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ORIGINAL ARTICLE

Combined medial open-wedge high tibial osteotomy and modified Maquet procedure for medial compartmental osteoarthritis and patellofemoral arthritis of the knee

Jae-Hwa Kim · Jung Ryul Kim · Dong Hoon Lee · Jin-Young Bang · In-Tae Hong

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Abstract
Purpose Patellofemoral arthritis comes frequently with medial compartmental osteoarthritis. The combination of closed wedge high tibial osteotomy with tibial tuberosity anteriorization osteotomy has been introduced in several reports, but this technique is a technically demanding procedure and the outcomes of this technique show variable results. This article describes a novel osteotomy technique that combines medial open-wedge high tibial osteotomy (HTO) and tibial tuberosity anteriorization osteotomy (TTAO) for medial compartmental osteoarthritis and patellofemoral arthritis of the knee.
Methods Twelve knees in 10 patients who were diagnosed with combined medial compartmental osteoarthritis with patellofemoral compartmental arthritis were treated with the combination of medial open-wedge HTO and TTAO and were followed up for more than 1 year. We evaluated the patients with the Lysholm functional questionnaires, the hospital for special surgery score (HSS), and the international knee documentation committee (IKDC) criteria (mean follow-up, 14.8 months).
Results Union was achieved in all cases within 12 weeks. The mean Lysholm score increased from 42 preoperatively to 82.5 postoperatively ($p < 0.001$), the HSS increased from 57.5 preoperatively to 83 postoperatively ($p < 0.001$), and the IKDC score increased from 51 preoperatively to 82 postoperatively ($p < 0.001$). There were no other complications, such as iatrogenic fractures, nonunion, wound problem, collapse or loss of correction, and so on.
Conclusions The combination of medial open-wedge HTO and modified Maquet procedure (TTAO) is considered to be an effective treatment modality for medial and patellofemoral compartmental osteoarthritis. This technique could, therefore, constantly provide a minimally invasive, precise correction of the deformity and a firm fixation that is enough to allow early rehabilitation.

Keywords Knee joint · Medial compartmental osteoarthritis · Patellofemoral arthritis · Medial open-wedge high tibial osteotomy · Modified Maquet procedure

Introduction

High tibial osteotomy (HTO) is a well-established procedure for the treatment of varus medial compartmental osteoarthritis of the knee [1–3]. This is accomplished by slightly overcorrecting mechanical axis to the lateral side, which results in partial unloading of medial compartment. According to recent reports, 80–90 % of patients show satisfactory results at 5 years and 50–90 % of patients at 10 years after HTO [1]. The medial open-wedge HTO has become a favored technique because there is less risk of peroneal nerve injury and no disruption of the proximal tibiofibular joint and lateral ligament and more precise correction can be achieved [3].

Clinically, medial compartmental osteoarthritis comes frequently with patellofemoral arthritis. This condition is known to be related to a poor prognosis after HTO [4]. Tibial tuberosity anteriorization osteotomy (TTAO) is a proven treatment of patellofemoral arthritis by reducing

J.-H. Kim (✉) · J. R. Kim · D. H. Lee · J.-Y. Bang · I.-T. Hong
Department of Orthopaedic Surgery, CHA Bundang Medical Center, CHA University School of Medicine, 351 Yatap-dong, Bundang-gu, Sung-nam, South Korea
e-mail: Ddolmania@yahoo.com

patellofemoral contact pressure [5]. Accordingly, combining HTO with TTAO seems to be a promising option for treating patellofemoral arthritis. The combination of closed wedge HTO with TTAO has been introduced in several reports [6–11], but there are few reports mentioning the combination of open-wedge HTO with TTAO.

The purpose of this article is to introduce a novel osteotomy technique that combines medial open-wedge HTO and TTAO. This technique constantly provides minimally invasive and precise correction of the deformity.

Patients and methods

Between March 2007 and January 2009, 12 knees in 10 patients were treated with the combination of medial open-wedge HTO and TTAO. The study is comprised of 3 knees in 3 male patients and 9 knees in 7 female patients with a mean age of 54 years (age range, 47–59 years). All patients were diagnosed with combined medial compartmental osteoarthritis with patellofemoral compartmental arthritis that was verified by preoperative MRI, and their medial proximal tibial angles (mPTA) exceeded 4° varus (normal range, 85–90°).

The inclusion criteria of the study were as follows:

1. patient with anterior and medial knee pain that is uncontrolled by conservative management;
2. age <60;
3. concomitant medial and patellofemoral compartmental arthritic change(s) by the Outerbridge classification grade >3 on MRI;
4. intact lateral compartmental articular cartilage on MRI;
5. Kellgren and Lawrence grade <4 on preoperative radiographs.

