# Vascularized bone graft of the distal radius for recalcitrant ulnar pseudoarthrosis

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## Abstract

**Introduction:** The aim of this study is to present medical and radiological results in a series of patients treated with pedicled vascularized bone graft from the distal radius for recalcitrant pseudoarthrosis in diaphysel or proximal ulnar bone.

**Materials and Methods:** We conducted a retrospective study which included patients with pseudoarthrosis in diaphyseal or proximal ulnar bone with <6cm-defects and, at least, three previous surgeries and a minimal follow-up of two years, treated with pedicled vascularized bone graft from the distal radius. We registered the number of previous surgeries. We evaluated elbow and wrist range of motion, comparative grip strength and pain by the visual analogue scale, the Quick-DASH questionnaire and the Mayo Clinic score for the elbow.

**Results:** We included seven patients. They averaged 42 years old (26-64 range). The average number of previous surgeries was 4 (3-7 range). The average follow-up was 31 months (24-43 range). All pseudoarthroses healed. The Mayo Clinic score was good in 4 patients, excellent in 2 and moderate in one patient. The average postoperative QuickDASH score was 13 (0-29 range). The wrist flexion/extension arch was 81 % as compared to the contralateral wrist. The elbow range of motion was >100º in 5 patients and 50º-100º in 2 patients.

**Conclusion:** Pedicled vascularized bone grafting from the distal radius is an effective alternative for the treatment of ulnar pseudoarthrosis.

**Key words:** Vascularized bone graft; distal radius; pseudoarthrosis; ulna.
**Level of evidence:** IV

### Injerto óseo vascularizado pediculado del radio distal para tratar la seudoartrosis recalcitrante del cúbito

## Resumen

**Introducción:** El objetivo de este trabajo es presentar los resultados clínicos y radiológicos de una serie de pacientes tratados con injerto óseo vascularizado pediculado del radio distal para seudoartrosis recalcitrantes de cúbito diafisario o proximal.

**Materiales y Métodos:** Se realizó un estudio retrospectivo que incluyó a pacientes con seudoartrosis del cúbito diafisario o proximal con defectos <6 cm y, al menos, tres cirugías previas y un seguimiento mínimo de dos años tratados con injerto

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óseo vascularizado pediculado del radio distal. Se registró la cantidad de cirugías previas. Se evaluaron el rango de movilidad del codo y la muñeca, la fuerza de puño comparativa, el dolor mediante la escala analógica visual, el cuestionario QuickDASH y el puntaje de la Clínica Mayo para codo.
**Resultados:** Se incluyó a siete pacientes. La edad media fue de 42 años (rango 26-64). El número promedio de cirugías previas fue 4 (rango 3-7). El seguimiento medio fue de 31 meses (rango 24-43). Todas las seudoartrosis consolidaron. El puntaje de la Clínica Mayo fue bueno en 4 pacientes, excelente en 2 pacientes y moderado en uno. El puntaje QuickDASH posoperatorio promedio fue de 13 (rango 0-29). El arco de flexo-extensión de la muñeca fue del 81% del contralateral. El rango de movilidad del codo fue >100° en 5 pacientes y de 50°-100° en 2 pacientes.
**Conclusión:** El injerto óseo vascularizado pediculado del radio distal es una alternativa eficaz para el tratamiento de la seudoartrosis del cúbito.

**Palabras clave:** Injerto óseo vascularizado; radio distal; seudoartrosis; cúbito.
**Nivel de Evidencia:** IV

## Introduction

Ulnar bone pseudoarthosis is associated with previous inadequate internal fixation and, in most cases, the treatment of choice is revision of osteosynthesis plus conventional bone grafting.[1,2] However, in case of infection, poor vascularization of surrounding tissues due to multiple previous surgeries, or failure in previous bone grafts, vascularized bone graft (VBG) comes as a valid alternative.[3,4]

In 2008, Zaidenberg et al.[5,6] described the use of pedicled VBG from distal radius for recalcitrant pseudoarthrosis in the distal humeral bone. In the same publication, they describe the possibility to use this technique for the treatment of ulnar bone defects.

The aim of this article is to report medical and radiologic results in a series of patients treated with pedicled VBG from distal radius for recalcitrant pseudoarthrosis in the proximal or diaphyseal ulnar bone with bone defect.

