EUR Research Information Portal

Redisplacement of reduced distal radius fractures in adults: does the type of casting play a role?

Published in:
Bone and Joint Journal

Publication status and date:
Published: 01/07/2024

DOI (link to publisher):
10.1302/0301-620X.106B7.BJJ-2024-0014.R1

Document Version
Publisher's PDF, also known as Version of record

Document License/Available under:
CC BY-NC-ND

Citation for the published version (APA):
Barvelink, B., Reijman, M., CAST study group, Smidt, S., Miranda Afonso, P., Verhaar, J. A. N., & Colaris, J. W. (2024). Redisplacement of reduced distal radius fractures in adults: does the type of casting play a role? The CAST study, a multicentre cluster randomized controlled trial. *Bone and Joint Journal*, *106-B*(7), 696-704. https://doi.org/10.1302/0301-620X.106B7.BJJ-2024-0014.R1

Link to publication on the EUR Research Information Portal

Terms and Conditions of Use
Except as permitted by the applicable copyright law, you may not reproduce or make this material available to any third party without the prior written permission from the copyright holder(s). Copyright law allows the following uses of this material without prior permission:

- you may download, save and print a copy of this material for your personal use only;
- you may share the EUR portal link to this material.

In case the material is published with an open access license (e.g. a Creative Commons (CC) license), other uses may be allowed. Please check the terms and conditions of the specific license.

Take-down policy
If you believe that this material infringes your copyright and/or any other intellectual property rights, you may request its removal by contacting us at the following email address: openaccess.library@eur.nl. Please provide us with all the relevant information, including the reasons why you believe any of your rights have been infringed. In case of a legitimate complaint, we will make the material inaccessible and/or remove it from the website.

Erasmus University Rotterdam
Making Minds Matter

■ WRIST & HAND

Redisplacement of reduced distal radius fractures in adults: does the type of casting play a role? The CAST study, a multicentre cluster randomized controlled trial

B. Barvelink, M. Reijman, S. Smidt, P. Miranda Afonso, J. A. N. Verhaar, J. W. Colaris, on behalf of the CAST study group

From Erasmus MC University Medical Center, Rotterdam, The Netherlands

Aims

It is not clear which type of casting provides the best initial treatment in adults with a distal radial fracture. Given that between 32% and 64% of adequately reduced fractures redisplace during immobilization in a cast, preventing redisplacement and a disabling malunion or secondary surgery is an aim of treatment. In this study, we investigated whether circumferential casting leads to fewer the redisplacement of fewer fractures and better one-year outcomes compared with plaster splinting.

Methods

In a pragmatic, open-label, multicentre, two-period cluster-randomized superiority trial, we compared these two types of casting. Recruitment took place in ten hospitals. Eligible patients aged ≥ 18 years with a displaced distal radial fracture, which was acceptably aligned after closed reduction, were included. The primary outcome measure was the rate of redisplacement within five weeks of immobilization. Secondary outcomes were the rate of complaints relating to the cast, clinical outcomes at three months, patient-reported outcome measures (PROMs) (using the numerical rating scale (NRS), the abbreviated version of the Disabilities of the Arm, Shoulder and Hand (QuickDASH), and Patient-Rated Wrist/Hand Evaluation (PRWHE) scores), and adverse events such as the development of compartment syndrome during one year of follow-up. We used multivariable mixed-effects logistic regression for the analysis of the primary outcome measure.

Results

The study included 420 patients. There was no significant difference between the rate of redisplacement of the fracture between the groups: 47% (n = 88) for those treated with a plaster splint and 49% (n = 90) for those treated with a circumferential cast (odds ratio 1.05 (95% confidence interval (CI) 0.65 to 1.70); p = 0.854). Patients treated in a plaster splint reported significantly more pain than those treated with a circumferential cast, during the first week of treatment (estimated mean NRS 4.7 (95% CI 4.3 to 5.1) vs 4.1 (95% CI 3.7 to 4.4); p = 0.014). The rate of complaints relating to the cast, clinical outcomes and PROMs did not differ significantly between the groups (p > 0.05). Compartment syndrome did not occur.

