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The Double-Edged Graft: Osteomyelitis Triggered by Bone Substitutes - A Case Series

Dr. Abhishek Shinde[1], Dr. Suryakant Perkar[2], Dr. Purnendu Panchal[3]

[1]MBBS, MS, DNB (Orthopaedics), Assistant Professor, MGM Medical College and Hospital, Chhatrapati Sambhajinagar, Maharashtra, India
Email: *drabhi.shinde[at]gmail.com*

[2]MBBS, MS (Orthopaedics), MGM Medical College and Hospital, Chhatrapati Sambhajinagar, Maharashtra, India
Email: *suryakantperkar39[at]gmail.com*

[3] MBBS, MS (Orthopaedics), MGM Medical College and Hospital, Chhatrapati Sambhajinagar, Maharashtra, India
Email: *purnendu.panchal[at]gmail.com*

Abstract: ***The uncommon but dangerous possibility of persistent osteomyelitis associated with synthetic bone graft substitutes is examined in this case series. Two example cases were analyzed using this method: a tibial tumor defect filled with calcium phosphate and a calcaneal fracture treated with calcium sulfate, both of which experienced chronic infections following indolent courses. The primary outcome was that to successfully eradicate the infection, both patients required extensive debridement to remove the biomaterial and diseased bone, followed by IV antibiotics and restoration. In order to ensure timely diagnosis and aggressive management, the conclusion emphasizes the importance of careful technique, appropriate patient selection, and a high index of suspicion for any persistent symptoms. These synthetic materials are valuable, but they can also act as a foreign body nidus for infection.***

Keywords: Osteomyelitis, Bone graft substitute, Synthetic graft infection, Case series

1. Introduction

One of the major obstacles in orthopaedic surgery includes the surgical correction of skeletal deformities, nonunions, and voids caused by trauma or tumor removal. Although being the gold standard for its osteogenic, osteoinductive, and osteoconductive characteristics, the historical dependence on autogenous bone transplant is hindered by factors such as donor site morbidity, limited accessible volume, and extended duration of operation. As a result, synthetic bone graft substitutes, or BGS, have become widely used in contemporary practice [1]. Osteoconductive scaffolds are the main function of these materials, which primarily consist of calcium-based substances including calcium sulfate, hydroxyapatite, and tricalcium phosphate, either by themselves or in composite formulations [2]. They obviate the need for a secondary harvest process by stimulating the ingrowth of osteoprogenitor cells and host vasculature, which in turn promotes the synthesis of new bone through a protected nidus. These biomaterials remain completely inert, despite their intrinsic biocompatibility. Any foreign element inserted into the body changes the biological environment there and might unintentionally exacerbate negative effects in some situations [3]. The emergence of deep surgical site infection is a serious, albeit rare, consequence [4]. Certain replacements' macro- and micro-architectures can serve as biofilm-sheltered nidus by offering a protected environment for bacterial adherence and colonization, even though they are perfect for vascular and cellular ingrowth. This danger is more significant when there is pre-existing subclinical contamination, weak soft tissue covering, or weakened host immunity [5].

A glycocalyx-enclosed biofilm forms on the implant surface as part of the pathophysiological process, providing significant resistance to systemic antibiotics and host immunological systems. This can result in a chronic, slow-moving osteomyelitis that frequently does not manifest itself for months or even years after the index surgery, creating a challenging diagnostic and treatment situation. Two such cases where synthetic bone graft substitutes were linked to the development of a persistent infection are described in this case series. By emphasizing the importance of careful long-term follow-up, a high index of suspicion in patients with persistent symptoms, and the need for aggressive, frequently surgical, intervention to achieve eradication, this presentation aims to increase clinical awareness among orthopaedic surgeons about this possible sequela [6].

2. Methodology

Two patients who experienced persistent osteomyelitis after using synthetic bone graft substitutes were retrospectively analyzed as part of the case series' methodology. The clinical, radiological, and histological data of both patients were carefully examined while they were under our care. Histopathological analysis, deep intraoperative tissue cultures, and sophisticated imaging (MRI) were used to confirm the diagnosis. Following the guidelines in Campbell's Operative Orthopaedics, the care protocol placed a strong emphasis on culture-specific intravenous antibiotic therapy, extensive surgical debridement, and the removal of all non-viable tissue and biomaterial. At six-month intervals, follow-up evaluations were carried out to check for recurrence.

