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Manuscript Draft

Manuscript Number:

Title: Double-Barrel Free Fibula Flap for Treatment of Infected Nonunion of Both Forearm Bones

Article Type: Case Report

Section/Category:

Keywords: Free fibula flap, double barrel, radius, ulna, nonunion, osteomyelitis

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Manuscript Region of Origin:

Abstract: The surgical treatment of chronic, infected nonunion of both forearm bones associated with significant segmental defects can be a daunting reconstructive challenge. The basic tenets of management include eradication of all infected nonviable bone, treatment with local and systemic antibiotic therapy, and formal reconstruction once the recipient site has been cleared of infection. Use of the double barrel free fibula flap can restore ulna and radius continuity to maximally preserve pronation-supination and long-term function.

*** Submission Letter**

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October 9th 2005

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Re: Manuscript submission: Double-Barrel Free Fibula Flap for Treatment of Infected Nonunion of both Forearm Bones

Dear Dr. Elliot,

We are submitting a case report to your journal on the use of the double-barrel free fibula flap for the treatment of infected non-union of both forearm bones. Management of chronically infected non-union of both the radius and ulna can represent a reconstructive challenge to hand surgeons. Articles have been published on the use of the fibula flap for single forearm bone reconstruction following osteomyelitis and trauma but very little information in the literature exists for salvaging both forearm bones using the double barrel free fibula flap. We feel that this case report of two patients would provide useful information on the evaluation and treatment of this difficult problem. Most importantly, this technique allows for maximal preservation of pro-supination and avoids conversion to a one bone forearm. We thank you for considering our manuscript and would be happy to provide any additional information.

Best regards

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Double-Barrel Free Fibula Flap for Treatment of Infected Nonunion of Both Forearm Bones

Introduction

Treatment of infected nonunions of the ulnar and radius can be challenging; these injuries must be approached aggressively to maximize long-term function. Extensive bony defects involving scarred, poorly vascularized recipient beds do not lend themselves well to nonvascularized bone grafting. Therefore, the basic tenets of initial management include sequestrectomy and eradication of all infected nonviable bone and soft tissue envelope with local and systemic antibiotic therapy. Once the recipient site has been cleared of infection, bone reconstruction can be performed.

Use of the fibula bone flap provides not only ample bone for reconstruction but also well-vascularized tissue for antibiotics delivery. The literature is replete with numerous examples of the use of the fibula flap in the reconstruction of long segmental bone defects. The fibula flap's dual endosteal and periosteal blood supply also makes it effective as a double-barrel or double-strut bone flap for the reconstruction of two or more bone segments. This double-barrel approach has been used successfully in the reconstruction of major long bone diaphyseal defects such as those of the femur, which requires extra bone stock to prevent stress fractures until bone hypertrophy occurs.

The use of the double-barrel fibula flap in the upper extremities is unusual; it has been limited mostly to the treatment of posttraumatic defects (Jones NF, Santanelli F). The fibula flap, with creation of a single forearm bone, has been used to treat complex nonunion of both forearm bones when they are recalcitrant to conservative management or multiple surgical attempts at union. The use of well-vascularized free fibula bone with proper bony fixation and débridement has been very successful. Nevertheless, this approach results in loss of pronation-supination, which can have a significant effect on the patient's quality of life, especially in the case of manual workers. Use of the double-barrel free fibula flap can restore ulna and radius continuity to maximally preserve pronation-supination and long-term function.

We present two cases of infected nonunion of both the ulna and radius treated with a double-barrel free fibula flap.

Case 1

A 16-year-old female fell while performing gymnastics and experienced a Gustillo IIIB compound fracture to the right ulna and radius **(Fig 1).** Initial treatment with open reduction and internal fixation was complicated by polymicrobial, gram-negative osteomyelitis and nonunion of the ulna and radius. After implant removal and wound débridement, an external fixator was applied with gentamycine-soaked antibiotic beads. Additional débridement of infected bone and soft tissue was required as well as prolonged systemic intravenous antibiotics.

Her injury failed to respond to treatment, and she presented at our institution 4 months later for reconstruction of a segmental 11-cm loss of the ulna and a 7-cm segmental loss of the radius **(Fig 2).** She underwent reconstruction of her bony radius and ulna defects with a 22-cm right free vascularized fibula flap. This included 7 cm for the radius defect, 4 cm for the periosteal bridge between both segments, and 11 cm for the ulna defect. The devitalized ends of both the ulna and radius were trimmed back, leaving healthy, bleeding bone, and all surrounding necrotic tissue was removed. The free fibula flap was harvested in a standard fashion and a 4-cm bony segment was removed between both fibula segments to pass the pedicle through the interosseous membrane between the ulnar and radial sides **(Fig 3).** This was also done to prevent kinking and tension of the pedicle and any potential synostosis secondary to bony contact between fibula segments. The fibula was then passed through the interosseous membrane, and congruent step-cut osteotomies of all four bony ends were fashioned and fixed using a single lag screw. The proximal peroneal pedicle containing the radius segment was anastomosed end-to-side to the radial artery and end-to-end to two venae comitans.

Low-molecular weight dextran was administered during an uneventful 5-day hospitalization. Intravenous antibiotics were continued for an additional 2 weeks. Mobilization of the elbow was started once adequate callous formation had been observed in both distal and proximal segments 6 weeks after surgery. Union occurred after 3 months **(Fig 4),** and bone scintigraphy showed uptake and perfusion of both fibula bone segments **(Fig 5).** Aggressive physical therapy was then instituted, with full elbow and wrist range of motion achieved at 2 months' follow-up. Unfortunately, despite seemingly adequate distancing of both fibula segments, synostosis occurred between the proximal radius and ulna segments. This severely impaired prosupination and required excision with placement of an interpositional fat pad flap between bony segments 16 months after surgery. At 2-years' final follow-up, full supination had been achieved with limited pronation. The patient was pain-free and able to return to regular activities with fully healed wounds and complete bony union **(Figs 6a,b,c)**.