Conclusion

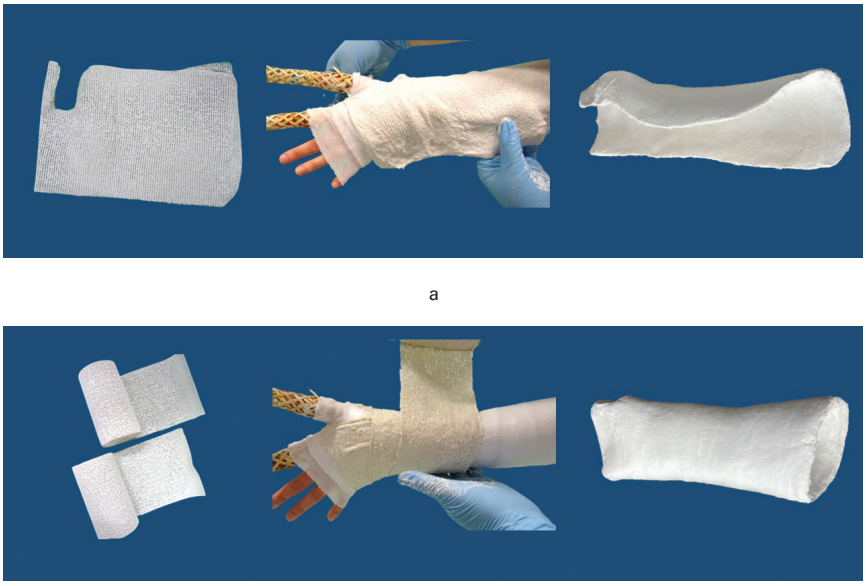
Circumferential casting did not result in a significantly different rate of redisplacement of the fracture compared with the use of a plaster splint. There were comparable outcomes in both groups.

Cite this article: *Bone Joint J* 2024;106-B(7):696–704.

Correspondence should be sent to B. Barvelink; email: b.barvelink@erasmusmc.nl

© 2024 Barvelink et al.
doi:10.1302/0301-620X.106B7.BJJ-2024-0014.R1 $2.00

Bone Joint J 2024;106-B(7):696–704.



a

b

Fig. 1

a) Plaster splint. b) Circumferential cast. Synthetic casting, instead of plaster of Paris, was also accepted.

Introduction

The optimal management of displaced distal radial fractures in adults remains controversial.[1,2] The high rate of redisplacement of these fractures after they have been reduced, reported to be between 32% and 64%, has contributed to the recent trend of managing them surgically.[3-5] Preventing redisplacement during immobilization in a cast, and thereby preventing malunion or subsequent surgery, should be an aim of treatment, to improve the outcome and reduce the need for further interventions and costs.

In current clinical practice, a plaster splint or a circumferential cast is used to stabilize the fracture. Plaster splinting is often preferred initially, mainly because of its ease of application and the fact that it allows for soft-tissue swelling. Circumferential casting, in theory, provides better fixation and is more likely to prevent redisplacement.[6] However, circumferential casting is sometimes associated with increased pressure within the cast, potentially increasing the risk of compartment syndrome, as described in a biomechanical model in the lower limb.[7] The results from studies focusing on the complications of casting when used for a distal radial fracture are inconclusive on this issue.[8,9]

Although we recently concluded from a retrospective multicentre study that circumferential casting might indeed reduce the risk of redisplacement of the fracture when compared with simple plaster splinting,[10] an earlier meta-analysis found insufficient evidence to determine the best type of cast and duration of immobilization, in the management of these fractures.[11] Furthermore, it is not known whether the type of cast influences patient-reported outcome measures (PROMs) and clinical outcomes. Also, no clinical trials have reported the patients' experiences and complaints when different types of cast are used.

This aim of this study, therefore, was to determine whether circumferential casting resulted in a lower rate of redisplacement in reduced distal radial fractures in adults, when compared with plaster splinting. We hypothesized that circumferential casting would provide better fixation and, therefore, would result in a lower rate of redisplacement. A further aim was to compare the complaints of patients relating to the cast, and the clinical outcomes at three months' follow-up, and PROMs and adverse factors during one year's follow-up.

