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ORIGINAL STUDY

Bilateral early knee osteoarthritis treated with unilateral proximal tibial osteotomy and contralateral non-surgical technique

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Some non-surgical techniques that decrease the mechanical load of the knee may be effective in treating early primary knee osteoarthritis. Thirty-six consecutive patients with bilateral early primary knee osteoarthritis and genu varum were treated with unilateral proximal tibial osteotomy in the more degenerated knee. After the osteotomized bone healed, ambulation with protected weight bearing using a cane in the contralateral hand was advised continuously for at least three months or until knee pain subsided bilaterally. Thirty-one patients were followed for an average of 4.6 years (range, 2.1-7.8 years). All osteotomized bones healed. Twenty patients (64.5%) had satisfactory knee function bilaterally. Eight patients (25.8%) only had satisfactory knee function in the operated knee. Thus, 28 patients (90.3%) improved operated knee function ($p < 0.001$). Non-operated knees improved to satisfactory function from 38.7% initially to 71.0% at the latest follow-up ($p = 0.01$). Bilateral early primary knee osteoarthritis may be successfully treated with unilateral proximal tibial osteotomy.

Keywords : bilateral ; knee osteoarthritis ; proximal tibial osteotomy ; unilateral.

INTRODUCTION

Knee osteoarthritis (OA) is a common condition, and the main etiology is factors such as age, increased body weight, and heavy working *(4)*. Mechanical overloading is considered the most critical contributing factor to primary knee OA *(23)*. Avoidance of overloading is the most reasonable principle to prevent progression of knee degeneration. Practically, osteotomy around the knee to shift load to the other compartment is a common and effective method *(26)*.

For early knee OA, valgus proximal tibial osteotomy (PTO) to correct a varus knee is commonly performed (1), and the progression of knee degeneration may cease for a couple of years. The success rate using PTO to treat early knee OA is reported to be 90-95% after 5 years, and 60-70% after 10 years *(7,14)*. However, surgical complications (e.g., nonunion, infection or neurovascular injuries) may occur, making the surgery less cost-effective *(9,20)*. Thus, a better technique for improving outcomes is required.

Most of patients with knee OA have bilateral diseases, and one knee is normally affected to a greater extent. In general, patients experience knee pain alternately. If one knee is effectively treated and can undertake most of the loading,

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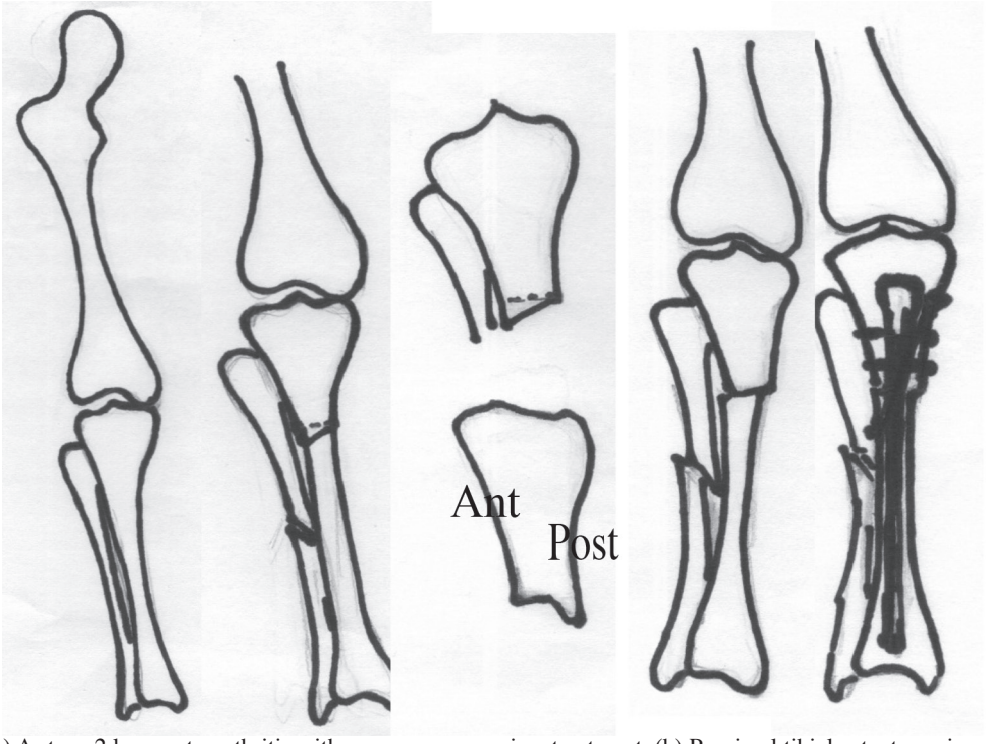

