

Anterior tibial tubercle osteotomy in adolescents and young adults: functional results and complications

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ABSTRACT

Introduction: Anterior tibial tubercle osteotomy (ATTO) is a surgical approach that allows for the restoration of distal patellar alignment in skeletally mature patients. The objectives of this study were to evaluate functional results and to discuss the risk factors associated with complications. **Materials and Methods:** We carried out a retrospective analysis of patients subjected to a ATTO between 2008 and 2016 and documented demographic and clinical data. Results were evaluated according to the Kujala Anterior Knee Pain Score and the Tegner-Lysholm Knee Scoring Scale. Complications were evaluated with a modified Clavien-Dindo Classification of Surgical Complications. **Results:** We evaluated 33 ATTOs in 29 patients (17 women) with a median age of 18 years (IQR 2, range: 14-39) and a median follow-up time of 49 months (IQR 2, range: 12-115). The Kujala and the Tegner-Lysholm scores improved from 61 and 61.5 to 94 and 92.3, respectively ($p=0.001$). Union was achieved at a median of 8 weeks. There were 9 complications (27%): a grade II complication (superficial infection) and 8 grade III complications (arthrofibrosis, tibial fractures, and anterior tibial tubercle fractures). Osteotomies in which the tibial tubercle was completely detached had a significantly higher rate of complications (51.5% vs. 11.1%, $p=0.029$). **Conclusions:** ATTO is an effective approach for the treatment of several conditions of the patellofemoral joint in adolescents and young adults. In our series, a high percentage of the procedures presented complications, although they did not affect the final result. Osteotomies that involved complete detachment of the tubercle and those associated with ligament reconstruction had an increased risk of complications.

Key words: Patellofemoral instability; pain; osteotomy; adolescents; young adults.

Level of evidence: IV


Osteotomía de la tuberosidad anterior de la tibia en adolescentes y adultos jóvenes: resultados funcionales y complicaciones

RESUMEN

Introducción: La osteotomía de la tuberosidad anterior de la tibia (O-TAT) es una técnica quirúrgica que permite restablecer la alineación distal de la rótula en pacientes esqueléticamente maduros. Los objetivos de este estudio fueron evaluar los resultados funcionales y analizar factores que influyeron en el desarrollo de complicaciones. **Materiales y Métodos:** Se analizaron retrospectivamente pacientes con O-TAT tratados entre 2008 y 2016. Se documentaron datos demográficos y clínicos. Los resultados fueron evaluados según las escalas de Kujala y Tegner-Lysholm, y las complicaciones, con una adaptación de la clasificación de Clavien-Dindo. **Resultados:** Se analizaron 33 O-TAT en 29 pacientes (17 mujeres). Mediana de la edad: 18 años (RIC 2, mín.-máx. 14-39). Mediana de seguimiento: 49 meses (RIC 2, mín.-máx. 12-115). Mejoría en las escalas de Kujala y Tegner-Lysholm de 61 y 61,5 a 94 y 92,3, respectivamente ($p = 0,001$). La mediana de tiempo de consolidación fue de 8 semanas. Hubo 9 complicaciones (27%): 1 grado II (infección superficial) y 8 grado III (artrofibrosis, fracturas de tibia y fracturas de TAT, $n = 2$). La tasa de complicaciones fue más alta en los pacientes sometidos a desinserción de la TAT (51,5% vs. 11,1%, $p = 0,029$). **Conclusiones:** La O-TAT representa una técnica eficaz para tratar diversas patologías de la articulación patelofemoral en adolescentes y adultos jóvenes. Hubo complicaciones en un alto porcentaje de los procedimientos, sin que esto afectara el resultado final. El riesgo de complicaciones fue mayor en las osteotomías que requirieron desinserción de la TAT y la reconstrucción ligamentaria.

Palabras clave: Patelofemoral; inestabilidad; dolor; osteotomía; adolescentes; adultos jóvenes.

