



# Fragment specific fixation with APTUS wrist system for volar rim fractures of the distal radius: a multicentric study

Marco Biondi<sup>1</sup> · Andrea Poggetti<sup>1</sup> · Alessandro Fagetti<sup>2</sup> · Agostino Di Maro<sup>3</sup> · Prospero Bigazzi<sup>1</sup> · Sandra Pfanner<sup>1</sup> · Giulio Lauri<sup>1</sup>

Received: 6 January 2021 / Accepted: 18 May 2021 / Published online: 26 May 2021  
© Springer-Verlag GmbH Germany, part of Springer Nature 2021

## Abstract

**Purpose** Volar rim fractures of the distal radius are a spectrum of pathology that must be well identified and treated to achieve good outcomes and avoid surgical failures. New devices of fragment specific fixation have been developed during the last decades to fix this fragment. The purpose of this retrospective study was to evaluate the ability of APTUS<sup>®</sup> wrist distal radius system to securely fix different types of volar rim fractures.

**Methods** Patients with at least 1 year of follow-up and a preoperative CT-scan evaluation of the fracture pattern were included in the study. Clinical, radiological and functional outcomes were assessed.

**Results** Sixty-eight patients with an average follow-up of 34, 1 months (12–61) were included in the study. There were no clinical and radiological complications, including loss of reduction, device failure and tendon ruptures. No patients required hardware removal. Wrist range of motion in flexion–extension averaged 96°, while in pronation–supination 144°. At final follow-up mean visual analogue scale pain was 1,8. Questionnaires, as dissabilities of the arm, shoulder and hand (DASH) score and patient-related wrist evolution (PRWE) score were 6,6 and 3 respectively. Grip strenght measured 86% compared to the normal side.

**Conclusion** APTUS<sup>®</sup> wrist presents a versatile set of fragment specific fixation plates able to easily and securely fix all types of volar rim fracture. The system can be used with other devices without any kind of interference between them. When correctly placed and used with the right indications, no late complications can be recorded.

**Keywords** Distal radius fractures · Volar rim · Fragment specific fixation · Key fragment · Distal radius classification · Lunate facet

## Introduction

The volar rim avulsion is a well-known type of distal radius fracture [1–4]. It is a volar ulnar part of the distal radius, which slopes over it to form a ridge under the lunate facet [5, 6]. This fragment represents the origin of some important radiocarpal and radioulnar ligaments as the long and

short radiolunate ligaments and distal radioulnar ligaments, which lesion may produce radiocarpal or radioulnar instability [7–11]. Whereas it acts a palmar bone support that resists to compression forces during volar radiocarpal dislocation, its avulsion can cause dorsal radiocarpal dislocation [12]. Its particular anatomy, distal to the watershed line, negatively influences the ability of standard locking plates to adequately fix this fragment, leading to loss of reduction and later radiocarpal dislocation [5, 13]. The biomechanical implication of this key fragment on articular fractures of the distal radius has been well described and classified recently by Hintringer [14] and, in last decade, many devices of fragment specific fixation have been developed to treat the various types of this lesion [15–21].

APTUS<sup>®</sup> distal radius system presents a set of three different plates developed as recent evolution of fragment specific fixation for treatment of the various subtypes of volar

✉ Marco Biondi  
marcobiondi@ymail.com

<sup>1</sup> Surgery and Reconstructive Microsurgery Unit of the Hand, Azienda Ospedaliero-Universitaria Careggi, Florence, Italy

<sup>2</sup> Microsurgery and Hand Surgery Unit, ASST Sette Laghi, Varese, Italy

<sup>3</sup> Division of Orthopaedics and Traumatology, Department of Biotechnology and Life Sciences (DBSV), University of Insubria, Varese, Italy

rim fractures. The purpose of this retrospective study was to evaluate the radiographic and clinical outcomes of these devices on 68 selected patients treated for various subtypes of volar rim fractures.

