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ORIGINAL PAPER

Utility of tibial tubercle osteotomy in the setting of periprosthetic infection after total knee arthroplasty

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Abstract
Purpose This study reports radiographic and clinical treatment outcomes of tibial tubercle osteotomy (TTO) used for two-stage revision total knee arthroplasty (TKA) in the setting of periprosthetic infection.
Methods Thirty-six patients with 51 TTOs used for infected TKA were retrospectively analysed from 2000 to 2010. In 15 of 36 patients, TTO was used in a sequential manner during both first and second stage procedures. The mean follow-up period was 57 months (range seven–126 months).
Results The mean pre-operative range of knee motion was 40° (range 10–90°), and at latest follow-up it was 92° (range 50–140°). The Knee Society knee scores and function scores were 47 and 9 pre-operatively and 82 and 72 at latest follow-up, respectively. Bony union was achieved in all cases except one nonunion of an avulsion fragment of the osteotomy segment without functional deterioration.
Conclusions TTO can be a useful extensile surgical approach for treatment of infected TKA with satisfactory clinical and radiographic outcomes.

Introduction

Adequate surgical exposure is crucial for successful performance of total knee arthroplasty (TKA) with correct component positioning. In most primary and revision TKA, the knee joint can be adequately exposed through a conventional medial parapatellar arthrotomy, or by a lateral parapatellar approach in severe valgus deformity [1–3]. However, in case of revision or difficult primary TKA such as extreme obesity, patella infera, previous high tibial osteotomy, bony deformity or soft tissue contracture and arthrofibrosis, safe exposure of the joint can be challenging [4]. Specifically in the setting of infection, inflamed soft tissue and poor bone quality makes the adequate exposure more challenging, and extensile surgical approaches are frequently necessary to avoid catastrophic complication of the extensor mechanism.

Traditionally, various reliable extensile approaches have been described to optimise exposure in complex TKA [5, 6]. Proximally, quadriceps snip or V-Y turndown have been known to be relatively easy to perform, but it may cause extensor mechanism scarring or extensor lag [7, 8]. On the other hand, tibial tubercle osteotomy (TTO) has been recognised as a reliable technique for improving exposure with reliable bony union [9] and satisfactory range of motion (ROM) [10], although it is considered a technique-dependent procedure [4, 11, 12].

There are numerous studies reporting satisfactory treatment outcome of TTO in primary or revision TKA [9–11, 13]. However, most studies have focused on the results of TTO in primary or aseptic revision TKA, and there are limited data regarding the results of TTO used in the setting of periprosthetic infection after TKA.

The purpose of this study was to evaluate the radiographic and functional outcome of TTO procedures used in revision arthroplasty for infected TKA.

Materials and methods

From January 2000 to August 2010, there were 91 patients treated by component removal and staged revision

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arthroplasty for infected TKA in our institution. Of 91 patients, 36 underwent staged revision procedures through surgical approach of TTOs and were included in this retrospective study. In 17 patients TTO was required at the time of the first stage procedure, and in 19 patients TTO was used during the second stage reimplantation surgery. Of 17 patients in whom TTO was performed at the time of the first stage procedure, 15 required repeat sequential TTO at the time of the second stage reimplantation. So, a total of 51 TTOs were included in the evaluation.

There were 16 women and 20 men and the mean age at the time of initial surgical treatment for infection was 67 years (range 38–87 years). The diagnoses for the primary TKA were osteoarthritis in 32 patients, congenital dislocation of the knee in one and unknown in three. Infection occurred after primary TKA in 21 patients, revision TKA in ten and a further five patients were referred from an outside hospital following a resection arthroplasty. The mean time from the primary TKA to the diagnosis of infection was 35 months (range one–168 months). Twenty-four patients had been treated for infection prior to our surgical management by a course of antibiotics (n=four), irrigation and debridement (I/D) with component retention (n=13) or implant removal treatment (n=seven). Twelve patients did not receive any prior treatment for infection. The mean number of prior operative procedures on the same joint was 2.3 (range one to five). Coagulase-negative *Staphylococcus* (n=12, 33 %) was the most common pathogen followed by *Staphylococcus aureus* (n=11, 30 %) (Table 1).

