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Case Report

High tibial osteotomy solely for the purpose of return to lifelong sporting activities among elderly patients: A case series study

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ABSTRACT

Knee osteoarthritis (KOA) is a common joint disease among older individuals, associated with increased mortality rates. The current study was conducted to examine whether open wedge high tibial osteotomy (OWHTO) is an effective treatment for elderly patients with a desire to return to sporting activities (RTS) who do not report inconvenience or pain in activities of daily living. We examined a case series of 9 KOA patients (12 knees) aged 50 or above with a desire for RTS, who underwent HTO. We assessed patients before surgery and 2 years after surgery to evaluate surgical outcomes and RTS. The results revealed that patients' average Japanese Orthopaedic Association score was significantly improved at 2 years after surgery (97.5 ± 4.5), compared with the preoperative score (87.9 ± 7.2; $p = 0.008$). In addition, the average Tegner activity level score was significantly improved at 2-year follow-up (5.8 ± 1.1) compared with the preoperative score (2.8 ± 1.1; $p < 0.001$). Eight of nine cases except a marathon runner returned to pre-symptom sporting performance levels. Overall, the current findings suggest that OWHTO provides an appropriate treatment for older KOA patients with a desire for RTS.

Introduction

Knee osteoarthritis (KOA) is a common joint disease that exhibits increased prevalence with age[1]. A previous study reported that the mortality rate after 10 years in patients with KOA was significantly increased compared with non-KOA individuals[2]. Thus, KOA treatment may be critical for extending the lifespan, as well as for pain relief and improving activities of daily living (ADL). However, the shortened healthy lifespan of KOA patients compared with the average lifespan raises concerns in the context of Japan's rapidly aging population. In response to this social problem, an increasing proportion of the Japanese population participate in lifelong sports to extend their healthy lifespan. Therefore, improving the rate of returning to sporting activities (RTS) after KOA may have significant health benefits for the elderly population in Japan.

For elderly patients with KOA who participate in lifelong sporting activity, high tibial osteotomy (HTO) is a potential treatment option. Satisfactory results for pain relief and improving ADL after HTO have been previously reported, regardless of the type of HTO (including open wedge HTO [OWHTO][3,4] and closed wedge HTO [CWHTO])[5]. In addition to ADL improvement after HTO, several previous studies reported that HTO enables RTS in young active patients with KOA at an equal or increased level[6,7]. In the current study, we hypothesized that OWHTO would provide a helpful treatment for middle aged and elderly KOA patients seeking RTS. In accord with this hypothesis, we indicated OWHTOs for athletic middle aged and elderly patients who had little or no ADL inconvenience. Thus, the objective of this study was to investigate the results of OWHTO solely for RTS in middle aged and elderly patients.

Materials and methods

Indication of OWHTO

HTO for KOA, whether OWHTO or CWHTO, is indicated when a

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patient satisfies the following criteria[8]: medial compartment Kellgren–Lawrence (KL) grade[9] I to IV KOA, hip-knee-ankle angle of <0° (HKA angle; The angle between the femoral and tibial mechanical axes in the anteroposterior view. Varus angles are expressed as negative and valgus as positive.), location of the center of the deformity around the proximal tibia, less than 10° of flexion contracture and the patient is physically active. In our series, OWHTO was chosen when a patient met all of the following additional criteria as well: preoperatively calculated opening wedge gap of<15 mm, smoking<20 cigarettes per day, and less than 5° of flexion contracture.

Inclusion and exclusion criteria

Among patients who received unilateral or bilateral OWHTO for KOA with varus from April 2009 to April 2017, only cases meeting the following criteria were included: 1) patients aged 50 or above; 2) preoperative Japanese Orthopaedic Association (JOA) score[10] of >80 points (*i.e.*, the patient did not report severe inconvenience in typical Japanese ADL); 3) preoperative knee pain of 0 or 1 on a visual analogue scale, (*i.e.* patients have no or negligible pain in ADL); 4) patients took part in a sporting activity with a Tegner activity scale[11] score of 5 or more immediately before being affected by KOA; 5) patients received OWHTO solely for RTS, not for improving ADL; and 6) patients completed at least 2 years of follow-up examinations. Patients undergoing concomitant anterior/posterior cruciate ligament reconstruction or meniscal repair were excluded from the study. This study was approved by the ethics committee (protocol number; 30-11). Consent for publication was obtained from the patients whose personal data was presented in this article.