## Materials and Methods

Between 2008 and 2014 we analyzed retrospectively a series of patients with pseudoarthrosis in the proximal or diaphyseal ulnar bone and, at least, three previous surgeries and a minimal 2-year follow-up, treated with the technique of pedicled VBG from the distal radius plus new internal fixation (Figure 1). We excluded patients with associated fracture of distal radius, >6 cm-bone defects, patients autologous bone graft had not been attempted before in, and patients with abnormal Allen test.

### *Surgical technique (4 steps)*

Before starting the procedure we carried out the Allen test in every patient so as to verify adequate circulation at ulnar artery level.

The first step consists of the specific treatment of ulnar pseudoarthrosis. Scraping the pseudoarthrosis spot is of

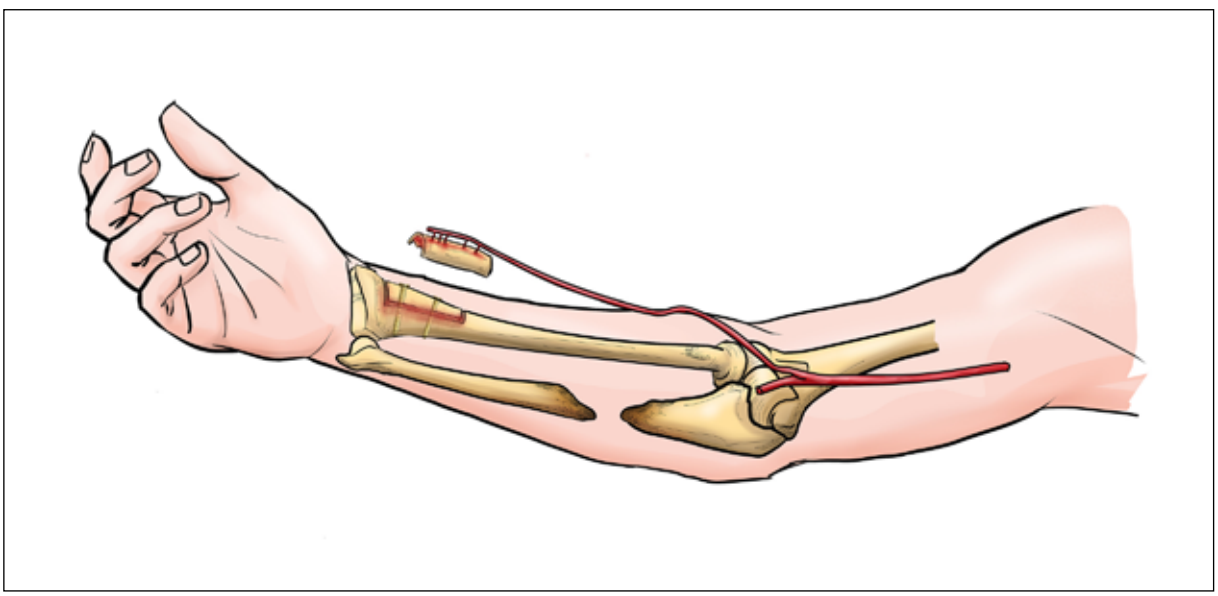

**Figure 1.** Sketch showing vascularized bone graft taken from the distal radius and pedicled with the radial artery.



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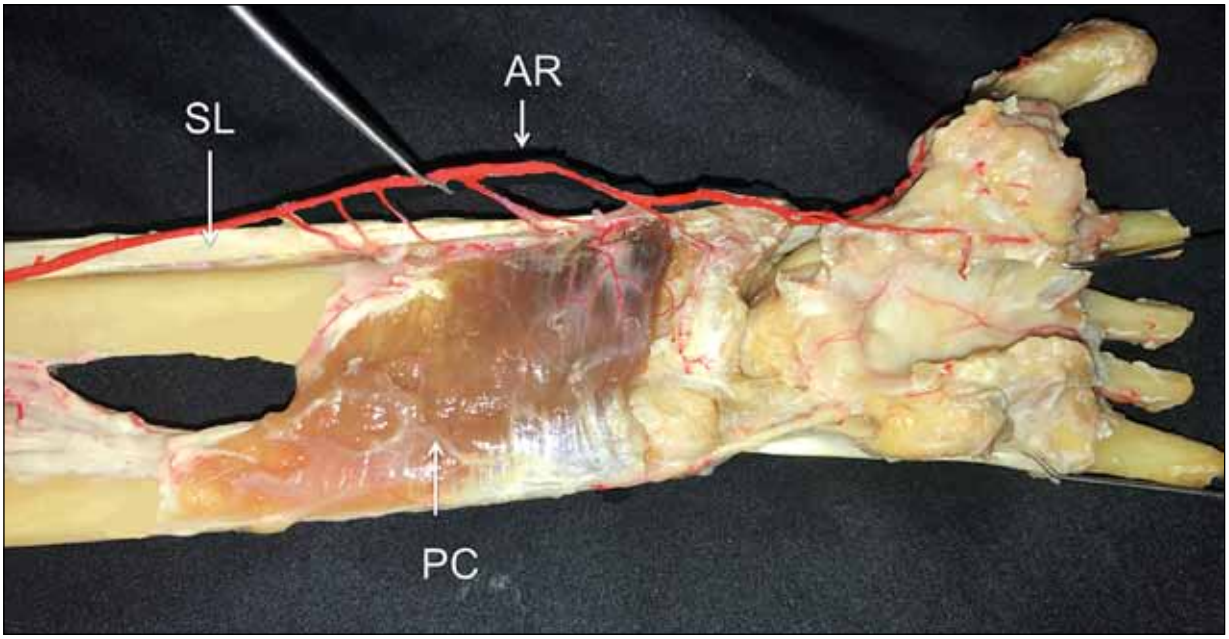


**Figure 2.** Anatomic dissection showing periosteal blood supply to the distal radius. BR= brachioradialis muscle; PQ= pronator quadratus muscle; RA= radial artery.

the utmost importance, as well as removing the osteosynthesis material, if any. A thorough preparation of the receptor field in both fragments is key to the procedure, removing all devitalized tissue until reaching bleeding tissue.

At second step-time, once the receptor field for bone graft has been prepared, we move on to transitory internal fixation to recover ulnar length. Usually we use a 3.5 mm LCP straight plate and olecranon locking plates for proximal pseudoarthrosis, as the specific case requires. Once the ulnar bone has been stabilized, what comes is the assessment of the remaining defect.

