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CASE REPORT

Prediction of the intramedullary nail size by fibula length in bilateral femur fractures.

Predicción del tamaño del clavo intramedular mediante la longitud de la fíbula en fracturas bilaterales de fémur

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Abstract

Case Description:

A 23-year-old male patient, with no relevant medical history, who received direct contusion to the lower limbs at the level of the thighs due to a fall from a sheet bending machine.

Clinical Findings:

Clinical and radiographic findings compatible with bilateral comminuted sub-trochanteric fractures, with extension towards the diaphysis in both, with a Trauma Severity Index of 16.

Treatment and Outcome:

Favorable clinical and radiological outcome after early definitive surgical stabilization of both extremities with cephalomedullary nails, rehabilitation with physical therapy and clinical follow-up.

Clinical Relevance:

High energy trauma, due to different causes, constitutes a challenge for all health personnel, due to the patient's own conditions, the individual inflammatory response, the associated musculoskeletal injuries, some not detected at the beginning, and additionally in other systems. Patients with bilateral femur fractures may present the conditions listed above, which requires early identification of the risks of respiratory and multi-organ failure, knowledge of their metabolic status and definition of their clinical situation, considered potentially or truly critical, which even with timely treatment Mortality figures of 6.9% to 27% are found. According to defined parameters, early and definitive osteosynthesis of fractures can be performed, but its characteristics may represent difficulties for surgical planning.

Conflicts of interest:

None declared by the authors.

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Resumen

Descripción del caso:

Paciente masculino de 23 años quien recibió contusión directa en los miembros inferiores a nivel de los muslos durante accidente laboral.

Hallazgos clínicos:

Hallazgos clínicos y radiográficos compatibles con fracturas sub-trocantéricas bilaterales conminutas, encontrándose en ambas, extensión hacia la diáfisis, con un Índice de Severidad del Trauma de 16.

Tratamiento y resultados:

Resultado clínico y radiológico favorable tras estabilización quirúrgica definitiva temprana de ambas extremidades con clavos cefalomedulares, rehabilitación con terapia física y seguimiento clínico.

Relevancia clínica:

Los traumatismos de alta energía, por diferentes causas, constituyen un reto para todo el personal sanitario debido a las propias condiciones del paciente, la respuesta inflamatoria individual y las lesiones musculoesqueléticas asociadas, algunas no detectadas inicialmente, y además en otros sistemas. Los pacientes con fracturas bilaterales de fémur pueden presentar las condiciones mencionadas, lo que requiere la identificación temprana de los riesgos de insuficiencia respiratoria y multiorgánica, el conocimiento de su estado metabólico y la definición de su situación clínica, considerada potencialmente o verdaderamente crítica. Incluso con un tratamiento oportuno, se observan cifras de mortalidad del 6.9% al 27%. Según parámetros definidos, se puede realizar una osteosíntesis temprana y definitiva de las fracturas, pero sus características pueden dificultar la planificación quirúrgica.

Introduction

Bilateral femoral fractures are typically the result of high-energy trauma, and their management requires consideration of patient-specific conditions, individual inflammatory response, and associated multi-organ injuries [1]. This type of trauma has a reported incidence of 18.2 cases per 100,000 inhabitants per year [2]. With appropriate treatment, the associated mortality rate may range from 6.9% to 27% [4,5]. Effective management necessitates early identification of risk factors to classify trauma severity, hemodynamic stabilization through a damage control approach, and timely planning of medical-surgical intervention based on the patient's clinical condition [3].

In polytraumatized patients, femoral shaft fractures may be closed (91%) or open (9%) [6] and can be associated with vascular injury [7]. Intramedullary nailing is considered the standard surgical treatment for uncomplicated femoral shaft fractures, as it is a less invasive technique with a lower risk of in-hospital complications compared to external fixation. External fixation is more commonly indicated in open fractures with significant contamination or in cases where definitive management is not immediately feasible, such as in polytraumatized patients with compromised acid-base balance [8].

