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Dorsal Support System Fixed to Volar Plate in Distal Articular Radius Fractures

Sistema de sostén dorsal fijado a placa volar en fracturas articulares de radio distal

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Abstract

Despite the development of new dorsal low-profile, locked plates to treat distal radius fractures with articular patterns that require a dorsal support, many published series revealed complications associated with such devices. In this paper, we present three cases of comminuted fractures and dorsal *die punch* fragment treated by osteosynthesis using volar plate and dorsal support screw with double washer fixed to the plate through a mini dorsal approach and, from a volar position, a cup inserted in one of the distal holes of the plate to which a screw and two 7- and 13-mm washers are threaded from the back. This technique is an alternative to other fixation methods, and it may lead to similar functional outcomes and reduce the complications associated with the use of dorsal plates to treat these fractures.

Keywords
- distal radius fracture
- treatment
- fracture fixation
- volar plate
- dorsal approach

Resumen

Pese a la aparición de técnicas quirúrgicas con nuevas placas dorsales de bloqueo y bajo perfil para las fracturas de la extremidad distal del radio con patrones articulares que precisan de un sostén dorsal, muchas series publicadas registran complicaciones asociadas a la utilización de esas placas. Se presentan 3 casos de fracturas con conminución y fragmento tipo *die punch* dorsal tratados mediante osteosíntesis con placa volar y tornillo de sostén dorsal con doble arandela fijado a placa, empleando un mini abordaje dorsal e insertando en un orificio distal de la placa desde el abordaje volar un casquillo al que se rosca desde dorsal un tornillo con dos arandelas de 7 y 13 mm. Esa técnica constituye una alternativa a otros métodos de fijación que podría igualar los resultados funcionales y disminuir las complicaciones asociadas al uso de placas dorsales para el tratamiento de esas fracturas.

Palabras clave
- fracturas de radio distal
- tratamiento
- fijación de fracturas
- placa volar
- abordaje dorsal

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Introduction

Today, intra-articular distal radius categorized as types B and C according to the new AO classification updated in 2018[1] are mostly treated through open reduction and internal fixation with a volar plate if surgical stabilization is required. This procedure results in reduced surgical time and improved functional outcomes, with a similar number of dorsal plate-related complications reported by recent series.[2]

Some patterns of intra-articular distal radius fractures require a dorsal support, but the literature regarding the recommended treatment and most optimal fixation method is controversial. In fractures with dorsal articular fragments or great dorsal comminution, volar plates do not provide adequate support; in addition, since volar screws usually do not give sufficient stability to these fragments, there is a risk of loss of fracture reduction.[3]

Despite the emergence of new surgical techniques with low-profile dorsal locking plates to treat these fractures, many published series regarding such devices report some postoperative complications, including implant-related discomfort (often requiring plate removal after fracture consolidation), extensor tenosynovitis, second, third and fourth extensor compartment tendons rupture, flexural deficit of the wrist compared to the mobility provided by volar plates, stiffness, arthrofibrosis, neuropathy of the sensory branch of the radial nerve, reflex sympathetic dystrophy and carpal tunnel syndrome.[4–6]

This paper aims to describe the dorsal support technique using double washer screws fixed to a volar plate as an alternative to dorsal plate in the treatment of distal radius fracture with comminution and dorsal fragment formation due to lunate fossa depression, which results from load transmission through the lunate bone (die punch fracture), and to describe the outcomes from our case series.

Indications

Based on the AO classification for distal radius fractures updated in 2018 by Kellam and Meinberg,[1] we believe that fixation with a dorsal support screw and a double washer screw attached to a volar plate can be used in partial articular Barton fractures, dorsal articular rim fractures (2R3B2.2, 2R3B2.3), other fracture patterns with simple or multifragmented complete joint involvement and simple metaphyseal involvement with die punch (2R3C1, 2R3C3.1).

According to this AO classification from 2018,[1] we believe that complete joint fractures with a large metaphyseal or diaphyseal component that would require implants with greater support and fixation points (2R3C2, 2R3C3.2 y 2R3C3.3) can be treated with a dorsal support, double washer screw supplemented with a longer volar plate or a low-profile dorsal plate.

Surgical Anatomy

At the wrist, 80% of the loads are transferred by the radiocarpal joint, whereas the remaining 20% are transferred through the carpal ulna joint. Considering the three-column principle at the wrist joint, the radial column articulates with the scaphoid bone, while the intermediate column articulates with the lunate bone through its facet or fossa, a structure damaged by impaction and displacement in die punch fractures.

