Observational Study

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Proximal fibular osteotomy relieves pain in spontaneous osteonecrosis of the knee

A retrospective study

Yu-Sheng Chen, MD[a], Min-De Ang, MD[b], Chyun-Yu Yang, MD[a,c,d], Chih-Wei Chang, MD, PhD[a,c,d,*]

Abstract

Spontaneous osteonecrosis of the knee (SONK) causes knee pain and joint motion limitation. Ischemia or insufficiency fracture may be the cause, but no consensus has been developed. Proximal fibular osteotomy (PFO) has been reported to relieve pain from osteoarthritis through medial compartment decompression. We reviewed the effect of this procedure on medial compartment SONK patients and explored clinical and radiological results.

Since January 2018 to January 2020, the data of 12 knees (8 right and 4 left) from 11 SONK patients (9 women and 2 men) who received PFO were analyzed. The average age was 61.5 years. The diagnosis of SONK was established through weight-bearing anterior–posterior radiographs or magnetic resonance imaging (MRI). Visual analog scale (VAS) scores, Oxford knee score (OKS), Femorotibial angle (FTA), medial joint space, and lateral joint space were documented preoperatively and at follow up visits. Outcome assessment for the clinical and radiographic data was reviewed at 12- and 24-month follow-up visits.

The mean follow up period was 33 months. All patients were able to walk with or without cane assistance the day after surgery. Both VAS score and OKS (preoperative: 6.6 ± 0.9 and 24.7 ± 3.8, respectively) improved significantly at the 12-month follow-up, and to 24-month follow-up (3.6 ± 1.3 and 35.6 ± 4.5, respectively, $P < .05$). Medial joint space ratio increased from 0.36 to 0.50 ($P < .05$). Changes of FTA were insignificant at any point of follow up. Four patients underwent follow-up MRI, and a decrease in the osteonecrotic area was clearly observed in 2 patients.

By achieving medial knee decompression, PFO allowed quick weight-bearing recovery, pain relief, and improvement in knee function in SONK patients.

Abbreviations: BMI = body mass index, FTA = femoral tibial angle, HTO = high tibial osteotomy, KSS = knee society score, MRI = magnetic resonance imaging, OA = osteoarthritis, OKS = Oxford knee score, PFO = proximal fibular osteotomy, ROM = range of motion, SIFK = subchondral insufficiency fractures of the knee, SONK = spontaneous osteonecrosis of the knee, TKA = total knee arthroplasty, UKA = unicompartmental knee arthroplasty, VAS = visual analog scale.

Keywords: knee osteoarthritis, osteonecrosis, proximal fibular osteotomy, SONK, spontaneous osteonecrosis of the knee

1. Introduction

Spontaneous osteonecrosis of the knee (SONK) is mostly seen in the middle-aged and older population, occurring in up to 9.4% of the population aged ≥65 years, and causes knee pain and joint motion limitation.[1] Secondary osteoarthritis due to subchondral collapse worsens joint degeneration, ultimately leading to gait instability.

The cause of SONK remains poorly understood and theories of ischemia or insufficiency fracture have been developed.[1–7] Various treatments have been developed but there has not been a gold standard due to the poorly understood pathophysiology.

Proximal fibular osteotomy (PFO) has recently been reported to significantly reduce pain, improve function, and improve radiographic alignment in knee osteoarthritis.[8] Some biomechanical studies have confirmed that disruption of the lateral fibular soft tissue construct in PFO allows the weight-bearing force to be redirected to the lateral compartment, resulting in medial compartment decompression.[9–11]

We propose that medial decompression from PFO can have an effect similar to HTO in relieving pain and halting disease progression in SONK; in other words, PFO may be an alternative joint-preserving surgery for SONK. This study evaluated the clinical and radiographic outcomes of patients with SONK treated with PFO.

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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2. Materials and Methods

2.1. Study registry

This research follows the protocol Strengthening the Reporting of Observational Studies in Epidemiology (STROBE).

2.2. Study design

This retrospective cohort study was conducted in a tertiary medical center in Taiwan. Informed consent was obtained from all patients. The study was approved by the institutional review board of our hospital (IRB#: B-ER-XXX-332). The objective of this study was to investigate the effect of medial knee decompression from PFO. Outcome assessment was reviewed at baseline, 12- and 24-month postoperative follow-up.

2.3. Patients

Since January 2018 to January 2020, a total of 47 PFO surgeries were performed on SONK patients. We reviewed medical records of all the cases and enrolled patients that meet the criteria of our study. The flow chart of patient selection is demonstrated in Figure 1. Ultimately, 12 knees from 11 patients met our inclusion and exclusion criteria.

The inclusion criteria are as follows: (1) Prominent medial knee pain, (2) SONK diagnosed on radiographs or magnetic resonance imaging (MRI), MRI images were obtained if the suspected lesions on the radiographs were too subtle, severity was graded according to Koshino et al[12] (Fig. 2). (3) Clinical follow time more than 24 months. Exclusion criteria are as follows: (1) Presence of lateral knee osteoarthritis or SONK, (2) Flexion contracture with range of motion (ROM) < 90°, (3) radiographically verified genu varum > 10°.

