GRADUAL BONE LENGTHENING ON NON-UNION OF THE RIGHT DISTAL FEMUR WITH CRITICAL SIZED BONE DEFECT AND SHORTENING : A CASE REPORT

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ABSTRAK

Penanganan *non-union* merupakan tantangan bagi ahli bedah ortopedi. Kami menyajikan kasus non-union femur distal kanan dengan defek tulang berukuran kritis dan pemendekan yang dilakukan pemendekan akut dikombinasikan dengan pemanjangan tulang bertahap. Seorang wanita berusia 20 tahun datang ke pusat kami karena ketidakmampuan berjalan dan nyeri pada femur kanan. Dua tahun sebelumnya, ia ditabrak mobil dari sisi kanan saat mengendarai sepeda motor. Di rumah sakit, ia menjalani debridemen dan osteotomi. Satu tahun kemudian, ia menjalani pemanjangan tulang dengan fiksator eksternal rel. Pasien didiagnosis sebagai fraktur tertutup terabaikan pada femur distal kanan pasca osteogenesis distraksi dengan fiksator eksternal dan konversi ke plat femur distal dilakukan. Setelah satu tahun tindak lanjut, ada perbaikan klinis dan tanda kalus. Pasien dapat menahan beban sebagian dan tidak ada tanda infeksi pada luka. Beberapa keuntungan dari pemanjangan femur termasuk suplai darah subtrokanterik yang sangat baik dari anastomosis antara cabang-cabang pembuluh darah femoralis sirkumfleks medial dan lateral. Akibatnya, pembentukan regenerasi biasanya baik jika prinsip umum osteotom diikuti. Pada nonunion femoralis dengan defek tulang segmental, perawatan yang sering digunakan meliputi cangkok tulang autolog pedikel vaskular, teknik osteogenesis intramembran, dan osteogenesis distraksi Ilizarov. Untuk pasien dengan nonunion femoralis dengan defek tulang segmental besar, fiksasi eksternal monolateral dapat memberikan stabilitas yang efektif, meningkatkan kepatuhan, dan mengurangi komplikasi.

Kata kunci **:** cacat tulang berukuran kritis, non-union**,** pemanjangan tulang, pemendekan, tulang femur

ABSTRACT

The management of non-union is challenging to orthopaedic surgeon. Here we present a case of non-union of the right distal femur with critical sized bone defect and shortening which was performed acute shortening combined with gradual bone lengthening. A 20-year-old woman came to our center due to inability of walking and pain at the right femur. Two years prior, she was hit by a car from the right side when was riding motorcycle. In hospital, she got debridement and osteotomy. One year later, she got bone lengthening with rail external fixator. The patient was diagnosed as neglected closed fracture at right distal femur post osteogenesis distraction with external fixator and convert to Distal femur plating was performed. After one year follow-up, there is a clinical improvement and sign of callus. Patient can partially weight-bearing and there was no sign of infection on the wound. Several advantages of femoral lengthening including subtrochanteric excellent blood supply from anastomoses between branches of the medial and lateral circumflex femoral vessels. Consequently regenerate formation is usually good if the general principles of osteotomy are followed. In femoral nonunion with segmental bone defects, the frequently used treatment include vascular pedicle autologous bone grafting, intramembranous osteogenesis technique, and Ilizarov distraction osteogenesis. For patients with femoral nonunion with large segmental bone defects, the monolateral external fixation can provide effective stability, improve compliance, and reduce complications.

Keywords ***:*** *bone lengthening, critical sized bone defect, femur, non-union, shortening*

INTRODUCTION

Non-union fractured bone was defined as a fracture that has not completely healed within 9 months of injury and that has not shown progression towards healing over 3 consecutive months on serial radiographs.(Zhang et al., 2017) Radiographically, a nonunion is defined by the presence of the following criteria: absence of bone trabeculae crossing the fracture site, sclerotic fracture edges, persistent fracture lines, and lack of progressive change towards union on serial radiographs. The presence or absence of callus is not a criterium since this depends on the site of the fracture, and whether there is primary or secondary bone healing involved.(Sanzana et al., 2016). Additionally, nonunion fractures often result in functional limitations, pain at the fracture site, and sometimes deformities, which can significantly impact the patient's quality of life. Early identification and appropriate intervention are critical to improving outcomes and preventing long-term complications

Non-union of bone is a challenging condition in orthopedics because it involves failure of bone healing that requires a complex treatment approach. This condition can be caused by various factors, including severe trauma, infection, significant loss of bone segments, or inadequate fixation stability. In certain cases, such as segmental bone defects in the distal femur, treatment requires a combination of surgical techniques to address multifaceted complications, including deformity, infection, and soft tissue defects. The main causes of this condition include severe trauma, acute bone loss, bone ischemia, and removal of dead or sclerotic bone during treatment of infection. The combination of these factors makes the management of bone non-union a challenge that requires a multidisciplinary approach and sophisticated surgical techniques.

