Rev Esp Cir Ortop Traumatol. 2013;57(4):276–281

Revista Española de Cirugía Ortopédica y Traumatología

www.elsevier.es/rot

ORIGINAL ARTICLE

Validity of modified radiological views to detect screw protrusion at the distal radius. A comparative study with computerized tomography☆

F.E. Mora-Pascual*, **L. Aguilella-Fernández**

Servicio de Cirugía Ortopédica y Traumatología, Hospital Universitario de la Ribera, Alzira, Valencia, Spain

Received 5 March 2013; accepted 2 May 2013

KEYWORDS
Distal radius fracture;
Screw protrusion;
X-rays views

Abstract Volar fixed-angle plates (VFAP) are currently widely used for the treatment of extra-articular distal radius fractures. Using these plates has a high risk of articular and dorsal screw protrusion due to their special configuration. The aim of this study is to assess the validity of the standard x-rays, performed with the help of wedged supports, in order to detect articular and dorsal screw protrusion. A comparison with computed tomography (CT) scan imaging has been made. The outcome of 26 patients with distal radius articular fracture, treated with a VFAP, is reported. Good correlation between modified x-rays and CT scan was observed. A sensitivity of 100% for articular protrusion and 66% for dorsal has been obtained. When detecting screw protrusion at the distal radius, the use of wedged supports to perform special x-rays intraoperatively is an effective tool.

PALABRAS CLAVE
Fractura radio distal;
Protrusión tornillos;
Proyecciones radiológicas

Validez de la radiología simple con proyecciones especiales para detectar la protrusión de tornillos en el radio distal. Estudio comparativo con tomografía axial computarizada

Resumen El tratamiento de las fracturas intraarticulares del radio distal mediante placas volares de ángulo fijo (PVAF) está ampliamente difundido en la actualidad. El uso de estas placas, debido a su peculiar configuración, conlleva un elevado riesgo de protrusión de los tornillos a nivel intraarticular y dorsal. El objetivo de nuestro trabajo es determinar la validez de las proyecciones radiológicas habituales, realizadas con la ayuda de soportes en forma de cuña, para detectar la protrusión de los tornillos a nivel intraarticular y dorsal, utilizando la

☆ Please cite this article as: Mora-Pascual FE, Aguilella-Fernández L. Validez de la radiología simple con proyecciones especiales para detectar la protrusión de tornillos en el radio distal. Estudio comparativo con tomografía axial computarizada. Rev Esp Cir Ortop Traumatol. 2013;57:276–81.

* Corresponding author.
E-mail address: fmora@hospital-ribera.com (F.E. Mora-Pascual).

1988-8856/$ - see front matter

tomografía axial computarizada (TAC) como prueba de referencia. En el estudio se presentan los resultados obtenidos en 26 pacientes tratados de una fractura articular de radio distal mediante una PVAF, modelo DVR®. Se ha observado una correlación satisfactoria entre los resultados de las radiografías con soportes cuando han sido comparadas con la TAC, con una sensibilidad del 100% para las protrusiones intraarticulares y del 66% para las protrusiones dorsales. Se recomienda la realización de estas proyecciones especiales de muñeca como una herramienta intraoperatoria útil para detectar la protrusión de los tornillos en las PVAF.

Introduction

Osteosynthesis of distal radius fractures with a volar fixed-angle plate (VFAP)[1,2] involves the risk of protrusion of the screws, which can invade the joint space or pierce the dorsal cortex. Tendon complications derived from dorsal protrusion are currently well documented.[3–5]In our department we have used the DVR® plate for the treatment of distal radius joint fractures since its introduction. Inadvertent protrusion of the screws is not uncommon, given the three-dimensional, diverging configuration of the screws of the DVR® plate, like that of many other VFAP, and the peculiar shape of the distal radius. This should be avoided during surgery through a careful radiological examination, which should take into account the natural, specific angulations of the distal radius: 11° palmar tilt and 22° ulnar tilt.[6,7]

Suspicion of protrusion of a screw during the postoperative follow-up period is difficult to confirm through a conventional radiographic study with anteroposterior (AP) and lateral (L) projections, since these are routinely performed without taking into account the aforementioned specific angulations. In general, it is necessary to conduct studies by computed tomography (CT) in order to determine if protrusion is truly present. Our group has developed a model of wedge-shaped supports which facilitate correct radiographic studies in order to obtain radiographs which are tangential to the joint surface of the distal radius.

The objective of this study is to evaluate the usefulness of special radiographic projections, with the aid of wedge-shaped supports, to detect intra-articular and dorsal protrusion of VFAP screws, using the CT diagnostic test as a reference.

