

Case Report

Open Access

A Bridge Too Far: A LISS Non-Union

H.C. Fayaz* and R. M. Smith

Department of Orthopaedic Surgery- Massachusetts General Hospital, Trauma Service, Yawkey Center 3C, 55 Fruit Street, Boston, Massachusetts 02114, USA

Abstract

A non-union of the tibia developed after the use of a LISS with a long bridging segment as a pure relative stability device for a comminuted tibial fracture. It was treated primarily by stiffening the construct which led to union. It is suggested that the non-union developed because of strain concentration and healed when this was neutralised.

The case illustrates an interesting failure mode, perhaps adds light to the biomechanical features of a LISS plate and suggests the role of strain in the process of bony healing.

Keywords: Non-union; Strain theory; Less invasive stabilization system; Stability

Introduction

Complex tibial fractures are challenging to treat and offer a number of therapeutic options. While external fixation may minimize some of the complications associated with more invasive treatment it implies a high risk of pin site infections, prolonged treatment time and long-term disability that confers significant morbidity and poor patient acceptability. Nails sound popular, are inserted biologically and present the primary choice for most diaphyseal fractures but can be difficult to place in more proximal fractures when they often build deformity into the reduction during insertion. The Less Invasive Stabilization System (LISS) is easier to use in proximal fractures with a small proximal segment. It combines both a minimally invasive approach and a fixed angle plate. It minimizes the soft tissue disturbance in the metaphyseal and diaphyseal regions. It also offers a high degree of angular stability by allowing the locking head screws to be inserted in “diverging” and “converging” directions into the proximal tibial segment of the implant [1]. When used in bridging mode there is no consensus regarding the length of the bridging segment and the optimum stability to aim to provide to the fracture. We have observed a specific complication where use of this bridging technique resulted in a non-union at a single site of stress concentration following persisting motion at the fracture site [2,3]. It was successfully treated by stiffening the construct. This clearly illustrates an interesting failure mode, which elucidates the biomechanical features of a LISS plate and the process of bony healing.

Case Report

A 60-year-old grave digger presented to our clinic with an open (grade 3A) segmental (AO-OTA 42-C3) tibial fracture following a severe crush injury sustained at work. After initial irrigation, debridement and application of an external fixator, a delayed primary closure associated with bony stabilization was performed with a 13-hole LISS plate at 48 hours. The LISS was employed because of the small proximal segment, its locking capabilities and the ability to insert it biologically to span the complex fracture pattern. The fracture pattern necessitated a long bridging segment, and 7 holes of the LISS were left empty (Figure 1 and 2).

The soft tissues and the majority of the bony fragments healed without incident, but three months later a persisting non-union was present at one site in the comminuted fracture (Figure 3). At non-union surgery, it was expected that the LISS would be loose but it was not. However, there was visible motion at the non-union site with clear bending of the central segment of the LISS despite it still being well fixed to the bone at each end. It was considered that the non-union

was associated with the motion at the site of focal strain concentration, as suggested by Perren’s theory of fracture healing. The non-union was treated by increasing the stability by the insertion of an additional three screws into the LISS (where there was now healed bone) and the application of a medial unilateral external fixation frame (Figure 4). Cancellous bone graft was also added.

Postoperative recovery was uneventful, and the patient was discharged on the fourth day.

Two months later, the tibia was found to be clinically and radiologically healed. The external fixator was removed, and the patient was able to bear weight without pain. He was subsequently discharged with a good functional outcome (Figure 5).

The patient was informed that data relating the case would be submitted for publication and he consented.



Figure 1: Anteroposterior radiograph of the left lower extremity. External fixation of a segmental comminuted fracture of the mid tibial shaft is in progress. External fixation pins extend through the proximal and distal tibial shaft. An associated segmental fracture of the fibula is shown.

***Corresponding author:** Hangama C. Fayaz, Department of Orthopaedic Surgery -Massachusetts General Hospital, Harvard Medical School, Trauma Service, Yawkey Center 3C, 55 Fruit Street, Boston, Massachusetts 02114, USA, Tel: 617-726-9111; Fax: 617-726-8214; E-mail: dr.hana.fayaz@hotmail.de

Received January 26, 2012; **Accepted** January 31, 2012; **Published** February 05, 2012

Citation: Fayaz HC, Smith RM (2012) A Bridge Too Far: A LISS Non-Union. J Trauma Treatment 1:110. doi:[10.4172/2167-1222.1000110](https://doi.org/10.4172/2167-1222.1000110)

Copyright: © 2012 Fayaz HC, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.



Figure 2: Anteroposterior radiograph of the left lower extremity. It presents a segmental comminuted fracture of the left tibial diaphysis with distraction of the mid segment fragment and the distal fragment. The tibial fracture is fixed with an LISS plate and multiple cortical screws.



Figure 3: Anteroposterior radiograph of the left lower extremity. It shows a large segmental fracture fragment that is mildly displaced and angulated medially. A continued distraction of the fracture fragments with no significant bony bridging is presented.

Discussion

Surgical treatment of complex open tibia fractures is difficult and carries high complication rates [4]. Plates, screws, intramedullary nails, condylar blades, and external fixators have been used to treat both the primary injury and non-unions [5-10]. External fixation is often used as an initial damage control procedure for the soft tissues and the definitive fixation implanted at a second procedure.