Currently, several techniques have been developed to address complex non-union cases. Popular techniques include vascularized bone grafting (such as ribs, ilium, and fibula), intramembranous osteogenesis (Masquelet technique), and distraction osteogenesis (Ilizarov distraction osteogenesis). Of the three techniques, the Ilizarov method has a special advantage because it can simultaneously address infection, bone and soft tissue defects, and correct deformity at an early stage of treatment. However, each technique has limitations, such as the need for repeated procedures, risk of complications, and high technical requirements.

The common causes of posttraumatic femoral nonunion with large segmental bone defect (> 6 cm) include acute bone loss, bone ischemia atrophy in nonunion sites, and surgical removal of dead bone and sclerotic bone after infection. Current treatment for the disease, in addition to the need of addressing the issue of bone nonunion with bone defect, soft tissue defect, nearby joint stiffness, deformities (rotation, angulation, and shortening), infection and many other issues should also be treated simultaneously.(Jardaly & Gilbert, 2021). Effective management of posttraumatic femoral nonunion with large segmental bone defects requires a multidisciplinary approach, combining advanced orthopedic techniques with meticulous planning. This includes the use of bone grafting, vascularized bone transfers, distraction osteogenesis, and modern fixation methods to restore structural integrity while addressing accompanying complications such as infection, soft tissue repair, and alignment correction. Comprehensive rehabilitation programs are also essential to ensure functional recovery and prevent recurrence of deformities.

At present, the common treatments include vascularized bone grafts (such as ribs, ilium, and fibula), intramembranous osteogenesis technique (Masquelet technique), and Ilizarov distraction osteogenesis. Among them, Ilizarov distraction osteogenesis can simultaneously address the issues of infection, bone and soft tissue defects, and correction of deformities and eventually achieves the fracture healing. It is one of the most effective therapeutic strategies for posttraumatic complex nonunion. Clinically, the Ilizarov circular frame, the Taylor spatial frame (TSF), the semicircular Ilizarov pin fixator, and the conventional external fixation are

applied to distraction osteogenesis.(Nayagam, 2010). These techniques have revolutionized the treatment of complex nonunion by offering versatile and customizable solutions tailored to individual patient needs. The Ilizarov method, in particular, is highly valued for its ability to promote biological healing through controlled mechanical stimulation, which encourages bone regeneration while addressing infection and soft tissue challenges. Furthermore, advancements in frame technology, such as the Taylor Spatial Frame (TSF), allow for precise correction of multiplanar deformities, making these approaches indispensable in modern orthopedic practice.

Here we present Non-Union of the Right Distal Femur with Critical Sized Bone Defect and Shortening and was performed Acute Shortening combined with gradual bone lengthening.

METHOD

The method used is a case report approach. This involves presenting a detailed account of the clinical presentation, treatment, and outcome of a specific patient with non-union of the distal femur and critical bone defects. It includes surgical procedures, follow-ups, and discussions about the applied techniques like acute shortening, gradual bone lengthening, and the use of external fixators. Case reports are qualitative and descriptive, focusing on individual cases to provide insights into clinical practice and treatment effectiveness.

Case Presentation

A 20 year old woman came to our center due to complaints inability to walking and pain at right femur. Two years prior to hospital admission, when the patient was riding motorcycle, he hit by car from right side. After the accident, the patient complained pain and wound at right femur. Because of her complaint, she was brought to Subang General hospital and referred to Hasan Sadikin Hospital, she get debridement and osteotomy. After 1 year later she get bone lengthening with rail external fixator.

Figure 1. Initial Clinical Appearance and Local Status

On the physical examination was found external fixation was effective, there wasa no discharge, there was tenderness around wound, distal sensibility normal compared to the other side, dorsalis pedis artery pulsation was normal compare to other side, tibialis posterior artery pulsation was normal compares to other side, and CRT <2". Range of movement was limited due to external fixation. The patient was diagnosed as neglected closed fracture at right distal femur post osteogenesis distraction with external fixator and convert to Distal femur plating was performed.