## Materials and methods

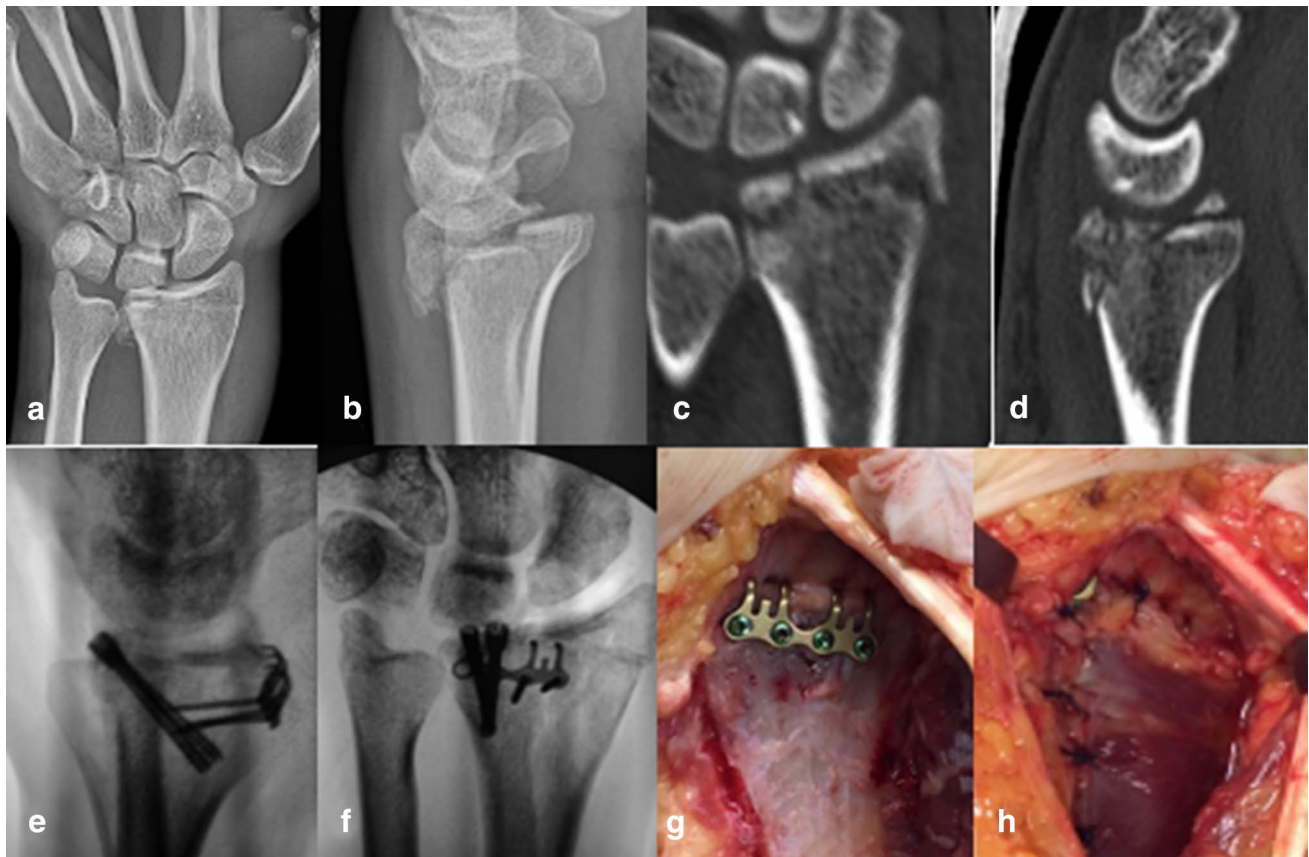
Local ethical board approval and informed consent from all patients were obtained. The study was carried out including patients treated for a volar rim fracture with APTUS® distal radius system (Medartis AG, Switzerland) from January 2015 to September 2019. Inclusion criteria were patients with at least 1 year of follow-up and with a preoperative CT-scan evaluation of the fracture lines.

Patients were retrospectively studied basing on Hintringer's classification for volar rim fractures [14]. This classification describes three subtypes of volar rim fragment: the palmar rim (a very small fragment that represents a bony ligament avulsion), the palmar ulnar (that consists of a larger piece of the volar rim fragment) and palmar radio ulnar fragments (an extension of the volar rim fragment on the radial side). A preoperative CT-scan evaluation was necessary to

properly evaluate fracture lines and classify each lesion. Although these distal radius fractures are inhomogeneous and involve multiple joint fragments, today there are no other classifications in the literature capable of grouping all types of volar rim fractures.

The three devices of APTUS® distal radius system 2.5 for fragment specific fixation are the hook plate, the rim plate and the lunate facet plate. All patients underwent open reduction and internal fixation carried out by specialist surgeons (MB, AP, AF, GL) [22].

