MEDWIN PUBLISHERS
Committed to Create Value for Researchers

Journal of Orthopedics & Bone Disorders
ISSN: 2577-297X

Anteromedializing Tibial Tuberosity Osteotomy According to the Modified Fulkerson Technique in the Treatment of Patellofemoral Malalignment: Case Series with Long-Term Follow-Up

Colmenares L[1], Leal J[2]* and Galban M[3]

[1]Limb Lengthening and Deformity Correction Surgeon, Hospital de Coria, Spain, ORCID: 0009-0007-2511-5671

[2]Limb Lengthening and Deformity Correction Surgeon, Hospital de Niños Dr. José Manuel de los Ríos, Venezuela, ORCID: 0009-0002-8083-6491

[3]Limb lengthening and Deformity Correction Surgeon, Clínica NOEL, Colombia, ORCID: 0000-0001-5455-3848

Research Article

Volume 10 Issue 4

Received Date: September 15, 2026

Published Date: October 14, 2026

DOI: 10.23880/jobd-16000297

***Corresponding author:** Juan Leal, Urb. La Granja, Residential Complex Valle Fresco I, Tower D, apt. D-J3, Naguanagua, 2005, Carabobo, Venezuela; email: juanenrriqueleal@gmail.com

Abstract

Objective: To evaluate the clinical outcomes, pain relief, and long-term satisfaction in patients with patellofemoral malalignment who underwent anteromedial osteotomy of the anterior tibial tuberosity using the modified Fulkerson technique.

Material and Methods: This was an observational, descriptive, prospective case series study (level of evidence IV). Forty-three knees in 38 patients (32 women and 6 men; age range: 14–68 years) operated on between 1999 and 2011 were evaluated, with a mean follow-up of 5.8 years (range: 1.5–12 years). The technical modification included a smaller incision (3.5 cm), a 30° medial osteotomy converging with the lateral cut at 45°, and preservation of the tibialis anterior muscle insertion. Pain was assessed pre- and postoperatively using the Numerical Rating Scale (NRS).

Results: Anterior knee pain was the main indication for surgery (44.18%). 52.63% of patients presented with severe to unbearable preoperative pain (VNS 7/10). At the postoperative follow-up, 97.68% of cases showed complete or substantial pain remission within 3 to 12 months. The overall satisfaction level was excellent or good in 95.3% of cases (n=41 knees). The overall complication rate was 11.6% (including hardware loosening, infrapatellar pain, and superficial infection), all of which were successfully resolved. Conclusions: The modification of the Fulkerson osteotomy technique is an effective, reproducible procedure with low morbidity for extensor mechanism realignment, offering pain reduction and high long-term satisfaction rates.

Keywords: Patellofemoral Malalignment; Tibial Tuberosity Osteotomy; Fulkerson; Anterior Knee Pain; Clinical Outcome

Abbreviations: NRS: Numerical Rating Scale; TTA: Anterior Tibial Tuberosity; CAT: Patellar Axial Computed Tomography; NEV: Numerical Visual Scale; AMTT-G: Anteromedial Tibial Tubercle Transfer modified by Galban; NVS: Numerical Visual Scale.

Introduction

Patellofemoral malalignment is one of the most frequent etiologies of anterior knee pain and joint instability in orthopedic practice [1]. Its pathophysiology responds to a

complex biomechanical imbalance of the extensor apparatus that alters the patellar displacement in the trochlear track, generating hyperpressure and asymmetric mechanical overload on the articular facets [2,3]. When conservative treatment through physiotherapy and pharmacological analgesia fails to control the symptoms after a minimum period of six months, surgical intervention is formally indicated [4,5].

Historically, multiple surgical procedures have been described for the realignment of the extensor apparatus [3,6,7]. Among the techniques of distal realigning in adults, the coronal flat osteotomy described by Elmslie-Trillat [8-10] and the anterior elevation of Maquet [11] have been widely used. In an effort to combine anterior decompression with lateral traction vector correction, Fulkerson developed the anteromedial transfer of anterior tibial tuberosity (TTA) by means of an oblique cut, demonstrating satisfactory results in more than 80% of cases [12].