Patients were clinically assessed preoperatively and at least 12 months postoperatively using the Lysholm functional questionnaires, the hospital for special surgery score (HSS), and the international knee documentation committee (IKDC) criteria.

Technique

The patient was positioned supine on the operating table and a thigh tourniquet was applied. Diagnostic knee arthroscopy was performed during which the menisci, ligaments, and articular cartilage were inspected and debridement or meniscal surgery was carried out if necessary.

A 5-cm longitudinal incision was made along the midpoint between the medial border of the tibia tubercle and the posteromedial border of the tibia, extending from 1 cm below the medial joint line downward to the distal part of the tibial tuberosity.

Primarily, TTAO was performed by first dissecting the patellar ligament along its posterior surface and loosening the infrapatellar fat pad sufficiently to permit the patella to ride free without tethering. Then, an osteotomy was made from a point 1 cm medial to the tibial tuberosity and extended distally for 10 cm with a thin osteotome. For adequate bone stock beneath tibial tuberosity, a shallow V-shaped osteotomy was created. The initial direction of an osteotome was from the anteromedial cortex to the midlateral cortex, and the osteotome was advanced approximately 10 mm. The direction of the osteotome was then turned to the anterolateral cortex in the lateral view (Fig. 1). By carefully hinging on an intact distal cortex, anterior elevation of the tibial tuberosity fragment, which is 1 cm thick, 2 cm wide, and about 10 cm long, was done.

Secondly, a medial open-wedge HTO was performed. A 2-cm longitudinal incision was made, and then the medial cortex of the proximal tibia was exposed through the sartorial fascia above the insertion of the pes anserine tendons. After identifying the upper margin of the tibial tuberosity, two 2.0-mm K wires were inserted as a guide for the osteotomy from the medial cortex, at a point approximately 3–4 cm distal from the medial joint line, toward the tip of the fibula in the anteroposterior view, both strictly parallel to each other. Behind the tibial tuberosity, the osteotomy was made to slide along the 2 wires with a thin osteotome, stopping 5 mm before the proximal lateral cortex. The extent of the osteotomy was checked from time to time using fluoroscopy to ensure the appropriate

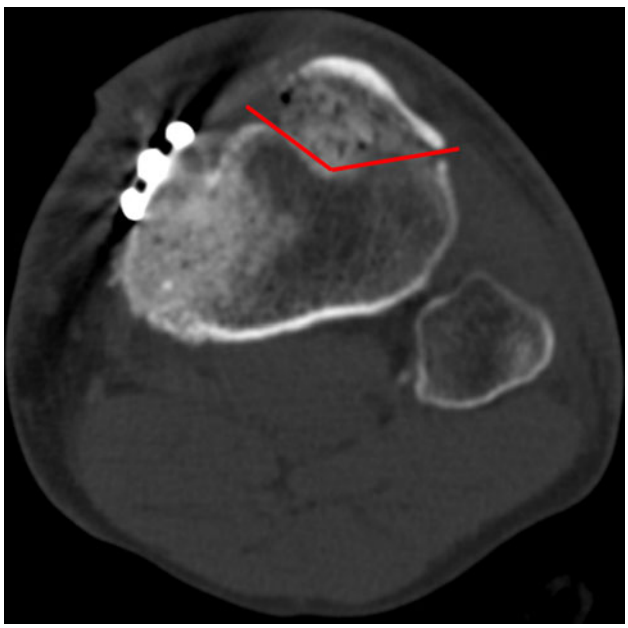

Fig. 1 V-shape osteotomy of tibial tuberosity

direction and depth of the cut. Serial osteotome blades were introduced sequentially over each other in the osteotomy line to stop at a predecided distance.

Fig. 2 Combining HTO (*asterisk*) with TTAO (*white arrow*)

The mobility of the osteotomy was checked by gentle manipulation of the leg with a valgus force. This manipulation was advanced slowly to allow gradual opening of the osteotomy without breaking the lateral cortex because rapid advancement can lead to fracture through the lateral condyle. The osteotomy gap was held open by a wide lamina spreader and the gap was measured in centimeters. Once the preoperatively decided wedge size was achieved, alignment was checked in both sagittal and coronal planes using fluoroscopy. A Bovie cord was placed from the center of the hip joint to the center of the ankle joint, and alignment was checked by adjusting the wedge size until the Bovie cord passes just lateral to the lateral tibial spine according to the work of Fujisawa [12] (Fig. 2).

