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Research Article

Bone Gutter and Myoosseous Muscle Flap in Chronic Femoral Osteomyelitis in Adults: A 2-Year Prospective Case Series

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Abstract

Background: Chronic osteomyelitis of the femur is a complex orthopedic challenge that needs comprehensive surgical and antibiotic treatment. Bone guttering with myoosseous muscle flap coverage offers promising outcomes in controlling infection and enhancing tissue healing. ***Objective***: To assess the effectiveness of bone gutter and myoosseous muscle flap in adult males with chronic femur osteomyelitis. ***Methods***: A prospective case series study enrolled 24 male patients with chronic femoral shaft osteomyelitis. (62.5%) Cases were managed by bone guttering, myoosseous muscle flap, or implant removal followed by the same procedure (37.5%). Antibiotics were given based on culture and sensitivity, and the Cierny-Mader classification was used for staging. The clinical outcome was assessed by infection resolution, wound healing, and recurrence rates over 24 months of follow-up. ***Results***: The mean age was 29.00±6.56 years. All cases presented with discharging sinus, *Staphylococcus aureus* (50.0%), and Streptococcus (25.0%), which were the most frequently reported microorganisms. 50.0% of cases were treated with fusidic acid, followed by Augmentin (25%) for 6 weeks. After 2 years of follow-up, complete infection resolution and healing were achieved (100.0%). ***Conclusions***: Bone guttering with myoosseous muscle flap is a simple, reproducible, and highly effective management strategy for chronic femoral osteomyelitis. The approach achieved complete bone infection control when combined with targeted antibiotics. Larger multicentric studies are recommended to generalize these findings.

Keywords: Bone gutter, Chronic osteomyelitis, Femur, Myoosseous muscle flap.

مزراب العظام والسديلة العضلية في التهاب العظم والنخاع الفخذي المزمن عند البالغين: سلسلة حالات مستقبلية لمدة عامين

الخلاصة

الخلفية: التهاب العظم والنقي المزمن في عظم الفخذ هو تحد معقد للعظام يحتاج إلى علاج جراحي ومضاد حيوي شامل. توفر المزاريب العظمية مع تغطية السديلة العضلية العضلية نتائج واعدة في السيطرة على العدوى وتعزيز التئام الأنسجة. **الهدف**: تقييم فعالية مزراب العظام والسديلة العضلية العضلية لدى الذكور البالغين المصابين بالتهاب عظم الفخذ المزمن. **الطرائق**: شملت دراسة سلسلة حالات مستقبلية 24 مريضا من الذكور يعانون من التهاب العظم والنقي المزمن في جذع الفخذ (62.5%) . تمت إدارة الحالات عن طريق المزاريب العظمية أو السديلة العضلية العضلية أو إزالة الغرسة متبوعة بنفس الإجراء (37.5٪). تم إعطاء المضادات الحيوية بناء على الثقافة والحساسية ، وتم استخدام تصنيف Cierny-Mader للتدريج. تم تقييم النتائج السريرية من خلال مستوى العدوى والتئام الجروح ومعدلات التكرار على مدى 24 شهرا من المتابعة. **النتائج**: بلغ متوسط العمر 29.0±6.56 سنة. جميع الحالات التي تم إفرازاتها من الجيوب الأنفية احتوت المكورات العنقودية الذهبية (50٪)، والمكورات العقدية (25٪)، والتي كانت أكثر الكائنات الحية الدقيقة التي تم الإبلاغ عنها شيوعا. 50٪ من الحالات عولجت بحمض الفوسيديك ، يليه أوغمنتين (25٪) لمدة 6 أسابيع. بعد عامين من المتابعة، تم تحقيق حل كامل للعدوى والشفاء (100٪). **الاستنتاجات**: المزاريب العظمية مع السديلة العضلية العضلية هي استراتيجية إدارة بسيطة وقابلة للتكرار وفعالة للغاية لالتهاب العظم والنقي الفخذي المزمن. حقق النهج السيطرة الكاملة على عدوى العظام عند دمجه مع المضادات الحيوية المستهدفة. يوصى بإجراء دراسات أكبر متعددة المراكز لتعميم هذه النتائج.

