Case report

Double segmental tibia fracture treated with intramedullary nail using multiple clamps technique to hold reduction: a case report and surgical technique

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Abstract:

Segmental tibial fractures are considered to be a severe injury associated with high complication rate. This type is not common in clinical practice. This pattern is generally caused by a high-energy trauma associated with severe soft tissue injury, potentially leading to compromised circulation to the underlying bone. It is potential to have complication during surgical procedures and it is possible to have rotational displacement during reaming. This report presents a case of a male patient who had a closed fracture with double segmental pattern on right tibia treated by percutaneously open reduction and intramedullary nail fixation using multiple clamps technique for holding the reduction. The united fracture occurred at twenty weeks and the patient regained full weight bearing. Radiographic healing was revealed at twenty weeks. Multiple clamps technique is able to reduce and maintain all segments to prevent rotational displacement before reaming and nailing, which could decrease complication during the procedure.

Keywords: ● *Segmental tibia fracture* ● *Tibia fracture* ● *Intramedullary nail*

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รายงานผู้ป่วย

รายงานกรณีผู้ป่วยกระดูกหน้าแข้งหักสี่ท่อนที่ทำการรักษาด้วยโลหะดามในแกนโพรงกระดูกและใช้อุปกรณ์หนีบหลายอัน

ญาณินภ์ ปลื้มอารมย์ ชลพรรษ ตั้งบุตราวงศ์ และ องอาจ พฤทธิภาส
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บทคัดย่อ

กระดูกหน้าแข้งหักแบบหลายท่อนถือว่าเป็นการบาดเจ็บและมีภาวะแทรกซ้อนที่รุนแรง พบได้ไม่บ่อยในเวชปฏิบัติ การบาดเจ็บลักษณะนี้มักจะมีสาเหตุจากการบาดเจ็บที่มีพลังงานสูง สัมพันธ์กับการบาดเจ็บของเนื้อเยื่อที่มาก ทำให้กระดูกนั้นขาดเลือดมาเลี้ยงได้ มีโอกาสที่จะเกิดภาวะแทรกซ้อนได้ในระหว่างที่ทำการผ่าตัด และเกิดการบิดหมุนของกระดูกแต่ละชิ้นได้ระหว่างทำการผ่าตัดขยายแกนโพรงกระดูก รายงานนี้เป็นกรณีผู้ป่วยชายที่มีกระดูกหน้าแข้งขวาหักสี่ท่อนถูกทำการรักษาด้วยการใช้อุปกรณ์หนีบกระดูกผ่านผิวหนังหลายอันเพื่อช่วยในการดึงกระดูกให้เข้าที่และตรึงกระดูกให้อยู่นิ่ง กระดูกสามารถติดได้ที่ 20 สัปดาห์ ผู้ป่วยสามารถลงน้ำหนักได้เต็มที่ ภาพฉายรังสีแสดงการติดของกระดูกที่ช่วงเวลาเดียวกัน การใช้วิธีการผ่าตัดโดยใช้อุปกรณ์หนีบกระดูกแบบหลายอันสามารถช่วยดึงกระดูกให้เข้าที่และตรึงให้อยู่กับที่ทุกท่อนช่วยป้องกันการเคลื่อนของกระดูกได้ก่อนที่จะเริ่มขยายแกนโพรงกระดูกและใส่โลหะดามในแกนโพรงกระดูก ซึ่งสามารถช่วยลดภาวะแทรกซ้อนระหว่างการผ่าตัดได้

คำสำคัญ: ● *กระดูกหน้าแข้งหักหลายท่อน* ● *กระดูกหน้าแข้งหัก* ● *โลหะดามในแกนโพรงกระดูก*

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Introduction

Segmental tibial fractures are considered to be a severe injury associated with high complication rate. This injury type is uncommonly seen in clinical practice. Segmental tibial fracture is defined as a fracture featuring at least 2 distinct fracture lines that create a completely cylindrical intermediate segment. This pattern is generally caused by a high-energy trauma associated with severe soft tissue injury, potentially leading to compromised circulation to the underlying bone.[1-2]

