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Original article

Impact of patellofemoral osteoarthritis on long-term outcome of high tibial osteotomy and effects of ventralization of tibial tubercle

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Abstract

Background. Medial compartment osteoarthritis (OA) of the knee frequently accompanies patellofemoral osteoarthritis (PF-OA). No consensus has been reached whether it is better to include treatment for the PF joint at the time of high tibial osteotomy (HTO), or if treatment of the PF joint is unnecessary. The purpose of this comparative retrospective study on medial compartment OA of the knee accompanying PF-OA was to examine the effects of PF-OA on the long-term outcome of HTO and to evaluate the significance of ventralization of the tibial tubercle when combined with HTO.

Methods. We studied the impact of PF-OA on the long-term outcome of HTO and the effects of ventralization of the tibial tubercle, which was performed in conjunction with HTO for medial and PF compartment OA more than 10 years previously. The 42 subjects included 14 men (15 knees) and 26 women (27 knees). Their mean age at the time of surgery was 60.7 years, and the follow-up period was 10–15 years (average 12 years). Ventralization of the tibial tubercle was performed on 18 knees.

Results. A significant relation was observed between improvement of the clinical knee score and preoperative radiological PF-OA stage in the HTO patients ($P < 0.05$). Radiologically, no correlation was observed between the shift in radiological PF-OA stage and the presence or absence of ventralization of the tibial tubercle. Among the preoperative radiological moderate and severe PF-OA cases, no significant relation was found between the presence or absence of ventralization of the tibial tubercle performed with HTO and improvement of the knee joint function score.

Conclusion. In cases of severe PF-OA in which HTO was performed, ventralization of the tibial tubercle as combined surgery did not prove effective at the long-term follow-up.

Introduction

Medial compartment osteoarthritis (OA) of the knee frequently accompanies patellofemoral osteoarthritis (PF-OA). There have been discussions regarding the effects of a high tibial osteotomy (HTO) on medial compartment OA of the knee accompanying PF-OA. Bauer[1] and Coventry[2] reported that HTO resulted in an improvement in the knee extension mechanism and the elimination of patient complaints concerning the PF joint. Nguyen et al.[3] found that the outcome of HTO with additional ventralization of the tibial tubercle did not differ from the outcome of HTO alone. On the other hand, Rudan and and Simurda[4] reported little alleviation of symptoms in severe PF-OA cases during an average follow-up of 5.8 years after HTO. Kettelkamp et al.[5] reported that HTO must be performed along with ventralization of the tibial tubercle. We have also included ventralization of the tibial tubercle in HTO surgery for medial and PF-OA and have previously reported good medium-term outcomes.[6]

Opinions are divided as to whether it is better to include treatment for the PF joint at the time of HTO,[4–6] or if treatment of the PF joint is unnecessary,[1,2] but no consensus has been reached. There have also been few reports regarding this problem based on follow-up findings exceeding 10 years. It is therefore believed that the present long-term follow-up study may contribute significantly to answering to this question.

The purpose of this comparative retrospective study on medial compartment OA of the knee accompanying PF-OA was (1) to examine the effects of PF-OA on the long-term outcome of HTO performed for medial and PF compartment OA, and (2) to prove the significance of ventralization of the tibial tubercle combined with HTO.

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Materials and methods

The present study was conducted under the rules and regulations of the institutional review board of Hokkaido University Hospital. HTO for medial and PF compartment OA was performed on 127 knees from 119 patients more than 10 years prior to this study. From our previous studies, it was suggested that the use of HTO be limited to knees with radiological OA classification (Table 1)[6] stage IV in tibiofemoral (TF) joints at the time of surgery.[7,8] Therefore, in this study, OA stage IV cases (27 knees) were excluded so we could rigorously examine the effects of PF-OA. The patients with a lateral femoral tibial angle (FTA) of >170° on one leg standing X-ray films at the time of bone union (15 knees) were also excluded because it was proved in our previous study that the weight-bearing FTA in patients with good long-term outcomes of HTO was 164° ± 5°.[6–8] As a result, the main purpose of this study was to observe more accurately the effects of PF-OA on the long-term outcomes of HTO by excluding cases where the application of HTO or the surgery itself could cause deterioration in the outcomes of HTO at an early stage. Therefore, we investigated patients who had TF-OA stage II or III at the time of surgery and whose weight-bearing FTA at the time of bone union was <170°.

