

Case Report

Bone transport procedure as an effective technique in managing large bone defect of tibia

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ABSTRACT

ABSTRAK

Introduction: Bone defects are serious issues in post-severe trauma conditions of the lower limb. Osteomyelitis may arise following untreated or even treated injuries leading to extensive bone resection. In addition, poor soft tissue condition makes the treatment more difficult that sometimes results in amputation and length discrepancy. Bone transport procedure using external fixator is considered as the most beneficial in managing large bone defects as well as soft tissue damage without the need of large amount of bone grafting material, which has high risk of failure.

Methods: We present a serial case of six males and one female, with age ranging from 12-47 years old, experiencing large bone defects of 10 cm or more in the tibia following extensive resection due to severe trauma and osteomyelitis in Fatmawati General Hospital. Seven patients were obtained from 2008 until 2016 with follow-up time of 2 years. Ilizarov frames were applied in all patients to perform bone transport distraction osteogenesis through osteotomy at proximal or distal metadiaphysis area of the rest segment, which subsequently allowed for recovery of poor soft tissue condition. One millimeter a day the distraction performed until docked and compressed at the edge of the rest segment. In patient 2, bifocal transport was conducted from the proximal segment and then continued from the distal segment until docked to each other in the middle. In patient 1, 3, and 4 conversions into internal fixation were performed to shorten the Ilizarov period.

Results: All large bone defects were restored along with soft tissue recovery. In patient 1, 3, and 4, Ilizarov were converted into internal fixation for more comfort and easier exercise. No complications of infection, neurovascular disturbance, non-union and joint stiffness were found.

Conclusions: Bone transport is a safe and effective choice to treat large bone defects of tibia by any cause of trauma complications, mostly osteomyelitis. Ilizarov frame provided stable construction that allowed for transport procedure while enhancing union at the docking site and poor soft tissue recovery. No bone graft was needed to fill the defect in the tibia. Amputation and length discrepancy could, therefore, be avoided.

Pendahuluan: Defek tulang merupakan masalah besar pada kasus pasca-trauma berat ekstremitas bawah. Osteomielitis dapat terjadi akibat cedera yang tidak ditangani atau bahkan cedera yang telah ditangani dan menyebabkan reseksi tulang yang ekstensif. Selain itu, kondisi jaringan lunak yang buruk menjadikan terapi semakin sulit dilakukan yang dapat berakhir pada amputasi dan *length discrepancy*. Transpor tulang menggunakan eksternal fiksasi merupakan teknik yang paling menguntungkan pada tatalaksana defek tulang dan kerusakan jaringan lunak masif tanpa memerlukan graf tulang dalam jumlah besar sehingga meningkatkan resiko kegagalan.

Metode: Kami menyajikan rangkaian kasus yang terdiri atas enam laki-laki dan satu perempuan dengan rentang usia 12-47 tahun, yang mengalami defek tulang 10 cm atau lebih pada tibia setelah reseksi ekstensif disebabkan trauma berat dan osteomielitis di Rumah Sakit Umum Pusat Fatmawati. Tujuh pasien dikumpulkan dari tahun 2008 sampai 2016 dengan waktu tindak lanjut selama 2 tahun. Rangka Ilizarov dipasang pada semua pasien untuk menghasilkan distraksi osteogenesis transpor tulang melalui osteotomi proksimal atau distal area metafisis pada segmen tulang sekaligus memperbaiki kondisi jaringan lunak yang buruk. Distraksi dilakukan dari satu ujung, satu milimeter per hari, hingga bertemu dan terkompresi pada ujung segmen yang lainnya. Pada pasien 2, transpor bifokal dilakukan dari segmen proksimal, dilanjutkan hingga distal, dan bertemu pada titik tengah. Pada pasien 1, 3, dan 4, konversi dengan fiksasi internal dilakukan untuk mempersingkat waktu penggunaan Ilizarov.

Hasil: Semua defek tulang besar diperbaiki bersamaan dengan penyembuhan jaringan lunak. Pada pasien 1, 3, dan 4, Ilizarov dikonversi menjadi fiksasi internal untuk kenyamanan dan prosedur yang lebih mudah. Tidak didapatkan adanya komplikasi infeksi, gangguan neuro vaskular, ketidak-sambungan, dan kekakuan sendi.