Even though several reports have demonstrated the outcome after treatment of segmental tibial fracture, almost all of them defined only a small number of patients. Additionally, some studies included non-segmental fractures because of low incidence of this fracture pattern. The incidence of segmental tibial fracture was between 3 and 12%.[3] High complication rate has been reported because of a damaged blood supply to the intermediate fragment and the surrounding soft tissue, leading to delayed fracture healing (up to 50%), compartment syndrome (up to 50%), and infections (up to 35%).[4-8] Therefore, several studies have shown that the segmental tibial fractures have more complications and longer healing times than nonsegmental fractures, and this pattern should be considered as a special type of injury.[8]

We report a case of a male patient with a double segmental tibial fracture from a motor vehicle accident. He was treated with intramedullary nail fixation using multiple clamps technique for holding a reduction. The patient was clinically and radiographically followed up until the fracture was finally healed with good clinical outcome. This knowledge could help orthopedic surgeons deal with a special situation as doble segmental tibial fracture. Informed consent was obtained from the subject used in the study with the IRB No.: IRBRTA 1357/2563.

Case report

A 34-year-old male sustained a closed fracture on right leg with marked swelling from a motorcycle accident. On physical examination, he had a limited range of motion of the right leg because of pain. Neither neurological nor vascular deficit was detected. He was admitted as an in-patient in order to observe his soft tissue conditions. He developed skin bleb at medial site of the leg 3 days later (Figure 1A). There were no other associated injuries. Plain anterior-posterior (AP) and lateral radiographs demonstrated a double segmental tibial fracture of right leg (Figure 1B-C). The patient was initially managed with a long leg splint.

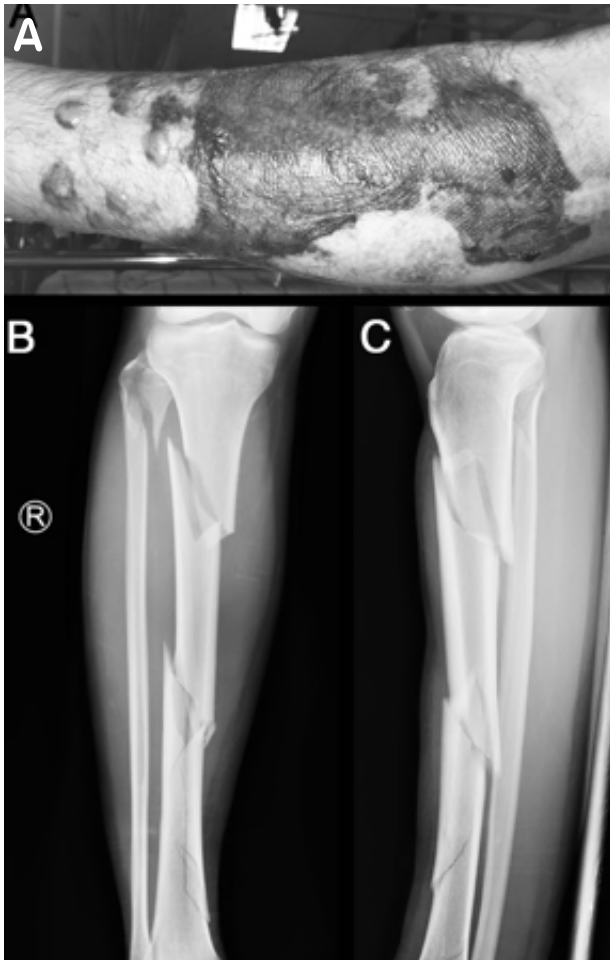

Figure 1 Clinical images and preoperative investigation **A)** Skin bleb at medial site of the leg 3 days after initial injury, **B-C)** The preoperative plain radiographs in AP (**B**) and lateral (**C**) views demonstrating the double segmental tibial fracture of right leg.

