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Triple positioning of tibial tubercle osteotomy for patellofemoral disorders

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ABSTRACT

Background and purpose: Patellofemoral disorders are often associated with patellofemoral malalignment. Tibial tubercle transfer is an effective method to correct the patellofemoral malalignment. This study evaluated the long-term results of triple positioning of tibial tubercle osteotomy for refractory patellofemoral disorders with 10-year follow-up.
Patients and Methods: Fifty-six patients with 62 knees underwent triple positioning of tibial tubercle osteotomy for refractory patellofemoral disorders. All patients received standard rehabilitation protocol postoperatively. The average length of follow-up was 128.5 ± 9.8 months (range 116 to 149). The evaluations included pain score, Kujala patellofemoral score, Lysholm score and radiograph of the knee.
Results: The overall clinical results were excellent in 41.9%, good in 37%, fair in 12.9% and poor in 5% at 1 year; and 29% excellent, 41% good, 18.3% fair and 9.3% poor at 10 years. Satisfactory results were 78.9% and 70.9%, and unsatisfactory results 21.1% and 29.1% at 1 year and 10 years respectively. There was no correlation of clinical outcomes with age, sex, body weight and height and preoperative pain score. However, there was a positive correlation of clinical outcomes with the improvement of the congruence angle on postoperative X-rays of the knee, and a negative correlation of clinical outcome with the severity of articular cartilage damage assessed in arthroscopy. The complications included 1 non-union and 1 infection with non-union.
Conclusion: Triple positioning of tibial tubercle osteotomy is effective and long lasting in patients with patellofemoral disorders with 70.9% satisfactory results at 10-year follow-up.
Level of evidence: IV (refer to instructions for detailed description on the level of evidence).

1. Introduction

Patellofemoral disorder is one of the most common knee disorders and is often associated with patellofemoral malalignment [1–3]. Diagnosis of patellofemoral disorder was made by history and physical examination, and radiographic evaluation of the knee. Patellofemoral disorder occurs predominantly in young to middle-age active individuals. Patients frequently present with anterior knee pain and crepitus, weakness and limping with or without overuse in daily activities. The symptoms are aggravated in stair climbing and kneeling or squatting, and somewhat relieved with rest in extension. Physical findings reveal patellofemoral compression pain, tenderness and crepitus, increased Q angle and laterally tilted patella in flexion. The medial excursion of the patella is usually decreased. Radiographic examination in anteroposterior, lateral and Merchant views often revealed increases in patellar height and congruence angle, and lateral displacement of the patella.

Patellofemoral malalignment may be translational subluxation of the patella or torsional patella tilt with or without patellar instability [4–7]. Patellofemoral malalignment can cause anterior knee pain associated with chondromalacia or patellofemoral arthritis. Patellofemoral disorder secondary to arthritis shows distinction from patellar instability, and usually affects older patients with pain as the predominant symptom. The presenting symptoms include anterior knee pain and crepitus, weakness in extension and limping. The etiology of patellofemoral disorder is multi-factorial including soft tissue imbalance and bony abnormality [8–10]. The initial treatment is conservative treatment that includes anti-inflammatory drugs, knee brace, physical therapy, muscle strengthening exercises and modification of activity levels [11]. Surgery is indicated in knees refractory to at least 6 months of conservative treatment [12,13]. Proximal realignment or medial patellofemoral ligament reconstruction is generally performed for knees with patellar instability [8,10,14,15], whereas distal realignment with tibial tubercle transfer for knees with patellofemoral malalignment [16–20]. For distal realignment with tibial tubercle osteotomy, many surgical techniques with different magnitudes of tibial tubercle transfer are described in the literature including Elmslie-Trillat and Fulkerson procedures, and the results varied considerably [13,18–23]. There is no consensus of opinions on the magnitude of tibial tubercle transfer in the treatment of patellofemoral disorder [5,13,16–18]. Likewise, there was no

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agreement on the best method of tibial tubercle transfer [16,17]. Based on cadaver study, triple positioning of tibial tubercle osteotomy that includes anterior, medial and proximal positioning of the tibial tubercle was developed to optimize the patellofemoral alignment [24]. The purpose of this retrospective study was to analyze the long-term effects of this procedure in 56 patients with 62 knees with 10-year follow-up.

2. Materials and methods

The Institutional Review Board of our institution approved this study protocol. Informed consent was signed prior to the participation in the study.

Between July 1997 and August 2000, 66 patients with 72 knees that met the inclusion criteria were operated on for patellofemoral disorders by a single surgeon. Surgery is indicated when conservative treatments had failed. The inclusion criteria for surgery included knees with progressive pain and functional disability with failure to at least 6 months of conservative treatment. The severity of patellofemoral pain was categorized into mild with less than 3 visual analog score (VAS), moderate with 4–6 VAS and severe with greater than 7 VAS. The exclusion criteria included patients with severe radiographic arthritis of any compartment of the knee, infection, rheumatic disease, trochlea hypoplasia, hypermobile patella, excessive body mass index, severe knee deformity and psychosomatic disorder. Ten patients with 10 knees were excluded due to lost to follow-up. The remaining 56 patients with 62 knees were included in the final analysis. The patient demographic characteristics are shown in Table 1.