Surgical Technique

The patient is placed in supine recumbency on an orthopedic table and an auxiliary hand table. The arm is attached to the auxiliary table and a fishing rod is attached to the opposite side of the lesion to facilitate positioning during arthroscopy. All patients were submitted to regional anesthesia and antibiotic prophylaxis with intravenous administration of 2 g of cefazolin. An ischemia cuff is placed at the arm at 100 mm Hg above the systolic pressure. The flexor carpi radialis sheath is approached, followed by the systematic release of the brachioradialis muscle attachment; the wrist is accessed through a small dorsal approach at the third extensor compartment, longitudinally opening the extensor retinaculum and lifting the fourth compartment subperiostatically towards the ulna without opening it, thus avoiding possible adhesions and dorsal fragments release. Arthroscopic control is performed mainly through 3-4 and 6R radiocarpal portals, as well as the radial and ulnar midcarpal portals.[7]

The fracture is reduced, and a provisional fixation is performed using isolated Kirschner wires and/or a plate. If the radioscopic control is adequate, arthroscopy using 3-4 and 6 R portals reveals the correct reduction of the articular fragments, as well as the integrity of the triangular fibrocartilage complex and distal radioulnar joint. Intrinsic carpal ligament structures are systematically reviewed using midcarpal portals.

After assuring the provisional fixation of the fracture, the final fixation is carried out using the Acu-loc2 7×4-hole low-profile locking plate (Acumed, Hillsboro, Oregon, USA) with proximal cortical fixation or 3.5-mm screws and distal, 2.3-mm locking screws with optional placement in a nominal angle predefined by a distal locking guide or in a variable angle using a 0-15° screw targeting device. The first 3.5-mm bicortical screw is placed in the proximal central hole and the 2.3-mm distal locking screws are placed over the targeting guide in the distal holes, except for the hole in which the dorsal screw will be positioned later. Subsequently, the remaining proximal screws are placed, and the correct joint reduction is rechecked by arthroscopy.

The dorsal ulnar fragment is accessed through a dorsal approach. Next, a 2.3-mm compression cap and a 0.3-mm guidewire (which was recovered through the dorsal area after fragment reduction) are inserted at the free hole in the distal row of the plate (the more ulnar hole is more commonly used, although this choice depends on the location of the main dorsal fragment). A 2.3-mm dorsal cannulated screw, with two 7 and 13-mm washers to increase the holding surface, is threaded into the volar compression

sleeve using the guidewire. The appropriate compression must be applied to avoid collapse, increased fragment comminution or screw head protrusion, which would subsequently affect the extensor apparatus of the wrist (►**Figure 1**).

In dorsal closure, the extensor pollicis longus tendon is left outside the reflection pulley of the Lister tuber, at the subcutaneous level. Since the fourth compartment has been raised subperiostatically but not opened, extensor retinaculum closure does not require a flap, avoiding the engagement of the fixation material to the extensor apparatus described in some case series.[8] The skin is closed with sutures or staples.

Postoperative Period

The patient is discharged before 24 hours post-surgery if no complications are reported. Immobilization with a metacarpal-antebrachial dorsal plastered splint in a functional position is performed at the operating room. The splint is kept for 3 weeks. Metacarpophalangeal joints remain free and active finger mobilization is recommended during this period. Skin sutures are maintained for 2 to 3 weeks. After splint removal, active wrist mobilization exercises and contrast baths are indicated, with no weight bearing or demanding manual activity up to 12 weeks. Radiological follow-up is performed at 4, 8 and 12 weeks.

Complications

The cases reported here presented no short- or medium-term complications; however, potential complications include those related to the treatment of distal radial articular fractures with locking plates, such as flexor pollicis longus tenosynovitis, flexor or extensor tendons rupture, surgical wound infection, median nerve or posterior interosseous nerve neuropathy, implant failure or osteosynthesis material loosening, delayed or absent consolidation, wrist stiffness and radiocarpal degenerative disease.

Clinical Cases

We present three female patients aged 52, 80 and 71 who came to the emergency room with pain and wrist functional disability after suffering a low-energy trauma. At the physical examination, they presented edema, deformity and pain on wrist mobilization in flexion-extension and radial and ulnar deviation. They did not show signs of distal neurovascular deficit, with good capillary filling and good finger coloration. One of the cases presented a 2 cm diameter wound at the ulnar dorsal level compatible with an open fracture, type 2 according to the Gustilo classification.[9] Anteroposterior and lateral radiographies of the wrist showed intra-articular distal radius fractures with radial styloid process fragments, dorsal and volar comminution