2.4. Surgical technique

All surgeries were performed by XXX. The patient was placed in lateral decubitus position. A pneumatic tourniquet was inflated around the thigh of the patient. A longitudinal skin incision was made approximately 8–15 cm below the fibular head. The peroneus brevis and peroneus longus muscles were retracted anteriorly and gastrocnemius posteriorly. Fibular osteotomy level was planned to be 10–13 cm below the fibular head. A blunt retractor was placed behind the fibula for protection. The osteotomy length was 2 times the width of the fibular diameter. The planned osteotomy levels were predrilled using Kirschner wires. Then, a Gigli saw was passed under the predrilled fibula, and osteotomy was performed by sawing. After surgery, immediate ambulation on the same day was permitted under tolerable wound pain.

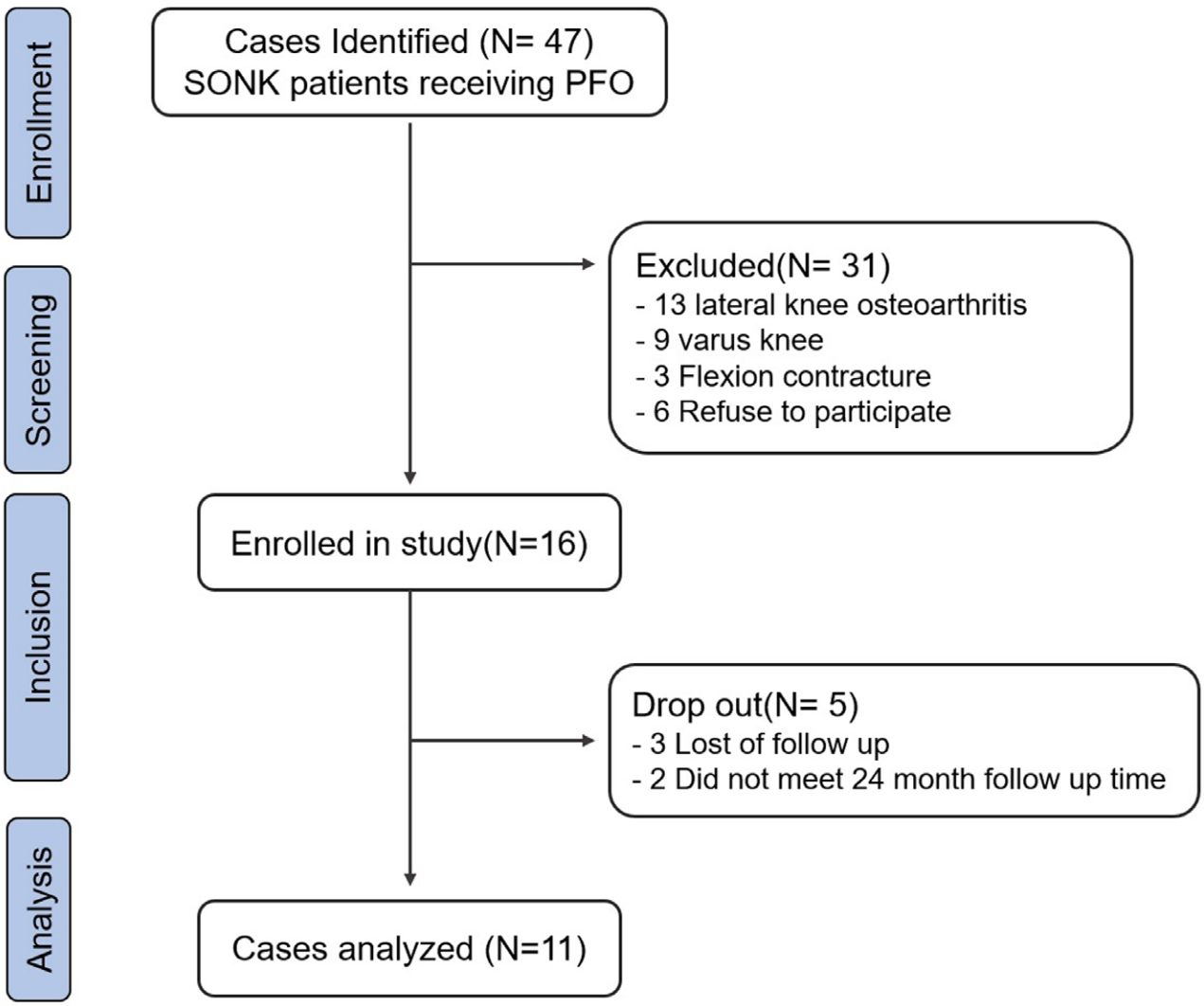

Figure 1. STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) flow chart of study participants.

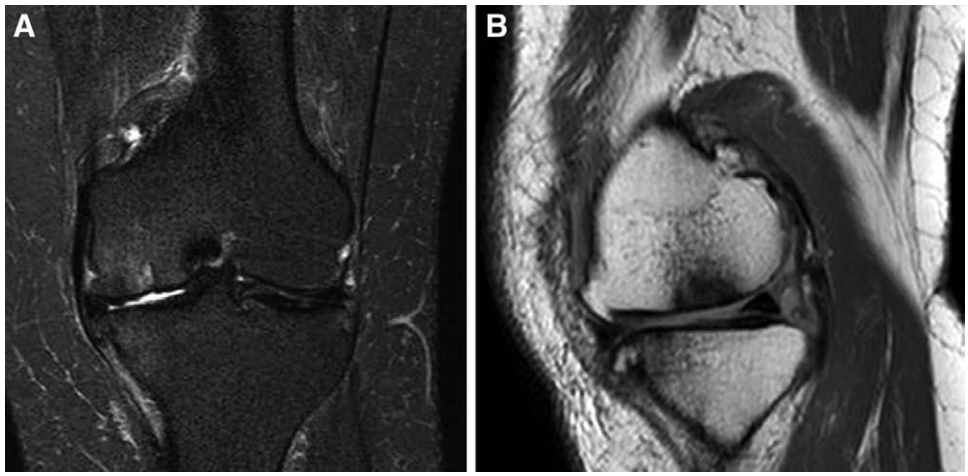

Figure 2. Preoperative MRI of a 50-year-old woman showing (A) a hyperintense signal on T2-weighted image on coronal view and (B) a hypointense signal on T1-weighted image at the medial femoral condyle on sagittal view.