Table 1 Microbiologic characteristics of 36 patients

Type of microorganism	Number of patients (%)
Gram-positive	
MSSA	8 (22)
MRSA	3 (8)
MSCNS	4 (11)
MRCNS	8 (22)
Streptococcus spp.	1
Actinomyces	1
Enterococcus	1
Gram-negative	
Enterobacter	1
Others	
Mycobacterium	1
Polymicrobial (MSCNS+MRCNS)	1
Microorganism unknown	7 (19)

MSSA methicillin-sensitive *Staphylococcus aureus*, *MRSA* methicillin-resistant *Staphylococcus aureus*, *MSCNS* methicillin-sensitive coagulase-negative *Staphylococcus*, *MRCNS* methicillin-resistant coagulase-negative *Staphylococcus*

The technique of TTO used in our series was similar to that described by Whiteside and Ohl [14]. The decision for TTO was made when adequate surgical exposure was not available without jeopardising the tibial attachment of the patellar tendon. The proximal quadriceps snip was not tried before TTO. Intra-operatively, the midline skin incision was extended about 10 cm below the tibial tubercle and conventional medial parapatellar capsular arthrotomy was made. After stripping the periosteum 1 cm medial to the tubercle, intended osteotomy measuring 8 cm long, 1.0–1.5 cm thick distal to the patellar tendon insertion was designed along the medial margin of the tubercle. The distal end of the osteotomy was tapered bevelling the fragment toward the anterior cortex distally. Osteotomy was carried out with an oscillating saw from medial to lateral until the saw blade reached the lateral cortical bone. Osteotomy was completed with a straight osteotome to make a breakage of the lateral cortex leaving the lateral periosteum and anterior musculature attached to the tubercle. This allowed excellent access to the entire knee joint and easy eversion of the patella. All osteotomies were limited to extramedullary leaving cancellous bone on the base of the osteotomy. There was no case that required intramedullary access to remove a preexisting implant. After removal of implants and necrotic materials including cement, a static cement spacer (n=16) composed of antibiotic-loaded cement was inserted between the resected femur and tibia when the cement reached a very doughy state. For one patient, an articulating prosthetic spacer (resterilised femoral component and polyethylene) coated with antibiotic cement was used. For reattachment of the osteotomy, drill holes were made from medial to lateral under the cut surface of the osteotomy, and then three to five 18-gauge monofilament stainless steel wires were passed through the holes and through the lateral soft tissues with the aid of a 14-gauge cannulated needle. The wires were then looped over the replaced tubercle and were twisted and tightened using a tension device. Wire knots were carefully embedded on the medial surface of the tibia. Postoperatively, the knee joint was placed in an extension brace and the patient was allowed partial weight-bearing. Parenteral antibiotics were administered for six weeks postoperatively.

For the second stage reimplantation procedure, TTO was performed by the same manner as the first stage operation. The mean time interval between the first and second stage operation was 6.8 months (range 1.5–28 months). When TTO was a case of sequential repeat osteotomy following the first stage TTO, removal of the fixation device used for the first stage TTO was done first. After removal of temporary spacers with thorough debridement, new components were implanted with cement fixation. Three to five wires were used for reattachment of the osteotomy except in three patients whose osteotomy was fixed by two cable wires (n=one) and two cancellous screws (n=two). Parenteral antibiotics were administered for two to three days

postoperatively. Patients were allowed tolerable partial weight-bearing immediately after the surgery and gradually shifted to full weight-bearing within six weeks depending on their tolerability and wound condition. ROM exercise was started from two weeks after the surgery. Implant position and bony union of the osteotomy was checked by radiographs including knee anteroposterior (AP), lateral and axial views at each follow-up. ROM and the Knee Society (KS) scores were also evaluated. All patients were followed up clinically and radiographically with the mean time of 57 months (range seven–126 months).

