Total knee arthroplasty following closed wedge high tibial osteotomy

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Abstract The purpose of this study was to evaluate the results of total knee arthroplasty (TKA) following a closed wedge high tibial osteotomy (HTO). A total of 16 TKAs were performed in 13 patients who had previously undergone a closed wedge HTO. The clinical results were reviewed using the Hospital for Special Surgery (HSS) score. The radiographic results were evaluated with respect to the femorotibial angle (FTA), joint line height (JLH) and tibial bone resection. The average HSS score before TKA was 63.6, which improved to 92.8 at the last follow-up. The FTA averaged varus 0.9° preoperatively and valgus 5.7° at the last follow-up. The JLH averaged 13.9 mm preoperatively and 15.6 mm at the last follow-up. The amount of tibial bone resection averaged 4.8 mm. A meticulous surgical technique can produce satisfactory results in TKA after HTO, considering the correction of the deformity, JLH and the amount of the tibial bone resection.

Introduction

The clinical results of high tibial osteotomy (HTO) deteriorate with time despite the initial satisfactory results [6, 18, 23]. Because of the loss of the correction angle and the pain caused by the progression of degenerative arthritis, some cases may require conversion to total knee arthroplasty (TKA). The increase in the average life expectancy has increased the frequency of conversion to

TKA. Various outcomes of TKA in patients after HTO have been reported. It is said that the clinical and radiological outcomes, complications and revision rates were either poorer after HTO [12, 16, 27] or similar [8, 15, 19, 22] (Table 1). These findings appear to be due to the differences in indication and methods of HTO. They are also affected by the surgical techniques of TKA and follow-up period [9, 19, 20].

The clinical and radiological results after TKA were analysed in patients, who had previously undergone a closed wedge HTO. In addition, the technical difficulty of TKA after HTO were examined along with a review of the literature.

Materials and methods

This study reviewed 13 patients (16 cases), who underwent conversion to TKA following a closed wedge HTO for degenerative osteoarthritis of the knee from March 1994 to July 2005. All of the patients were female, and the mean age at the time of TKA was 64.9 years (53–78 years). Eight procedures were performed on the right and eight on the left side. The mean height and weight was 153.8 cm (146–160 cm) and 64.4 kg (50–73 kg), respectively. The mean interval from HTO to TKA was 12.0 years (2.2–18.3 years), and the mean follow-up period after TKA was 4.7 years (2–12.3 years). HTOs were performed at our hospital in 12 cases and at other hospitals in four cases. Three cases from other hospitals were converted to TKA after progression of the medial compartment osteoarthritis accompanied by the recurrence of a varus knee. Twelve cases from our hospital and one case from another hospital were converted to TKA because of the deterioration of the medial compartment osteoarthritis and

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Table 1 The reported results of TKA following HTO

First author	Journal	Year published	Success rate (%)
Mont	Clin Orthop	1994	64
Windsor	J Bone Joint Surg Am	1988	80
Katz	J Bone Joint Surg Am	1987	81
Haddad	J Arthroplasty	2000	84
Stacheli	J Bone Joint Surg Am	1987	89
Parvizi	J Bone Joint Surg Am	2004	92
Meding	Clin Orthop	2000	96

progression of osteoarthritis to the lateral joint or the patellar femoral joint.

The implants in the osteotomy site were removed through the previous skin incision scar in all cases. As a surgical approach, the medial parapatellar capsular approach was used in all cases. In cases where subperiosteal exposure was difficult due to soft tissue adhesion around the osteotomy site, infrapatellar adhesion was dissected stepwise and carefully. In some cases, avulsion of the patellar tendon was prevented with a staple. A posterior cruciate ligament substituting prosthesis was used in 13 cases, and a posterior cruciate ligament retaining prosthesis was used in three cases. A Press Fit Condylar (Johnson & Johnson, Warsaw, IN, USA), PFC-RPF, Ortholoc (Wright, Arlington, TN, USA), NexGen (Zimmer, Warsaw, IN, USA), Genesis (Smith and Nephew, Memphis, TN, USA) and Total Condylar IV (Kirschner, Fairlawn, NJ, USA) were used in nine, two, two, one, one and one case, respectively. The mean thickness of the polyethylene insert was 11.1 mm (8–14 mm) (Table 2). In all cases, the prosthesis was inserted with cement. No cases required lateral release or lateral retinacular release for balance of ligaments, but nine cases required medial release.