Materials and methods

Out of all patients undergoing VFAP surgical interventions for distal radius fractures in our service, 26 agreed to participate in the study. We obtained informed consent in all cases. We conducted a physical examination of both wrists, measuring active palmar flexion, active and passive dorsal extension, ulnar and radial deviation and grip strength with a Jamar® dynamometer. We assessed 2 subjective parameters: pain measured by a visual analog scale (VAS) and satisfaction index expressed on a numerical scale from 0 to 10, with 0 representing total dissatisfaction and 10 representing the maximum possible satisfaction.

Following the examination, we conducted studies with 2 specific scales to assess independence and mobility of the affected upper limb: the Quick Dash[8] scale and the Mayo[9] wrist scale.

Radiographs (Rx) of each operated wrist were obtained using AP and L projections. Both projections were obtained by positioning wrists on wedge-shaped supports, designed for this study. The supports had inclinations of 11° and 22°, so as to obtain Rx which were tangential to the joint surface of the radius in the AP and L projections, respectively (Fig. 1).

We requested a multisection CT scan of all patients, obtaining images in all 3 dimensions. This imaging test was considered as the reference against which to compare radiographic images in the AP and L projections.

The evaluation of the images from the plain radiography and the CT scan were performed independently by the 2 researchers, with each patient being assigned a number, and findings were subsequently contrasted.

We defined the following situations:

- Absence of any type of protrusion.
- Slight articular protrusion of a screw.
- Slight dorsal protrusion of a screw.
- Clear articular protrusion of a screw.
- Clear dorsal protrusion of a screw.

Slight protrusion was considered as the simple prominence of the end of a screw beyond the cortex, whereas clear protrusion was considered when the prominence included the thread of the screw.

The results of the evaluation of the images were entered into an Excel® spreadsheet and statistical analysis was performed using the software package SPSS® for Windows version 15.0 (SPSS Inc., Chicago, IL, USA).

Results

The sample consisted of 17 females and 9 males, with a mean age of 58.55 ± 10.12 years (range: 36–76 years). A total of 17 patients suffered left wrist fractures, whereas 9 suffered right wrist fractures.

Of the 26 CT requested we only obtained images from 20 patients, for reasons unrelated to the study (appointment errors and computer problems).

The results of the physical examination are shown in Table 1. Regarding the results of the scales, the Quick Dash presented a mean score of 17.5 ± 18 (range: 0–66), whilst the Mayo wrist scale presented a mean score of 74.5 ± 12.43 (range: 35–90).

The subjective test results presented a mean VAS score of 1.76 ± 6.34 (range: 0–8), and a mean satisfaction score

Table 1 Patient data and results of the exploration.

	Age (years)	Gender	Side	Quick dash	Mayo	VAS	Satisfaction	Flexion	Extension	Passive extension	Radial deviation	Ulnar deviation	Pronation	Supination	Strength	Dominant side	Percentage compared to healthy
1	79	Female	Right	25	70	1	3	30	35	55	5	30	−15	−20	12	Yes	63
2	23	Male	Left	4.5	75	2	8	44	48	60	28	34	−10	0	42	No	79
3	48	Male	Left	18.2	75	2	7	40	50	60	35	45	0	0	35	No	81
4	61	Female	Left	0	90	0	10	52	62	80	20	48	5	10	55	No	94
5	63	Female	Left	54.5	75	0	8	56	34	56	22	30	−5	0	22	No	77
6	68	Female	Left	2	75	2	10	60	50	64	24	20	0	0	38	No	88
7	74	Female	Left	16	90	0	10	44	40	50	20	34	0	0	22	No	95
8	58	Female	Left	23	90	2	8	32	36	42	20	30	0	0	35	No	83
9	76	Female	Left	2	70	0	10	48	50	70	20	38	0	0	30	No	120
10	63	Female	Left	0	90	0	10	50	50	80	22	35	0	0	30	No	100
11	65	Male	Right	0	85	0	10	46	48	70	14	30	0	−5	70	Yes	83
12	58	Male	Right	45.5	35	5	6	40	58	70	10	50	0	0	30	No	76
13	60	Female	Right	34	70	0	10	50	55	60	25	20	0	0	100	No	93
14	47	Female	Left	4.5	90	0	10	40	43	60	20	35	0	−5	10	Yes	77
15	54	Female	Left	25	75	0	10	40	60	60	20	20	−5	0	90	Yes	78
16	57	Male	Left	0	80	0	10	40	50	50	20	40	−5	0	80	Yes	78
17	56	Male	Left	16	75	0	10	35	65	80	25	30	−5	−5	40	Yes	86
18	63	Female	Left	25	75	8	8	50	50	80	10	40	0	0	60	No	95
19	46	Male	Left	20.5	70	4	8	50	40	50	10	30	−5	0	45	No	93
20	36	Female	Right	66	50	7	5	70	75	80	20	40	0	0	40	No	100
21	57	Male	Right	7	70	0	9	55	50	75	20	30	0	0	50	No	95
22	41	Male	Right	2	70	4	10	50	70	80	10	45	0	0	80	No	93
23	63	Female	Left	41	75	7	9	20	20	30	10	40	0	0	50	Yes	73
24	65	Female	Right	23	60	2	4	45	60	60	25	40	0	0	60	No	95
25	64	Female	Left	0	80	0	10	30	40	60	15	40	0	0	40	Yes	85
26	59	Female	Right	0	75	0	10	50	40	65	40	30	0	0	35	No	89