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INTRODUCTION

Pain and patellofemoral instability are frequent causes of consultation in adolescents and young adults^{1,2}. Patients suffering from these symptoms often have limitations in their daily, work and sports life. Surgery is the last treatment resource when medical treatment fails to provide results.

The anterior tibial tubercle (ATT) osteotomy is usually reserved for patients with patellofemoral instability or patellofemoral syndrome, or to decompress lateral or distal chondral lesions of the patella³. Several methods for distal realignment have been described, including anterior tubercle osteotomy for medialization, anteromedialization, distalization or a combination of distalization and medialization⁴⁻⁸. The aim of these procedures is the correction of the underlying misalignment of the extensor mechanism, which presents with an increase in the TT-TG (tibial tuberosity-trochlear groove) distance with respect to the height of the patella. Although restoring the anatomy of the extensor mechanism usually achieves good clinical results, the available techniques carry some complications⁹. The most common complications mentioned in the literature are: implant prominence, superficial infections of the surgical wound, deep vein thrombosis, proximal tibial or anterior tubercle fractures, arthrofibrosis, nonunion, neurovascular injuries, medial dislocation of the patella and patellofemoral arthritis¹⁰⁻¹³. Most of these complications are related to technical errors and, therefore, could be preventable.

The objectives of this study were to evaluate the functional results and discuss the factors that promoted the development of complications after distal realignment procedures performed in isolation or combined with proximal procedures for the treatment of patellofemoral syndrome or recurrent instability of the patella.

MATERIALS AND METHODS

Study design

We performed a comparative retrospective study that included patients <40 years of age who underwent an ATT osteotomy over a period of eight years (January 2008-January 2016). The surgery was carried out by three surgeons in patients with patellofemoral syndrome or recurrent instability of the patella. The surgeon chose the type of approach, according to clinical and radiological features of the patient. The approaches used were Elmslie-Trillat (medialization)¹⁴, Fulkerson (anteromedialization)⁷, distalization or a combination of medialization and distalization. In patients presenting with instability, reconstruction of the medial patellofemoral ligament was also carried out. Patients with a follow-up <12 months were excluded from the study, as well as those with insufficient data on the medical records, lack of preoperative scans and those who could not be contacted for the study.

Patient evaluation

We extracted the following information from the medical records and scans: demographic data, diagnosis, previous surgeries, osteotomy configuration, morphology of the osteotomy¹⁵, related surgical procedures and follow-up time. We analyzed the configuration of the osteotomies as per Luhmann¹⁵ and divided them into three categories: a) blade, b) slope, and c) greenstick ([Figure 1](#)). Postoperative complications were classified according to the modified Clavien-Dindo Classification used in Orthopedic Surgery¹⁶, which divides complications into four types: I - no need for intervention, II - requiring pharmacological treatment, III - requiring hospitalization or surgical treatment, IV - life-threatening complication.

The analysis and storage of the scans were carried out with the digital imaging software Kodak Carestream PACS Version 10.2. By looking at preoperative and postoperative X-rays, we discussed the characteristics of the patellofemoral joint, the osteotomy configuration and the time to consolidation. MRI scans were used to evaluate the TT-TG distance and the height of the patella before surgery. The TT-TG distance was assessed in axial sections by positioning the cursor on the ATT at the patellar tendon's insertion and the most medial femoral trochlea. Using the "ruler" icon on the toolbar, we measured the distance between the two in millimeters^{17,18}. The patellar height was evaluated in T1-weighted sagittal sections by the Miller method¹⁹, which measures the length of the patellar tendon from the posterior surface of its patellar insertion to the posterior surface of its tibial insertion. This measurement is then divided by the length of the patella at the patellar midline.

The functional status of the patients before and after surgery was evaluated using the Kujala²⁰ and the Tegner-Lysholm scores²¹. The experience of the surgeons involved in the study was graded according to the Tang scale²².