Methods

The CAST study was a pragmatic, open-label, multicentre, two-period cluster-randomized superiority trial to compare the rate of redisplacement in displaced and reduced distal radial fractures treated with plaster splinting compared with circumferential casting. The rationale and design of the study have been published previously.[12] The ethical board of the Erasmus MC University Medical Center (Rotterdam, the Netherlands) approved the trial in 2019 (MEC-2019-0528). Enrolment took place between 30 May 2020 and 11 November 2021. The administration of the trial, management of the data, and analyses were conducted at the Erasmus MC University Medical Center.

The trial involved several stages. A panel of patients with a distal radial fracture was initially formed to help us with different aspects of the the trial. Structured interviews were conducted with a subgroup of patients who helped to determine the preferred method of communication for the results,

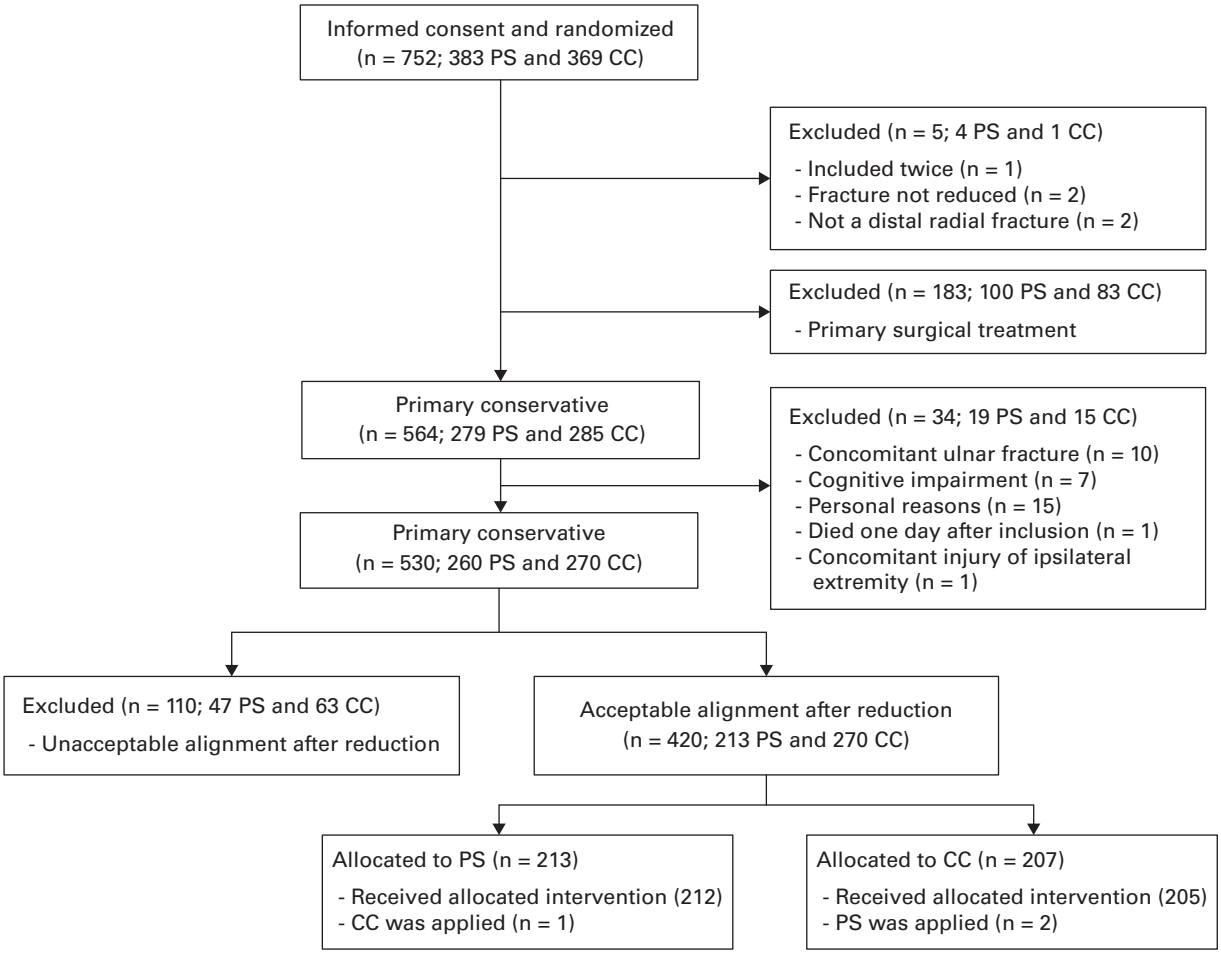


Fig. 2

Flowchart of the patients. According to Dutch privacy law, it is forbidden to screen the electronic records of eligible patients who did not participate in our study. Cases were analyzed according to the intention-to-treat principle. CC, circumferential cast; PS, plaster splint.

which are to be disseminated in a mailed newsletter, and will be summarized on a dedicated webpage.

