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Recurrent Midshaft Clavicle Nonunion with a Large Segmental Bone Defect Treated with Autologous Iliac Crest Bone Graft and Dual Plating: A Case Report

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Learning Point of the Article:

Large segmental clavicle non-unions can be successfully treated with autologous iliac crest bone grafting and dual plating, restoring clavicular length and achieving durable union.

Abstract

Introduction: Clavicle fractures are common, and although most midshaft fractures heal successfully, large segmental defects are associated with an increased risk of nonunion. Clavicle nonunion is often severely disabling, with patients experiencing chronic pain, progressive deformity, reduced shoulder strength, and impaired upper-extremity function. The standard approach reserves non-vascularized iliac crest bone graft (ICBG) for defects up to about 3 cm, whereas larger defects are conventionally reconstructed with vascularized grafts. Reports of successful non-vascularized iliac crest grafting for very large segmental defects, particularly in the revision setting after prior failed fixation and grafting, are uncommon. We present this case to expand the documentation of non-vascularized reconstruction and to offer technical guidance for this challenging clinical scenario.

Case Report: A 40-year-old woman of Hispanic (Puerto Rican) background presented with right shoulder pain and functional limitation after two prior operations for a displaced midshaft clavicle fracture, which left a 4.5-cm segmental defect. She had a longstanding heavy smoking history. After confirmed smoking cessation and nutritional optimization, she underwent open reconstruction with a tricortical autologous iliac crest graft harvested using an ultrasonic bone scalpel, combined with orthogonal dual plating. At 2-year follow-up, she had full active range of motion, normal strength, restored clavicular length, and stable fixation, with no donor-site complications.

Conclusion: A large segmental midshaft clavicle defect exceeding the size usually considered suitable for non-vascularized grafting was reconstructed successfully with autologous ICBG and dual plating, with durable clinical and radiographic results. The case supports non-vascularized grafting as a reasonable option in selected patients, particularly where vascularized grafting is not readily available, and underscores the importance of addressing modifiable risk factors such as smoking before reconstruction. It adds to a small body of evidence and may broaden reconstructive options in orthopedic and trauma practice.

Keywords: Clavicle nonunion, large segmental bone defect, iliac crest bone graft, dual plating, case report.

Introduction

Clavicle fractures are common injuries, accounting for approximately 5–12% of all adult fractures, with more than two-thirds involving the midshaft region [1]. Conventionally, these fractures were treated nonoperatively because of low reported nonunion rates of about 1% and concerns regarding surgical

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Author's Photo Gallery


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Figure 1: Pre-operative radiograph of the right clavicle showing a midshaft nonunion with a large segmental defect. Anteroposterior radiograph of the right clavicle obtained at initial presentation, demonstrating a midshaft nonunion with a large segmental bone defect of approximately 4.5 cm.

complications [2]. Recent evidence has challenged this approach, demonstrating higher nonunion rates and poorer functional outcomes in displaced midshaft fractures managed without surgery [3]. A meta-analysis reported nonunion in approximately 15% of nonoperatively treated patients compared with about 1% of those treated operatively [4]. Recognized risk factors for nonunion include smoking, comminution, advanced age, and displacement >2 cm [5].

Clavicle nonunion, although relatively uncommon, can be severely disabling, producing chronic pain, deformity, reduced shoulder strength, and impaired function, and such sequelae are common after clavicular injury [6,7]. In fact, the impact of clavicle nonunion on health-related quality of life may even exceed that of nonunion in long bones such as the tibia, femur, or humerus [8]. Large segmental defects causing shortening of more than 1.4–2 cm are more likely to be symptomatic and can impair abduction and flexion and reduce internal rotation [9,10].

The treatment of clavicle nonunion, particularly with segmental bone loss, often requires reconstructive procedures [6,11]. Although early approaches included resection as a salvage procedure, this is now avoided because of the risk of compromising shoulder girdle stability [6]. Modern surgical management involves open reduction and internal fixation (ORIF) using a range of implants, including intramedullary devices (e.g., Steinmann pins, Kirschner wires, and elastic nails), external fixators, and plates, particularly for displaced or complex injuries [6,12,13]. Although nonunion after ORIF is uncommon, when it occurs and becomes symptomatic, it can cause poor outcomes and functional impairment of the upper extremity [14].

