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Case report

Iliac bone graft for the treatment of bone loss and non-union of the distal radius

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Abstract. *Background/Aim of the work:* Open distal radius fractures are rare compared to closed ones. They mainly affect young people with high-energy trauma and are burdened with a high number of complications, including non-union. In this case report, we describe the technique used to manage bone loss and non-union of the distal radius of a polytraumatized patient with an open Gustilo IIIB fracture of the wrist. *Case Report:* 58-year-old man, suffering from head trauma and open right wrist fracture after motorcycle accident, underwent emergency damage control with debridement, antibiotic prophylaxis and stabilization in an external fixator. Then, he developed infection and bone loss, associated with an injury of the median nerve. Non-union were treated with iliac crest bone graft, open reduction and internal fixation (ORIF). *Outcomes:* At the follow-up 6 months after the bone graft and ORIF procedure and 9 months after the trauma, the patient was clinically healed, with good performance status. *Conclusions:* Treatment of non-union in open distal radius fractures with iliac crest bone graft is a viable, safe and easy surgical choice. (www.actabiomedica.it)

Key words: open wrist facture, non-union, iliac bone graft

Introduction

Wrist fractures are very common in old age, while in young people they are less common and due to high-energy trauma, often during sports or work activity. Data from a cohort of 208.094 patients from the United States revealed that the radius was the most common long bone to fracture. This type of fracture accounts for 26% -46% of all ones observed in the primary care setting (1). It is most commonly caused by a fall on an outstretched hand, causing fracture occurring approximately 2 cm above the distal articular surface of the radius at the junction where the cortical bone becomes thinner (2). Open wrist fractures are definitely the minority, because the rate of these injuries is approximately 6% (3). These are often accompanied by severe bone comminution, loss of substance and contamination with external material. Therefore, the risk of osteomyelitis, septic arthritis of the wrist, delayed union and non-union is very high. Furthermore, vascular-nerve injuries often coexist. The purpose of treating these fractures is to stabilize and prevent infection. Furthermore, in high-energy trauma, skeletal stabilization is the basis for all reconstructive procedures: a stable skeleton allows the surgeon to focus on microsurgical anastomoses and nerve, tendon and muscle reconstruction. In the case of open fractures type I and II according to Gustilo, irrigation, antibiotic prophylaxis and open reduction and internal fixation (ORIF) are the most recommended choices. Major controversies concern the timing of the definitive treatment and the choice of the fixation tool in Gustilo's type III open fractures (4). In these cases, it is recommended to carry out an emergency damage control through irrigation, antibiotic prophylaxis and stabilization with an external fixator and repair of any severe associated vascular-nervous or tendon injuries, postponing the definitive treatment to a later time.

Our case report illustrates the management of a polytraumatized patient with a rare and severe open

wrist fracture, in which the treatment of damage control and subsequent definitive osteosynthesis was complicated with bone resorption and non-union.

This case report has been prepared according to the SCARE CRITERIA (5). The patient expressed written informed consent to the description of the case and the reproduction of the photographic and radiographic images. This study was conducted under the principles of the Declaration of Helsinki.

Case report

58-year-old Caucasian male patient polytraumatized in a motorcycle-to-car road accident reported a commotional head injury and deformity of the right wrist with bone exposure. The patient's clinical history was collected with the help of family members. He suffered from arterial hypertension. The dominant limb was reported to be the right. He was a smoker (20 cigarettes a day), habitual drinker of beer, wine and spirits and occasionally user of abuse drugs.

Investigation and Emergency Treatment

Upon arrival in the emergency room, he underwent a total body computerized tomography (CT) scan, radiography in two projections of the right wrist and subsequent CT scan of the wrist with three dimensional (3D) reconstructions (Fig. 1).