The clinical outcome was evaluated using the Hospital for Special Surgery (HSS) knee rating score and the range of motion of the knee. Cases with a HSS score of 85–100, 70–84, 60–69 and < 60 were considered excellent, good, fair and poor, respectively. The radiological results were evaluated by the femorotibial angle (FTA) [2], the radiographic evaluation method of the American Knee Society [5], the height of the knee joint line [13, 15], the amount of tibial bone resection and the Insall-Salvati ratio (ISR) [11]. The lateral joint line height (JLH), measured from the fibular head on the anteroposterior view of the standing X-ray, was retrospectively recorded (Fig. 1) [13, 15]. The amount of bone resection at the tibial plateau in TKA was measured radiographically on the anteroposterior view of the X-ray (Fig. 2). The ISR was measured, which is the ratio of the length of the patellar tendon to the length of the patella on the lateral view of the X-ray (Fig. 3) [11]. The preoperative ISR and that at the last follow-up were compared (correlation analysis).

Results

With regard to clinical outcome, the average HSS score before TKA was 63.6 ± 7.4 , which improved to 92.8 ± 5.4 at the last follow-up. Before TKA, there were three, ten and three cases of good, fair and poor, respectively. At the last follow-up, 14 and two cases were excellent and good, respectively. The flexion contracture decreased from $7.8 \pm 8.0^\circ$ before TKA to 0° at the last follow-up. The range of motion increased from $106.3 \pm 18.4^\circ$ before TKA to $127.5 \pm 14.3^\circ$ at the last follow-up.

As to the radiological outcomes, the average FTA was corrected from varus $0.9 \pm 4.9^\circ$ (varus 12.2° –valgus 6.3°) before TKA to valgus $5.7 \pm 1.6^\circ$ (valgus 4° – 9°) at the last follow-up. Using the radiographic evaluation method of the American Knee Society, the average α , β , γ and δ angle at the last follow-up were 96.0, 89.7, 2.3 and 86.7° , respectively. None of the knees demonstrated progressive or symptomatic radiolucent lines having a width of 2 mm or more at any follow-up period. The average JLH was 13.9 ± 8.1 mm preoperatively and 15.6 ± 8.7 mm at the last follow-up. The average amount of tibial bone resection was 4.8 ± 1.5 mm (Table 3). The average ISR was 0.86 ± 0.15 preoperatively and 0.85 ± 0.17 at the last follow-up ($r=0.852$, $p=0.000$).

Discussion

It has been reported that the reasons for performing TKA after HTO were pain caused by the recurrence of the varus deformity primarily within three years and the progression of osteoarthritis to other compartments after three years

Table 2 Thickness of the polyethylene insert

Ranges (mm)	Number of knees
8–9	2
10–11	7
12–13	5
14	2

Fig. 1 The JLH was measured from the fibular head on the anteroposterior view of the X-ray. The anatomical position of the lateral joint line was re-established with minimal resection of the lateral tibial bone and enough thickness of polyethylene insert usage. The postoperative JLH (b) was raised from the preoperative JLH (a)

[24]. In our cases, three patients who had HTO performed at other hospitals underwent conversion TKA due to the recurrence of the varus deformity at an average of 2.9 years (24–39 months) after the HTO. Twelve patients who had HTO performed at our hospital and one patient who underwent HTO at another hospital had conversion TKA