Surgical procedure

Bi-planar OWHTO was performed using the method described by Staubli et al.[12] with some modifications[8]. TomoFix® small plates (Synthes GmbH, Solothurn, Switzerland), or TriS® plates (Olympus Terumo Biomaterials Corp., Tokyo, Japan) were used for fixation. No bone substitute or graft was used from April 2009 to May 2012 (Case 1 to the left knee in the Case 4, The details of Case 3 are demonstrated in Fig. 1), and a bone substitute (Osferion 60®, Olympus) was used to fill the opening gap after June 2012 (The right knee in the Case 4 to Case 9), according to Takeuchi et al.[4] (Table 1). Our standard target weight-bearing line ratio[4] (WBLR) was around 62%[8], which was almost equivalent to the HKA angle of 4°. However, it was modified depending on the cases. For example, the Case 9 (Fig. 2) was a member of an over-aged national hockey team, and was eager to return to world cup competition. We applied intentional under-correction in this case for several reasons: 1) playing hockey at a high level itself may carry a high risk of anterior cruciate ligament (ACL) injury; 2) landing with the knee in valgus is a risk factor for non-contact ACL injury[13]; and 3) the knees are typically used at mid-flexion not at full extension while playing hockey. The target HKA angle was −2° (WBLR = 45%), which was equivalent to the unaffected knee. Informed consent was received from the patient, because the mid-to long-term results may be worse than for conventional over-correction, and there was a possibility of the need for re-operation in the near future.

Postoperative rehabilitation

Postoperatively, the active and passive range of movement exercises were started after the suction drain had been removed, typically within 48 hours of surgery. Standard protocols of partial and full weight-bearing were started at 1 and 3 weeks after surgery, respectively[8]. After confirming bone union of the anterior flange and the hinge, jogging was allowed at three months. Return to sporting activity was allowed gradually six to 12 months postoperatively, and after one year without any restrictions. This protocol was modified if an unstable lateral hinge fracture was confirmed.

