Case Report

A lifelong story: a case report of a successfully treated femoral shaft infected nonunion

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ABSTRACT

Introduction: Fracture healing is a very important clinical event for fracture-patients and for the doctors who treat them. Many factors can interfere with bone healing. The interference may cause delayed union or even nonunion. Nonunion management may cause financial and disability problems to the patient. Diamond concept taught us the importance of bone healing nature. In this case report, we will present the importance of diamond concept in the treatment of a nonunion case.

Case Report: We present a 21-year-old obese-heavy smoker-male with chief complaint of pain on the left thigh since a year ago and was diagnosed with infected nonunion of the left femur. The patient had a history of moderate head injury and closed fracture of the left femur as the result of motor vehicle accident. He was treated in the first hospital by open reduction and internal fixation (ORIF) with plate and screw. Unfortunately, the pain still persisted and the implant was broken. Five months after the first surgery, he underwent another surgery in the second hospital and had an ORIF revision with plate and screw. Four months after the surgery, the wound was not healed, the pain still persisted and the implant was broken again. The patient came to our center, and we performed debridement, ORIF revision with longer plate, intraoperative deep specimen culture, decortication, and bone grafting. Empirical antibiotics by culture was given postoperatively and specified antibiotics was given by culture results. The wound healed, but the pain still persisted and in 8 months, the implant was broken once more. The patient underwent another surgery and had an ORIF revision with plate and screw and bone grafting in our center. In another seven months, finally, the left femur was joined.

Results: Seven months after the last surgery, clinical and radiological union were achieved, and there was no sign of infection. The patient was quite happy with the result eventhough with a leg length discrepancy. He can do his daily activities with additional footwear.

ABSTRAK

Pendahuluan: *Penyembuhan patah tulang adalah peristiwa klinis yang sangat penting untuk pasien patah tulang dan untuk dokter yang merawat. Banyak faktor yang dapat menghambat penyembuhan tulang. Gangguan tersebut dapat menyebabkan* delayed-union *atau bahkan* nonunion. Delayed union *dan nonunion dapat menimbulkan berbagai masalah untuk pasien, terutama finansial dan disabilitas. Konsep berlian mengajarkan kita pentingnya sifat alamiah penyembuhan tulang. Dalam laporan kasus ini kami akan menyajikan pentingnya konsep berlian dalam penatalaksanaan kasus* nonunion.

Laporan Kasus: *Kasus dari seorang laki-laki berusia 21 tahun dengan keluhan utama nyeri pada paha kiri sejak 1 tahun yang lalu yang didiagnosis sebagai* nonunion *femur kiri terinfeksi. Pasien juga seorang perokok berat dengan obesitas. Ia memiliki riwayat cedera kepala sedang dan fraktur tertutup tulang femur kiri akibat kecelakaan kendaraan bermotor. Pasien ditatalaksana di rumah sakit pertama dengan reduksi terbuka dan fiksasi internal (ORIF) menggunakan* plate *dan* screw. *Namun, keluhan nyeri masih berlanjut, dan implannya pun patah. Lima bulan setelah operasi pertama, ia menjalani operasi lain di rumah sakit kedua, yaitu revisi ORIF dengan* plate dan screw. *Empat bulan setelah operasi, lukanya tidak kunjung sembuh, rasa sakit masih terus berlanjut dan implan sekali lagi patah. Pasien datang ke rumah sakit kami dan dilakukan debridemen kembali, revisi ORIF dengan* plate *yang lebih panjang, kultur spesimen intraoperatif, dekortikasi, dan pencangkokan tulang. Antibiotik empiris melalui kultur diberikan pasca-operasi dan antibiotik khusus diberikan berdasarkan hasil kultur. Luka sembuh, namun rasa sakit masih berlanjut dan dalam 8 bulan, implan patah lagi. Pasien menjalani operasi kembali dengan revisi ORIF menggunakan* plate *dan* screw *dan pencangkokan tulang di rumah sakit kami. Dalam tujuh bulan berikutnya, akhirnya tulang paha kiri berhasil bertaut kembali.*

