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## Functional and Clinical Outcomes After Modified Fulkerson Osteotomy for Patellar Maltracking

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**Abstract:** Patellar maltracking syndrome (PMS) is characterized by abnormal patellar motion, leading to anterior knee pain, instability, and patellofemoral joint degeneration. Often associated factors are patella alta, trochlear dysplasia, increased quadriceps angle, and vastus medialis oblique weakness. When conservative management, including physical therapy and McConnell taping fails, surgical intervention is required. This retrospective study, performed at the University Clinic for Surgical Diseases 'St. Naum Ohridski' – Skopje, North Macedonia, evaluates the clinical efficacy of modified Fulkerson tibial tubercle osteotomy in 30 patients with PMS. Diagnosis was based on clinical assessment and radiographic imaging. The preoperative Kujala Score ranged from 46 to 63 (mean 54.5, average 56), while the preoperative KOOS score ranged from 24 to 57 (mean 40.5, average 41.55), indicating moderate functional impairment. Depending on cartilage wear, either medialization or anteromedialization was performed through tibial tubercle osteotomy. Postoperatively, the patients were put on a partial weight – bearing for six weeks. Afterwards, strict rehabilitation program was followed to restore muscle strength, flexibility and patellar tracking. The postoperative outcomes showed a significant clinical improvement. Kujala scores range from 74 to 91 (mean 82.5, average 84) and KOOS score range from 50 to 85 (mean 67.7, average 62.62). Statistical analysis showed significant clinical improvement regarding pain and function ( $p < 0.001$ ). Four patients experienced mild lateral knee pain which was successfully treated conservatively. There were not reported any cases of deep vein thrombosis, infection or fractures. The downside of this technique is the hardware removal which was required by eight patients after an average time of 2 years from the surgical intervention. This study claims that the modified Fulkerson osteotomy is successful in the treatment of PMS, when the conservative treatment fails. Significant clinical improvements in pain, function, and stability are achieved through this technique while maintaining a low complication rate.

**Keywords:** Patellar maltracking, Fulkerson osteotomy, Tibial tubercle transfer, Kujala Score, KOOS

### Introduction

Anterior knee pain is commonly associated with patellar maltracking syndrome, resulting from abnormal alignment and movement of the patella in the trochlear groove. Anterior knee pain significantly compromises

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functional mobility in daily activities and has negative impact on athletic performance. Additionally the performance of routine motor tasks essential for independent living, such as walking, stair climbing, and transitioning from sitting to standing is compromised.

Patellar maltracking occurs as a result of an imbalance in the dynamic relationship between the patella and trochlea. This is often secondary to an underlying structural abnormality. Malalignment may be attributed to trochlear dysplasia, quadriceps insufficiency, patella alta, or excessive tibial tuberosity trochlear groove (TT-TG) distance (Jibri et al., 2019). Anterior knee pain (AKP) is one of the most common conditions to bring active young patients to a sports injury clinic. It is a heterogeneous condition related to multiple causative factors. Compared to the general population, there appears to be a higher risk of development of patellofemoral osteoarthritis in patients with AKP (D'Ambrosi et al., 2022). While the first line of treatment is conservative management, including physiotherapeutic intervention aimed at addressing quadriceps muscle imbalances, quadriceps retraining is associated with good clinical outcomes in patients found to have VMO impairments and taping for quadriceps muscle activation in subjects with PMS (McConnell taping), surgical intervention is justified when symptoms persist.

## Method

This is retrospective study which included 30 patients diagnosed with PMS, all treated with Modified Fulkerson TTO at the University Clinic for Surgical Diseases 'St. Naum Ohridski' in Skopje. Inclusion criteria were: patients between 16 and 45 years of age with clinically and radiologically confirmed PMS, who underwent at least six months of conservative treatment, and showed no clinical improvement. All surgeries were carried out by the last author, Dr. Nebojsa Nastov, to ensure consistency in surgical technique. Structured diagnostic protocol was used, combining patient history, clinical examination and radiological evaluation to identify both structural and functional contributors to instability. Besides standard X-ray imaging, dynamic MRI allowed assessment of MPFL integrity, cartilage lesions, trochlear dysplasia, and associated soft tissue structures. According to Walter et al. (2022), when combined with detailed clinical assessment, real-time MRI confirmation of joint kinematics can significantly validate the choice between surgical intervention and targeted physical therapy.

The Caton-Deschamps index was measured on MRI using a cross-sectional imaging method. The assessment of CDI on MRI using a cross-sectional imaging method has a better correlation with traditional X-Ray assessment of CDI than single-slice assessment (Palmowski et al., 2024). CT imaging was used to quantify TT-TG distance, providing precise quantification of patellar lateralization relevant to surgical indication.

