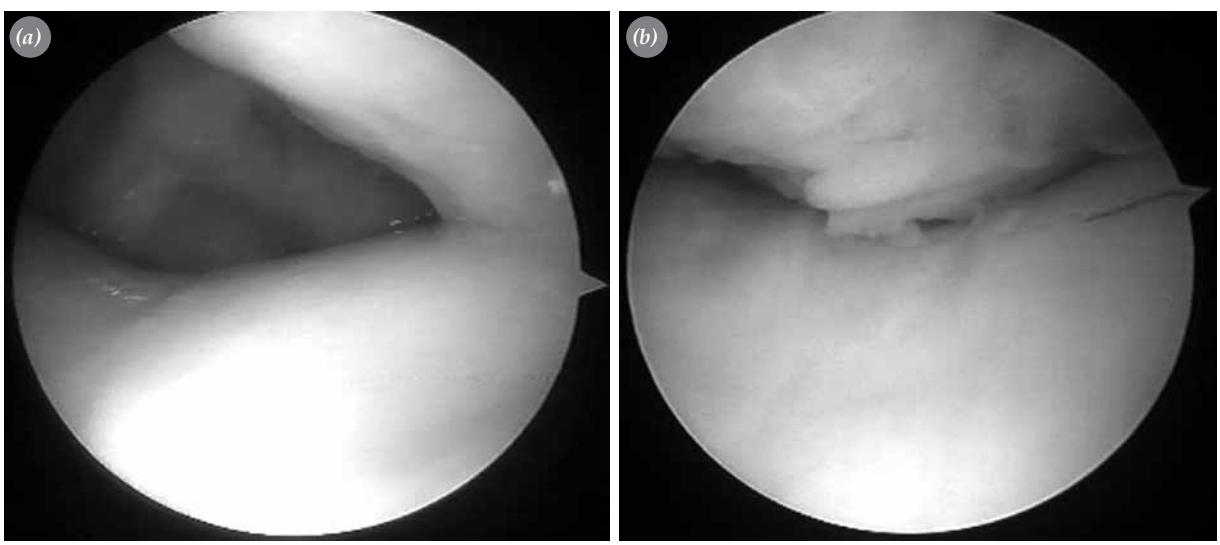

Fig. 2. **(a)** Diagnostic arthroscopy in 30° knee flexion showing obvious patellar subluxation. **(b)** Arthroscopic view after anteromedialization and temporary fixation.

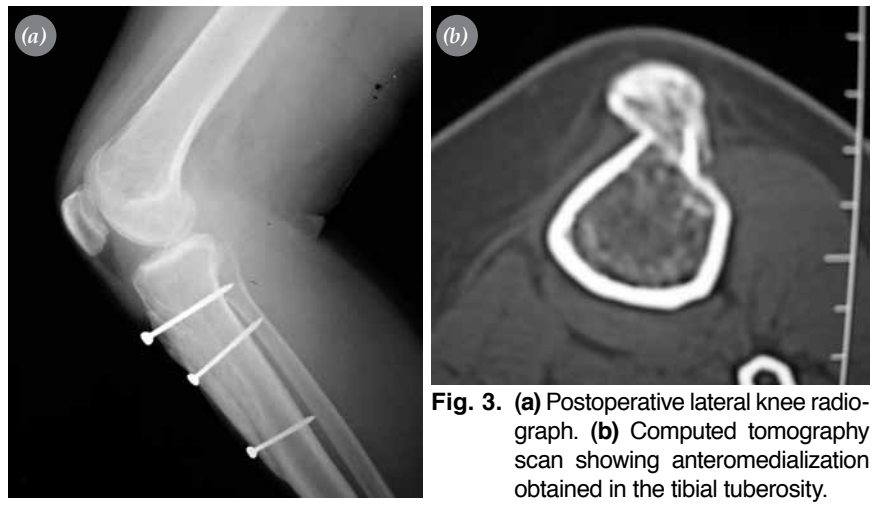

Fig. 3. **(a)** Postoperative lateral knee radiograph. **(b)** Computed tomography scan showing anteromedialization obtained in the tibial tuberosity.