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Figure 2. Clinical Picture Of Patient After Ilizarov with Rail External Fixation

a b c d

Figure 3. Radiographic Examination Of Femur (A) Post – External Fixation (B) Post Illizarov (C) Initial Right Femur Fracture (D) Left Femur

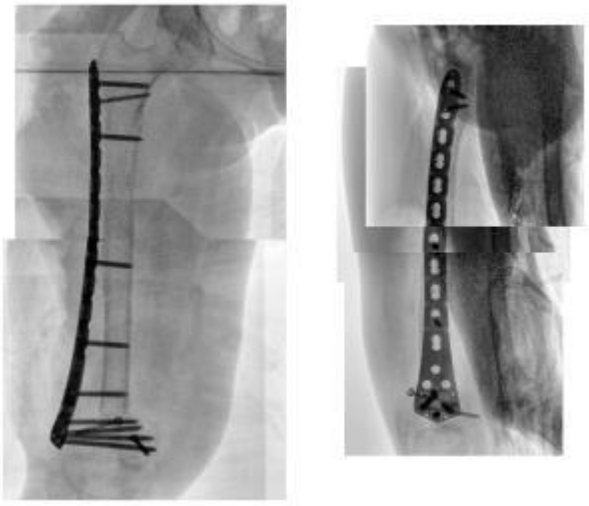

Figure 4. Remove Rail External Fixator, Illizarov and Convert To ORIF Plate and Screw

Surgical Procedure

Procedure performed with patients in supine position. Manual traction was performed to correct deformities. Maintaining axial traction would optimize the pin placement. Then, the pin was placed in safe zone of femur after soft tissue was dissected. Then framed the construction/ reduction and fixation of femur. Then the pin sites were having wound care daily and the patients assessed regularly for the first two weeks then subsequently 6 and 12 weeks follow ups. Then the external fixation was removed and convert to ring fixator illizarov which performed in supine position. This procedure done by placing proximal ring, and distal ring on the femur. The patient got pin site care daily, allowed for hip, knee and ankle joint mobilized as exercised for partial weight bearing with crutches. After, clinical and radiographical bony healing, the fixator was removed and convert to plate and screw.

Figure 5. Remove Rail External Fixator, Illizarov and Convert To ORIF Plate and Screw

Figure 6. Remove Rail External Fixator, Illizarov and Convert To ORIF Plate and Screw

Outcome

After a year, there is a clinical improvement. There is a sign of callus which will form a new bone. Patient can partially weight-bearing. There was no sign of infection on the wound.

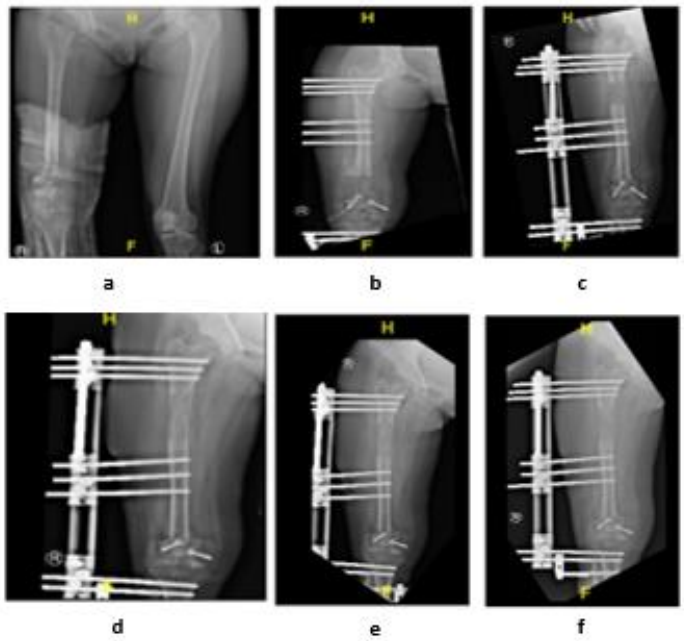

Figure 7. Periodic Progression While Combined Ring Fixator and Rail Fixator Preformed. This Figure Showed Effective External Fixation

