Vascularized Ulnar Periosteal Graft for the Treatment of Recalcitrant Nonunion of the Radius. Case Report

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ABSTRACT
There are many techniques described to achieve consolidation in the nonunion of long bones, including morselized cancellous or structural non-vascularized bone graft, vascularized bone graft, or the induced-membrane technique. In 2018, Barrera-Ochoa described the anatomy of a vascularized ulnar periosteal flap based on the posterior interosseous vascular axis and showed his initial experience using it on children to treat a radius atrophic nonunion and bone defect secondary to the exeresis of an Ewing Sarcoma. We present our experience with a vascularized ulnar periosteal graft for the treatment of a recalcitrant nonunion of the radius shaft in an adult patient.
Keywords: radius; nonunion; periosteal vascularized graft; induced-membrane technique.
Level of Evidence: IV

Injerto perióstico vascularizado de cúbito para el tratamiento de la seudoartrosis recalcitrante de radio: A propósito de un caso

RESUMEN
Se han desarrollado distintas técnicas para estimular la consolidación ósea en las seudoartrosis de huesos largos, como el uso de injerto óseo molido o estructural, injertos vascularizados o la técnica de membrana inducida. En 2018, Barrera-Ochoa describió la anatomía de un injerto perióstico vascularizado del cúbito con eje vascular interóseo posterior, y mostró su experiencia clínica inicial en niños utilizándolo en una seudoartrosis atrófica de radio y un defecto óseo después de la exéresis de un tumor de Ewing. Presentamos nuestra experiencia con el injerto perióstico vascularizado de cúbito para el tratamiento de una seudoartrosis recalcitrante en la diáfisis de radio de un paciente adulto.
Palabras clave: Radio; falta de consolidación; injerto perióstico vascularizado; técnica de membrana inducida.
Nivel de Evidencia: IV

CLINICAL CASE

The patient was a 39-year-old man, who was admitted to the Emergency Service after suffering multiple injuries from a motorcycle traffic accident. He was diagnosed with an exposed Galeazzi fracture-dislocation in the right forearm, and a Gustilo II fracture (comminuted radial diaphyseal fracture and irreducible distal radioulnar dislocation) (Figures 1 and 2), for which antibiotics and emergency surgery were indicated according to the protocol for open fractures. Seven days later, definitive open reduction and internal fixation of the right radius plus stabilization of the distal radioulnar joint were carried out, with good initial clinical-radiological results (Figure 3).

Six weeks after surgery, the patient consulted due to pain and seropurulent discharge from the previously healed surgical wound. On radiographs, signs of bone resorption were seen at the focus, with no signs of implant loosening (Figure 4); acute-phase reactant values (erythrocyte sedimentation rate, white blood cells, and C-reactive protein) were normal.

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Figure 1. Galeazzi exposed fracture-dislocation in the right forearm, Gustilo II.

Figure 2. Anteroposterior and lateral forearm radiographs. Galeazzi exposed fracture-dislocation in the right forearm, Gustilo II.

Figure 3. Anteroposterior and lateral forearm radiographs. Initial radiographic result. Reduction and osteosynthesis.

Figure 4. Clinical-radiological findings 6 weeks after surgery. **A.** Active fistula. **B.** Radiological osteolysis at the fracture site.

With the clinical suspicion of late post-osteosynthesis infection, extensive surgical debridement of the focus was performed, with sampling for bacteriological study. When a 3 cm bone defect was discovered in the same surgical procedure, the induced membrane technique, described by Masquelet, was used, using orthopedic cement with antibiotics (vancomycin 2 g/cement dose) and stained with methylene blue to recognize it when extracted.[1] The decision was made to preserve the implant due to the solidity of the fixation, the time since surgery, the low virulence and the good condition of the patient.

Empirical antibiotic treatment was initiated and then directed against *S. epidermidis* and *P. acnes* (germs isolated in cultures from surgery).

The second stage of the Masquelet technique was performed eight weeks after the procedure; there was no infection in the tissues and the laboratory parameters were normal. An iliac crest bone graft was used to fill the bone defect. (Figure 5).

