ORIGINAL STUDY

acta orthopaedica belgica, 2023, 89, 709-717

doi.org/10.52628/89.4.11188

Is the 'safe zone' identified in preoperative computed tomography helpful for choosing optimal implant for fixation of radial head fracture?

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The purpose of this study is to assess the clinical significance of the radiologic safe zone based on computed tomography and to compare the outcomes of three different implants for fixation of isolated radial head fractures. We retrospectively reviewed 367 patients who underwent internal fixation for isolated radial head fractures. We newly defined two subtypes of Mason type II fractures associated with the radiographic safe zone (IIA, two-part fracture allowing for safe fixation of plate; IIB, two-part fracture not allowing for safe fixation). 170 patients (CCS group, n = 82; HCS group, n = 31; plate group, n = 57) were investigated with no significant differences in demographics. The range of pronation and supination at 1 month postoperatively (*P* = 0.04 and *P* = 0.04) and the range of supination at 6 and 12 months postoperatively (*P* = 0.03 and *P* = 0.03) were significantly smaller in the plate group. In Mason type IIB fractures, the average MEPS was higher in the CCS and HSC groups than in the plate group (*P* = 0.01 and *P* = 0.02). And the average DASH score was lower in the CCS and HCS groups (*P* < 0.01 and *P* < 0.01). Evaluation of the radiologic safe zone is potentially helpful in selecting better surgical fixation option. For type III fractures, 2.3-mm cortical screws would be a better option than Acutrak screws. Plates would not be suitable for type IIB radial head fractures.

Key words: Radial head fracture, Mason classification, safe zone, cortical screw, headless compression screw, plate.

INTRODUCTION

Radial head fractures account for one-third of all elbow fractures[1,2]. To manage displaced radial head fractures, several factors including fragment number, displacement, impaction, bone quality, fracture of radial neck, presence of mechanical block, and the potential associated injuries, have been considered for proper surgical treatment[3-5]. In addition, computed tomography (CT) scans were used to understand more elliptical than circular morphology of radial head and assess the fracture patterns in relationship to proximal radioulnar articulation which are important for surgical treatment[6,7]. How isolated fractures, particularly Mason type II fractures, are fixed in association with different fracture patterns has not been established clearly, despite the modifications of the original Mason classification[8,9]. Thus, we thought that identifying and defining the patterns of fractures on CT axial scans would be helpful for deciding treatment options.

For surgical fixation using plates, exposure of the hardware associated with impingement of cartilage and soft tissue often poses problems, specifically in the articulating portion of the radial head[7,10]. Recent anatomical studies have demonstrated that the safe zone in relation to bicipital tuberosity could be used to ensure the safe placement of the proximal radial plate, easily identified on intraoperative radiographs or preoperative axial view of radial head on CT scans[11].

Various headless compression screws (HCSs) have been frequently used for fixation of radial head fractures that allows absent screw head to be buried within the articular surface[9,12-16]. However, as these HCSs have a relatively larger diameter (≥2.5 mm) and require a reaming procedure that could break small fragments, we often experienced difficulty in stabilizing comminuted fractures with more than four fracture fragments or poor bone quality. On the contrary, small diameter (2.3 mm) conventional cortical screws (CCSs) with countersunk head may be used more efficiently for treating comminuted fractures, without concerns of intra-articular protrusion of the screw head[17]. However, clinical trials demonstrating the efficacy of small cortical screws for fixation of radial head fractures are lacking. We speculated that identifying displaced fracture patterns or multiple small fragments of comminuted fractures on CT axial scans would be associated with the outcomes of the use of HCC, CCS, and plate.

Therefore, the purpose of this study was to assess the clinical significance of our new classification of radial head fractures based on CT axial scans and the radiologic safe zone of the radial head for deciding the surgical options and to compare the clinical outcomes of the three implant options (CCS, HCS, and plate) for internal fixation of isolated radial head fractures according to the classification. We hypothesized that each surgical outcome of those three implants would be different according to the fracture types based on the radiologic safe zone.

MATERIALS AND METHODS

Institutional review board approval was obtained before the commencement of this study. This study was designed as a retrospective comparative clinical review and an outcome analysis.