Case 2

A 33-year-old right hand-dominant manual worker experienced a fall that resulted in fractures of both the ulna and radius of his right forearm. This was treated with open reduction and internal fixation at an outside institution. The patient presented to our hand care center with a history of pain, swelling, and deformity of the right forearm 3 months after surgery. Radiographic evaluation showed nonunion with extensive osteomyelitis of both forearm bones as well as hardware loosening **(figure 7).** The patient underwent a first-stage clearance of his infected nonunion with débridement and excision of the infected ulna (7.5 cm) and radius (6 cm) segments **(figures 8a,b).** A vancomycin-impregnated methylmetacrylate spacer was interposed between the bony segments and fixed using a unicortical locking compression plate that served as an internal-external fixator. The patient's symptoms improved after surgery, and a 6-week course of intravenous vancomycin was completed before definitive reconstruction.

Two months later, a double-barrel free fibula flap was used to reconstruct the segmental ulna and radius bony defects. The fibula flap was harvested in a standard fashion and slotted into the proximal and distal radius and ulna bone ends using step-cut osteotomies. The 7-cm radius segment of the fibula was trimmed and inset first, followed by removal of a central 4-cm segment of bone that allowed safe, tension-free passage of the pedicle across the interosseous membrane. Fixation was accomplished with lag screws and a locking compression plate for both bones **(figure 9).** The peroneal artery was anastomosed end-to-side to the radial artery, and the peroneal vein was anastomosed end-to-end to the radial venae comitans.

The patient underwent aggressive postoperative therapy to maximize range of motion. Electrical stimulation was used to promote bony healing. At follow-up 10 months after reconstruction, radiographs showed signs of bony union with callous formation at the osteotomy sites and no signs of osteomyelitis **(figure 10).** The patient's pain was significantly reduced. Range of motion was as follows: Wrist flexion 55 degrees, extension 25 degrees; radial deviation 0 degrees; ulnar deviation 20 degrees; elbow flexion 160 degrees, extension 20 degrees; pronation 15 degrees; and supination 10 degrees **(figures 11a,b,c).**

Discussion

The surgical treatment of chronic, infected nonunion of both forearm bones associated with significant segmental defects can be a unique challenge. The first stage of treatment should be to eradicate all necrotic and infected bone and soft tissue and provide temporary fixation. Placement of antibiotic-impregnated spacers can maintain bony length and help prevent soft tissue envelope contracture and muscle imbalances during antibiotic therapy. The scarred and poorly vascularized environment created by the infected nonunion lends itself well to the use of vascularized bone using a free fibula flap. The fibula's periosteal blood supply allows multiple osteotomies to be performed safely without undue devascularization of the distal segments, as shown by previous injection studies (NF Jones et al.). Clinically, this has also been demonstrated routinely in mandibular and maxilla reconstruction, in which up to three segments of fibula are sometimes required to reconstruct complex three-dimensional defects. The fibula could potentially be converted to a triple-barrel flap for reconstruction of multiple bony segments of the hand if required.

Both patients reported here experienced bony union with significant resolution of their symptoms. Although range of motion improved following an aggressive physical therapy regimen, pronation was adversely affected. One possible explanation may be the radius' bow-like shape, which allows it to prosupinate over the ulna. Recreating this shape with a straight fibula bone can be challenging. This problem is further compounded if synostosis develops between both bony segments of the radius and ulna. Primary prevention using an interpositional fat flap between the osteotomized, exposed periosteal ends can help minimize this risk. Also, both the cases of chronic infected nonunion reported here involved prolonged immobilization prior to reconstruction. Chronic edema with scarred and infected necrotic tissue surrounding the nonunion and interosseous membrane can significantly impede pronation and supination despite aggressive resection at the time of bony reconstruction and postoperative physical therapy. These factors may explain why early treatment of posttraumatic segmental losses of both forearm bones with a double-barrel flap usually yields better prosupination motion results.

Chronic infected nonunions involving large segmental defects of both forearm bones are a truly unique challenge; they must be treated aggressively to ensure any useful long-term function.

References

Safoury Y. Free vascularized fibula for the treatment of traumatic bone defects and nonunion of the forearm bones. J Hand Surg [Br]. 2005;30:67-72.

Adani R, Delcroix L, Innocenti M, Marcoccio I, Tarallo L, Celli A, Ceruso M. Reconstruction of large posttraumatic skeletal defects of the forearm by vascularized free fibular graft. Microsurgery. 2004;24(6):423-9.

Yajima H, Tamai S, Ono H, Kizaki K. Vascularized bone grafts to the upper extremities. Plast Reconstr Surg. 1998;101(3):727-35.

Yajima H, Tamai S, Ono H, Kizaki K, Yamauchi T. Free vascularized fibula grafts in surgery of the upper limb. J Reconstr Microsurg. 1999;15(7):515-21.

Dell PC, Sheppard JE. Vascularized bone grafts in the treatment of infected forearm nonunions. J Hand Surg [Am]. 1984;9(5):653-8.

Jupiter JB, Gerhard HJ, Guerrero J, Nunley JA, Levin LS. Treatment of segmental defects of the radius with use of the vascularized osteoseptocutaneous fibular autogenous graft. J Bone Joint Surg Am. 1997;79(4):542-50.

Banic A, Hertel R. Double vascularized fibulas for reconstruction of large tibial defects. J Reconstr Microsurg. 1993;9(6):421-8.

Santanelli F, Latini C, Leanza L, Scuderi N. Combined radius and ulna reconstruction with a free fibula transfer. Br J Plast Surg. 1996;49(3):178-82.

Bessy H, Leemrijse T, Cadot B, Touam C, Oberlin C. [Reconstruction of the loss of bone substance of the forearm by cubitalization of the radius (one bone forearm). Apropos of 6 cases]. Ann Chir Main Memb Super. 1996;15(4):199-211.

Radial reconstruction in segmental defects of both forearm bones. J Bone Joint Surg Br. 1988;70(5):815-7.

Wood MB. Free vascularized bone transfers for nonunions, segmental gaps, and following tumor resection. Orthopedics. 1986;9(6):810-6.

Arai K, Toh S, Yasumura M, Okamoto Y, Harata S. One-bone forearm formation using vascularized fibula graft for massive bone defect of the forearm with infection: case report. J Reconstr Microsurg. 2001;17(3):151-5.

Chang MC, Lo WH, Chen CM, Chen TH. Treatment of large skeletal defects in the lower extremities using double-strut, free vascularized fibular bone grafting. Orthopedics. 1999;22(8):739-44.