1) *Case Reports*

Case 1:
A 35-year-old male sustained a comminuted, depressed intra-articular calcaneal fracture (Sanders type IV) following a high-energy trauma. Given the extent of articular

impaction and subchondral bone loss, open reduction and internal fixation were performed via an extended lateral approach. To address the residual metaphyseal defect and provide structural support, a synthetic calcium sulfate-based bone graft substitute was implanted. [fig 1.1 and 1.2] The immediate postoperative course was uncomplicated, with wound healing achieved primarily.

Approximately one year postoperatively, the patient developed intermittent seropurulent discharge from a sinus tract located at the proximal aspect of the surgical incision. Initial management involved superficial wound swabs, which identified Enterobacter *species*, and a course of empirical oral antibiotics was initiated. This resulted in transient symptomatic improvement but failed to eradicate the infection. Plain radiographs demonstrated persistent lucency around the graft site but no clear signs of sequestrum or loosening of the implant. Given the recurrent drainage, the decision was made to remove the implant [fig 1.3]. Intraoperative cultures were obtained, and targeted intravenous antibiotic therapy was administered for six weeks based on sensitivities.

However, six months following, the patient presented with recurrent symptoms, including increased local pain, erythema, swelling, and frank purulent discharge. Advanced imaging with magnetic resonance imaging (MRI) was obtained, which revealed classic features of chronic osteomyelitis: marrow edema, cortical breaching, and a fluid collection contiguous with the residual bone substitute material [fig 1.4 A and B]. The patient underwent radical surgical debridement. The procedure exposed a well-defined cavitary lesion filled with necrotic bone, residual fragments of the non-resorbed graft material, and abundant pus. [fig1.5] All necrotic tissue and residual biomaterial were meticulously excised. Deep tissue specimens were sent for microbiological and histopathological analysis, which confirmed the diagnosis of chronic osteomyelitis. A prolonged course of culture-directed intravenous antibiotics was administered postoperatively. At the six-month follow-up, the patient was asymptomatic, with a healed wound, no evidence of drainage, and radiographs showing no progression of osteolysis. [fig 1.7]

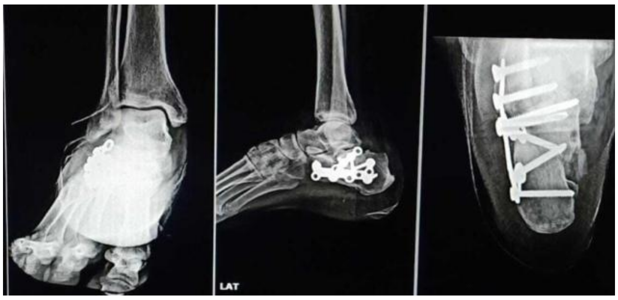
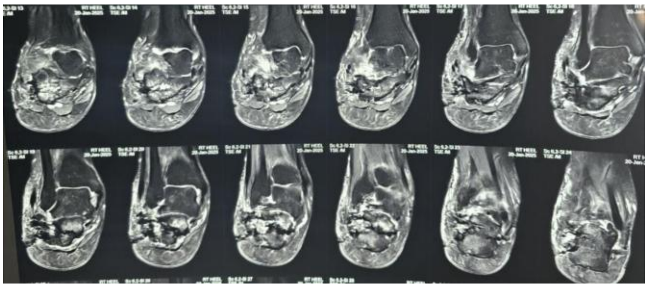


Figure 1.1: Post operative x-ray of open reduction and internal fixation with calcaneum plating with synthetic bone graft.

Figure 1.2: Intra-operative picture showing placement of bonegraft into the debrided cavity

Figure 1.3: Post implant removal X-ray



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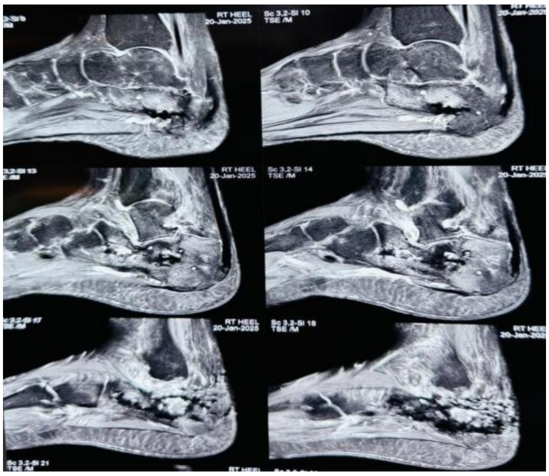