Kesimpulan: Transpor tulang adalah pilihan metode yang aman dan efektif untuk terapi defek tulang besar tibia akibat berbagai kondisi trauma, yang seringnya adalah osteomielitis. Rangka Ilizarov menghasilkan konstruksi stabil yang memungkinkan prosedur transpor sekaligus penyambungan pada titik temu, dan juga perbaikan kondisi jaringan lunak yang buruk. Dengan metode ini, graf tulang tidak diperlukan untuk mengisi defek pada tibia. Oleh karenanya, amputasi dan *length discrepancy* dapat dihindari.

Keywords: Large bone defect, bone transport, Ilizarov, outcome

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INTRODUCTION

Bone defect has become a large issue in post-severe trauma conditions.¹ A critical defect is a bone void that will not be filled in by new bone or bone defect that will not heal naturally without intervention. The diagnosis is subjective hence difficult and generally has circumferential loss of >50% or more than 2 cm long.² Significant traumatic bone loss is rarely found. Subcutaneous border in tibial diaphysis is the most frequent area affected. This type of injuries commonly occurs in young adults and with associated soft-tissue loss. There is no widely accepted classification of bone defect, and the most commonly used is the open fracture classification by Gustilo and Anderson.¹ Osteomyelitis may arise following untreated open injury that connects directly into the bone compartments.³ The risk of infection spread increases with time, and amputation is sometimes unavoidable. In Gustillo–Anderson grade III with bone loss is also a hard case to treat. It will lead to bone defect that cause lower extremity discrepancy at a later time.⁴

The management of bone defect resulted from trauma is the same as all fractures. The initial management follows the standard trauma resuscitation protocols. Once the primary survey is completed, the thorough secondary survey is assessed on the injured limbs. Massive muscle loss, severe contamination and vascular injuries are probably the indications for amputation. If the defect is considered viable and a good prognosis is predicted, attempts on limb salvage should be done. The initial debridement and fracture must be stabilized. Debridement is done radically to remove soft tissues and/or grossly contaminated bone. The choice of definitive stabilization and management of bone defect varies individually because of the unpredictable nature of injuries.¹

The goal in bone defect definitive management is solid bone union with acceptable alignment, equal limb length, and function restoration.¹ Bone defect may be managed by bone grafting, bone transport, stem cell application or masquelet techniques. Masquelet techniques and bone transport are contemporary managements of large bone defect.² Masquelet procedures may not be reliable due to bad condition of soft tissues (the wound) caused by severe trauma or infections.

In addition, this technique is hard to perform in conditions of devitalized tissues, which also need to be restored.

Bone transport, also called distraction osteogenesis, involves segment transport of bone controlled by external fixator, for example Ilizarov apparatus or intramedullary device. Bone transport is a reliable method for reconstruction of bone defects in tibia and remains a safe treatment when bone infection occurred.⁵ This technique allows simultaneous management of bone loss, non-union, infection, and deformity. The bone is divided proximally to produce a short segment, which is then gradually moved distally using an external fixator to eventually connects with the distal part. The trailing defects filled with regenerated bone. Docking time is defined as the time of distal bone contact and may be explored and applied with bone graft.¹ The advantages of using this method include reliability, minimal risk of further soft tissue injury, weight-bearing ability, and absent of limits regarding the defect size. The main disadvantages are reconstruction period and the risk of pin tract infection.²

The majority of complications occurred may relatively be treated by simply non-operative or a straightforward operative procedure. Other studies have documented varying results of complications with most of the soft tissue complications, including wound breakdown and joint contractures, were not very common.⁵ Prolonged treatment and repeated prescriptions needed from surgery make this method not suitable for socially disadvantaged individuals, patients with mental illness or those without family support.⁶

This case series present cases of large bone defects of tibia with poor condition of soft tissue treated with bone transport by using Ilizarof ring external fixator. Evaluation of the outcome will be revealed and discussed.