Table 1

Patient demographic data.

	Age	Sex	BMI (kg/m²)	Side	Koshino	F/U (mo)	Complication
Patient 1	68	F	26.1	R	2	34	Dorsal foot numbness
Patient 2	77	F	26.2	L	4	24	
Patient 3	65	F	24.7	R	1	26	
Patient 4	54	F	27.9	R	1	27	Dorsal foot numbness
Patient 5*	68	F	26.5	R/L	1/1	40/40	Right drop toe and dorsal foot numbness
Patient 6	51	F	26.8	L	2	42	
Patient 7	61	M	27.4	L	1	35	
Patient 8	62	F	29.1	R	3	27	
Patient 9	78	M	31.1	R	2	40	
Patient 10	42	F	40	R	1	37	
Patient 11	50	F	23.7	R	1	24	
Mean	61.5		28.1			33	

BMI = body mass index, F = female, F/U = Follow up, L = left, M = male, R = right.
*Bilateral surgery performed simultaneously.

Table 2

Clinical data before and after surgery.

	PreOP		PostOP 12 months		PostOP 24 months	
	VAS	OKS	VAS	OKS	VAS	OKS
Patient 1	8	31	7	38	5	40
Patient 2	6	24	2	39	2	39
Patient 3	6	18	7	28	7	30
Patient 4	5	25	3	35	3	37
Patient 5*	R:6/L:6	20	R:2/L:1	37	R:1/L:1	37
Patient 6	8	28	4	38	4	38
Patient 7	3	27	3	38	2	40
Patient 8	7	17	7	17	7	17
Patient 9	8	39	1	47	1	47
Patient 10	8	21	6	31	6	31
Patient 11	8	22	4	36	4	36
Mean	6.6 ± 0.9	24.7 ± 3.8	3.9 ± 1.4	34.9 ± 4.5	3.6 ± 1.3	35.6 ± 4.5
P			<.05*	<.001*	= .17†	= .07†

L = Left, OKS = Oxford knee score, OP = operation, R = Right, VAS = visual analog scale.
*Twelve months postoperation comparison with preoperation.
†Twenty-four months comparison with 12 months post operation.

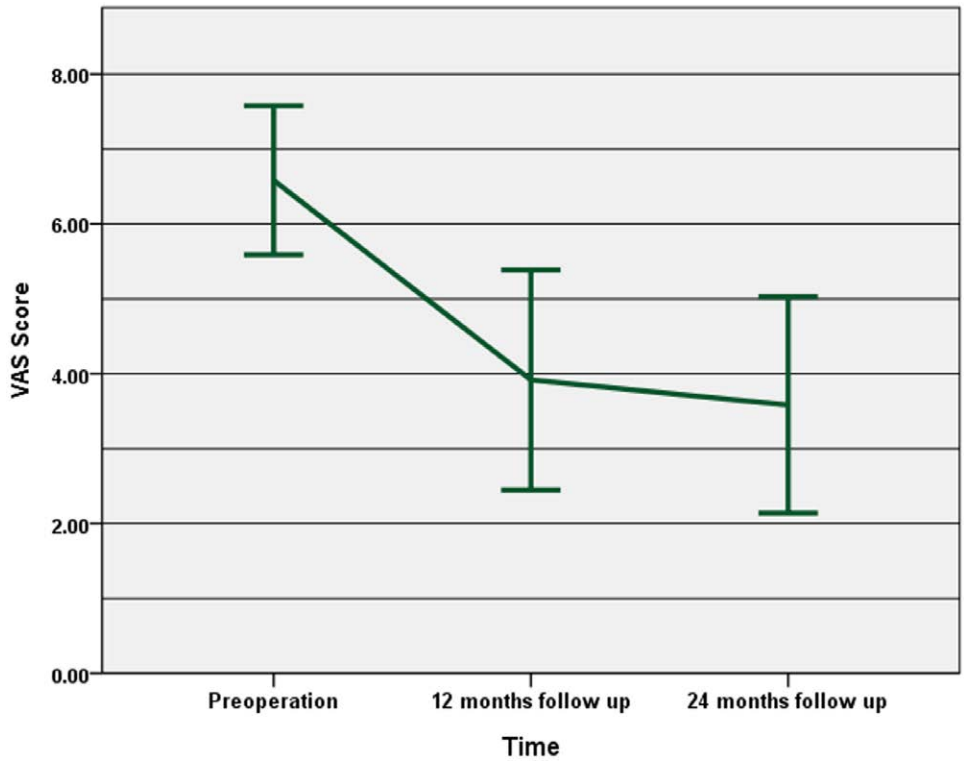

Figure 3. Preoperative and 12- and 24-month follow-up VAS scores.