Despite its recognized benefits, the traditional surgical approach to Fulkerson's osteotomy requires wide incisions and considerable muscle and periostic detachment [13]. This dissection can compromise the vascularization of the transferred fragment, increase the risk of consolidation delays or pseudoarthrosis, and increase the morbidity of the surgical wound [14].

In order to optimize the biological viability of the bone graft and reduce perioperative complications, in 1999 Dr. Miguel Galban introduced a technical modification to the Fulkerson procedure. This technical variant consists of the execution of a medial cut at 30° with respect to the horizontal plane that converges with the lateral osteotomy at 45° around the TTA, performed through a reduced incision of 3.5 cm. This modification preserves the insertion of the anterior tibial muscle and the regional periostic vascularization.

The objective of this work is to present the clinical results, the effectiveness in pain relief and the degree of long-term satisfaction in a series of cases of patients with patellofemoral malalignment operated on by Galban-modified Fulkerson anteromedializing osteotomy.

Materials and Methods

Study Design and Sample Selection

An observational, descriptive, prospective, and IV level of evidence study (case series) was designed to evaluate the effectiveness of anterior tibial tuberosity (TTA) anteromedializing osteotomy using the Galban-modified Fulkerson technique in the treatment of patellofemoral malalignment.

The study universe was made up of patients evaluated in our surgical center between January 1999 and November 2011. The inclusion criteria were: Skeletal maturity (closure of radiologically confirmed growth cartilages). Persistent symptoms of patellofemoral pain and instability (subluxation, dislocation or poor patellar follow-up) not responding to conservative treatment for more than six months. Increased Q angle (>14°). Classification of patellofemoral malalignment types I, II or III according to Schutzer-Fulkerson. Patients with previous TTA surgeries or postoperative follow-up less than 12 months were excluded.

The final sample consisted of 43 knees in 38 patients. Since in 5 patients the condition was bilateral with independent surgical requirement, the clinical evaluation and analysis of results were performed using the operated knee as an analysis unit. All patients signed the corresponding informed consent after intervention, following the principles of the Declaration of Helsinki.

Clinical and Radiological Evaluation

The preoperative protocol included complete medical history, detailed physical examination and imaging evaluation. The angle Q was measured with the knee in full extension (0°). Patellar apprehension maneuvers (at 30° and 45° flexion) and patellofemoral compression test in flexion-extension range were performed.

The imaging study consisted of simple comparative X-rays, lower limb telemetry with mono/bipodal support in the coronal plane and patellar axial computed tomography (CAT) at 0°, 15° and 30° quadriceps flexion (in relaxation and isometric contraction).

Pain was measured pre- and postoperatively using the Numerical Visual Scale (NEV) of pain (range 0-10, where 0 represents absence of pain and 10 the maximum unbearable pain). Additionally, the level of patient satisfaction was categorized at the end of the follow-up into four degrees: Excellent, Good, Regular and Bad.

Surgical Technique (Modification of Galban)

All interventions were performed by the same senior surgeon (MG) under pneumatic ischemia with adjusted minimum occlusion pressure.

Approach: A reduced longitudinal incision of 3.5 cm was made on the TTA. The patellar tendon was dissected and isolated in its distal insertion and the periosteum was incised longitudinally, exposing the lateral and medial faces of the tibia in an extension of 4 to 5 cm.

Copyright© Colmenares L, et al.

Osteotomy: Unlike the traditional technique, a medial cut was performed at 30° with respect to the coronal plane that converged with the lateral cut at 45° around the TTA. Perforations were performed with a 2.7 mm drill bit connected with an osteotome, completely preserving the insertion and origin of the anterior tibial muscle (Figure 1).