We retrospectively reviewed 367 patients with radial head fractures who underwent internal fixation between May 2007 and April 2020. The inclusion criteria were as follows: (1) displaced radial head fracture (Mason type II or III), (2) open reduction with internal fixation using only one type of implant (CCS, HCS, or plate), and (3) ≥12 months of follow-up after surgery. The exclusion criteria were (1) open fracture, (2) associated ligament injuries or instability requiring additional surgical repair, (3) concomitant injury in the ipsilateral extremity making clinical outcomes difficult to evaluate, (4) Essex-Lopresti fracture-dislocation, and (5) abnormal elbow function before injury.

In our institute, we started using 2.3-mm diameter fully threaded CCSs (Acumed, Hillsboro, OR) for screw fixation of radial head fractures in 2010. Prior to their use, 3.2-mm diameter Acutrak mini screws (Acumed, Hillsboro, OR) as HCSs were utilized. Unlike the general shape of the cortical screws, the small-sized head with a shallow depth of the 2.3-mm CCS allowed

Figure 1. — Implants used in our institution. From left to right: (1) 2.3-mm diameter fully threaded conventional cortical screw (Acumed, Hillsboro, OR), (2) 3.2-mm diameter Acutrak mini (Acumed, Hillsboro, OR), (3) 2.7-mm radial head plate (Acumed, Hillsboro, OR), and (4) 2.4-mm limited-contact radial head plate (Synthes, Bettlach, Switzerland).

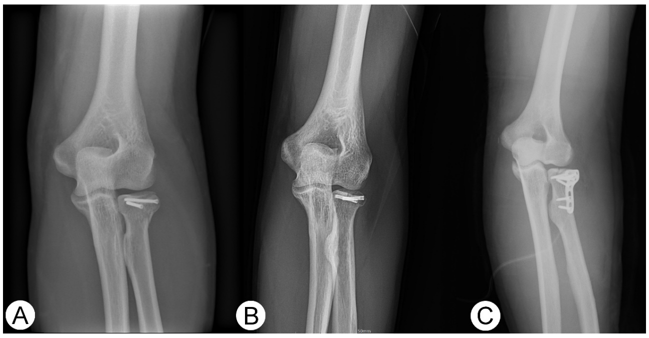

Figure 2. — Postoperative elbow anterior-posterior radiographs by each group. (A) Conventional cortical screw group (CCS group), (B) headless compression screw group (HCS group), and (C) plate group.

screws to be buried under the cartilagnious surface of the radial head (Fig. 1). Regardless of surgery time, 2.7-mm radial head plates (Acumed, Hillsboro, OR) or 2.4-mm limited-contact radial head plates (Synthes, Bettlach, Switzerland) were used to stabilize and buttress displaced fragments based on the surgeon's preference. We then classified the patients into three groups: CCS, HCS, and plate groups (Fig. 2).

All patients were scheduled for further follow-up at 2 weeks and at 1, 6, and 12 months postoperatively. Additional follow-ups were recommended for patients who complained of discomfort in the injured elbow.

Standard anteroposterior, lateral, and oblique radiographs were obtained pre- and postoperatively. Radiographic outcomes and complications, including nonunion, metal failure, heterotropic ossification, and arthritis, were evaluated at each follow-up. Fracture-healing was identified by the clinical evaluation and the serial radiographs.

CT was performed preoperatively in all patients. The axial slices were aligned parallel to the articular surface of the radial head. In cases of fracture with a significant articular depression, the CT axial scans were reconstructed perpendicular to the long axis of the proximal radius to evaluate intra-articular fractures on the true axial view of the radial head. As the suggested center of the safe zone is 166° ± 10° from the greatest prominence of the bicipital tuberosity and the arc is approximately 110° in recent cadaveric studies, we reproduced individual safe zone for each patient on preoperative CT scans (Fig. 3)[11,20]. As this radial safe zone was referenced to the ipsilateral bicipital tuberosity, the measurement could be reproduced easily, regardless of forearm position (pronation or supination) with good reproducibility. We could define new two subtypes of Mason type II fractures associated with the radiographic safe zone (Fig. 4). In the present