Hasil: *Tujuh bulan setelah operasi, pertautan tulang secara klinis dan radiografi telah tercapai, dan tidak ditemukan tanda-tanda infeksi. Pasien sangat senang dengan hasil yang didapat walaupun terjadi perbedaan panjang tungkai. Pasien dapat menjalani aktivitas sehari-hari dengan alas kaki tambahan.*

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INTRODUCTION

Nonunion has been defined in various ways, with 55% disagreement among clinicians on timing. The US Federal Drug Administration defines it as "failure to achieve union by 9 months since the injury, and for which there has been no signs of healing for 3 months". Others, however, have recommended that for long bones this should be revised to a period of 6 months if no evidence of radiological fracture healing is present. Instability at the fracture site in true nonunion is often associated with ongoing pain, and as such, clinical signs are as important in diagnosis as the radiological examination.[1–4]

Femoral shaft fractures are common type of fracture among adults and has a high level of union. Bone healing is a unique repair procedure that allows recovery of bone integrity. Orthopaedic procedures such as osteotomy, arthrodesis, and osteosynthesis cannot be done without the ability of this amazing organ. Disorders of healing can cause nonunion, which is defined as the cessation of bone healing after fractures.[4]

Since its inception, the diamond concept has proven itself to be an important framework for understanding the minimal requirements for fracture healing. Osteoinductive, osteoconductive, osteoprogenitor cells and mechanical environment play major roles in fracture healing. Moreover, diamond concept has shown itself to be particularly useful when planning surgical management of fracture nonunion of both upper and lower extremities.[5,6]

Well vascularised fracture sites with abundant fracture haematoma but in unstable mechanical environment will usually develop 'hypertrophic' non-union, whereas impaired blood supply in combination with local strain concentration has been suggested to lead to 'atrophic' non-union. These definitions are based on the radiographic appearance of the non-union. The presence or absence of infection is also important in terms of classification, which can further complicate the clinical picture and treatment modality.[7,8]

Incidence of non-union has been variably reported in the literature, depending on the study size, patient demographics, injury location and severity, and method of treatment, from anywhere between 2 and 30%[9], with an estimated of 100,000 episodes of fracture non-union per year in the USA.[3] A recent study from Australia on 853 patients showed that overall 8% of patients who had fractures, being admitted to hospital per year for fracture healing complications.[9] However, a recent much larger population-based study done in Scotland showed lower overall incidence than previously reported, which is 1.9% in adult population, with incidence of non-union for pelvis and femur fractures of 13 per 1000, humerus of 30 per 1000 and tibia of 55 per 1000; incidence was seen to peak in the 25–44 years of age group.[10] This comes with significant financial implications, with reported overall costs between 21,183 and 33,752 dollar per patient.[11]

Common factors that may contribute to nonunion including infection, impaired biology, and metabolic disorders. Therefore, new and evolving strategies for diagnosing the cause and effectively treating nonunion, including the diagnosis of infection, metabolic workup, bone grafting, cell-based therapies, and biological adjuvants, are reviewed and discussed.

Atrophic nonunion, although it is a rare complication of femoral fractures, can be very difficult to treat. Bone loss associated with this nonunion usually occurs after multiple failed attempts in trying to achieve union or as a result of the debridement of an open fracture. Typically, treatment involves exposure of the nonunion, decortication, internal or external fixation, and bone graft. Internal fixation in atrophic nonunion is commonly performed by plating, but intramedullary nails have also been described.

Nonunion is difficult to treat and have a high financial impact. Indirect costs, such as productivity losses, are the key driver for overall costs in fracture and non-union patients. Therefore, all strategies that help to reduce the healing time with faster resumption of work and activities will not only improve medical outcomes for the patients, but also help to reduce the financial burden in fracture and non-union patients.

Case Illustration

We present a 21-year-old obese-heavy smoker male patient with chief complaint of left thigh pain since a year ago. The patient had a history of open fracture of left femur and moderate head injury caused by motor vehicle accident. The patient was diagnosed with infected nonunion of the left femur. The patient also suffered from severe head injury that he was treated for 15 days in an unconscious state in the ICU. The patient was obese with body mass index of 28,3 kg/m^2 and he smoke 2 packs of

cigarettes per day.