The defect was filled with iliac bone graft or bank bone, and then a plate was positioned on the anteromedial surface of the tibia. A periarticular medial distal tibial plate (Zimmer, USA) was used with at least four 4.0-mm cancellous screws or 3.5-mm cannulated locking screws proximally and at least four 3.5-mm cortical screws distally using a minimal invasive osteosynthesis technique. The plate was centered on the

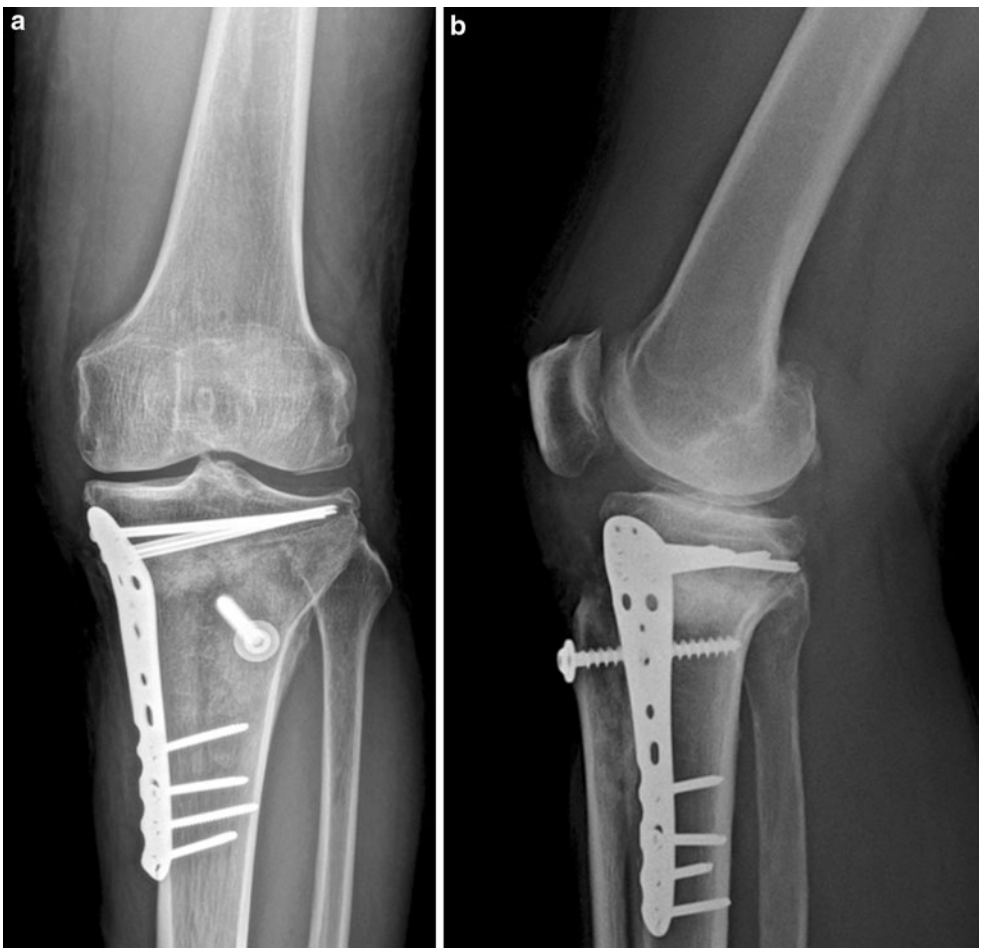

Fig. 3 **a** Immediate postoperative anteroposterior and **b** lateral radiographs

sagittal axis to prevent the alteration of the natural tibial slope. Using a fluoroscope, a final check of the osteotomy, hardware position, filling of defect with graft, and alignment was performed. After fixation with the plate, TTAO was fixed with a 5.5-mm cancellous screw and a washer. The wound was irrigated, a suction drain was placed, and the wound was closed in layers. A long leg splint was applied. Any varus force was avoided during dressing or application of the splint (Fig. 3).

Postoperative management

The reconstruction was stable enough to allow passive range of knee motion and active quadriceps strengthening exercises the day after surgery. No weight bearing was permitted on the operated side for 3 weeks. Patients then started partial weight bearing with crutches for 4 weeks. At 7 weeks after surgery, full unguarded weight bearing was allowed.