tive medial, lateral, proximal, and distal retractions, a sufficient exposure was obtained during all interventions. The vertical lateral release line was joined subcutaneously with the incision made perpendicular from the lower incision. The patellar tendon and tibialis anterior muscle were separated with the help of an electrocauter; then, using the electrocauter and with attention not to disturb the anterior compartment, the tibialis anterior muscle was separated from the bone till the tibiofibular joint. Then, for control of the osteotomy site and in accordance with the osteotomy line, three Kirschner (K) wires were inserted parallel to each other and at 2-3 cm intervals, through the tibial tuberosity distally, from lateral to medial, and from the posterior plane to the anterior plane, respectively. The positions of the K-wires representing the osteotomy line were checked visually and by measurements. The tibial tuberosity was osteotomized 7-8 cm distally with a motorized saw, the K-wires being removed one after another. The osteotomized portion extending distally which was still attached to the tibia was split by stretching and controlled breaking. The tibial tuberosity was temporarily fixed with a K-wire after being shifted anteromedially, and the position of the patella was checked arthroscopically to ensure adequate anteromedialization (the intra-articular fluid is minimal to avoid misinterpretation) (Fig. 2). Then, the osteotomized portion was fixed to the tibia with two or three 4-mm cannulated screws or 4.5-mm malleolus screws placed at 2 cm intervals (Fig. 3). The tibialis anterior muscle together with its sheath was attached as much as possible to its former place by absorbable sutures. Two drains were placed, one in the area of the tibial tuberosity and the other in the knee joint, with their ends being brought out from the arthroscopic portals.

The operated lower extremities were placed in a full extension sling in the operating room, which was then replaced by an extension brace three days postoperatively. In the first week, flexion within a range of 0° to 30° was allowed on the continuous passive motion device, and was gradually increased to reach 90° at the end of the third week. Thereafter, with radiographic control, weight bearing was allowed avoiding open kinetic chain knee extension movements. Within this period, isometric exercises and electric stimulation were also applied. In the sixth week, full weight bearing was initiated allowing open kinetic chain movements.

Upon observation of pain control with oral analgesics and problem-free wound site, the drains were removed and the patients were discharged on the second postoperative day after.

In addition to physical examination, the patients were questioned with regard to postoperative satisfaction, recurrent dislocations, and return to their predisease activity levels using questionnaires proposed by Kujala et al.[8] and Crosby and Insall.[9] For radiographic grading of osteoarthritis, the classification system developed by Iwano et al. and modified by Palmer et al. was used.[10,11] The mean follow-up period was 2.6 years (range 24 to 53 months).

Results

During arthroscopy, eight knees exhibited severe (Outerbridge grade III-IV) and nine knees had moderate (grade I-II) retropatellar cartilage damage.

Table 1
Osteoarthritic changes observed in different compartments on pre- and postoperative radiographs[8]

	Tibiofemoral joint (17 knees)				Patellofemoral joint (17 knees)			
	Preoperative		Postoperative		Preoperative		Postoperative	
Osteoarthritis	n	%	n	%	n	%	n	%
Normal	16	94.1	14	82.4	10	58.8	6	35.3
Mild	1	5.9	2	11.8	4	23.5	5	29.4
Moderate	–		1	5.9	3	17.7	4	23.5
Severe	–		–		–		2	11.8

Surgical treatment consisted of lateral release and tibial tubercle osteotomy in all the knees, while three knees required medial plication due to loosening of the medial structures.

Follow-up evaluations showed effusion in two knees, subluxation in two knees, and a positive apprehension test in three knees. The mean flexion loss was 8° (range 0° to 20°), and one patient who had an extension loss of 10° regained full extension following a six-week physical therapy program.

Postoperative computed tomography scans were evaluated with respect to patellofemoral congruity, subluxation, and patellar tilt (patellofemoral congruity angle and lateral patellofemoral angle) and it was found that patellar tilt and subluxation were corrected in all but two patients.

Preoperative radiographies showed signs of degenerative arthritis in the tibiofemoral joint in one knee (5.9%), and in the patellofemoral joint in seven knees (41.2%). The number of knees presenting degenerative changes increased on postoperative radiographs, being three knees (17.3%) in the tibiofemoral joint, and 11 knees (64.7%) in the patellofemoral joint (Table 1).