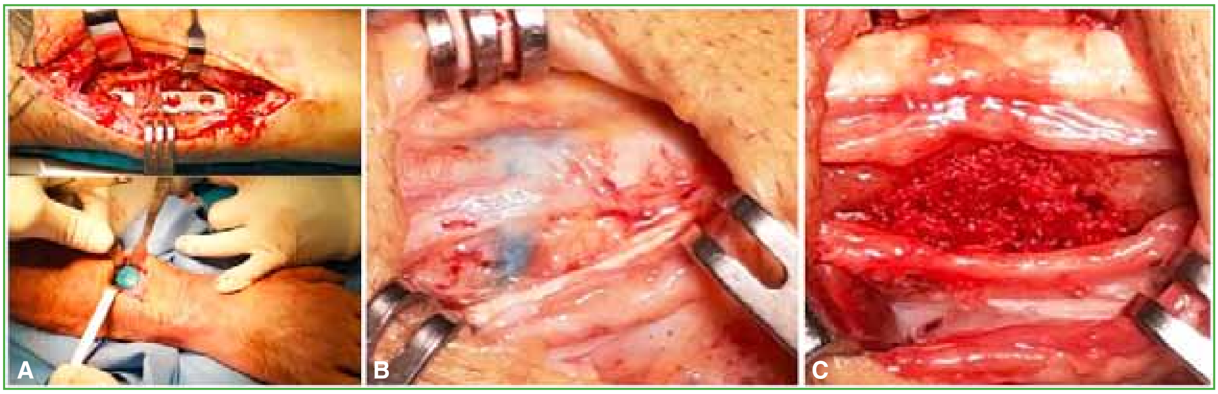

Figure 5. Induced membrane technique. **A.** First stage: debridement and filling of the bone defect. **B.** Second stage: neoformed pseudomembrane. **C.** Bone filling of the defect.

The patient's evolution was satisfactory, with correct healing, pain relief, and normal laboratory parameters. Serial clinical and radiographic controls revealed that the bone defect was progressively filling, allowing the patient to gradually resume his activities.

Eight months after surgery, he referred pain during weight-bearing. Filling of the bone defect was seen on radiographs, but with persistence of the focus of linear pseudarthrosis and implant failure due to fatigue (Figure 6).

Figure 6. Anteroposterior and lateral forearm radiographs. Filling of the bone defect, with linear pseudarthrosis. Fatigue and rupture of the implant.

As a result, a new intervention was performed to remove the implant, explore the focus, collect bacteriological samples, and provide external stabilization with plaster (Figure 7).

Figure 7. Anteroposterior and lateral forearm radiographs. Removal of the implant. Linear recalcitrant pseudarthrosis (with filling of the previous bone defect).

Given the negative results of the tissue samples sent to bacteriology analysis and the recalcitrant pseudarthrosis of the radius, it was decided to perform a new intervention with revision and fibrous debridement of the bone focus, stabilization with a 3.5-mm diameter straight plate and filling with allogeneic ground bone graft from the tissue bank (Figure 8).

Figure 8. Anteroposterior and lateral forearm radiographs. Internal fixation with plate and 3.5 mm straight screws.

To improve the biological contribution in the nonunion focus, the vascularized periosteal flap of the ulna described by Barrera-Ochoa was performed during the same surgical procedure (Figure 9).