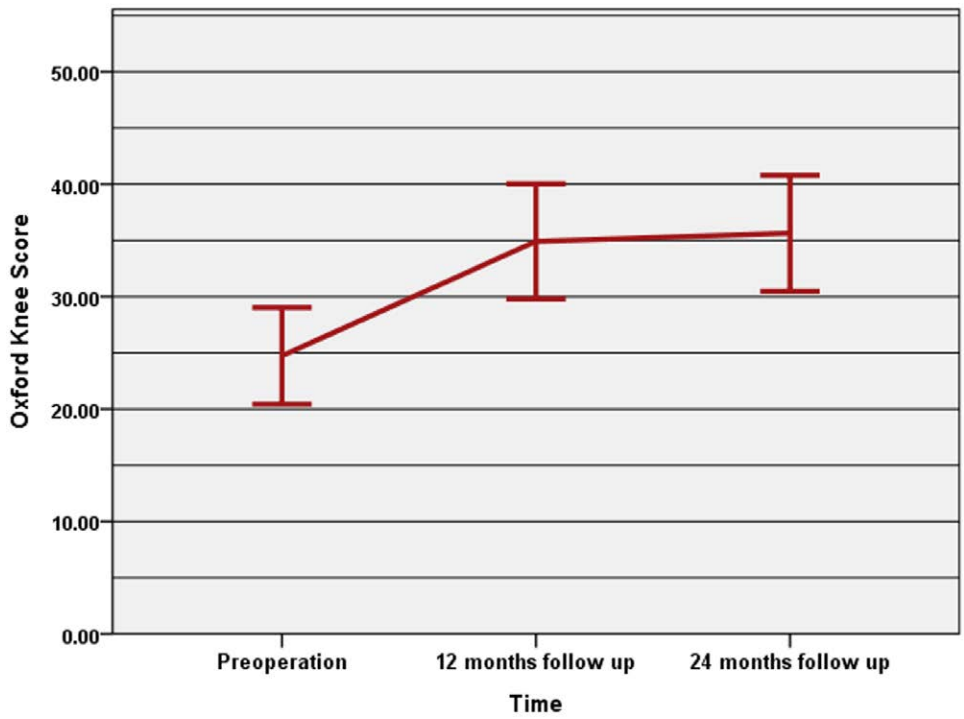

Figure 4. Preoperative and 12- and 24-month OKS.

2.5. Outcome measurement

2.5.1. Primary outcome measurement. Improvement of the patient's knee pain and functional status is the main effect from PFO. Therefore, visual analog scale (VAS) and Oxford knee scores (OKS) are essential parameters to assess the efficacy of the surgery.

2.5.2. Secondary outcome measurement. The femoral tibial angle (FTA) was recorded to document change in knee alignment. The medial joint space ratio was calculated to determine the medial joint space opening effect.[13] Medial and lateral joint spaces were obtained by measuring the lowest point from the femoral condyle to the tibial plateau. MRI was

conducted for definite diagnosis in 7 knees preoperatively, and during postoperative follow up 4 knees underwent MRI to inspect changes in the osteonecrotic area. The other outcomes included complications such as neurovascular injury, extensor hallucis weakness, and ankle instability.

2.6. Calculation

The Wilcoxon signed-rank test was used to compare pre- and postoperative clinical and radiographic data, including VAS score, OKS score, medial joint space ratio, and femorotibial angle. Statistical significance was set at $P < .05$. All statistical analyses were performed using SPSS for Windows, version 22 (IBM, Armonk, NY).

3. Results

We included 12 knees (8 right knees and 4 left knees) of 11 patients (9 women and 2 men), with an average age of 61.5 ± 11.3 years (range: 42–78), who received PFO. The average follow-up duration was 33 months (range 24–42 months). Table 1 summarizes patient demographic data.

3.1. Primary outcome

The preoperative VAS score for medial knee pain was 6.6 ± 0.9 (95% confidence interval), which improved to 3.9 ± 1.4 in 12 months and to 3.6 ± 1.3 in 24 months after the operation (Table 2, Fig. 3). The preoperative OKS was 24.7 ± 3.8, which also markedly improved to 34.9 ± 4.5 and 35.6 ± 4.5 at the 12-month and 24-month follow-up respectively (Table 2, Fig. 4). The range of improvement of the OKS score ranged from 0 to 17.

3.2. Secondary outcome

The mean preoperative medial joint space ratio was 0.36, which significantly improved to 0.50 ($P < .05$) after surgery (Table 3). Radiographic follow-up did not reveal significant changes in the FTA of the operated lower extremities ($P = .20$). In 3 patients, a decreased radiolucent area was observed (Fig. 5). Among the 4 patients who underwent MRI follow-up after surgery, osteonecrotic lesions in 2 patients were similar to preoperative imaging; the other 2 patients exhibited a marked decrease in the hypointense area on T1- and T2-weighted images (Fig. 6).

Table 3

Radiographic data before and after surgery.

	PreOP		PostOP	
	Joint space ratio	FTA	Joint space ratio	FTA
Patient 1	0.29	175.05	0.92	174.73
Patient 2	0.81	178.02	0.65	177.59
Patient 3	0.37	180.06	0.41	180.26
Patient 4	0.11	183.55	0.08	184.97
Patient 5*	R:0.04/L:0.11	185.16/184.3	R:0.41/L:0.34	182.42/182.95
Patient 6	0.29	181.52	0.46	181.35
Patient 7	0.34	179.67	0.39	180.44
Patient 8	0.48	181.8	0.80	181.98
Patient 9	0.54	179.21	0.51	177.72
Patient 10	0.56	180.91	0.53	180.51
Patient 11	0.36	183.03	0.48	182.21
Mean	0.36 ± 0.13	181.0 ± 1.7	0.50 ± 0.13 ($P < .05$)	180.6 ± 1.6 ($P = .20$)

FTA = femoro-tibial angle, L = left, OP = operation, R = right.
*Bilateral surgery performed simultaneously.