Tests performed revealed a skull base fracture with cerebral hematoma. He also reported an open comminuted fracture of the distal end of the right radius and a fracture of the ulna. Exposure was localized in the volar meta-epiphyseal area with loss of bone stock. There was no appreciable major vascular-nerve damage, but a medium size bone fragment resulted injuring the epineurium of the median nerve. The fracture was classifiable as Gustilo IIIB, AO/OTA 2.3.C3. The injury was treated with abundant washing, debridement and stabilization with a radio-II metacarpus Hoffmann II external fixator, after placing a K wire in the ulna to restore length and axis (Fig. 2).

In consideration of the severity of the patient neurological condition, an intensive care hospitalization lasting about one month followed.

During this period, wrist local clinical conditions worsened. The right wrist appeared swollen with signs of an infectious process in progress. Microbiological examinations revealed a Staphylococcus Aureus infection. Laboratory tests showed an increase in the C-reactive protein (CRP) (150mg/dl; range: 0.5-1mg/dl) and white blood cells (20.000/mm^3). Wrist X-ray revealed an important and widespread reduction in the calcic tone of the wrist and hand, as in the Sudek's algo dystrophy, and bone resorption of the radius distal epiphysis (Fig. 3).

It was thus decided to undertake targeted antibiotic therapy, remove the external fixator and replace it with a splint. He then began cautious finger mobilization of his right hand. In addition, clodronate was administered (200 mg/day for 10 days; then 200mg/week for 3 months).

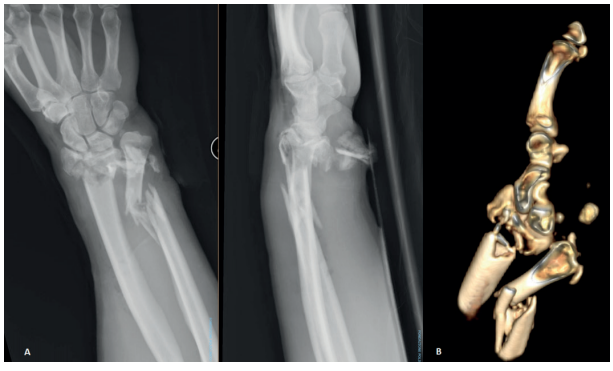

Figure 1. X-ray of the right wrist in 2 projections (A) and three-dimensional CT-scan reconstruction (B): high-energy trauma with comminuted fracture of the distal epiphysis of the radius and ulna. In the lateral view, it is possible to appreciate the bone fragment that escaped from the volar exposure area.

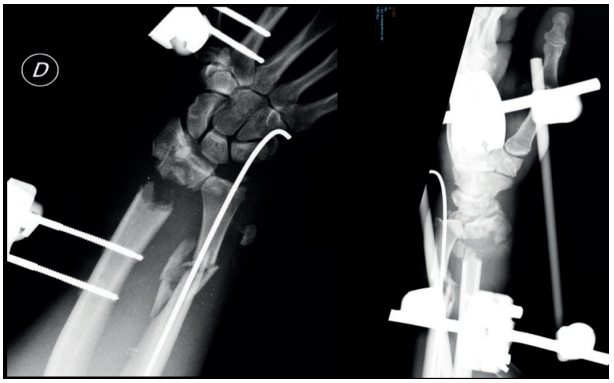

Figure 2. X-ray of the right wrist in 2 projections after stabilization with external fixator and Rush's nail in the ulna.

At 3 months after the trauma, the clinical and radiographic evaluations had significantly improved. Bone density was increased and local signs of infection were no longer evident, with normalized C-reactive protein and white blood cells. There was evident discrepancy between the radius and ulna, extensive loss of meta-epiphyseal bone stock with volar subluxation of the distal epiphysis of the radius. Clinically, the range of motion (ROM) was severely compromised. The DASH scale was 76.7 (better: 0; worse: 100) and the Mayo Wrist score was 20 (worse: 0; better: 100). In addition, the patient complained pain at rest (VAS 3; range: 0-10) exacerbated with wrist mobilization (VAS 6), and a neuralgic pain with the presence of a trigger point in the area of the median nerve at wrist, treated at first with non-steroidal anti-inflammatory drugs. In consideration of the resolution of the infectious state and the severe aesthetic and functional deficit and pain, an ORIF with associated cortico-cancellous iliac crest autologous bone graft was proposed to the patient. Concerning the painful median nerve injury, an external neurolysis associated with covering by a fat local flap was also envisaged.