Fig. 2 The amount of bone resection at the tibial plateau in TKA was measured radiographically on the anteroposterior view of the X-ray. “c” was defined as the shortest vertical distance between the fibular head and the lateral tibial plateau before TKA. “d” was defined as the shortest vertical distance between the fibular head and the tibial cut surface at the last follow-up. The amount of bone resection at the tibial plateau in TKA was calculated as “c–d”

Fig. 3 The ISR on the lateral view of the X-ray. The preoperative ISR is the ratio of the length of the patellar tendon to the length of the patella and is denoted by LT/LP . The ISR at the last follow-up is the ratio of the length of patellar tendon to the length of the patella and is denoted by LT'/LP' . Preoperative ISR and ISR at the last follow-up were compared (correlation analysis)

due to the progression of osteoarthritis to the medial and other compartments at an average of 13.6 years (72–192 months) after the HTO (Fig. 4).

Patella baja, soft tissue scarring and limited knee motion make the surgical approach difficult. Also, the anatomical distortion and bone defect of the proximal tibial metaphysis after HTO make the conversion to TKA difficult and can lead to a poor result [15, 16]. For successful TKA after HTO, correction of the deformity and proper positioning of the implant are required. Preoperative deformities include varus or valgus and rotational deformity, a change in the tibial slope angle and medial displacement of the tibial anatomical axis [3, 14]. Restoration of the normal joint line with careful determination of the tibial bone resection level and proper soft tissue balancing are also required [3, 14].

After HTO, dynamic changes to the patellofemoral joint, such as patella baja, alteration of the Q angle and patellar subluxation, are associated with the fixation methods of osteotomy and the method of postoperative rehabilitation [4, 27]. Inadequate fixation of the osteotomy site can delay rehabilitation and increase the likelihood of patella baja [20]. The patellar tendon may be shortened by excessive new bone formation during osteotomy healing. Windsor et al. [27] reported that the average ISR was 0.7 preoperatively, and in 32 of 45 cases it was less than 0.8. In our cases, the average ISR was 0.86 before TKA and 0.85 at the last follow-up. There were five cases with ISR of less than 0.8 before TKA and four cases at the last follow-up.

Table 3 The amount of bone resection at the tibial plateau

Ranges (mm)	Number of knees
3–5	11
5–7	4
7–9	1

The surgical approach to the proximal tibial metaphysis and patellar eversion are difficult in many cases when performing TKA after a closed wedge HTO due to patella baja, infrapatellar adhesion and adhesion around the osteotomy site [12, 16, 21, 25, 27]. This can necessitate a special approach technique, such as quadriceps snip, V-Y plasty of the quadriceps, tibial tubercle osteotomy, early release of the lateral retinaculum, lateral parapatellar approach and/or the release of the patellofemoral ligament [12, 15, 16, 27]. Infrapatellar release was performed carefully and in a stepwise manner in order to prevent patellar tendon injury in our cases. No case underwent quadriceps snip or lateral retinacular release.

Implants at the osteotomy site that would interfere with the placement of the tibial components should be removed [15], and indeed were removed in all cases of this study whether or not they interfered with the tibial component. The surgical approach for removing fixators can be through the previous skin incision scar for HTO. A midline skin incision for TKA should be made in order to ensure a sufficient gap from the separate skin incision for implant removal.

In TKA in patients who underwent closed wedge HTO, tibial metaphyseal bone loss after osteotomy requires a smaller amount of tibial bone resection [12, 14, 27]. Meding et al. [15] reported that the average amount of tibial bone resection was 7.5 mm in a group without a previous HTO and 3.3 mm in a group with a previous HTO. In this study, the average amount of resection was 4.8 mm, and the average thickness of the polyethylene insert was 11.1 mm (8–15 mm) to restore the normal joint line and gain a proper ligament balance.