The patients were recruited from ten hospitals: one university hospital and nine teaching hospitals, located in the Netherlands (details in Supplementary Material). Adult patients, aged ≥ 18 years, who presented to the emergency department with a displaced distal radial fracture requiring closed reduction were invited to participate. Both extra- and intra-articular fractures were included. Exclusion criteria included fractures of both the radius and ulna (patients with an additional fracture of the ulnar styloid were included), patients with associated injuries to the ipsilateral limb, those with polytrauma (with an Injury Severity Score of ≥ 16),[13] or inability to complete the questionnaires for the study due to cognitive impairment or unfamiliarity with the Dutch language. Written informed consent was obtained in the emergency department before closed reduction of the fracture. The alignment after reduction was therefore not known at the time of enrolment. The patients were included in the study when the treating physician decided, based on the post-reduction alignment, to treat the fracture conservatively. During review of the data, we discovered that many conservatively treated fractures had unacceptable post-reduction alignment as determined by the Dutch guidelines for the management of these fractures.[14] We therefore decided to refine the inclusion criteria so as only to include fractures which were adequately reduced.

Patients were randomized to be treated either with immobilization in a below-elbow plaster of Paris volar-dorsal splint or a below-elbow complete circumferential cast, as shown in Figure 1. Casting is undertaken directly after reduction. If one of the interventions was not frequently used in a participating hospital, staff applying the casts were trained and provided with instructional videos and posters. Circumferential casts could be made with either plaster of Paris or synthetic material such as fibreglass, based on availability or the preference of the person who applied the cast.

Randomization involved clustering at the hospital level, with a crossover to the other treatment arm when half of those who were needed per hospital had been included. Before the start of the study, an independent research worker randomly allocated the initial treatment among the participating hospitals. Treatment started directly after randomization, and physicians and patients were not blinded as the type of cast could be easily

Table I. Characteristics of the patients and fractures in the main cohort and the unacceptably reduced cohort.

Variable	Main cohort		Unacceptably reduced
	PS	CC	
Characteristics of the patients			
Total, n	213	207	110
Female, n (%)	177 (83)	174 (84)	94 (86)
Mean age, yrs (SD)	62.2 (15.4)	62.9 (15.7)	69.9 (4.5)
Mean BMI, kg/m² (SD)	25.5 (5.0)	24.3 (3.8)	25.3 (4.2)
Osteoporosis, n (%)	44 (21)	35 (17)	26 (24)
Diabetes, n (%)	16 (8)	12 (6)	9 (8)
Current smoker, n (%)	25 (12)	22 (11)	9 (8)
Fracture characteristics			
Dominant side affected, n (%)	108 (51)	110 (53)	47 (43)
Ulnar styloid fracture, n (%)	98 (46)	109 (53)	58 (53)
Dorsal angulation, n (%)	201 (94)	194 (96)	103 (95)
Mean angulation, ° (SD)	21.7 (11.4)	21.1 (10.5)	24.4 (13.3)
Mean radial inclination, ° (SD)	16.7 (5.5)	16.7 (6.3)	11.1 (6.6)
Radial shortening, n (%)	102 (48)	101 (50)	75 (70)
If yes, mean ulnar variance, mm (SD)	2.5 (1.4)	2.9 (2.3)	3.9 (2.4)
Intra-articular, n (%)	85 (40)	95 (46)	76 (69)
Post reduction alignment			
Dorsal angulation, n (%)	101 (47)	106 (51)	88 (80)
Mean angulation, ° (SD)	5.3 (3.8)	5.4 (4.0)	11.4 (7.5)
Mean radial inclination, ° (SD)	21.8 (3.5)	22.3 (3.5)	16.5 (5.3)
Radial shortening, n (%)	25 (12)	30 (15)	48 (44)
If yes, mean ulnar variance, mm (SD)	1.6 (0.7)	1.4 (0.6)	2.7 (1.3)

CC, circumferential casting; PS, plaster splint; SD, standard deviation.

identified. The interventions were masked during analysis of the data.