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INTRODUCTION

Chronic osteomyelitis (COM) remains a persistent challenge in adult orthopedic practice, characterized by recurrent infection, bone necrosis, and soft tissue involvement. It typically appears 6 weeks or more after bone infection associated with bone destruction and sequestrum [1,2]. Typically, patients present with a history of acute osteomyelitis, trauma, or previous surgical intervention to the bone and mostly present with long-term discharging sinus, fistula, and/or bone pain [3]. Most of the affected cases below the age of 70 years are male, owing to behavioral and social factors that make them engage in high-velocity activity and thus be exposed to high-velocity traumas, while women are at risk of femur fracture due to osteoporosis after the age of 70 years [2,3]. Its diagnosis relies on combining history, physical examination, and lab work, which often shows increased inflammatory markers, increased erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP), white blood cell count (WBC), and imaging studies [4,5]. The latter includes radiological studies and CT scans, which are the gold standard [6].

COM management requires multiple surgeries and prolonged antibiotic therapy. Despite advances in antimicrobial therapy and surgical techniques, managing COM remains challenging, with a recurrence rate of 20% - 30% [7] compounded by the persistent nature of COM that impacts patients' quality, physical health, and health mentality [8]. Rarely, the disease may transform into a malignant tumor at the site of infection [9]. These factors make orthopedic surgeons emphasize a successful evidence-based management protocol [10]. The femur is particularly vulnerable to chronic osteomyelitis owing to high-energy trauma or internal fixations. Treatment failure of chronic osteomyelitis is often attributed to the persistence of necrotic bone, inadequate soft tissue coverage, and biofilm formation. Timely diagnosis and extensive management of COM are important to achieve infection resolution and good functional restoration [11,12]. Recent studies have postulated the importance of combining radical debridement (bone guttering) with vascularized soft tissue flaps to manage dead space, improve vascularity, and facilitate antibiotic delivery [13]. Myoosseous muscle flaps offer mechanical and biological advantages, promoting healing and reducing recurrence. A limited number of studies have evaluated this technique, and most of them are outdated [14]. Moreover, not all existing studies from the area had a standardized reporting system like Cierny–Mader staging [15]. The current study assessed the clinical and microbiological outcome among adult Iraqi males with COM of the femur treated by combining bone guttering and myoosseous muscle flap reconstruction. We aim to bring contemporary, relevant evidence that helps guide surgical decision-making in COM of the femur.

METHODS

Study design and setting

A case series study prospectively enrolled adult patients with confirmed femoral COM attending Al Yarmouk Teaching Hospital. Eligible cases were followed up from January 2020 to March 2025 after giving verbal consent and a brief explanation about the purpose of the study and its benefits. All study tests were done following the Helsinki umbrella. The ethics committee of Mustansiriyah University issued the study approval (IRB: 807 dated 5/12/2020).

Inclusion criteria

Skeletally mature adults (≥ 18 years). History of post-surgical infection following internal fixation of closed long bone fractures. Duration of symptoms ranging from 6 to 12 months prior to enrollment. All cases enrolled were male, which is unstable owing to behavioral and social factors that expose males to high-velocity activities and, thus, fractures.

Exclusion criteria

History of infection post-arthroplasty. Immunocompromised patients (uncontrolled diabetes, patients with renal and hepatic diseases). Patients are classified as type IV based on the Cierny and Mader classification system. History of open fractures at the infection site.

Data collection

Study parameters were gathered through a questionnaire designed by the researcher. Patients were categorized into anatomical and host classifications after a detailed history, physical examinations, and lab and imaging tests. The anatomical classification was made based on the Cierny and Mader classification [15]: Type I (Medullary Osteomyelitis), Type II (Superficial Osteomyelitis), Type III (Localized Osteomyelitis), and Type IV (Diffuse Osteomyelitis). Hosts were classified as follows: A) hosts were normal, and B) hosts were either locally (Bl), systemically (Bs), or both locally and systemically compromised (Bls), and C) hosts were those for whom treatment posed a greater risk than the disease itself [16]. Eligible cases that satisfied our criteria were recruited from the Al Yarmouk Teaching Hospital outpatient clinic. A comprehensive history and medical examination were taken, followed by laboratory findings (CBC and virology screen), ESR, culture sensitivity from sinus discharge, X-ray, CT scan, and MRI. The combination of medical assessment, lab, and imaging tests confirmed the diagnosis of COM. The final number analyzed was 24 males. Data from the patients were gathered alongside basic preoperative investigation. Cases were classified based on the types of infection according to Cierny–Mader classification (Figure 1).