A coronal or rotational deformity of the tibial plateau and a change in the posterior slope angle can occur after HTO. Hence, conversion TKA requires good understanding of the tibial deformity [7]. In addition, the relative position of the tibial plateau on the anatomical axis of the tibia may change after HTO. Generally, the tibial anatomical axis may pass the medial or the anteromedial point in the tibial plateau, and the tibial component stem may come into contact with the lateral tibial cortex [17]. This problem can be solved by medial positioning of the tibial component stem and the use of an offset stemmed tibial component [17].

For the balance of soft tissues, medial, lateral and posterior release may be performed [1, 15], and it has been reported that the frequency of requiring medial, lateral and posterior release was similar in the patient group with and without performing HTO [1, 13, 15]. In our cases, medial release was required in nine cases (56.2 %), and there were no cases requiring lateral release or lateral retinacular release.

Hofmann and Kane [10] recommended the use of the posterior cruciate ligament substituting prosthesis for TKA

Fig. 4 a The preoperative roentgenograms of the left knee of a 63-year-old woman with a prior history of HTO 18 years earlier showed joint space narrowing and a varus deformity. JLH was 14.5 mm and ISR was 0.95. **b** This patient underwent TKA under navigation control. The X-rays taken at the last follow-up show good alignment and a restoration of the JLH. The JLH was 15.2 mm and ISR was 0.91. The amount of tibial bone resection was 3.0 mm

after HTO because of posterior cruciate ligament contracture. Walther et al. [26] claimed that it was difficult to maintain the appropriate tension of the posterior cruciate ligament and balance the flexion and extension gap because of the tibial bone defect and the relaxation of the posterior cruciate ligaments. In this study, the posterior cruciate ligament substituting prosthesis was used in 13 of 16 cases, and the posterior cruciate ligament retaining prosthesis was used in three cases in which the posterior cruciate ligament did not show severe degeneration, maintained appropriate tension and could obtain an accurate balance of the flexion and extension gaps.

Various complications including patellar dislocation, joint stiffness, loosening of the component and deep infection have been reported [7, 27]. However, there were no complications in our 16 cases, and no case required additional surgery or revision arthroplasty during an average follow-up period of 4.7 years.

This study has some limitations. This was a retrospective study. The number of subjects was small, the deformity of the subjects was not too severe, i.e. the average FTA before TKA was varus 0.9° (12.2° varus– 6.3° valgus), and the follow-up period was relatively short with an average of 4.7 years (2–12.3 years). However, the patients of this study had good or excellent results at an average follow-up of 4.7 years. This suggests that HTO does not have a clinically significant negative effect on later TKA.

Conclusion

It is generally accepted that TKA after closed wedge HTO is technically more difficult. However, the previous HTO itself had no deleterious effect on the outcome of the subsequent TKA. The correction of the deformity, small amount of tibial bone resection and sufficient thickness of the polyethylene insert, with restoration of the JLH and adequate ligament balancing can overcome the technical challenges encountered in TKA following HTO.