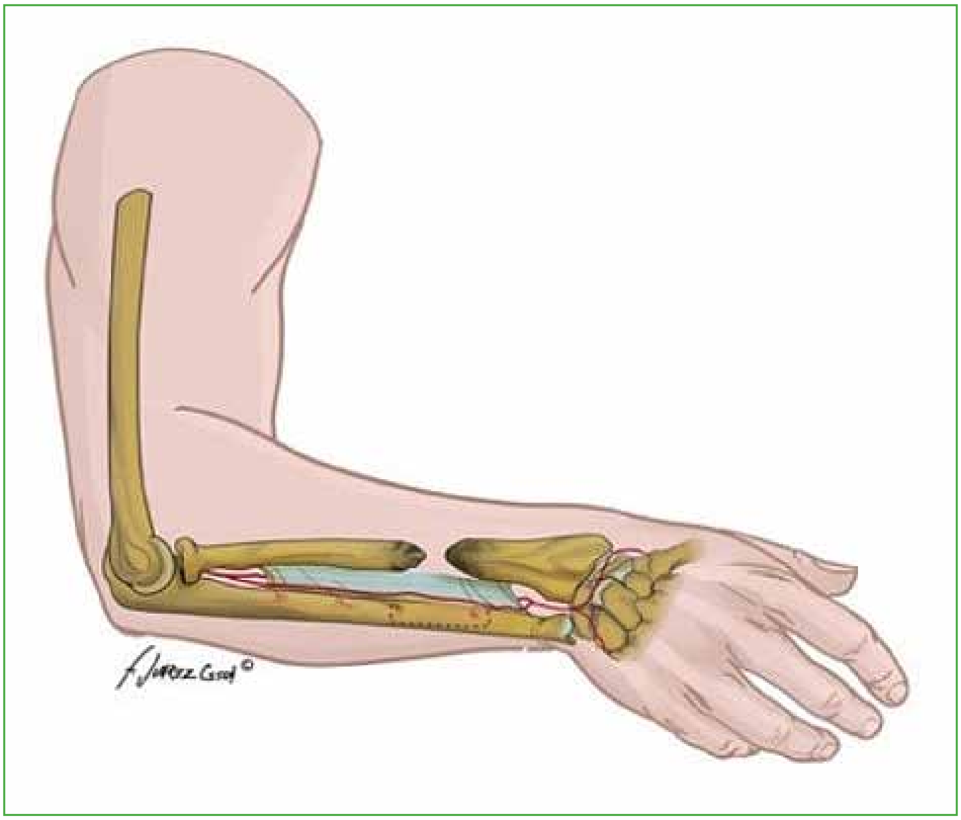

Figure 9. Barrera-Ochoa vascularized periosteal graft.

Summary of the technique

1) Cutaneous marking of the flap along the axis of the posterior interosseous artery, drawing a line connecting the epicondyle to the distal radioulnar joint while keeping the elbow flexed.

2) Initial distal wrist dissection with opening of the extensor retinaculum over the 6th compartment, from a point 2 cm proximal to the distal radioulnar joint (anastomosis level of the recurrent branch of the anterior interosseous artery and the posterior interosseous artery) . In this compartment, the extensor carpi ulnaris tendon is easy to identify, but the vascular axis is not recognizable.

3) Opening of the 5th extensor compartment containing the extensor digiti minimi with recognition of the posterior interosseous artery on the radial side of the intercompartmental septum between the 5th and 6th compartments (Cavadas modification).[2]

4) Initial carving of the pedicle.

5) Ligation of the pedicle's cutaneous and muscular branches; release from a plane immediately superficial to the ulna's periosteum.

6) Once the pedicle has been cut long enough for transposition, the periosteal graft is designed to be large enough to cover the nonunion.

7) Taking the periosteal graft with a thin layer of muscle to preserve its irrigation and respecting the posterior interosseous pedicle.

8) Tunneling of the graft in the subcutaneous plane without tension to cover the largest possible area of the nonunion site. Fixation with non-absorbable suture.

9) Temporary removal of the hemostatic cuff to confirm the vitality of the graft (Figure 10).