The primary outcome was the rate of redisplacement of the fracture during immobilization in the cast, thus at five weeks' follow-up. Redisplacement was defined by the Dutch guidelines for distal radial fractures.[14] These describe that a fracture is unacceptably aligned or redisplaced when it meets one or more of the following criteria: ≥ 15° of dorsal angulation, ≥ 20° of volar angulation, ≤ 15° of radial inclination, ≥ 3 mm of radial shortening, and ≥ 2 mm of intra-articular gap or step-off. The measurements were performed on all radiographs at the time of presentation, post-reduction, and at one, two, and five weeks' follow-up by two investigators (BB, SS). The inter- and intraobserver reliability of these measurements were recorded using the intraclass coefficient (ICC), which showed almost perfect reliability for all measurements (ICCs between 0.84 and 0.99). Only gap and step-off measurements on lateral radiographs showed moderate intraobserver reliability, with an ICC of 0.56.

Secondary outcomes included clinical outcomes, PROMs and adverse events. The clinical outcomes included: the range of motion (ROM) of the wrist, grip strength, sensory nerve testing, opposition of the thumb using the Kapandji score,[15] testing distal radioulnar joint (DRUJ) stability with the ballottement test,[16] and analysis of complex regional pain syndrome (CRPS) using the Budapest criteria.[17] Members of the research team, who were not involved in the treatment, recorded these findings at three months' follow-up. Details of the assessments of clinical outcome were described in the original paper.[12] These included complaints relating to the cast, the severity of pain using the numerical rating scale (NRS), and function using the abbreviated version of the Disabilities of the Arm, Shoulder and Hand (QuickDASH)[18] and Patient-Related Wrist/Hand Evaluation (PRWHE) scores.[19] The patients completed questionnaires at one, two, and six weeks, and three, six, and 12 months' follow-up. Complaints relating to the cast and NRS scores were recorded at one and two weeks, and the QuickDASH and PRWHE scores were recorded from six weeks to 12 months. Adverse events were recorded up to 12 months.

Statistical analysis. Statistical analysis was performed using SPSS v. 28.0.1.0 (IBM, USA) and R v. 4.2.2 (packages lme4 v. 1.1.31 and nlme v. 3.1.162; R Foundation for Statistical Computing, Austria). We considered a two-sided p-value of < 0.05 to be significant. A detailed description of the calculation of the sample size was reported in the original paper.[12] We hypothesized that redisplacement would occur in 20% of fractures treated with a plaster splint compared with 10% of those treated with a circumferential cast. In order to detect a significant difference between the groups with 93% power at a 0.05 level of significance, 500 patients were needed. Accounting for 10% loss to follow-up, we required 560 patients (280 per group).

All outcomes were analyzed as randomized (intention-to-treat), and included all patients who were initially treated conservatively with at least one follow-up appointment and radiographs after one week. Those in whom immediate surgical treatment was to be undertaken, with or without acceptable alignment after reduction, were excluded as no assumptions can be made about stability when the fracture is surgically fixed.

For analysis of the primary outcome, we performed multivariable logistic mixed-effects regression. The following variables were included in the model to correct for potential