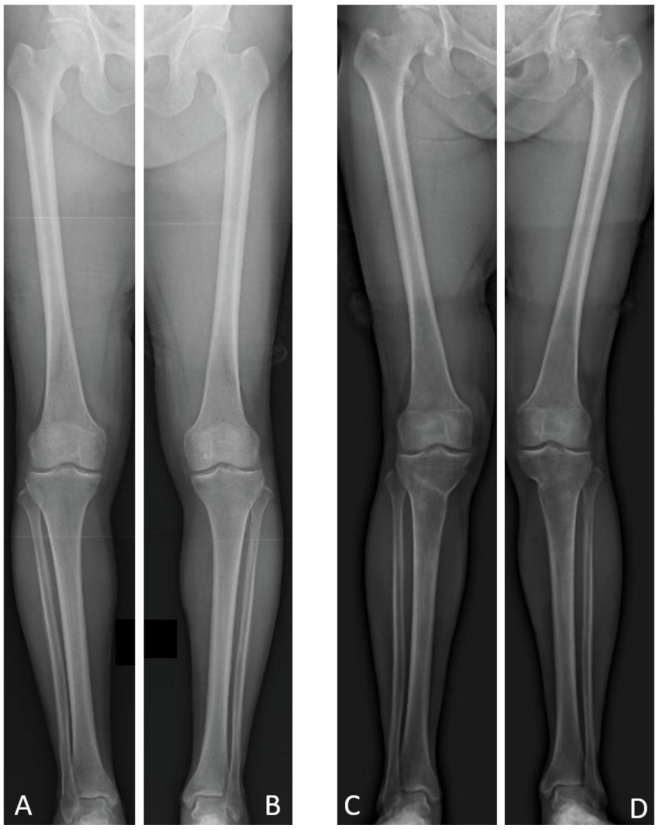

Fig. 1. Full-length anteroposterior view of Case 3, who engaged in mountain climbing. She was able to climb mountains as high as 3000 m 1 year after surgery (13 and 12 months after the right and left open wedge high tibial osteotomies, respectively).
A. Right leg (Preoperative HKA angle = −5°).B. Left leg (Preoperative HKA angle = −5°).C. Right leg (2 years after surgery, HKA angle = 6°).D. Left leg (2 years after surgery, HKA angle = 5°). HKA angle; hip-knee-ankle angle, Varus angles are expressed as negative and valgus as positive.

Assessment

Regarding the details of the OWHTOs, the use of a plate for fixation, the presence or absence of a bone-substitute, and complications were recorded (Table 1). Radiological evaluation consisted of anteroposterior weight-bearing view of the knee and a full-length anteroposterior view of the leg taken pre-operatively and at one month postoperatively (Table 1). KL grade and HKA angle were evaluated on the anteroposterior view of the knee and the full-length anteroposterior view of the leg, respectively (Table 1). The JOA score and range of knee flexion were assessed preoperatively and 2 years after OWHTO (Table 1). Participation in sports was examined using the Tegner activity scale at pre-symptoms, preoperatively, and 2 years after OWHTO was also evaluated (Table 1). When the patient fully returned to their desired sport, the duration between OWHTO and returning to their pre-symptom sporting performance level was recorded (Table 1).

Table 1
Details of the cases.

Case	Side	Age (years)	Gender	Sports	Plate for fixation	Bone-substitute	Complication	KL grade	Hip-knee-ankle angle (°) Preop	Hip-knee-ankle angle (°) Postop	Japanese Orthopaedic Association score Preop	Japanese Orthopaedic Association score 2-year	Knee flexion range (°) Preop	Knee flexion range (°) 2-year	Tegner activity level scale Pre-symptom	Tegner activity level scale Preop	Tegner activity level scale 2-year	RTS (months)
1	R	65	F	mountain climbing and cycling	TomoFix	−		2	−2	3	100	100	155	155	6	2	6	10
2	R	62	F	mountain climbing and skiing	TomoFix	−	LHF type III	1	−3	5	80	95	150	155	6	2	6	18
3	R	59	F	mountain climbing and cycling	TomoFix	−		1	−5	6	85	100	150	155	6	2	6	13
	L	59			TomoFix	−		1	−5	5	85	100	140	155	6	2	6	12
4	L	53	F	aerobics	TomoFix	−		2	−3	7	80	100	140	155	5	2	5	15
	R	55			TomoFix	+		2	−1	3	100	100	155	155	5	2	5	8
5	L	71	M	social dance	TomoFix	+		1	−1	5	90	85	145	150	5	3	5	17
6	R	53	F	marathon and aerobics	TomoFix	+		2	−7	4	90	100	150	155	6	3	5	NR
7	R	69	M	spirint	TomoFix	+		1	−5	4	80	100	155	155	5	3	5	20
8	R	71	F	mountain climbing	TriS	+		2	−2	3	85	95	140	140	6	3	6	13
	L				TriS	+		2	−9	1	85	95	140	140	6	3	6	11
9	L	62	M	hockey	TriS	+		1	−9	−2	95	100	140	155	9	6	9	19
Mean		61.7						1.5	−4.3	3.7	87.9	97.5	146.7	152.1	5.9	2.8	5.8	14.2
SD		6.7						0.5	2.8	2.4	7.2	4.5	6.5	5.8	1.1	1.1	1.1	3.9

KL; Kellgren-Lawrence[19], Preop; preoperative, Postop; postoperative (Postoperative full-length anteroposterior view of the leg was taken at one month after the osteotomy.), RTS; return to sporting activity, NR; not returned to the pre-symptom level, LHF; lateral hinge fracture (The type is classified according to Takeuchi et al.[21]), SD; standard deviation.