Treatment

The surgical procedure was performed after a few weeks and divided into two distinct surgical times. Antibiotic prophylaxis with cefazolin 2g was performed one hour before the start of the procedure. In supine decubitus and under general anaesthesia, a straight skin incision of about 8-10 cm in length is made at the iliac crest. After the incision of the subcutaneous tissue, the raphe that joins the transverse and internal oblique muscles of the abdomen with the bone is identified and sectioned. Muscles are spread apart and therefore the iliac crest is exposed. A bone saw is used to draw the flap to be removed. The bony box is drawn, which will encompass the cortical and a certain amount of cancellous bone. An accurate haemostasis of the donor site is conducted, before the suture. Once removed from its natural site, the bone tissue is immersed in an isotonic solution to prevent dehydration, ensuring its implantation in the receiving site as soon as possible. The second surgical time, consists in implanting the bone graft in the receiving site and in performing the ORIF. In supine decubitus, with the right upper limb on a radiolucent table and with a tourniquet at the root of the limb, the volar access to the distal third of the radius, extended distally to the carpal tunnel, is performed according to the modified Henry's approach. After skin and subcutaneous incision centred on the radial carpal flexor tendon, this tendon is spread apart on the ulnar side together with the underlying long flexor of the thumb. The median nerve was identified, surrounded by scar adhesions. A careful neurolysis was then performed, discovering a traumatic neuroma. The radial artery is protected on the radial side for the entire duration of the surgical procedure, without isolating it. In order to expose the bony plane, the pronator quadrate muscle is disengaged from its radial insertion. The latter already appeared partly scarred by the trauma, but its anterior fat pad was still present and well represented. Once on the bone plane, the large and documented loss of radial meta-epiphyseal bone stock and the volar comminution of the epiphysis were visualized. The bone surfaces were then bloodied and the cortico-cancellous bone graft taken from the iliac crest was implanted, taking care to arrange the cortical anteriorly and sinking the cancellous bone into the epiphysis to regain the physiological length between the forearm bones. In the details, the iliac graft was customized in a cuneiform shape to fit at best the bone loss. Then, osteosynthesis was performed with Medartis Aptus Volar 2.5mm 10 + 7 holes plate, under

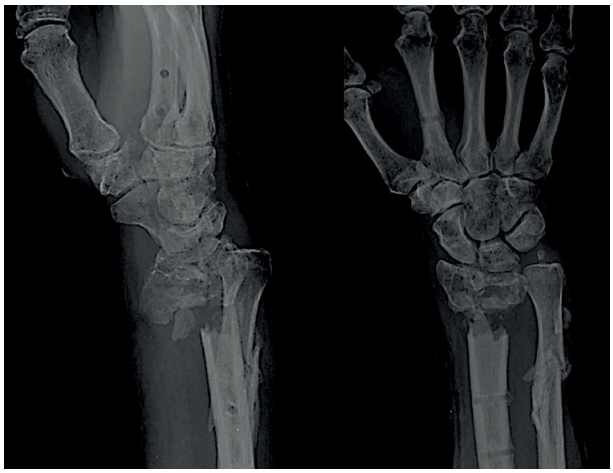

Figure 3. X-ray of the right wrist in 2 projections one month after the injury and after removal of the external fixator and Rush's nail: radiographic signs of algo dystrophy.