Stevanovic M, Gutow AP, Sharpe F. The management of bone defects of the forearm after trauma. Hand Clin. 1999;15(2):299-318.

Yajima H, Kobata Y, Shigematsu K, Kawamura K, Kawate K, Tamai S, Takakura Y. Vascularized fibular grafting in the treatment of methicillin-resistant Staphylococcus aureus osteomyelitis and infected nonunion. J Reconstr Microsurg. 2004;20(1):13-20.

Greenberg BM, Jupiter JB, McKusick K, May JW Jr. Correlation of postoperative bone scintigraphy with healing of vascularized fibula transfer: a clinical study. Ann Plast Surg. 1989;23(2):147-54.

Doi K, Kawakami F, Hiura Y, Oda T, Sakai K, Kawai S. One-stage treatment of infected bone defects of the tibia with skin loss by free vascularized osteocutaneous grafts. Microsurgery. 1995;16(10):704-12.

Jones NF, Swartz WM, Mears DC, Jupiter JB, Grossman A. The "double barrel" free vascularized fibular bone graft. Plast Reconstr Surg. 1988;81(3):378-85.

Captions to figures

Figure 1. Initial Gustillo IIIB compound fracture to the right ulna and radius.

Figure 2. Segmental 11-cm loss of the ulna and a 7-cm segmental loss of the radius following an infected nonunion treated with gentamycin beads and an external fixator.

Figure 3a,3b. A 4-cm bony segment was removed between both fibula segments to pass the pedicle through the interosseous membrane. Osteotomies of the double barrel fibula bone flap are shown for combined reconstruction of the radius and ulna bony segments.

Figure 4. Bony union of the ulna and radius 3 months after surgery.

Figure 5. Bony scintigraphy of the forearm demonstrating good uptake and vascularization of both fibula bones.

Figure 6a,b,c. Range of motion at final follow-up two years post-operatively.

Figure 7. Radiograph showing hardware loosening and nonunion of radius and ulna.

Figure 8a,b. Removal of infected radius nonunion.

Figure 9. Fixation was accomplished with lag screws and a locking compression plate for both the radius and ulna.

Figure 10. Bony union and callous formation of radius and ulna at 10 months post-operatively.

Figure 11a,b,c. Range of motion at 10 months post-operatively.

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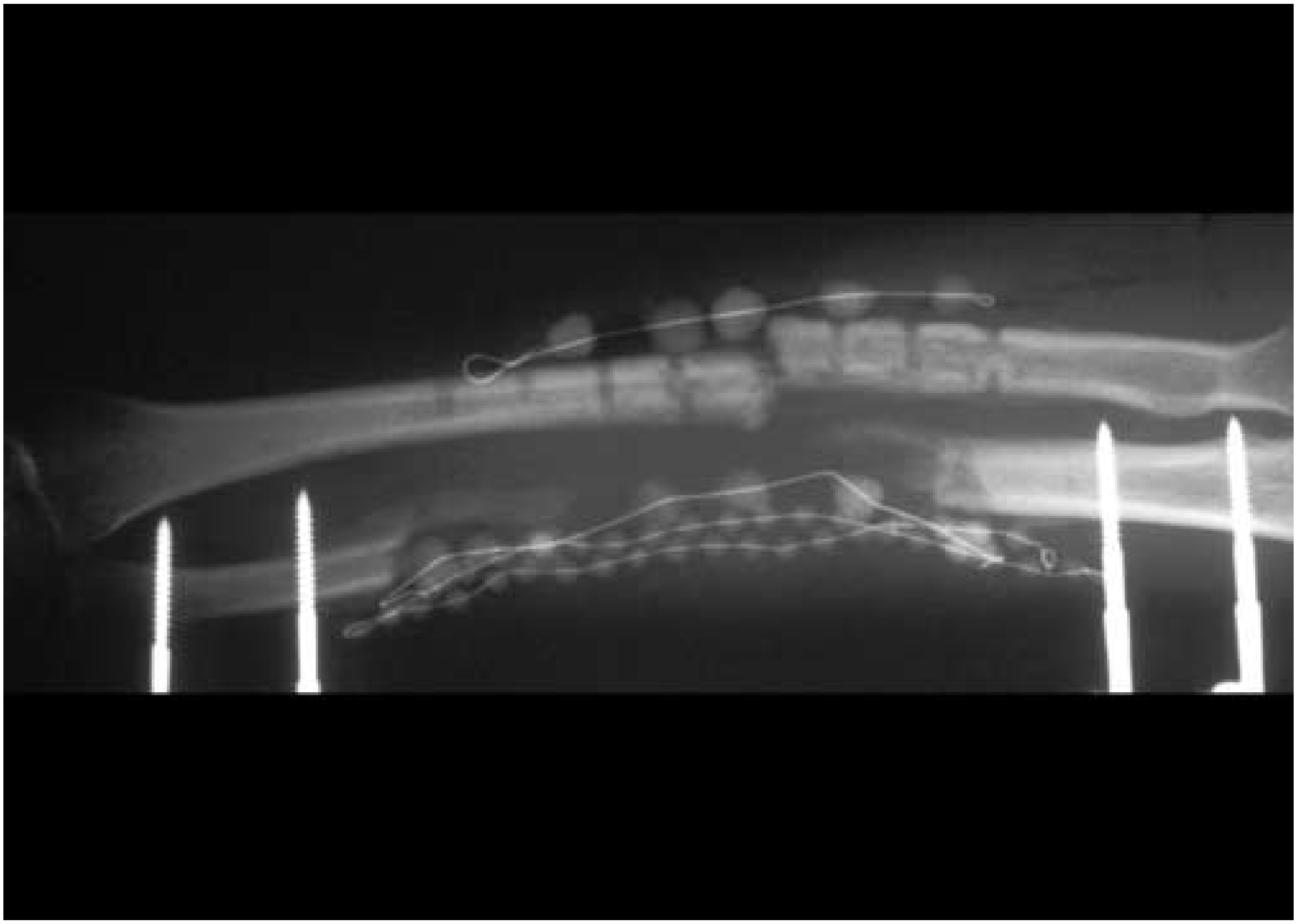