The Hook Plate is available in two different widths with two or four (double hook plates) low-profile (0.6 mm) distal hooks and with two or four distal holes that accommodate 1.5 mm self-drilling SpeedTip screws. These small devices are mainly indicated to fix small fragments at their capsulo-ligamentous interface, as Hintringer calls the palmar rim fragments. These small fragments are often a bony avulsion of the capsule and of the short and long radiolunate ligaments and they mainly represent a ligament injury rather than a bone deficiency. Loss or inadequate fixation of palmar rim fragments, as a ligament injury, can lead to dorsal radio-carpal dislocation. The hook plates are very small devices that lie over the watershed line and can be used alone (Fig. 1)



**Fig. 1** a, b Dorsal radiocarpal fracture-dislocation. c, d Preoperative CT-scan evaluation in cast showed a palmar rim fragment according to Hintringer's classification. e–h The volar rim fragment was fixed using double Hook Plate that was completely covered by pronator quadratus suture

or in association with standard volar locking plate in complex distal radius fractures.

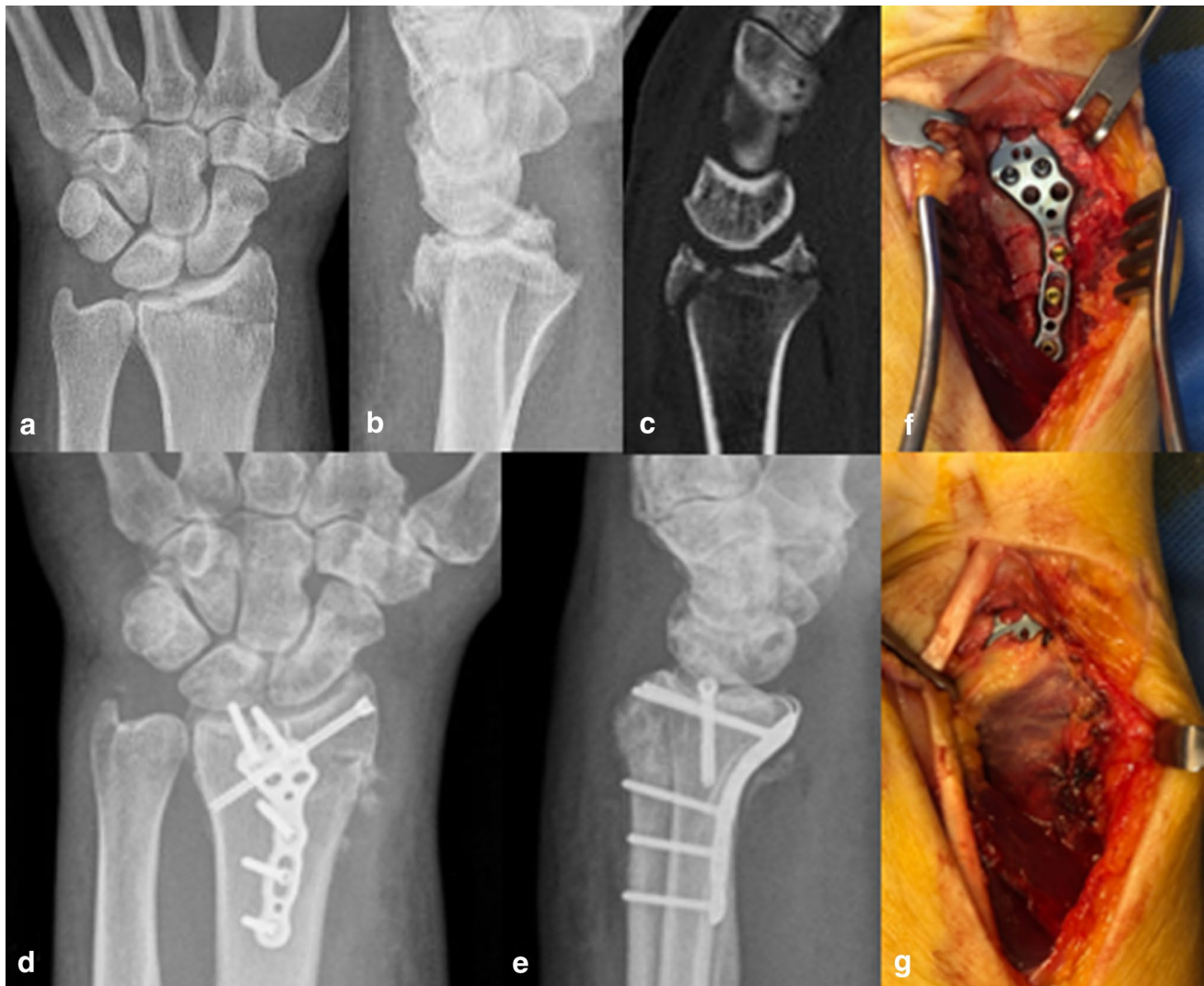
The Lunate Facet Plates are low-profile volar plates with two distal hooks and two small holes that allow additional soft tissue repair. These plates are used to fix small or larger fragments of the volar rim. With respect to the Hook Plates they allow fixation of larger fragments with simple proximal extension of fracture lines, allowing more secure metaphyseal fixation (Fig. 2).