DISCUSSION

The incidence of femoral nonunion is increasing, with a recent report published in JAMA indicating that it is as high as 13.9%.(Calder et al., 2019) This increase may be related to the increasing number of patients with severe fractures (higher degrees of open and comminuted fracture) caused by high-energy injuries (traffic, high-level fall, and crush injuries). When this condition is combined with large bone segment defects (> 6 cm) and infection, it becomes even more difficult to solve. Traditional treatment requires multiple operations at different stages. Only under the premise that a thorough debridement is conducted to control the infection or there is clearly no infection can the next step in the treatment strategy for bone defect repair be

determined. Traditional surgical methods often cannot effectively and simultaneously solve a series of problems including bone and soft tissue defects, lower limb deformity (rotation, angulation, and shortening), fracture nonunion, and infection.(Santoso et al., 2021; Zhang et al., 2017)

Distal femur fractures seen in both young and old patients. In the young, it is usually a sequelae of a high energy road traffic accident and in the elderly from a trivial fall. Precise reduction and fixation of distal femur fractures with adequate stability allowing early mobilization is crucial. Non-unions of distal femur do not commonly occur. However, if it happens it causes significant morbidity and remains a nightmare to treat. The typical diagnostic criteria of non-union are pain and tenderness over the fracture site along with serial radiographic evidence showing no visible progressive signs of healing for three months, six months after the fracture.(Jardaly & Gilbert, 2021; Peng et al., 2022; Zhang et al., 2017)

Non-unions are broadly classified into septic and aseptic non-unions. Aseptic non-union is further divided into atrophic or hypertrophic. Atrophic non- union is avascular, nonviable and avital. It is associated with inadequate or poor vascularity with poor healing. Radiographically, it exhibits minimal callus formation filling the fracture gap surrounded by fibrous tissue. Hypertrophic non-union is said to be hypervascular, viable and vital and occurs due to inadequate immobilization. The vascularity and healing is adequate. Radiographically, hypertrophic non- union shows increased callus formation in a horseshoe or elephant foot pattern.(Li et al., 2022; Zhang et al., 2017)

Paul J Harwood et al. categorized the causes of non-union into four main groups, namely due to deficient of bone producing cells, deficient of signaling molecules, deficient of stability and deficient of bone conducting framework. Craig S. Roberts et al. on the other hand categorized the causes of non-union into two main categories, namely the systemic causes and local causes. Systemic causes such as malnutrition, diabetes mellitus, cigarette smoking and nicotine use, osteoperosis and use of nonsteroidal anti- inflammatory drugs have been said to be the cause on non-union. As for the local causes, impaired vascularity, unstable fixation, presence of bone gap, infections, mal- alignment or rotation, lack of stimulation (eg: weight bearing), impact of injury (high- energy versus low- energy) and iatrogenic factors such as aggressive periosteal stripping plus local trauma to soft tissue and bone vascularity during fixation are the causes of non-union.(Huang et al., 2022; Lu et al., 2022; Sanzana et al., 2016)

In terms of femoral nonunion with segmental bone defects, the frequently used treatment methods include vascular pedicle autologous bone grafting (such as ribs, ilium, and fibula), intramembranous osteogenesis technique (Masquelet technique), and Ilizarov distraction osteogenesis. All of these methods have their advantages and limitations. Autologous bone grafting with a vascular pedicle requires high level of microsurgical techniques; the bone supply is limited, and it will cause a secondary damage to the donor site; failure of revascularization of the transplanted bone segment will lead to the failure of fracture healing, and insufficient femoralization of the transplanted bone segment will result in poor bone strength, which then becomes prone to refracture.(Calder et al., 2019; Huang et al., 2022; Nayagam, 2010)

The Masquelet and Ilizarov techniques are the main surgical methods for the treatment of large segmental bone defects of the femur. With the internal fixation, the Masquelet technique allows the patients to avoid carrying a bulky circular external fixator and its associated complications, thereby increasing patient's compliance.(Calder et al., 2019; Huang et al., 2022; Nayagam, 2010) However, this technique has a higher requirement for the integrity of muscle soft tissue; it requires multiple operations (at least 2) and a large amount of autologous bone; it has a higher risk of reinfection and failure of revascularization and ossification of the transplanted bone region, and it is poor at correcting severe deformities. The Ilizarov technology has unique advantages in the treatment of femoral nonunion, especially with large-

segment bone defect, as it can simultaneously address infection, bone and soft tissue defects, and corrections of deformities at the primary stage. It is suitable for various types of nonunion with a lower requirement for soft tissue covering and a higher fracture healing rate.