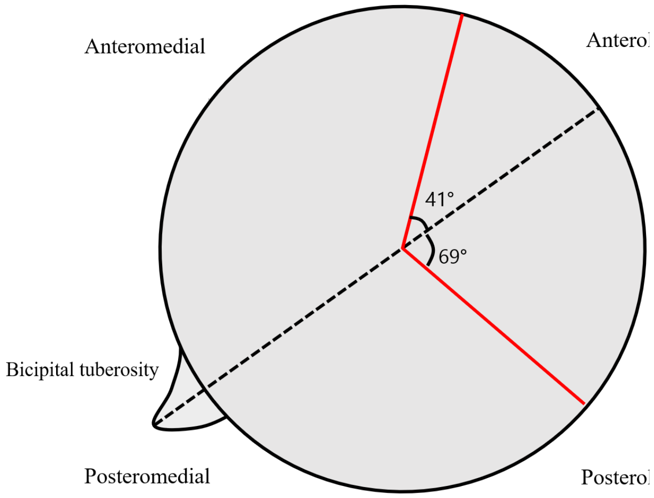

Figure 3. — Schematic of method measuring the radiologic safe zone on computed tomography axial scans. Hoekzema et al. suggested that the center of the safe zone is 166° ± 10° from the greatest prominence of the bicipital tuberosity and the arc is approximately 110° [11]. We modified the original method. Dotted line was drawn connecting bicipital tuberosity and the center of the radial head on the CT axial images. As the center of the safe zone is 166° from the greatest prominence of the bicipital tuberosity and the arc is approximately 110°, we defined the radiologic safe zone as the arc, involving 41° from anteromedially and 69° from posterolaterally based on the line.

study, subtype IIA was defined when the displaced fracture with two fragments, allowed the plate to be placed in the safe zone while the screws were positioned perpendicular to the fracture lines. Subtype IIB was defined when the displaced fracture with two fragments, did not allow the plate to be placed in the safe zone. Type III was defined when comminuted fractures with entire head of the radius were identified with more than three fragments, as defined by the original Mason classification[1].

All procedures were performed by a single surgeon using the posterolateral (Kocher) approach between the extensor carpi ulnaris and anconeus. After dissection of the annular ligament, the fracture was exposed and reduced under C-arm fluoroscopy. In the case of plate fixation, we attempted to place the plate in the safe zone using palpable landmarks on the distal radius (90° angle localized by palpation of radial styloid and Lister's tubercle). We aimed to screw the plate in a manner as close to perpendicular to the fracture line as possible[18]. In the case of screw fixation using both CCS and HCS (Acutrak mini screw), screws were placed perpendicular to the fracture line, regardless of the safe zone, with the proper length of the screws