The Rim Plate presents the advantages of both standard locking plates and fragment specific fixation. It has two bendable distal flaps that accommodate two self-drilling SpeedTip screws. It is designed to treat distal radius fractures where the volar rim is large enough to accommodate the two screws. This plate presents the advantages of low-profile marginal locking plates and allows treatment of radial

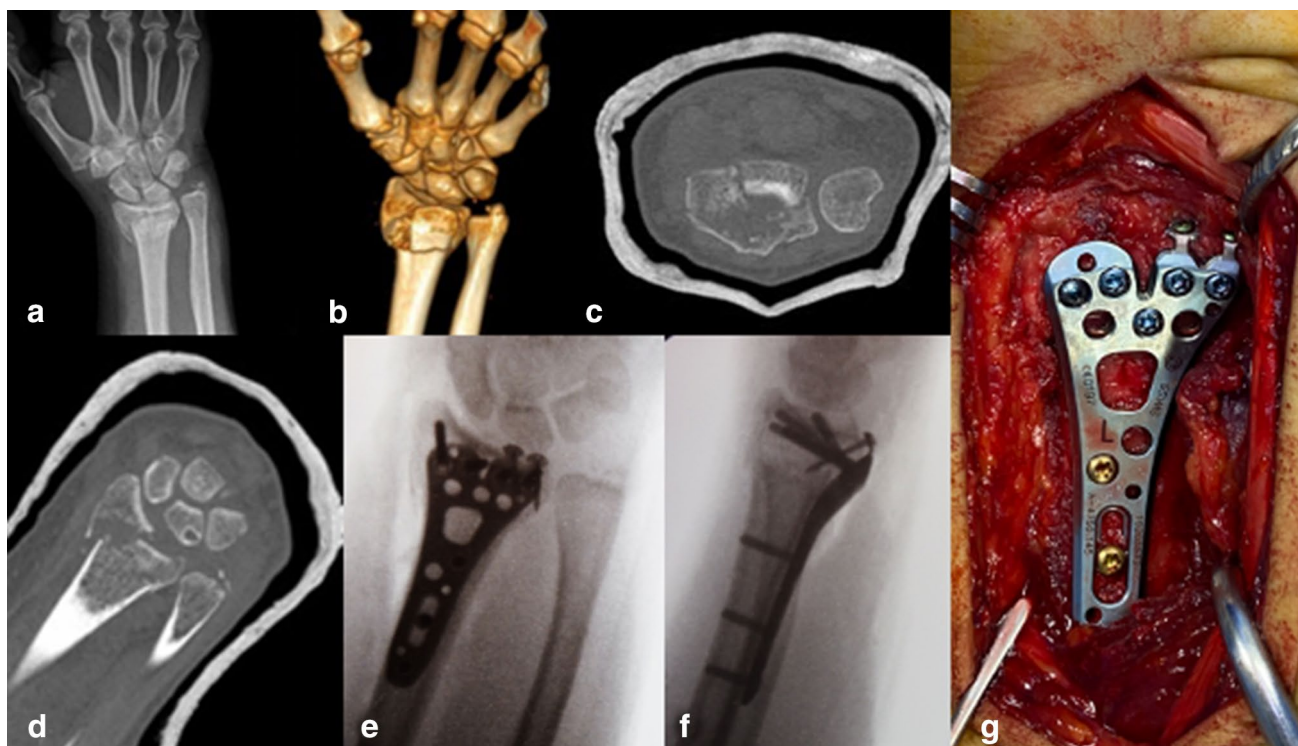
extension of the volar rim fractures, as well as the palmar radio ulnar fragments described by Hintringer (Fig. 3).

Patients were evaluated on postoperative follow-up considering the active range of motion (aROM) in flexion–extension, pronation–supination, ulnar deviation and radial deviation. Grip strength was assessed with Jamar dynamometer and reported as an average of three consecutive attempts at maximal grip compared to the contralateral side.