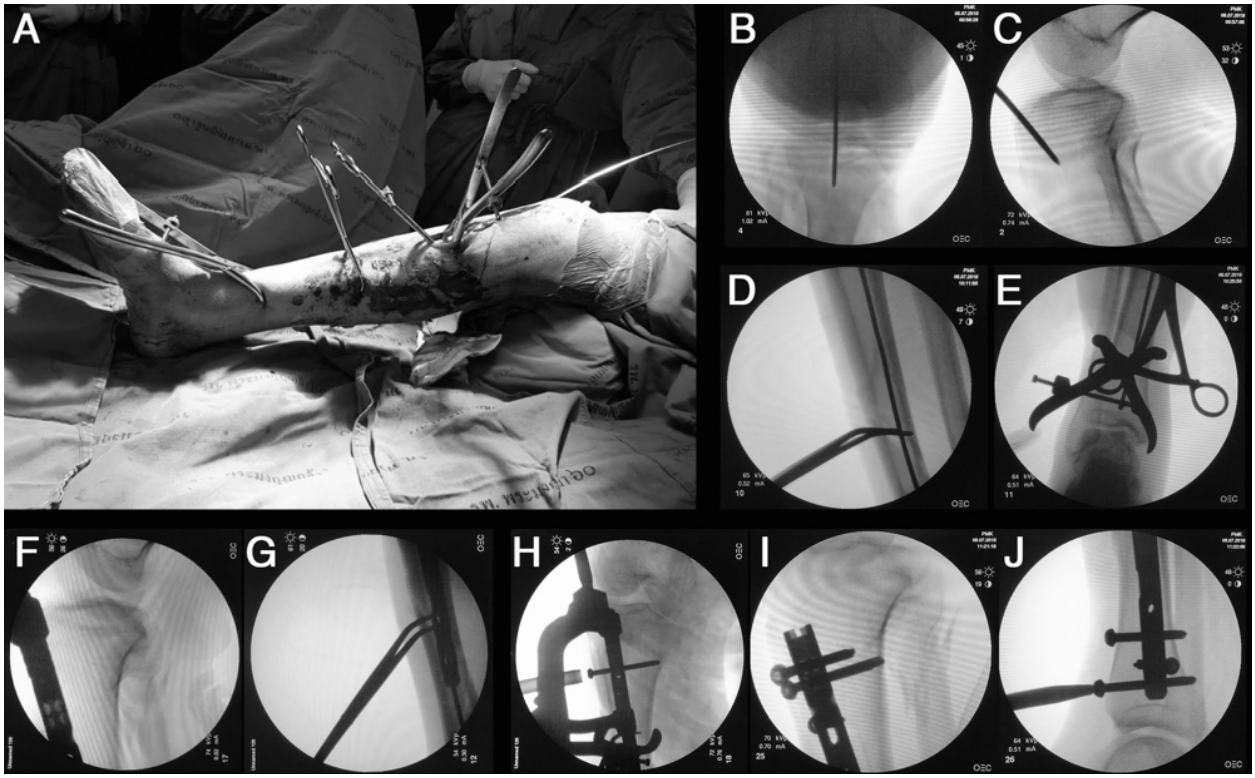

Figure 2 Intraoperative reduction and fixation techniques. **A**) Open reduction at the proximal segment was performed and clamped using large bone reduction forceps. The remaining segments were percutaneously clamped with 2 reduction with point forceps. **B-C**) The corrected position of the entry point was checked under fluoroscopy both AP and lateral view. **D-E**) Reaming guide was centrally inserted into the intramedullary canal to reach the physeal scar. **F-G**) 11 millimeters in diameter of a tibial nail (A-tech®, 11 mm in diameter) was inserted into the intramedullary canal through the reaming guide while each segment was held by a reduction with point forceps. **H-J**) Four screws were proximally inserted into the nail to secure proximal segment. Three screws were distally locked into the distal of the nail to stabilize the distal segment.

Definitive treatment with closed reduction and internal fixation through a split patellar approach was performed. Even though the double segmental fragments were aligned, there was not perfectly reduced. Therefore, open reduction at the proximal segment was performed and clamped using a large bone reduction forceps in order to hold and prevent spinning of the fragment. The remaining segments were percutaneously clamped with 2 reduction with point forceps (Figure 2A). As the second and third fragments were minimally displaced, they are percutaneously all clamped and held with point forceps to remain in place during reaming and to reduce soft tissue damage in a minimally invasive way. In addition, the remaining part of the fourth segment was nondisplaced, it was simply held with another large bone reduction forceps percutaneously aiming to prevent spinning or further displacement during reaming process. After all segments were held with multiple-clamp technique, knee hyperflexion (approximately 140 degrees) was performed to start the entry point. The corrected position of the entry point was checked under fluoroscopy in both Anteroposterior (AP) and lateral view (Figure 2B-C). Reaming guide was centrally inserted into the intramedullary canal for reaching the physeal

scar (Figure 2D-E). Reaming was respectively performed using a reamer to the proper size of the nail which was over reaming 1.5 mm. larger than the diameter of the nail. Eleven millimeters in diameter of a tibial nail (A-tech®, 11 mm. in diameter) was inserted into the intramedullary canal through the reaming guide while each segment was held by a reduction with point forceps (Figure 2F-G). Through the reaming process, all fracture segments were held in the correct position with multiple-clamp technique. Four screws were proximally inserted into the nail to secure proximal segment. Three screws were distally locked into the distal of the nail to stabilize the distal segment (Figure 2H-J). The final construct was confirmed by fluoroscopy and the fixation was stable during knee motion assessed intraoperatively.