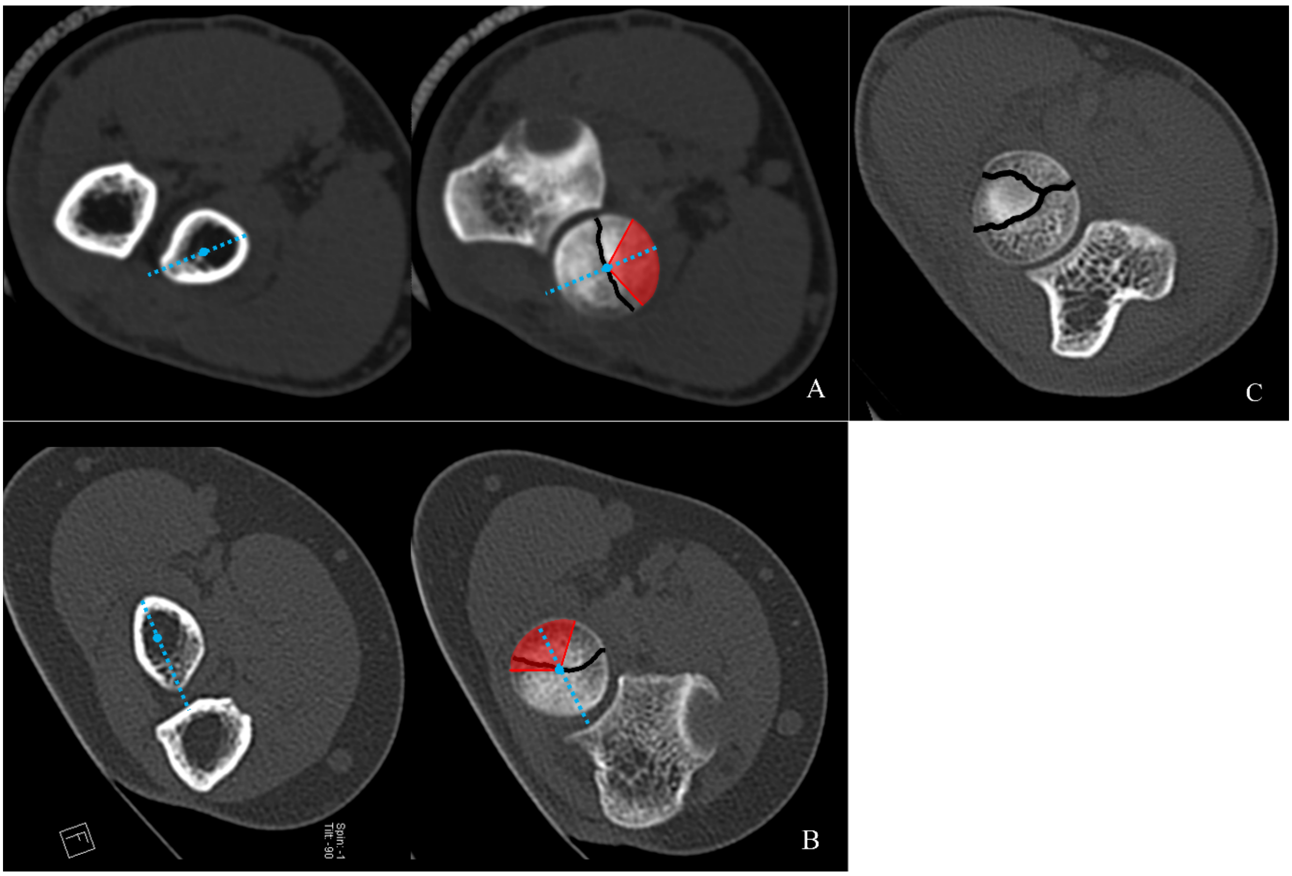

Figure 4. — Measurement of the radiologic safe zone and new classification based on the safe zone. Blue dotted line is connecting bicipital tuberosity and the center of the radius. Fracture line is marked by thick black line. Finally, the radiologic safe zone is identified as the red arc. (A) Type IIA, (B) type IIB, and (C) type III.

Table I. — Patients demographics

	CCS (n = 82)	HCS (n = 31)	Plate (n = 57)	P value
Mean age (years) [range]	53.2 [21-71]	51.9 [26-69]	54.1 [21-73]	0.102
Gender (no. of patients)	Male 36 Female 46	Male 14 Female 17	Male 31 Female 26	0.431
Dominant hand injured (%)	59.8	54.8	50.9	0.143
Fracture type (no. of patients) [%]				0.622
IIA	34 [42]	13 [42]	26 [46]	-
IIB	21 [26]	13 [42]	14 [25]	-
III	27 [33]	5 [16]	17 [30]	-
Radial neck fracture (no. of patients) [%]	18 [22]	5 [16]	14 [25]	0.216
Operation time (minutes) [range]	28.3 [21-42]	29.1 [22-36]	35.4 [31-47]	0.081
Follow-up period (weeks) [range]	53.5 [48-84]	56.6 [48-92]	55.3 [49-79]	0.163
Hospital stays (days) [range]	4.3 [1-4]	4.1 [1-5]	4.4 [1-6]	0.317

CCS: conventional cortical screw group; HCS, headless compression screw group; Plate: plate group.

Table II. — Clinical and radiographic outcomes

	CCS (n = 82)	HCS (n = 31)	Plate (n = 57)	P value
Time to bone union (weeks) [range]	8.4 [6-10]	8.2 [6-10]	12.3 [7-16]	0.27
MEPS (points)	89.4 [70-100]	89.3 [75-100]	83.2 [70-95]	0.08
DASH score (points)	12.4 [5-25]	13.2 [5-30]	14.3 [5-35]	0.10
ROM at 1-month (degrees) [SD]				
Flexion	85.4 [22.2]	84.5 [23.5]	84.6 [25.1]	0.23
Extension	- 10.2 [4.3]	- 11.4 [4.6]	- 12.2 [5.6]	0.19
Pronation	32.3 [10.2]	31.6 [10.2]	27.5 [11.4]	0.04 *
Supination	31.4 [9.6]	31.2 [10.1]	28.6 [9.7]	0.04 *
ROM at 6-months (degrees) [SD]				
Flexion	118.4 [31.6]	118.1 [32.4]	116.5 [31.3]	0.12
Extension	-1.4 [3.1]	-1.8 [3.3]	-2.4 [4.1]	0.22
Pronation	60.1 [15.6]	61.2 [15.8]	58.3 [16.7]	0.06
Supination	64.2 [18.9]	65.5 [20.1]	59.4 [19.2]	0.03 *
ROM at 12-months (degrees) [SD]				
Flexion	126.6 [32.3]	125.3 [31.1]	125.1 [31.6]	0.23
Extension	-0.8 [2.8]	- 1.2 [3.6]	-1.4 [4.1]	0.16
Pronation	64.2 [19.1]	64.4 [20.3]	61.1 [17.3]	0.07
Supination	67.7 [20.2]	68.3 [21.6]	62.6 [18.5]	0.03 *
Complications (no. of patients) [%]				
Discomfort due to stiffness	3 [3.7]	1 [3.2]	8 [14.0]	0.02 **
Implant-related discomfort	1 [1.2]	1 [3.2]	3 [5.3]	0.04 **
Infection	1 [1.2]	0 [0]	1 [1.8]	0.33
Implant failure	1 [1.2]	0 [0]	2 [3.5]	0.09
Heterotropic ossification	1 [1.2]	1 [3.2]	2 [3.5]	0.11
Non-union	1 [1.2]	1 [3.2]	2 [3.5]	0.24
Painful arthritis	5 [6.1]	2 [6.5]	5 [8.8]	0.13
Revision radial head arthroplasty	1 [1.2]	0 [0]	2 [3.5]	0.09