Patients were assessed for pain using VAS (visual analogue scale) and questionnaires such as the patient-related wrist evaluation (PRWE) score and the disabilities of the arm, shoulder and hand (DASH) score. Radiographic evaluation at latest follow-up was carried out for volar tilt, radial inclination and ulnar variance measurements and to look for signs of complications such as loss of reduction, device



**Fig. 2** a–c Preoperative X-rays and CT-scan show avulsion of the volar rim fragment and impaction of the dorsal cortex. d–g Fixation of the radial styloid with headless screw and of the volar rim with the Lunate Facet Plate allowed concentric reduction of the lunate



**Fig. 3** a–d Distal radius fracture with involvement of the radial styloid, volar rim and dorsal cortex. The volar rim can be classified as the palmar ulnar fragment according to Hintringer’s classification. e–g The volar rim was large enough for Rim Plate fixation and its two distal screws

failure, plate loosening, nonunion, late tendon ruptures or tendinitis and secondary osteoarthritis.

## Results

Overall, 68 patients were included with an average age at time of injury of 46, 5 months (19–82). There were 42 males (76, 5%) and 26 (23, 5%) females. The most common causes of injury were accidental falls, road accidents and sport injuries. The dominant side was involved in 63% of cases. The average follow-up was 34, 1 month (12–61).

Hook plates were used in 20 patients (Table 1): seven were applied to fix a palmar rim fragment, eight for a palmar ulnar fragment and five to fix the palmar radio ulnar fragment. Hook plates were the only volar fixation device applied in 11 patients, but they were always combined to dorsal plates and/or headless compression screws for dorsal cortex and radial styloid fixation. In complex fractures with involvement of metaphyseal bone the Hook Plates were combined to a volar plate fixation in nine cases.

Double Hook Plates were used in 19 patients: 5 were used to fix the palmar rim fragment, 7 for the palmar ulnar fragment and 7 a palmar radio ulnar fragment. They were the only volar fixation device in 11 patients, while they were associated to a volar plate fixation in 8 patients.

The Lunate Facet Plate was applied in 18 patients. It was used to fix the palmar rim fragment in 4 cases, a palmar ulnar fragment in 12 and a radioulnar fragment in 2. Dorsal plates were associated in eight patients.

The Rim Plate was used in 11 patients. It was used to fix larger palmar radio ulnar fragments in four cases and palmar ulnar fragments in seven. An extended radial volar approach was performed in all patients [23]. In this volar approach, the skin incision is made directly over the course of the flexor carpi radialis tendon and zigzags to the radial styloid ending to the flexion crease of the wrist. A combined volar and dorsal approach was performed in 26 patients. Of these, 20 presented with a dorsal radiocarpal fracture-dislocation where the volar rim represented an avulsion of the short and long radiolunate ligaments. Ten patients showed a volar radiocarpal fracture-dislocation, where the impaction of the volar rim caused a loss of bone support and articular contact between radius and lunate. In six cases a volar non-invasive approach was performed, detaching or preserving the distal part of the pronator quadratus. This was performed when a small fragment of the volar rim was the only palmar fragment that needed fixation with a Hook Plate [15]. This approach allowed to preserve pronator quadratus attachment and vascularization. Depending on the type of fracture of the patient, other surgical devices were used, such as dorsal plates, headless screws, K-wires and volar plates. All

**Table 1** Types of volar rim fractures treated with APTUS wrist system according to Hintringer's classification

Device	Patients	Palmar rim fragment	Palmar ulnar fragment	Palmar radio ulnar fragment
Hook plate	20	7	8	5
Double hook plate	19	5	7	7
Lunate facet plate	18	4	12	2
Rim plate	11	0	7	4

patients started early mobilization of the wrist after an average of 17 days postoperatively (13–23). At last clinical evaluation, patients showed adequate return of function based on average arc of flexion–extension and, especially, of pronation–supination where the volar rim fragment caused less impairment (Table 1). Jamar dynamometer analysis revealed a grip strength average value of 29, 6 months (17–46) that was 86% of contralateral side. Mean DASH score was 6, 6 months (0–21), mean PRWE score was 3 (0–13) and mean VAS score for pain was 1, 8 months (0–4).

Radiographic follow-up showed adequate radiographic parameters (Table 2) and did not report main complications. One patient presented for a postoperative dorsal wall loss of reduction after reduction and fixation with the rim plate from a palmar approach. ACT-scan evaluation showed that the volar rim was well reduced and fixed, so the rim plate was not removed and a revised dorsal reduction and fixation was performed with a dorsal buttress plate. In one case, during the distal flaps bending procedure of the rim plate one of them broke. However, the plate was fixed distally with one screw and patient reported no radiological or clinical complications at the last 20th month follow-up. In another patient, one SpeedTip screw for hook plate fixation was noted very close to the articular surface of the distal radius and was changed after 5 weeks, leaving the Hook Plate in place.