Fig. 1. — (a) A stage 2 knee osteoarthritis with genu varum requires treatment. (b) Proximal tibial osteotomy is performed. A line (line 1) vertical to the medial tibial cortex and an oblique line (line 2) are marked. The intersection angle of two lines is equal to the planned correction angle. (c) The tibia is osteotomized along the line 2 with a power saw (upper). The anterior cortex of the proximal fragment is removed along the line 1. A cam (arrow) is created in the posterior cortex (lower). (d) The distal fragment is rotated and the cam of the proximal fragment is sunk into the distal fragment. Let two lines close together. (e) A dynamic tibial locked nail is inserted and a derotational interfragmental screw is augmented.

the contralateral knee may improve after the load is lowered. Theoretically, lowering load may be implemented with protected weight bearing using a cane in the contralateral hand *(17)*. After some period of lowering knee load, the effect of non-surgical treatment may be similar to osteotomy. The purpose of this retrospective study was to determine the effect of using a cane to lower the load on a mildly degenerative knee after the contralateral varus knee was surgically corrected.

MATERIALS AND METHODS

From March 2003 to December 2011, 36 consecutive patients with bilateral primary knee OA were treated with the described regimen at the author's institution. All patients were treated and followed by the author. Patient age ranged from 48 to 64 years (average, 57 years), with a male to female ratio of 1:3. No patients had a history of knee trauma or infection. Knee pain was progressive for a couple of months, and alternately bilaterally. The pain was described as aching, was located around the medial aspect of the knee, and subsided at rest. All knees had various degrees of varus deformities (Fig.1a). All patients failed conservative treatment methods (oral analgesics, joint injection, modification of daily activity, and walking aids) at local clinics.

All patients were seen at the outpatient department (OPD) of our institution, and their general condition, symptoms of the knee, and pain location were confirmed. Knee function was evaluated by a modified Knee Society Score (10). Standing and standing full-length plain radiographs of the knee were taken. The more degenerative knee was chosen for surgical correction, and

the treatment plan was thoroughly explained. In principle, only stage 2 OA (Ahlbäck classification) knees with various degrees of varus deformity were chosen for surgical correction *(5)*. The associated varus deformity was from 2° to 12°(average, 7°) and the correction technique was PTO. There were no patients with valgus deformity. Over-correction to valgus deformity of 3°was considered the most suitable *(14,17)*. Inclusion criteria for this study were all patients with early primary knee OA, varus deformity, and treated with the described PTO technique. Exclusion criteria were patients with bilaterally operated knees or failed conservative treatment of the contralateral knee due to other causes (e.g., leg trauma). The non-operated knee was not strictly treated with a designed protocol.

Surgical technique

Under spinal anesthesia or general anesthesia with endotracheal intubation, the patient was placed on the operating table in the supine position. A pneumatic tourniquet was routinely used.

First, an oblique mid-third fibulotomy was performed (Fig.1b).

A medial para-patellar tendon approach was used. The tibial marrow cavity inlet was created, and the tibial diaphyseal cavity was reamed as widely as possible. Then, the length and size of a tibial locked nail (Zimmer, Warsaw, Ind) were decided. With the locked nail as a template, the osteotomy site in the proximal tibia was chosen, which was required to ensure insertion of two transverse locked screws. Then, the skin incision was extended to achieve adequate exposure of the proximal tibia.