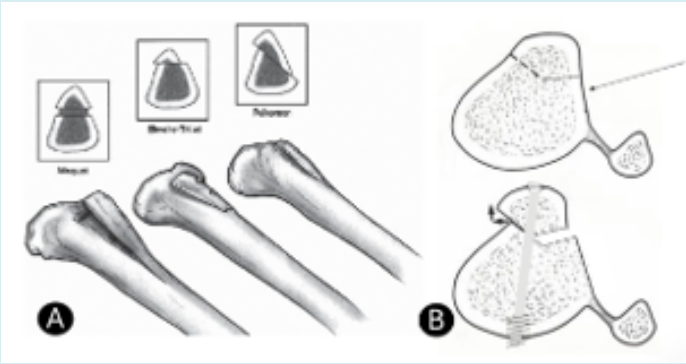

Figure 1: A: Osteotomy Techniques: Maquet, Elmslie-Trillat and Fulkerson, B: Fulkerson Technique modified by Galban.

Back and Fixation: The fragment of the released TTA moved in the anteromedial direction between 8 and 10 mm on the plane of the osteotomy to normalize the angle Q. The rigid fixation was achieved by means of a 6.5 mm spongy screw (32 mm partial screw) after drilling with a 3.2 mm drill bit directed towards the posterior cortical of the tibia. Closed suction drainage (Hemovac) was placed and closure was made by planes without tension (Figure 2).

Figure 2: A: Preoperative Planning, B: Translation Plus Fixation, C: Close with Hemovac.

Postoperative Protocol

Initial immobilization with inguinal-pedic splint in extension and continuous cryotherapy. Isometric strengthening exercises of quadriceps were started immediately. Walking in strict discharge with crutches was allowed from the first postoperative day. When observing bridges of radiological bone consolidation (weeks 4 to 6), the splint was removed and progressive partial support and active-assisted mobilization began. Full support and gradual return to low-impact activities (swimming, cycling) was authorized after complete clinical and radiological consolidation (weeks 8-12).

Bio-Statistical Analysis

The data were processed using the SPSS v.26 statistical package (IBM Corp., Armonk, NY, USA. USA). Qualitative and categorical variables were expressed in absolute frequencies and percentages (n, %). Continuous quantitative variables (age, tracking) were reported as mean +/- standard deviation (ED) and range. To analyze the change in pain intensity (VN) before and after surgery, being an ordinal variable with non-parametric distribution, the Wilcoxon sign range test was used for related samples (establishing a significance level of $p < 0.05$).

Results

Characteristics of the Sample

43 knees corresponding to 38 patients (32 women; 84.21% and 6 men; 15.79%). 62.79% of the procedures (n=27) were performed on the right knee and 37.21% (n=16) on the left. The average age at the time of surgery was 28.4+/-12.6 years (range: 14 to 68 years). The distribution by age groups showed a clear frequency in the young population: 41.87% of the knees belonged to patients between 14 and 24 years old (n=18), and 90.70% were under 47 years old.

Copyright© Colmenares L, et al.

The average post-operative follow-up was 5.8+/-3.2 years (range: 1.5 to 12 years). Five patients (corresponding to 5 knees) were lost for the direct evaluation to the final follow-up due to migration abroad, although indirect confirmation with relatives reported the absence of complications; so the rate of complete direct follow-up through a structured survey was 88.37% (n=38 knees). 68.93% of patients came to our consultation with a history of previous failed arthroscopic procedures in other centers.

Indications and Associated Procedures

The main reason for consultation and surgical indication was anterior knee pain associated with increased Q angle (44.18%; n=19), followed by recurrent subluxation or dislocation type instability (37.21%; n=16 combined) (Table 1).

Variable	Category / Parameter	Value (n, % or Average ± SD)
Age (years)	Average ± SD (Range)	28,4 ± 12,6 (14 – 68)
Age groups	14 – 24	18 (41,87%)
	25 – 35	10 (23,25%)
	36 – 46	7 (16,28%)
	47 – 57	4 (9,30%)
	≥ 58	4 (9,30%)
Gender	Female	32 (84,21%)
Variable	**Category / Parameter**	**Value (n, % or Average ± SD)**
	Male	6 (15,79%)
Laterality	Right Knee	27 (62,79%)
	Left Knee	16 (37,21%)
Clinical Picture / Indication	Angle Q > 14° + Pain	19 (44,18%)
	Angle Q > 14° + Subluxation	9 (20,93%)
	Angle Q > 14° + Pain + Subluxation	7 (16,28%)
	Angle Q > 14° + Pain + Subluxation + Mal-tracking	5 (11,62%)
	Inveterate / Recurrent dislocation	3 (7,00%)

Table 1: Demographic and clinical-radiological characteristics of the sample.

