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Medial opening wedge high tibial osteotomy in patients with posttraumatic medial tibial plateau bone defect: A case report

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ABSTRACT

INTRODUCTION: Traumatic uncontained bone defect in the knee joint is one of the most serious knee injuries. As the knee joint is the main weight-bearing joint of the body, the problem of weight loading should be addressed while restoring the bone defect. However, no consensus exists regarding the treatment of this injury.

PRESENTATION OF CASE: Two patients in separate cases initially sustained traumatic uncontained proximal tibial bone defects secondary to passenger traffic accidents. After recovery from the initial trauma, these patients underwent medial opening wedge high tibial osteotomy (MOWHTO) and femoral head allograft augmentation simultaneously.

DISCUSSION: Treatment of traumatic uncontained bone defect in the knee joint should be considered separately as tumorous or osteoarthritic bone defects. Especially, the effects of the defective supporting soft tissue structures should be considered.

CONCLUSION: We considered that MOWHTO was capable of solving problems of both bone stock restoration and weight loading. After the operation, the patients' knee joint pain was relieved and stable ambulation was possible.

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1. Introduction

Surgeons may encounter various knee injuries with high severity. Among them, total loss of the articulating bone in the knee joint is catastrophic; one cannot stand upright on the defective knee joint, and normal knee joint range of motion becomes impossible. In this injury, the problem of weight loading should be addressed while treating bone loss that occurred adjacent to the knee joint because the knee joint is a major weight-bearing joint of the body. Regardless of bone stock recovery, the injured knee joint is at risk of developing posttraumatic arthritis [1]. We considered that medial opening wedge high tibial osteotomy (MOWHTO) was capable of treating the problem of both bone stock restoration and weight loading. MOWHTO is a common joint-sparing surgical technique with numerous good to excellent result reports [2–4]. Here, we report two cases which were treated using MOWHTO with femoral head allograft for the traumatic medial tibial plateau bone defect and varus deformity. The patients were operated and followed in university hospital setting. The work has been reported in line with the SCARE criteria [5].

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2. Presentation of cases

2.1. Case 1

A 57-year-old male patient, who was injured in the medial aspect of his left knee joint 22 months ago in a passenger traffic accident, visited an outpatient clinic. The patient was otherwise healthy before the accident. On admission, he was suspected to have sustained Gustilo–Anderson type 3B open fracture [6] with AO 41-B1 fracture based on the photographic and radiographic documentation of the initial injury (Fig. 1A and B). It was suspected that the bone fragment could not be salvaged because of severe comminution and contamination. The medial aspect of the patient's left knee was healed with large partial-thickness skin graft upon presentation to our clinic. The chief complaint was persistent global pain in the left knee, which was aggravated by weight-bearing activities. Resting pain was 9 in the visual analog scale (VAS) [7]. The bone defect in the medial tibial plateau was visible in the plain radiograph. The defective area was approximately 15% of the medial tibial plateau articular surface in three-dimensional computed tomography (3D CT) measurement using picture archiving and communication system (PACS) region-of-interest (ROI)-curved function in Maroview ver. 5.3 PACS (MAROTECH, Republic of Korea) (Fig. 2). His left lower extremity mechanical alignment showed a 2° varus deformity in the long-standing anteroposterior radiograph.

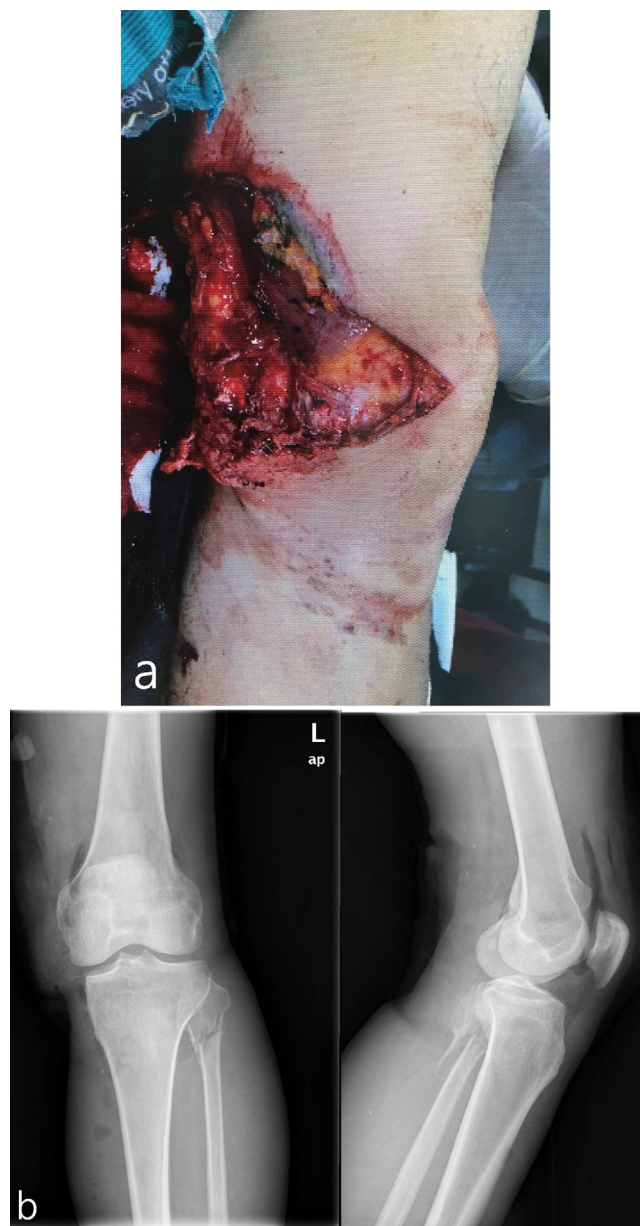


Fig. 1. Case 1: (A) The patient presented highly contaminated Gustilo-Anderson type 3B open fracture upon initial trauma. (B) Uncontained medial proximal tibial bone defect secondary to AO 41-B1 fracture and proximal fibular fracture were observed in the immediate posttraumatic radiography.