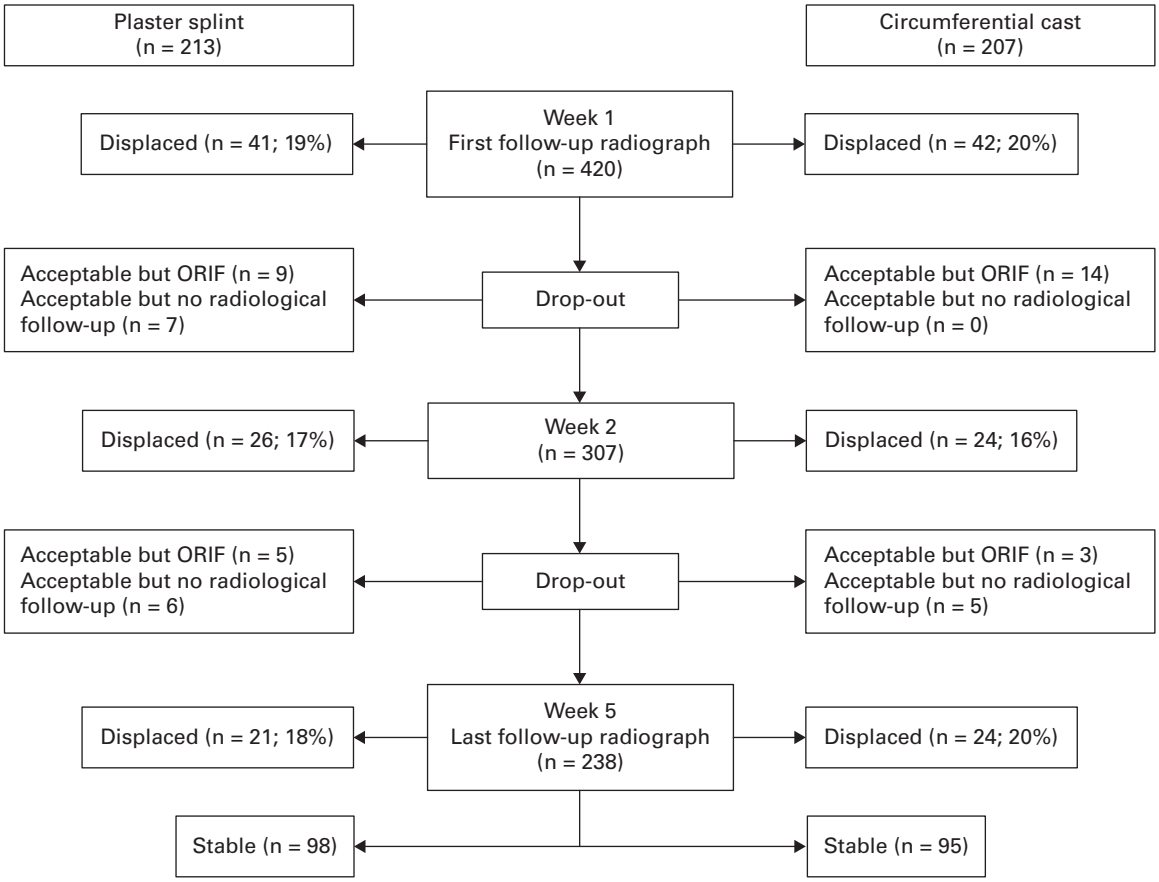


Fig. 3

Flowchart of the rate of redisplacement per intervention during follow-up. ORIF, open reduction and internal fixation.

confounding: baseline age, sex, those who were receiving pharmacological treatment for osteoporosis, the severity of angulation (°), inclination (°), radial shortening (mm), and the intra-articular incongruence of the fracture (defined as a gap or step-off). Age, angulation, inclination, and radial shortening were treated as continuous variables. Sex, osteoporosis, and articular incongruence were added as dichotomous variables. We included a random intercept at the hospital level to account for within-hospital correlation.

Clinical outcomes at three months, complaints relating to the cast, analgesic use, and adverse events were reported as relative frequencies and tested using an independent-samples *t*-test for normally distributed data and a Mann-Whitney U test for non-normally distributed data. We analyzed the NRS, QuickDASH, and PRWHE scores using linear mixed-effects models. In order to evaluate the differences between the groups during follow-up, we included an interaction between the timepoint of follow-up and the randomization. Baseline age and sex were included in the models as independent variables to correct for potential confounding. We considered an unstructured covariance matrix to account for both the within-patient correlation of repeated measurements and the between-patient variation across different hospitals. We assessed the model's underlying assumptions, particularly regarding the normality and homoscedasticity of the residuals. We also report the proportions of loss to follow-up and patterns of missing data, based on individual characteristics and those of the fracture.

Results

A total of 752 patients with a displaced distal radial fracture agreed to participate and were enrolled (Figure 2). From this cohort, 183 patients were to undergo surgery immediately and were excluded. Of 567 conservatively treated fractures, 110 were excluded as they were unacceptably aligned after reduction. The final sample comprised 420 patients, 213 treated with a plaster splint and 207 treated with a circumferential cast, as shown in Table I.

