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Case Report

Dynamization of the locking compression plate for treating tibia nonunion: a case report

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Abstract: There have been a large number of clinical studies to approve the application of locking compression plate (LCP) is effective in treatment of comminuted fracture of long bones. However, orthopedists also find stiffness of the LCP construct lead to nonunion by preventing micromotion at the fracture site. Distinctly, treatment of bone nonunion is challenging as a more effective operation mode is always a necessity. The dynamization surgery, which is often applied to intramedullary nails to generate micromotion, may be one possible solution for fracture nonunion that caused by the extremely rigid LCP. We herein introduce a splintered tibiofibular fracture case treated with the LCP but developed into bone nonunion. The patient was treated with dynamization surgery, namely, by taking out three locking screws closest to the fracture site, and then achieved successful bone healing one year later. In this regard, we aimed at understanding the principle of the LCP more in-depth to correctly utilize it for treating complicated comminuted fractures.

Keywords: Dynamization, locking compression plate, bone nonunion

Instruction

Among various techniques that have been applied to restore the integrity of bone after fracture, the LCP is one of the most active ways for immobilizing bone fracture [1]. In terms of the definition of the LCP, it's a biological plate functioned as an alternative internal fixator, which consists of the conventional hole and the threaded hole [2]. It has been recommended as a favorable instrument in treating complex fractures, but incidents of nonunion or refracture occurs when the LCP construct is fixed very rigid [3]. Kubiak *et al*. reported that despite "the good feeling" for its ease of use and firm fixation in operation, the locked plate may fail to obtain bone union as a result of poor new bone quality and nonunion would occur consequently [4]. We hereby applied the concept of dynamization of the plate-bone structure in clinical practice to make it less stiff to stimulate bridging callus formation.

Case report

A 50-year-old man was knocked down by a car side when riding for work, injuring his left leg. On examination of his legs, the physical exam indicated no neurological findings or impaired blood vessels. X-ray plain film showed closed multiple tibiofibular fractures (AO-OTA 42C23) on his left lower limb region (**Figure 1**). Besides, the patient had a smoking history for over 30 years with one pack of cigarettes a day, without other chronic diseases or relevant surgical history. After being admitted, the patient was given calcaneal traction immediately. He was taken to operating room a week after injury for limited open reduction and percutaneous LCP fixation to restore tibiofibular fractures. Successfully, postoperative plain radiography showed good alignment and reduction (**Figure 2**). The patient was evaluated regularly with radiography in postoperative follow-up.

Over four months after the surgery, distal tibia fracture line was vague, while the patient started to walk with weight. About seven months later, distal tibia fracture line disappeared, with fibular fracture line blurred. However, the radiographs and two-dimensional CT taken about one year after the operation have failed to show the sign of union in the proximal tibia fracture line (**Figures 3** and **4**). So, after considering

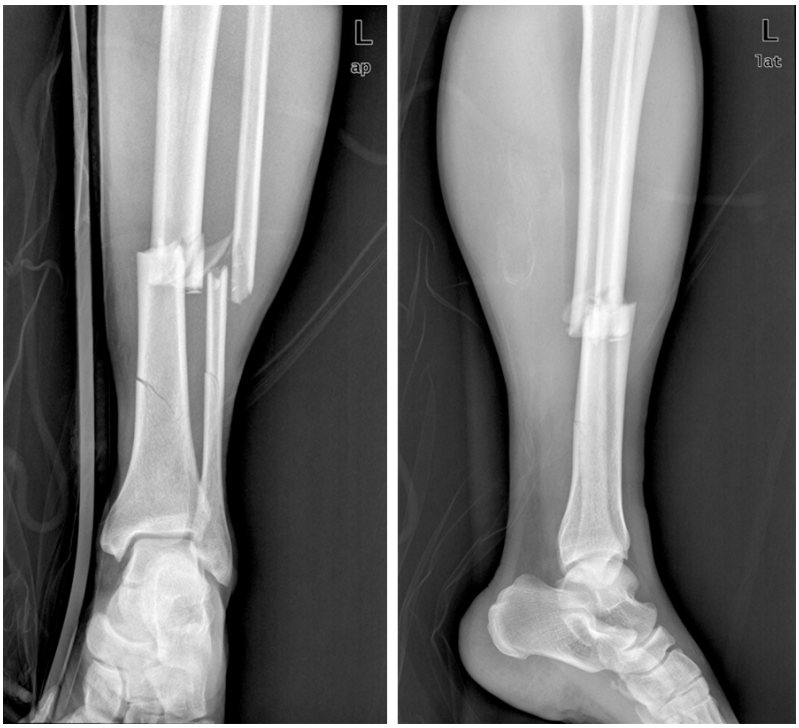

Figure 1. Left tibiofibular fracture (AO-OTA 42C23), on September 4th, 2012.