After excluding cases of death (16 knees), patients who had undergone total knee arthroplasty (9 knees), those lost to follow-up (18 knees), and patients who were sedentary because of severe general conditions (5 knees), a total of 42 knees in 40 knee OA patients were categorized as PF-OA with radiological classification stage I–III in the PF joint: 15 knees from 14 men and 27 knees from 26 women. The age of the subjects at the time of surgery was 42–72 years (mean 60.7 years), and the follow-up period was 10–15 years (average 12 years). In the investigated cases, the preoperative weight-bearing FTA was 185.6° ± 3.9°.

The HTOs were performed according to Coventry's method,[9] and external skeletal fixation was used to fix the osteotomy. For the patient having PF-OA with pain elicited by direct compression of the patella onto the trochlea, ventralization of the tibial tubercle according to Maquet[10] was performed combined with HTO. As for bone grafts for ventralization of the tibial tubercle, wedge-shaped bone pieces extracted during the HTO were used, and the forward transfer distance was 1 cm.[6] Among these cases, the mild PF-OA group (preoperatively radiological PF-OA classification stage I) included 16 knees, 12 of which did not undergo ventralization of the tibial tubercle and 4 of which underwent ventralization of the tibial tubercle. The moderate and severe PF-OA group (same classification stages II and III) included 26 knees, 12 of which did not undergo ventralization of the tibial tubercle and 14 of which underwent ventralization of the tibial tubercle (Fig. 1).

We conducted a clinical examination of the knee joint function and allocated assessment scores (full marks 100 points)[6–8] for each case both preoperatively and at the final assessment. Radiologically, using a Skyline view of the knees in the supine position bending at 45° at the time of postoperative bone union and at the time of final observation, the PF-OA stage, the changes in the width of the joint space, and the degree of change in the bony spur were examined.

The PF-OA stage was assessed according to the OA classification criteria preoperatively and at the final assessment. To evaluate the width of the joint space and assess the bony spur objectively, we used a previously reported method.[7] The width of the joint space and the size of the bony spur were measured using the same scale. As for the width of the joint space, each width of the medial and lateral patellofemoral joint spaces was measured, and the percentage of the joint space in comparison to that at the time of postoperative bone union was calculated. The size of the bony spur in the medial and lateral patella was measured with a digital planimeter. The value obtained from the digital planimeter was divided by the transverse diameter of the original patella without a bony spur to the second power and then was multiplied by 10^3 to obtain an absolute number, which was then used as the osteophyte index.

Table 1. Radiological staging of the tibiofemoral and patellofemoral joints

Stage	Tibiofemoral joint	Patellofemoral joint
I	Bony spur only	Bony spur only
II	Narrowing of joint space (less than one-half of normal joint space)	Narrowing of joint space (less than one-half of normal joint space)
III	Narrowing of the joint space (more than one-half of normal joint space)	Narrowing of the joint space (more than one-half of normal joint space)
IV	Obliteration of joint space or minor bone attrition (<1 cm)	N/A
V	Major bone attrition (>1 cm) or subluxation, or secondary lateral arthrosis	N/A

The following points were examined to achieve the goals of this study (Fig. 1). First (study I), we examined the impact of the severity of PF-OA on knee joint function after a single HTO to observe the effect of PF-OA on the long-term outcome of HTO for medial and PF-OA. The 24 knees in the patients with single HTO without ventralization of the tibial tubercle were divided into two groups according to preoperative radiological PF-OA stage (Table 1): stage I, mild PF-OA group; stages II and III, moderate and severe PF-OA groups, respectively. The degree of improvement in the clinical assessment score was also classified into three groups: a good improvement group with scores of >30; a moderate improvement group with scores of 11–29; and a poor improvement group with scores of <10. The relation between the PF-OA stage and the improvement of the clinical assessment score was examined using the chi-squared test.