In bilateral femoral shaft fractures, there is no established consensus on the surgical management, particularly in cases involving comminuted or segmental fractures. This is

partly due to the difficulty in accurately measuring femoral length to select the appropriate implant—an essential step to prevent complications such as limb shortening and length discrepancies [9]. Closed reduction and intramedullary nailing, whether antegrade or retrograde, is the generally accepted technique, as it preserves the fracture hematoma and promotes early bone consolidation. This approach supports early rehabilitation, enabling prompt initiation of ambulation and daily activities [9].

For proximal third or subtrochanteric fractures, the use of a locked cephalomedullary nail may be required, as it has been shown to provide additional stability [10]. In other cases, such as fractures located in the midshaft or distal third of the femur, particularly in obese patients, retrograde intramedullary nailing is considered a viable alternative. This procedure, performed in the supine position on a conventional operating table, facilitates the fixation of concurrent fractures involving the knee, upper extremities, pelvis, and other secondary injuries that require multidisciplinary surgical management [11]. Techniques have been described to accurately estimate the optimal measurement for intramedullary implant osteosynthesis [11].

We present the case of a 23-year-old patient with bilateral subtrochanteric femur fractures extending into the diaphysis, accompanied by comminution. Surgical management followed the strategy described by Karakas and Harma [12], which calculates femoral length based on the sum of two anatomical measurements from the lower limb structures that remain intact following the traumatic event.

Case description

A 23-year-old male patient presented with bilateral lower limb and thigh crush injuries and contusions caused by a sheet metal bending machine accident, accompanied by severe pain and musculoskeletal deformity. Upon arrival at the emergency department, his vital signs were within normal limits: blood pressure of 124/74 mmHg, heart rate of 84 beats per minute, respiratory rate of 18 breaths per minute, and oxygen saturation of 97%. Physical examination revealed bilateral thigh edema, shortening and external rotation of both lower limbs, negative open and closed book maneuvers, preserved distal pulses, capillary refill time under 3 seconds, preserved toe mobility, and significant functional impairment.

Thoracic, abdominal, pelvic, and cranioencephalic trauma were ruled out. Radiographic imaging revealed a subtrochanteric fracture of the left femur extending into the diaphysis with associated comminution, and a subtrochanteric fracture of the right femur with a butterfly fragment (Figure 1). The Injury Severity Score (ISS) was 16/75.

Given the patient's overall clinical condition and stable hemodynamic and metabolic status, definitive fixation of both limbs with cephalomedullary nails was planned within the first 24 hours to reduce the risk of complications and facilitate early recovery. External fixators were also prepared as a backup in case intraoperative use became necessary.

External measurements of both limbs and radiographs of the pelvis, bilateral femurs, and the left leg were taken to estimate the required nail length. The femoral length (FL) was estimated using a method based on the sum of two anatomical structures that remain intact after the traumatic event. Specifically, FL was calculated as the sum of fibular length (FLi) and femoral head diameter (FHD), providing an accurate approximation of femoral length from the trochanteric region (piriform fossa) to the condylar region (intercondylar notch): FL = FLi + FHD (Figure 2).

Fixation began with the femur considered technically less complex, with adequate reduction and alignment of the fragments, visualized on the image intensifier. Subsequently, in coordination with the anesthesiology team, the patient's condition was assessed and deemed stable enough to proceed with the contralateral femur osteosynthesis. The position on the