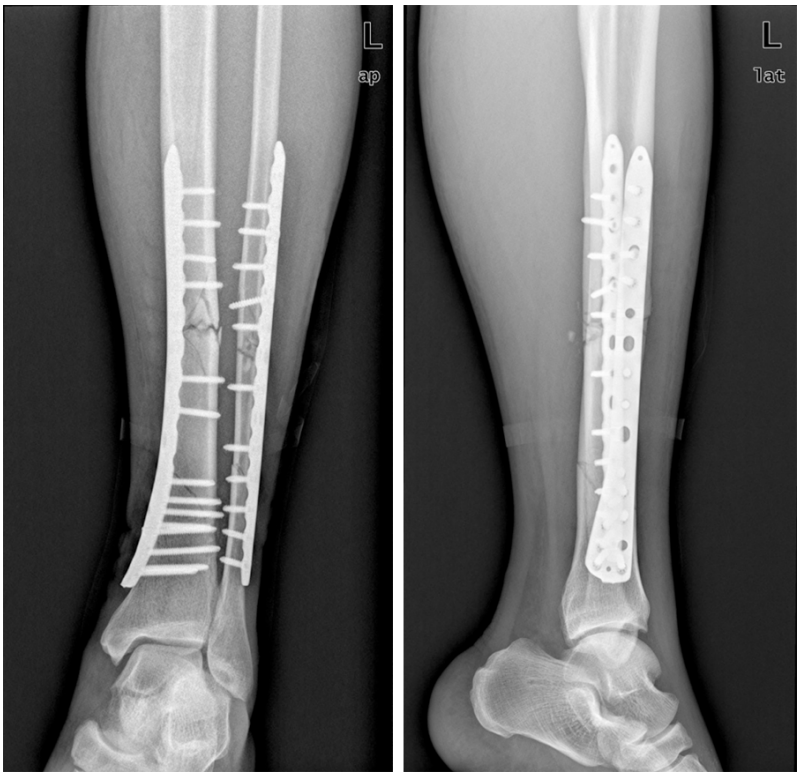

Figure 2. Limited open reduction and percutaneous locking compression plate was performed for fixation, on September 17th, 2012.

carefully and gaining patient's informed consent, we practiced dynamization to the LCP (**Figure 5**), in other words, three locking screws were removed from the center of the LCP [5, 6]. Meanwhile, autologous iliac graft was transplanted to the fracture site for the optimal therapeutic effect. The principle of dynamization was to enhance micromotion in fracture site so as to stimulate callus formation through a given load. Six weeks after dynamization, the broken end displayed callus growth. Radiographs taken three months after dynamization displayed solid fracture healing and bridging callus formed across the gap (**Figure 6**), which means the callus kept increasing and remodeling. So we suggested the patient started walk with weight again. We removed the internal fixation on account of patient's demand since the fracture was healed a year and a half later, but one locking screw broke and remained (refer to the **Figure 7** for details). Up to now, the patient walked with weight painlessly and refracture has not happened again.

Discussion

The LCP therapy and intramedullary nail therapy are two major treatment of comminuted fracture of long bones currently. Dynamization of Intramedullary nail can speed up the process of bone healing in most cases, while the dynamization of LCP was not reported until 2011 by a