METHODS

We present a serial case of 6 males and 1 female, with mean age of 25.6 years old, ranging from 12 to 47 years old, with chief complaint of large bone defects due to severe open fracture with bone loss or non-vital fragment and post-bone segmental resection due to osteomyelitis in Fatmawati General Hospital. Seven patients were obtained from 2008 until 2016 with 2-year follow up period.

Name (initial)	Age (Years old)	Gender	Defect length (cm)	Diagnosis	Docking time (month)	Consolidation time (month)
Patient 1	21	M	10	Open fracture	3	6
Patient 2	13	M	19	Severe crush injury	5	9
Patient 3	28	M	12	Open fracture	3	6
Patient 4	12	M	16	Osteomyelitis	4	8
Patient 5	47	M	23	Osteomyelitis	5	9
Patient 6	43	F	22	Osteomyelitis	5	9
Patient 7	15	M	20	Osteomyelitis	5	9
Mean	25.6		17.42		4.28	8
(SD=14.39)						

Table 1. Sample characteristics

X-ray confirmed large bone defects with mean value of 17.42 cm (ranging from 10-23cm). We then performed bone transport procedure resulting in distraction osteogenesis using Ilizarov frame through osteotomy at proximal or distal metadiaphysis area of the rest healthy bone segment. One millimeter a day divided into four times quarter every 6 hours of transport segment was distracted until docked and compressed at the edge of the rest segment. In patient 2, bifocal transport procedure performed from the proximal segment and continued from the distal segment and docked to each other at the middle site. (Figure 2) Intramedullary wire facilitated the direction or tracking the transport of the segments to the docking site. (Figure 3, 4) In patient 1, 3, and 4, conversions into internal fixation were performed to shorten the Ilizarov period. (Figure 1, 3, 4)

The large bone defects were restored in varying range. From the follow-up imaging (X-ray), it was confirmed that new bone had grown and consolidated subsequently. (Table 1) And no bone graft was needed to fill both the defect and the docking site.

By using the Ilizarov frame, all kind of poor soft tissue conditions had a chance to be treated secondarily without any prior plastic procedure except the skin graft. (Figure 2, 5, 6) All patients achieved recovery and continued the transport of bone segment throughout the procedure.

During the procedure, the patients were rehabilitated to exercise their knees and ankle joints and only allowed for partially weight-bearing. No complications of infection, neurovascular disturbance, non-union and joint stiffness were found.



Figure 1. Patient 1, 21 yo, Open fracture of right distal tibia with bone loss. Before (Left) and after (Right) treatment.



Figure 2. Patient 2, male 13 yo, Severe crush injury on left tibia with large necrotic bone and massive skin loss. Bifocal transport from proximal segment initially (upper) followed by distal segments until docked and compressed at the middle area (bellow).



Figure 3. Patient 3, 28 yo, open fracture of left distal tibia. Before (left) and after (right) treatment.