CCS: conventional cortical screw group; HCS, headless compression screw group; Plate: plate group; MEPS: mayo elbow performance score; DASH: disabilities of the arm, shoulder, and hand; ROM: range of motion; SD: standard deviation. * P value < 0.05 using one-way analysis of variance. ** P value < 0.05 using Chi-squared test.

on C-arm fluoroscopy. When using the Acutrak mini screw, the reaming process through the guide wire was carefully performed to avoid destroying the small proximal fragment. The reaming process was not required for CCS placement. After confirming that no prominent mechanical block or impingement occurred during passive supination and pronation of the forearm, wound closure including annular ligament repair was performed.

A removable long-arm splint with active range of motion (ROM) exercise was applied to all patients on the day after surgery. Full activities of daily living were allowed at 8 weeks postoperatively.

The functional status was assessed using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire (Institute for Work and Health, Toronto, Ontario, Canada) with lower scores indicating less disability and Mayo Elbow Performance Score (MEPS) with lower scores indicating more disability during activities of daily living[19]. Using a goniometer, we assessed ROM (in degrees) including passive elbow flexion-extension and forearm pronation-supination. DASH scores and MEPS were assessed at the final follow-up, and ROM was measured at 1, 6, and 12 months postoperatively. Any discomfort that patients complained or complications, including stiffness, implant-related discomfort, infection, implant failure, and revision radial head arthroplasty, were recorded.

Statistical analysis was performed using SPSS version 20.0 (IBM Corporation, Armonk, NY). The preoperative baseline characteristics were compared among the three groups (CCS, HCS, and plate groups) using one-way analysis of variance (ANOVA) for numerical variables and chi-squared test for categorical variables. Clinical outcome measurements, including the DASH score, MEPS, and ROM, were assessed for superiority among the three groups at the final follow-up using the Mann-Whitney U test. Repeated measures ANOVA was performed to assess ROM among the three groups over the follow-up period as independent variables. Statistical significance was set at $P < 0.05$.

RESULTS

According to our inclusion and exclusion criteria, 197 of the 367 patients were excluded from this study. A total of 170 patients (CCS group, n = 82; HCS group, n = 31; plate group, n = 57) were investigated. Detailed patient demographics are described in Table I, with no significant differences among the three groups. Although patients with Mason type III fractures seemed to be fewer in the HCS group, the difference was not