His knee joint range of motion was limited to only 85° flexion from a 5° flexion contracture (Fig. 3). In the stress radiograph, the left knee showed grade 1 valgus instability. The medial meniscus, which was unsupported by a bony structure but surrounded by soft tissues fixed on the edge of the bone defect by a suture anchor, was detected on magnetic resonance imaging (MRI) (Fig. 4). The anterior and posterior cruciate ligaments were intact on MRI.

2.2. Case 2

A 19-year-old male patient who was run over by a truck 2 years prior visited an outpatient clinic. The patient was otherwise healthy before the accident. At the time of his initial injury, he sustained multiple skeletal traumas, including right femoral subtrochanteric fracture (AO 31-A3), left femoral shaft fracture (AO 32-A2), bilateral malleolar fracture (AO 43-B1 and 44-A1), and severe crushing in the medial aspect of his left knee which involved both the medial femoral condyle (AO 33-B2) and the medial tibial

plateau (AO 41-B1) (Fig. 5). The patient underwent an initial operation in the local clinic. Closed reduction of the right femur was maintained using external fixator, and the left femur underwent open reduction using dynamic compression plate. The anterosuperior half of the left medial femoral condyle and medial tibial plateau bone were severely comminuted and contaminated during the initial trauma, and could not be salvaged. The posteroinferior half of the left medial femoral condyle that contained most of the articular surface could be only salvaged and fixed on the distal femur using two 4.5-mm cannulated screws. In our clinic, he complained of persistent pain of the left knee during weight-bearing activities with posttraumatic varus limb alignment and limited motion. His pain was 8 in VAS. He had a huge bone defect in the medial tibial plateau and medial femoral condyle. His left lower extremity mechanical alignment showed 9° varus deformity in the long-standing anteroposterior radiograph because of deficient medial bone support. His knee joint range of motion was limited to 70° flexion from full extension. In the stress radiograph,

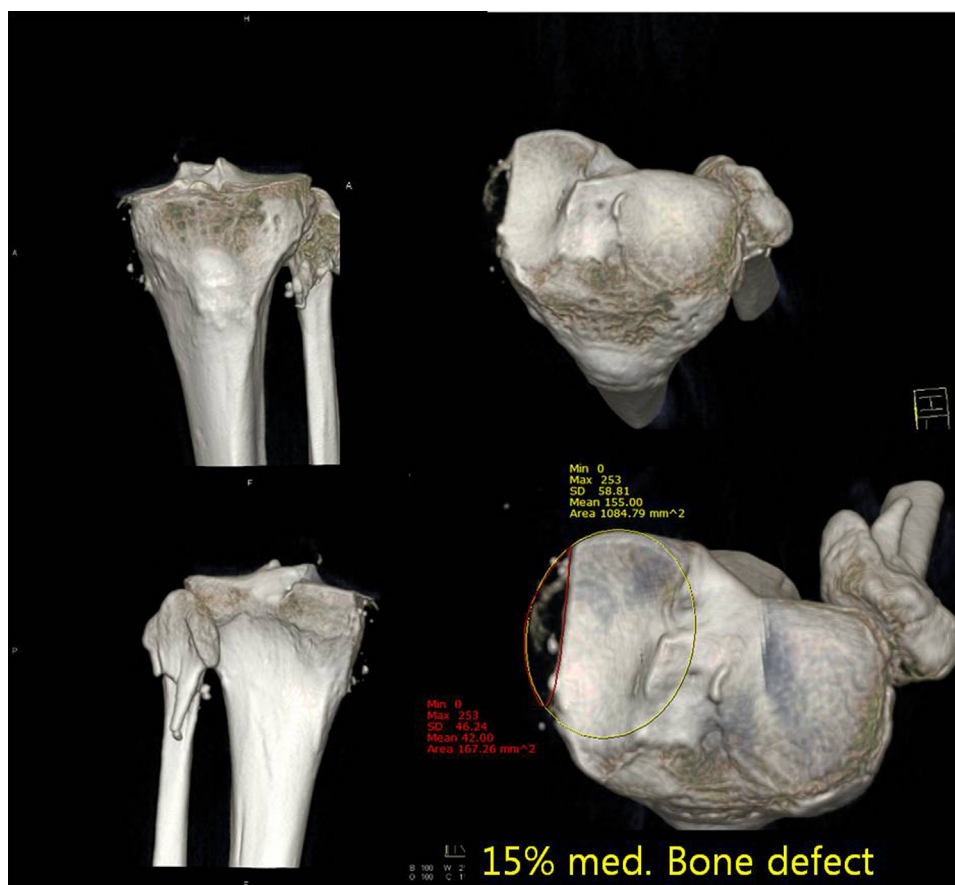


Fig. 2. Case 1: Three-dimensional computed tomography showing 15% defect in the medial tibial plateau articular surface.

the left knee showed grade 3 valgus instability because the initial injury devastated the medial soft tissue structures, including the medial collateral ligament (MCL). However, the knee was stable against anterior–posterior and posterior–anterior direction stress on physical examination. In addition, the patient did not complain any feeling of instability. A large area of the medial aspect of the left knee was sunken and covered by grafted skin. Preoperative measurement using PACS ROI-curved function in 3D CT revealed that almost 40% of the medial tibial plateau articular surface was lost, whereas the medial femoral condyle appeared to have relatively preserved articulating bone stock even if the bone did not seem to have an intact articular cartilage (Fig. 6).