A CT-scan study was also performed at the last follow-up in 34 patients to evaluate the healing of the volar rim, the presence of loss of radiocarpal alignment, devices failure and presence/absence of conflicts of the plates with other surgical devices. No main complications were recorded because all the volar rim fragments healed without loss of radiocarpal alignment, loss of reduction, device loosening or failure. Cases of delayed union and nonunion were not recorded. Due to their low profile, no device required later removal and at the last clinical follow-up no cases of tendinitis or tendon rupture were recorded.

## Discussion

Fixation of volar rim fragments in distal radius fractures is a well-known problem for standard locking plates [24–28]. The volar rim presents a complex anatomy distal to the watershed line, with thickness of 5 mm and anterior projection to the flat surface of 3 mm [5, 29–31]. It supplies support to resist volar impaction of the lunate fossa. Furthermore, the volar rim represents the attachment site of important radiocarpal ligaments, as the long and short radiolunate ligaments, whose avulsion must be repaired to avoid a late radiocarpal dislocation [32–34]. These anatomical characteristics make standard locking plates unable to fix this fragment leading to loss of reduction [5, 13, 34]. In the past,

**Table 2** Clinical and radiological outcomes of patients at least 1 year of follow-up

General data	Mean (range)
Age (years)	46, 5 (19–82)
Follow-up (months)	34, 1 (12–61)
Clinical data	Mean (range)
Flexion–extension (°)	96 (40–160)
Pronation–supination (°)	144 (85–180)
Radial deviation (°)	13 (5–26)
Ulnar deviation (°)	18 (10–27)
Grip strength (kg)	29, 6 (17–46)
VAS	1.8 (0–4)
DASH score	6, 6 (0–21)
PRWE score	3 (0–13)
Radiographic data	Mean (range)
Volar tilt (°)	6 (0–18)
Radial inclination (°)	17 (5–28)
Ulnar variance (°)	– 1 (– 3; 2)

K-wires and cortical screws were used to fix the volar rim, but with high risk of loss of reduction and poor ligament repair [35, 36]. To solve this problem, in the last decades, different types of fragment specific fixation devices have been developed. Small plates, marginal locking plates, hooks attached to plates and plates with small holes for ligaments repair have been proposed [37–40].

APTUS<sup>®</sup> distal radius system presents a set of three fragment specific fixation devices. Hook Plates are available on the market from 2015 while Rim Plate and Lunate Facet Plate from 2018. All plates are available in the same surgical set, so the surgeon can choose which one to use during the surgical procedure.

The Hook Plates revealed the ability to fix small fragments of the volar rim, as the palmar rim fragment. A previous work already used the hook plates system in a case series of 23 cases pointing out the importance of these devices to fix small fragments on their capsuloligamentous insertion, leading to both osseous and ligament repair [15]. The Hook Plates can also be used to fix larger fragments of the volar rim. In this case, care must be taken to not put the screws into the fracture line avoiding loss of reduction and device failures. To solve this problem, before the advent of Lunate Facet Plate and Rim Pplate, we secured the Hook Plates with small plates placed over them. This procedure did not register long-term surgical, radiographic or clinical complications. Hook Plates can be fixed with two or four self-drilling SpeedTip screws that are easy to insert. However, this procedure must be carried out carefully in a distal to proximal direction avoiding radiocarpal or radioulnar intra-articular placement of the screws. Surgical approach must be carried

out opening distally the flexor carpi radialis sheath which ensures a wide exposure and better reduction of the volar rim. When the Hook Plates were the only volar surgical device, a non-invasive volar approach could be performed opening only the distal insertion of the pronator quadratus, preserving soft tissues and bone vascularization.

The Lunate Facet Plate adapts well to fix both small and larger fragments of the volar rim at their capsuloligamentous interface. This device is well used when the volar rim is the only volar fragment that must be fixed. The plate cannot be used to fix dorsal fragments, radial styloid or complex metaphyseal fractures. The small distal holes at the base of the hooks, with the additional function of soft tissue repair, were never used, because the plate adheres perfectly to the distal articular surface, making unnecessary to use them.