B

Figure 1.4: Coronal section of calcaneum MRI showing classic features of chronic osteomyelitis: marrow edema, cortical breaching, and a fluid collection with a sinus tract of 3.1 cm

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Figure 1.5: intra-operative picture of calcaneum with sequestered bone and cavity

Figure 1.6: Follow-up X-ray after 3 months of debridement

Case 2:

A 24-year-old male presented with activity-related pain in his proximal tibia. Radiographs and subsequent MRI revealed an expansive, lytic lesion in the metaphysis with a pathological fracture, highly suggestive of an aggressive benign tumor[fig2.1]. An open biopsy confirmed the diagnosis of a giant cell tumor (GCT). The patient underwent aggressive intralesional curettage with high-speed burring to extend the margin of normal bone. The resulting sizable defect was stabilized with a buttress plate and filled with pre-formed blocks of a synthetic composite graft comprising hydroxyapatite and β-tricalcium phosphate to provide immediate structural support and encourage osseous integration. [fig2.2]

Five months postoperatively, the patient acutely developed systemic symptoms, including fever, alongside localized signs of warmth, tenderness, significant swelling, and purulent drainage from the surgical site. Laboratory investigations revealed elevated inflammatory markers (ESR and CRP). Advanced imaging with magnetic resonance imaging (MRI) was obtained, which revealed classic features of chronic osteomyelitis: marrow edema, cortical breaching, and a fluid collection contiguous with the residual bone substitute material [fig2.3 A and B]. The patient was taken urgently to the operating room for irrigation and debridement. Upon exposure, the graft site was found to be surrounded by inflamed granulation tissue and pockets of pus. The synthetic graft material, which showed no signs of incorporation, was identified as the nidus of infection. [fig 2.4]. It was completely removed along with all necrotic soft tissue and bone. The implants were also removed due to biofilm formation. Intraoperative cultures grew *Pseudomonas aeruginosa*, guiding a six-week course of postoperative intravenous antibiotics. At the six-month follow-up, the patient was fully ambulatory and asymptomatic, with normalized inflammatory markers and no clinical signs of recurrent infection.

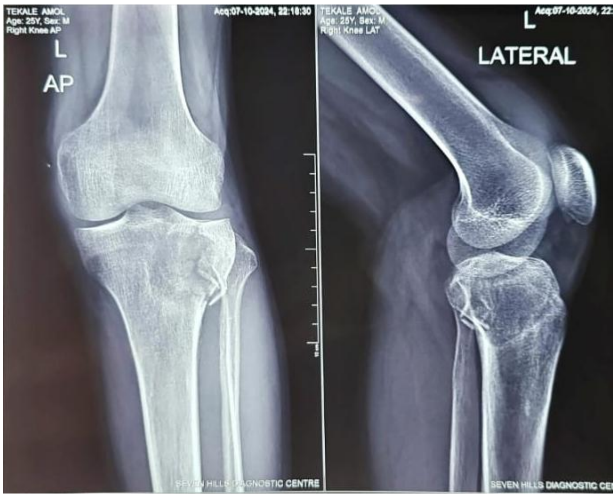

Figure 2.1: X-Ray showing pathological proximal tibia fracture

Figure 2.2: Post operative X-ray showing open reduction and internal fixation with proximal tibia buttress plate with synthetic bone graft .

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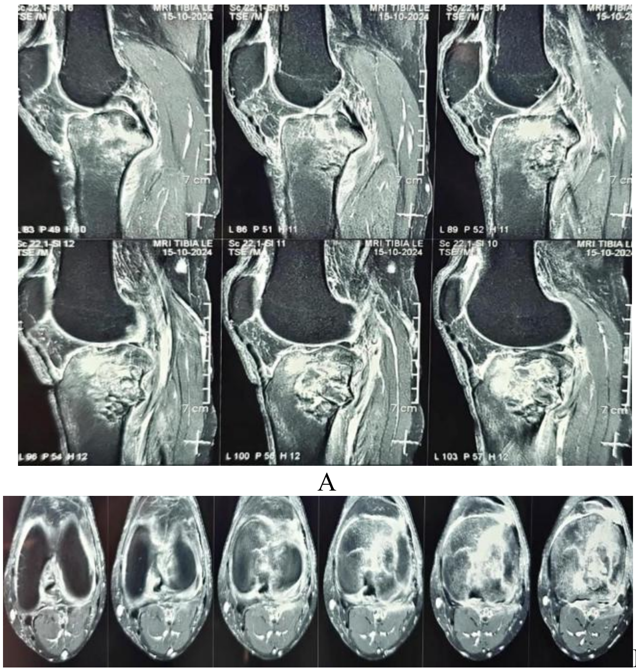