According to the Crosby and Insall[9] scoring system, five knees had excellent, seven knees had good, five knees had moderate scores. All the patients rated the condition of the knee as better compared to the preoperative state. The mean Kujala score was 82.6 (range 44 to 100) postoperatively (Table 2).

Discussion

Although the majority of patients with patellofemoral problems are treated with conservative methods, surgical treatment has also been shown to be useful in selected patients.[12] Among the surgical methods are open or arthroscopic lateral release, medial plication, proximal alignment procedures, trochleoplasty, and distal alignment procedures (tibial tubercle osteotomy).[12]

Despite some controversy as to tibial tubercle osteotomy, its role in patellofemoral alignment procedures cannot be neglected.[12,13] The Maquet osteotomy and Elmslie-Trillat procedure were the first techniques described in which the tibial tubercle is shifted anteriorly and medially, respectively.[14,15] Later, Fulkerson, in an attempt to combine the advantages of both techniques, developed the Fulkerson anteromedialization osteotomy (Fig. 4).[16,17] Finally, Farr,[4] with the permission of Fulkerson, described the modified Fulkerson osteotomy technique. There are some differences in our technique: one is the separation of the osteotomized tubercle from the tibia by

Table 2
Postoperative Kujala scores

	Mean score
Limping	4.2
Weight bearing	4.3
Walking	4.6
Stairs	8.7
Squatting	3.5
Running	8.5
Jumping	8.6
Prolonged sitting with flexed knees	7.7
Pain	8.1
Swelling	9.3
Painful patellar movements	8.3
Thigh muscle atrophy	2.5
Flexion deficiency	3.5
Total	82.6

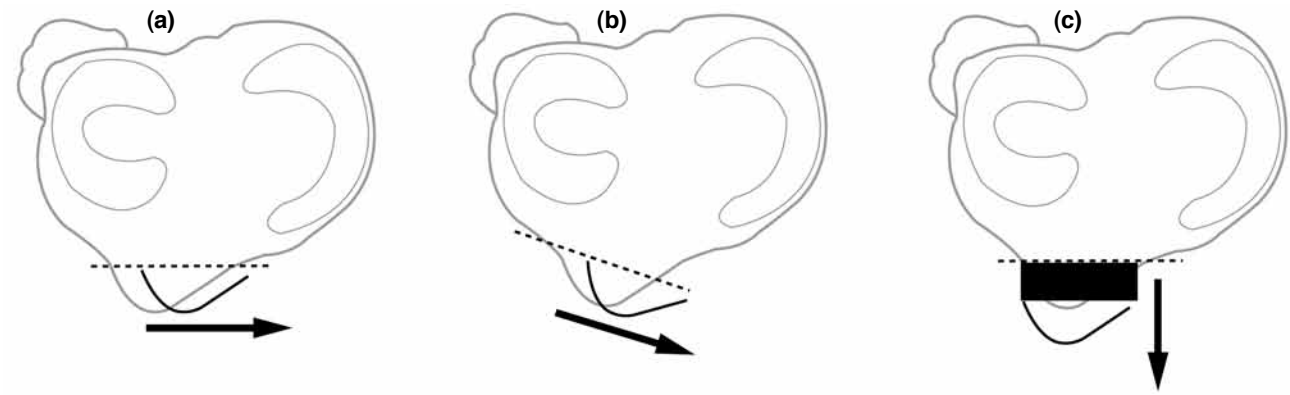

Fig. 4. Schematic illustration of the **(a)** Elmslie-Trillat, **(b)** Fulkerson, and **(c)** Maquet techniques.

splitting, not by cutting so that the periosteum can be kept intact. Another difference is the use of a double transverse incision technique.

Intraoperative arthroscopic congruity examination is another feature that we routinely incorporate into our technique. The mean values of anteromedialization aimed in the Fulkerson osteotomy have been described and taken into consideration in relevant studies.[18] In our technique, after shifting, we re-evaluate the patellar congruity arthroscopically and then fix the osteotomized portion.