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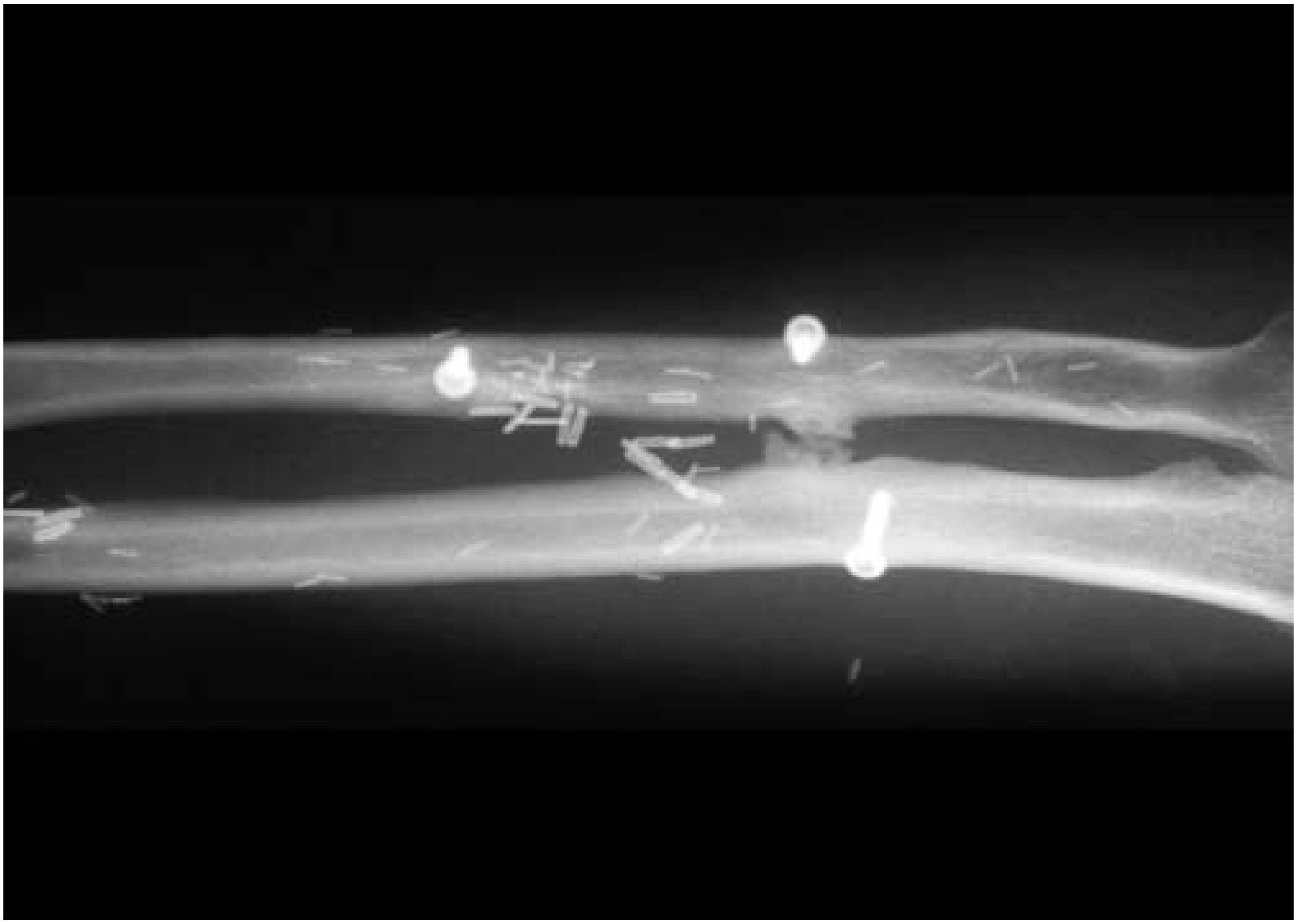

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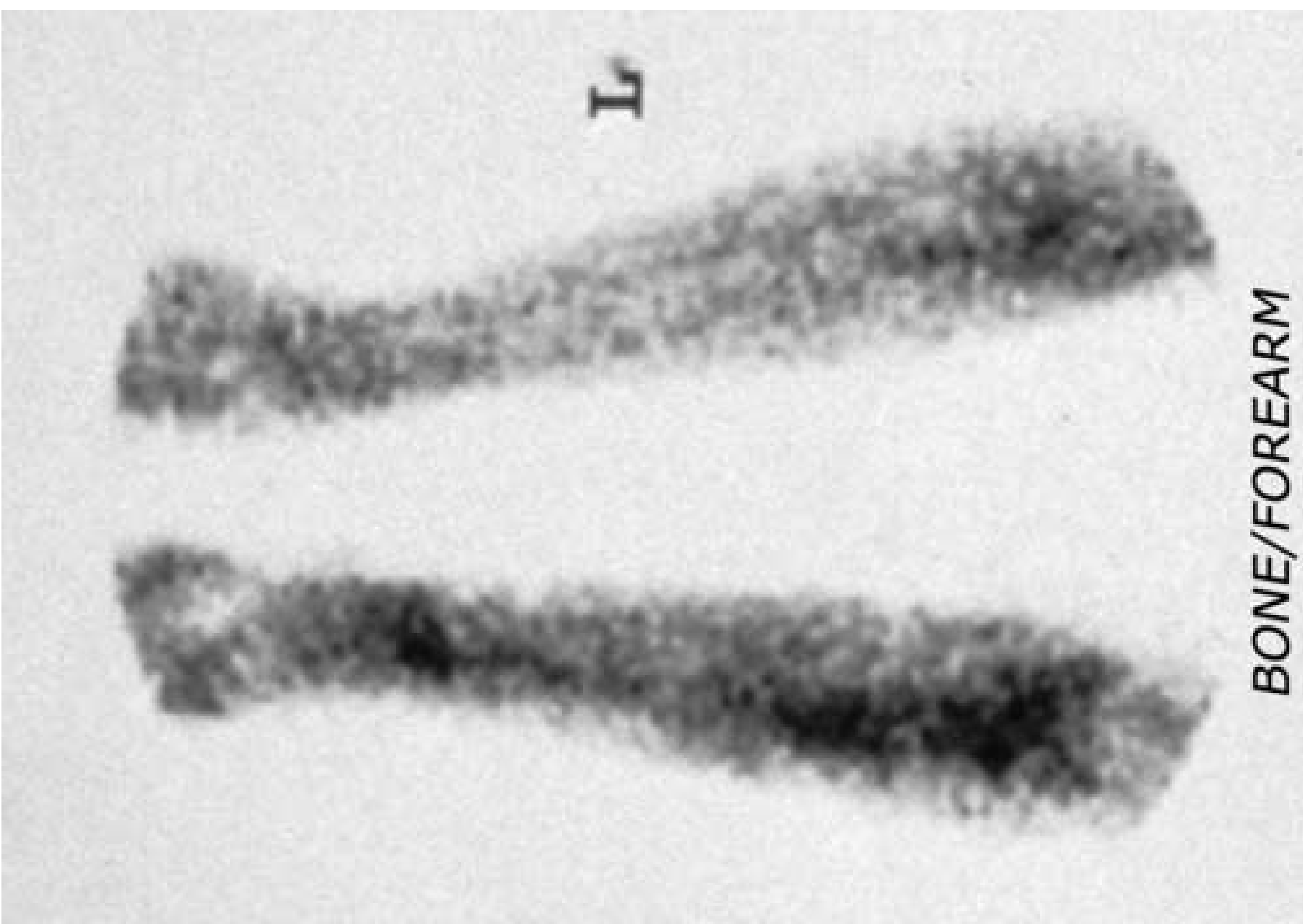