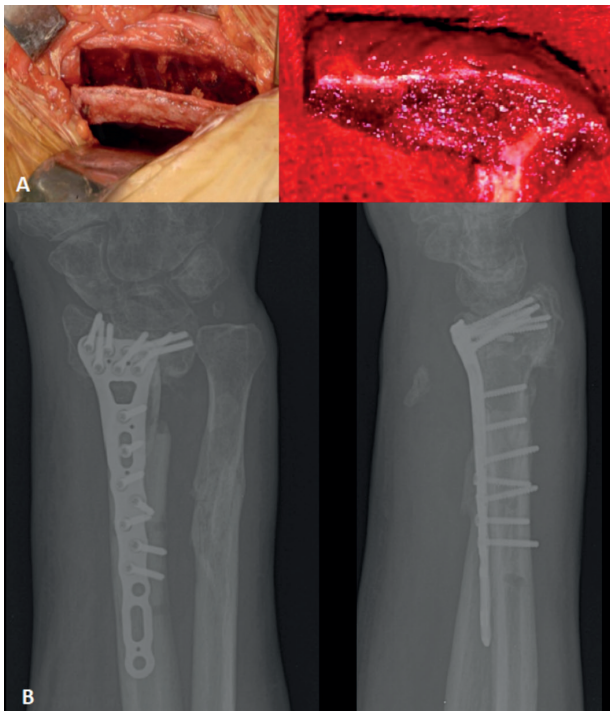

Figure 4. X-ray of the right wrist in two pre-operative projections, intra-operative views of the surgical procedure performed with iliac crest bone graft and ORIF and post-operative right wrist X-ray.

fluoroscopic guidance (Fig. 4).

At the end of the procedure, in order to create a favourable peri-neural environment, a fat local flap was then raised from the pronator quadratus, to surround the traumatized median nerve segment (Fig. 5) (6).

Release of the tourniquet and accurate haemostasis was conducted, before the suture of the skin. The post-operative course was regular, the removal of the sutures took place about 2 weeks after the surgical procedure.

Outcomes

At 1-month radiographical and clinical evaluations, tools used for osteosynthesis were intact and in place, even if there was a modest resorption of the autologous bone graft. The patient did not complain of pain on mobilization, despite having a wrist flexion-extension deficit. The neuralgic pain was no more reported by the patient, and the trigger point disappeared from the median nerve area. Therefore, he began physiotherapy treatment.

At the check-up 3 months after the surgical procedure, the volar plate and screws appeared intact and

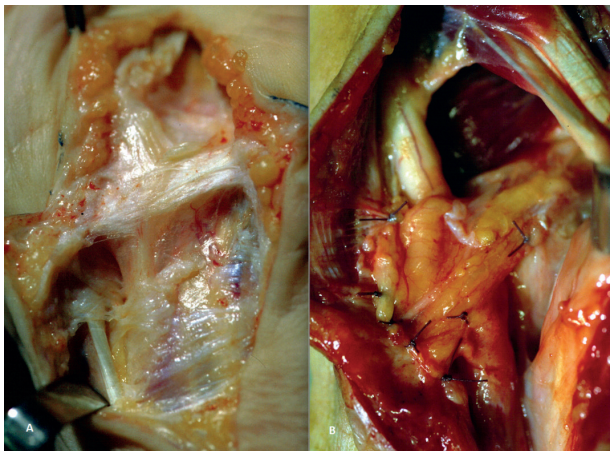

Figure 5. Intraoperative view showing the median nerve compressed by scar tissue (A) and the fat local flap realised to protect the nerve after neurolysis (B).

in place with complete bone healing, without further resorption of the bone graft. However, the patient still showed a modest deficit of the wrist ROM. Therefore, an indication has been given to continue the rehabilitation protocol.

At the follow-up 6 months after the bone graft and ORIF procedure and 9 months after the trauma, the patient was clinically healed. The DASH score was 25, the Mayo Wrist score 65, VAS 1 under exertion, 0 at rest. Right wrist ROM was: complete prone-supination, 45 ° of wrist flexion and 30 ° of wrist extension. A strength test was also performed (JAMAR test), managing to generate a force equal to 35 kg with the grip (Fig. 6).