3. Surgical treatment

The surgical procedure was performed by an expert knee trauma surgeon (RSJ). The approach was made through an anteromedial longitudinal knee incision that begins from the supracondylar level of the femur, which is slightly anterior to that for conventional high tibial osteotomy. Because the mangled medial soft tissue cover was merged to the medial joint capsule, the skin incision was extended until the bone was exposed in a one-layer flap. The capsular adhesion from the medial tibial bone defect crater was meticulously dissected, and the dimension of the crater was measured. In case 2, the crater measured 6×3 cm in semicircular shape. Commercially available γ -irradiated whole femoral head allograft was transected using motorized sagittal saw to fit the crater dimension with adequate parabolic height. The tailored allograft was temporarily fixed on the tibia using multiple 1.6-mm Kirschner wires. The osteotomy level was set to 4.5 cm from the medial tibial joint line, and biplanar osteotomy was performed (Figs. 7 and 8). In case 1, the correction

angle was set to 8° valgus correction with 8-mm posteromedial cortical distraction considering the 2° varus malalignment. Moreover, an osteotomy gap was left unfilled (Fig. 9). In case 2, the correction angle was set to 12° valgus correction with 12-mm posteromedial cortical distraction considering the 9° varus malalignment and deficient MCL restraint. The remnant of the femoral head allograft was inserted in the gap to support the gap and enhance the osteotomy site union (Fig. 10A and B). The plate and screw fixation technique should be modified from the conventional MOWHTO considering the risk of screw penetration into the joint space. Because the unfitting contour of the allograft was pushing the proximal locking holes of the TomoFix plate (TomoFix Osteotomy System; DePuy-Synthes) to face upward, first, we inserted three proximal locking screws ahead to confer them as safe and long trajectory as possible under the articular surface. Then, a cortical compression screw was inserted in the most proximal hole of the four distal locking holes to approximate the plate on the tibia and to push the allograft firmly against the tibial crater simultaneously; this technique was based on the well-known mechanism of precontoured locking compression plate [8]. The rest of the procedure was similar to conventional MOWHTO.

Postoperative rehabilitation protocol was equally applied in both cases. Immediate quadriceps muscle strengthening exercise was encouraged. Range of motion exercise was begun on the third postoperative day. Patient began crutch ambulation from the first postoperative week and recommended to use crutches until the second postoperative month. In their second outpatient clinic visit, in the second postoperative month, the patients were allowed to walk without crutches.

In case 1, the patient reported pain improvement of VAS 4 during follow-up visit on sixth postoperative month. He could walk stably



Fig. 3. Case 1: 22 months after the trauma, the patient's left lower extremity mechanical alignment showed 2° varus deformity in the long-standing anteroposterior radiograph.

without crutches. However, unfortunately, surgical site infection on the left knee joint occurred 1 year after the index operation. The medial aspect of his left knee joint including the surgical site was swollen with heat. C-reactive protein value was greater than 5 in the laboratory test. Methicillin-resistant *Staphylococcus aureus* was identified in the joint fluid and wound culture. Because the osteotomy site union was evident in the radiograph, the metal plate was removed, and the surgical site and knee joint were debrided

and irrigated. After 4 weeks of intravenous administration of vancomycin, the infection was controlled and did not recur until 2 years after the operation.

In case 2, the patient walked into the clinic with apparent valgus thrust gait in his third visit. MCL brace was prescribed, and the patient was educated to wear the brace during ambulation and when sleeping. Valgus thrust tendency was gradually decreased on the next visit. In the first postoperative year visit, follow-up long-

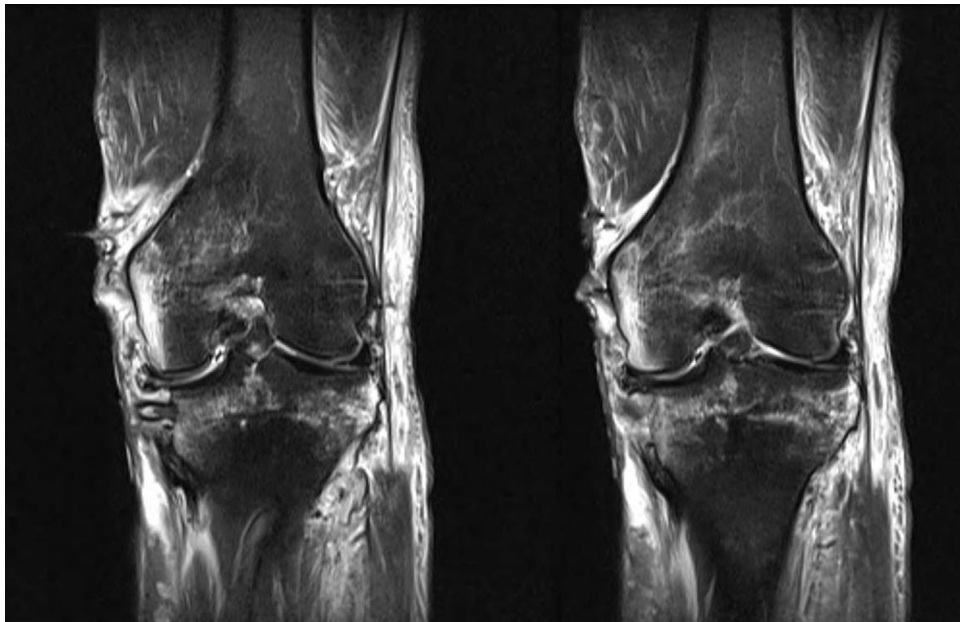


Fig. 4. Case 1: MR image showing the medial meniscus covered with soft tissue fixed on the edge of the bone defect by a suture anchor.