Second (study II), to examine radiologically the effects of ventralization of the tibial tubercle performed as combined surgery with HTO, we examined whether differences occurred in the shifts at the PF-OA stage and in the changes in the width of the medial and lateral joint space and the bony spur due to the presence or absence of ventralization of the tibial tubercle. The chi-squared test was used to determine the shift at the OA stage, and the paired *t*-test was used to determine any changes in the bony spur and the joint space.

Third (study III), the effects of performing ventralization of the tibial tubercle as combined surgery with HTO on the knee joint function more than 10 years after surgery were examined in radiologically moderate and severe PF-OA cases, specifically, the 26 knees in preoperative PF-OA stages II and III. These 26 knees were divided into the HTO group consisting of 12 knees and the ventralization of the tibial tubercle with HTO (Vent.–HTO) group comprising 14 knees. The correlation between combined surgery and the improvement scores for knee joint function was examined using the chi-squared test.

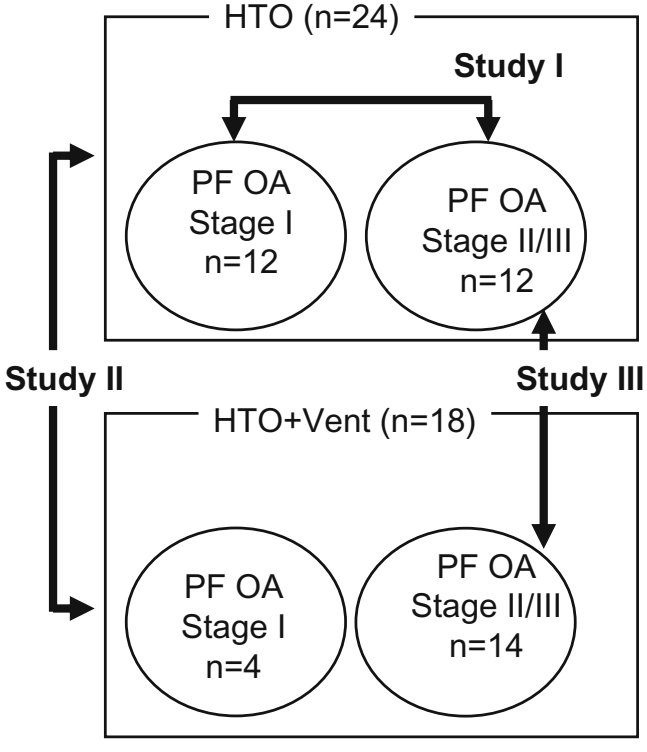

Fig. 1. Details of patients enrolled in the present study. *PF OA*, patellofemoral osteoarthritis; *HTO*, high tibial osteotomy; *Vent*, ventralization of the tibial tubercle

Results

The average of the preoperative knee function score in PF-OA stage I patients was 60.2 ± 8.5 points. In PF-OA stage II and III patients, the average of the preoperative clinical score was 59.1 ± 7.5 points. There was no significant difference in preoperative knee function score between PF-OA stage I patients and PF-OA stage II and III patients.

Study I. Effects of PF-OA on long-term outcomes of HTO for medial and patellofemoral compartment OA

At the final follow up, the average knee function score in PF-OA stage I patients and PF-OA stage II and III patients improved to 81.4 ± 10.1 points and 80.7 ± 8.4 points, respectively. Although there was marked improvement in four knees in the patients with scores of >30 in preoperative PF-OA stage I, none of those with moderate or severe cases of PF-OA stage II and III showed such improvement in long-term outcome. A significant relation was observed between the preoperative severity of PF-OA and an improvement in the knee joint function score ($\chi^2 = 7.50$, $P = 0.024$) (Table 2).