From his medical history, he came to the first hospital with an open wound on his left thigh with deformity. From radiological examination, it was revealed a femur fracture with a simple fracture line configuration with small fragment comminution and was classified as Winquist-Hansen type II. The patient was then performed an open reduction internal fixation (ORIF) at day-16 after the accident. After the surgery, the patient did not routinely control to the first hospital. His weight increased and the patient was still smoking.

Figure 1. Initial X-Ray (left) showed simple fracture pattern with small comminution. 1st postoperative X-Ray (right) showed fixation using plate and screw surgery.

Five months later, the patient felt pain on the left thigh, there was no problem with the wound, but the patient could no longer walked. The patient decided to go to the second hospital and performed an X-Ray examination. From the radiology, it was found that the implant was already detached and the screws were pulled out at the proximal segment of the femur. ORIF with shorter plate and decortication was performed by the second surgeon accompanied with osteotomy without bone graft application.

Unfortunately, two months after the second surgery, there was discharge from the surgical wound. The patient was given oral antibiotics, yet there was still no progress. Four months after the surgery, there were signs of deformity and the pain worsened. The patient was then referred to our center. From the physical examination, we found pus from the wound and discrepancy of 3cm on the left leg. From the X-ray, we found the distal screws were pulled-out and there were also broken screws. We then performed thorough debridement and did implant revision with longer implant and autologous bone graft by ipsilateral proximal tibia. Deep sample for culture was taken. Empirical intravenous antibiotics by 3rd generation of cephalosporine was given for 7 days. Oral antibiotics specified according to the culture was also given for a month. We asked the patient to stop smoking and loss some weight. After the surgery, there were no sign of infection. Routine radiological examination was performed, and until seven months there were no signs of union.

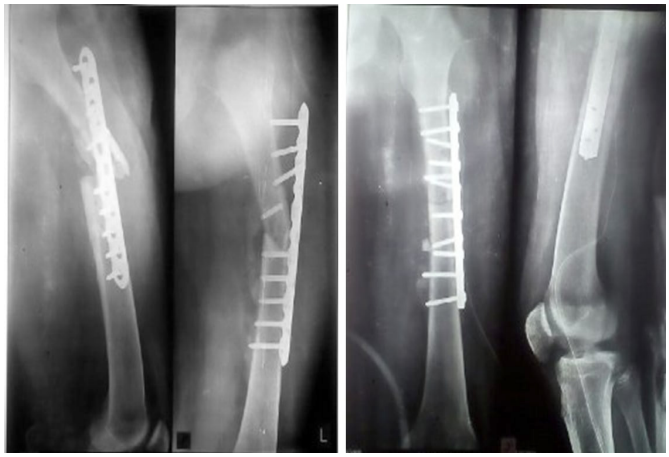

Figure 2. 1st Implant Failure X-Ray (left) showed proximal screws pulled-out and broken screw. 2nd post-operative X-Ray showed ORIF revision surgery using plate and screws. Both X-rays were taken 5 months after the 1st surgery.

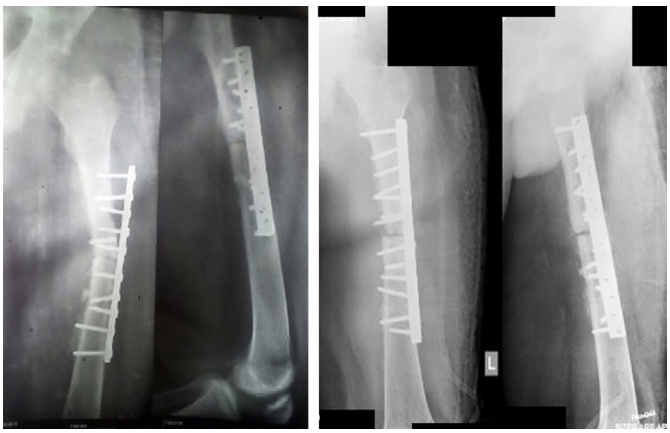

Figure 3. 2nd implant Failure X-Ray (left) showed Proximal screws Pulled-out. 3rd postoperative X-Ray (right) showed ORIF revision surgery using longer plate. Both X-rays were taken 4 months after the second surgery