A

B

Figure 2.3: A and B magnetic resonance imaging (MRI) showing heterogeneously enhancing lesion in proximal tibial epiphysis and metaphysic with linear undisplaced fracture on the lateral aspect of proximal tibia in intercondylar eminence with marrow edema

Figure 2.4: Intra-operative imagining suggestive of necrotic and dead synthetic bone graft

2) Investigation

A thorough preoperative workup comprising a history, physical examination, laboratory testing (CBC, ESR, and CRP), and plain radiography was part of the inquiry for both instances. MRI's advanced imaging capabilities were essential in detecting the fluid collections, cortical breaches, and marrow edema that are hallmarks of persistent osteomyelitis. To confirm the diagnosis and provide targeted antibiotic therapy, deep tissue specimens were taken during surgery for microbiological culture and histological examination. These research procedures are in line with accepted practices for treating infections of the musculoskeletal system.

3. Discussion

Because of their proven osteoconductive qualities, structural value in managing defects, and ability to eliminate donor site morbidity linked to autograft harvest, synthetic bone graft substitutes are widely used in orthopaedic treatment. Nevertheless, as seen by the cases that were reported, these biomaterials are not immunologically inert and can, in certain situations, significantly increase morbidity. Their bioactive architecture presents a basic paradox: the exact characteristics that facilitate osteoconduction—a large surface area and interconnected porosity that are perfect for cellular migration and neovascularization—also make them vulnerable to bacterial colonization and the production of biofilms [7]. A biofilm confers resistance to host immune systems and systemic antibiotic penetration by establishing a protected microbial environment. This can result in a slow-burning infection that may not show symptoms for months or even years after the host's defenses are slightly weakened [8].

The delayed onset of symptoms and the lack of any recorded preoperative or intraoperative contamination in both cases clearly suggest that the implanted graft material is the main source of infection [9]. The avascular character of the graft remnants, especially in the initial instance where non-resorbed material was discovered a year after implantation, produces an environment akin to a sequestrum that is inaccessible to phagocytic cells and circulating antibiotics. By compromising local immune surveillance and the administration of systemic antibiotics, patient-specific co-morbidities, such as diabetes or other illnesses that cause microvascular impairment and delayed healing, might make this risk even worse. This leads to a difficult clinical situation where medical therapy alone is frequently used to achieve suppression rather than eradication. As shown above, a radical and careful surgical approach is the key to successful management. This requires that all avascular tissue, any remaining graft material, and frequently the related hardware—which may include biofilm—be completely removed. Targeted, culture-specific antibiotic therapy, usually given intravenously for 4-6 weeks, must be delivered after extensive drainage and debridement. It is impossible to overstate the importance of acquiring deep intraoperative tissue cultures rather than relying on superficial swabs, as this informs the choice of antimicrobials [10]. Recurrence is inevitable if these musculoskeletal infection care guidelines are not followed.

4. Conclusion

A useful tool in the orthopedic surgeon's toolbox, synthetic bone graft substitutes provide notabl benefits in the restoration of skeletal deformities. However, their use requires a careful and prudent approach. Although these materials are intended to integrate, surgeons need to be aware that they can act as foreign objects and increase the risk of deep infection. Any patient who exhibits delayed or ongoing postoperative pain, wound leakage, or inflammatory signs—even years after the initial procedure—must be treated with a high index of suspicion. In certain situations, a low threshold for acquiring sophisticated imaging (MRI, CT) is justified. The fundamentals of infection control are still crucial in the end: culture-directed antibiotic therapy, radical debridement of all non-viable and foreign material, and early detection are necessary to completely eradicate infection and achieve a successful outcome.

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Clinical Message
Osteomyelitis can arise even from synthetic bone substitutes. Timely diagnosis and treatment can lead to excellent outcomes.

Conflicts of Interest
None declared.

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Author Profile

Dr. Abhishek Shinde*, MBBS, MS, DNB (Orthopaedics) Assistant Professor, MGM Medical College and Hospital Chhatrapati Sambhajinagar, Maharashtra, India

Dr. Suryakant Perkar, MBBS, MS (Orthopaedics), MGM Medical College and Hospital, Chhatrapati Sambhajinagar

Dr. Purnendu Panchal, MBBS, MS (Orthopaedics), MGM Medical College and Hospital, Chhatrapati Sambhajinagar.