A complete arthroscopic examination of the knee joint was performed with attention to the patellofemoral articulation. The severity of cartilage damage of the patellofemoral joint was assessed arthroscopically and recorded on four variables including the description of the articular surface, the extent (depth) of involvement, the diameter of the lesion and the location of the lesion [25]. Arthroscopic debridement and radiofrequency chondroplasty were performed in knees with grade II or more cartilage damage. Concomitant surgery for meniscus tear if any, was also performed. The tightness of the lateral retinaculum was assessed by the medial excursion of the patella with the knee in extension. The patella was defined tight when the medial excursion of the patella was less than half of the patellar width.

After arthroscopy, a 5-cm longitudinal incision was made on the proximal tibial. The patella tendon was dissected free on both sides. Lateral retinacular release was performed subcutaneously from the level of tibial tubercle to the origin of vastus lateralis. A 5-cm long tibial tubercle bone block was marked and pre-drilled. An oblique osteotomy of the tibial tubercle was made 30° of the vertical line from medial to lateral aspect. The magnitudes of anterior, medial and proximal positioning of the tibial tubercle osteotomy were assessed and determined individually based on the algorithm shown in Table 2. The magnitudes of anterior, medial and proximal transfer of the tibial tubercle were affected by the severity of patellofemoral malalignment that varied among patients. The severity of patellofemoral malalignment was graded according to the magnitude of tibial tubercle transfer with 0–5 mm as mild, 5–10 mm as moderate and greater than 10 mm as severe. Patients with predominant lateral patellar tilt required more medial transfer of the tibial tubercle, whereas patients with more patellofemoral compression pain and crepitus needed more anterior transfer of tibial tubercle. Additional proximal transfer of tibial tubercle was indicated if persistently tight patellofemoral joint or patella baja was noted after anteromedial transfer of the tibial tubercle. Once the location of the optimal tibial tubercle transfer was established, the tibial tubercle bone block was rigidly fixed with two screws. The medial gap between bone block and tibial cortex and the gap distal to the bone block were filled with bone grafts harvested from the lateral aspect of the proximal tibial, and the lateral defect was filled with osteoset bone substitute (Wright Medical, Arlington, Tennessee) (Fig. 1).

Postoperatively, the knee was immobilized in a knee immobilizer during ambulation. Patients ambulated with partial weight bearing on the operated leg, and performed range of motion, quadriceps and hamstring strengthening exercise. Full weight bearing was allowed in 6 to 8 weeks when there was evidence of radiographic healing of the tubercle osteotomy.

The follow up examinations were scheduled at 1, 3, 6 and 12 months, and then yearly. The evaluation parameters included pain score, Kujala patellofemoral score [26], Lysholm score [27], the Q angle, articular cartilage damage and radiographs of the affected knees. The maximal Lysholm score is 100 points, and the score chart is classified as excellent with 95–100 points, good with 84–94 points, fair with 65–83 points and poor with <64 points. The severity of articular cartilage damage was documented during the initial arthroscopy. Radiographic examinations including patella height, congruence angle of the patella and spur formation were used to assess the severity of patellofemoral malalignment and osteoarthritis of the patellofemoral and femorotibial joints before and after surgery [3,28].

Table 1
Patient demographic characteristics.

# Patients / # knees	56/62
Gender:	
Females	46 (82%)
Males	10 (18%)
Age (years)	45.7 ± 11.3
(Range)	(22–74)
Side	
Right knee	34
Left knee	28
Bilateral knees	6
Ave. body weight (kg)	61.6 ± 13.6
(Range)	(52–75)
Ave. body height (cm)	160 ± 9.2
(Range)	(129–184)
Tibial tubercle transfer	
Anterior transfer (mm)	14.3 ± 2.7
(Range)	(5–20)
Medial transfer (mm)	9.2 ± 3.4
(Range)	(0–15)
Proximal transfer (mm)	4.7 ± 1.4
(Range)	(3–7)
Ave. tibial shingle (mm)	55 × 14 × 7
Ave. follow-up (months)	128.5 ± 9.8
(Range)	(116–149)

2.1. Statistical analysis

The data presented in the study were shown in mean ± SD. The pre- and post-operative pain score, functional score, patellofemoral score and the Q angle were compared and analyzed statistically using paired *t* test. The correlations of outcomes with the inherent factors, and the comparison between satisfactory and unsatisfactory knees were analyzed statistically using Chi-Square test. A *p*-value of less than 0.05 was considered to be statistically significant.

3. Results

The pain score, Kujala patellofemoral score, Lysholm score and the Q angle are shown in Table 3. Significant improvements in pain score, Kujala score and Lysholm score were noted at 1 year and 10 years postoperatively. The Q angle was 17.6 ± 5.2 (10–30) preoperatively and 15.3 ± 3.0 (9–22) postoperatively. Significant improvement in Q angle was noticed after surgery ($p = 0.001$). Overall, satisfactory result was 78.9% at one-year, and 70.9% at 10-year follow-up. There was a trend of increase in pain score and a decrease in functional score from one-year to 10-year follow-up, however, the difference was statistically not significant ($p > 0.05$). All knees could flex 120 degrees or more, and none showed extension lag.

The correlations of clinical outcomes with the inherent factors are analyzed statistically and the results are shown in Table 4. There is no statistical correlation of clinical outcome with age, sex, body weight, body height and the preoperative pain score.

The correlations of the clinical outcome and the severity of articular cartilage damage assessed during the initial arthroscopy are shown in Table 5. There is a negative correlation