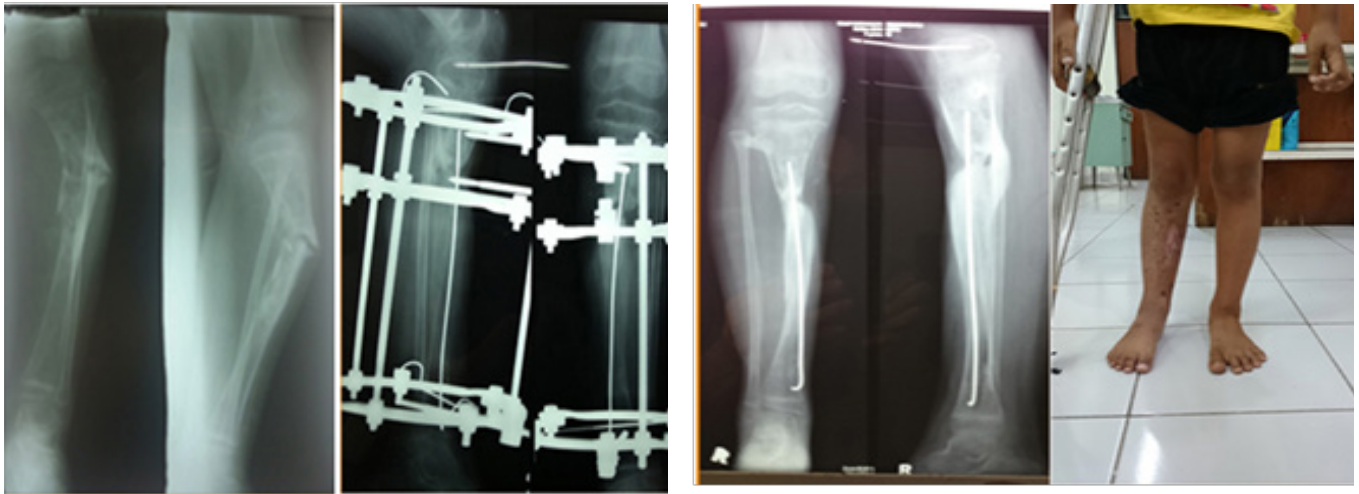


Figure 4. Patient 4, 12 yo, chronic osteomyelitis. Before (left) and after (right) treatment.

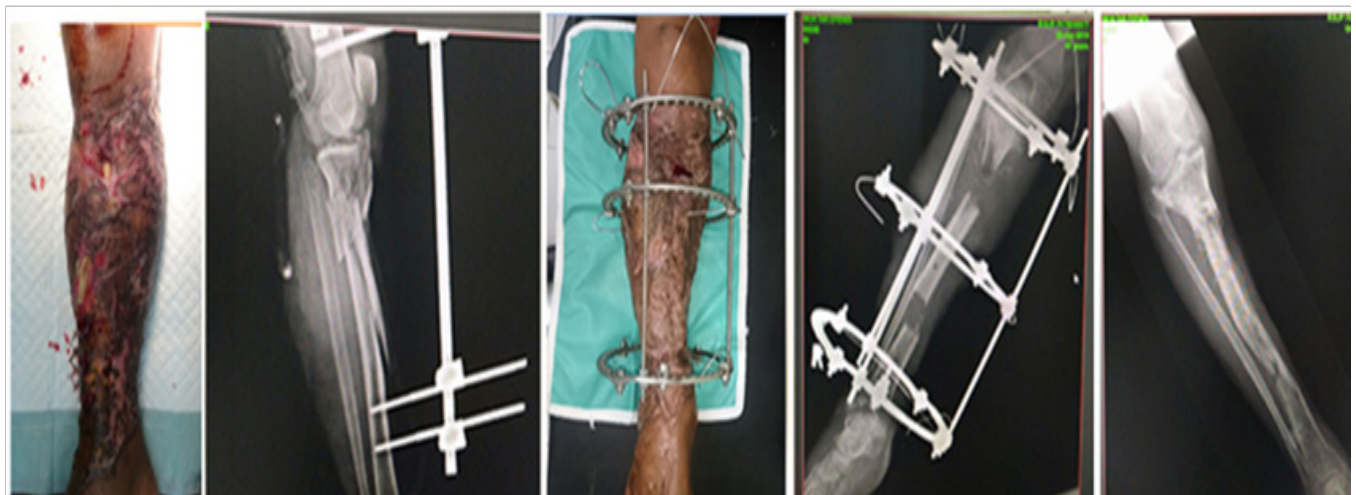


Figure 5. Patient 5, 47 yo, chronic osteomyelitis. Before (left) and after (right) treatment.

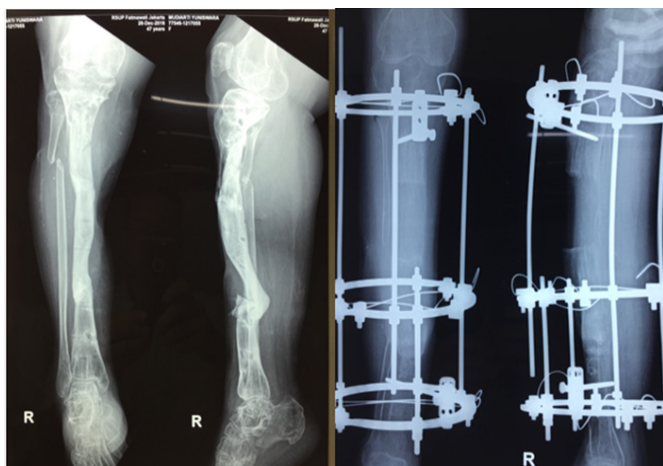


Figure 6. Patient 6, 43 yo, chronic osteomyelitis. Before (left) and after (right, below) treatment