In the planned osteotomy site of the tibia, a transverse line vertical to the medial tibial cortex was marked (line 1, Fig.1b). An oblique line from the medial tibial cortex downwards inferolaterally was also marked (line 2, Fig.1b). The planned correction angle was the intersection angle of the two lines. With a power saw, a tibial osteotomy was performed along line 2 (Fig.1c, upper). The anterior cortex of the lateral aspect of the proximal fragment was removed along line 1 with a power saw and a rongeur clamp, and the posterior cortex was preserved (Fig.1c, lower). Thus, a cam in the proximal fragment was created. Then, the distal tibial fragment was displaced laterally and posteriorly. The cam in the proximal tibial fragment was sunk into the marrow cavity of the distal fragment, and line 1 was closed to line 2 (Fig. 1d). Thus, correction of the tibial varus deformity was finished.

A large amount of cancellous bone graft was procured from the tibial inlet. With maintenance of the reduced fragments, a dynamic mode of a tibial locked nail was inserted. An interfragmental cortical screw (Synthes, Bettlach, Switzerland) was inserted to reinforce the rotational stability (Fig. 1e). Cancellous bone grafts were packed in the osteotomy site, and the wound was closed.

Postoperatively, patients were allowed to ambulate with partial weight bearing as early as possible. Knee range of motion exercise was performed. Patients were followed-up at the OPD at 4-6 week intervals. Wound and bony healing processes were recorded. After the osteotomized bone healed, patients were advised to use a cane in the operated side. The contralateral lower extremity required partial weight bearing for three months. Use of the cane was discontinued only after both knees had no aching pain. If aching pain recurred, use of the cane was again required. After patients were stable, they were followed yearly or as necessary.

Bony union was defined as lack of pain and tenderness, the ability to walk without aids, and radiographic evidence of solid callus bridging fragments in three of four cortices (18). Nonunion was defined as a fracture that was unhealed one year after treatment or requiring additional surgery to achieve union (22).

Knee function was evaluated with the modified Knee Society Score (10). The total score was 100 points (pain, 50 points, and walking function, 50 points). Scores were divided into four categories: excellent, $\geq$ 90 ; good, $\geq$ 80 ; fair, $\geq$ 70 ; poor, <70. An excellent or good score was considered a satisfactory result. The modified Knee Society Score is a simplified version of the classic Knee Society Score. The latter includes 200 points, and was too complex to be evaluated before surgical treatment. In addition, it includes evaluation of