The use of a tibial LISS has been described by a number of authors. While Gosling et al. observed some difficulties with the technique they concluded that unilateral locked screw plating is an effective option for the treatment of problematic fractures of the tibial plateau that are linked with soft-tissue injury and metaphyseal comminution [11]. Reporting on 23 cases of open acute segmental tibial fractures that were treated with a long tibial LISS plate similar to that described in this report, Reynders described good bone healing outcomes considering that the enhanced elasticity of the bone-plate complex without any high degree of instability of the intercalary bone segment contributed to improved bone healing [12].

Similar results and the use of a LISS after initial external fixation has also been described by Ma et al. [13]. If the primary bone fixation fails to achieve union there is no single consensus on the best way of treating non-union successfully.

There are enthusiasts for a wide variety of techniques including mechanical stabilisation with internal or external devices or biological stimulation with a number of devices or agents ranging from ultrasound or electrical stimulation to bone graft or application of highly active biological stimulants [6,9,10,14]. The range and variety of techniques available suggest that none is superior and that those that work many may be addressing the same basic principles leading to increased stability and the biological stimulation of bone healing. The most dramatic technique is perhaps the use of the Ilizarov device which has particular advantages for bone transport to fill massive bone defects [15]. As is often the case, failure is more educational than success and in this situation seems to illustrate the effect of mechanics on bone healing. The failure described seems to demonstrate an element of Perren's strain theory of bone healing, as the comminuted segment healed until only one fracture plane was left and the excess strain was concentrated at one site. This focal strain as allowed by the flexible implant was then too great to allow bone healing [2,3]. The concept is further illustrated by the healing of the non-union after the construct was stiffened. Whereas the use of bone graft spoils the experiment, we did not feel courageous enough to simply stiffen the construct although with ongoing experience would do only that in the absence of necrotic bone or a segmental defect. Despite the initial non-union, we remain optimistic that unilateral locked plating inserted biologically is the best technique for bridging complex meta-diaphyseal fractures.



Figure 4: Anteroposterior radiograph of the left lower extremity. It demonstrates a medially positioned external fixator in place on the tibia. The fracture of the tibial midshaft is spanned by a lateral compression plate and screws. Bone graft has been added at the tibial fracture site.



Figure 5: Anteroposterior radiograph of the left lower extremity. It demonstrates a solid bony bridging of the tibia. Radiographic union is evident.

References

1. Sommer C, Schuetz M, Wagner M (2007) Internal Fixator. In: Ruedi TP, Buckley RE, Moran CG (ed) AO Principles of Fracture Management. Thieme 320-335.
2. Perren SM (1979) Physical and biological aspects of fracture healing with special reference to internal fixation. Clin Orthop Relat Res 138: 175-196.
3. Perren SM (2002) Evolution of the internal fixation of long bone fractures. The scientific basis biological internal fixation: choosing a new balance between stability and biology. J Bone Joint Surg Br 84: 1093-110.
4. Stannard JP, Finkemeier CG, Lee J, Kregor PJ (2008) Utilization of the less-invasive stabilization system internal fixator for open fractures of the proximal tibia: A multi-center evaluation. Indian J Orthop 42: 426-430.
5. Carpenter CA, Jupiter JB (1996) Blade plate reconstruction of metaphyseal non-union of the tibia. Clin Orthop Relat Res 332: 23-28.
6. McKibbin B (1978) The biology of fracture healing in long bones. J Bone Joint Surg Br 60: 150-162.
7. Helfet DL, Jupiter JB, Gasser S (1992) Indirect reduction and tension-band plating of tibial non-union with deformity. J Bone Joint Surg Am 74: 1286-1297.
8. Johnson KD (1987) Management of malunion and non-union of the tibia. Orthop Clin North Am 18: 157-171.
9. McLaren AC, Blokker CP (1991) Locked intramedullary fixation for metaphyseal malunion and nonunion. Clin Orthop Relat Res 265: 253-260.
10. Johnson EE, Marder RA (1987) Open intramedullary nailing and bone-grafting for non-union of tibial diaphyseal fracture. J Bone Joint Surg Am 69: 375-380.
11. Gosling T, Schandelmaier P, Muller M, Hankemeier S, Wagner M, et al. (2005) Single lateral locked screw plating of bicondylar tibial plateau fractures. Clin Orthop Relat Res 439: 207-214.
12. Reynders P (2009) Open acute segmental tibial fracture fixation using the Less Invasive Stabilisation System (LISS): study of 23 consecutive cases. Injury 40: 449-454.
13. Ma CH, Wu CH, Yu SW, Yen CY, Tu YK (2010) Staged external fixation and internal Less-invasive stabilisation system plating for open proximal tibial fractures. Injury 41: 190-196.
14. Fayaz HC, Giannoudis PV, Vrahas MS, Smith RM, Moran C, et al. (2011) The role of stem cells in fracture healing and nonunion. Int Orthop 35: 1587-1597.
15. Abdel-Aal AM (2006) Ilizarov bone transport for massive tibial bone defects. Orthopedics 29: 70-74.