3.3. Complications

All 11 patients could walk postoperatively on operation day with minimal assistance after PFO. Seven of them could walk independently, and 4 needed a walker, 1 of whom had undergone simultaneous bilateral PFO. With stable ambulation, the patients were discharged 1–2 days after surgery. During the follow-up visits, no joint contracture or ROM limitation was noted.

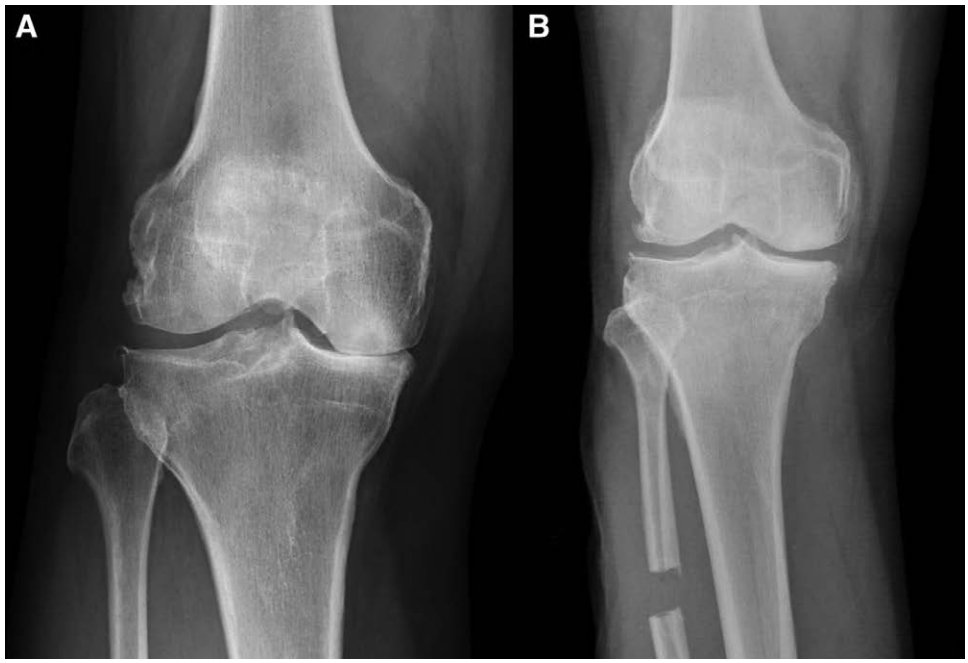

Figure 5. (A) A 61-year-old man with spontaneous osteonecrosis of the medial femoral condyle. (B) Postoperative radiograph showing increased medial compartment space and a decrease in the SONK radiolucent area.