The patient complained about the reoccurred pain and deformity on his left thigh eight months after the third surgery. The implant also pulled out and the screw was broken. Another surgery was performed in the form of ORIF revision and autologous bone graft application from the ipsilateral iliac wing. After a serial surgery, fi-

nally, there were clinical union signs and from the radiological examination there was seen abundant callus production. Full weight bearing was started 4 months after the operation. At present, the patient can walk with full weight bearing and is planned, next month, for the removal of the implant after one year follow-up.

Figure 4. 3rd Implant Failure X-Ray (left) showed distal screws pulled-out and broken screws. 4th postoperative X-Ray (Right) showed ORIF Revision using even longer plate with bone graft application. Both X-rays were taken 8 months after the 3rd surgery.

Figure 5. Seven months follow-up after the 4th surgery (left) showed abundant bridging callus. One year follow-up X-Rays (Right) after the 4th surgery showed a radiological union.

DISCUSSION

At the first hospital, the patient was diagnosed with moderate head injury and closed fracture of the left femur. The operation was delayed for 16 days due to his unstable condition to perform definitive surgery. If this patient was classified as a polytrauma patient in the first hospital, it was necessary to classified it based on the Hannover criteria. If the patient was previously classified as unstable, we ideally had to apply damage control orthopaedically by performing external fixator application. If the patient was stable enough, we could proceed to the definitive treatment by internal fixation. The patient had a surgery in the 16th day after the diagnosis, which means he was in the immunosuppression phase. It might be better if the previous surgery was performed in the window phase (5-10 days) or in the recovery phase (after day 21) to avoid the second hit.

The first operation was performed by open reduction and internal fixation by plate and screw. The reduction was good enough. The plate was already using the minimal contact plate. The fifth screw, however, were too close to the fracture site that it could interfere with the hematome formation phase of bone healing. The concept of fixation was absolute stability. In the author's opinion, it might be better if the fixation used relative stability based on the fracture comminution and the fracture in the femur bone as the lower limb.[12, 13]

The patient did not regularly control to the first hospital on the reason of distance and financial problem. After the treatment, the patient did not follow any aftercare protocols. He was still smoking and his weight also increased. Postoperative fracture management phase was divided into 3 phases: first phase (pain management, antibiotics, dressings, elevation and support of injured limbs, mobilization and thrombosis prophylaxis, activity and weight bearing, and the last one is communication), second phase (Clinical care outside the hospital, X-ray and clinical monitoring, early removal of implants), and third phase (after regaining full capacity of normal activity and working).[12] Since the patient's compliance was not good enough, it may lead to future problems such as nonunion, delayed union and implant failure.

The patient lost to follow up until 5 months after the first surgery. He began to feel pain on his left thigh with frank deformity. He came to the second hospital and X-Ray was performed. Unfortunately, the previous fracture was not united. From figure 2, since there was no callus seen in the X-Ray, we might conclude that delayed union with the implant occurred in the patient's femur. Delayed union is when a fracture takes longer than usual to heal, but still progressing. Non-union has been defined in various ways, with 55% disagreement amongst clinicians on timing. The US Federal Drug Administration defines non-union as 'failure to achieve union by 9 months since

the injury, and for which there has been no signs of healing for 3 months.[1–4,12]

The second surgery was performed by the second surgeon. ORIF revision and shortening osteotomy were performed by plate and screw with shorter plate and without application of bone graft. In the author's opinion, it would be better to treat the patient with longer plate to avoid implant pull-out and provide stability. In addition, for the delayed union, autologous bone graft can provide osteoinductive (growth factors, enhance vascularity, enhance cells differentiation), osteoconductive (Scaffold) and osteoprogenitor cells (multipotent cells) as the completion of the diamond concept.[4,5] Education and communication also play role in the first phase of postoperative fracture management. The patient must be well reminded that he has two main risks to avoid: obesity and heavy-smoking. Obesity can lead to wound healing complication while heavy smoking can lead to nonunion. [12]