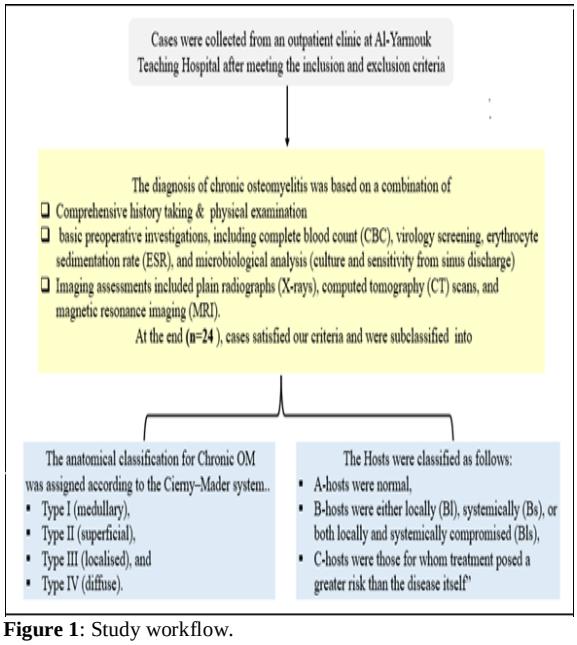

Figure 1: Study workflow.

Surgical intervention

An appropriate anesthesia method (GA, spinal, or Bier's block) was selected based on the patient's condition. The operative field was sterilized, disinfected, and draped with sterile towels. Longitudinal skin was made, followed by fascial and

muscle dissection in layers to expose the infected bone. The sinus tract was identified, and intraoperative cultures were taken for all patients. Multiple unicortical bone drill holes (3.5 mm) were created to create a rectangular area connected using an osteotome to excise the unicortical bony gutter. The medullary cavity was debrided and copiously washed with normal saline. Additional drill holes were made at the edge of the cortical bone to make a home for the anchorage of the muscular stitches. The vastus lateralis muscle was mobilized and released. 3-4 No. 1 nylon stitches were inserted in the muscle fascia, covering a chosen edge. One vial of powdered vancomycin (1 g) was inserted into the medullary cavity. The vastus lateralis muscle was sutured to the bony gutter edge, so the main muscle bulk is embedded into the medullary cavity to obliterate the dead space and enhance vascularity (Figure 2).

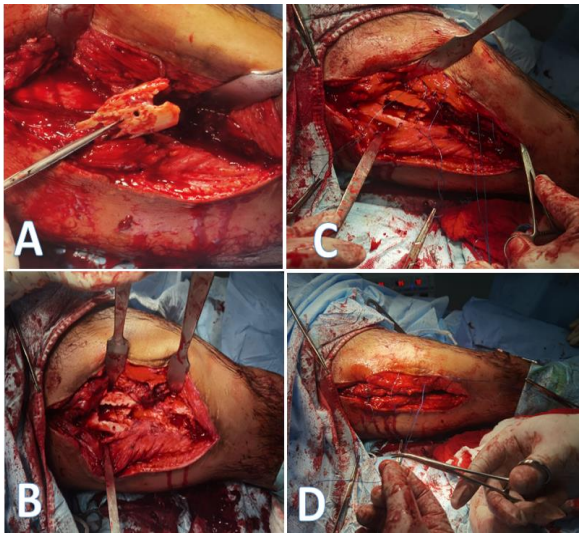

Figure 2: Surgical procedure for thirty years old male patients with chronic osteomyelitis of the left femur. **A**) Excision of sequestrum; **B**) Demarcation and Excision of rectangular bone gutter; **C)** Nylon stay suture placed in the bony edge and the vastus lateralis edges; **D)** Muscle embedded inside the medullary canal with Nylon suturing.

In the postoperative period, all patients were treated with empirical antibiotics, which were changed later according to the C&S results. The soft tissue condition was regularly evaluated during the first 2 postoperative weeks to monitor wound healing, flap viability, and any inflammation signs. Partly weight-bearing exercise was initiated 6 weeks postoperatively, while full weight-bearing started within 12 months, depending on individual patient tolerance and radiological progress. ESR was monitored to exclude any inflammatory activity. An early rehabilitation program was implemented by encouraging a passive range of motion exercise followed by an active range of motion therapy supervised by a physiotherapist. Patients were encouraged to continue exercising at home to enhance limb function and prevent joint stiffness (Figure 2).