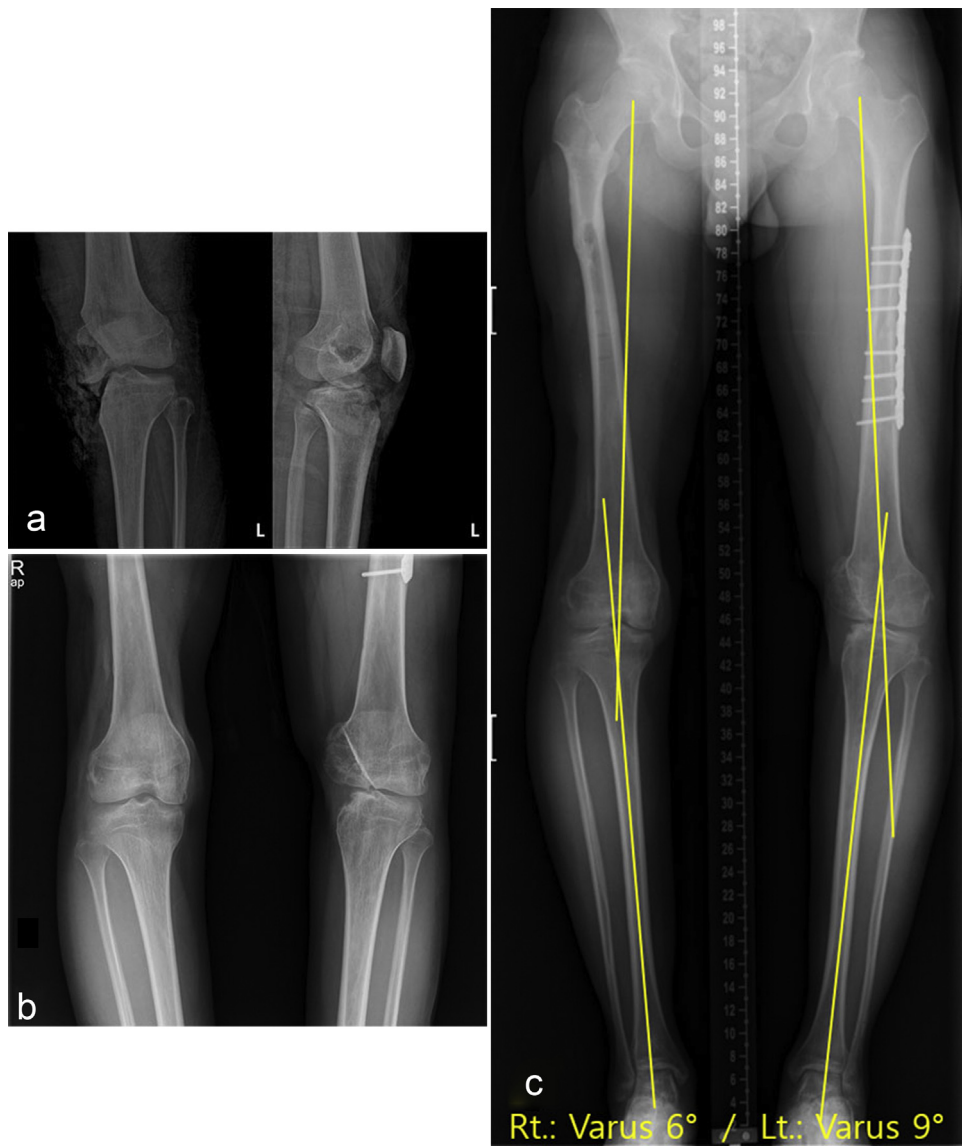


Fig. 5. Case 2: (A) Radiographs taken immediately after the initial injury in the local clinic. The patient presented severe crushing and bone loss in the medial aspect of the left knee joint. (B,C) At 16 months after the initial trauma, the patient visited our clinic with 9° varus deformity on the left knee.

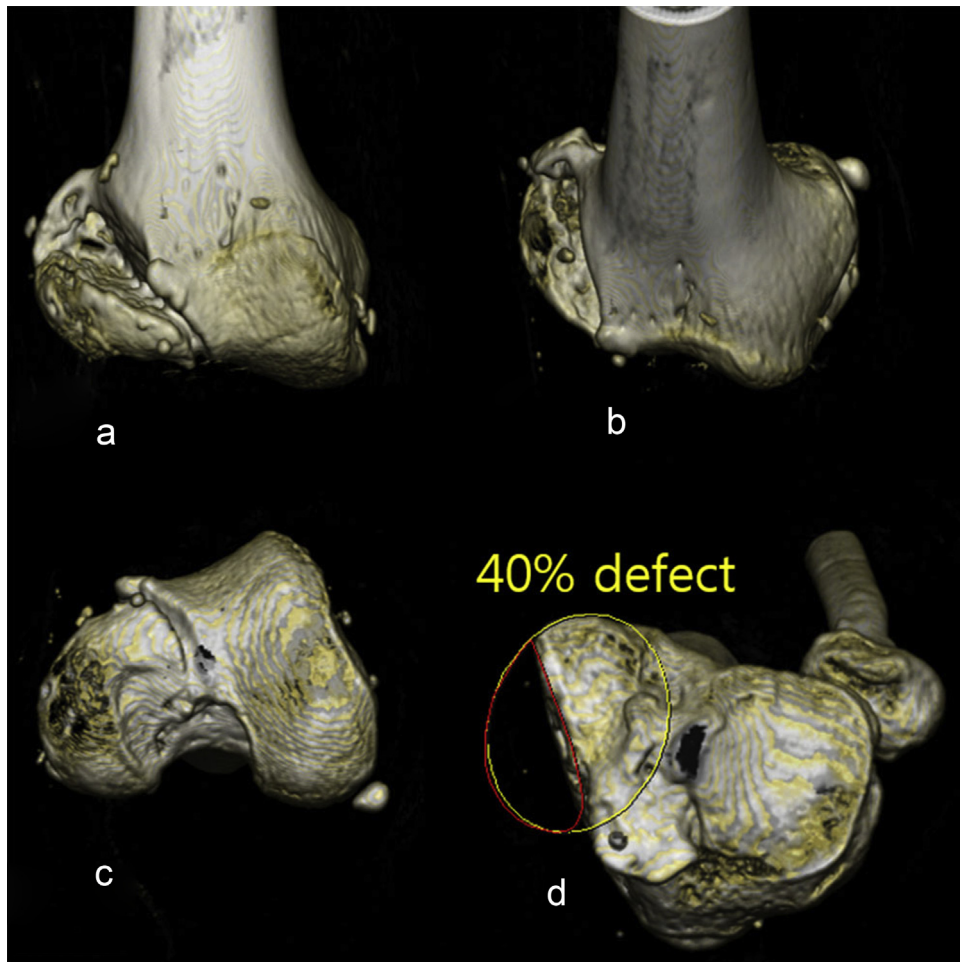


Fig. 6. Case 2: (A–D) Three-dimensional computed tomography showing 40% defect in the medial tibial plateau articular surface, whereas the medial femoral condyle was relatively spared.