12 months after the surgical procedure, the volar plate and screws were removed. The patient has also returned to heavy manual work (bricklayer) (Fig. 7).

Discussion and conclusion

Open distal radius fractures are very serious injuries, but rare. The risk of local complications is very high in the short and long term. Initially, the infectious risk is the main one, then, replaced by the risk of non-union and malunion. In particular, collapse, loss of normal palmar tilt, radial shortening, articular incongruity and permanent deformity with pain and loss of function may result. Volar and dorsal angulation of radiocarpal joint surface worsen functional outcome when it exceeds 20°

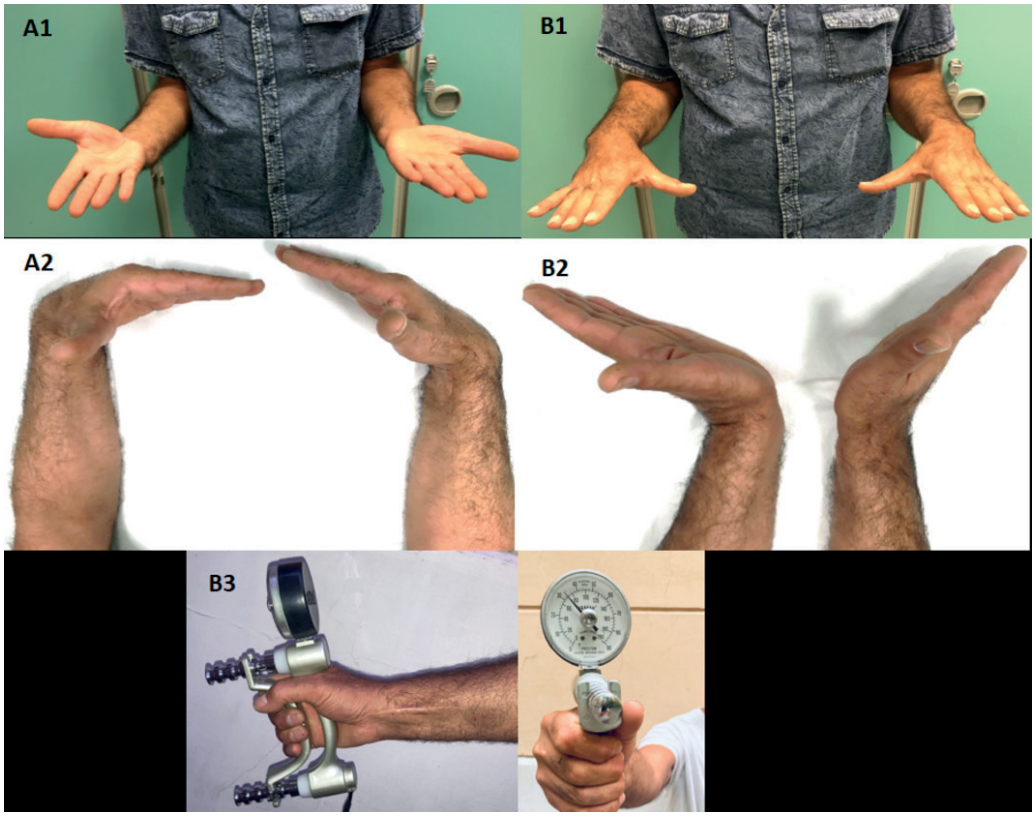

Figure 6. Clinical examination at 6 months (A) and 12 months (B) after grafting and osteosynthesis: progressive improvement in the range of motion.