Table 2. Improvement of knee score and preoperative PF-OA stage in the high tibial osteotomy group

	No. of patients, by the PF-OA stage	
Improvement of knee score	I	II and III
Excellent (>30)	4	0
Good (10–29)	3	9
Fair (<10)	5	3

PF-OA, patellofemoral osteoarthritis
$\chi^2 = 7.50$, $P < 0.05$

Study II. Radiological effects of ventralization of the tibial tubercle performed as combined surgery with HTO

Radiologically, no correlation was observed between the shift in PF-OA stage and the presence or absence of ventralization of the tibial tubercle ($\chi^2 = 4.33$, $P = 0.11$) (Table 3). As for the width of the PF joint space, the medial compartment was 87.7% ± 79.4% and the lateral compartment was 90.6% ± 49.3% in the group with ventralization of the tibial tubercle, and the medial compartment was 126.6% ± 66.6% and the lateral compartment 103.2% ± 44.9% in the group without ventralization of the tibial tubercle. Thus, there was no significant difference in the two groups.

As for the osteophyte index, the value changed from 4.0 ± 4.5 preoperatively to 9.4 ± 10.3 postoperatively for the medial compartment and from 6.1 ± 9.0 to 7.7 ± 9.5 for the lateral compartment in the group with ventralization of the tibial tubercle. Similarly, it changed from 5.0 ± 15.3 to 8.6 ± 15.2 for the medial compartment and from 1.5 ± 2.5 to 4.2 ± 3.2 for the lateral compartment in the group without ventralization of the tibial tubercle. Thus, the bony spur increased significantly only in the lateral PF joint in the group without ventralization of the tibial tubercle ($P < 0.01$).

Study III. Significance of ventralization of the tibial tubercle performed as combined surgery with HTO

Table 4 shows the results of the study on the effect of performing ventralization of the tibial tubercle as a combined surgery with HTO on knee joint function after a prolonged course of more than 10 years. Among the preoperative PF-OA stage II and III cases, no significant relation was found between the presence or absence of ventralization of the tibial tubercle performed with HTO and improvement of knee joint function ($\chi^2 = 1.41$) (Figs. 2, 3).

Table 3. Change of radiological PF-OA stage in the HTO group and the HTO + ventralization group

Radiological change of PF-OA	Surgery	
	HTO	HTO + ventralization
Improved	0	3
No change	15	9
Progressed	9	6

HTO, high tibial osteotomy
$\chi^2 = 4.33$, $P = 0.11$

Table 4. Improvement of knee score in the HTO group and the HTO with ventralization group in patients with PF-OA stage II and III

Improvement of knee score	Surgery	
	HTO	HTO + ventralization
Excellent (>30)	0	1
Good (10–29)	9	8
Fair (<10)	3	5