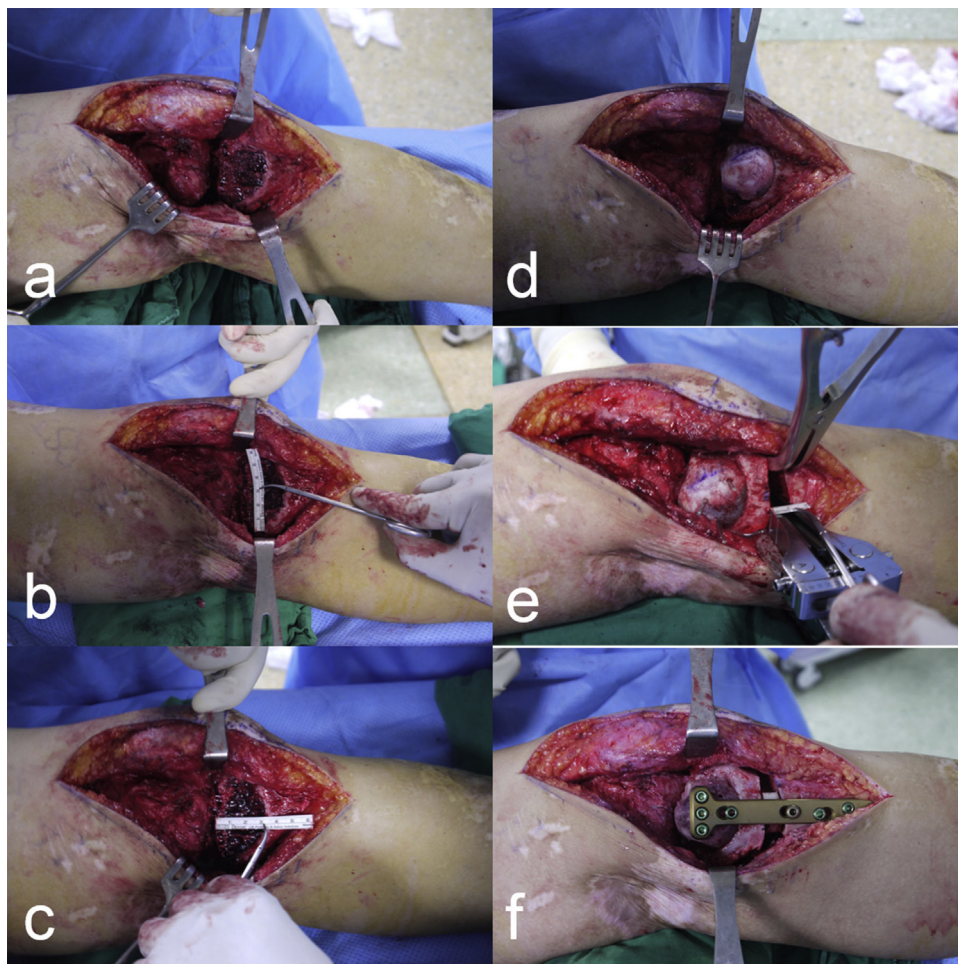


Fig. 7. Case 2: (A) Meticulous deep soft tissue dissection was performed in the medial side of the left knee to expose the crater of the bone defect. (B) Horizontal dimension of the crater was 6 cm. (C) Vertical dimension of the crater was 3 cm. (D) Femoral head allograft was prepared to fit the medial bone defect. (E) Medial opening wedge high tibial osteotomy was performed with the allograft temporarily fixed in position using multiple Kirschner wires. (F) Remnant femoral head allograft was inserted into the osteotomy gap, and TomoFix plate was inserted to stabilize both the grafted proximal allograft and osteotomy site.