VAS: visual analog scale.

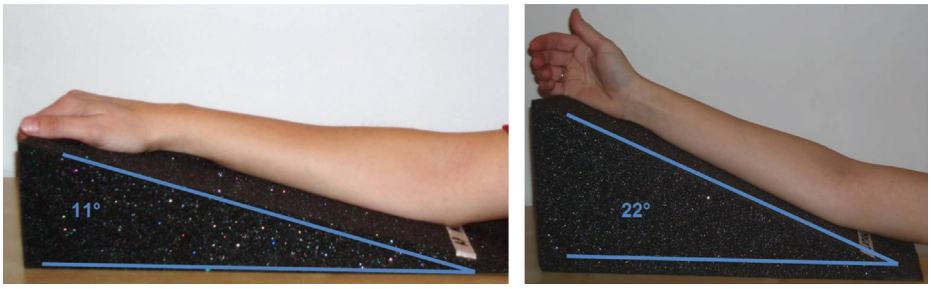

Figure 1 Placement of the supports for radiographic projections.

of 8.57 ± 2.04 (range: 3–10). These results reflect a low incidence of residual pain and a high level of overall satisfaction.

When comparing the findings of the AP and L radiographic images obtained with the aid of wedge-shaped supports, with those obtained by CT scan, we observed a statistically significant relationship in all types of protrusion, except for clear protrusion of screws at the dorsal level (Tables 2–5).

Table 2 Detection of slight articular protrusions in Rx with supports.

	Slight articular protrusion in Rx		Number of total
	No	Yes	
Slight articular protrusion in CT			
No	13	4	17
Yes	0	3	3
Total	13	7	20

$P < .05$.

Table 3 Detection of slight dorsal protrusions in Rx with supports.

	Slight dorsal protrusion in Rx		Number of total
	No	Yes	
Slight dorsal protrusion in CT			
No	13	1	14
Yes	2	4	6
Total	15	5	20

$P < .05$.

Table 4 Detection of clear articular protrusions in Rx with supports.

	Clear articular protrusion in Rx		Number of total
	No	Yes	
Clear articular protrusion in CT			
No	15	1	16
Yes	2	2	4
Total	17	3	20

$P < .05$.

Regarding the reliability of these special radiographic projections, we obtained the following results:

For the diagnosis of slight intra-articular screw protrusion, the sensitivity of special projections was 100% and the specificity was 76%. For the assessment of slight dorsal protrusion, the special projections presented a sensitivity of 66% and a specificity of 92%.

For the diagnosis of clear intra-articular screw protrusion, the special projections offered a sensitivity of 50% and a specificity of 93%. Regarding clear dorsal screw protrusion, the special projections showed a sensitivity of 0% and a specificity of 100%.

Discussion

Internal fixation with VFAP has been established as an effective technique for the surgical treatment of complex fractures of the distal radius. Radiographic control to verify the correct placement of the screws is essential during surgery. Lister's tubercle, the triangular profile of the dorsum of the distal radius and the shape of the sigmoid cavity are some of the specific anatomical features which impede the assessment of the adequate length of the screws intraoperatively.[10] It is not uncommon for protrusions up to 2–3 mm to go unnoticed using standard radiographic projections.[11] The phenomenon known as ''skiving''[12] (also referred to as ''slight protrusion''), which represents a breakage of the cortex with bulging of the articular cartilage but without clear screw protrusion, is also currently attracting notable attention. It has been speculated that this condition may cause long-term joint damage.

Apart from the obvious implications of intra-articular protrusions, dorsal protrusion is also associated with extensor tendon tears,[13] given their proximity to the dorsal

Table 5 Detection of clear dorsal protrusions in Rx with supports.