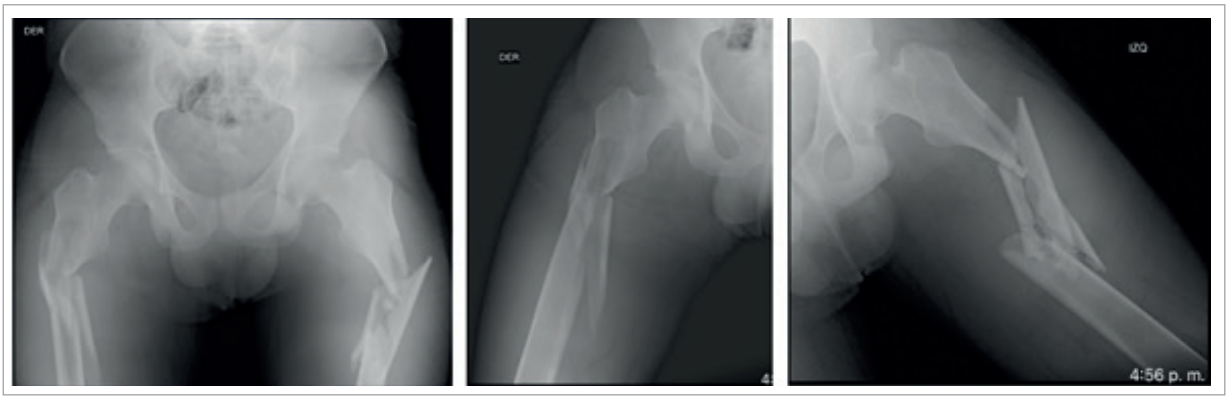

Figure 1. Bilateral femur and anteroposterior pelvic radiographs. Subtrochanteric fracture of the left femur extending into the diaphysis with associated comminution, and subtrochanteric fracture of the right femur with a butterfly fragment, with no pelvic, femoral head, or bilateral neck fractures or dislocations.

fracture table was adjusted by modifying the traction support point for the limb to be operated on next. Both procedures were successfully completed in a single operative session. Right and left cephalomedullary nails measuring 11 × 400 mm at 130 degrees were used, with 10.5 × 90 mm cephalic screws for closed reduction and fracture fixation, secured with two distal locking screws each (Figure 3).

The postoperative course was favorable, with no neurological or vascular deficits, adequate limb mobility, and decreased pain. Clinical evaluation showed no angular or rotational deformities and no limb length discrepancy. The patient remained hemodynamically and metabolically stable, with vital signs within normal limits.

Postoperative hemoglobin was measured at 6.1 g/dL, requiring the transfusion of two units of red blood cells, with no reported complications, and increased hemoglobin level to 9.3 g/dL, as patients with femoral fractures can experience significant hemorrhage at the fracture site, with an estimated blood loss of up to 1,000 cc. Additionally, intramedullary fixation is associated with ongoing intramedullary bleeding, which is difficult to quantify and even more significant in bilateral fractures [8].

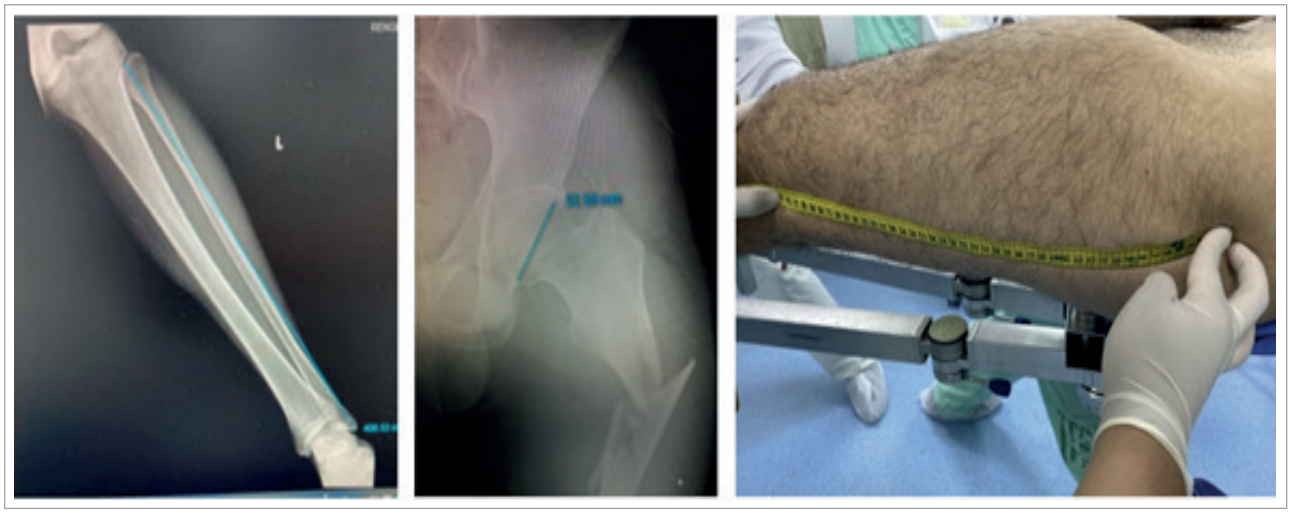

Figure 2. Measurement strategy based on the length from the tip of the trochanter to the lateral epicondyle of the femur (FL).