The third step consists of designing the VBG at distal radius level—the radius is approached from the anterior-outer aspect of the forearm starting from the elbow crease towards the wrist and following the path of the radial artery (alongside releasing cutaneous and muscle branches). The radial artery is covered by the muscle mass of the brachioradialis muscle and, in its distal third it follows a superficial path where it gives little branches (between 2 and 7) which give blood supply to the distal radius. These branches, which enter the radius in the form of periosteal arteries, should be preserved and they are to be found between the medial aspect of the brachioradialis muscle and the radial attachment of the pronator quadratus muscle (Figure 2). Once the radial artery has been released, what comes is the design of the VBG from the distal radius (consistently with the patient's defect). We avoid grafts that are greater than 6 cm in length and 1.5 cm in width so to prevent potential radius fractures. The donor site in the distal radius is reinforced by iliac crest graft anyway, which is fixed using two 3.5 mm-screws. The fourth step consists of inserting the VBG from the distal radius into the ulnar receptor field, and fixing it definitely. Once the VBG has been gathered, it is subcutaneosly tunnelized towards the back and plugged into the receptor field. The VBG is fixed with a 3.5 mm-screw to the plates previously inserted, creating definite internal fixation. Postoperative mobilization consists of brachiopalmar splinting for two weeks and, afterwards, of "sugar tong" splinting for the patient to move his or her elbow up to signs of radiologic bone healing.[7]

Radiologic bone healing has been defined as the presence of, at least, three out of the four cortical bone aspects in AP and lateral X-rays. However, when in doubt, we resorted to CT scan so as to confirm the integration of the vascularized bone graft.

We registered the number of previous surgeries. We evaluated range of motion in both the elbow and the wrist, comparative grip strength, as well as pain by the visual analogue scale, the QuickDASH questionnaire and the modified Mayo Clinic score for the elbow.[8] We also assessed the time of radiologic bone healing. We registered complications and the need to reoperate the patient on.