Results

The mean of preoperative knee ROM was 40° (range 10–90°). At latest follow-up, the mean ROM was 92° (range 50–140°). The KS knee score was 47 preoperatively and 82 at latest follow-up. The KS function score was nine preoperatively and 72 at latest follow-up.

Proximal migration of the entire osteotomy was observed in five patients (15, 11, 14, 19 and 13 mm) at five, five, four, four and six weeks, respectively. All migrations were observed after the second stage reimplantation procedure (three after repeat TTO and two after TTO for reimplantation) (Fig. 1), and ROM exercise was restricted in these patients until radiographic union process was observed. However, bony union of the osteotomy was achieved in all cases at the mean time of 11 weeks (range five–21 weeks) after the first stage osteotomy and 21 weeks (range four–52 weeks) after the second osteotomy.

Partial proximal avulsion fracture of the osteotomy segment with proximal migration was observed in two patients. The first avulsion fracture occurred at seven weeks after the second osteotomy with 8 mm proximal migration of the fragment, which showed complete bony union at latest follow-up of 31 months. The second avulsion fracture occurred at seven weeks after the second stage osteotomy with 6 mm proximal migration. The fracture fragment remained in a nonunion state at latest follow-up of 54 months with 9 mm displacement.

The mean of patellar height measured by the Insall-Salvati ratio [15, 16] was 1.18 (range 0.91–2.31) preoperatively and 1.08 (range 0.65–1.91) at latest follow-up. For those patients who had proximal migration or avulsion fracture of the osteotomy, patellar height was 1.13 (range 0.95–1.26) preoperatively and 0.94 (range 0.73–1.15) at latest follow-up.

Two patients necessitated manipulation of the knee joint due to arthrofibrosis at five and eight weeks after reimplantation surgery. One patient had spacer subluxation which was managed by closed reduction and long leg cast immobilisation under anaesthesia. One patient developed a tibial shaft fracture through the distal end of the osteotomy where an unintentional step-cut was made at surgery. There was no wound complication or hardware-related complication. The rate of major complications directly related to osteotomy was 16 % (8/51) of TTOs and 22 % (8/36) of patients (Table 2).

Fig. 1 **a** Radiograph of a 66-year-old female patient shows cement spacer. **b** Patient underwent spacer removal and reimplantation of prosthesis through TTO approach. **c** Six-week follow-up radiograph shows 13 mm proximal migration of osteotomy (*arrow*). **d** Complete bony union is observed at 28-month follow-up radiograph

Ten patients required additional surgeries for recurrent infection (27.7 %), while 18 of 55 patients (33 %) who underwent revision without TTO had a recurrent infection. Two patients had recurrent infection after the first stage operation. Of two, one patient was managed by I/D and reimplantation, but the other patient underwent arthrodesis. Eight patients had recurrent infection after the second stage reimplantation. Five of them were treated by additional I/D procedures, but three of them underwent above knee amputation (n=two) and resection arthroplasty (n=one) due to uncontrolled chronic infection.

Table 2 Complications associated with treatment (n=51 TTO)

Complications	Knee (%)
Major complications related to osteotomy	
Proximal migration of osteotomy	5 (10)
Avulsion fracture of osteotomy segment	2 (4)
Anterior knee pain	0
Tibia fracture	1 (2)
Minor complications	
Arthrofibrosis	2 (4)
Wound complication	0
Spacer subluxation	1 (2)

Discussion

TTO is a well-recognised technique for improving exposure in complex primary and revision TKA [10, 14, 17, 18]. Advantages of this technique include maintenance of the quadriceps tendon with blood supply to the patella, strong healing through the bone-to-bone union and concurrent medullary accessibility for extraction of well-fixed stemmed tibial components [17, 19].