$\chi^2 = 1.41$, $P = 0.49$

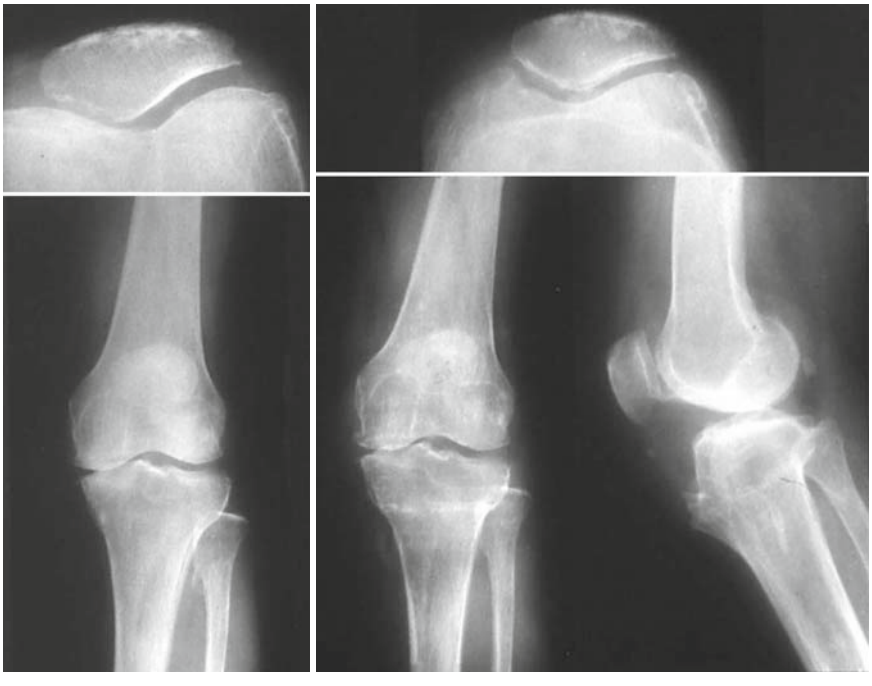

Fig. 2. Case demonstrating excellent improvement in the knee score for a patient who underwent HTO combined with ventralization of the tibial tubercle. Preoperative roentgenogram shows narrowing of the medial patellofemoral joint space. Ten years after surgery, the joint congruity was observed to have improved

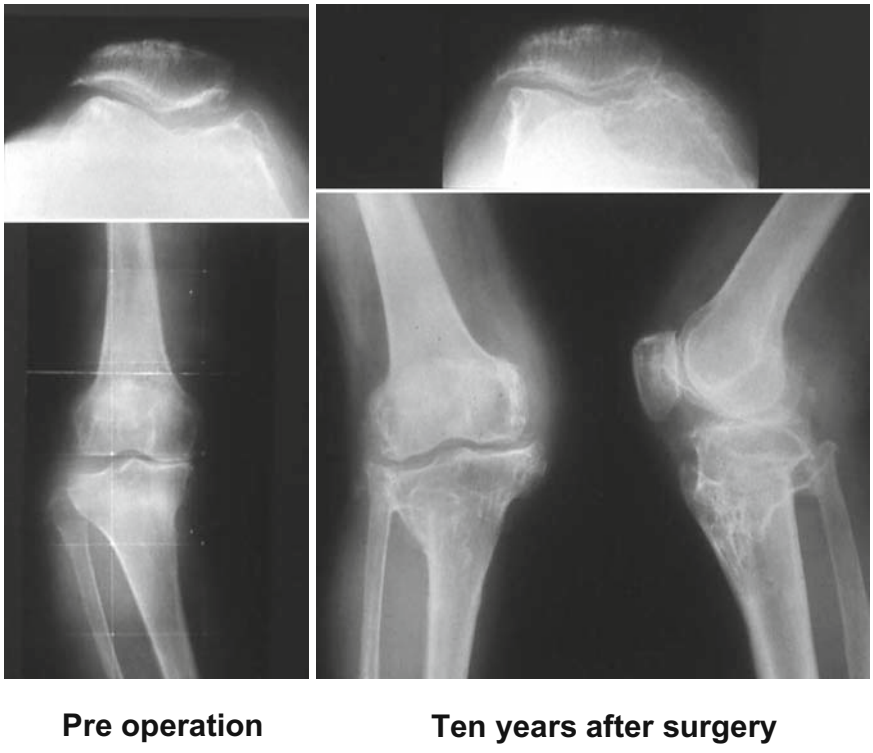

Fig. 3. Case showing poor improvement in the knee score for a patient who underwent HTO combined with ventralization for the treatment of tibial tubercle. Ten years after surgery, PF-OA was found to have progressed