To achieve a more anatomical contour of the proximal tibia, we used a modification of the technique originally described by Tom Minas (*Minas, 2011*), which allows for consistent reduction of the anteromedial prominence of the tuberosity. Compared to conventional techniques, this approach involves a more extensive medial dissection. Full-thickness elevation of the medial periosteal sleeve was done, carried to the posteromedial cortex of the tibia. This approach enabled easier reapproximation of the subperiosteal flap during closure and minimized the likelihood of leaving a residual bony prominence. This modification improved aesthetic outcomes and patient satisfaction.

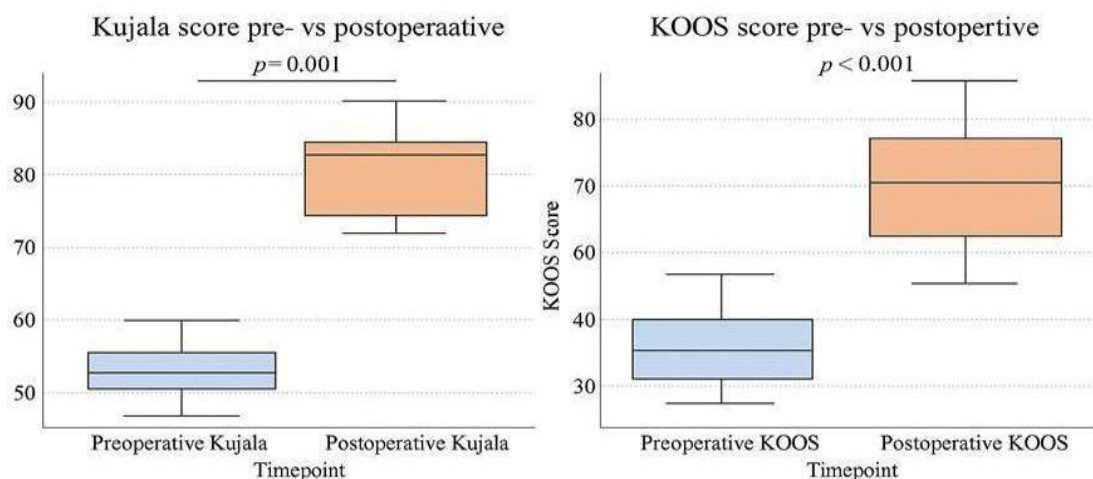


Figure 1. Patient-reported outcome measures after tibial tubercle osteotomy

With this approach precise correction of the lateralization of the tibial tubercle, patellar height and stress unloading of the patellofemoral joint was enabled. The amount of anterior and medial displacement can be adjusted based on the steepness of the osteotomy (Ridley et al., n.d.). The parameters shown in Table 1 were considered as surgical indications for tibial tubercle osteotomy.

Table 1. Osteotomy indications

Indication	Treatment
TT–TG $\geq 20$ mm	Medialize tibial tubercle
Patella alta (CD ratio $>1.2$ )	Distalize tibial tubercle
Focal chondral lesion	Anteriorize tibial tubercle

*Note: Treatments may be combined for those with multiple indications. CD, Caton–Deschamps; TT–TG, tibial tuberosity–trochlear groove*

Postoperative care involved six weeks of partial weight-bearing, followed by a progressive rehabilitation protocol to restore knee function and optimize patellar tracking. Outcome measures included the Kujala Score for pain, KOOS for functional assessment, and clinical tests for stability (Patellar Apprehension and Tilt Tests).

## Results and Discussion

Patient records from January 2021 to December 2022 were reviewed, allowing for a minimum follow-up of 1 year for clinical outcome evaluation and up to 3 years for postoperative events such as hardware removal. Preoperative Kujala Scores ranged from 46 to 63 (mean 54.5, average 56), and KOOS ranged from 24 to 57 (mean 40.5, average 41.55). Postoperative Kujala Scores ranged from 74 to 91 (mean 82.5, average 84), and KOOS from 50 to 85 (mean 67.5, average 62.62), showing a statistically significant improvement in pain and function ( $p < 0.001$ ) (Figure 1.). The clinical outcomes, including Kujala and KOOS scores, were evaluated at one year postoperatively. In correlation with clinical improvement, both the patellar tilt test and patellar apprehension test showed clinically evident improvement, suggesting restored patellar stability. Four patients reported mild lateral knee pain which resolved with conservative treatment. No major complications such as deep vein thrombosis, infections, or fractures occurred.

