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Case report

Low profile external fixation using locking compression plate as treatment option for management of soft tissue problem in open tibia fracture grade IIIA: A case series

Luthfi Hidayat [a,b], Aditya Fuad Robby Triangga [a], Caesarean Rayhan Cein [a,*], Ardicho Irfantian [a], Bernadeta Fuad Paramita Rahayu [a], Alan Philips Resubun [a], Rahadyan Magetsari [a]

[a] Orthopaedics and Traumatology Department, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada/Dr. Sardjito Hospital, Yogyakarta, Indonesia
[b] Orthopaedics and Traumatology Department, Universitas Gadjah Mada Academic Hospital, Yogyakarta, Indonesia

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ABSTRACT

Introduction: External fixators are the most common fixation method for fractures with substantial soft tissue compromise. Nonetheless, the frames used are bulky, uncomfortable, and cumbersome to patients. Using locking compression plate (LCP) as an external fixator (low profile external fixation/LPEF) owns the same properties as standard external fixators but may overcome disadvantages because of its low-profile frame. This case series aims to evaluate the results of LPEF for the management of tibia fracture with soft tissue compromise.

Presentation of cases: We reviewed five patients at our centers who underwent surgery in 2020 with the application of LPEF. These patients had grade IIIA open tibia fracture with respective complications. The follow-up duration was 6 months post-operative in which we assessed Southampton Wound Assessment Scale (SWAS), laboratory infection markers, radiographic evaluation, and the Lower Extremity Functional Scale (LEFS). The results showed all wounds healed and cases with infection showed tendency of resolving, alongside varying degree of bone healing. The implant was well tolerated for patients and the functional outcome was overall good (mean LEFS: 71.26%).

Discussion: The LPEF is fortuitously lightweight and more convenient for patients to ambulate, thus the compliance of early functional exercise is more likely to happen.

Conclusion: Application of LPEF can be considered as an option for treating soft tissue compromised tibia fracture. In our experience, it is low profile, more acceptable to the patients, and displayed favorable outcomes especially in terms of soft tissue or skin healing and infection resolution.

1. Introduction

High energy, open fractures of the tibia are associated with significant soft tissue injury and prone to develop infection [1]. Aggressive antibiotics, debridement, and stabilization of fracture are the main treatment for this condition [2]. Adequate bony stabilization should be achieved as instability may further compromise the soft tissue and interfere with the elimination of infection [3,4].

External fixators are the most commonly used fixation method for cases of fracture with substantial soft tissue compromise. It can preserve the soft tissue and bone vascularization as well as providing inspection of the soft-tissue which is necessary for fracture healing. Associated treatments such as dressing, irrigation, skin and bone graft are therefore possible while maintaining bone fixation [5]. Nonetheless, the external fixator frames used have several disadvantages [6,7]. They are bulky, uncomfortable, and cumbersome to the patients, causing inconvenience in day-to-day activities and hindering ambulation. Also, disturbance of gait often occurs while trying to clear from the opposite limb.

External fixation using locking compression plate (LCP) had been considered as an alternative to standard external fixators. LCP differs from conventional plates, in which the latter depend on friction between screws and bone for stability. LCP has stable connection of locking screws to the plate, providing angular stability of the fixation, similar to the concept of external fixator. This property leads to the idea of using LCP as an external fixator (low profile external fixation/LPEF), that may overcome the external fixation disadvantages because of its low-profile

* Corresponding author.
E-mail address: rayhan.cein@yahoo.com (C.R. Cein).

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frame. The frame can be constructed in close proximity to the skin so that it can be covered under clothing. In this way, it will be more comfortable and well tolerated by patients. Kloen called this technique as "supercutaneous plating" [8].

A number of publications have reported satisfactory results with this technique. The indications were infected non-union fracture, open fracture, closed fracture, as well as adjunct in distraction osteogenesis [9]. However, the use of locking plate as external fixator remains an unorthodox treatment that is not generally recognized. Furthermore, most established studies focus mainly on the fracture union aspect.

Therefore, this case series aims to evaluate the results of LPEF for the management of tibia fracture with soft tissue compromise, especially in regards to wound healing in our patients.

2. Case series

We studied five patients who underwent surgery using LPEF in Dr. Sardjito General Hospital and Universitas Gadjah Mada Academic Hospital. The LPEF technique was applied to three patients with infected non-union (Figs. 1 and 3), one patient with fixation failure accompanied with infected wound (Fig. 2), and one patient with grade IIIA open fracture. The procedures were done in 2020 by an orthopaedic surgeon who specializes in the lower extremity. All patients were non-smoker and had no history of other comorbid. The patients' characteristics, diagnosis, and surgical procedure are described in Table 1.