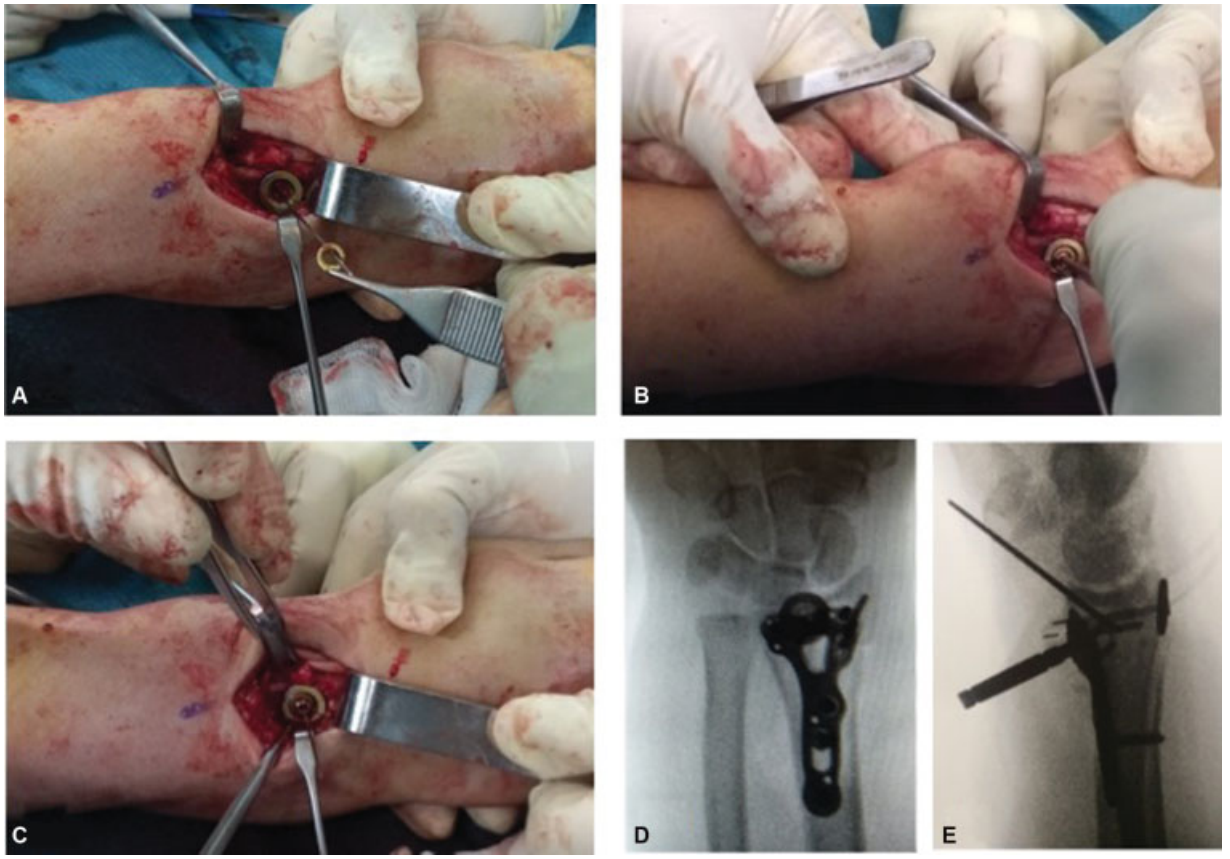

Fig. 1 Intraoperative images showing the placement of double dorsal, 7 and 13-mm washers using a guidewire (**1A**). Placement of the 2.3-mm back support screw threaded to the volar compression sleeve over the double washer and guidewire (**1B, 1C**). Arthroscopic images after screw placement (**1D, 1E**).

and dorsal fragments with articular sinking consistent with die punch.

All patients were submitted to a closed reduction after intrafocal infiltration with 10 mL of 2% mepivacaine; 2 g of cefazolin were intravenously administered in the case of open fracture. Next, patients were immobilized with an antebrachial cast that was subsequently opened in its entire length for radiological follow-up assessments (►**Figure 2**). The three cases were evaluated by physicians from the Upper Limb Unit from our Department, and all were submitted to surgical treatment with open reduction and plate osteosynthesis. One of the cases required an additional plate due to radial styloid process fragmentation through the same approach used for volar plate fixation. Another case required radial fixation using a volar plate with metaphyseal prolongation and ulnar fixation by a distal ulnar plate in an additional dorsal ulnar approach due to metaphyseal comminution and fracture instability (►**Figure 3**). None of these cases presented triangular fibrocartilage complex or intrinsic carpal ligaments lesions.

At the outpatient postoperative follow-up, the range of mobility, Disability of the Arm Shoulder and Hand (DASH) questionnaire score[10] and average Visual Analog Scale (VAS) score[11] were recorded; in addition, complete consolidation fracture was verified radiologically. Twelve weeks after surgery, outcomes included the following:

Case 1: 50° dorsal flexion, 40° volar flexion, complete supination, -20° pronation. Mean DASH questionnaire score, 40 points; mean VAS scale score, 4 points.

Case 2: 45° dorsal flexion, 40° volar flexion, complete supination, complete pronation. Mean DASH questionnaire score, 35 points; mean VAS scale score, 3 points.