The Rim Plate found less applications because only large fragments are amenable for screws fixation. The two distal cortical screws present some risk of fragmentation of the volar rim and its fixation can fail when it is small or comminuted. In our experience, this device revealed excellent ability to fix larger fragments of the volar rim formed from volar radiocarpal dislocations. Bending of the distal flaps must not be stressed repeatedly to avoid breakage. However, as marginal low-profile locking plate, it can be useful to fix other fragments as the radial styloid, dorsal fragments and proximal extensions of the articular fractures. In young patients, its removal must be taken into consideration.

This study has some limitations and bias of retrospective studies like heterogeneity of the type of fractures, limited numbers of patients and limited long-term follow-up. Clinical and radiographic follow-up revealed adequate

return of function without complication, although further long-term follow-up are needed to confirm hardware-related complications.

In conclusion, APTUS® wrist system presents a versatile set of fragment specific fixation plates able to easily and securely fix all types of volar rim fracture. The system can be used with other devices to fix other fragments, such as headless screws, K-wires, dorsal and volar plates, without any kind of interference between them. When correctly placed with the right indications no late complications can be recorded.

**Funding** There is no funding source.

## Declarations

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** Study was approved by the Local Ethical Committee as protocol number 19/2018 of Azienda Ospedaliero-Universitaria Careggi, Florence, Italy.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

## References

- Melone CP Jr. Articular fractures of the distal radius. *Orthop Clin North Am.* 1984;15(2):217–36.
- Melone CP Jr. Distal radius fractures: patterns of articular fragmentation. *Orthop Clin North Am.* 1993;24(2):239–53.
- Medoff RJ. Essential radiographic evaluation for distal radius fractures. *Hand Clin.* 2005;21(3):279–88.
- Jupiter JB, Fernandez DL, Toh CL, Fellman T, Ring D. Operative treatment of volar intra-articular fractures of the distal end of the radius. *J Bone Jt Surg Am.* 1996;78(12):1817–28.
- Harness NG, Jupiter JB, Orbay JL, Raskin KB, Fernandez DL. Loss of fixation of the volar lunate facet fragment in fractures of the distal part of the radius. *J Bone Jt Surg Am.* 2004;86(9):1900–8.
- Mekhail AO, Ebraheim NA, McCreath WA, Jackson WT, Yeasting RA. Anatomic and X-ray film studies of the distal articular surface of the radius. *J Hand Surgery Am.* 1996;21(4):567–73.
- Berger RA, Landsmeer JM. The palmar radiocarpal ligaments: a study of adult and fetal human wrist joints. *J Hand Surgery Am.* 1990;15(6):47–854.
- Berger RA. The anatomy of the ligaments of the wrist and distal radioulnar joints. *Clin Orthop Related Res.* 2001;383:32–40.
- Kitay A, Mudgal C. Volar carpal subluxation following lunate facet fracture. *J Hand Surg.* 2014;39(11):2335–41.
- Harness NG. Fixation options for the volar lunate facet fracture: thinking outside the box. *J Wrist Surg.* 2016;5(1):9–16.
- Zumstein MA, Hasan AP, McGuire DT, Eng K, Bain GI. Distal radius attachments of the radiocarpal ligaments: an anatomical study. *J Wrist Surg.* 2013;2(4):346–50.
- Biondi M, Lauri G. Dorsal fracture-dislocation of the radiocarpal joint: a new classification and implications in surgical treatment. *J Hand Surg Eur.* 2020;45(7):700–8.
- Andermahr J, Lozano-Calderon S, Trafton T, Crisco JJ, Ring D. The volar extension of the lunate facet of the distal radius: a quantitative anatomic study. *J Hand Surg Am.* 2006;31(6):892–5.
- Hintringer W, Rosenauer R, Pezzei C, et al. Biomechanical considerations on a CT-based treatment-oriented classification in radius fractures. *Arch Orthop Trauma Surg.* 2020;140(5):595–609.
- Biondi M, Keller M, Merenghi L, Gabl M, Lauri G. Hook plate for volar rim fractures of the distal radius: review of the first 23 cases and focus on dorsal radiocarpal dislocation. *J Wrist Surg.* 2019;8(2):93–9.
- Lam JW, Wolfe SW. Distal radius fractures: what cannot be fixed with a volar plate? The role of fragment-specific fixation in modern fracture treatment. *Op Tech Sports Med.* 2010;18(3):181–8.
- Bakker AJ, Shin AY. Fragment-specific volar hook plate for volar marginal rim fractures. *Tech Hand Up Extrem Surg.* 2014;18(1):56–60.
- Orbay JL, Rubio F, Vernon L. Prevent collapse and salvage failures of the volar rim of the distal radius. *J Wrist Surg.* 2016;5(1):17–21.
- Obata H, Baba T, Futamura K, et al. Difficulty in fixation of the volar lunate facet fragment in distal radius fracture. *Case Rep Orthop.* 2017;2017:6269081.
- Wiesler ER, Chloros GD, Lucas RM, Kuzma GR. Arthroscopic management of volar lunate facet fractures of the distal radius. *Tech Hand Up Extrem Surg.* 2006;10(3):139–44.
- Schumer ED, Leslie BM. Fragment-specific fixation of distal radius fractures using the trimmed device. *Tech Hand Up Extrem Surg.* 2006;9(2):74–83.
- Tang JB, Giddins G. Why and how to report surgeons' levels of expertise. *J Hand Surg Eur.* 2016;41(4):365–6.
- Orbay JL, Fernandez DL. Volar fixation for dorsally displaced fractures of the distal radius: a preliminary report. *J Hand Surg.* 2002;27(2):205–15.
- Soong M, Earp BE, Bishop G, Leung A, Blazar P. Volar locking plate implant prominence and flexor tendon rupture. *J Bone Jt Surg Am.* 2011;93(4):328–35.
- Souer JS, Ring D, Jupiter JB, Matschke S, Audige L, Marent-Huber M, AOCID Prospective ORIF Distal Radius Study Group. Comparison of AO type-B and type-C volar shearing fractures of the distal part of the radius. *J Bone Jt Surg Am.* 2009;91(11):2605–11.
- Orbay JL, Touhami A. Current concepts in volar fixed-angle fixation of unstable distal radius fractures. *Clin Orthop Rel Res.* 2006;445:58–67.
- Mathews AL, Chung KC. Management of complications of distal radius fractures. *Hand Clin.* 2015;31(2):205–15.
- Prommersberger KJ, Fernandez DL, Ring D, Jupiter JB, Lanz UB. Open reduction and internal fixation of un-united fractures of the distal radius: does the size of the distal fragment affect the result? *Chir Main.* 2002;21(2):113–23.
- Lewis OJ, Hamshere RJ, Bucknill TM. The anatomy of the wrist joint. *J Anat.* 1970;106:539–52 (Pt 3).
- Paryavi E, Christian MW, Eglseider WA, Pency RA. Sustentaculum lunatum: appreciation of the palmar lunate facet in management of complex intra-articular fractures of the distal radius. *Am J Orthop (Belle Mead, NJ).* 2015;44(9):E303–7.
- Beck JD, Harness NG, Spencer HT. Volar plate fixation failure for volar shearing distal radius fractures with small lunate facet fragments. *J Hand Surg Am.* 2014;39(4):670–8.
- Mandziak DG, Watts AC, Bain GI. Ligament contribution to patterns of articular fractures of the distal radius. *J Hand Surg Am.* 2011;36(10):1621–5.
- Bain GI, Alexander JJ, Eng K, Durrant A, Zumstein MA. Ligament origins are preserved in distal radial intraarticular two-part fractures: a computed tomography-based study. *J Wrist Surg.* 2013;2(3):255–62.