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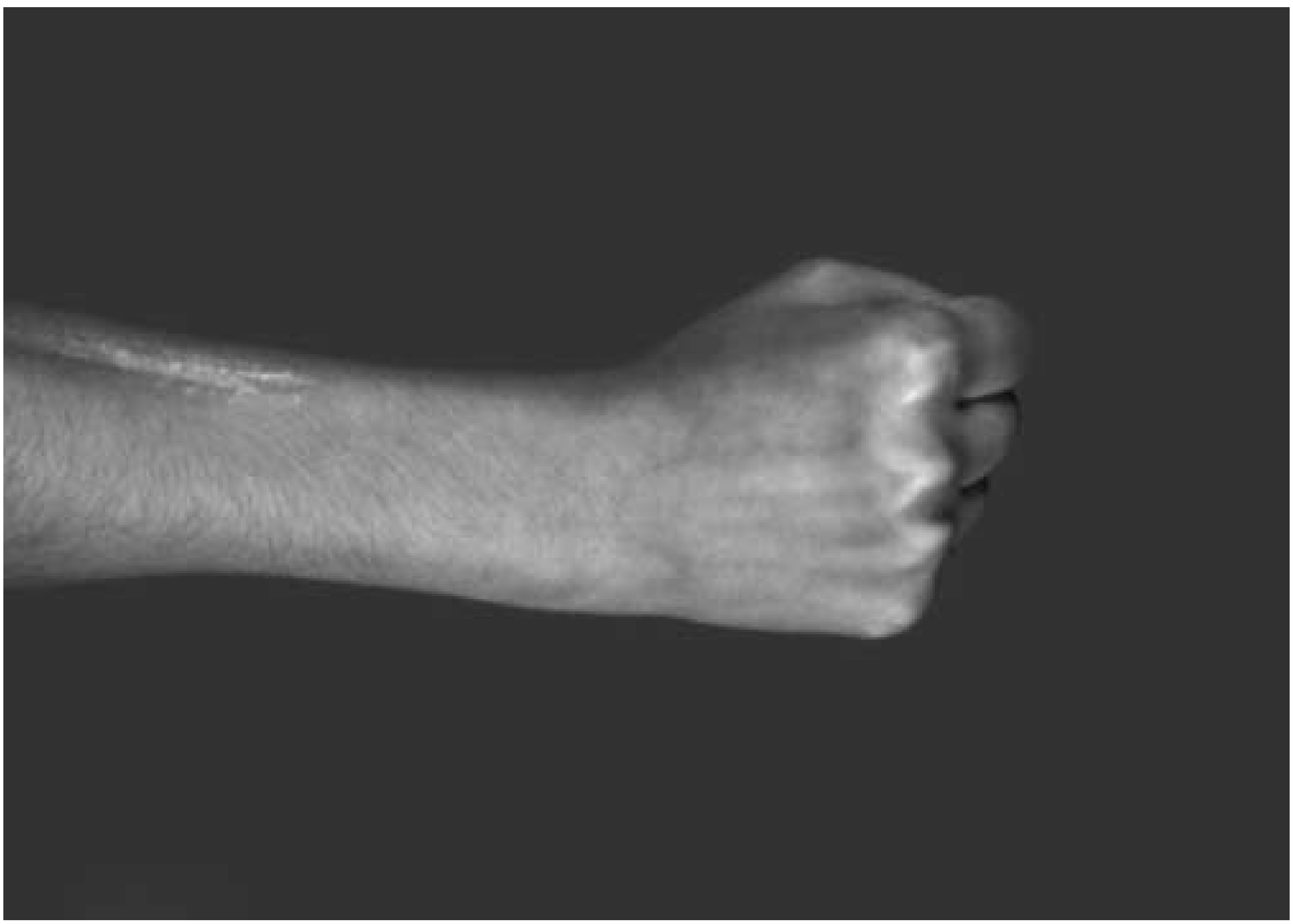