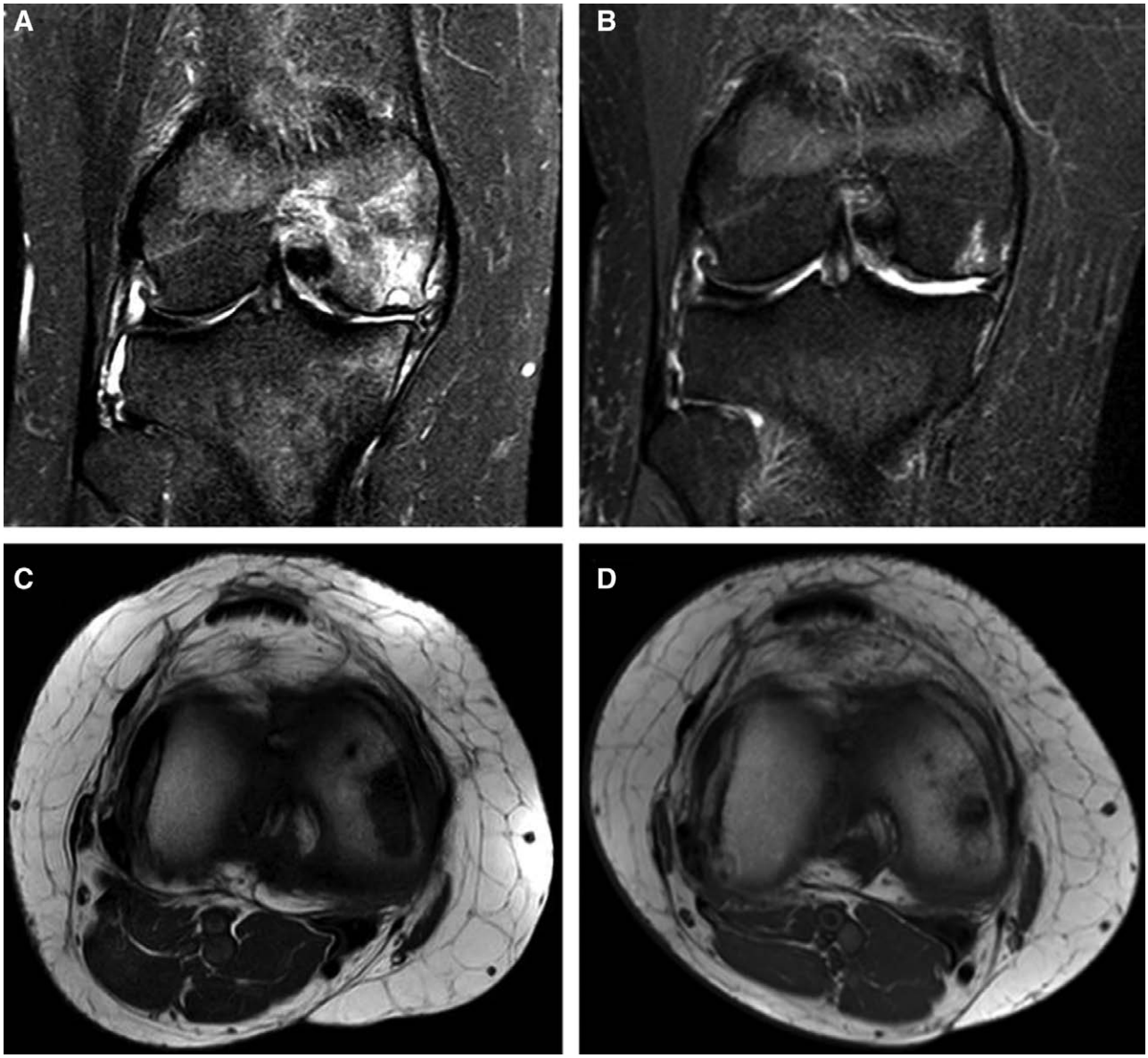

Figure 6. A 51-year-old woman who received right knee PFO surgery due to SONK. Coronal and axial MRI revealed a large hyperintense area on the T2-weighted image (A) and hypointense area on the T1-weighted image (C). Significant reduction of the osteonecrotic area after surgery on T1- (B) and T2-weighted images (D).

Drop toe occurred in 1 knee and dorsal foot numbness in 3; both complications subsided by 6 months. No wound infection or compartment syndrome was reported. No complications related to immediate weight bearing after surgery or ankle instability were noted during the follow-up.

4. Discussion

In our series, apart from 1 patient who reported no improvement in pain and OKS score, others reported substantial improvements in knee pain and function. Yang et al observed a reduction in the VAS score from 7.6 to 1.7 and an improvement in the Knee Society Score from 45.0 to 92.3 in a follow-up ranging from 24 to 189 months.[8] Wang et al reported a reduction in the VAS score from 8.0 to 2.7 and an improvement in the Knee Society Score from 85.7 to 136.7 with follow-up from 12 to 18 months.[13] Compared with previous studies, our 12-month follow-up data revealed rapid improvements in pain and function. The average VAS score for knee pain and OKS improved from 6.6 to 3.9 and 24.7 to 34.9 at 12 months, respectively. The improvements were maintained over 24 months, and no patient required further surgical intervention during follow-up.

Compared with other surgical methods, PFO facilitates relatively quick recovery. HTO for SONK or osteoarthritis requires approximately 2 weeks for full weight wearing.[14,15] In UKA and TKA, weight bearing is also usually commenced the day after surgery, but full weight bearing and rehabilitation takes longer, usually 3 to 6 weeks.[16] Our patients who received PFO were able to walk with full weight bearing by using minimal assistive aids the day after surgery. We attributed the quicker recovery associated with PFO to its extraarticular intervention and minimal insult to the surrounding soft tissue and weight-bearing tibia.

Moreover, bone resection and implant positioning are crucial in UKAs and TKAs, and complicated surgical instruments are often required to assure correct positioning of the prosthesis.[17] The surgical procedures of PFO are relatively simple and leaves the intraarticular joint intact if future treatment is required.

The fibula distributes approximately 6.5% to 16% of force transmitted through the tibia and fibula.[18,19] With age, the tibial