34. Apergis E, Darmanis S, Theodoratos G, Maris J. Beware of the ulno-palmar distal radial fragment. *J Hand Surg Br.* 2002;27(2):139–45.
35. Chin KR, Jupiter JB. Wire-loop fixation of volar displaced osteochondral fractures of the distal radius. *J Hand Surg Am.* 1999;24(3):525–33.
36. Moore AM, Dennison DG. Distal radius fractures and the volar lunate facet fragment: Kirschner wire fixation in addition to volar-locked plating. *Hand (NY).* 2014;9(2):230–6.
37. Saw N, Roberts C, Cutbush K, Hodder M, Couzens G, Ross M. Early experience with the TriMed fragment-specific fracture fixation system in intraarticular distal radius fractures. *J Hand Surg Br.* 2008;33(1):53–8.
38. Konrath GA, Bahler S. Open reduction and internal fixation of unstable distal radius fractures: results using the trimmed fixation system. *J Orthop Trauma.* 2002;16(8):578–85.
39. O’Shaughnessy MA, Shin AY, Kakar S. Volar marginal rim fracture fixation with volar fragment-specific hook plate fixation. *J Hand Surg Am.* 2015;40(8):1563–70.
40. Kachoei AR, Tarabochia M, Jupiter JB. Distal radius volar rim fracture fixation using depuy-synthes volar rim plate. *J Wrist Surg.* 2016;5(1):2–8.