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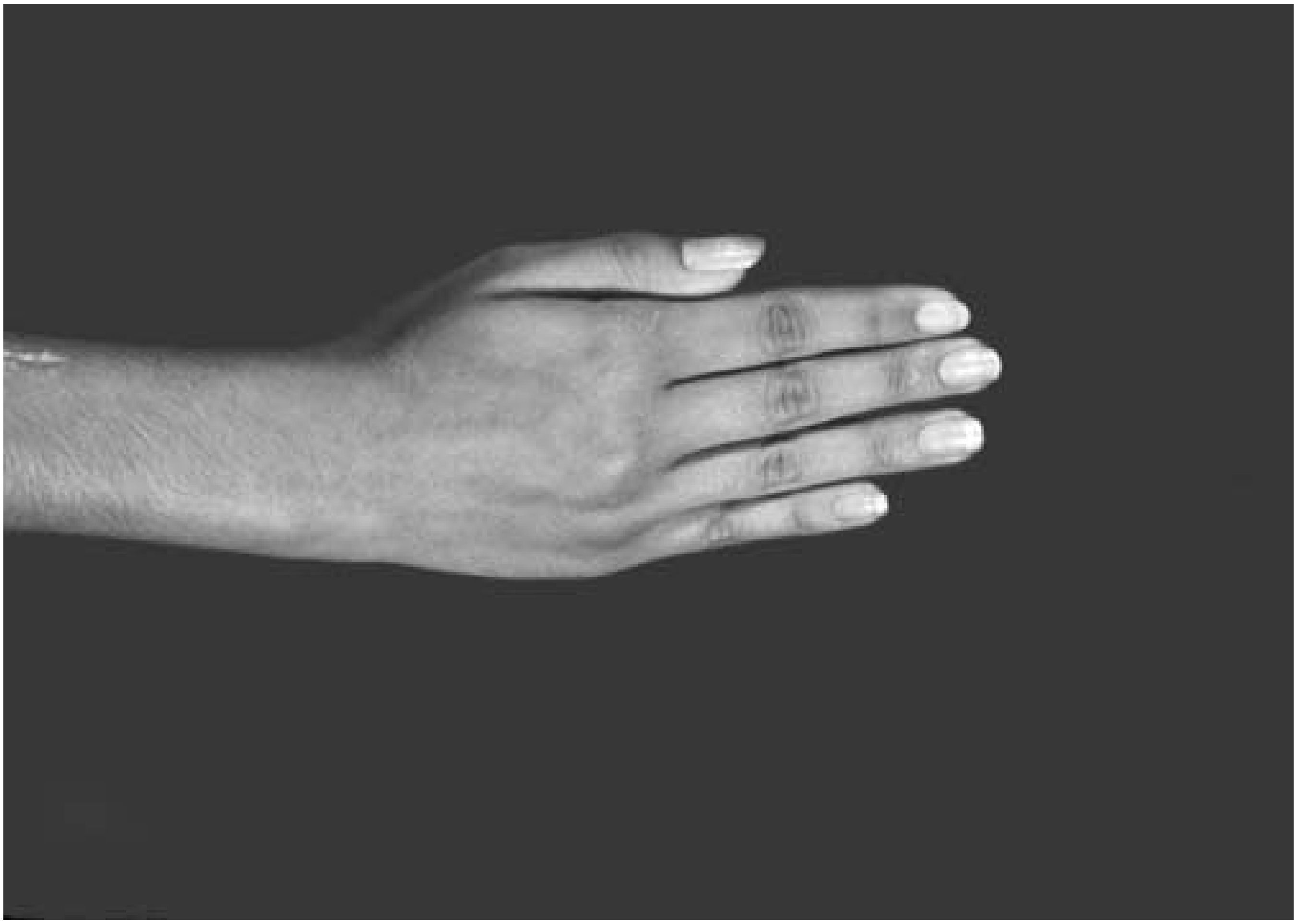

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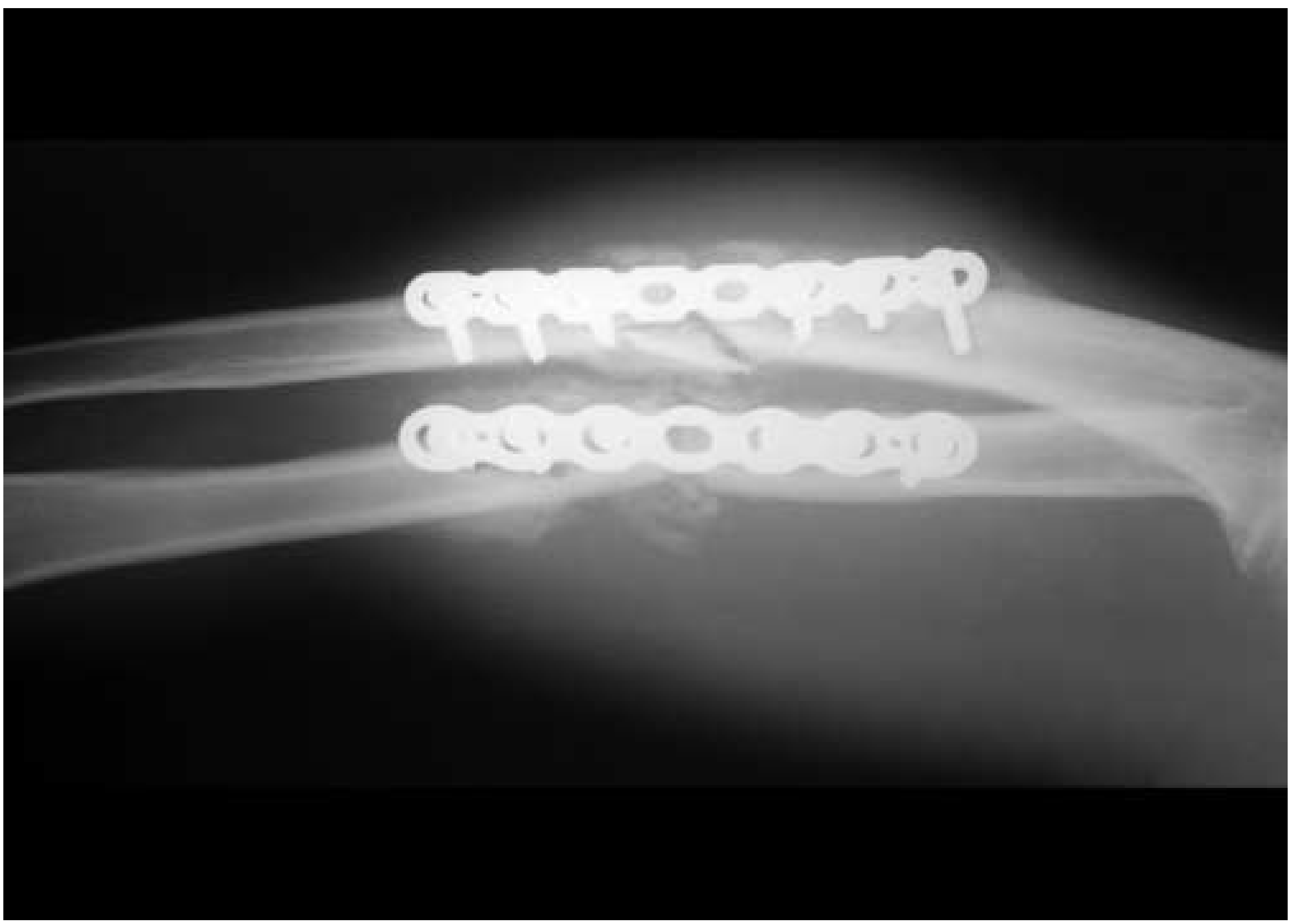