In 30.84% of cases (n=14), modified Fulkerson osteotomy was associated with other joint realining or reconstruction procedures. The most frequent concomitant technique was the release of the lateral patellar aleron (20.93%; n=9), alone or associated with trochlear surcoplasty (7.00%; n=3) (Table 2).

Surgical Procedure	n	(%)
Isolated modified Fulkerson osteotomy (AMTT-G)	29	67,44%
Concomitant Procedures		
Surgical Procedure	**n**	**(%)**
AMTT-G + Lateral Patellar Aleron Release	5	11,63%
AMTT-G + Lateral Release + Troclear Surcoplasty	3	7,00%
AMTT-G + Isolated Trochlear Surcoplasty	2	4,65%
AMTT-G + Lateral Release + Advancement of the Internal Vast	2	4,65%
AMTT-G + Plication of the Medial Patellar Retinaculum	1	2,32%
AMTT-G + Retinacular Interposition Arthroplasty	1	2,32%
Total	**43**	**100,00%**

AMTT-G = Anteromedial Tibial Tubercle Transfer modified by Galban.
Table 2: Distribution of concomitant surgical procedures.

Copyright© Colmenares L, et al.

Pain Assessment and Patient Satisfaction

In the preoperative period, the intensity of pain evaluated by EVN was classified as moderate (EVN 4-6) at 11.42% (n=4), severe (VNV 7-9) in 28.57% (n=10) and unbearable (VNV) in 42.86% (n=15). The median score of preoperative pain was 8 points (interquartile range, RIC: 6-10).

After the intervention, 97.68% of patients reported complete or almost complete remission of painful symptoms in an interval of 3 to 12 months. The median postoperative pain score dropped to 0 points (RIC: 0-2). The Wilcoxon sign range test demonstrated a statistically significant reduction in pain intensity after surgical realignment with the modified technique ($Z=-5.42$; $p< 0.001$).

The level of satisfaction reported by the patients was 95.3% (n=41 knees with Excellent or Good result). Only two knees (4.7%) reported a Regular result: one due to local discomfort on the head of the fixing screw and another due to persistence of quadriceps strength deficit (grade 4/5). No patient classified the result as Bad.

Complications

The overall complication rate was 11.60% (n = 5 knees):

Symptomatic Loosening of the Fixing Screw: 2 cases (4.65%), which required minor reintervention for the removal of the osteosynthesis material after the consolidation of the osteotomy.

Infectious Complication/Wound Exudate: 1 case (2.32%), successfully managed by surgical cleaning and intravenous antibiotic therapy without loss of fixation.

Infrapatellar Pain with Quadricipital Weakness: 1 case (2.32%), which improved after an intensive physical rehabilitation protocol.

Painful Keloid Scar: 1 case (2.32%).

No cases of pseudoarthrosis, consolidation delay or fracture of tibial tuberosity or proximal tibia were recorded during follow-up.

Discussion

The main finding of the present study shows that anteromedializing osteotomy of anterior tibial tuberosity (TTA) using Galban-modified Fulkerson technique provides long-lasting symptomatic relief and high rates of long-term satisfaction (95.3%) in the treatment of patellofemoral malalignment [15]. This technical variant manages to normalize the quattrocipital traction vector and decompress the joint facets through a reduced invasive approach that preserves the muscle envelope and periostic vascularization.

Patellofemoral decompression by anteromedial transfer of TTA was originally described by Fulkerson in 1983 to overcome the deficiencies of the purely anterior Maquet osteotomy and the simple medialization of Elmslie Trillat [8,11,12]. In the original series of Fulkerson JP [12], the combined elevation and medialization significantly reduced the patellar contact pressures in the lateral facet, obtaining 83% of excellent or good results in an average follow-up of 2 to 9 years. In our series, with an average prolonged follow-up of 5.8 years (up to 12 years), the overall satisfaction rate reached 95.3% (n=41 knees). This percentage is in line with what was reported by Pirodiano M, et al. [16], who in a series of 30 patients using the Fulkerson technique reported 90% of symptomatic relief after 4 years of follow-up.

