Systematic Review

# The Incidence of Complications of Tibial Tubercle Osteotomy: A Systematic Review

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**Purpose:** The goal of this review was to quantify the risk of perioperative and early postoperative complications of tibial tubercle osteotomy (TTO) with different techniques. **Methods:** A systematic review of multiple databases was performed to identify studies that reported complications of TTO. Complications were defined as any adverse outcome, including osteotomy site nonunion, fracture, infection, wound complications, neurovascular complications, deep vein thrombosis (DVT), and pulmonary embolism (PE). Major complications were defined as nonunion, fracture, infections/wound complications requiring return to the operating room, and DVT or PE. The risk of subsequent hardware removal was also quantified. **Results:** The 19 identified studies included a total of 787 TTOs: 472 direct medialization procedures (Elmslie-Trillat technique), 193 anteromedialization procedures (Fulkerson technique), and 102 procedures in which the tibial tubercle was completely detached for medialization or distalization, or a combination. The overall complication risk was 4.6%. The risk of complications was higher when the tibial tubercle was completely detached (10.7%) than with Elmslie-Trillat (3.3%) or Fulkerson (3.7%) procedures ($P = .004$). The overall risk of major complications was 3.0%. Hardware removal was performed in 36.7% of osteotomies and was less frequent with the Elmslie-Trillat technique (26.8%) than with the Fulkerson technique (49.0%) or complete tubercle detachment (48.3%) ($P < .001$). **Conclusions:** Tibial tubercle osteotomy is a complex surgical procedure with a significant risk of complications. Osteotomies that involve complete detachment of the tubercle have an increased risk of complications compared with those in which a distal cortical hinge is maintained. **Level of Evidence:** Level IV, systematic review of Level IV studies.

*See commentary on page 1826*

Patellar dislocations can have a significant negative impact on knee function and quality of life in young active patients.[1] Although management of acute primary patellar dislocation has historically been conservative, operative treatment is indicated in the setting of recurrent lateral patellar instability.[2] Although surgical treatment frequently includes reconstruction of the medial patellofemoral ligament,[3] the decision to include additional surgical procedures is influenced by multiple factors, including the specific anatomy of each individual patient.

Key anatomic factors associated with recurrent patellar instability include trochlear dysplasia, patella alta, and increased tibial tubercle–trochlear groove distance.[2] In patients with severe patella alta or increased tibial tubercle–trochlear groove distance, the addition of a tibial tubercle osteotomy (TTO) to a medial patellofemoral ligament reconstruction may decrease the risk of redislocation. These procedures seek to normalize anatomy through distalization or medialization (or both) of the tibial tubercle. Although the addition of a TTO may decrease the risk of redislocation, this technique prolongs surgical and recovery time and increases the risk of complications.[4]

Multiple potential complications of TTO have been described in the literature. These complications range from minor (superficial wound infections and skin irritation) to severe (tibial fracture, osteotomy nonunion, neurovascular complications, deep infection) and can result in significant morbidity.[4,5] Previous reports of complications are typically case series or case reports focused on specific complications[6-8] or are more

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general reviews with a focus on avoidance of complications.[4,5] As a result, the specific risks of individual complications are difficult to estimate, and data regarding the influence of surgical technique on the risk of complications are lacking.

The goals of this review were to quantify the risk of specific perioperative and early postoperative complications after TTO and determine whether osteotomy technique influences the risk of complications. We hypothesized that procedures in which the tibial tubercle was completely detached would be associated with an increased risk of complications.