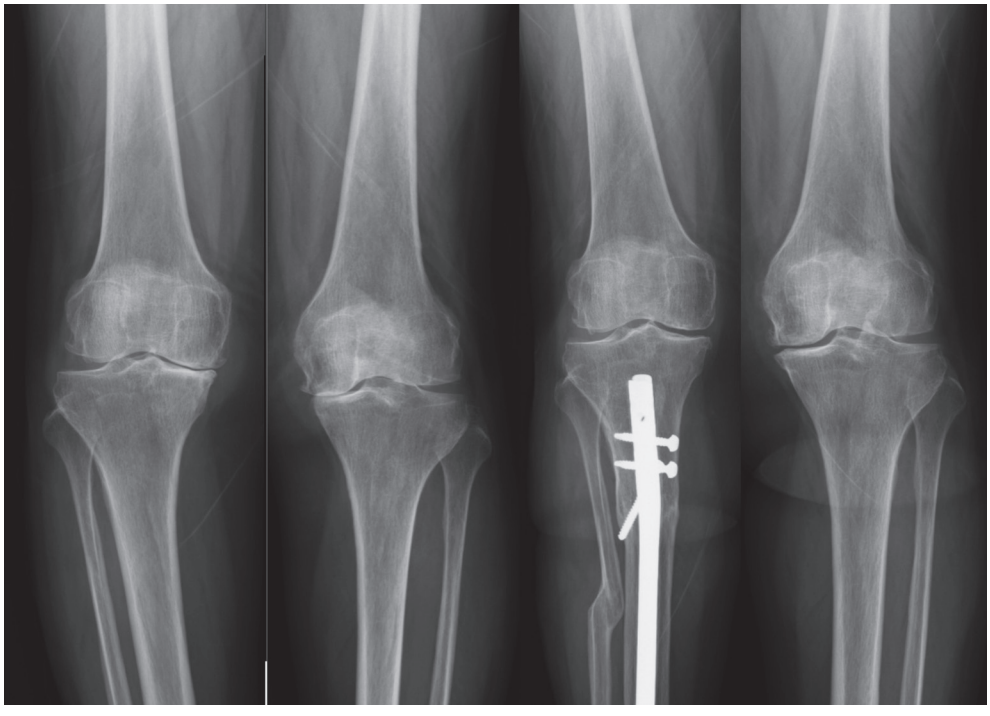

Fig. 2. — *Case 1*. A 61-year-old woman sustained bilateral stage 2 knee osteoarthritis. Right knee was associated with 10 degrees of varus deformity. Right knee was treated with proximal tibial osteotomy and left knee was non-surgically treated as schedule. Bilateral knees achieved satisfactory function and improved radiological stages at a 7.8-year follow-u

stairs climbing, which involves the patellofemoral joint.

Statistical comparisons were performed using Fisher's exact test, chi-square test, and paired Student's t-test. A value of $p < 0.05$ was considered statistically significant. The relationship between radiological and knee functional results was studied by Pearson product-moment correlation coefficient.

RESULTS

Thirty-one patients completed an average follow-up of 4.6 years (range, 2.1- 7.8 years). Five patients were lost to follow-up despite the maximal efforts to contact them. Thus, the follow-up rate was 86.1% (31/36, Tables 1,2).

All osteotomized bones healed with an average union time of 3.4 months (range, 2.5-4.0 months). There were no deep infections, nonunion or malunion (varus or valgus deformity > 5°).

Before surgical correction, of the 31 patients that completed follow-up, 27 operated knees were stage 2 and 4 knees were stage 3. After surgery, 13 knees were stage 0, 16 were stage 1, and 2 were stage 2 ($p < 0.001$, paired Student's t-test; Figs.2,3). Of the 31 non-operated knees, 12 knees were stage 1 and 19 knees were stage 2 prior to surgery. After surgical correction of the contralateral knees, 14 of the non-operated knees were stage 0, 15 were stage 1, and 2 were stage 2 ($p < 0.001$, paired Student's t-test; Figs.2,3).

Before surgical correction, the average varus deformity in the 31 operated knees was 7.3°(range, 5°-12°). After PTO, the average varus deformity was 0.9°(range, varus 4°- valgus 3°) in the 31 operated knees ($p < 0.001$, paired Student's t-test). In the 31 non-operated knees, the average varus deformity was 4.3° (range, 2°-8°) before surgery. After surgical correction of contralateral knees, the average varus deformity was 2.6° (neutral-varus 6°) in the non-operated knees ($p < 0.001$, paired Student's t-test).

Before surgical correction, function in all 31 operated knees was unsatisfactory (scores < 80