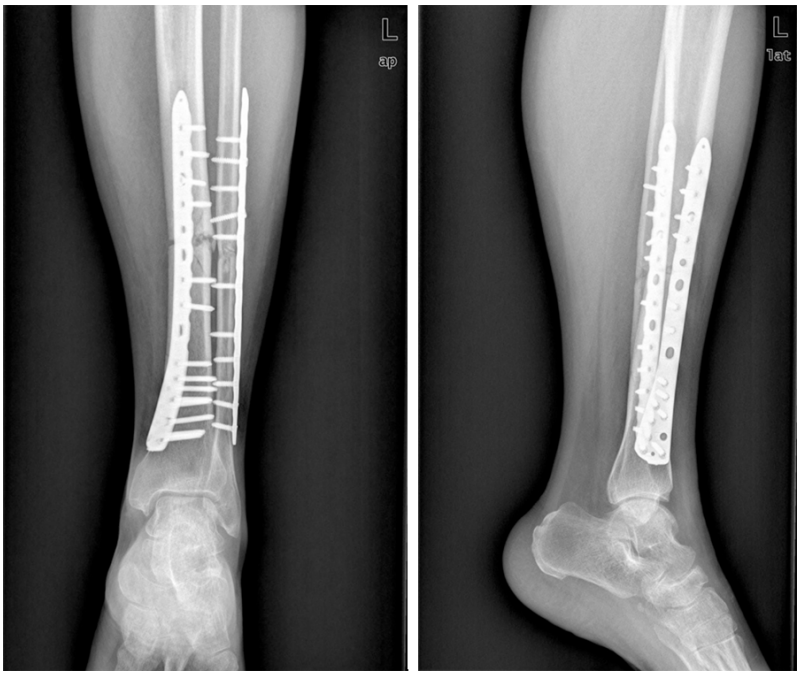

Figure 3. Distal tibia fracture line disappeared and fibular fracture line was vague about one year after the surgery, on October 14th, 2013.

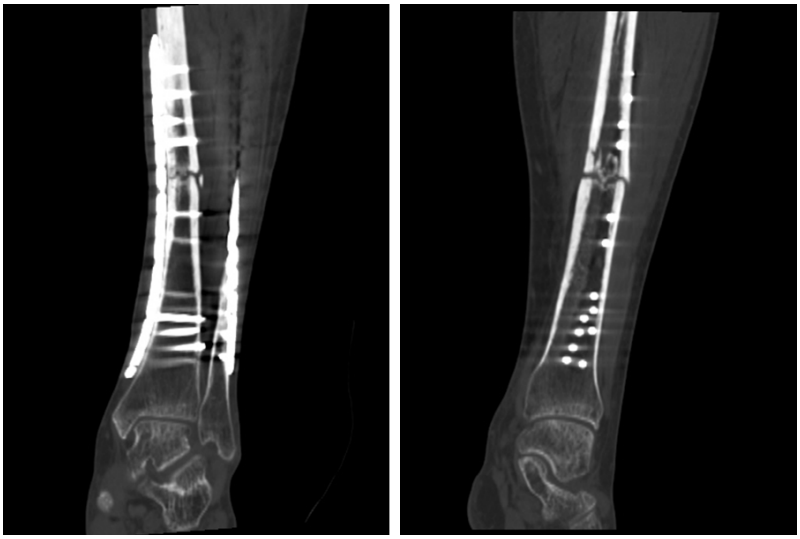

Figure 4. Two-dimensional CT showed bone non-union on October 28th, 2013.

Korean scholar [7]. But poor reduction of fracture and removed lag screws instead of not locking screws for dynamization were two major problems in the report, and there were also some relevant querying reports later [6]. There are few relevant reports of malunion after the LCP treatment published because the internal fixation was in frequenly taken out in other countries, while in China, patients usually ask for removing the internal fixation. That's why the incident of refracture is much more common in China [8]. With the popularization of the LCP treatment in the past decades, the efficacy of LCP in treatment of comminuted fracture of long bones has been recognized, despite some failure cases [9].

It is secondary bone healing mostly when applying LCP to treat comminuted fracture of long bones, which takes a long course. At the early stage, the broken end is relatively stable because stress is bore by the LCP, and primary callus is forming at the fracture end through cell proliferation and differentiation at the same time. Afterwards, woven bone and lamellar bone formed at the middle and later stages through matrix mineralization and deposition, finally, union will be achieved by means of continuously molding and rebuilding. But at later stage, stress shielding as a result of rigid LCP construct may lead to low bone strength, even result in fatigue rupture or loosening of internal fixation, which was rare when treated with ordinary compression plate previously. Meanwhile, if the LCP is removed all at once after fracture union, refracture at the same site tend to occur within a short period of time. It is known that fracture site need comparable stress stimulation at different stages during the healing process. Stress stimulation comes from interfragmentary movement. As the vital biomechanical and biological factor, interfragmentary movement depends on the rigidity of the fixation, load of the operated leg due to gravity and muscles