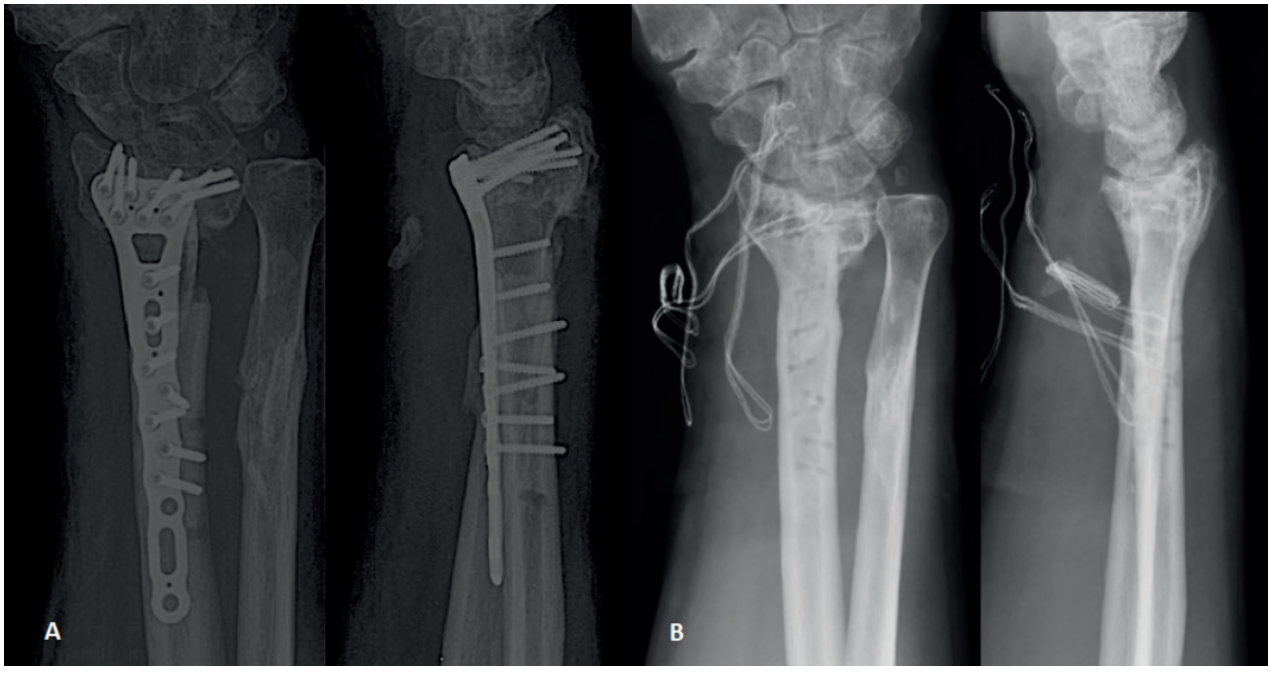

Figure 7. Radiographic checks of the right wrist after the surgical procedure and after the removal of the plate and screws. A progressive improvement can also be noted in the bone density of wrist and carpal bones.

(3). Two types of malunions of the distal radius should be distinguished: extra-articular and articular. Extra-articular malunion after treatment of open distal radius fracture is relatively rare complication. Malunion of the distal radius is particularly problematic at the distal radioulnar joint. As radial height is lost, radio-ulnar length mismatch may result in distal radioulnar joint incongruity, causing instability, decreased motion, and early arthrosis (7). Furthermore, malunions frequently have an unappreciated rotational component that may affect distal radioulnar joint (DRUJ) motion and stability. In a study that examined computed tomography (CT) scans of both affected and normal wrists, Prommesberger et al. confirmed this problem which contributes to worsening the clinical outcome (8).

Bytyqui et al. reports the case of a 32-year-old patient suffering from malunion after open fracture Gustilo IIIB successfully treated with corrective osteotomy and plate and screw fixation (9).

It can therefore be said that low-grade open distal radius fractures are associated with better outcomes and fewer complications, leading the authors to conclude that grade I open injuries behave more like their closed counterparts whereas grades II and III injuries have a guarded prognosis (10).