Tubercle osteotomy was performed in two cases with trochlear dysplasia. In the presence of trochlear dysplasia, the Fulkerson osteotomy changes the Q angle by the anteromedialization of the tubercle, and biomechanically decreases the need for static stabilizing effect of the trochlea. Criteria in selecting ideal patients for trochleoplasty involve especially the presence of healthy patellofemoral cartilage and age below 30 years.[19] Two patients with trochlear dysplasia were both beyond 30 years of age and, like all the remaining patients, had patellofemoral cartilage degeneration.

As previously emphasized in other studies, our deductions as to the main points of achieving the best results may be listed as a good preoperative evaluation, determination of the factors leading to the pathology, and performing appropriate surgical procedures to correct the pathology.

Despite the small number of the patient group, our study has some important assets. All surgical procedures were performed by the same surgeon, using the same technique, and all the patients had a follow-up of at least two years. The number of patients that were lost to follow-up after two years was only two out of 18 patients, which represents a low rate. When reporting the results of orthopedic procedures, a follow-up period of two years is generally accepted as adequate to assess the effects of the procedure. However, Fielding et al.[20] reminded that the results of patellofemoral surgery might worsen after two years. We are planning to extend the follow-up period to five years in the same patient group and report our results. The patient group was mostly composed of individuals having a low activity level. Although patellofemoral complaints are more commonly encountered in females, it was of note that males constituted the majority in our study group. Nonetheless, the number of females was higher in the original group of 59 patients, from which 16 patients were selected for evaluation. Thus, male predominance may simply be incidental.

When the patients were asked to rate the operation results as good or bad, all the patients gave a supportive response. Preoperatively, the number of knees with more than 10 dislocations exceeded half of the study group. Besides dislocations, fear of subsequent dislocations by the patient associated with the patellofemoral joint also decreases the quality of life. In addition, severe retropatellar cartilage damage seen in nearly half of the knees has an adverse effect on the quality of life. In view of the good results of patellofemoral surgery in our study and in other studies, we suggest surgical treatment in patients whose quality of life has been compromised by patellofemoral disorders.

Arthroscopic lateral release has been the standard procedure in our clinic. However, we preferred open lateral release in this group. The most important side effect after arthroscopic lateral release is abundant bleeding.[21] The source of bleeding is the lateral genicular artery and the release path extending into the vastus lateralis muscle. However, in open lateral

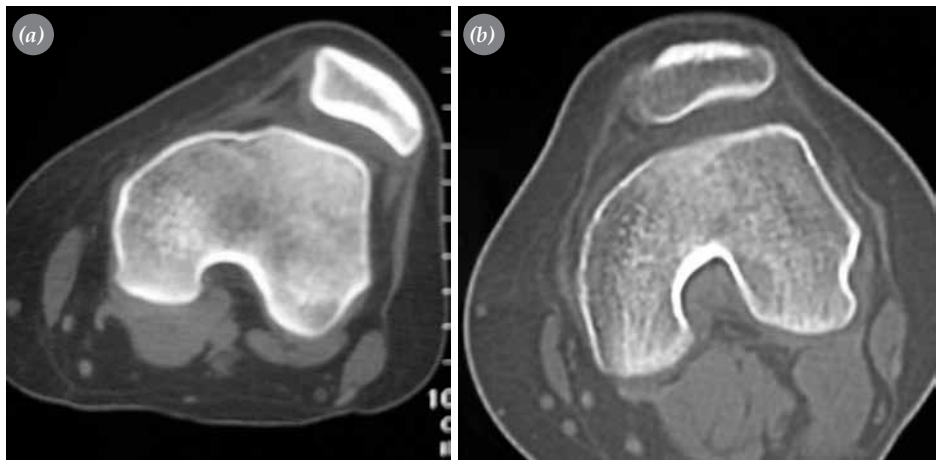

Fig. 5. **(a)** Preoperative and **(b)** postoperative computed tomography scans obtained in knee extension showing patellar subluxation and reduced patella, respectively.