Statistical analysis

Being nonparametric, the variables are described as median (interquartile range, min.-max.). Categorical variables are represented as absolute frequencies (%). For the analysis, we evaluated the differences between 1) adoles-

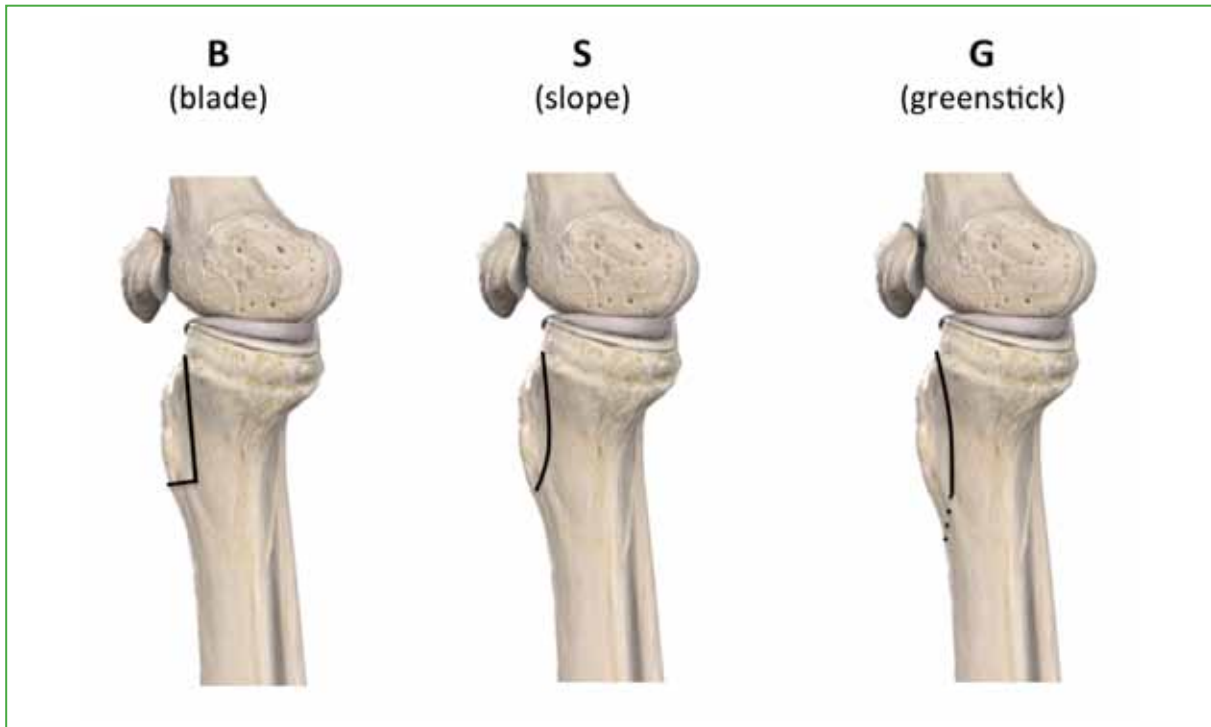


Figure 1. Anterior tibial tubercle osteotomy configuration. (Modified from Luhmann SJ, Fuhrhop S, O'Donnell JC, Gordon JE. Tibial fractures after tibial tubercle osteotomies for patellar instability: A comparison of three osteotomy configurations. *J Child Orthop* 2011;5:19-26.)

cent patients (≤ 19 years old) and young adults (20 to 40 years old), 2) the osteotomy configuration¹⁵, 3) osteotomies with distal detachment or without it, and 4) isolated osteotomies and those associated with medial patellofemoral ligament reconstruction. The change was analyzed by using the Wilcoxon signed rank test. The ratio was expressed as an odds ratio (OR). The hypothesis test was carried out by the chi-squared and Fisher's exact tests, while the correlation of categorical variables was measured by the phi coefficient. A p value ≤ 0.05 was considered statistically significant.