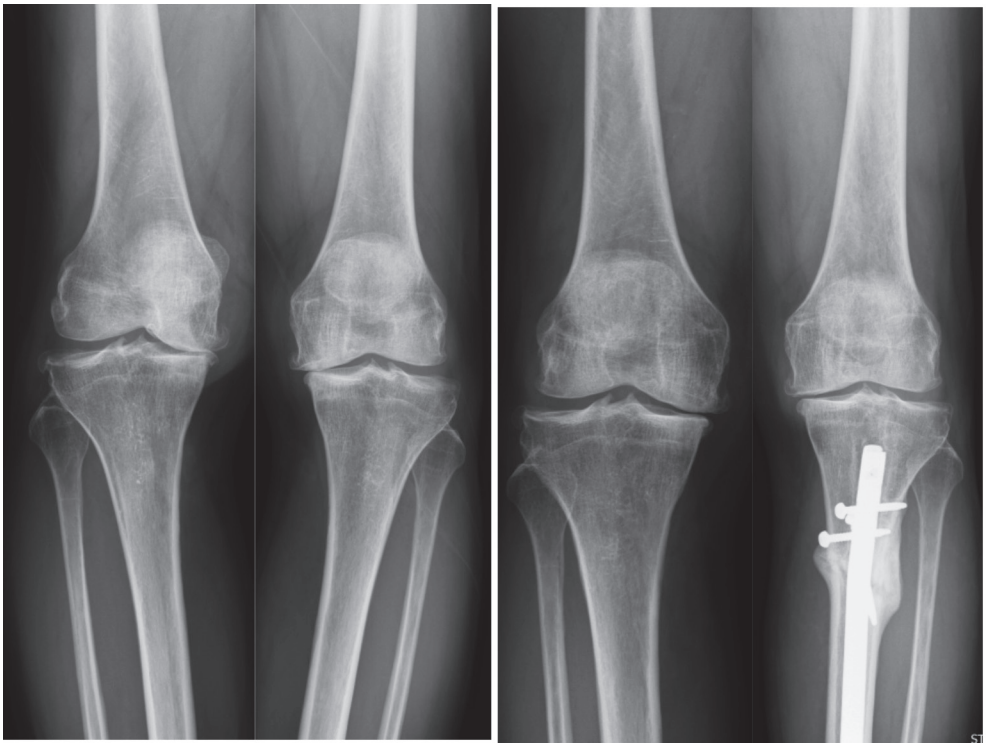

Fig. 3. *Case 2.* A 56-year-old woman sustained left stage 3 and right stage 2 knee osteoarthritis. Left knee was associated with 10 degrees of varus deformity. Left knee was treated with proximal tibial osteotomy and right knee was non-surgically treated as schedule. Bilateral knees achieved satisfactory function and improved radiological stages at a 7.6-year follow-up.

points). Of the non-operated knees, function in 19 was unsatisfactory and satisfactory in 12 knees (38.7%). After surgical correction, 28 operated knees had satisfactory function (90.3%, p< 0.001, Fisher's exact test). Of the 28 patients, 20 had satisfactory results in both knees and eight satisfactory results in only the operated knee. Twenty-two non-operated knees achieved satisfactory results (71.0%, p=0.01, chi-square test). No deterioration of knee function occurred in any knee. Although PTO was suggested for patients with an unsatisfactory outcome in the non-operated knee, no patients underwent surgery.

The correlation between varus correction and knee function improvement was moderate in operated knees (r = 0.536), and low in non-operated knees (r = 0.281). The correlation between improved stage and knee function was moderate in operated knees (r = 0.730), and moderate in non-operated knees (r = 0.449). The correlation between improved stage and varus correction was moderate in operated knees (r = 0.493), and moderate in non-operated knees (r = 0.458).

DISCUSSION

The concept of lowering load to improve primary OA in the involved joint has been promoted for a long time. The knee sustains loads of 3-5 times body weight in level walking *(6)*. Because of the flat contour in the knee, the medial compartment sustains 60-75% of the load through the knee *(8)*. Normally, long-term overloading can cause damage to the articular cartilage and bone in the medial compartment, leading to varus deformity. Severe degeneration of the knee requires treatment with total knee replacement *(16)*. However, early degeneration of the knee may be treated with load-shifting techniques, and PTO or distal femoral osteotomy is the most common surgical technique *(27)*. In the present study, the more degenerated knee was surgically corrected, and the contralateral knee with less degeneration was non-surgically treated by loading-modification. With a 4.2-year follow-up period, the rate of functional improvement of the operated knee was 90.3%, and that of the non-

Table I. — Bilateral early primary knee osteoarthritis treated with unilateral proximal tibial osteotomy and contralateral non-surgical technique (n= 36)