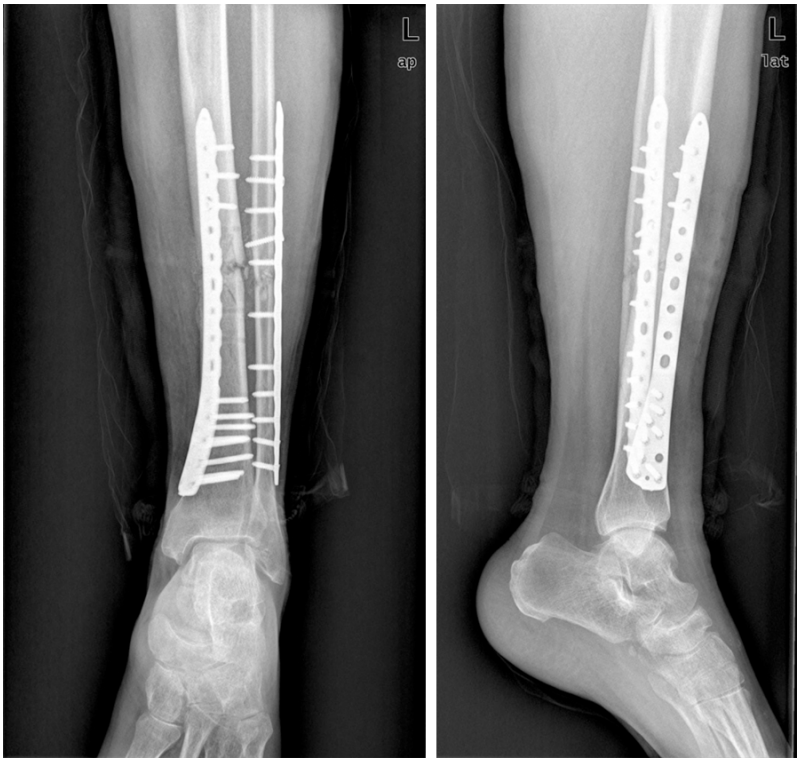

Figure 5. Dynamization surgery: removed 3 locking screws from the center on November 7th, 2013.

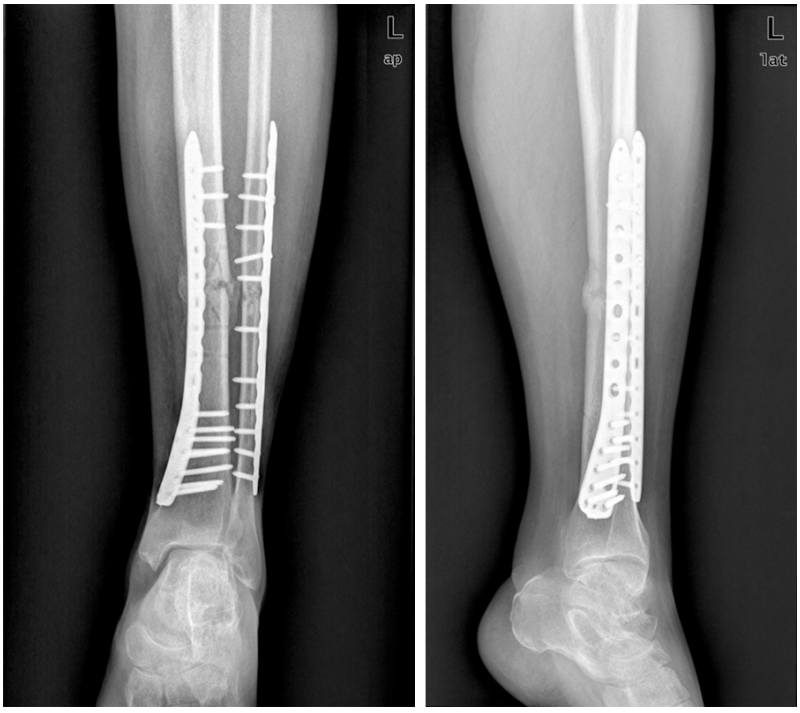

Figure 6. Bridging callus formed three months after dynamization surgery, on February 21st, 2014.

forces, and the number of load cycles [10]. It's worth thinking that whether the LCP shall be taken out gradually in order to train the fracture end step by step for further molding until the patient meet the requirement of bearing loads in daily life completely.