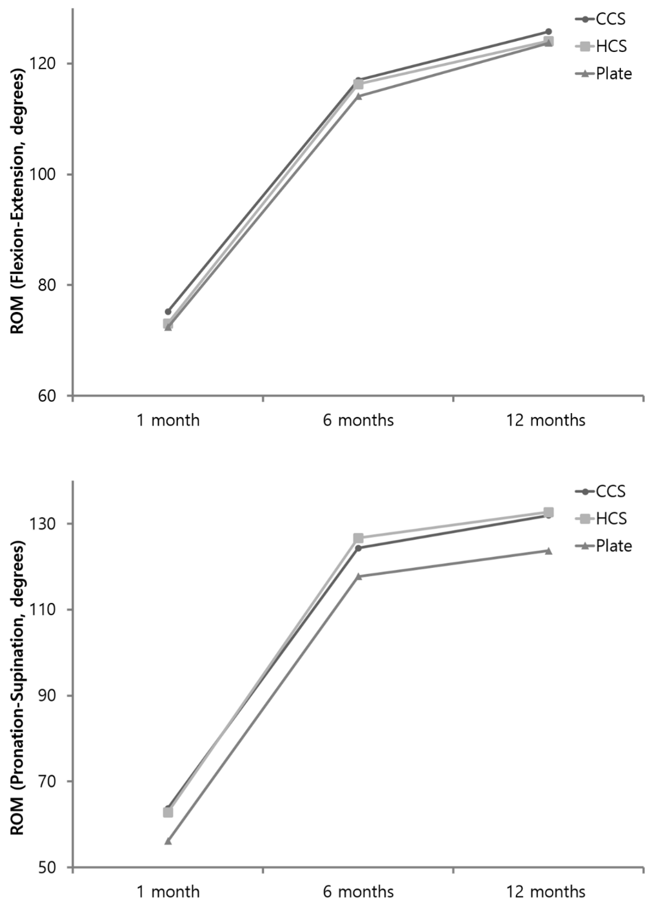

Figure 5. — Range of motion at each follow-up. CCS, cortical screw group; HCS, headless compression screw group; plate, plate group.

statistically significant. Some accompanying radial neck fractures were included in those groups, with no differences in numbers among the groups.

A comparison of clinical and radiographic outcomes is described in Table II. Functional assessments including MEPS and DASH scores at the final follow-up showed no significant differences among the groups. This finding indicates that the patients showed generally satisfactory outcomes after the surgery regardless of the variety of implants. In ROM measurements, significant differences were found in pronation and supination at 1 month postoperatively (P = 0.04 and P = 0.04, respectively), and supination at 6 months postoperatively (P = 0.03), which showed significantly lower values in the plate group. At 12 months of follow-up after surgery, a significant difference was also observed among the groups with gradual improvement of the values in all three groups (P = 0.03) (Fig. 5). Almost all the problems after the primary surgery were resolved with conservative treatments or implant removal surgery; however, three patients had undergone revision radial head arthroplasty after 1 year because of non-union of fracture and related painful arthritis

Table III. — Comparison of MEPS and DASH scores according to fracture type

	CCS	HCS	Plate	P value
MEPS (points) [SD]				
Type IIA	91.4 [21.4]	90.1 [22.1]	89.2 [21.7]	CCS vs. HCS 0.33 CCS vs. Plate 0.41 HCS vs. Plate 0.26
Type IIB	90.2 [22.3]	89.1 [23.2]	82.3 [19.8]	CCS vs. HCS 0.27 CCS vs. Plate 0.01 * HCS vs. Plate 0.02 *
Type III	81.5 [19.1]	77.1 [18.3]	82.4 [21.5]	CCS vs. HCS 0.02 * CCS vs. Plate 0.31 HCS vs. Plate 0.02 *
DASH score (points) [SD]				
Type IIA	7.2 [6.7]	7.3 [6.9]	6.6 [5.4]	CCS vs. HCS 0.41 CCS vs. Plate 0.29 HCS vs. Plate 0.37
Type IIB	9.8 [7.1]	9.1 [6.6]	15.3 [10.6]	CCS vs. HCS 0.46 CCS vs. Plate < 0.01 * HCS vs. Plate < 0.01 *
Type III	14.6 [10.3]	17.3 [12.5]	13.4 [5-35]	CCS vs. HCS 0.03 * CCS vs. Plate 0.25 HCS vs. Plate 0.02 *

CCS: conventional cortical screw group; HCS: headless compression screw group; Plate: plate group; MEPS: mayo elbow performance score; DASH: disabilities of the arm, shoulder, and hand; SD: standard deviation. * P value < 0.05 using the independent t-test.