release, the bleeding can be controlled by cauterizing the lateral genicular artery under direct vision, or avoided by keeping the release path in the vastus lateralis tendon around the patella causing no protrusion to the muscle. Among many reported complications of surgery for patellofemoral malalignment is iatrogenic medial patellar subluxation, insomuch that surgery for patellofemoral malalignment has been implicated as the most important cause of this complication.[22] Although medial plication effectively prevents lateral shifting, we preferred medial plication in carefully selected knees in which, we believed, medial plication would not cause iatrogenic medial shifting. This decision was made by the surgeon after preoperative and intraoperative assessments of patellar movements. A review on recent studies demonstrated that medial patellofemoral ligament reconstructions provided successful results in the treatment of recurrent cases.[23] However, the authors suggested that these studies be evaluated cautiously due to some limitations with regard to sample size, statistical methods, and the absence of a control group.[23] Because of the retrospective design of our study, preoperative magnetic resonance evaluations of the medial patellofemoral ligament were absent.

Taking into account previous clinical studies on the Fulkerson osteotomy, we used the Crosby and Insall, and Kujala scoring systems.[16,24] As reflected by the Kujala scores objectively, in general, the technique we used provided satisfactory results, but it could not correct all the pathologies in the knee while correcting some of them perfectly. Postoperative Kujala scores demonstrated that the technique prevented effusion (93.5%), provided a more comfortable gait (92.9%), and allowed comfortable stair climbing (87.7%) in a great majority of the cases. However, the results were not satisfactory with respect to muscle strength (51.8%), squatting (70.6%), maintenance of flexion (71.8%), or long sitting with the knee in flexion (77.7%). It is possible that success rates can be increased by modifying the surgical technique and postoperative rehabilitation based on the expectations of the patients and existing pathologies in the knee.

In our study, radiographic results at the end of at least two years were not consistent with favorable clinical results. Increases in degenerative changes were almost 200% and 50% in the tibiofemoral joint and the patellofemoral joint, respectively. Our study does not provide an answer to the question of when and how this radiographic worsening observed at final follow-up assessments would start to affect the clinical condition. Osteophyte formation is known after patellofemoral surgery.[25,26] It is also known that knees with patellofemoral instability have a higher risk for degeneration.[27] To determine whether joint degeneration occurring after patellofemoral surgery is a natural course of patellofemoral instability or is secondary to osteotomy, double-blinded, controlled studies with long term follow-up are required.

In spite of our fast rehabilitation program consisting of immediate mobilization after surgery and initiation of full weight bearing after the observation of callus formation in the third week, two knees developed joint stiffness. After manipulation under general anesthesia at 9 and 10 weeks, respectively, both knees reached the desired range of motion. Joint stiffness is a reported

complication after patellofemoral surgery[28] and probably results from suprapatellar adhesions.

We were convinced that reduction of the patella was achieved in all but two cases with subluxation (Fig. 5). One of the patients with subluxation had a history of previous surgery (lateral release and vastus medialis plication) for patellofemoral malalignment at the age of 13 years and underwent osteotomy after the adolescence period. The other patient was the one who had experienced the highest number of dislocations preoperatively, which could be defined as a chronic case of dislocation.

Our surgical technique which consists of transverse double incisions parallel to the Langer's lines provides better cosmetic results. We think that the double-incision technique would not pose any surgical difficulty. None of the patients had any complaint associated with the cosmetic results of the incision scars. Considering scar-related concerns of patients undergoing surgery with the single-incision technique in previous years, we believe that this double-incision technique offers a considerable advantage. In addition, with the mean age being 25 years, the transverse incisions will not cause any problem in the future for possible total knee arthroplasty operations. Vince and Abdeen[29] reported that the transverse incision that had been made for any reason long years before a planned knee arthroplasty operation would not have an adverse effect on the anterior longitudinal incision used in arthroplasty.

In conclusion, the modified Fulkerson osteotomy technique is composed of pieces complementing each other. With the right indications and planning, surgical procedures performed aiming at elimination of patellofemoral complaints of the patients, combined with an appropriate physical therapy program may lead to successful results as in our study. However, the question as to why radiographic results are not consistent with clinically successful results has yet to be answered. We think that the results of 5-year follow-up may provide satisfactory information on the development of adverse radiographic changes, whether they are due to the natural course of the pathology or induced by surgery.

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