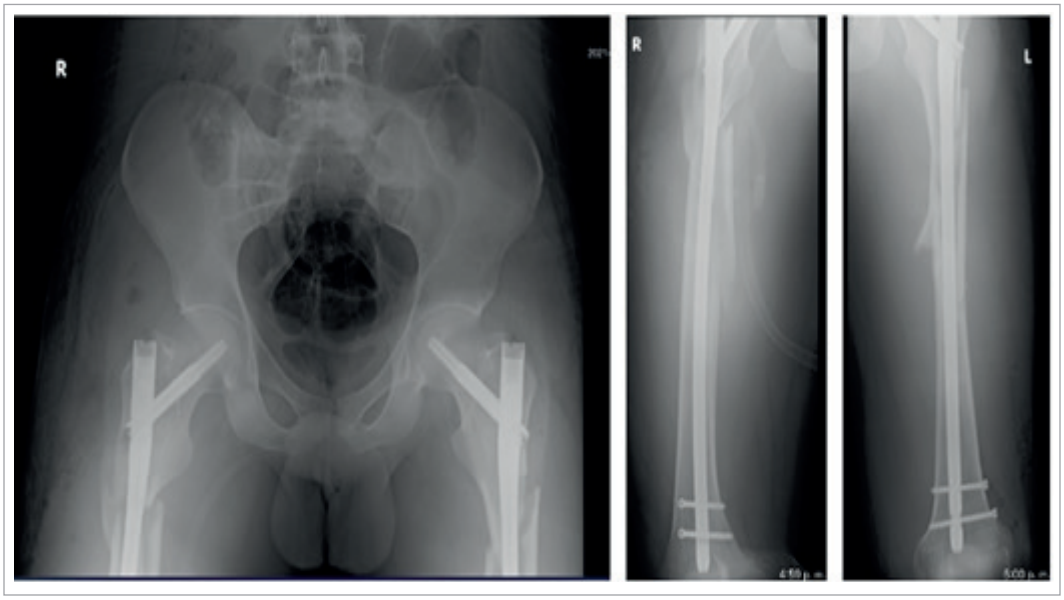

Figure 3. Fracture fixations result with cephalomedullary implants.

The patient was discharged in good condition with general recommendations and a follow-up appointment. On subsequent follow-ups, improvement in gait pattern was observed, along with overall physical condition and progress in returning to basic daily activities. Follow-up radiographs showed favorable and progressive fracture consolidation (Figure 4), and continued rehabilitation was recommended.

Later, a panoramic radiograph of the lower limbs was requested to confirm the absence of clinically suspected limb length discrepancy. However, due to the patient's return to work and scheduling constraints, he was unable to continue with postoperative follow-up or undergo the requested imaging.

Consent

Written informed consent was obtained from the patient for the publication of this case report and the accompanying images.

Discussion

The surgical management of bilateral femoral fractures remains a topic of debate [13]. Evidence-based strategies have been described, including **Damage Control Orthopedics (DCO)**[14], which involves temporary stabilization of fractures using external fixation followed by definitive surgical treatment in patients at high risk of clinical deterioration, and **Early Total Care (ETC)**, which proposes immediate fixation of both fractures with intramedullary nailing in a single surgical session, avoiding a second intervention [15].