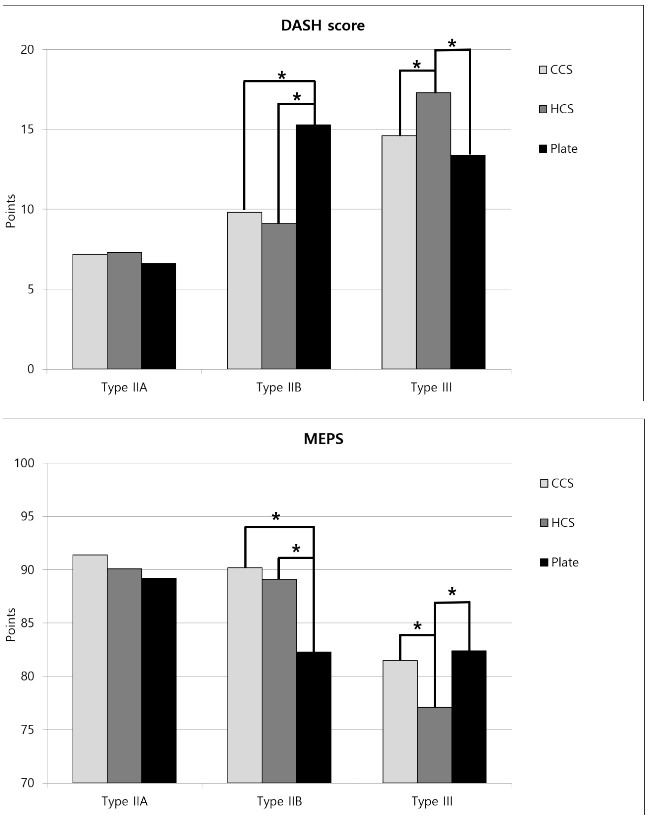

Figure 6. — Functional outcomes at the final follow-up by each fracture type. CCS, cortical screw group; HCS, headless compression screw group; plate, plate group; DASH, Disabilities of the Arm, Shoulder, and Hand; MEPS, Mayo Elbow Performance Score.

of the proximal radioulnar articulation (one patient in the CCS group and two patients in the plate group). Discomfort associated with stiffness and implant-related discomfort were more frequent in the plate group ($P = 0.02$ and $P = 0.04$, respectively). Although one patient of the CCS group and two patients of the plate group underwent revision radial head arthroplasty, no statistically significant differences were found.

To assess the clinical significance of our newly classified subtypes of Mason type II fractures based on the safe zone in preoperative CT axial views, we compared the functional outcomes according to the three fracture types (Table III and Fig. 6). To prove the superiority of the outcomes of each group compared with others, we performed each comparison between two groups using an independent t-test. Significant differences were not found in Mason type IIA fractures. In Mason type IIB fractures, the average MEPS was higher in the CCS and HSC groups than in the plate group ($P = 0.01$ and $P = 0.02$, respectively). The average DASH score was lower in the CCS and HCS groups than in the plate group ($P < 0.01$ and $P < 0.01$, respectively). However, no significant differences were observed in the MEPS and DASH scores between the CCS and HCS groups. In Mason type III fractures, the average MEPS was higher in the CCS and plate groups than in the HCS group ($P = 0.02$, and $P = 0.02$, respectively). The average DASH score was lower in the CCS and plate groups than in the HCS group (P = 0.03 and P = 0.02, respectively). No significant differences were noted in MEPS and DASH scores between the CCS and plate groups.

DISCUSSION

In this study, we suggested new subtypes of Mason type II radial head fracture based on the radiological safe zone of the radius and assessed clinical outcomes according to the three fixation options. We demonstrated the clinical efficacy of 2.3-mm CCSs for managing displaced radial head fractures, compared with Acutrak mini screws and locking plates. For type IIA fractures, the three implants showed similar outcomes. However, for type IIB fractures, locking plates resulted in a decreased range of supination-pronation and poorer functional outcome scores with some mechanical impingement during ROM. Between the two screws, 2.3-mm cortical screws showed similar outcomes for treating isolated Mason type IIA and IIB fractures and better outcomes for Mason type III fractures, compared with Acutrak mini screws.

The similar outcomes among the three options in type IIA fractures indicate that any of the three implants could be selected along with the surgeon's preference. Not only the headless screws (Acutrak screw), but also the 2.3mm CCS could be buried below the cartilaginous surface of the radial head. This allows safe fixation of both screws without impingement during the forearm rotation, regardless of the position of the screw associated with the articulating surface of the radial head. On the contrary, plate off the safe zone could not be free from the impingement and the related complications. Therefore, for type IIB fractures, the use of a locking plate could result in irritation to adjacent structures associated with loss of ROM or stiffness after surgery.