According to Perren's strain theory, bone fracture would have healed in secondary intention under a deformation of 2% to 10% [11]. The broken end would grow into bone malunion or even nonunion as a result of instability if the deformation after internal fixation is over 10%. For such cases, treatments are usually replacing or adding internal fixations (intramedullary nail, locking plate, blocking nail, etc.) to make the broken end become stable. There are also cases with so stable construction of the LCP that make the deformation less than 2%, indicating insufficient stress stimulation at the broken end and a tendency to develop into bone atrophy and nonunion. This kind of case is treated with replacing internal fixation conventionally. Above all, it would speed up the process of fracture healing as well as decrease failure of internal fixation and occurrence of refracture with the help of progressive stress training due to timely dynamization to stiff LCP construction at the later stage of fracture union [12].

Accordingly, we propose a new concept of dynamization of the LCP, which is

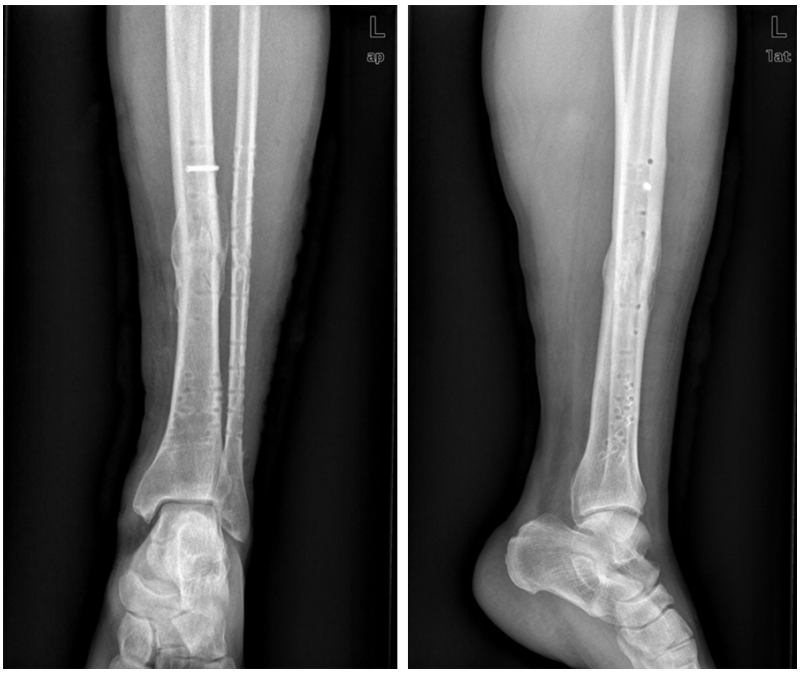

Figure 7. Internal fixation was taken out one year after dynamization surgery, on March 18th, 2015.

mainly applicable to patients who display nonunion or delayed union in response to absolute stability after using the LCP to treat comminuted fracture of long bones. Actually, dynamization is a derivative concept after the extensive clinical application that base on Wolff's law of bone growth and remodeling, Perren's strain theory, as well as bridging working principle of the LCP [13-16]. It mainly has two advantages: firstly, reducing the economic burden comes from replacement of internal fixation; and secondly, avoiding the possibility of refracture because of insufficient osseous strength at the early phase after removing internal fixation. As a result, patients would have one more choice except replacing internal fixation for nonunion if this concept applied to clinical practice.

Stress shielding because of the over stiff LCP construction was considered the reason of the patient's bone nonunion, in other words, low stress stimulation prevented the newly regenerated bone transformed from fibrous cartilage into primary callus. So we tried to practice dynamization to the LCP so as to make micromotion in the construction. And the break of the locking screw was considered fatigue fracture due to the last second locking screw at the proximal end endured most stress after the dynamization surgery, combined with the requirement of longer working distance of the LCP with the increased stress after the patient walked with weight. The other possibility is the steel plate was too short.

The patient in the case achieved bone union after dynamization therapy. However, this is just a case and the patient had received autogenous bone graft. It required further verification by large sample clinical study and fundamental research to determine whether dynamization surgery plays the leading role in fracture healing.

Disclosure of conflict of interest

None.

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