The common external fixation systems with the Ilizarov technique include the Ilizarov circular frame, the TSF, the semicircular Ilizarov pin fixator, and the conventional external fixator. However, they are often full-circular or hybrid external fixation frames, which are bulky for patients to carry and affect the exercise of adjacent joints, they also have high demands in terms of the surgeon's technique. Therefore, Harshwal used monolateral external fixation frames to treat 7 cases of femoral nonunion, and 5 cases achieved fracture healing with good function.(Hosny, 2020; Li et al., 2022; Lu et al., 2022; Peng et al., 2022; Sangkaew, 2005; Zhang et al., 2017)

Lengthening the femur with an external fixator is commonly practised for a wide variety of pathologies. This technical report includes tips derived from observation and experience in a busy limb reconstruction unit. It focuses on the use of a rail fixator, although some of the descriptions are applicable to lengthening by circular fixators.(Mohammed et al., 2022; Sangkaew, 2005) The usual chosen sites of femoral osteotomy for lengthening are metaphyseal regions, often the subtrochanteric or supracondylar areas. These areas are predictably good at regenerate formation and offer a greater bone width in comparison with the diaphysis. Diaphyseal lengthening is also carried out but adjustments to the lengthening rate (0.75 mm per day is preferable to the usual 1.0 mm per day) are needed in order to compensate for slower regenerate formation.(Calder et al., 2019; Mohammed et al., 2022)

There are several advantages of femoral lengthening, including subtrochanteric area has an excellent blood supply from anastomoses between branches of the medial and lateral circumflex femoral vessels. Consequently regenerate formation is usually good, provided the general principles of osteotomy are followed.(Calder et al., 2019; Mohammed et al., 2022)

Additionally, As the site of lengthening is proximal, there is less interference with knee joint movement distally. However, if the insertion of gluteus maximus inserts into the distal segment created by the osteotomy, the increasing tension in this muscle from lengthening may produce an abduction contracture at the hip. Awareness of this possibility should be shared with the physical therapists who may notice the patient walking with a pelvic obliquity, despite achieving leg length equality. Gradual stretching of the gluteus maximus will reduce the problem.(Arora et al., 2012; Hosny, 2020; Poh Thean, 2019)

Indication For Limb Lengthening

In general, the indications for limb lengthening are controversial. Classic teaching classifes shortening into 3 categories: less than 2 cm, which can be ignored; 2–4 cm, with the possibility of lengthening; and more than 4 cm where lengthening is needed to avoid possible complications of lower limb length inequality such as pelvic obliquity and scoliosis. Also, a discrepancy of about 5 cm between leg lengths can be treated by epiphysiodesis in growing legs, or shortening of the longer leg at an appropriate time. However, this classifcation did not take into consideration the patient's height, heel size, tolerability of the shoe lift, family opinion and psychological aspects. With growing experience of the new advances in limb lengthening, these factors usually play an important role in decision making. The aetiology of bone shortening and associated deformities is important for planning. The cause may be congenital deficiencies such as fibular hemimelia.(Arora et al., 2012; Hosny, 2020; Poh Thean, 2019)

Complications

Results of limb lengthening are significantly affected by the clinical experience of the operating surgeon. The most common complication of external fxation is pin track infection, with a variable incidence which may reach 100% of treated patients. There are many variables

which afect the frequency of this complication, such as duration of fxation, material of the wires or half pins, surgical procedure and wound care. Many pin site care programmes are designed to prevent the development of infection but are not supported by reliable evidence. Treatment usually starts with oral antibiotics and increasing the frequency of pin site cleaning in mild cases and ending up with removal of the pin in severe cases. The use of hydroxyapatite coated pins can reduce the incidence of pin site infection significantly.(Arora et al., 2012; Mohammed et al., 2022; Poh Thean, 2019; Santoso et al., 2021)

Poor regeneration is a serious problem during limb lengthening and results from many systemic or local causes. It is important to modify the rate and frequency of distraction according to regeneration. Once delayed regeneration has been diagnosed, alternate cycles of compression distraction can solve the problem.(Arora et al., 2012; Mohammed et al., 2022; Poh Thean, 2019)

CONCLUSION

Non-union fractured bone was defined as a fracture that has not completely healed during a periods of time. In terms of femoral nonunion with segmental bone defects, the frequently used treatment methods include vascular pedicle autologous bone grafting (such as ribs, ilium, and fibula), intramembranous osteogenesis technique (Masquelet technique), and Ilizarov distraction osteogenesis. For patients with femoral nonunion with large segmental bone defects, the monolateral external fixation can provide effective stability, improve compliance, and reduce complications.

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