	Clear dorsal protrusion in Rx		Number of total
	No	Yes	
Clear dorsal protrusion in CT			
No	16	0	16
Yes	4	0	4
Total	20	0	20

$P > .05$.

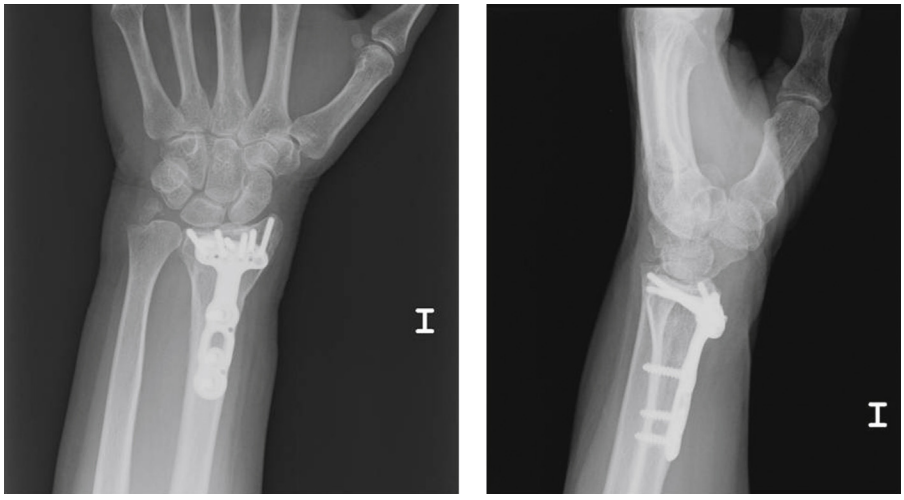

Figure 2 Radiographic projections with correcting supports. The slight protrusion of screws at the intra-articular and dorsal levels can be observed.

cortex. In our series we did not detect any cases of tendon rupture, although the limited sample size did not allow any firm conclusions to be drawn about its true incidence.

As we have observed in this postoperative study, the use of special AP and L projections, tangential to the articular surfaces, can provide a more sensitive detection during the surgical procedure. Obtaining a projection tangential to the longitudinal axis of the dorsal of the radius is also useful, although we have observed that the wrist hyperflexion required for the test hinders its execution. Joseph et al.[14] used this projection in an intraoperative study on 15 patients. In 4 cases (26.6%) they had to modify the screws after detecting a dorsal protrusion. Another projection that can provide information is the oblique pronated to 45°, as described by Smith and Henry,[15] which enables visualization of the scaphoid and lunate facet of the radius.

The use of supports to modify common radiographic projections has already been reported previously by other authors.[16] Boyer et al.[17] conducted a study on cadavers, establishing the variability between the observations in conventional Rx and *in situ* findings. They concluded that a projection tangential to the articular surfaces enables a better assessment of the protrusion of the screws. Our experience is similar, as we have repeatedly observed the existence of screw protrusions which had gone unnoticed in conventional projections. As shown in Figs. 2 and 3, the length of the screws can be assessed correctly in the Rx images obtained using wedge-shaped supports, without the need to obtain CT images.

The present study has demonstrated a satisfactory correlation between plain radiography performed with wedge-shaped supports and CT studies. The main limitation of the study is the sample size. A larger sample size would probably offer similar results regarding assessment of clear dorsal protrusion to those obtained with other protrusions. In fact, the lack of correlation in this type of protrusion is

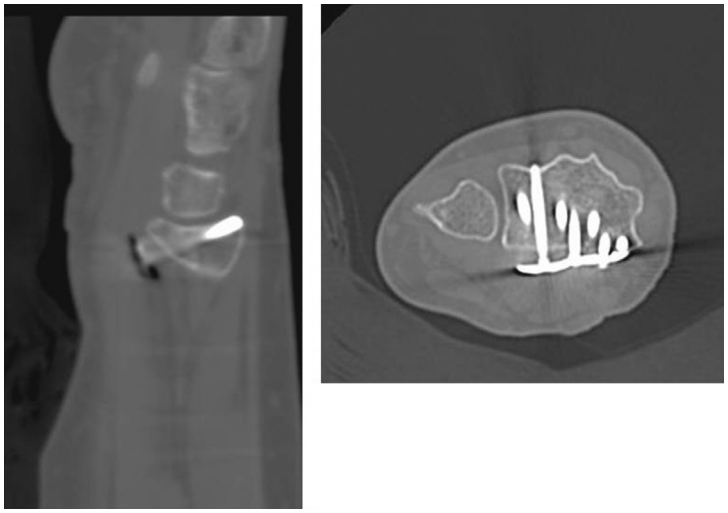

Figure 3 Images from the CT study compared with Rx using supports. It is possible to confirm the slight dorsal protrusion observed in Fig. 2.