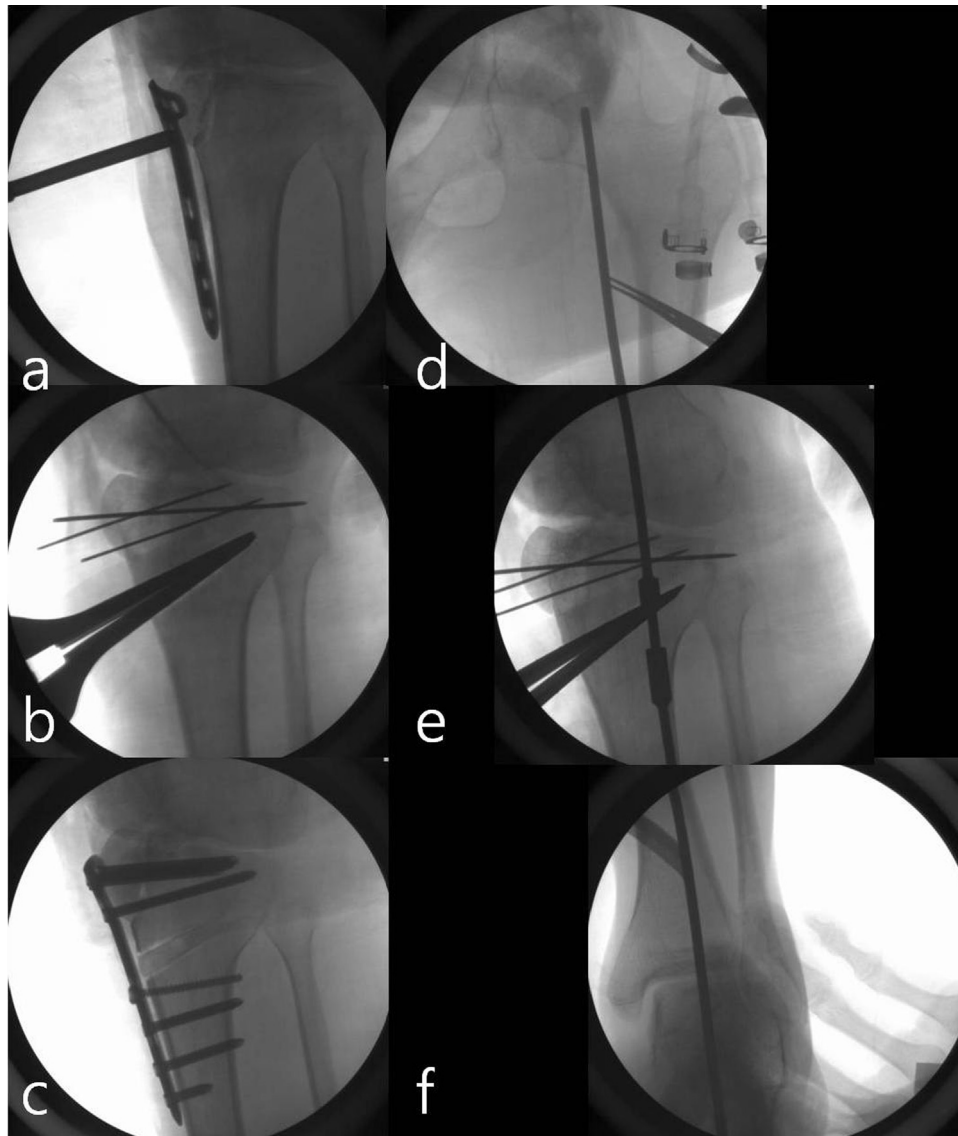


Fig. 8. Case 2: Fluoroscopic images showing the operative procedure. (A) Osteotomy level was determined with allograft and TomoFix plate located in virtual position. (B) Osteotomy gap was gradually distracted using the distractor. (C) Plate fixation was complete with allograft augmentation on the medial tibial defect and in the osteotomy gap. (D–F) Alignment correction was checked intraoperatively using metal rod.



Fig. 9. Case 1: Immediate postoperative radiograph showing 6° valgus left lower limb alignment.

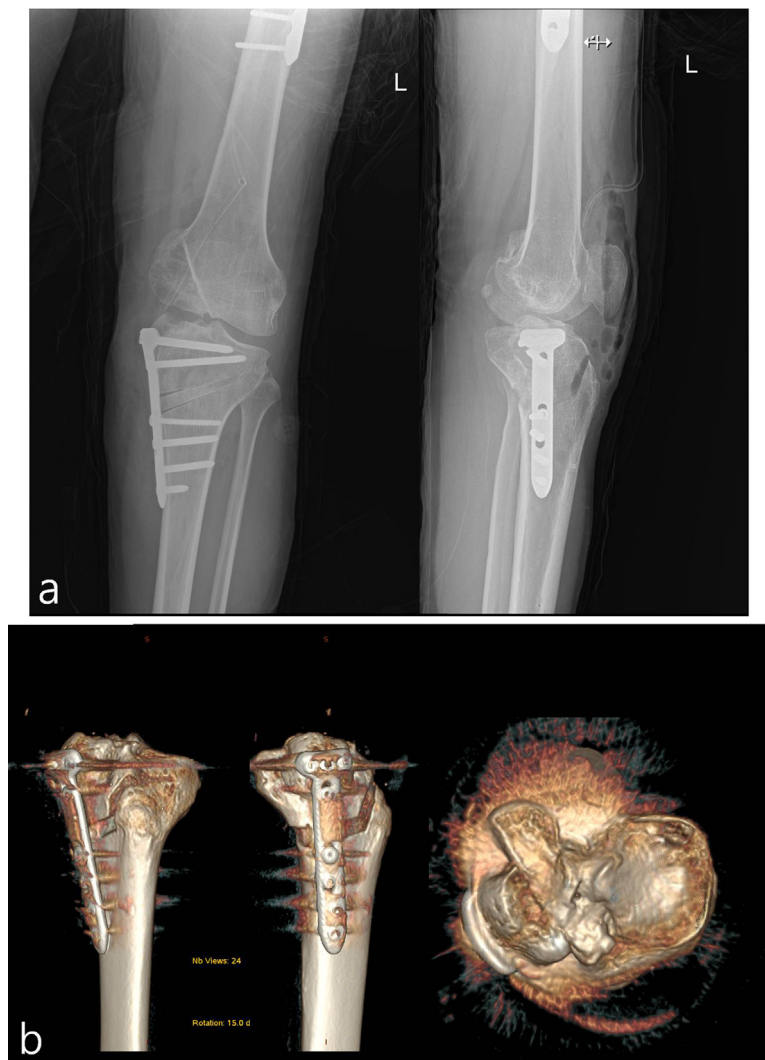


Fig. 10. Case 2: (A) Immediate postoperative radiograph. (B) Postoperative follow-up computed tomography showed considerable amount of bone stock restoration in the medial tibial plateau.