## Results

Seven patients met the inclusion criteria: four males and three females who averaged 42 years old (ranging from 26 to 64). The average number of previous surgeries was 4


**Figure 3. A and B** Patient with elbow fracture-dislocation. **C.** Osteosynthesis with plate as initial treatment. **D.** Pseudoarthrosis and loosening of the implant 6 months later.

(ranging from 3 to 7). Time between the initial injury and the VBG was 16 months on average (ranging from 10 to 19). Five patients showed pseudoarthrosis in the proximal ulnar bone and two, in the ulnar diaphysis (Figure 3). Four patients had history of infection. The average follow-up was 31 months (ranging from 24 to 43). The average length of the VBG was 4.8 cm (ranging from 4 to 6). All pseudoarthroses healed. The average time up to radiologic bone healing was 3.8 months (ranging from 3 to 6).

The Mayo Clinic score was good in four patients, excellent in two and moderate in one patient. The average posoperative QuickDASH score was 13 (ranging from 0 to 29). Average preoperative pain according to the visual analogue scales was 4.4 (ranging from 2 to 6) and it was 0.5 (ranging from 0 to 2) at final follow-up. At that moment, wrist flexion/extension range of motion was 81% as compared to the contralateral wrist, and pronation-supination arch was 93%. The elbow range of motion was > 100º in five patients and between 50º and 100º in two patients. Grip strength was 79% as compared to the contralateral hand. All patients were able to retake their jobs fully. There were no reoperations. There were neither cases of postoperative pain nor cases of donor site fracture at final follow-up (Figures 4 and 5).


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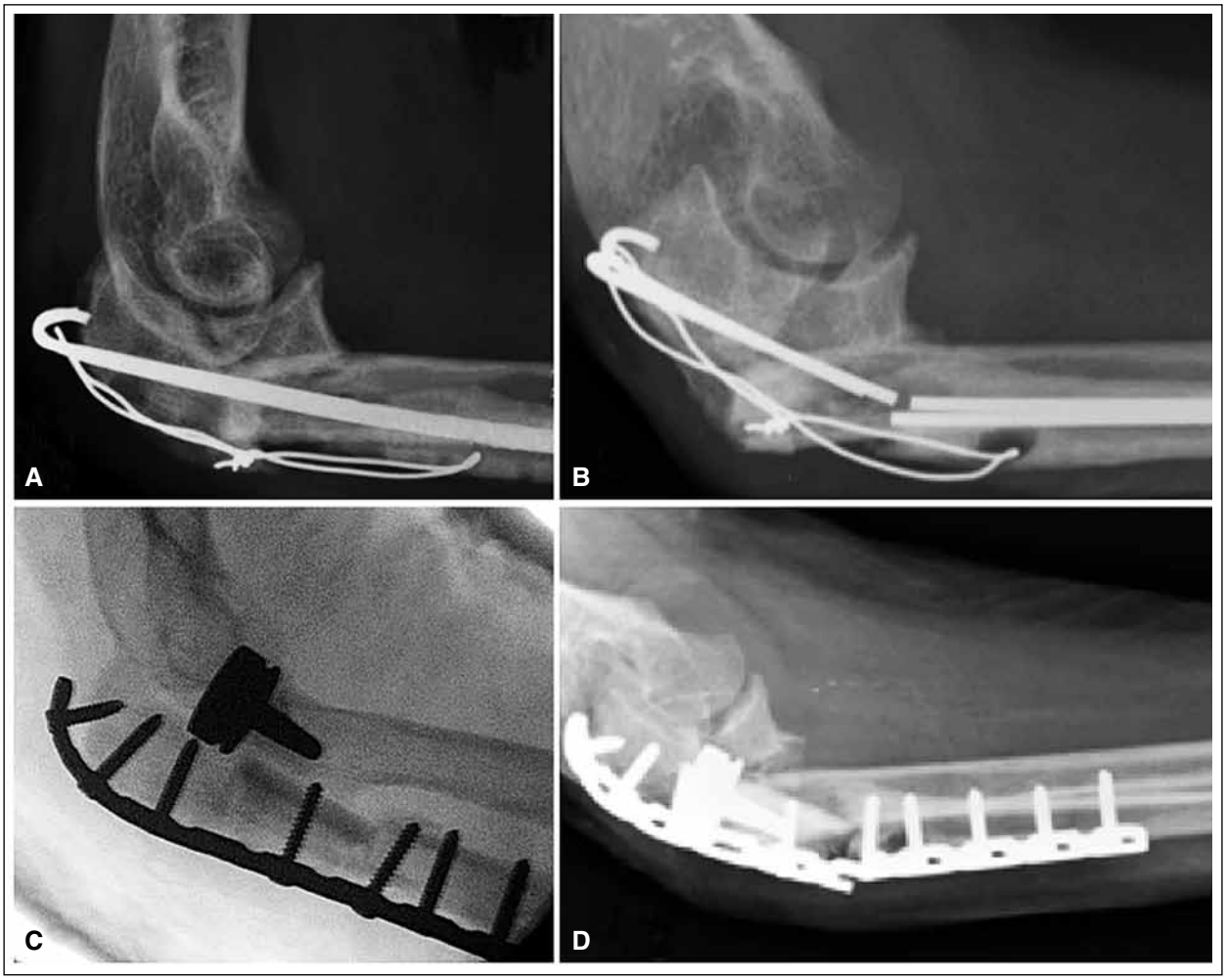