A total of 88 fractures (47%) of those treated with a plaster splint redisplaced compared with 90 (49%) of those treated with circumferential casting. This difference was not significant (adjusted odds ratio (OR) 1.05 (95% confidence interval (CI) 0.65 to 1.70); p = 0.854). A flowchart of the timing of redisplacement during follow-up is shown in Figure 3. Of the 420 patients, 49 (12%) were not included in the analysis of the primary outcome, due either to missing radiographs or having a fracture which was surgically fixed while not having redisplaced. The baseline characteristics of these 49 patients and those of the fracture were not significantly different from

Table II. Range of motion and grip strength at three months' follow-up.

Variable	PS (n = 195)		CC (n = 192)		p-value*
	Mean (SD)	Mean percentage compared with the uninjured side (SD)	Mean (SD)	Mean percentage compared with the uninjured side (SD)	
Palmar flexion	43° (13.1°)	69 (19.5)	45° (13.8°)	72 (20.4)	0.175
Dorsal flexion	48° (15.1°)	79 (22.4)	49° (13.1°)	81 (24.2)	0.772
Radial deviation	16° (6.1°)	89 (45.2)	16° (6.6°)	90 (33.8)	0.235
Ulnar deviation	23° (8.6°)	77 (31.6)	23° (8.6°)	73 (21.4)	0.465
Pronation	71° (13.4°)	92 (14.3)	71° (13.0°)	91 (14.3)	0.807
Supination	67° (15.8°)	84 (18.2)	67° (15.0°)	83 (17.6)	0.648
Grip strength	14 kg (8.4)	54 (23.0)	14 kg (8.0)	55 (24.1)	0.727

*Mann-Whitney U test.
CC, circumferential cast; PS, plaster splint; SD, standard deviation.

those of the patients in the main study (Supplementary Table i). Therefore, missingness was assumed to be independent of the outcome to be measured, and was thus disregarded in the analysis.

Physical examination at three months' follow-up was undertaken in 387 patients: 92% of those treated with a plaster splint and 93% of those treated with a circumferential cast. The mean interval between injury and this appointment was 98 days (74 to 184; standard deviation (SD) 15.7). There were no significant differences between the groups for the ROM, grip strength, opposition of the thumb, or stability of the DRUJ (Table II).

During the first week of treatment, pain at rest was significantly more severe for those treated with plaster splintage than in those treated with a circumferential cast (estimated mean NRS 4.7 (95% CI 4.3 to 5.1) vs 4.1 (95% CI 3.7 to 4.4); p = 0.014) measured using linear mixed-effects models (Table III). During the second week, there were no significant differences in all pain scores. Outcomes of analgesic use and cast comfort were compared between interventions with the chi-squared test. Analgesic use in the first two weeks was comparable (86% (n = 183) in week one in those treated in a plaster splint, and 89% (n = 184) in those treated in a circumferential cast (p = 0.396) and 71% in week two in those treated in a plaster splint, and 62% in those treated in a circumferential cast (p = 0.062)). Regarding the comfort of the cast, there was no difference between the groups in the first week. At two weeks, 12.5% (n = 27) of those treated with plaster splintage reported that their cast was very uncomfortable, compared with 5.1% (n = 11) of those treated in a circumferential cast, though this was not significant (p = 0.073). There were no differences for complaints relating to the cast, such as tightness, swollen fingers, insufficient support, tingling, or itchiness. At two weeks' follow-up, those treated with a plaster splint reported severe complaints of swollen fingers more often, though this was not significant (15.1% (n = 25) vs 9.6% (n = 14); p = 0.082). There were no significant differences in the PROMs, QuickDASH, and PRWHE scores between the groups at any of the timepoints (Table IV).

The adverse events are shown in Table V. The number of unplanned extra visits to hospital during immobilization in a cast did not differ between the groups. The reason for these visits was because of complaints relating to the cast in 37 of those treated with a plaster splint (88%) and 34 of those treated with a circumferential cast (70%). No patients developed compartment syndrome. Seven patients died during the one-year follow-up period, four of whom were treated with a plaster splint, and three in a circumferential cast.