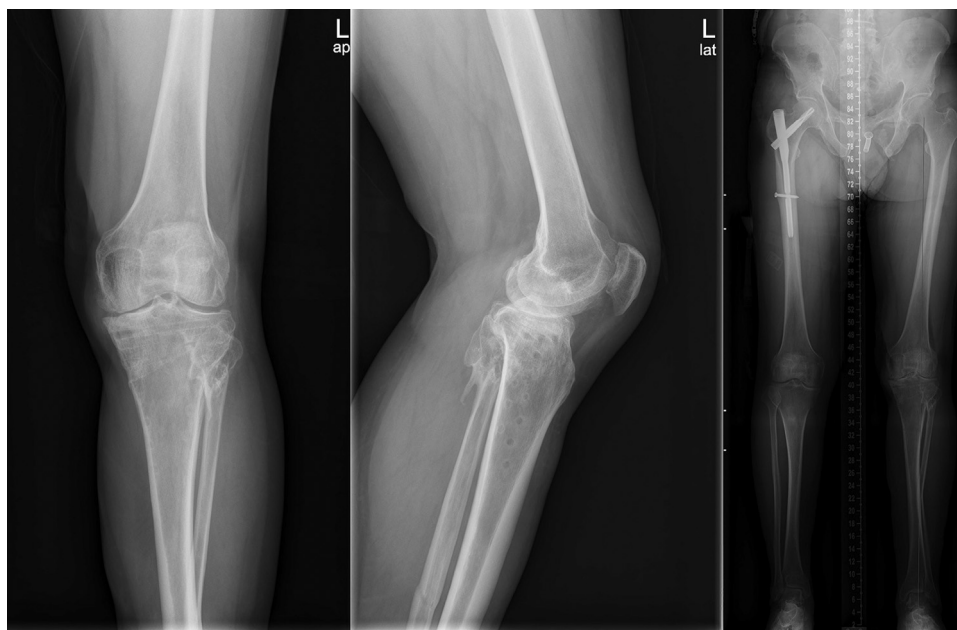


Fig. 11. Case 1: At 3 years after the operation on the last follow-up visit, osteotomy site was completely united, and the metal plate was removed.



Fig. 12. Case 2: At 3 years after the operation on the last follow-up visit, the osteotomy site was completely united, and the patient could walk without pain despite overcorrection and joint line obliquity.

standing radiograph showed 7° valgus alignment of the patient's left lower extremity (Fig. 11). MCL restraint deficiency was suspected, which contributed to the magnification of correction angle as we have predicted. However, the patient reported pain improvement of VAS 2, and he was satisfied with the modified left lower limb alignment. Left knee joint range of motion was increased to 90° flexion. He could walk fast and stably without MCL brace. Valgus thrust was completely corrected. Complete union of the osteotomy site was also verified in the follow-up 3D CT. Until the last follow-up visit in the third postoperative year, the patient's left knee was doing well (Fig. 12).

4. Discussion

Traumatic loss of medial tibial plateau is not well documented although there are numerous possible causative accidents in modern societies. Most studies that have reported about medial tibial bone defect are related to tumorous conditions and advanced-stage osteoarthritis with varus deformity [9,10]. Osteoarticular allograft or tumor endoprosthesis can be considered for the bone defects after the tumor resection [9]. Broad-spectrum bone substitutes, such as bone cement, auto-/allo-bone graft, metal wedge or block combined with total knee implant, structural bone allograft, and tantalum metaphyseal cone are used in osteoarthritic

bone defect [10]. However, those treatment modalities cannot be applied equally to traumatic cases. In the posttraumatic medial tibial bone defect, the remaining part of the joint is intact, and the patient is possibly young. Tumor endoprosthesis or total knee arthroplasty can be an overtreatment even though future development of the posttraumatic arthritis is apparent. Despite a few case reports on good postoperative outcome after knee osteochondral defect reconstruction using osteoarticular allograft [9,11], this procedure is unavailable in some countries, and finding allograft of matching size is even more difficult, in addition to the high cost and handling requirements. Risk of disease transmission or rejection should be considered. Moreover, no data regarding long-term post-traumatic arthritis prevention effect of the osteoarticular allograft are available. In our case, we used femoral head allograft, which has sufficient supply.

Data regarding the favorable joint-sparing results of high tibial osteotomy has been accumulated for more than three decades in various mid- to longer-term studies [2–4]. Simultaneous correction of mechanical alignment and unloading of the arthritic compartment of the joint is a major goal of high tibial osteotomy [3,4,12]. In the presented cases with traumatic medial tibial plateau defect, MOWHTO was preferred over allograft bone augmentation. Considering that no treatment is available to restore the normal joint of this patient, and eventual posttraumatic arthritis is inevitable, the goal of our surgical treatment is medial compartment unloading and medial bone stock restoration, which can favorably allow future arthroplasty. During the surgical procedure of MOWHTO, the biomechanical characteristics of TomoFix plate were highly advantageous in these cases. Lag screw insertion into the hole just distal to the osteotomy conferred compressive force in the proximal and distal ends of the plate; hence, the allograft located between the plate and proximal tibia became pressurized to promote union on the host bone [8]. In surgical planning of MOWHTO, the target lower limb mechanical alignment is between the neutral and 3–4° valgus alignment, according to the work of Fujisawa [13]. However, in these cases, we tried valgus overcorrection past the Fujisawa point to achieve 6°–8° valgus alignment according to Mina et al. [12]. They reported that the medial compartment contact pressure of the knee joint was remarkably reduced at between 6° and 8° of valgus than the neutral to under 6° valgus correction, and complete unloading of the medial compartment was expected in 6°–8° valgus alignment. We should be more cautious to avoid inadvertent overcorrection since these patients were devoid of their normal medial soft tissue and supporting structures. To the best of our knowledge, no literature has reported the quantitative effect of medial collateral ligament laxity on the correction angle of MOWHTO. Ogawa et al. [14] reported that in the knees with varus laxity, soft tissue correction after MOWHTO increased by 0.59° for every 1° of preoperative varus laxity. We applied this correlation similarly to valgus laxity and adjusted the combined amount of bony correction and predicted soft tissue correction to accomplish the target correction. Moreover, tenting and tensioning of the medial soft tissue caused by the increased medial proximal tibial volume, owing to the allograft and TomoFix plate, were expected to neutralize the ligament insufficiency. As seen in case 1, infection risk exists in these highly traumatized cases. We should be cautious about possible superficial and deep infections related to poor soft tissue coverage and bone defect; they are susceptible to disease transmission because of poorly sterilized allograft. In addition, MOWHTO is reported to bear considerable superficial and deep infection rate [15].