Case 3: 40° dorsal flexion, 35° volar flexion, -10° supination, -20° pronation. Mean DASH questionnaire score, 50 points; mean VAS scale score, 4 points.

Discussion

To reduce the rate of complications associated with dorsal plates in distal radius fractures, such as tenosynovitis, extensor tendons rupture or implant-related discomfort, some series describe other techniques and alternative surgical maneuvers for dorsal fragments reduction, such as provisional partial volar radial decortication through the plate with subsequent lifting and dorsal fragment reduction with an elevator or periosteotome inserted through the decortication area[12] or the use of an anteroposterior compression clamp to help fracture reduction in the sagittal plane, allowing sufficient dorsal distal fragments displacement to adequately fix them with Kirschner wires and volar screws.[13] In our three cases, using the dorsal support technique and volar plate fixation, none of the previously described complications associated with dorsal fixation systems were recorded.

Recent series limited the number of postoperative complications by using innovative dorsal plates and other fixation methods.[14] Some publications compare the radiological and functional outcomes from dorsal plates to those obtained with volar plates.[3–5] Other studies report that routine removal of dorsal fixation material is not required unless there are signs such as dorsal wrist pain that does not improve during the postoperative follow-up period, which is the main indicator of implant-related soft tissue problems.[15]

Dorsal die punch fixation with a volar plate and a dorsal, double washer screw fixed to the plate may be an alternative to other fixation techniques to reduce articular fragments and treat the associated comminution. This dorsal screw allows compression of the main dorsal joint fragment, but it can increase the comminution, increasing the risk of fracture collapse in cases of severe osteoporosis. The double 7- and 13-mm washers add a suitable back support surface to avoid such complications in small fragments. This technique also allows other surgical maneuvers, such as the use of autologous bone graft in cases of bone loss, arthroscopic-assisted joint fragment reduction, or the placement of an osteosynthesis plate for the radial styloid process or distal ulna as an additional fixation method.

In summary, we consider that osteosynthesis using a volar plate and a dorsal support screw with a double washer through the plate can lead to similar functional outcomes and reduce the rate of complications associated with the treatment of intra-articular distal radius fractures associated with dorsal die punch and commutation with dorsal plates; in addition, this technique provides greater stability compared to volar plates for dorsal fragments fixation. However,

Fig. 2 Preoperative radiographs of a 52-year-old patient with an articular distal radius fracture with radial and ulnar styloid fragments and one dorsal die punch fragment (**2A, 2B**). Post-immobilization, preoperative radiographs of an 80-year-old female patient with an articular distal radius fracture with a displaced volar fragment and large dorsal comminution (**2C, 2D)**. Post-immobilization, preoperative radiographs of a 71-year-old patient with an articular distal radial and ulnar fracture with large dorsal, metaphyseal, and distal ulnar comminution (**2E, 2F**).

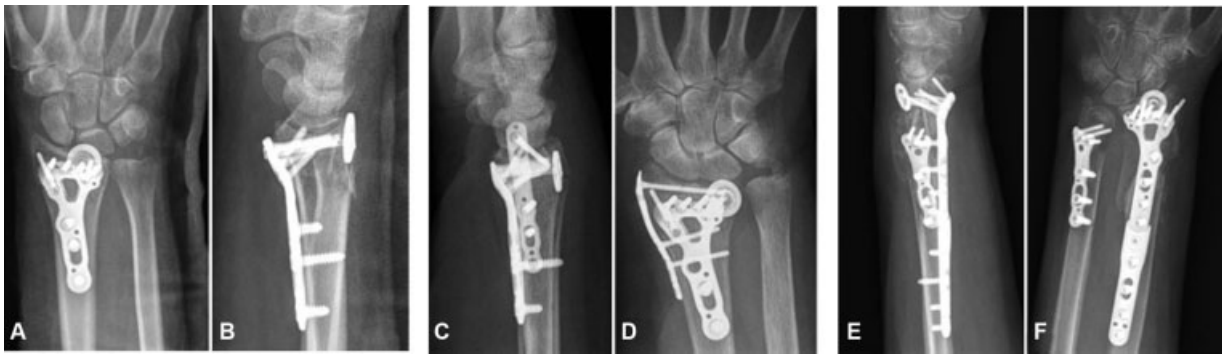

Fig. 3 Postoperative radiographs from case 1 after 4 weeks. Dorsal die punch fragment reduction with a double washer, dorsal support screw (**3A, 3B**). Postoperative radiographs from case 2 after 12 weeks. Reduction with a volar plate and a radial styloid plate (**3C, 3D**). Postoperative radiographs from case 3 after 12 weeks. Reduction with a volar plate, metaphyseal extension and an ulnar plate (**3E, 3F**).

further studies with a greater number of cases and longer follow-up periods are required to obtain more solid conclusions on the effectiveness of this fixation method.

Conflict of Interests

The authors declare that no conflict of interests.

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