due to 2 false negatives: one due to an excessively cubital position of the plate, which hindered the visualization of the sigmoid fossa, and another one due to a bone deformity of the patient, who had undergone a corrective osteotomy prior to placement of the plate. The other 2 false negatives detected are assumable by possible interobserver error. The strong point of the study is the fact of having CT studies available as a reference test to validate the results obtained, unlike other studies which did not perform these CT studies.[14]

In conclusion, obtaining radiographic projections tangential to the articular surface of the radius aided by wedge-shaped supports is an effective method to detect protrusion of VFAP screws. Their use during surgery in order to adequately modify the length of the screws is recommended.

Level of evidence

Level of evidence I.

Ethical responsibilities

Protection of people and animals. The authors declare that this investigation did not require experiments on humans or animals.

Confidentiality of data. The authors declare that they have followed the protocols of their workplace on the publication of patient data and that all patients included in the study received sufficient information and gave their written informed consent to participate in the study.

Right to privacy and informed consent. The authors declare having obtained written informed consent from patients and/or subjects referred to in the work. This document is held by the corresponding author.

Conflict of interests

The authors have no conflict of interests to declare.

References

1. Heim D. Plate osteosynthesis of distal radius fractures-incidence, indications and results. Swiss Surg. 2000;6:304–14.
2. Orbay JL, Touhami A. Current concepts in volar fixed-angle fixation of unstable distal radius fractures. Clin Orthop Relat Res. 2006;445:58–67.
3. Rein S, Schikore H, Schneiders W, Amlang M, Zwipp H. Results of dorsal or volar plate fixation of AO type C3 distal radius fractures: a retrospective study. J Hand Surg Am. 2007;32:954–61.
4. Koo SC, Ho ST. Delayed rupture of flexor pollicis longus tendon after volar plating of the distal radius. Hand Surg. 2006;11:67–70.
5. Al-Rashid M, Theivendran K, Craigen MA. Delayed ruptures of the extensor tendon secondary to the use of volar locking compression plates for distal radial fractures. J Bone Joint Surg Br. 2006;88:1610–2.
6. Af Ekenstam F, Hagert CG. Anatomical studies on the geometry and stability of the distal radio ulnar joint. Scand J Plast Reconstr Surg. 1985;19:17–25.
7. Schimmerl-Metz SM, Metz VM, Totterman SMS. Radiologic measurement of the scapholunate joint: Implications of biologic variation in scapholunate joint morphology. J Hand Surg. 1999;24:1237–44.
8. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand). Am J Ind Med. 1996;29:602–8.
9. Amadio PC, Berquist TH, Smith DK, Ilstrup DM, Cooney 3rd WP, Linscheid RL. Scaphoid malunion. J Hand Surg Am. 1989;14:679–87.
10. Berger RA, Kauer JMG, Landsmeer JMF. Radioscapholunate ligament: a gross anatomic and histologic study of fetal and adult wrists. J Hand Surg. 1991;16:350–5.
11. Maschke SD, Evans PJ, Schub D, Drake R, Lawton JN. Radiographic evaluation of dorsal screw penetration after volar fixed-angle plating of the distal radius: a cadaveric study. Hand. 2007;2:144–50.
12. Takemoto RC, Gage MJ, Rybak L, Walsh M, Egol KA. Articular cartilage skiving: the concept defined. J Hand Surg Eur. 2011;36:364–9.
13. Berglund LM, Messer TM. Complications of volar plate fixation for managing distal radius fractures. J Am Acad Orthop Surg. 2009;17:369–77.
14. Joseph SJ, Harvey JN. The dorsal horizon view: detecting screw protrusion at the distal radius. J Hand Surg Am. 2011;36:1691–3.
15. Smith DW, Henry MH. The 45 degrees pronated oblique view for volar fixed-angle plating of distal radius fractures. J Hand Surg Am. 2004;29:703–6.
16. Pace A, Cresswell T. Use of articular wrist views to assess intra-articular screw penetration in surgical fixation of distal radius fractures. J Hand Surg Am. 2010;35:1015–8.
17. Boyer MI, Korcek KJ, Gelberman RH, Gilula LA, Ditsios K, Evanoff BA. Anatomic tilt X-rays of the distal radius: an ex-vivo analysis of surgical fixation. J Hand Surg Am. 2004;29:116–22.