Among reconstructive options, autologous bone grafting remains the gold standard, particularly using the iliac crest [15,16]. Iliac crest bone graft (ICBG) is commonly used to bridge defects of 2.5–3 cm; for defects larger than 3 cm and for cases in which previous surgery has failed, vascularized grafts are generally preferred [11]. Even so, ICBG is favored for its osteogenic, osteoconductive, and osteoinductive properties, which promote healing and integration [16]. Despite the potential for donor-site morbidity, major complications are rare [17], and harvesting from the iliac crest avoids the immunologic and infection-related risks associated with allografts and synthetic substitutes [18,19]. At present, there is no consensus on the management of large segmental defects exceeding 3 cm treated with ICBG.

Here, we present a rare case of recurrent clavicle nonunion with a 4.5-cm segmental defect successfully managed with ICBG. The case highlights the value of stable internal fixation with dual plating and the challenges of treating large bone defects after failed ORIF and bone grafting.

Case Report

Initial presentation and previous surgeries

A 40-year-old woman presented to the orthopedic clinic with right shoulder pain, mild swelling, and tenderness on palpation over the mid-clavicle. The patient had undergone two previous procedures for a displaced midshaft clavicle fracture. The first was an ORIF with a plate construct, which failed because of poor fixation of the medial fragment. The second, performed 6 months before presentation to our clinic, involved removal of

Figure 2: Three-dimensional computed tomography reconstruction of the right midshaft clavicle defect. Three-dimensional computed tomography reconstruction of the right clavicle at presentation, demonstrating the large segmental midshaft defect.

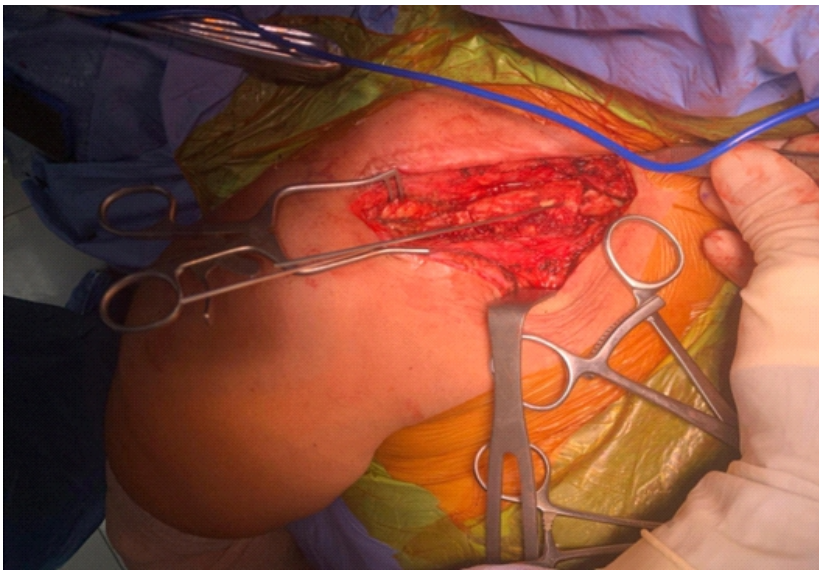

Figure 3: Intraoperative photograph of the iliac crest graft with temporary Kirschner wire fixation. Intraoperative photograph of the right clavicle during definitive reconstruction, showing the 4.5-cm tricortical autologous iliac crest bone graft within the segmental defect, held with temporary Kirschner wire fixation.

the fixation, debridement of the fracture site, and placement of demineralized bone matrix allograft in the defect. This sequence resulted in a 4.5-cm segmental defect of the mid-clavicle (Fig. 1). A detailed history and physical examination were performed, and new radiographs and computed tomography (CT) were obtained (Fig. 2). Passive range of motion (ROM) was preserved in all planes, but active motion was markedly limited and painful, with particular weakness in abduction and external rotation. She was unable to perform overhead activities or exercises such as bench pressing and front and side raises. The skin showed a well-healed transverse anterior clavicular incision with no fluid collection. Underlying infection was a concern, but serum inflammatory markers were negative, and the patient reported no soft-tissue healing problems after the previous procedures.

Smoking as a risk factor

The patient had a longstanding history of heavy tobacco use since the age of 14 years. Given the known association between smoking and impaired bone healing, she was counseled on smoking cessation before further surgery. After a 3-month cessation period confirmed by repeated negative nicotine testing, she was reassessed for definitive reconstruction. Calcium and Vitamin D supplementation was also prescribed.