Statistical analysis

It was carried out using Microsoft Excel 2016 and the statistical package of IBM SPSS-29 (IBM Statistical Package for Social Sciences, version 29, Chicago 2, USA); statistical significance was set whenever *p*-value was < 0.05.

RESULTS

This case series included 24 adult male patients diagnosed with COM with a mean of 29.0±6.56 years and a range of 21-43 years. The most common presenting feature in all patients was a recurrent discharging sinus with a mean symptom duration of 19.50±7.89 months, ranging between 6 and 12 months. Of the total cases, 15 age cases (62.5%) had previously undergone open reduction and internal fixation with plates and screws, while 9 cases (37.5%) were treated with closed reduction and internal fixation using intramedullary nails. According to the Cierny–Mader classification, type 3 osteomyelitis was observed in 18 patients (75.0%), and type 1 osteomyelitis was observed among 6 patients (25.0%). All 24 (100%) patients were classified as type Bl hosts. The most commonly isolated microorganism was *Staphylococcus aureus* 12 (50.0%), followed by *Streptococcus* 6 (25.0%) and *Pseudomonas aeruginosa* 3 (12.5%). Table 1.

Table 1: Clinical data of the study cases (n=24 in each group)

Variables		n(%)
Cierny–Mader stage	Type 1	6(25)
	Type 3	18(75)
Cierny–Mader host	Bl	24(100)
Organism (C&S)	*Staphylococcus aureus*	12(50)
	Streptococcus	6(25)
	Pseudomonas Aeruginosa	3(12.5)
	Inconclusive	3(12.5)

Bone guttering and myoosseous flap were done among 15 (62.5%) patients, while implant removal, then bone guttering and myoosseous flap, were done among 9 (37.5%) patients. According to the postoperative culture and sensitivity, 12 patients (50.0%) were given Fusidic acid for 6 weeks, while 6 patients (25.0%) were given Augmentin for 6 weeks, 3 patients (12.5%) were given Amoxil caps for 6 weeks, and 3 patients (12.5%) were given Ciprofloxacin for 3 weeks. After 2 years of follow-up, all 24 patients (100%) achieved healing without recurrence, the outcome among which was a clinically significant outcome with $p < 0.001$ (Table 2).

Table 2: Surgical data and outcome among patients (n=24)

Variables		n(%)
Type of surgery		
Bone guttering & myoosseous flap		15(62.5)
Implant removal, bone guttering, & myoosseous flap		9(37.5)
Medical treatment		
Fusidic acid for 6 weeks		12(50)
Augmentin for 6 weeks		6(25)
Amoxicillin for 6 weeks		3(12.5)
Ciprofloxacin for 3 weeks		3(12.5)
Outcome after 2-year follow-up	Healed	24(24)
	Recurrent	0(0.0)