Recently, Zonnenberg et al. [6] performed a literature review for TTO and stated that proximal migration of the osteotomised site, avulsion fractures of the tubercle and TTO-related pain are the most reported complications of this technique [6]. In our study, proximal migration of the osteotomy was observed in five of 51 osteotomies (10 %, 5/51), which was within the wide range of incidence reported in the literature (1–22 %). Mendes et al. [17] and Young et al. [10] reported a 19 % (13/67) and 22 % (9/41) incidence of proximal migration of the osteotomy in their series of revision TKA, respectively. On the other hand, Whiteside and Ohl [14] reported a 1 % incidence of migration in their early series of TTO. In our study, avulsion fracture of the osteotomy was also observed in 4 % (2/51), which was similar to the previous reports of a 3–4 % incidence [9, 20]. All of these proximal migrations and avulsion fractures, except in one patient in whom nonunion of the avulsion fracture remained, achieved bony union without adverse effects on functional results at latest follow-up. For TTO-related pain, there might be controversies on the relation between fixation method and anterior knee pain, given that anterior knee pain has been observed in both screw [9, 21] and wire [17, 18] fixation. In biomechanical studies, screw fixation was shown to provide stronger fixation than wires [6, 19, 22]. However, wire fixation is easier to place and may be preferable when tibial stems are used for reimplantation [6, 22]. In our series, most osteotomies were fixed by wires and no patient specifically complained about hardware-related anterior knee pain or showed a skin-related complication. This may be attributed to the careful handling with the wire knots. Recently, Deane et al. [23] described the Ethibond (Ethicon, Somerville, NJ, USA) suture technique without using metal, and Chalidis and Ries [20] left the TTO unfixed for six to eight weeks until the second stage treatment in their treatment for infected TKA. However, further studies might be necessary for these techniques to be validated.

In terms of functional results in our study, the mean ROM of the knee joint improved from 40° pre-operatively to 92° at latest follow-up. The KS knee score and function score also improved from 47 and nine pre-operatively to 82 and 72 at follow-up, respectively. Although all patients in this series were infected cases and most of them experienced prior multiple surgical procedures, functional ROM could be achieved through the TTO approach, which is consistent with previous reports of TTO applied for primary or aseptic revision TKA [9–11, 13]. In addition, even though in most patients an articulating spacer was not used, which is known to be preferred for better interim and final functionality [24, 25], a satisfactory functional outcome was obtained by the TTO approach.

In the setting of infection, Chalidis and Ries [20] reported 38 cases of infection treated using TTO approaches (33 for reimplantation and five for implant removal) in their series of 87 TTOs, which showed satisfactory bone healing. Whiteside [18] reported that no evidence of nonunion occurred in 24 TTOs performed for infected TKA. Mendes et al. [17] described the use of TTO for ten patients with infected TKA in their series of 67 TTOs. Five patients required TTO at both the implant removal and reimplantation procedure and five other patients required a TTO only for the reimplantation. Nine of ten infections were successfully managed without significant extensor mechanism complications. These findings along with our results suggest that the presence of infection does not impede the bony union and functional outcome of TTO.

The limitation of this study includes its retrospective design. Our study group was established over a long period of time and there was no standardised surgical technique of different surgeons during the periods. It might have led to a heterogeneous fixation technique and affected treatment outcome. A prospective comparative investigation with different extensile approach and different fixation method may be required as a future study.