RESULTS

We analyzed 33 ATT osteotomies in 29 patients (17 women). Demographic data of the study population is summarized in [Table 1](#). Two of the surgeons had a level II experience, and one of them, a level IV. Consolidation of the osteotomy was achieved at a median of eight weeks. Preoperative scores using the Kujala and Tegner-Lysholm scores improved significantly from 61 and 61.5 to 94 and 92.3, respectively ($p=0.001$).

There were nine complications (27%) ([Table 2](#), [Figures 1 and 2](#)): one grade II (superficial infection [$n=1$]) and 8 grade III (arthrofibrosis [$n=4$]; ATT fractures [$n=2$] and tibial fractures [$n=2$]). There were no differences between the group of adolescents (22 knees, 6 complications) and the one of young adults (11 knees, 3 complications). Upon analyzing the osteotomy configuration of the osteotomy, the rate of complications was higher in patients undergoing a distal blade osteotomy ([Table 2](#)). Patients who underwent ATT detachment for distalization or distalization-medialization had a significantly higher rate of complications (51.5% vs. 11.1%, OR = 0.14 [0.02-0.76]), $p=0.029$). Likewise, those who underwent reconstruction of the medial patellofemoral ligament were prone to a higher rate of complications (38% vs. 20%, OR = 2.0 [0.40-9.91], $p=0.324$).

Table 1. Demographic data

Features	Value
Age (years)*	18 (4, 14-39)
Gender	
Female	23
Male	10
Side	
Right	18
Left	15
Diagnosis	
Instability	17
Patellofemoral syndrome	16
Osteotomy configuration	
Medialization	19
Anteromedialization	1
Medialization + Distalization	7
Distalization	6
Related procedures	
Medial patellofemoral ligament reconstruction	17
Lateral retinaculum release	9
Patellar mosaicplasty	1
Follow-up (months)*	49 (2, 12-115)

*Values expressed as a median value (interquartile range, min.-max.).

Table 2. Correlation between osteotomy configuration and complications

Configuration	N	Complications	Correlation*	p**
Blade	11	5 (45.5%)	0.304	0.218
Slope	8	2 (25%)		
Greenstick	14	2 (14.3%)		

*Phi coefficient, **Chi-squared test.

DISCUSSION

ATT osteotomy is an approach that allows for the restoration of the anatomical position of the tibial tubercle in skeletally mature patients. Although multiple complications have been described, there are few studies looking at the impact of the surgical approach^{3,9,15}. The objectives of this study were to evaluate the functional results and discuss the factors that promoted the development of complications.

In this series, the Kujala and Tegner-Lysholm functional scores improved significantly. In the final follow-up, all patients presented relief of the symptoms that originated the surgery, as well as a functional improvement. These results are similar to those of other series²³⁻²⁸ that show the effectiveness of this procedure. Despite achieving good functional results, the rate of complications was high (27%) in our study, even higher than those published in other series^{9,15,23}. We believe that, among other factors, it could be related to the surgeons' level of experience with the procedure. In our series, more than 90% of the procedures were performed by surgeons at the beginning of their learning curve (level II)²². To our knowledge, no previous study on this subject has documented the level of experience of the surgeons involved. We consider this information critical, since it reflects the technical difficulty of the procedure and, eventually, results in the approach being widely used. Looking back, some of the reported complications could have been prevented by refining the surgical approach. In the two ATT fracture patients, the incision was not sufficiently deep (<10 mm), which caused the fixation to be suboptimal. Both presented in the immediate postoperative period (at 6 weeks), when physical therapy (PT) was intensified (Figure 2).



Figure 2. A. 21-year-old patient with patellofemoral syndrome and *patella alta*. B. An anterior tibial tubercle osteotomy was performed with a very superficial incision. C. Fracture and loss of fixation at six weeks during PT. D. Lateral X-ray of the knee after surgical revision.