**Figura 4.** Continuation of the case in Figure 3. **A**. Removal of material and tension band wiring to olecranon. **B.** Osteosynthesis rupture. **C**. Fifteen months after the original lesion, new surgery with locking plate and conventional bone graft in the bone defect. **D.** Four months later, X-rays showing lack of bone healing and plate rupture.


**Figura 5. A.** New osteosynthesis and pedicled vascularized bone graft 19 months after the fracture. **B.** X-ray showing radiologic bone healing at final follow-up.

## Discussion

This study analyzes a series of patients with pseudoarthrosis in the proximal or diaphyseal ulnar bone and an average of four previous surgical failures treated by internal fixation and pedicled VBG from the distal radius. We got radiologic bone healing in all cases, and Mayo Clinic score-results were good or excellent in six out of the seven patients.

There are reports on diverse surgical alternatives for the treatment of ulnar pseudoarthrosis.[9-14] Internal fixation combined with non-vascularized bone graft is the alternative of choice in most of the cases of either diaphyseal or proximal pseudoarthrosis.[1] Ring et al. got excellent results in the treatment of diaphyseal pseudoarthrosis with plate and autologous bone graft. However, in this series, 31 out of the 35 patients had undergone only one previous surgery and the average bone defect was 2.2 cm. Therefore, they differ from our series, where average bone defects were 4.8 cm with an average of four previous surgeries.

Free VBG from the fibular bone is usually indicated for > 6cm-bone defects in the upper limb. Aldany et al.[16] revised a series of 10 patients with an average bone defect of 8.4 cm after osteomyelitis debridement treated with vascularized bone graft from the fibular bone. In this series, patients had undergone four previous surgeries on average and, in 9 out of the 10 patients they got bone healing in average 4.8 months. However, in <6cm-defects where conventional bone graft has already been used, pedicled vascularized bone graft from the distal radius has the advantage of not requiring microvascular suture in a scar (caused by the multiple previous surgeries); therefore, it results to be a technically simpler and faster technique with similar results, according to different previous reports.

Finally, there is controversy in literature concerning the risk of fracture in the donor site. Sinclair et al. in a series of 218 patients used free VBG from the distal radius of up to 12 cm to reconstitute the mandible and reported only one fracture in the donor site (0.5%).[17] Anyway, in our cases we preferred to use up to 6 cm-bone grafts and add graft to the donor site so as to avoid this complications. Using this approach, patients suffered neither postoperative pain nor fracture in the radial donor site.

This study shows some limitations. First of all, it is a retrospective study conducted in a small number of patients. Secondly, there was no control group; therefore, it is impossible to make comparisons with other therapeutic alternatives. However, we acknowledge that this is a hardly prevalent condition, what makes it difficult to analyze it by other types of study associated with higher levels of evidence.

## Conclusion

Pedicled VBG from the distal radius is an effective alternative for the treatment of ulnar pseudoarthrosis with <6cm-bone defects.

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