Postoperatively, patient was able to gently passive knee ROM exercises during hospital admission. He could bear partial weights on the right leg with axillary crutches at 2 weeks follow up in out-patient department and he could perform progressive weight bearing with a single axillary crutch at 1 month follow up in out-patient department. Finally, at twenty weeks after surgical fixation, the radiographs demonstrated union of the fracture (Figure 3A-E). The patient was able to walk without any support. Knee joint range of motion was 0 to 140 degrees. The patient was followed up at the clinic until one year.

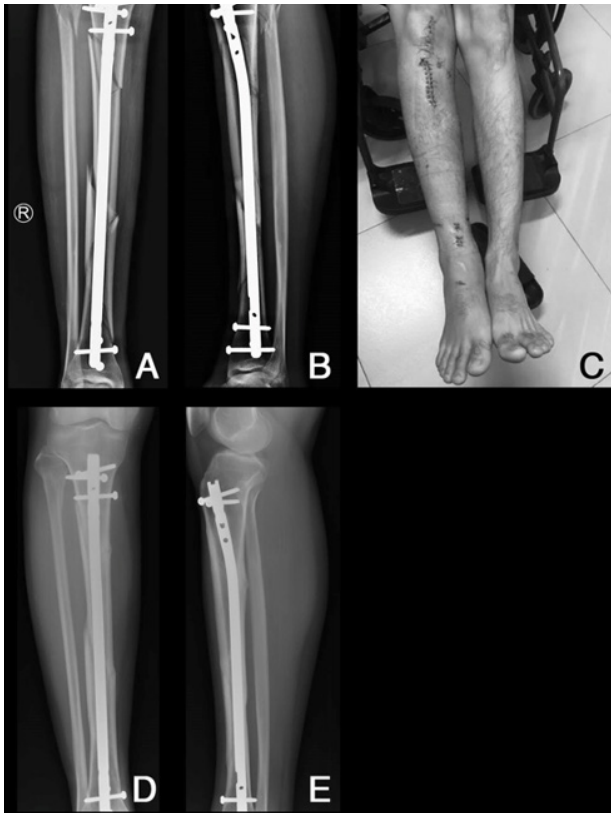

Figure 3 Postoperative radiographs, **A-B**) Postoperative radiographs in AP (**A**) and lateral (**B**) views demonstrating the final construct of fixation. **C**) Clinical picture of closed incision after surgery, **D-E**) Radiographs in AP and lateral views demonstrating radiographic union at twenty weeks follow up.

Discussion

Treatment of segmental tibial fracture remains technically challenging for surgeons. The difficulties are often encountered intraoperatively. The main surgical treatment is good reduction to ensure good alignments of the fracture ends and maintain a good reduction during the operative field. Moreover, soft tissue disruption should be prevented throughout the procedures.[9] Because these fractures are high energy fracture patterns, the final result can be problematic with healing problems or infections.[4,6,10-11] Rommens, et al. reported 29% non-unions[12], and Giannoudis, et al. studied 27 segmental fractures and reported a second surgical procedure in 13 cases, 2 amputations, 4 deep infections, and 3 compartment syndrome cases.[6] Reynders, et al. reported 23 consecutive cases of open acute segmental tibial fracture fixation treated by the Less Invasive Stabilisation System (LISS) and they recommended using the LISS plate for fixation these difficult fractures, but an immediate fixation should be avoided. A staged sequential procedure with a temporary spanning external fixation and definitive treatment after soft-tissue healing is preferred.[13] Ma, et al. applied two-stage procedure for

treatment of segmental tibial fractures. These fractures achieved good reduction with stable temporary fixation, soft-tissue reconstruction, ease of subsequent definitive fixation, and high union rates. Patients in the study obtained excellent knee and ankle joint motions, good functional outcomes, and a comfortable clinical course.[1]