## Methods

In October 2014, a literature search of Scopus and PubMed was undertaken. The search terms that were used included "Elmslie" or "Elmslie-trillat" or "Fulkerson" or "Tibial Tubercle Osteotomy" or "TTO" or "Distalization" or "Anteromedialization" or "Medialization" and "Dislocation" or "Subluxation" or "Instability," with the search limited to human studies in English. The search yielded 576 proposed articles, 104 of which were duplicates. The review process of the remaining 472 articles involved 2 authors (R.A.M., J.P.) according to the inclusion and exclusion criteria (Table 1), with disagreements resolved by consensus. Of the 472 articles, 453 were excluded, including 284 that were unrelated to the topic of interest, 48 technique articles without complication data, 37 imaging studies, 29 basic science articles, 24 review articles, 15 articles with a focus on pediatrics, 4 studies reporting on 5 or fewer patients, 2 reports of Maquet-type procedures, one duplicate publication, and 6 studies without documentation of complications. The remaining 19 articles were used in this review (Fig 1).[9-27]

Data were extracted using a template and included study characteristics, patient demographics, surgical technique, length of follow-up, and complications. Complications, for purposes of this review, were defined as osteotomy site nonunion, fracture, infection, wound complications, neurovascular complications, deep vein thrombosis (DVT), and pulmonary embolism (PE). The incidence of symptomatic hardware removal was also recorded. Major complications were defined as fractures, nonunions, infections or wound complications that required surgical intervention, and symptomatic DVT/PE.

The risk of complications was calculated on a per study basis as well as an overall risk over all studies. In addition, the risk of complications was calculated based on the specific TTO technique that was used. The risk of complications and the major risk of complications were compared based on osteotomy type using a Fisher exact test. The incidence of symptomatic hardware removal was also determined. For this analysis, studies that made no mention of hardware removal and those studies in which hardware was removed from all patients regardless of symptoms were excluded.

**Table 1.** Inclusion and Exclusion Criteria

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| Published studies describing TTO | Focus on skeletally immature patients |
| Treatment primarily for patellar instability | Studies of TTO for other indications |
| Report complication incidence | No report of complications |
| Human studies | Basic science or animal studies |
| English language | Studies in other languages |
| | Studies with 5 or fewer patients |

TTO, tibial tubercle osteotomy.

## Results

The 19 studies included a total of 787 TTOs. There were 472 direct medialization procedures (Elmslie-Trillat technique) in 11 studies,[10-12,14,15,17,19,22-24,26] 193 anteromedialization procedures (Fulkerson technique) in 5 studies,[9,13,20,25,27] and 102 procedures in 3 studies[16,18,21] in which the tibial tubercle was completely detached for medialization, distalization, or a combination.

The mean patient age varied across the studies from 20 to 31 years. Seventeen of the studies included more women than men, many by a significant margin. The 2 exceptions were studies that were performed in military populations.[11,14] The majority of studies included only patients being treated for patellar instability,[9,10,13,14,17-19,21,22,24-27] whereas the remainder included patients with instability, as well as those with pain and patellar malalignment (Table 2).[11,12,15,16,20,23]

The risk of complications ranged from 0% to 11% in the individual studies (Table 3). The overall risk of complications was 4.6% (36 complications in 787 procedures) (Table 4). The risk of osteotomy site nonunion was 0.8%, the risk of tibial fracture was 1.0%, the risk of wound complications was 0.8% (primarily wound hematomas and one wound dehiscence), and the risk of infection was 1.0%, although only one deep infection was noted. Rarer complications included neurologic complications (saphenous neuromas and temporary peroneal nerve palsies), DVT, PE, and medical complications such as urinary tract infections. The risk of complications was higher when the tibial tubercle was completely detached (10.7%) than with Elmslie-Trillat (3.3%) or Fulkerson (3.7%) osteotomies ($P = .004$).

The risk of major complications was 3.0% (24 complications in 787 procedures). The risk of complications was higher when the tibial tubercle was completely detached (5.7%) than with Elmslie-Trillat (2.3%) or Fulkerson (3.1%) operations, although statistical significance was not reached ($P = .14$).

Ten studies reported the incidence of symptomatic hardware removal,[12-17,19,20,23,25] 7 studies made no mention of symptomatic hardware,[9-11,18,21,26,27] and all hardware was removed regardless of symptoms in