Flagstad et al. [16], identified three key factors in the selection of the surgical strategy: the patient volume at the institution, the Injury Severity Score (ISS), and lactate levels at admission. In high-volume centers, bilateral femur fractures often occur in patients with severe injuries; thus, management is influenced by institutional protocols, multidisciplinary team perspectives, and available hospital resources. Furthermore, elevated lactate levels reflect systemic hypoperfusion and anaerobic metabolism, which are associated with the need for an initial damage control approach. Previous studies have suggested that patients with lactate ≥2.5 mmol/L for over 24 hours benefit from damage control orthopedics, whereas those with levels <2 mmol/L may be candidates for definitive intramedullary fixation [17,18].

Figure 4. Post-surgical radiographs showing fractures in the consolidation process.

In the described case, early definitive management was chosen because the patient presented with stable metabolic and hemodynamic status, an ISS of 16 points, and no systemic compromise warranting delayed fixation. Intramedullary fixation of both fractures was performed in a single surgical session, minimizing the risk of complications associated with multiple surgeries and promoting faster recovery.

Locked intramedullary nailing is currently the treatment of choice for diaphyseal femur fractures, including bilateral comminuted fractures [19]. However, its use may be associated with complications such as limb length discrepancies due to inadequate reductions or

Figure 5. Representation of the digital measurement of radiographic images obtained with the CT scanner, showing the measurements that were assessed. Diameter of the femoral head (HD), femoral medullary length (ML), and fibular length (FL) obtained from the left lower limb 12.

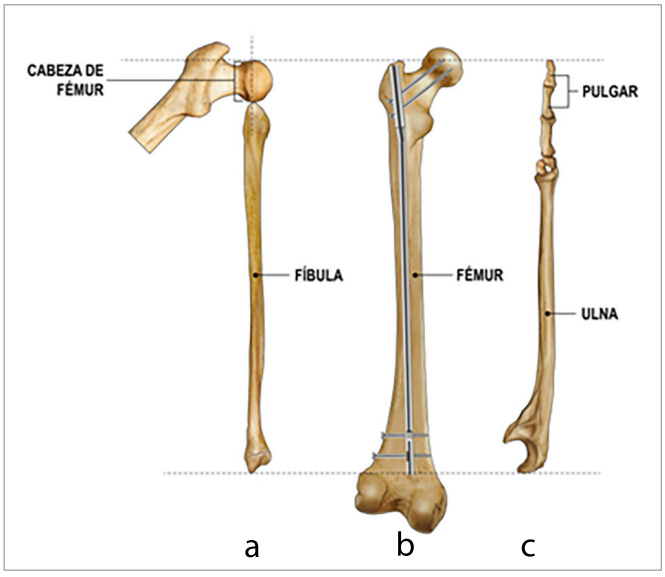

Figure 6. Methods using anatomical references to calculate the length of the intramedullary nail in comminuted bilateral femur fractures. a. Karakas' proposal: adding the length of the fibula + the diameter of the femoral head on a radiograph. b. Nail length from the tip of the trochanter to the lateral epicondylar area. c. Chung's proposal: measurement from the olecranon prominence to the tip of the thumb.

intraoperative measurement difficulties [20,21]. Several strategies exist for accurately selecting the implant size, such as "The Box Technique", which uses intraoperative fluoroscopy to align and compare the length of the proximal and distal femur before implanting the nail [22].

In this case, a method based on the study by Karakas et al. [12], was used. They demonstrated that femoral medullary length can be accurately estimated by summing the fibular length and the diameter of the femoral head. In their experimental study, digital images obtained via CT scan in healthy subjects determined that the fibular length (measured from its proximal to distal ends) and the diameter of the femoral head (distance between its inferomedial and superolateral points) significantly correlated with femur length (distance between the piriform fossa and the intercondylar notch) (Figure 5). Their Pearson correlation analysis showed a highly significant relationship ($r = 0.942$, $p < 0.0001$), with no differences between sex genders.

This method is particularly useful in cases of bilateral comminuted fractures, where the contralateral femur is not available as a reference. In the patient from this case report, the application of this technique allowed for accurate selection of the intramedullary nail size and minimized the risk of limb length discrepancy, optimizing both the surgical and functional outcome (Figure 6) [12,23].

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