Six months after LPEF application, the patients were followed-up, during which we monitored wound healing by the Southampton Wound Assessment Scale (SWAS); clinical signs of infection and inflammation; laboratory inflammatory markers for infection using leukocyte count, erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP); radiographic progress of bone healing; and functional outcome using the Lower Extremity Functional Scale (LEFS). In addition, we also noted whether the patient was experiencing any pain or discomfort associated with the applied implants.

At the time of follow-up, all wounds have been healed, no signs of infection or inflammation were found, no disturbing pain or discomfort was experienced, and all patients were fully weight bearing. The laboratory, radiology, and LEFS results are presented in Table 2. The laboratory examination revealed four patients had normal leukocyte count as well as decreasing CRP to normal values. One patient had achieved union and the rest had signs of callus formation. The average LEFS score was 74.51% (range: 55–95%). Neither osteofixation failure nor redisplacement of the fracture was found for all patients.

This case series has been reported in line with the PROCESS Guideline at the end of the methods section [10].

Fig. 1. A 67-year-old man (Patient 1) was admitted to our center following a motorcycle accident. He was inflicted with a grade IIIA right open tibial plateau Schatzker VI (A). Initially, the patient was treated with debridement and ORIF using double plating technique (B). Unfortunately, 4 years after the procedure, the patient came back with the complaint of pain and discharge at the former fracture site. Our physical and supporting examination showed signs towards osteomyelitis developing giving way to infected nonunion of the fracture site (C). We then went on to perform debridement and conversion from internal to external fixation with 7-hole proximal lateral tibial (PLT) locking plate (D). Six months postoperative, the infection had ceased and the patient was able to stand without any difficulty (E). The follow-up radiographic showing bony union has not been achieved, even though callus formation was developed around the fracture site (F).

Fig. 2. A 20-year-old college student (patient 2) came to our emergency department after a motorcycle and car collision. He suffered multiple traumas among which was a grade IIIA open proximal third tibia fracture and segmental fibular fracture (A). The patient was managed with debridement and ORIF with 6-hole Tibial Lateral Condyle (TLC) plate (B). Two months postoperative, the patient presented with a wound at the distal most part of the former surgical site, leaving the plate exposed (C). Radiographic appearance showing fixation failure and no furthering of bone healing (D). After thorough debridement and implant removal, we corrected the deformity and placed a 5-hole TLC locking plate as an external fixator (E). Six months postoperative, the infection had stopped, the wound had healed, and the patient was able to perform daily activities (F). Radiographic evaluation displayed bony union (G).

3. Discussion

This study describes our experience in using the LPEF technique to treat tibia fractures complicated with infection as well as to directly treat grade IIIA open tibia fracture.

Using LCP as an external fixator owns the same properties as a standard external fixator. Regardless of the type of fixation, a close distance of the load carrier (bone plate or linkage) from the bone provides stronger structural stiffness. Greater plate thickness also would greatly enhance the axial and bending loading capacity. Both these feats hint that from morphological and biomechanical perspective, LPEF is comparable to that of standard external fixators [11]. However, LPEF overcomes external fixation disadvantages because of its low-profile frame.

From our experience, the outcome of LPEF was promising, mainly on wound healing and infection resolution. While radiographic evaluation showed varying results for the five patients included in this study, all cases with infection displayed a tendency of resolving and all the wounds healed. Moreover, there were no patients that acquired pin tract infection or skin irritation.

Similar results had been reported by previous studies. Tulner et al. reported all patients in their study showed infection-free and well-healed wounds at the latest follow up (range: 4–31 months) [3]. Generally speaking, the principle of external fixation in regards to wound or soft tissue is providing stability to the fracture site that prevent further injury to the tissue around it. In that sense, the stability of LPEF was comparable to that of standard external fixators, nonetheless LPEF is potentially superior in terms of facilitating the wound or soft tissue healing [11]. LPEF is fortuitously lightweight and more convenient for patients to ambulate, so that the compliance of early functional exercise is more likely to happen [3]. During the repair and remodeling phase of tissue healing, early functional exercise has the benefit of accelerating restoration of tissue structure and function [12].

Compared to the other fixation method that also aimed to preserve the soft tissue such as minimal invasive subcutaneous plate, LPEF resulted in shorter operative time, length of hospital stay, and union time [7]. It has the potential to be done as a one-stage reconstruction, decreasing the hospital admission and cost compared to two-stage reconstructions. For that reason, we also considered this technique to be beneficial when used during the COVID-19 pandemic, as the shortest possible hospital stay duration is recommended [13].

In our study, the patients reported that the implant was not causing any disturbing pain or discomfort. They were fully weight-bearing at the latest follow-up and their functional outcome was overall good and comparable to the earlier studies [3,14]. Two patients who scored 55% and 56% were both elderly and age is negatively correlated with the

Table 1
Patients' characteristics, diagnosis, and the received surgical procedure.