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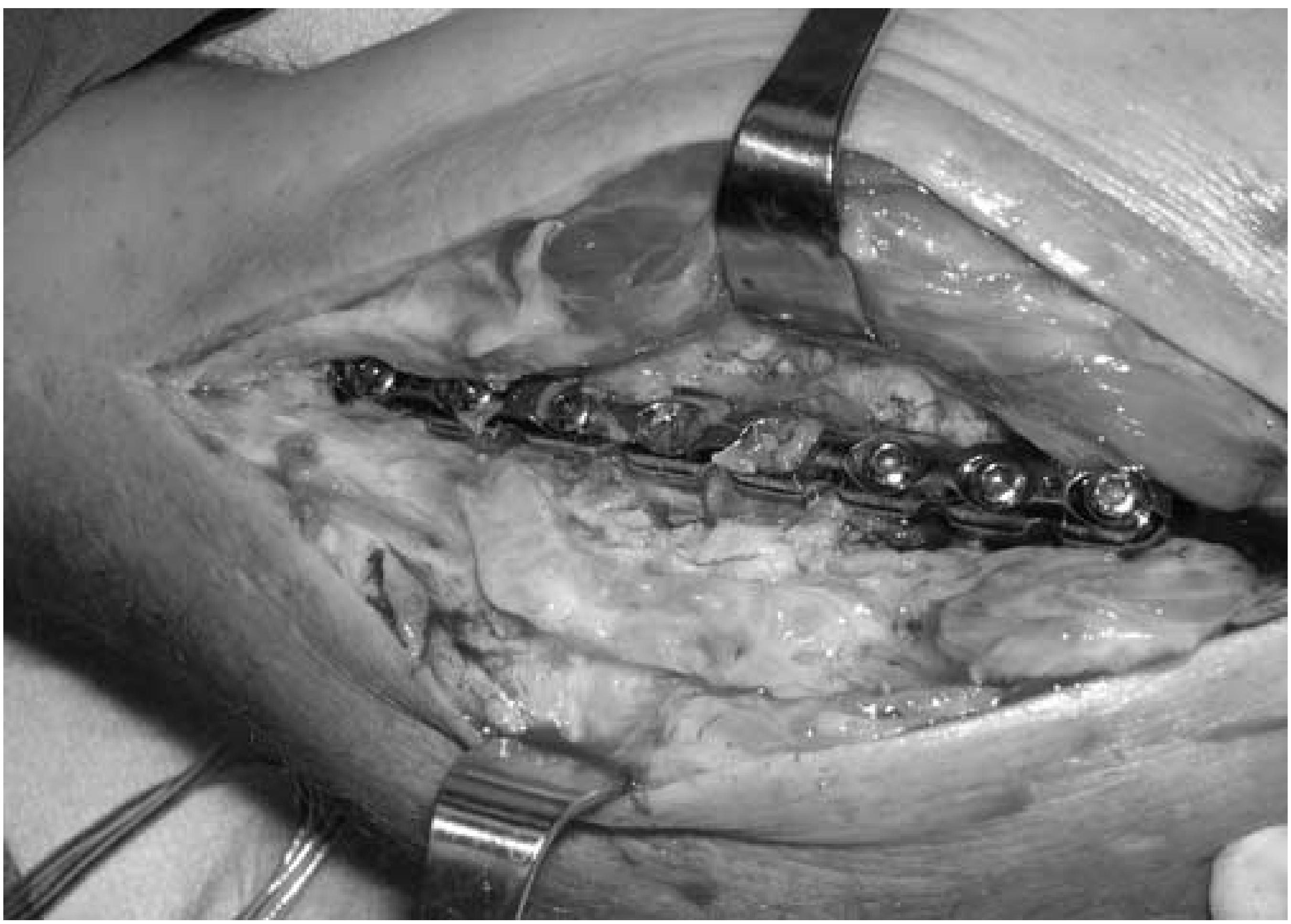