Definitive surgery

The third procedure was an open repair of the clavicle nonunion with autologous ICBG and dual plating. The patient was positioned in the beach-chair position, and the upper right extremity and the contralateral iliac crest region were prepared and draped in sterile fashion. While the lead shoulder surgeon performed the clavicular reconstruction, a second surgeon harvested graft from the contralateral iliac crest. The defect was identified and thoroughly debrided to determine the final defect length, which was confirmed against measurements of the contralateral clavicle.

An ultrasonic bone scalpel (BoneScalpel; Misonix, Farmingdale, New York, USA) was used to make precise cuts in the iliac crest and to obtain a tricortical autograft of the required dimensions, measuring 4.5 cm in length and 1.8 cm in diameter, which fit well within the defect. Temporary Kirschner wire fixation (Fig. 3) was followed by spanning dual plating using two stainless-steel plates (Evos Mini Plating System; Smith and Nephew, Birmingham, Alabama, USA) applied in an anterior and superior (orthogonal) configuration (Fig. 4).

Post-operative course and outcome

Immediate post-operative radiographs demonstrated dual-plate fixation with the interposed iliac crest graft (Fig. 5). The

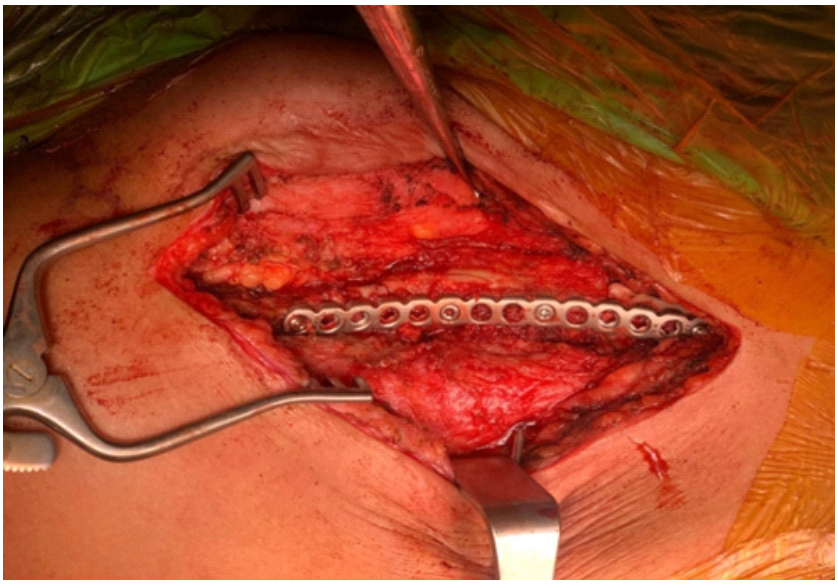

Figure 4: Intraoperative photographs of anterior and superior plate fixation. Intraoperative photographs during definitive reconstruction of the right clavicle. (A) Anterior plate spanning the medial native clavicle, the iliac crest graft, and the lateral clavicle. (B) Superior plate providing supplemental orthogonal fixation with additional screws.

Figure 5: Immediate post-operative radiograph showing dual-plate fixation and grafting. Post-operative anteroposterior radiograph of the right clavicle, demonstrating dual-plate fixation of the midshaft nonunion with the autologous iliac crest bone graft.

patient tolerated the post-operative period well and was placed in a sling for the first 6 weeks, allowing early passive ROM and Codman exercises. Physical therapy was prescribed, and active ROM was permitted at 6 weeks. Gentle strengthening was introduced at 2 months. At 6-month follow-up, she had regained full active ROM in all planes, although strength remained slightly reduced compared with the contralateral side, and additional strengthening therapy was prescribed. Radiographs at that time showed restored clavicular length comparable to the contralateral side and well-positioned implants. Graft incorporation was difficult to assess radiographically because of the dual-plate construct, and CT was not considered clinically necessary. At final follow-up 2 years postoperatively, the patient had full active ROM in all planes with strength equal to the contralateral side. Radiographs confirmed maintained clavicular length, alignment, and fixation without hardware migration, consistent with graft incorporation (Fig. 6).

Discussion

This case demonstrates successful reconstruction of a large segmental midshaft clavicle defect measuring 4.5 cm with autologous ICBG. The defect represented nearly one-third of the reported average female clavicle length of 15.1 cm [20]. Although ICBG is generally considered appropriate for defects of 2.5–3 cm, with larger defects typically reconstructed using vascularized grafts [11], this case supports the potential of ICBG as an effective alternative for larger defects.