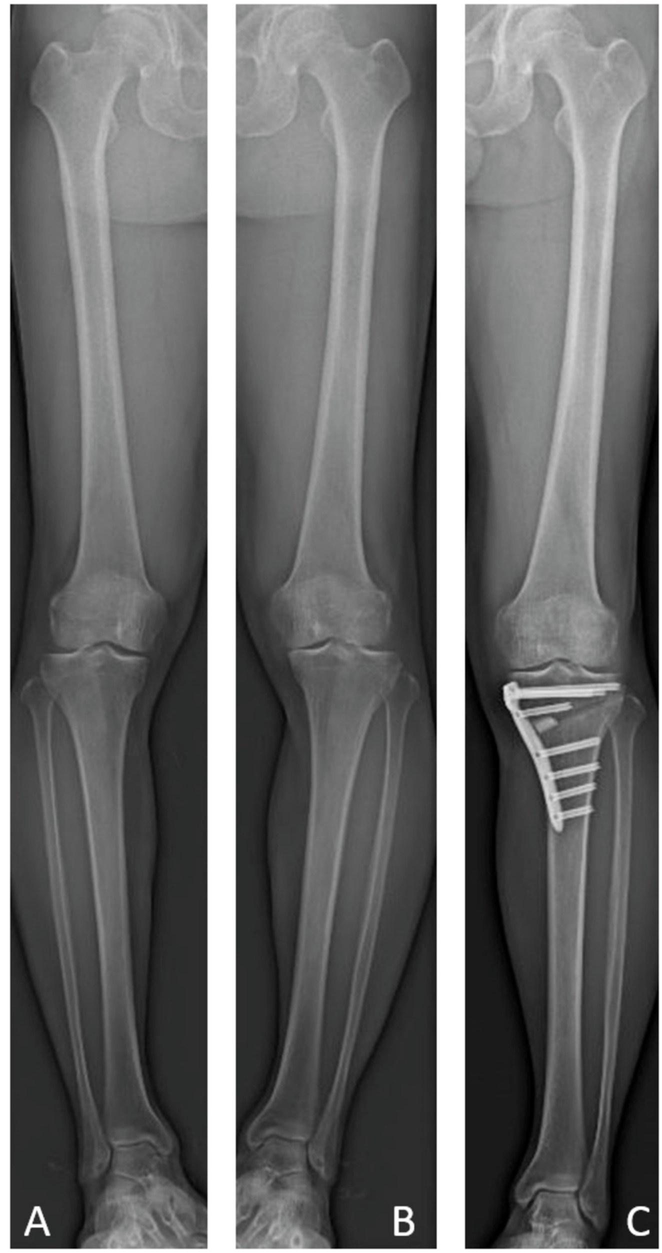

Fig. 2. Full-length anteroposterior view of Case 9, who belonged to an over-aged national hockey team. He returned to world cup competition 1.5 years after surgery.
A. Right leg (unaffected leg, HKA angle = −2°).B. Left leg (Preoperative HKA angle = −9°).C. Left leg (1 year after surgery, HKA angle = −2°). HKA angle; hip-knee-ankle angle, Varus angles are expressed as negative.

Statistical analysis

A paired *t*-test and Wilcoxon's signed-rank test were used to compare pre-/post-operative, preoperative/2-year, or pre-symptom/preoperative/2-year values of each radiological and clinical result. Statcel (OMS Publishing, Tokyo, Japan) software was used for statistical analysis. A p-value < 0.05 was considered to indicate statistical significance.

Results

Among 815 knees treated with various types of HTO between 2009 and 2017, nine cases (12 knees) met the inclusion criteria

(Table 1). Three men and six women were included in the study sample, with an average age of 61.7 ± 6.7 years (range: 53–71 years) (Table 1). The gap was not filled in five out of 12 knees, and was filled with a bone substitute in the remaining seven OWHTO cases (Table 1). Nine TomoFix small plates and three TriS plates were used for the OWHTO fixation. Regarding complications, we observed a Takeuchi type III lateral hinge fracture[14] in the Case 2 (Table 1).