DISCUSSION

In the Cierny–Mader classification, type 3 predominates (75.0%) of patients, while type 1 was observed among 25.0% of patients; all of the involved cases were Bl host (100%). The microorganism was mostly Staphylococcus aureus 12 (50.0%), then *Streptococcus* 6 (25.0%), and *Pseudomonas aeruginosa* 3 (12.5%). In the study by Gokalp *et al*., patients were distributed one case at stage 1A, one at 2A, two at stage 2B, twelve at 3A, five at 3B, seven at stage 4A, and two at 4B. *Staphylococcus aureus* was identified as the most common pathogen, accounting for 56.6%, in line with our findings [16]. In this study, bone guttering and myoosseous flap were done among 62.5% of patients, while implant removal of bone guttering and myoosseous flap was done for 37.5%. Anthony *et al*. studied 34 patients with COM who were treated with debridement and immediate muscle flaps. Among the 27 patients who were followed for five years, 89% achieved sustained healing, with only 3 patients suffering recurrence. Two of these were cured after another procedure, yielding an overall success rate of 96% [17]. Another study by Lok *et al*. reported 12 cases of COM treated by gutter and muscle flap transfer. After a 2-year follow-up, no cases of recurrence were observed [18]. Necmioglu *et al*. applied the same procedure to six patients with femoral chronic osteomyelitis and observed no recurrences after 4 years of follow-up, suggesting its potential as an excellent alternative to conventional methods [19]. Fitzgerald *et al*. reported that local muscle flaps effectively manage bone and extensive soft tissue defects. This approach can lead to a favorable outcome in treating chronic osteomyelitis when combined with thorough debridement and culture-directed antibiotic therapy [20]. Ngoí *et al*. study reported a successful outcome in 4 patients with chronic osteomyelitis. Treated using local muscle flaps after sequestrectomy. The effectiveness of this approach is attributed to establishing a new vasculature that improves nutrient delivery and adequate antibiotic penetration [21]. In this study, postoperative antibiotics were given for 3-6 weeks according to the culture and sensitivity results. Haider et al. reported that several studies support shorter antibiotic courses, especially when extensive debridement and vascularized flap reconstruction were done, as they encourage vascularity [22]. Similarly, Calhoun and Manring recommended tailoring antibiotic duration to the Cierny–Mader staging system, suggesting a short course (two weeks) for the I and II stages and extended therapy (4 up to 6 weeks) for the III-IV stages [23]. In agreement with our study, Pande et al. postulated that the correct staging and identification of COM and the causative organism are important for effective treatment. [25], which was in the layout of our study [24]. Anthony *et al*. confirmed that a single-stage dependent with immediate muscle flap reduces the antibiotic duration and enables future bone grafting if needed [19]. Mathes *et al*. study highlighted two factors that affected the muscle flap in the osteomyelitis context: complete debridement and direct application of well-vascularized muscle, offering an excellent source of antimicrobial support [25]. The current study's 2-year healing rate was 100.0%, with no recurrence. Similarly, Gokalp *et al*. reported complete sinus closure and normal radiographical findings [16]. In contrast, a study by Ikpeme *et al*. in 2013 achieved a 77.8% healing rate following debridement, sequestrectomy, and antibiotics. [26] Differences in the healing rate between studies might reflect differences in surgical techniques, debridement depth used, and overall vascularity [26]. In this study, bone guttering with muscle flaps improved healing by enhancing vascular supply. In contrast, Ikpeme *et al*. [27] used a standard debridement of necrotic tissue alone, resulting in 77.8% cure rates, probably due to limited vascularization and residual dead space. Ger et al. reported success with muscle transposition with delayed skin grafting among patients with osteomyelitis [28]. Limited research addressed the technique of gutter creation and muscle flap transposition. The current study suggests that this is a practical and relatively simple approach for managing the COM of the long bones. Thus, if this technique is performed correctly and supported by suitable antibiotic therapy, this method can yield a highly satisfactory outcome with a very high cure rate [29,30].

Study limitations

This study was limited by a small sampling size and single-center design, which impedes the generalization of its results. In addition, the absence of a control group managed by the alternative surgical approach hinders the direct comparison and limits solid conclusions regarding the superiority of this approach.

Study strengths

This was the first Iraqi study to evaluate the combined surgical approach of bone guttering and myossus muscle flap in managing COM, potentially laying the groundwork for future evidence-based national guidelines tailored to Iraqi patients. The technique used here was reproducible and straightforward, utilizing bone and muscle to enhance vascularity and healing. Moreover, we have adopted culture-guided antibiotic therapy to align with evidence-based infection control practice. Finally, the high cure rate (100%) with no recurrence over 2 years of follow-up validates its usefulness. Future multicentric trials with larger samples are needed to enhance the generalizability of study results. A comparative study is recommended to compare the results with other surgical techniques to confirm the approach's efficacy.

Conclusions

Bone guttering with a myoosseous flap is a simple yet highly effective procedure, achieving complete healing in all cases with COM. The dominance of Staphylococcus aureus underscores the need for targeted antibiotic therapy based on culture and

sensitivity; the use of fusidic acid was most frequently effective. The success highlights the critical role of early intervention, thorough debridement, and vascularized coverage. This approach deserves greater clinical consideration due to its simplicity and high cure rate. Larger multicenter studies, with long follow-ups, are needed to confirm broader applicability and long-term benefits in chronic osteomyelitis.

Conflict of interests

The authors declared no conflict of interest.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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