The management of nonunion is not easy. We, however, can consider the principles of diamond concepts in the management of nonunion. Before the introduction of reamed exchange nailing, the use of compression plating for femoral shaft nonunion was the gold standard with autologous bone graft application. In their book on nonunion, Weber and Cech advocated debridement, sequesterectomy, use of plates for mechanical rest and massive cancellous autograft.[14]

The mainstay of surgical treatment for nonunion with impaired biology (atrophic nonunion) is autologous bone grafting. Three attributes are essential for successful grafting: osteogenesis, osteoinduction, and osteoconduction. Osteogenesis is defined as the ability of a cell to differentiate into a bone matrix producing osteoblasts. Osteoinduction is the ability of a growth factor to induce osteogenic differentiation of skeletal progenitor cells or induce osteoid deposition by osteoblasts. Osteoconduction describes the ability of a material to provide a scaffold for the attachment and subsequent bone matrix deposition of bone-forming cells. All 3 elements are essential for successful healing in the setting of atrophic nonunion. Autograft has been the gold standard for atrophic nonunion treatment for decades.[15-17]

Two months after the surgery, the patient had a discharging wound from his left thigh. Infection is another complication that can be occurred in fracture management. From Figure 3 we can see there is another implant failure in the 4th month after the second surgery. Infection is an important consideration in the workup and treatment of a patient with nonunion. When assessing for infection, consideration should be given to risk factors of infection, including the patient factors such as conditions of immune compromise, malnutrition, or smoking status, and injury factors such as open fractures, delayed wound healing, or previous external fixation. Infection should be strongly considered as a potential contributing factor to nonunion in the presence of any of these risk factors. In addition, any patient presenting with a fracture nonunion after a surgical treatment should be considered and worked up for infection.[18]

In our center, the patient was treated with ORIF Revision with a longer plate, decortication, recanalization, and bone graft application. Deep sample for culture was taken. Empirical and specified antibiotics were also given. The diamond concept was considered in the surgery, but in the author's opinion, the treatment should include a staged approach to eradicate the infection and fill the gap to avoid length discrepancy. The function of the autologous bone graft, which has roles as osteoinductive, osteoconductive and osteoprogenitor cells, may not fully optimal due to the active infection.

When the diagnosis of infection is confirmed before treatment in the setting of nonunion, a staged treatment approach is recommended. The initial stage should consist of debridement, removal of any loose or chronically infected hardware, revision fixation/stabilization of the nonunion, and treatment of infection with culture-specific local and systemic antibiotics. Local antibiotic treatment can be achieved by a variety of methods including antibiotic nails, antibiotic cement beads, bioresorbable antibiotic pellets, or antibiotic cement spacers. Antibiotic cement spacers not only can help to eradicate the infection, but also can promote the formation of an osteogenic induced membrane (Masquelet technique). There are also a number of options for revision fixation including both temporary (external fixation and antibiotic nails) and definitive (intramedullary nails and plates) fixations. Soft tissue coverage may also be required at this stage in the form of flap or rotational coverage. The second stage generally proceeds after a period of systemic antibiotic therapy and when both clinical and serological signs of infection are absent. This reconstructive stage to address the nonunion may consist of definitive fixation, bone grafting, other biologic treatment, or bone transport, depending on the specific characteristics of the

non-union.[17,19,20]

Fortunately, the wound healed and the sign of infection was diminished. However, in another 8 months the implant pulled-out once more. The patient underwent another ORIF Revision with a longer plate, and bone grafting. The failure of healing may be caused by the previous active infection. After revising the implant for the second time, we got clinical signs from the patient and enough callus to support the radiological union. In the follow up, a year after the 4th surgery, we plan to immediately remove the implant.

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CONCLUSION

Nonunion cases need to be treated holistically. Infection must be well-eradicated. Biological factors must be treated locally and systemically. Diamond concept must be applied in every situation in order to achieve union. An understanding in various existing options and the evidences that support the biological use are crucial for successful nonunion management.

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