Case no.	Age/Gender (yr)	Initial knee OA						Union time in osteotomy (m)
		Stage		Function score		Varus deformity (deg)		
		Op	Non-op	Op	Non-op	Op	Non-op	
1	61/F	2	2	75	80	10	2	3.5
2	56/F	3	2	65	75	10	8	4.0
3	58/M	2	1	75	75	8	6	4.0
4	52/F	2	2	70	75	5	3	4.0
5	62/F	2	2	75	75	8	4	3.0
6	63/F	2	1	70	80	5	2	3.0
7	58/M	2	1	75	80	5	3	3.5
8	60/F	2	2	75	75	6	4	2.5
9	54/F	2	1	70	75	8	3	2.5
10	64/F	2	2	75	75	7	5	4.0
11	54/M	2	2	75	80	8	6	4.0
12	48/F	2	2	75	80	6	5	4.0
13	52/F	2	2	70	75	5	3	4.0
14	62/F	2	2	70	75	8	4	3.0
15	62/F	2	1	70	75	6	2	3.0
16	58/M	2	1	75	80	5	3	3.5
17	60/F	2	2	75	75	6	4	2.5
18	54/F	3	1	65	75	8	3	2.5
19	64/M	2	2	75	75	7	5	4.0
20	54/F	2	2	75	75	8	6	4.0
21	48/F	2	2	75	75	6	5	4.0
22	57/F	2	1	75	85	7	5	3.5
23	50/F	2	2	75	80	8	6	3.0
24	48/M	2	1	75	80	8	5	4.0
25	52/F	2	2	70	77	5	3	4.0
26	62/F	2	2	75	75	8	4	3.0
27	60/F	2	1	70	80	5	2	3.0
28	58/F	2	1	75	80	5	3	3.5
29	62/F	2	2	75	75	6	4	2.5
30	54/M	3	1	65	75	10	3	2.5
31	52/F	2	2	75	75	7	5	4.0
32	54/M	2	2	75	80	8	6	4.0
33	48/M	2	2	75	80	6	5	4.0
34	56/M	3	1	65	75	12	3	2.5
35	58/F	2	2	75	75	7	5	4.0
36	59/F	2	2	75	75	8	6	4.0

F = female ; M = male ; OA = osteoarthritis ; Op = operation ; Non-op = non-operation.

operated knee was 32.3%. These results confirm that lowering load can prevent joint degeneration.

Clinically, complete deprival of load in the knee joint to prevent degeneration is impractical. The nutrition supply for articular cartilage requires joint movement *(15)*. Without load transfer in the knee, osteoporosis will occur and the risk of fractures may increase *(11,12)*. In the present study, partial weight bearing using a cane and adjustment following change of pain were shown to be effective in the treatment of the non-operated knees. Because knee pain is bilateral and occurs alternately,

Table II. Bilateral early primary knee osteoarthritis treated with unilateral proximal tibial osteotomy and contralateral non-surgical technique (n= 36)