Differentiated from the previous studies, our results showed the efficacy of using the 2.3-mm cortical screws compared with the HCS (Acutrak mini screws), particularly for comminuted fractures or type III fractures. Previous clinical studies have demonstrated satisfactory outcomes of HCS for managing Mason type II and even for some Mason type III with or without complex injuries[9,12-14]. However, we have experienced difficulties fixing comminuted radial head fractures with HCS due to the screw's need for reaming process and its larger diameter. This is reflected in our results when 2.3-mm CCS showed better outcomes for type III fractures, compared with HCS. Although a biomechanical study demonstrated the stability of the small CCS for radial head fracture was similar compared with the 3.0-mm HCS, only few clinical studies have assessed the usefulness of CCS for managing radial head fractures[17]. Therefore, our study is the first to demonstrate the efficiency of small-sized CCS for managing radial head fractures, compared with Acutrak screws, and locking plates. Although the plate or CCS showed satisfactory results for some Mason type III fractures, arthroplasty of the radial head is still a suitable treatment option for severely comminuted fractures or combined associated injuries. Thus, our results should not be misunderstood as screws would be an optimal treatment method for Mason type III radial head fractures.

In the present study, we found that even comminuted radial head fractures with or without accompanying radial neck fracture were managed well using 2.3-mm cortical screws, with satisfactory clinical outcomes. In the plate group, the ROM, including supination and pronation, showed poorer outcomes compared with the groups using screws. As discomfort due to stiffness and implant-related discomfort were frequently reported in the plate group, it was suggested that the plate might interrupt and irritate the proximal radioulnar articulation and adjacent soft tissue. Despite our efforts to place the plate in the safe zone, in some cases, the plate might get out of the safe zone for stable fixation of the fracture, while the screws are placed perpendicular to the fracture line. If we had identified the fracture patterns relative to the safe zone, we would choose screws for specific fracture patterns that were classified as type IIB. Although we had confirmed that no prominent mechanical block or impingement was observed during passive ROM of the forearm intraoperatively, a decrease in ROM and some discomfort arising from the plate occurred postoperatively. This might suggest that while intraoperative confirmation of no plate impingement is important, it does not always predict satisfactory outcomes. Therefore, the fracture patterns identified on preoperative CT axial views can be used as a basis for choosing the screws for type IIB fractures rather than plates, which would improve the outcomes.

Despite the importance of the safe zone for placing the plate to manage radial head fractures, accurate intra- or preoperative measurements have not been established[21-23]. The intraoperatively measured safe zone, based on the Lister's tubercle or radial styloid process, provides inaccurate measurements with un-satisfactory reproducibility. Previous biomechanical studies demonstrated that the radial head with a circular arc of 20 mm or less, or plates wider than the 12.7 mm maximum width would make exact plate placement more difficult in the center of the individual's safe zone, which may be related to implant impingement and that plates placed within 15° of this central point were completely in the safe zone[7,11]. Moreover, with considerable efforts to reproduce the individual safe zone of the radial head on CT axial scans, a recent cadaveric study described the radiologic safe zone based on the bicipital tuberosity[11]. However, clinical trials assessing the practical usefulness of the radiologic safe zone are lacking[24,25]. In our study, we first assessed the clinical significance of the radiologic safe zone measured on preoperative CT axial scans. And this was the first study to compare the clinical outcomes of three surgical fixation methods for managing radial head fracture and to suggest the efficacy of small-sized cortical screws, comparable with the HCS and the plate. We anticipate that this study is potentially helpful for deciding the fixation options of radial head fracture and for planning further related research.

This study has also several limitations. First, it was a retrospective study conducted at a single center. Second, arthroplasty or excision of the radial head or fragments was excluded from this study, which might have resulted in selection bias for collecting Mason type III fractures. In addition, some cases attempting to stabilize the comminuted radial head fractures, which were converted to radial head arthroplasty intraoperatively, were also excluded from this study. Third, as the use of plate rather than screws was decided by the surgeon's preference based on individual conditions or intraoperative findings, the selection bias might have affected the results, despite the lack of differences in the epidemiology of fracture type among the groups. Finally, although radial head fractures are often accompanied by associated injuries, we only included patients with isolated radial head fractures. Further studies that include comminuted fractures with or without associated injuries would suggest more helpful guidelines for managing radial head fractures.

CONCLUSION

Each surgical outcome of those three implants (CCS, HCS, and plate) was different according to the newly suggested subtypes of Mason type II fractures. For type IIA fractures, any of the three implants would be a proper option with similar outcomes. For type IIB fractures, the plate would not be a suitable option. For type III fractures, 2.3-mm cortical screws and the plate would be a better option than Acutrak mini screws. Therefore, identifying the radiologic safe zone in preoperative CT is potentially helpful in selecting better surgical fixation method.

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