For statistical analysis, the pre- and postoperative functional scores were compared with Wilcoxon signed-rank test. $p < 0.05$ was considered statistically significant throughout the article. MedCalc (ver. 11.6 MedCalc Software, Broekstraat 52, 9030, Mariakerke, Belgium) and R (ver. 2.12 Comprehensive R Archive Network, GNU General Public License, Massachusetts, USA) were used for all statistical analysis.

Results

Union was achieved in all cases within 12 weeks. The final evaluation was conducted at least 12 months after surgery (mean follow-up, 14.8 months). The mean Lysholm score increased from 42 (range, 30–48) preoperatively to 82.5 (range, 70–89) postoperatively ($p < 0.001$), the HSS increased from 57.5 preoperatively (range, 40–65) to 83 (range, 73–90) postoperatively ($p < 0.001$), and the IKDC score increased from 51 preoperatively (range, 31–65) to 82 (range, 63–90) postoperatively ($p < 0.001$). The mechanical axis line passed the point of average of 35–62 % from the medial tibial plateau margin postoperatively. There were no other complications, such as iatrogenic fractures, nonunion, wound problem, collapse or loss of correction, and so on. Postoperatively, 75 % of patients were painless, 17 % had mild or occasional pain while kneeling, and 8 % had pain during walking.

Discussion

HTO is a reliable surgical procedure for the treatment of medial compartmental arthrosis of the knee if the patient is selected properly and with a precise surgical technique [1, 3]. Young patients (<60 years of age) and patients with isolated medial osteoarthritis and a good range of motion without ligamentous instability are the ideal candidates for HTO [3]. However, some patients suffer from osteoarthritis of the knee with degeneration in two different compartments, such as medial and patellofemoral compartmental osteoarthritis of the knee. Medial and patellofemoral compartmental osteoarthritis of the knee has been a relative contraindication for HTO [4] and an indication for total knee arthroplasty [13]. With total knee arthroplasty, significant concerns remain regarding the longevity of the prostheses, particularly in younger patients.

TTAO as a treatment for isolated patellofemoral arthritis was first introduced by Maquet [5]. TTAO is an effective procedure for the treatment of patellofemoral arthritis by reducing patellofemoral pressure.

Although HTO, either open- or closed wedge HTO, is an effective procedure for medial compartmental arthrosis, it alters the patellar height and consequently alters the patellofemoral contact pressure, especially in increasing trend [14]. The increase in patellofemoral contact pressure may be the cause of the patellofemoral compartmental pain or arthritis. Combining HTO and TTAO compensates this disadvantage of isolated HTO on patellofemoral kinematics by reducing patellofemoral contact pressure. Moreover, combination of HTO and TTAO is considered to be an effective method for medial and patellofemoral compartmental osteoarthritis, which has been a relative contraindication for isolated HTO. Thus, a combination of HTO and TTAO as a treatment modality for both compartmental osteoarthritis has received considerable attention.

HTO combined with TTAO has been reported to be performed using two different techniques. The first technique is an isolated closed wedge HTO that comprises anterior displacement of the distal tibial fragment [6, 10]. The second technique is a closed wedge HTO combined with TTAO as a separate osteotomy in the form of a Maquet or a modified Maquet procedure [6–9, 11]. These techniques are technically demanding procedures, and the outcomes of these techniques show variable results [6–11].

On the other hand, there are few reports that introduce the combination of medial open-wedge HTO with TTAO. Medial open-wedge HTO has several clinical advantages [1]. Precise correction of the deformity in the coronal and sagittal planes can be obtained and by approaching medially. This method also evades neurological complications such as peroneal nerve palsy and can overcome the difficulties associated with a total knee arthroplasty after a lateral closed wedge HTO. Thus, we adopted the combination of medial open-wedge HTO with TTAO.

For our combination technique, we used a rigid long plate with at least four 4.0-mm cancellous screws or 3.5-mm cannulated locking screws proximally and at least four 3.5-mm cortical screws distally and achieved fixation

firm enough to allow early rehabilitation. Agneskirchner et al. [15] measured axial load and displacement and reported that less displacement was seen with rigid long medial tibial plate fixators with locking bolts compared to short spacer plates. To facilitate bony union and avoid heat damage to the bone, we only used an osteotome for the osteotomy and performed minimal soft tissue dissection.

The extent of anterior advancement of the tibial tuberosity is still controversial. In the original Maquet osteotomy, more than 2 cm elevation of the anterior tibial tubercle was recommended for patients with symptomatic patellofemoral osteoarthritis based on their clinical result [5]. However, anterior advancement exceeding 2 cm has disadvantages of high wound complication rate, nonunion, and unsatisfied cosmetic problems due to prominence of the tibial tubercle [16].