Patient	Age, sex	Initial diagnosis	Associated injury	Previous surgical procedure	Complication	Infecting agent	Definitive treatment
1	67, M	Grade IIIA open tibial plateau fracture Schatzker VI	Subarachnoid hemorrhage, Lefort type II fracture	Debridement, ORIF using double plating technique (a T-plate and a TLC plate)	Infected nonunion (4 years post initial surgical procedure)	*Candida albicans*	Debridement, implant removal, application of LPEF using 7-hole proximal lateral tibial (PLT) locking plate
2	20, M	Grade IIIA open proximal third tibia fracture	Cerebral edema, pulmonary contusion, closed fracture of the right 2nd rib, and closed fracture of the middle third of the right femur	Debridement, ORIF using 6-hole TLC plate	Fixation failure with infected wound (2 months post initial surgical procedure)	*Morganella morganii*	Debridement, implant removal, application of LPEF using 5-hole TLC locking plate
3	25, F	Grade IIIA open fracture of the middle third of the right tibia with skin degloving	Grade IIIA open fracture of the proximal third of the right fibula, open partial rupture of the right extensor digitorum longus muscle belly	First surgery: Debridement and external fixation Second surgery: Internal fixation using 11-hole narrow plate with bone graft as the patient developed atrophic non-union (10 months after the first surgery)	Infected non-union (2 years after the second surgical procedure)	*Acinetobacter baumannii* and *Pseudomonas aeruginosa*	Debridement, implant removal, application of LPEF using 11-hole narrow locking plate
4	66, M	Grade IIIA open fracture of distal third of the right tibia in patient with union of the right proximal tibia post ORIF	Grade IIIA open fracture of middle third of the right fibula, close fracture of distal end of the left clavicle Neer type I	ORIF with T-plate (16 years earlier)	–	–	Debridement, implant removal on the united proximal tibial fracture, stabilization of the recent fracture with LPEF using a 10-hole locking narrow plate
5	21, M	Grade IIIA open fracture of the middle third of the right tibia	Grade IIIA open segmental fracture of middle third of the right fibula	Debridement, ORIF with 11-hole narrow plate	Infected non-union (2 years post initial surgical procedure)	MRSA and *Pseudomonas aeruginosa*	Debridement, implant removal, application of LPEF using 11-hole narrow locking plate

M: male; F: female; ORIF: open reduction and internal fixation; TLC: tibial lateral condyle; LPEF: low profile external fixation; MRSA: methicillin-resistant *Staphylococcus aureus*.

Fig. 3. Satisfactory progress of wound healing in a 21-year-old male sustained infected non-union of the right tibia treated with LPEF (Patient 5). Progression: 2 weeks after surgery (A), 1 month (B), 2 months (C), 6 months (D).

LEFS scores [15]. Increasing age is also associated with decreased fracture healing potential [16].

Despite the satisfying results, the locking plates in Indonesia are far more expensive than the standard external fixation. The average cost of locking plates is at least twice that of standard external fixators. Therefore, the application of LPEF is still limited. To the best of the author's knowledge, this is the first report describing the application of LPEF in Indonesia.

Further studies with larger sample size should be conducted to further evaluate the outcome and the cost-benefit analysis, as well as supplementary biomechanical analysis. Hopefully, this study can serve as a preliminary to larger studies that could offer a potential area of

Table 2
SWAS laboratory, radiology, and LEFS results.

Patient	SWAS	Leucocyte count ($\times 10^9$/L)	CRP (mg/L)	ESR (mm/h)	Radiographic evaluation	Osteofixation failure	LEFS (%)
1	0 (normal healing)	6.12	<5	40	Union (−), callus (+)	No	55.0
2	0 (normal healing)	6.58	<5	2	Union (+)	No	95.0
3	0 (normal healing)	9.43	<5	45	Union (−), callus (+)	No	78.8
4	0 (normal healing)	7.38	5	21	Union (−), callus (+)	No	56.25
5	0 (normal healing)	12.3	17.1	45	Union (−), callus (+)	No	87.5

CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; LEFS: Lower Extremity Functional Scale.

collaborative research on the development of more affordable, low-profile external fixators that can be used as alternative to the standard external fixators.

4. Conclusion

Application of LPEF can be considered as an alternative to standard external fixation. It is low profile and more acceptable to the patients, thus bode better for postoperative mobilization and functionality. In our experience, all cases displayed favorable outcomes in regards to wound healing and infection resolution and thus provide an attractive treatment option for soft tissue compromised tibia fracture.

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Hidayat, L: Conceptualization, Supervision.
Triangga, AF: Conceptualization, Supervision.
Cein, CR: Conceptualization, Reviewing, Editing.
Irfantian, A: Writing, Reviewing, Editing.
Rahayu, BF: Writing, Reviewing, Editing.
Resubun, AP: Editing, Revisions.
Magetsari, R: Critical appraisal.

Declaration of competing interest

The authors report no declarations of interest.

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