Case no.	Latest knee OA						Latest knee function grade		Follow-up (yr)
	Stage		Function score		Varus deformity (deg)				
	Op	Non-op	Op	Non-op	Op	Non-op	Op	Non-op	
1	0	0	85	85	-3	0	G	G	7.8
2	1	1	80	80	-2	2	G	G	7.6
3	0	1	80	75	0	4	G	Fa	7.2
4	0	2	80	75	2	4	G	Fa	6.9
5	1	2	80	75	0	4	G	Fa	6.8
6	0	1	85	85	0	0	G	G	6.5
7	1	1	80	80	2	2	G	G	6.2
8	--	--	--	--	--	--	--	--	---
9	0	1	85	80	-2	2	G	G	5.8
10	1	1	80	75	0	5	G	Fa	5.5
11	0	0	80	85	0	2	G	G	5.5
12	1	0	80	80	2	2	G	G	5.4
13	--	--	--	--	--	--	--	--	---
14	0	0	85	80	-2	2	G	G	5.1
15	1	1	80	75	0	2	G	Fa	4.9
16	--	--	--	--	--	--	--	--	---
17	1	0	80	80	2	2	G	G	4.8
18	0	0	80	80	1	1	G	G	4.4
19	0	0	80	80	2	2	G	G	4.2
20	1	1	80	75	0	6	G	Fa	4.2
21	1	1	80	75	0	5	G	Fa	4.0
22	0	0	85	85	0	2	G	G	4.0
23	1	1	80	80	2	4	G	G	3.9
24	2	1	75	80	4	5	Fa	G	3.8
25	--	--	--	--	--	--	--	--	---
26	1	1	75	75	4	4	Fa	Fa	3.5
27	0	0	80	85	0	0	G	G	3.4
28	1	0	80	85	2	0	G	G	3.1
29	2	0	75	80	4	2	Fa	G	3.0
30	1	0	80	80	2	0	G	G	3.0
31	--	--	--	--	--	--	--	--	---
32	0	1	80	80	0	5	G	G	2.7
33	1	1	80	80	2	4	G	G	2.5
34	1	0	80	80	4	0	G	G	2.4
35	0	0	80	80	2	3	G	G	2.2
36	1	1	80	75	0	6	G	Fa	2.1

Fa = fair ; G = good.

surgical correction of the more degenerated knee in order to undertake loading in daily activity is reasonable. Surgical correction of both knees may be unnecessary, thus reducing the overall risk of surgical complications.

Factors favoring fracture healing are minimal gap, adequate stability, and sufficient nutrition supply *(13)*. In the present study, PTO was performed and a cam was created. When the cam in the proximal fragment is sunk into the marrow cavity of the distal fragment, stability to prevent fragment sliding is greatly increased. After a dynamic locked nail was inserted, a derotational interfragmental screw was used for augmentation. This maintains local

stability, and a 100% union rate with a 3.2-month union time was achieved. Cancellous bone grafts procured from the tibial condyle (metaphysis) can eliminate the gap when fragments are reduced.

Inserting an intramedullary nail in proximal tibial fractures is believed to easily introduce valgus deformity *(6,28)*. Therefore, it is suggested that the tibial inlet is located laterally. Because varus deformity was corrected in this series, the tibial inlet was located medially to the patellar tendon. After tibial alignment was maintained, a locked nail was inserted, and all operated knees achieved the planned alignment.

PTO may be performed with dome or wedge osteotomy *(1)*. The wedge osteotomy may be closed or open *(3,5)*. Methods of fixation include cast, plates or external fixators *(1)*. However, the use of a locked nail has been rarely reported, and the surgical technique is not well-defined. In the present study, a nailing technique was used and a 100% union rate with satisfactory alignment was achieved.

For a varus knee requiring surgical correction, over-correction to slight valgus is reasonable *(14,17)*. If correction to valgus is not achieved, 60-75% of knee load still passes through the medial compartment *(8)*, and operative results may be unsatisfactory. However, the present study did not especially focus on the outcome in operated knees. Theoretically, all surgical techniques which can correct varus deformity are useful. The present study emphasizes the effect of non-surgical treatment of knee OA.

During follow-up of both operated and non-operated knees, radiological and knee functional improvements were moderately correlated ($0.4 < r < 0.8$). Therefore, plain radiographs of the knee may not accurately reflect the success of treatment. Other studies, however, have reported a high correlation of radiological and knee function results *(2,19,21)*.

There are some limitations to the current study. Patients were instructed on cane use; however, the degree of compliance cannot be accurately determined. During non-surgical follow-up, the non-operated knee may be treated with joint injection (hyaluronic acid or platelet-rich plasma) which could influence the results. *(24,25)*.

In conclusion, bilateral early primary knee OA may be successfully treated with unilateral proximal tibial osteotomy. After loading is decreased in the more degenerated knee, both knees may achieve significant improvement in function during a midterm follow-up.

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