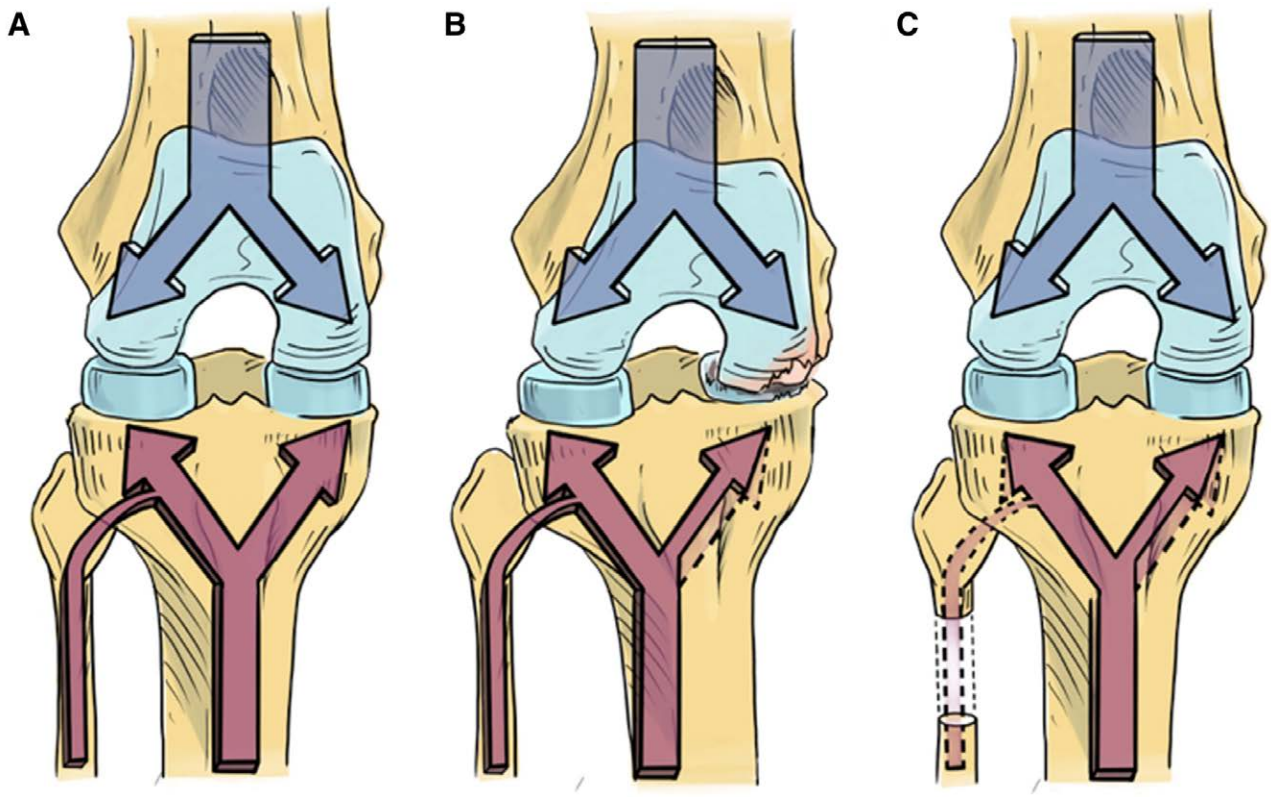

Figure 7. (A) Symmetric load on medial and lateral knee compartment, with stronger support in the lateral compartment due to additional fibular support. (B) With age, medial knee support weakens more than the lateral support because of a decreased tibial cortical bone area but nearly unchanged lateral fibular support. This nonuniform settlement results in load medialization and a net varus force. (C) After proximal fibular osteotomy, lateral fibular support is disrupted. Weight load can settle on the lateral side, reaching a more symmetric load distribution.

cortical bone area decreases by 14% to 22%, whereas the fibular cortical area undergoes little change.[18,19] This leads to a "nonuniform settlement" in the tibial plateau. Weight is unable to settle on the lateral side of the knee and shifts medially due to the stronger support of the fibula, eventually leading to medial shearing force, worsening of medial compartment osteoarthritis, and finally varus deformity (Fig. 7).

By removing the fibular support from the lateral tibial plateau, the load force of the body is redistributed to the lateral side of the knee.[8,13,20] A biomechanical cadaver study by Baldini et al confirmed that peak force, contact area, and pressure in the medial knee compartment all decreased after fibular osteotomy.[11] A biomechanical series by Huang et al found a 1.80° improvement of the hip–knee angle from varus to a more neutral alignment 6 months after fibular osteotomy.[21]

Wang et al reported an increase of medial joint space ratio from 0.40 to 0.58.[13] In our study the increase was from 0.36 to 0.50. Among 7 patients who received MRI for diagnosis, follow-up MRI in 4 patients revealed significant reductions in T1 hypointense and T2 hyperintense areas. This suggests that the patients' clinical improvement can be attributed to the increased medial joint space and reduction in osteonecrotic areas.

Our patients experienced pain relief after PFO, but the varus-correcting effect in previous literature was not found. Yang et al reported that FTA improved from 182.7° to 179.4° in 110 patients, and Wang et al observed that 17% of patients had an obvious alignment correction observed on lower extremity radiographs.[8,13] A cadaveric study by Yazdi et al found decreased medial compartment pressure and increased lateral compartment pressure after PFO.[22] Therefore, we believe isometric decompression to the medial knee joint is sufficient for pain relief without the necessity of varus correction.

Complications associated with PFO include injury to the common or superficial peroneal nerve (3.6%), causing temporary lower leg numbness.[23–25] Among our patients, 1 had drop toe and 3 had lower leg numbness initially, which improved by 6 months. In a study by Yang et al, recovery from nerve injury was observed between 3 and 10 months.[8] Other series involving 47 knees and 111 knees did not report any nerve injury.[13,26] Ankle instability was more common when the distal fibular length was <6–8 cm or 10% of the whole fibular length.[27] In PFO, the residual distal fibula had an average length of 15 cm.

This study presents clinical improvement of PFO with relevant radiograph and MRI data. However, there are several limitations. We did not include a control group for comparison. Our sample size was small, and the 24-month follow-up period may have been too short. Further research is warranted to verify our results using more advanced imaging techniques.

5. Conclusions

PFO leads to decreased VAS score and recovery of knee OKS scores in nonvarus and mild varus SONK. The improvement was prompt and maintained for at least 2 years postoperatively.

Author contributions

Conceptualization: CWC, CYY.
Data curation: YSC, MDA.
Formal analysis: YSC, MDA.
Investigation: YSC.
Methodology: CWC, YSC.
Project administration: CWC, CYY.
Resources: CWC.
Software: MDA.

Supervision: CWC.
Validation: CWC, CYY.
Visualization: YSC, MDA.
Writing–original draft: YSC.
Writing–review & editing: YSC, CWC.