Other authors have also warned against the risk of very superficial incisions and their complications^{9,29}. Two patients suffered tibial fractures. In both cases, the distal incision was made with a blade, resecting a fragment to distalize the ATT. The osteotomy was consolidated proximally, but a small defect persisted on the cortical bone, which served as a weak point promoting the fracture (Figure 3). In our series, the abovementioned osteotomy configuration (blade) was related to a higher rate of complications. Luhmann and colleagues¹⁵ reported a 12% fracture rate when using this type of incision. In a recent systematic review, Payne and colleagues⁹ found that osteotomies that completely detached the ATT had a three-times higher rate of complications than those sparing a distal hinge. Four patients presented restricted mobility (arthrofibrosis) in the postoperative period that required mobilization under general anesthesia. In all four, the ATT osteotomy was performed together with a medial patellofemoral ligament reconstruction, which implies a higher degree of soft-tissue dissection with subsequent fibrosis. In a systematic literature review, Longo and colleagues³ reported a higher incidence of arthrofibrosis when combining both procedures. For this reason, we currently prescribe PT with full range of motion from the first postoperative day in these cases.

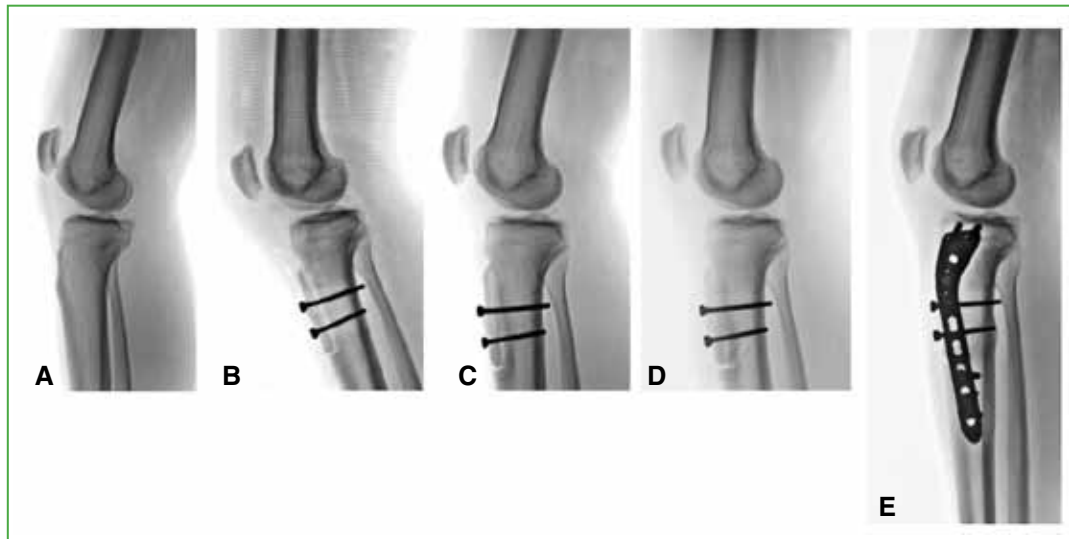


Figure 3. A. 21-year-old patient with patellofemoral syndrome and *patella alta*. B. An anterior tibial tubercle osteotomy was performed with a blade incision. C. At six months, we observed proximal consolidation of the osteotomy and a distal defect. D. At nine months, the patient presented with tibial fracture. E. Internal fixation.

The results of this work should be interpreted in the context of a retrospective study with a limited sample. On the other hand, the functional scores used, although they were translated into Spanish, are not validated in our language. Despite these limitations, we believe that this study provides valid information for surgeons dealing with conditions of the patellofemoral joint, mainly on the technical details that should be considered at the time of surgery (osteotomy configuration, thickness and length of the incision, postoperative management).

ATT osteotomy is an effective approach for the treatment of several conditions of the patellofemoral joint in adolescents and young adults. In our series, complications occurred in a high percentage of the procedures, although they did not affect the final result, and excellent averages were achieved on the functional scores. The risk of complications was higher in osteotomies with a 90° blade incision at the distal cortex, those that required detachment of the ATT and those associated with ligament reconstruction.

Conflict of interest: Authors claim they do not have any conflict of interest.

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