From the biomechanical point of view, the orientation of the bone sections determines the relative magnitude of the medialization and the previous advance [12,17]. The modification described by Galban introduces a medial cut at 30° with respect to the coronal plane in convergence with a lateral cut at 45°. This geometric configuration guarantees a harmonic anteromedial translation (from 8 to 10 mm), sufficient to correct increased Q angles without generating an excessive anterior protruding of the TTA that causes prominence of the material or suffering of the overlying skin.

A differentiating and critical technical aspect of the Galban modification is the preservation of the insertion and origin of the anterior tibial muscle through a reduced incision of 3.5 cm. In conventional Fulkerson osteotomy, broad dissection of the anterior compartment and extensive subperiodic elevation of the anterior tibial are standard steps that increase surgical morbidity, postoperative hematoma and the risk of compartment syndrome [14,18]. By keeping the muscle coverage and nutritional vascularization of the TTA unharmed, the consolidation rate in our series was 100%, with no cases of consolidation delay, pseudoarthrosis or necrosis of the transferred fragment.

In relation to complications, the literature reports rates between 10% and 21% in traditional distal realigning osteotomies, highlighting loss of fixation, tibia or TTA fractures and pain on osteosynthesis material [13,14]. Bellemans J, et al. [19] reported 12% of complications in a cohort of 42 cases of distal realinging. In our series, the overall complication rate was 11.6% (n=5 knees), all satisfactorily resolved and without permanent functional sequelae. The use of a single 6.5 mm sponge screw with 32 mm partial thread provided the necessary rigidity to allow early active mobilization, recording only 2 cases (4.65%) of screw loosening that required its removal after bone consolidation.

We recognize certain limitations in the present study. First, its one-center observational design without a direct

Copyright© Colmenares L, et al.

comparison group limits the causal inference of the technical modification against the original Fulkerson technique. Secondly, although the Numerical Visual Scale (NVS) was used for pain measurement, knee-specific validated functional scales such as the Kujala Anterior Knee Pain Scale [20] or Lysholm were not administered throughout the recruitment period (1999-2011). However, the strengths of the study lie in the long average follow-up time (5.8 years), the homogeneity in the surgical technique performed by a single senior surgeon and the demonstration of the clinical effectiveness of a minimally invasive approach in reconstructive orthopedic surgery.