References

[1] Pape D, Seil R, Fritsch E, et al. Prevalence of spontaneous osteonecrosis of the medial femoral condyle in elderly patients. Knee Surg Sports Traumatol Arthrosc. 2002;10:233–40.
[2] Mont MA, Marker DR, Zywiel MG, et al. Osteonecrosis of the knee and related conditions. J Am Acad Orthop Surg. 2011;19:482–94.
[3] Reddy AS, Frederick RW. Evaluation of the intraosseous and extraosseous blood supply to the distal femoral condyles. Am J Sports Med. 1998;26:415–9.
[4] Yamamoto T, Bullough PG. Spontaneous osteonecrosis of the knee: the result of subchondral insufficiency fracture. J Bone Joint Surg Am. 2000;82:858–66.
[5] Ramnath RR, Kattapuram SV. MR appearance of SONK-like subchondral abnormalities in the adult knee: SONK redefined. Skeletal Radiol. 2004;33:575–81.
[6] Hussain ZB, Chahla J, Mandelbaum BR, et al. The role of meniscal tears in spontaneous osteonecrosis of the knee: a systematic review of suspected etiology and a call to revisit nomenclature. Am J Sports Med. 2019;47:501–7.
[7] Plett SK, Hackney LA, Heilmeier U, et al. Femoral condyle insufficiency fractures: associated clinical and morphological findings and impact on outcome. Skeletal Radiol. 2015;44:1785–94.
[8] Yang ZY, Chen W, Li CX, et al. Medial compartment decompression by fibular osteotomy to treat medial compartment knee osteoarthritis: a pilot study. Orthopedics. 2015;38:e1110–1114.
[9] Zhang Y LC, Li J, et al. The pathogenesis research of non-uniform settlement of the tibial plateau in knee degeneration and varus. J Hebei Med Univ. 2014; 35:218–9.
[10] Zheng Z SY, Zhang X, Chen W, et al. The pathogenesis and clinical imageology research of the knee osteoarthritis. J Hebei Med Univ. 2014; 35:599–600.
[11] Baldini T, Roberts J, Hao J, et al. Medial compartment decompression by proximal fibular osteotomy: a biomechanical cadaver study. Orthopedics. 2018;41:e496–501.
[12] Koshino T, Okamoto R, Takamura K, et al. Arthroscopy in spontaneous osteonecrosis of the knee. Orthop Clin North Am. 1979;10:609–18.
[13] Wang X, Wei L, Lv Z, et al. Proximal fibular osteotomy: a new surgery for pain relief and improvement of joint function in patients with knee osteoarthritis. J Int Med Res. 2017;45:282–9.
[14] Takeuchi R, Aratake M, Bito H, et al. Clinical results and radiographical evaluation of opening wedge high tibial osteotomy for spontaneous osteonecrosis of the knee. Knee Surg Sports Traumatol Arthrosc. 2009;17:361–8.
[15] Takeuchi R, Ishikawa H, Aratake M, et al. Medial opening wedge high tibial osteotomy with early full weight bearing. Arthroscopy. 2009;25:46–53.
[16] Milne S, Brosseau L, Robinson V, et al. Continuous passive motion following total knee arthroplasty. Cochrane Database Syst Rev. 4260;2003:Cd00.
[17] D'Ambrosi R, da Silva M, Moura JLM, et al. Radiographic and clinical evolution of the oxford unicompartmental knee arthroplasty [published online ahead of print July 16, 2021]. J Knee Surg. doi: 10.1055/s-0041-1731718.
[18] Goh JC, Mech AM, Lee EH, et al. Biomechanical study on the load-bearing characteristics of the fibula and the effects of fibular resection. Clin Orthop Relat Res. 1992;279:223–8.
[19] McNeil CJ, Raymer GH, Doherty TJ, et al. Geometry of a weight-bearing and non-weight-bearing bone in the legs of young, old, and very old men. Calcif Tissue Int. 2009;85:22–30.
[20] Huang W, Lin Z, Zeng X, et al. Kinematic characteristics of an osteotomy of the proximal aspect of the fibula during walking: a case report. JBJS Case Connect. 2017;7:e43.
[21] ZeYu Huang YN, Xu B, Shen B, et al. Evidence and mechanism by which upper partial fibulectomy improves knee biomechanics and decreases knee pain of osteoarthritis. J Orthop Res. 2018;36:2099–108.
[22] Yazdi H, Mallakzadeh M, Mohtajeb M, et al. The effect of partial fibulectomy on contact pressure of the knee: a cadaveric study. Eur J Orthop Surg Traumatol. 2014;24:1285–9.
[23] Vail TP, Urbaniak JR. Donor-site morbidity with use of vascularized autogenous fibular grafts. J Bone Joint Surg Am. 1996;78:204–11.
[24] Minami A, Kasashima T, Iwasaki N, et al. Vascularised fibular grafts. An experience of 102 patients. J Bone Joint Surg Br. 2000;82:1022–5.
[25] Liu S, Tao S, Tan J, et al. Long-term follow-up of fibular graft for the reconstruction of bone defects. Medicine. 2018;97:e12605.
[26] Liu B, Chen W, Zhang Q, et al. Proximal fibular osteotomy to treat medial compartment knee osteoarthritis: preoperational factors for short-term prognosis. PLoS One. 2018;13:e0197980.
[27] Pacelli LL, Gillard J, McLoughlin SW, et al. A biomechanical analysis of donor-site ankle instability following free fibular graft harvest. J Bone Joint Surg Am. 2003;85:597–603.