On the other hand, the most fearful of complications is the non-union with loss of bone stock, as in the illustrated case. This clinical condition is also difficult to manage. It is known that open Gustilo III fractures are burdened by a greater number of complications and less satisfactory results in the long term. In this regard, Iorio et al. documented increasing injury severity by Gustilo classification was associated with a greater number of poor results and postoperative complications (11).

The choice of the best management of a non-union in these cases is very difficult and the rescue intervention itself is burdened by many risks. Definitely, it is necessary to opt for a bone graft that bridges the loss of bone stock that has occurred. The goal is not only to restore the aforementioned criteria, which are also valid for the management of malunion, but it is also necessary to give length to the radius and structural support. We find in the literature references to the use of vascularized and non-vascularized bone graft. The bone graft technique has been used for years for the management of pseudarthrosis of different bone segments, with good results (12). With particular reference to upper limb surgery, the use of iliac crest bone graft for the management of non-union is a common and consolidated practice in scaphoid fractures, but its use in the distal radius non-union is certainly less common (13). In addition, the use of a vascularized bone graft is burdened by greater technical difficulties in consideration of the need to perform microsurgical vascular anastomoses in the receiving site. This consequently translates into a greater risk of technical error and failure. In this regard, the most used vascularized bone graft is undoubtedly the fibula or distal radius bone graft (14). What makes our case interesting is the excellent clinical and radiographic result obtained with the use of a non-vascularized bone graft, and in particular from the iliac crest. This involves less difficulty in picking up and positioning, as it does not require microsurgical procedures. On the other hand, the risk of resorption of the graft is obviously greater, in consideration of its non-vascularization. However, we can affirm that in our case this complication did not occur and that the patient underwent healing without significant signs of bone resorption or mobilization of the implanted osteosynthesis tools. Furthermore, our patient was neither particularly young (58 years old), nor in ideal general clinical conditions (heavy smoker, drinker and occasional drug user). Confirming our result, Liu et al. published a similar case report on an adolescent patient treated with the same technique for distal radius non-union after an open wrist fracture (15). The use of bone graft for the management of non-union is certainly more practiced for scaphoid fractures, as previously mentioned. And it is precisely from the scientific literature on this topic that we can draw evidence in favour of the use of non-vascularized bone grafts. A comparative study by Braga-Silva et al. on a large number of patients demonstrated how the use of non-vascularized iliac crest bone graft is not burdened by a greater number of complications or failures than the distal radius vascularized bone graft for the treatment of scaphoid non-union (16). Another key point to evaluate for the correct choice of the bone graft to use is the following: cortico-cancellous bone graft vs cancellous bone graft. A recent study by Kim et al. suggests comparable results in the two cases, but in apparently shorter times if a cancellous bone graft is used. This evidence seems to us to be justified by the microarchitecture of the cancellous bone and by

the presence within it of bone progenitor cells. In our case, a cortico-cancellous bone graft was instead used with optimal results. Bone healing was achieved in a timely manner, compatible with the bone repair process. It would be interesting to repeat the treatment with an architecturally different bone graft and study the differences in clinical and radiographic evolution (17). These evidences and the results obtained in our experience can also be considered valid for the management of non-union of the distal radius. Studies on this subject could therefore confirm what has occurred. In addition, it is essential in patients suffering from non-union of the distal radius to restore correctly the DRUJ. The latter in fact is fundamental for the restoration of prone-supination, essential in the activities of daily life. In fact, we think that the good function of the wrist in this patient at the end of the treatment is largely due to the correct restoration of this joint. Likewise, forging the bone graft to best accommodate bone loss is critical. In fact, this allows to optimize bone contact, but also to restore the length of the forearm bones and their interaction.

Treatment of distal radius non-union with iliac crest non-vascularized bone graft and ORIF offers a reasonable treatment option in patients with open fracture and bone loss. This type of treatment has made it possible to achieve excellent clinical and radiographic results.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Ethics approval and consent to participate: This study does not require the approval of the local ethics committee. Written consent was obtained from the patient.

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