References

1. Post WR (1999) Clinical evaluation of patients with patellofemoral disorders. Arthroscopy 15(8): 841-851.
2. Schutzer SF, Ramsby GR, Fulkerson JP (1986) Computed tomographic classification of patellofemoral pain patients. Orthop Clin North Am 17(2): 235-248.
3. Insall J, Bullough PG, Burstein AH (1979) Proximal "tube" realignment of the patella for idiopathic patellar subluxation. Clin Orthop Relat Res 144: 63-69.
4. Barber FA, McGarry JE (2008) Tibial tubercle anteromedialization for patellofemoral arthrosis: a 2- to 12-year follow-up. Arthroscopy 24(11): 1233-1240.
5. Palmer SH, Servhe F, Cross MJ (2000) Anteromedialization of the tibial tubercle for patellofemoral pain and instability. J Bone Joint Surg Br 82(6): 826-830.
6. Ferguson AB Jr (1982) Elevation of the insertion of the patellar ligament for patellofemoral arthritis. J Bone Joint Surg Am 64(5): 766-771.
7. Pridie KH (1959) A method of resurfacing osteoarthritic knee joints. J Bone Joint Surg Br 41: 618-619.
8. Elmslie RC (1935) Recurrent dislocation of the patella. Ann Surg 102(4): 796-799.
9. Morshuis WJ, Pavlov H, Dehne R (1990) Long-term results of the Elmslie-Trillat procedure for patellofemoral instability. Am J Sports Med 18(6): 624-628.
10. Cox JS (1976) An evaluation of the Elmslie-Trillat procedure for patellar dislocation and subluxation. Am J Sports Med 4(2): 72-80.
11. Maquet P (1963) Advancement of the tibial tuberosity in the treatment of osteoarthritis of the knee. Rev Chir Orthop Reparatrice Appar Mot 49: 285-389.
12. Fulkerson JP (1983) Anteromedialization of the tibial tuberosity for patellofemoral malfunction. Clin Orthop Relat Res 177: 176-181.
13. von Knoch F, Boehm T, Burgi M, Cikes A, Hasler CC (2007) Tibial tubercle transfer for patellofemoral malalignment: comparison of Elmslie-Trillat and Fulkerson techniques. Arch Orthop Trauma Surg 127(9): 827-832.
14. Buuck DA, Cox JS (1998) Tibial tubercle osteotomy for patellofemoral realignment: a long-term follow-up study. Am J Knee Surg 11(2): 92-96.
15. Koeter S, Diks MJ, Anderson PG, Louwerens JW (2007) A modified Fulkerson osteotomy for patellofemoral instability or pain: a 2- to 12-year follow-up study. Knee Surg Sports Traumatol Arthrosc 15(11): 1322-1328.
16. Pirodiano M, Carrillo J, Parada A (2004) Resultados de la osteotomía de realineación distal de la tuberosidad tibial anterior en el dolor patelofemoral. Rev Esp Cir Ortop Traumatol 48(3): 185-191.
17. Teitge RA, Faerber W, Deland E (1996) Tibial tubercle transfer for patellofemoral arthrosis. Clin Orthop Relat Res 332:112-121.
18. Fulkerson JP, Becker GJ, Meaney JA, Miranda F, Mastrodimitropoulos CR (1990) Gastrocnemius-semimembranosus bursa extension into the tibia after patellofemoral realignment. Am J Sports Med 18(5): 490-496.
19. Bellemans J, Cauwenberghs F, Witvrouw E, Brys P, Victor J, et al. (1997) Anteromedial tibia tubercle transfer in patients with patellofemoral malalignment and articular cartilage lesions. Knee 4(4): 231-235.
20. Kujala UM, Jaakkola JH, Koskinen SK, Taimela S, Hurme M, et al. (1993) Scoring of patellofemoral disorders. Arthroscopy 9(2): 159-163.

Copyright© Colmenares L, et al.

YOUR RESEARCH DESERVES GLOBAL VISIBILITY

• Publish • Discover • Share • Connect

MEDICAL	CLINICAL	LIFESCIENCES	PHARMA
90+ OPEN ACCESS JOURNALS		400+ RESEARCH TOPICS	

SUBMIT YOUR RESEARCH
Submit your manuscript through our online submission system.

REPRINTS
If you require a reprint of any article, please contact us.
info@medwinpublishers.com

BECOME A REVIEWER
Share your expertise and contribute to scholarly publishing.

SCAN TO EXPLORE MEDWIN JOURNALS

• Journals • Submit Manuscript • Reviewer Program • Article Tracking

Our Journals indexed in

Embase® ELSEVIER | PubMed National Library of Medicine NLM | Crossref | Google Scholar | INDEX COPERNICUS INTERNATIONAL | ISSN INTERNATIONAL STANDARD SERIAL NUMBER INTERNATIONAL CENTRE | ROAD DIRECTORY OF OPEN ACCESS SCHOLARLY RESOURCES | EuroPub | Scilit | WorldCat® | Academic Resource Index ResearchBib | ADVANCED SCIENCE INDEX | INTERNATIONAL Scientific Indexing | ICMJE INTERNATIONAL COMMITTEE of MEDICAL JOURNAL EDITORS

This article published by Medwin Publishers, 28475 Witherspoon Dr, Novi, MI 48377, United States, +1-248-247-6042, WhatsApp +1 (248) 275-1133, info@medwinpublishers.com

© 2026, by the Authors. The articles published from this journal are distributed to the public under "Creative Commons Attribution License" (https://creativecommons.org/licenses/by/4.0/). Therefore, upon proper citation of the original work, all the articles can be used without any restriction or can be distributed in any medium in any form.