Figure 7. Patient 7, 15 yo, with post traumatic osteomyelitis and poor soft tissue condition proximally. Bone transport performed from proximal segment

DISCUSSION

Radical debridement was performed first and consisted of excision of the whole necrotic and infected soft tissue and bone. Ilizarov frame were applied in all patients as a stable construct along with dynamic properties to perform distraction osteogenesis through bone transport procedure. The procedure started one week after the application of Ilizarov frame with osteotomy at metadiaphysial area of the rest proximal (Figure 1, 3) or distal segment (Figure 2, 4, 5, 6), which was considered as the latent period when abundant neovascular network was formed. A Quarter circle of 10 mm screw every 6 hours was performed to distract the transport segment. This will achieve one mm of bone transport every day

until it docked to the edge of the heading segment. Compression was applied at the docking site to enhance the union as the superiority of the construct. Callus was then formed along the process of distraction osteogenesis and become consolidated within 2-3 months following the docking time. Consolidation was defined as 3 cortical views on minimally 2 projections on X ray, which is the safe time to remove the frame.

In patient 2, bifocal transport procedure performed from the proximal segment, and continued from the distal segment and docked and compressed to each other at the middle site. (Figure 2)

In patient 1, 3, 4, Ilizarov frames were converted into internal fixation: plate and screw, IM nail, or intramedullary wire, to shorten the Ilizarov period for more comfort and easier exercise. (Figure 1, 3, 4)

Ilizarov frame also allowed the treatment of poor soft tissue conditions. Secondary healing occurs on skin loss area or dehiscence wound following soft tissue procedure, such as split thickness skin graft (STSG). (Figure 2, 5, 6) With this method using the Ilizarov frame, bone defect restoration and soft tissue recovery could be managed in one single step. The transport segment could adapt in its track to the soft tissue condition. In Patient 2 with severe skin loss following massive STSG only, the transport segment still could find the way below it. Bifocal transport performed initially from the proximal segment stocked at middle area and then continued by transporting the distal segment until docked and compressed to each other (Figure 2).

Bone graft was almost not needed in this procedure. Usually, a large amount of graft should be prepared to fill such large defect. However, there is limitation in the source of the graft and the cost is high when using an allograft or combined with BMP or stem cells. Hence, this still has the risk of failure or non-union.

Another procedure, such as Masquelet technique, is hard to perform in poor soft tissue conditions which also needs to be restored. Masquelet procedures and bone graft are not reliable due to bad conditions of soft tissues (the wound) due to severe trauma or infections.

During the bone transport procedure, rehabilitation program was performed to avoid stiffness of the knee and the ankle joint and allowed for partial weight-bearing,

which was possible due to good stability of the Ilizarov frame and enhanced the union at the docking site. (Table 2)

No neurovascular disturbance occurred with meticulous application of the frame regarding safe pin placement and appropriate frequency of gradual distraction, which was 1 mm a day divided into four times quarter every 6 hours. (Table 2)

The pin treatment was mandatory to be performed every day using normal saline followed by compression-closure or antibiotics, if necessary. All patients still showed slight to moderate pin tract infection that readily subsided after removal of the pin. (Table 2)

CONCLUSION

In all patients, large bone defects of tibia by any cause of trauma complications, mostly osteomyelitis accompanied with poor soft tissue conditions, could be effectively treated with bone transport procedure using Ilizarov frame. The stable construct allowed for distraction osteogenesis and enhanced the union at the docking site, which was followed by poor soft tissue recovery. No bone graft was needed to fill the defect in the tibia and no complications of neurovascular disturbance, infections, non-union and joint stiffness were found in this procedure. Advantageously, amputation and length discrepancy could be avoided.

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