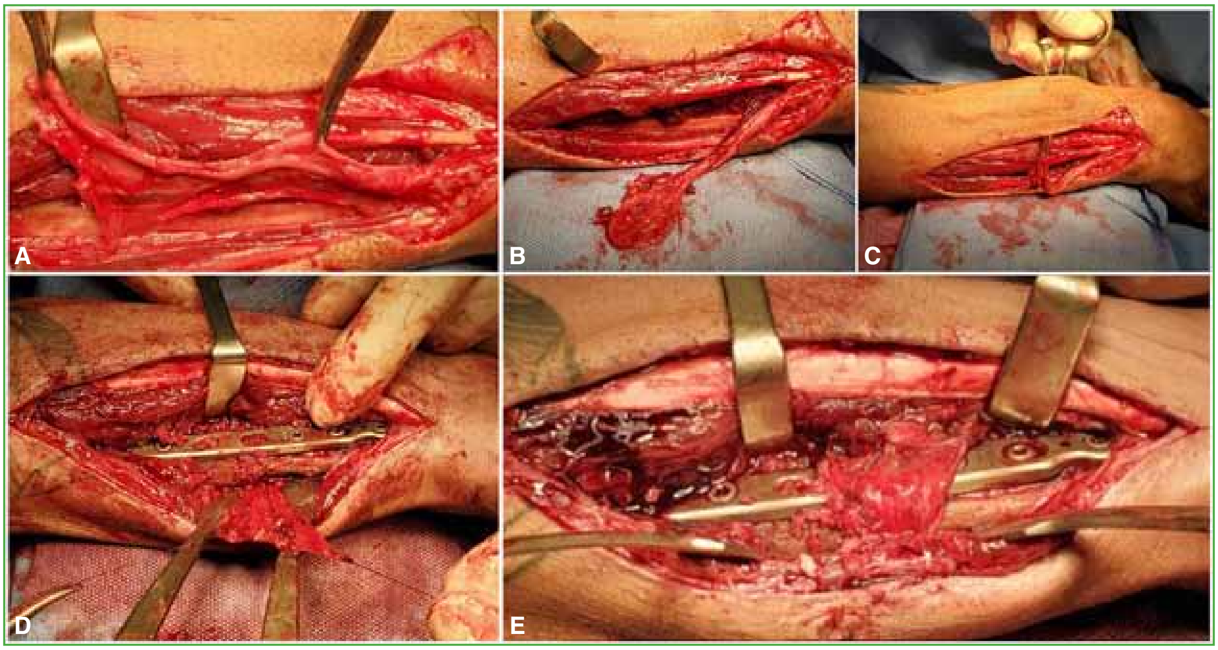

Figure 10. A. Sculpting of the vascularized periosteal graft with visualization of the periosteal perforator. **B.** Carved graft. **C.** Tunneling and passage of the vascularized graft. **D.** Graft placement with coverage around the entire circumference of the radius. **E.** Graft placed.

The patient evolved to complete radiological consolidation (by radiography and computed tomography) in all the cortices 2 months after surgery; with complete subjective recovery of the strength and range of motion of the limb, and return to his professional and sporting activity four months after surgery (Figure 11).

Figure 11. Clinical and radiographic results 4 months after surgery.

DISCUSSION

The treatment of pseudarthrosis continues to be a difficult problem to solve, which requires stability and biological support. Vascularized grafts provide both resources; however, they entail technical difficulties.

In 1978, Finley et al. described the osteogenic and angiogenic potential of vascularized periosteum taken from ribs in tibial bone defects of dogs.[3] In 1990, Penteado et al. experimentally showed the anatomical bases for the carving of different vascularized periosteal grafts.[4] In 1991, Sakai et al. reported excellent outcomes from the treatment of upper limb nonunion with a corticoperiosteal flap from the medial femoral condyle.[5] Qi et al. described the use of periosteal grafting of the greater trochanter to treat nonunion of the femoral neck in children,[6] and Soldado et al. published the use of a vascularized periosteal flap from the fibula for the treatment of pseudarthrosis of the tibia in children, and achieved union rates close to 100%.[7]

In 2018, Barrera-Ochoa et al. described the anatomical basis for the use of a vascularized ulna graft, based on the axis of the posterior interosseous artery. In addition, they reported its use in an atrophic radial nonunion and in a radial bone defect after excision of an Ewing tumor (both in children).[8,9]

Based on the good results, promising case series have been published for the treatment of nonunion of the scaphoid,[10] humerus[11] and forearm[12] in children or adolescents. The biological superiority is evident, as well as the greater thickness of the periosteum in the pediatric population,[12] which limited the development of this technique in adults. When carving this type of graft, there is also concern about potential injury to the osteoperiosteal cambium, the home of periosteal stem cells.

However, in 1994, Camilli and Penteado confirmed the efficacy of periosteal and osteoperiosteal grafts in rats.[13]

In 2021, Barrera-Ochoa et al. extended the indication for periosteal grafts to adults in a series of 11 radius nonunions treated with vascularized periosteal grafting of the ulna, with 100% consolidation and good functional outcomes.[14]

Due to their osteogenic properties, vascularized periosteal grafts, like vascularized bone grafts, may provide the necessary biologic support.

Our report cannot validate the use of this technique, but it does allow us to explore this new option for the management of recalcitrant pseudarthrosis (a term introduced by Zaidenberg in 2008 in the national literature),[15] especially of the radius.

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