We performed precise osteotomy ensuring the osteotomy fragment was of appropriate thickness, and did not overcompress it during fixation. We believe that this was crucial for not having fractures in our cohort. Similar results and recommendations were advocated by Payne et al. (2015). Orthopaedic patients are considered to be at particularly high risk for deep vein thrombosis (DVT) and venous thromboembolism (VTE). With routine VTE prophylaxis, fatal pulmonary embolism is uncommon in orthopaedic patients and the rates of symptomatic VTE within three months are in the range of 1.3% to 10%. LMWH seems to be more efficient overall compared with the other available agents (Fleivas et al., 2018). We administered Enoxaparin (Clexane) for 28 days postoperatively.

Hardware removal was necessary in eight cases due to anterior knee pain (screw prominence), performed at an average of 2.5 years post-surgery. In comparison to the findings reported by Davis et al (2025) where the hardware removal rate was 21.1%, our cohort demonstrated a slightly higher incidence of hardware removal at 26.67%. In both studies, the predominant indication for hardware removal was persistent anterior knee pain.

## Conclusion

The modified Fulkerson tibial tubercle osteotomy demonstrates excellent clinical efficacy in treating patellar maltracking syndrome, resulting in significant improvements in pain relief, knee function, and patellar stability (Buuck & Fulkerson, 2000). The procedure's success hinges on careful patient selection, thorough preoperative planning, and meticulous surgical execution. When appropriately indicated and performed, TTO can lead to significant improvements in patient outcomes (Sherman et al., 2014). With a low complication rate and favorable long-term outcomes, this surgical technique is a reliable option for patients who do not respond well to conservative treatment.

## Recommendations

Further prospective studies with larger cohorts and long-term follow-up are recommended to validate these findings and to explore the biomechanical impacts of tibial tubercle repositioning strategies in PMS management.

## Scientific Ethics Declaration

\* The authors declare that the scientific ethical and legal responsibility of this article published in EPHELS journal belongs to the authors.

## Conflict of Interest

\* The authors declare that they have no conflicts of interest

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## References

- Buuck, D. A., & Fulkerson, J. P. (2000). Anteromedialization of the tibial tubercle: A 4- to 12-year follow-up. *Operative Techniques in Sports Medicine*, 8(2), 131–137.
- D'Ambrosi, R., Meena, A., Raj, A., Ursino, N., & Hewett, T. E. (2022). Anterior knee pain: State of the art. *Sports Medicine - Open*, 8(1), 98.
- Davis, M., Meta, F., Dancy, M. E., Scott, P. A., Pan, X., Tagliero, A. J., Krych, A. J., Hevesi, M., & Okoroa, K. R. (2025). Pain and hardware removal after tibial tubercle osteotomy: Incidence, associated factors, and outcomes. *Orthopaedic Journal of Sports Medicine*, 13(3), 23259671251324481.
- Flevas, D. A., Megaloikonomos, P. D., Dimopoulos, L., Mitsiokapa, E., Koulouvaris, P., & Mavrogenis, A. F. (2018). Thromboembolism prophylaxis in orthopaedics: An update. *EFORT Open Reviews*, 3(4), 136–148.
- Jibri, Z., Jamieson, P., Rakhra, K. S., Sampaio, M. L., & Dervin, G. (2019). Patellar maltracking: An update on the diagnosis and treatment strategies. *Insights into Imaging*, 10(1), 65.
- Minas, T. (2012). A primer in cartilage repair. *The Journal of Bone & Joint Surgery British* 94(11), 141-146.
- Palmowski, Y., Jung, T., Hellwig, S., Oehme, S., Fahy, S., & Bartek, B. (2024). An evaluation of a novel method for the MRI-based assessment of caton-deschamps index in the knee. *Archives of Orthopaedic and Trauma Surgery*, 144(7), 3161–3165
- Payne, J., Rimmke, N., Schmitt, L. C., Flanigan, D. C., & Magnussen, R. A. (2015). The incidence of complications of tibial tubercle osteotomy: A systematic review. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*, 31(9), 1819–1825.
- Ridley, T. J., Baer, M., & Macalena, J. A. (2017). Revisiting Fulkerson's original technique for tibial tubercle transfer: Easing technical demand and improving versatility. *Arthroscopy Techniques*, 6(4), e1211-e1214.
- Sherman, S. L., Erickson, B. J., Cvetanovich, G. L., Chalmers, P. N., Farr, J., Bach Jr, B. R., & Cole, B. J. (2014). Tibial tuberosity osteotomy: indications, techniques, and outcomes. *The American Journal of Sports Medicine*, 42(8), 2006-2017.
- Walter, W. R., & Burke, C. J. (2022). Editorial commentary: real-time dynamic magnetic resonance imaging of the patellofemoral joint: ready for prime time?. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*, 38(5), 1581-1583.

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