In summary, TTO can be successfully performed in revision arthroplasty for infected TKA. While migration of the osteotomy or avulsion fracture of the osteotomy segment occurred, satisfactory radiographic and functional results were achieved with complication rates comparable to primary or aseptic revision TKA. TTO can be a useful extensile surgical approach in patients undergoing staged revision in the setting of periprosthetic infection after TKA.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Fiddian NJ, Blakeway C, Kumar A (1998) Replacement arthroplasty of the valgus knee. A modified lateral capsular approach with repositioning of vastus lateralis. J Bone Joint Surg Br 80:859–861
2. Keblish PA (1991) The lateral approach to the valgus knee. Surgical technique and analysis of 53 cases with over two-year follow-up evaluation. Clin Orthop Relat Res 271:52–62
3. Keblish PA (2003) The lateral approach for total knee arthroplasty. J Knee Surg 16:62–68
4. Clarke HD (2003) Tibial tubercle osteotomy. J Knee Surg 16:58–61
5. Della Valle CJ, Berger RA, Rosenberg AG (2006) Surgical exposures in revision total knee arthroplasty. Clin Orthop Relat Res 446:59–68
6. Zonnenberg CB, Lisowski LA, van den Bekerom MP, Nolte PA (2010) Tuberositas osteotomy for total knee arthroplasty: a review of the literature. J Knee Surg 23:121–129
7. Barrack RL, Smith P, Munn B, Engh G, Rorabeck C (1998) The Ranawat Award. Comparison of surgical approaches in total knee arthroplasty. Clin Orthop Relat Res 356:16–21
8. Trousdale RT, Hanssen AD, Rand JA, Cahalan TD (1993) V-Y quadricepsplasty in total knee arthroplasty. Clin Orthop Relat Res 286:48–55
9. Ries MD, Richman JA (1996) Extended tibial tubercle osteotomy in total knee arthroplasty. J Arthroplasty 11:964–967
10. Young CF, Bourne RB, Rorabeck CH (2008) Tibial tubercle osteotomy in total knee arthroplasty surgery. J Arthroplasty 23:371–375
11. Piedade SR, Pinaroli A, Servien E, Neyret P (2008) Tibial tubercle osteotomy in primary total knee arthroplasty: a safe procedure or not? Knee 15:439–446
12. Wolff AM, Hungerford DS, Krackow KA, Jacobs MA (1989) Osteotomy of the tibial tubercle during total knee replacement. A report of twenty-six cases. J Bone Joint Surg Am 71:848–852
13. Bruce WJ, Rooney J, Hutabarat SR, Atkinson MC, Goldberg JA, Walsh WR (2000) Exposure in difficult total knee arthroplasty using coronal tibial tubercle osteotomy. J Orthop Surg (Hong Kong) 8:61–65
14. Whiteside LA, Ohl MD (1990) Tibial tubercle osteotomy for exposure of the difficult total knee arthroplasty. Clin Orthop Relat Res 260:6–9
15. Insall J, Salvati E (1971) Patella position in the normal knee joint. Radiology 101:101–104
16. Phillips CL, Silver DA, Schranz PJ, Mandalia V (2010) The measurement of patellar height: a review of the methods of imaging. J Bone Joint Surg Br 92:1045–1053
17. Mendes MW, Caldwell P, Jiranek WA (2004) The results of tibial tubercle osteotomy for revision total knee arthroplasty. J Arthroplasty 19:167–174
18. Whiteside LA (1995) Exposure in difficult total knee arthroplasty using tibial tubercle osteotomy. Clin Orthop Relat Res 321:32–35
19. Davis K, Caldwell P, Wayne J, Jiranek WA (2000) Mechanical comparison of fixation techniques for the tibial tubercle osteotomy. Clin Orthop Relat Res 380:241–249
20. Chalidis BE, Ries MD (2009) Does repeat tibial tubercle osteotomy or intramedullary extension affect the union rate in revision total knee arthroplasty? A retrospective study of 74 patients. Acta Orthop 80:426–431
21. van den Broek CM, van Hellemondt GG, Jacobs WC, Wymenga AB (2006) Step-cut tibial tubercle osteotomy for access in revision total knee replacement. Knee 13:430–434
22. Caldwell PE, Bohlen BA, Owen JR, Brown MH, Harris B, Wayne JS, Jiranek WA (2004) Dynamic confirmation of fixation techniques of the tibial tubercle osteotomy. Clin Orthop Relat Res 424:173–179
23. Deane CR, Ferran NA, Ghandour A, Morgan-Jones RL (2008) Tibial tubercle osteotomy for access during revision knee arthroplasty: Ethibond suture repair technique. BMC Musculoskelet Disord 9:98
24. Jämsen E, Sheng P, Halonen P, Lehto MU, Moilanen T, Pajamäki J, Puolakka T, Konttinen YT (2006) Spacer prostheses in two-stage revision of infected knee arthroplasty. Int Orthop 30:257–261
25. Pitto RP, Castelli CC, Ferrari R, Munro J (2005) Pre-formed articulating knee spacer in two-stage revision for the infected total knee arthroplasty. Int Orthop 29:305–308