Previous studies have defined treatments of segmental fractures in different aspects: Öztürmen, et al. reported good to excellent outcome after acute treatment of 24 segmental tibial fractures by Ilizalov method[14] while Kakar, et al. reported a large series of segmental fractures treated with a single technique of non-reamed intramedullary nailing and they found that non-reamed nailing was associated with high union rates, few complications, and limited indications for secondary procedures in the management of segmental tibia fractures.[15] Additionally, McMahon, et al. found that intramedullary nail had the fastest time to fracture union. However, there are concerns regarding an increased deep infection rate in open segmental tibial fractures. In this subgroup, the data suggested that circular external fixator provided the most satisfactory outcomes. Nevertheless, the literature did not provide sufficient details to make this statement with certainty because the evidence was with poor quality and dominated by retrospective case series.[3,16] Yoon, et al. found that combined intramedullary and plate fixation is a reliable device not only in the treatment of fractures of the proximal tibia, but also for those fractures in the diaphysis and segmental fractures with proximal and/or distal metadiaphyseal extension, with consistent ability to achieve high union rates and maintain alignment.[17]

Although the method of fixation for this fracture pattern is heterogeneous, the main treatment is predominantly with intramedullary locked nailing.[6,18-19] Many of these casualties have multiple injuries due to high-energy trauma. There are two possible causes of delayed bone healing in segmental fracture pattern. Firstly, it is an ischemia due to interrupted blood supply to two bone segments. Secondly, the intercalary bone segments are usually detached from the surrounding soft tissues (skin, periosteum and muscle attachments).[20] The method of stabilization of these fractures remains controversial with clinical outcomes often being unsatisfactory. Most surgeons, however, agree that internal fixation using intramedullary nailing with interlocking bolts improves the outcome. If the bone segments are extensively exposed (Gustillo grade 3a/3b), a direct reduction is possible. However, closed fractures with minimal soft tissue damage (Gustillo grade 1 and 2) may be more challenging because closed reduction and passing the intramedullary nail may be more difficult. Distraction often occurs between proximal and distal segments as the remaining soft tissue poorly maintains the position of the central segment.[9]

Our patient is a rare closed fracture with double segmental pattern on right tibia treated with multiple-clamp technique in order to aid for reduction and to maintain each segment of the fracture with ream nailing. However, we could not achieve a good reduction of the bone end of the proximal segment with a closed reduction maneuver. Therefore, open incision and reduction with a large forceps was applied to reduce and hold that segment. The remaining distal segments were clamped percutaneously from proximal to distal one as shown in picture A. After that, the upper bone end was maintained with stable position so that hyperflexion of the knee could be obtained to start the entry point. Kamal B, et al. reported an unusual case of segmental fracture pattern which was similar to our case and was treated successfully using tibial interlocking nail.[21] Mateen, et al. found that long diaphyseal segmental tibial fractures (Melis Type III) rotated more than short diaphyseal segmental tibial fractures (Melis Type IV). The larger reamers the surgeons used in

the study, the more rotational displacement they could occur resulting from soft tissue stripping.[22] Therefore, the authors recommended to always clamp the fracture during reaming to avoid rotational displacement, which was applied to our case.

With this patient, open incision and reduction with large forceps were done to reduce and maintain that segment. The rest of the distal segments were clamped percutaneously from proximal to distal one in order to avoid rotational displacement of all segments during reaming the intramedullary canal. It was important to hold all segments in stable positions as the patellar tendon split approach was applied. Hyperflexion knee was performed during an entry point identification. When reaming process was done, all segments was stably maintained using multiple-clamp technique. After that intramedullary nail was inserted in usual manner. The patient was followed up until all segments were completely healed at twenty weeks and still had appointments at the clinic until one year without any complication.

Conclusion

Double segmental tibial shaft fractures are often associated with severe polytrauma and are often mostly associated with soft tissue injuries. Reamed intramedullary nail insertion after appropriate resuscitative and stabilization methods can result in good alignments, and union in these fractures. Importantly, in our case report, multiple-clamp technique was able to reduce and maintain all segments to prevent rotational displacement before reaming and nailing, which could diminish complication during the procedure.

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Ethical approval

This article was approved by Ethical committee of Phramongkutklao College of Medicine, Bangkok, Thailand. IRB No.: IRBRTA 1357/2563

Contribution

YP contributed this case. YP wrote the manuscript. CT assisted in writing the manuscript and preparing figures. OP critiqued and commented on the manuscript.

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