References

- Bäthis H, Perlick L, Tingart M, Lüring C, Perlick C, Grifka J (2004) Flexion gap configuration in total knee arthroplasty following high tibial osteotomy. *Int Orthop* 28:366–369
- Bauer GC, Insall J, Koshino T (1969) Tibial osteotomy in gonarthrosis (osteo-arthritis of the knee). *J Bone Joint Surg Am* 51:1545–1563
- Bergenudd H, Sahlström A, Sanzén L (1997) Total knee arthroplasty after failed proximal tibial valgus osteotomy. *J Arthroplasty* 12:635–638
- Closkey RF, Windsor RE (2001) Alterations in the patella after a high tibial or distal femoral osteotomy. *Clin Orthop* 389:51–56
- Ewald FC (1989) The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. *Clin Orthop* 248:9–12
- Fisher DE (1998) Proximal tibial osteotomy 1970–1995. *Iowa Orthop J* 18:54–63
- Gill T, Schemitsch EH, Brick GW, Thornhill TS (1995) Revision total knee arthroplasty after failed unicompartmental knee arthroplasty or high tibial osteotomy. *Clin Orthop* 321:10–18
- Haddad FS, Bentley G (2000) Total knee arthroplasty after high tibial osteotomy: a medium-term review. *J Arthroplasty* 15:597–603
- Haslam P, Armstrong M, Geutjens G, Wilton TJ (2007) Total knee arthroplasty after failed high tibial osteotomy long-term follow-up of matched groups. *J Arthroplasty* 22:245–250
- Hofmann AA, Kane KR (1994) Total knee arthroplasty after high tibial osteotomy. *Orthopedics* 17:887–890
- Insall JN, Salvati EA (1971) Patella position in the normal knee joint. *Radiology* 101:101–104
- Katz MM, Hungerford DS, Krackow KA, Lennox DW (1987) Results of total knee arthroplasty after failed proximal tibial osteotomy for osteoarthritis. *J Bone Joint Surg Am* 69:225–233
- Kazakos KJ, Chatzipapas C, Verettas D, Galanis V, Xarchas KC, Psillakis I (2008) Mid-term results of total knee arthroplasty after high tibial osteotomy. *Arch Orthop Trauma Surg* 128:167–173
- Krackow KA, Holtgrewe JL (1990) Experience with a new technique for managing severely overcorrected valgus high tibial osteotomy at total knee arthroplasty. *Clin Orthop* 258:213–224
- Meding JB, Keating EM, Ritter MA, Faris PM (2000) Total knee arthroplasty after high tibial osteotomy. A comparison study in patients who had bilateral total knee replacement. *J Bone Joint Surg Am* 82:1252–1259
- Mont MA, Antonaides S, Krackow KA, Hungerford DS (1994) Total knee arthroplasty after failed high tibial osteotomy. A comparison with a matched group. *Clin Orthop* 299:125–130
- Nagamine R, Miura H, Bravo CV et al (2000) Anatomic variations should be considered in total knee arthroplasty. *J Orthop Sci* 5:232–237
- Papachristou G, Plessas S, Sourlas J, Levidiotis C, Chronopoulos E, Papachristou C (2006) Deterioration of long-term results following high tibial osteotomy in patients under 60 years of age. *Int Orthop* 30:403–408
- Parvizi J, Hanssen AD, Spangehl MJ (2004) Total knee arthroplasty following proximal tibial osteotomy: risk factors for failure. *J Bone Joint Surg Am* 86:474–479
- Rozbruch SR (2004) Total knee arthroplasty following proximal tibial osteotomy. *J Bone Joint Surg Am* 86:2571
- Scuderi GR, Windsor RE, Insall JN (1989) Observations on patellar height after proximal tibial osteotomy. *J Bone Joint Surg Am* 71:245–248
- Stacheli JW, Cass JR, Morrey BF (1987) Condylar total knee arthroplasty after failed proximal tibial osteotomy. *J Bone Joint Surg Am* 69:28–31
- Stukenborg-Colsman C, Wirth CJ, Lazovic D, Wefer A (2001) High tibial osteotomy versus unicompartmental joint replacement in unicompartmental knee joint osteoarthritis: 7–10-year follow-up prospective randomised study. *Knee* 8:187–194
- Takai S, Yoshino N, Hirasawa Y (1997) Revision total knee arthroplasty after failed high tibial osteotomy. *Bull Hosp Jt Dis* 56:245–250
- Tigani D, Ferrari D, Trentani P, Barbanti-Brodano G, Trentani F (2001) Patellar height after high tibial osteotomy. *Int Orthop* 24:331–334
- Walther M, König A, Kirschner S, Gohlke F (2000) Results of posterior cruciate-retaining unconstrained total knee arthroplasty after proximal tibial osteotomy for osteoarthritis. A prospective cohort study. *Arch Orthop Trauma Surg* 120:166–170
- Windsor RE, Insall JN, Vince KG (1988) Technical considerations of total knee arthroplasty after proximal tibial osteotomy. *J Bone Joint Surg Am* 70:547–555