5. Conclusion

We considered that MOWHTO with allograft augmentation is advantageous for the treatment of traumatic medial tibial bone

defect in terms of pain relief, bone stock restoration, and posttraumatic osteoarthritis prevention. However, operators should pay particular attention to prevent inadvertent overcorrection because of deficient medial soft tissue restraint and should be cautious about infection-prone situation related to poor medial soft tissue cover.

Conflicts of interest

The authors of this article declare no conflict of interest.

Sources of funding

The authors of this article declare no funding for this research.

Ethical approval

No ethical approval is required since this article is not regarding any human trial.

Consent

Informed consent was obtained from all the patient in the article.

Author contribution

Dr. Yoon Young, Choi radiologically evaluated the case patients pre- and postoperatively, and wrote the discussion part of this paper.

Dr. Seung Joon, Rhee operated and followed the case patients, and set the concept of the case report. He wrote the case report part of this paper.

Guarantor

Dr. Seung Joon, Rhee

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References

- [1] D. Wasserstein, P. Henry, J.M. Paterson, et al., Risk of total knee arthroplasty after operatively treated tibial plateau fracture: a matched-population-based cohort study, *J. Bone Joint Surg. Am.* 96 (January (2)) (2014) 144–150, PubMed PMID: 24430414.
- [2] S. Akizuki, A. Shibakawa, T. Takizawa, et al., The long-term outcome of high tibial osteotomy: a ten- to 20-year follow-up, *J. Bone Joint Surg. Br. Vol.* 90 (May (5)) (2008) 592–596, PubMed PMID: 18450624. Epub 2008/05/03. eng.
- [3] P. Schuster, M. Schulz, P. Mayer, et al., Open-wedge high tibial osteotomy and combined abrasion/microfracture in severe medial osteoarthritis and varus malalignment: 5-year results and arthroscopic findings after 2 years, *Arthroscopy* 31 (July (7)) (2015) 1279–1288, PubMed PMID: 25861712. Epub 2015/04/12. eng.
- [4] M.J. Yoo, Y.E. Shin, Open wedge high tibial osteotomy and combined arthroscopic surgery in severe medial osteoarthritis and varus malalignment: minimum 5-year results, *Knee Surg. Relat. Res.* 28 (December (4)) (2016) 270–276, PubMed PMID: 27894173 PubMed Central PMCID: PMC5134789. Epub 2016/11/29. eng.
- [5] R.A. Agha, A.J. Fowler, A. Saeta, et al., The SCARE statement: consensus-based surgical case report guidelines, *Int. J. Surg.* 34 (October) (2016) 180–186, PubMed PMID: 27613565.
- [6] R.B. Gustilo, J.T. Anderson, Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses, *J. Bone Joint Surg. Am.* 58 (June (4)) (1976) 453–458, PubMed PMID: 773941.
- [7] C.R. Joyce, D.W. Zutshi, V. Hrubes, R.M. Mason, Comparison of fixed interval and visual analogue scales for rating chronic pain, *Eur. J. Clin. Pharmacol.* 8 (August (6)) (1975) 415–420, PubMed PMID: 1233242.

- [8] A.E. Staubli, C. De Simoni, R. Babst, P. Lobenhoffer, TomoFix: a new LCP-concept for open wedge osteotomy of the medial proximal tibia—early results in 92 cases, *Injury* 34 (November Suppl. 2) (2003) B55–B62, PubMed PMID: 14580986. Epub 2003/10/29. eng.
- [9] D.L. Muscolo, M.A. Ayerza, G. Farfalli, L.A. Aponte-Tinao, Proximal tibia osteoarticular allografts in tumor limb salvage surgery, *Clin. Orthop.* 468 (May (5)) (2010) 1396–1404, PubMed PMID: 20020336 Pubmed Central PMCID: PMC2853677. Epub 2009/12/19. eng.
- [10] T. Sugita, T. Aizawa, N. Miyatake, et al., Preliminary results of managing large medial tibial defects in primary total knee arthroplasty: autogenous morcellised bone graft, *Int. Orthop.* 21 (November) (2016), PubMed PMID: 27872980. Epub 2016/11/23. eng.
- [11] F.J. Hornicek Jr., W. Mnaymneh, R.D. Lackman, et al., Limb salvage with osteoarticular allografts after resection of proximal tibia bone tumors, *Clin. Orthop.* (July (352)) (1998) 179–186, PubMed PMID: 9678046. Epub 1998/07/25. eng.
- [12] C. Mina, W.E. Garrett Jr., R. Pietrobon, et al., High tibial osteotomy for unloading osteochondral defects in the medial compartment of the knee, *Am. J. Sports Med.* 36 (May (5)) (2008) 949–955, PubMed PMID: 18413679. Epub 2008/04/17. eng.
- [13] Y. Fujisawa, K. Masuhara, S. Shiomi, The effect of high tibial osteotomy on osteoarthritis of the knee. An arthroscopic study of 54 knee joints, *Orthop. Clin. North Am.* 10 (July (3)) (1979) 585–608, PubMed PMID: 460834. Epub 1979/07/01. eng.
- [14] H. Ogawa, K. Matsumoto, T. Ogawa, et al., Preoperative varus laxity correlates with overcorrection in medial opening wedge high tibial osteotomy, *Arch. Orthop. Trauma Surg.* 136 (October (10)) (2016) 1337–1342, PubMed PMID: 27443167.
- [15] R. Martin, T.B. Birmingham, K. Willits, et al., Adverse event rates and classifications in medial opening wedge high tibial osteotomy, *Am. J. Sports Med.* 42 (May (5)) (2014) 1118–1126, PubMed PMID: 24634450.

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