All osteotomies were performed for early OA of KL grade 1 or 2 (Table 1). The HKA angle was significantly corrected from −4.3 ± 2.8° to 3.7 ± 2.4° ($p < 0.001$) (Table 1). Clinically, the average JOA score was significantly improved from 87.9 ± 7.2 to 97.5 ± 4.5 at 2 years after surgery ($p = 0.008$) (Table 1). In addition, knee flexion range was significantly improved from 146.7 ± 6.5° to 152.1 ± 5.8° ($p = 0.018$) (Table 1).

The types of sporting activity, with some overlap, were as follows: mountain climbing (four cases), cycling (two cases), aerobics (two cases), marathon (one case), skiing (one case), social dance (one case), sprint (one case), and hockey (one case) (Table 1). The average preoperative Tegner activity level scale score (2.8 ± 1.1) was significantly lower than the pre-symptom score (5.9 ± 1.1) ($p < 0.001$) because of pain due to KOA (Table 1). All patients had recovered to the better performance than the preoperative one, and the Tegner score at 2-year follow-up was significantly improved from 2.8 ± 1.1 to 5.8 ± 1.1 ($p < 0.001$), which was similar to the pre-symptom level ($p = 0.317$) (Table 1). Eight of nine cases except a marathon runner returned to their pre-symptom sporting performance level, and the duration between OWHTO and return to pre-symptom sporting performance level was 14.2 ± 3.9 months (Table 1).

Discussion

Despite many reports of the high rate of RTS after HTO in young active patients[6,7,15-17], RTS in middle aged and elderly patients remains controversial. However, Salzmann et al. reported that an older patient group (over 51 years old) exhibited postoperative increases in Tegner scores[18], in accord with the current results. In the current study, eight of nine cases (11 out of 12 knees) returned to their desired sport at the pre-symptom performance level, suggesting that OWHTO for middle aged and elderly patients may provide satisfactory RTS for the majority of cases.

Furthermore, HTO is generally indicated for patients experiencing some inconvenience or pain during typical ADL. When patients desire RTS, HTO would be widely accepted because return to painless ADL after HTO would be beneficial even if RTS could not be achieved. In contrast, most surgeons who perform knee osteotomies would hesitate regarding the HTO indication for RTS when patients report little or no inconvenience or pain during typical ADL. For such patients, HTO without RTS would be assumed to provide no benefit after surgical intervention. Accordingly, in spite of the many reports of the high rate of RTS after HTO[6,7,15-17], the indication for HTO solely for sporting activities also remains controversial. The current results suggest that KOA patients without ADL inconvenience who desire RTS are suitable candidates for OWHTO.

Regarding the types of sporting activities, Faschingbauer et al. reported that patient participation in high impact activities such as ball games, jogging or tennis was significantly decreased, and participation in low impact activities like swimming, cycling and hiking exhibited a lower rate of decrease[17]. A systematic review conducted by Hoorntje et al. also reported that an overall trend was observed towards participation in lower impact activities after surgery.[7] In the current study, all patients who participated in low impact sporting activities accomplished full recovery to pre-symptom levels, in accord with previous reports. In addition, among high impact sporting activities, instantaneous activities that repeat stop-and-go exercises such as sprint or hockey exhibited the same tendency of satisfactory recovery as low impact sports. In contrast, returning to marathon running, a typical endurance exercise, at pre-symptom levels appeared to be harder compared with other kinds of sports in this series. Weakened muscle endurance in the latter half of marathon competition may induce knee kinematic changes despite the improved knee alignment by HTO[19].

The current study involved several limitations that should be considered. First, this was a retrospective investigation with a small number of cases. Furthermore, the types of sporting activities were too varied for comprehensive analysis.

Conclusion

OWHTO for middle aged and elderly patients could provide satisfactory RTS for the majority of cases.

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Declaration of competing interest

Dr. Ryuichi Nakamura has a consultancy with Olympus Terumo Biomaterials. All other authors have no conflicts of interest relevant to this article.

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