Discussion

This study revealed that in medial compartment OA of the knee the severity of PF-OA is one of the significant factors in determining the long-term outcome of the knee following HTO. Furthermore, no difference between the presence and absence of the ventralization of the tibial tubercle was recognized in moderate and severe radiological PF-OA cases as a long-term effect. Ventralization of the tibial tubercle is an effective surgical technique, and favorable outcomes have been reported in terms of its effect on OA only in the PF joint.[10] In our experience, the 5- to 6-year outcome of ventralization of the tibial tubercle for medial compartment OA of the knee accompanying PF-OA was favorable.[6] However, the results of the present long-term follow-up study show that no correlation exists between the presence or absence of ventralization of the tibial tubercle combined with HTO and any improvement in knee joint function in cases of medial compartment OA of the knee accompanying moderate and severe radiological OA in the PF joint. Ventralization of the tibial tubercle combined with HTO was not effective according to the long-term results (i.e., 10 years or more after treatment). This may be because the pattern of contact in the PF joint changes as a result of HTO,[11] and even HTO alone would thus produce a favorable effect on the PF joint. Among the patients who underwent HTO with ventralization of the tibial tubercle, some had good outcomes for 5–6 years;[6] however, the reduced effect in the longer term could be attributed to degeneration due to aging.

Hofman et al.[12] indicated that other treatment methods should be chosen because the combination of HTO and ventralization of the tibial tubercle for two-compartmental OA has greater operative stress while showing less improvement in the outcomes. Insall[13] also indicated that the combination of HTO and ventralization of the tibial tubercle often produces complications so it can be applied in limited cases. HTO or HTO plus ventralization of the tibial tubercle for medial compartment OA of the knee accompanying PF-OA is therefore not recommended. However, there are problems in these reports, such as a small number of cases; it is also not clear that complications occurred because of HTO itself or the addition of ventralization of the tibial tubercle because there were no cases used for comparison purposes.

The subjects in this study were limited to those in TF-OA stages II and III and those who were considered the most appropriate candidates for HTO. In this group of patients, the variability in the preoperative weight bearing FTA value was relatively small. As for knee joint function, the preoperative assessment scores showed no significant difference between the patients with ventralization and the patients without ventralization. Therefore, this study was believed to be significant, as only those cases deemed appropriate for comparison

were included and the effect of PF-OA on HTO for medial and patellofemoral compartment OA was studied based on long-term outcomes of more than 10 years.

In the cases investigated in this study, the forward transfer distance of tibial tuberosity was targeted at 10 mm. It can be assumed that more forward transfer distance is needed to obtain the effect of ventralization of the tibial tubercle. There was a report in which a 37-mm forward transfer of tibial tuberosity was described as optimal for decreasing the contact pressure of the PF joint in a knee from a cadaver.[14] However, because excessive forward transfer can decrease the strength of terminal extension of the knee, with pseudarthrosis and malunion in the osteotomic regions, as well as pain and tenderness in the tibial tuberosity, it is not practical. The conclusion of this study should thus be recognized as a practical effect of ventralization of the tibial tubercle.

Our study does not rule out the value of ventralization of the tibial tubercle. Even though such an improvement may last only 5–6 years, the combination of ventralization of the tibial tubercle with HTO shows improved outcomes of HTO for medial compartment OA of the knee accompanying PF-OA.[6] However, it should be kept in mind that it is difficult to maintain these good outcomes for more than 10 years.

Limitations of the present study are the following. First, the study was conducted in a retrospective manner. Surgical indications for adding ventralization of the tibial tubercle were not controlled in a randomized design. There is a possibility that surgical criteria for adding ventralization of the tibial tubercle has a selection bias. Second, we could not separately evaluate the symptoms of the TF joint and the PF joint. Practically, it is difficult to distinguish the clinical symptoms of TF joint from those of the PF joint, especially for the patient with a degenerative knee joint. Therefore, the present study could not evaluate the effect of ventralization strictly as a combined surgery of HTO.

We believe that HTO is basically an effective operative procedure for OA; and when age and activity are taken into consideration, this surgery may be considered for the treatment of medial compartment OA of the knee accompanying PF-OA. On the other hand, when treating medial compartment OA of the knee accompanying severe PF-OA, a treatment plan should be made with good knowledge of the limitations of ventralization of the tibial tubercle. Practically, some of these patients should be treated with total joint replacement.

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