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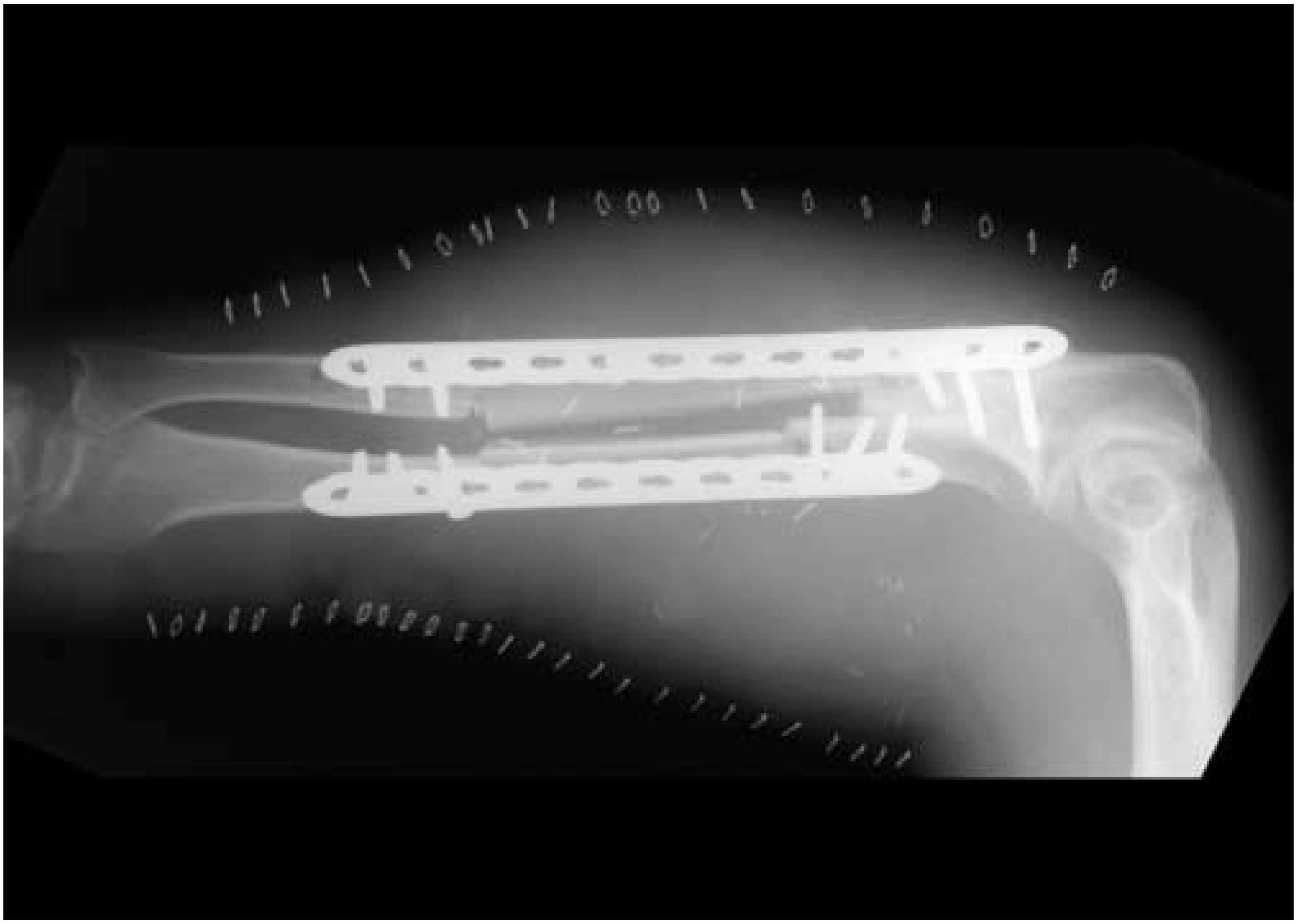

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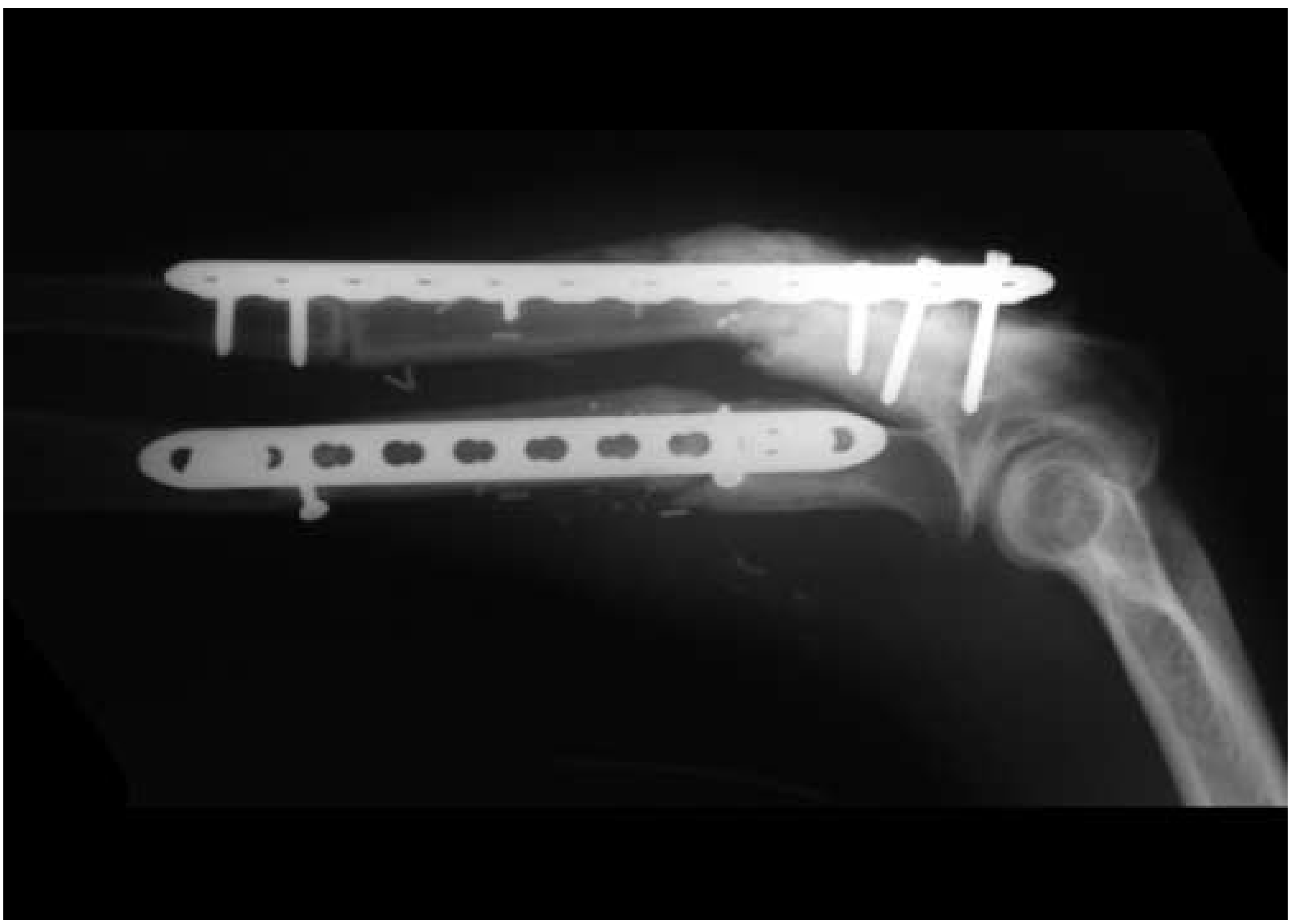

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