Although ICBG is criticized for donor-site morbidity, including chronic pain, gait disturbance, hypertrophic or painful scarring, and nerve injury [21], our patient experienced no donor-site complications at 2 years. The graft was harvested with a high-frequency ultrasonic bone scalpel, which allowed precise harvest while minimizing adjacent soft-tissue trauma. This favorable outcome is consistent with a meta-analysis by Allsopp et al., which questioned the necessity of vascularization for longer bone grafts [22]. Vascularized grafts also carry potential disadvantages, including longer operative times, increased infection risk, and longer hospital stays [23]. In this context, ICBG may offer a simpler and safer alternative with favorable outcomes in selected patients, particularly in settings where vascularized grafting is not routinely performed.

With respect to fixation, dual plating has demonstrated biomechanical superiority over single plating, with reported improvements in union rates, reduced implant irritation, and a lower incidence of nonunion [14]. Advances in surgical technique have further contributed to improved functional recovery and fewer complications compared with non-operative treatment [10,24,25].

This case also illustrates several common risk factors for clavicle nonunion, including comminution, displacement >2 cm, and a long history of heavy smoking. Nonunion after ORIF for displaced midshaft fractures is generally uncommon but increases substantially in the presence of such risk factors

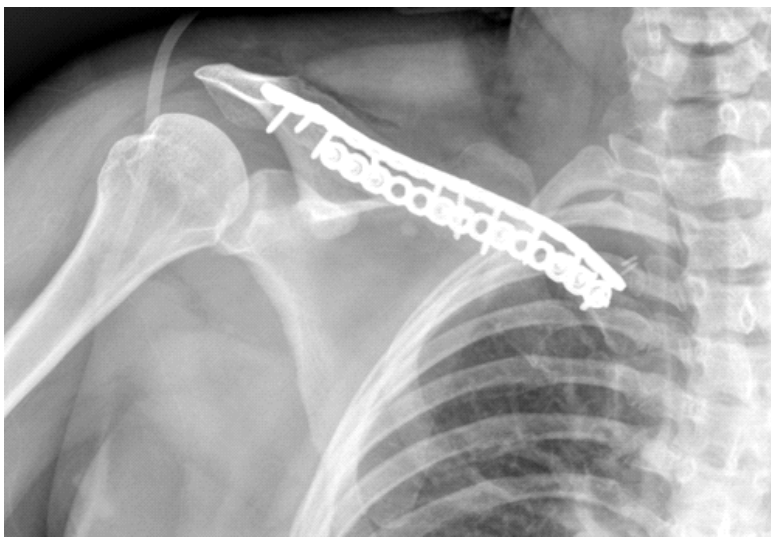

Figure 6: Two-year post-operative radiograph showing restored clavicular length and alignment. Anteroposterior radiograph of the right clavicle 2 years after reconstruction, demonstrating restored clavicular length and alignment compared with the contralateral side, with maintained fixation.

[5,11]. The patient's smoking history, large segmental defect, and prior hardware failure likely contributed to delay healing. Importantly, smoking cessation before and throughout the post-operative period may have supported improved healing.

This report has limitations. As a single case, the findings cannot be generalized, and studies with larger cohorts are needed to confirm the role of ICBG as an alternative to vascularized grafting for large segmental clavicle defects. A further limitation is that graft incorporation could not be confirmed with advanced imaging. Nevertheless, the case demonstrates that ICBG may be a viable option for large midshaft clavicle defects and supports further investigation.

Conclusion

This case demonstrates successful treatment of a recurrent midshaft clavicle nonunion with a large 4.5-cm segmental defect using autologous ICBG and dual-plate fixation. Despite a defect size exceeding the range traditionally considered suitable for non-vascularized grafting, the patient regained clavicular length and achieved complete functional recovery at 2-year follow-up. Attention to modifiable risk factors, particularly smoking cessation, together with stable dual-plate fixation, likely contributed to this favorable outcome. The case is of interest to orthopedic and trauma surgeons and suggests that autologous ICBG may broaden the reconstructive options available for large segmental clavicle defects, warranting further study.

Clinical Message

Large segmental midshaft clavicle non-unions, even those exceeding 3 cm, can be reconstructed successfully with autologous tricortical iliac crest bone graft and orthogonal dual plating. Optimizing modifiable risk factors such as smoking and ensuring stable fixation are central to achieving durable union and functional recovery, and non-vascularized grafting may be a practical alternative to vascularized grafting in selected patients.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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