We limited anterior advancement of the tibial tuberosity to 1–1.5 cm, a distance enough to reduce patellofemoral contact pressure [17]. To achieve a firm fixation and to avoid nonunion of the osteotomy site, we made the tibial tuberosity fragment about 10 cm long, which was long enough to avoid abrupt angulation of the fragment, and anterior elevation was performed carefully by hinging on an intact distal cortex.

Conclusion

We strongly believe that this combination of medial open-wedge HTO and modified Maquet procedure (TTAO) is considered to be an effective treatment modality for medial and patellofemoral compartmental osteoarthritis. This technique could constantly provide a minimally invasive, precise correction of the deformity and a firm fixation that is enough to allow early rehabilitation. However, further studies should be conducted on patellofemoral contact pressures, a possibility of collapse or loss of correction compared between combining open-wedge HTO with TTAO, and other surgical methods in the future.

Conflict of interest The authors did not receive and will not receive any benefits or funding from any commercial party related directly or indirectly to the subject of this article.

References

1. Amendola A, Bonasia DE (2010) Results of high tibial osteotomy: review of the literature. Int Orthop 34(2):155–160. doi:10.1007/s00264-009-0889-8
2. Coventry MB (1979) Upper tibial osteotomy for gonarthrosis. The evolution of the operation in the last 18 years and long term results. Orthop Clin North Am 10(1):191–210
3. Dowd GS, Somayaji HS, Uthukuri M (2006) High tibial osteotomy for medial compartment osteoarthritis. Knee 13(2):87–92. doi:10.1016/j.knee.2005.08.002
4. Rudan JF, Simurda MA (1990) High tibial osteotomy. A prospective clinical and roentgenographic review. Clin Orthop Relat Res 255:251–256
5. Maquet P (1976) Advancement of the tibial tuberosity. Clin Orthop Relat Res 115:225–230
6. Bourguignon RL (1981) Combined coventry-maquet tibial osteotomy: preliminary report of two cases. Clin Orthop Relat Res 160:144–148
7. Hofmann AA, Wyatt RW, Jones RE (1984) Combined coventry-maquet procedure for two-compartment degenerative arthritis. Clin Orthop Relat Res 190:186–191
8. Nguyen C, Rudan J, Simurda MA, Cooke TD (1989) High tibial osteotomy compared with high tibial and Maquet procedures in medial and patellofemoral compartment osteoarthritis. Clin Orthop Relat Res 245:179–187
9. Putnam MD, Mears DC, Fu FH (1985) Combined maquet and proximal tibial valgus osteotomy. Clin Orthop Relat Res 197:217–223
10. Saito T, Takeuchi R, Ara Y, Yoshida T, Koshino T (2002) High tibial osteotomy with anterior advancement of distal fragment for medial and patellofemoral compartmental osteoarthritis of the knee. Knee 9(2):127–132
11. Sasaki T, Yagi T, Monji J, Yasuda K, Tsuge H (1986) High tibial osteotomy combined with anterior displacement of the tibial tubercle for osteoarthritis of the knee. Int Orthop 10(1):31–40
12. Fujisawa Y, Masuhara K, Shiomi S (1979) The effect of high tibial osteotomy on osteoarthritis of the knee. An arthroscopic study of 54 knee joints. Orthop Clin North Am 10(3):585–608
13. Berman AT, Bosacco SJ, Kirshner S, Avolio A Jr (1991) Factors influencing long-term results in high tibial osteotomy. Clin Orthop Relat Res 272:192–198
14. Stoffel K, Willers C, Korshid O, Kuster M (2007) Patellofemoral contact pressure following high tibial osteotomy: a cadaveric study. Knee Surg Sports Traumatol Arthrosc 15(9):1094–1100. doi:10.1007/s00167-007-0297-9
15. Agneskirchner JD, Freiling D, Hurschler C, Lobenhoffer P (2006) Primary stability of four different implants for opening wedge high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc 14(3):291–300. doi:10.1007/s00167-005-0690-1
16. Saleh KJ, Arendt EA, Eldridge J, Fulkerson JP, Minas T, Mulhall KJ (2005) Symposium. Operative treatment of patellofemoral arthritis. J Bone Joint Surg Am 87(3):659–671. doi:10.2106/JBJS.D.03035
17. Nakamura N, Ellis M, Seedhom BB (1985) Advancement of the tibial tuberosity. A biomechanical study. J Bone Joint Surg Br 67(2):255–260