Table III. The numerical rating scale (NRS) for pain, corrected for baseline age and sex. The NRS ranges from 0 to 10, with higher scores indicating more pain.

Variable	Week 1	Week 2
Response rate, %		
Plaster splint	91	87
Circumferential cast	92	91
Mean pain at rest (95% CI)		
Plaster splint	4.7 (4.3 to 5.1)	3.3 (2.9 to 3.7)
Circumferential cast	4.1 (3.7 to 4.4)	3.1 (2.7 to 3.4)
Between-group difference	-0.6 (-1.2 to -0.1)*	0.4 (-0.1 to 0.9)
Mean pain during activity (95% CI)		
Plaster splint	6.6 (6.2 to 6.9)	5.5 (5.1 to 5.8)
Circumferential cast	6.2 (5.8 to 6.5)	5.3 (4.9 to 5.6)
Between-group difference	-0.4 (-0.9 to 0.1)	0.2 (-0.3 to 0.6)
Mean worst pain this week (95% CI)		
Plaster splint	7.6 (7.3 to 8.0)	6.3 (5.9 to 6.6)
Circumferential cast	7.4 (7.1 to 7.8)	6.1 (5.8 to 6.5)
Between-group difference	-0.2 (-0.7 to 0.2)	0.1 (-0.4 to 0.6)
Mean frequency of pain this week (95% CI)		
Plaster splint	6.1 (5.8 to 6.5)	5.1 (4.7 to 5.4)
Circumferential cast	5.7 (5.3 to 6.0)	4.7 (4.4 to 5.1)
Between-group difference	-0.5 (-1.0 to 0.0)	0.1 (-0.3 to 0.6)

*p-value < 0.05.
CI, confidence interval.

Discussion

We found that the type of cast – plaster splinting or a circumferential cast – did not influence the rate of redisplacement in reduced distal radial fractures in adults. Clinical outcomes were comparable between the two groups after three months' follow-up, and QuickDASH and PRWHE scores did not differ significantly at any time during follow-up. The rate of complaints relating to the the cast were also similar between the groups, although those treated with plaster splinting reported slightly more pain during the first week, a difference that was probably not clinically relevant.

In this large cohort, nearly half of the fractures redisplaced. This high rate has been previously reported.[3-5] We found that redisplacement often occurred during the second week or later,

Table IV. The abbreviated version of the Disabilities of the Arm, Shoulder and Hand and Patient-Rated Wrist/Hand Evaluation scores during follow-up, corrected for baseline age and sex. The scores range from 0 to 100, with higher scores indicating a greater level of disability, pain, and functional disability.

Variable	6 weeks	3 months	6 months	12 months
Response rate, %				
Plaster splint	92	94	86	87
Circumferential cast	89	93	86	91
QuickDASH (95% CI)				
Plaster splint	46 (44 to 49)	29 (27 to 32)	18 (16 to 21)	16 (13 to 18)
Circumferential cast	47 (44 to 49)	28 (25 to 31)	19 (16 to 21)	16 (13 to 18)
Between-group difference	0.2 (-3.3 to 3.8)	-1.6 (-4.7 to 1.5)	0.2 (-3.7 to 4.0)	-0.5 (-4.5 to 3.6)
PRWHE (95% CI)				
Plaster splint	61 (58 to 64)	39 (36 to 42)	24 (21 to 27)	19 (16 to 22)
Circumferential cast	60 (57 to 63)	37 (34 to 40)	23 (20 to 26)	19 (16 to 22)
Between-group difference	-0.6 (-4.9 to 3.8)	-1.6 (-5.4 to 2.2)	0.1 (-4.6 to 4.8)	0.5 (-4.4 to 5.4)

CI, confidence interval; PRWHE, Patient-Rated Wrist/Hand Evaluation; QuickDASH, abbreviated version of the Disabilities of the Arm, Shoulder and Hand.

emphasizing the need for regular radiological review during immobilization.[3,4,20]

No clinically relevant differences were found in terms of pain or discomfort in the cast. However, some findings are worth highlighting. The rate of extra hospital visits due to complaints relating to the cast was high in both groups, and casts were generally found to be uncomfortable. Future research should focus on designing more comfortable methods of immobilization. Patients treated with a circumferential cast reported significantly less pain in the first week, and fewer severe complaints such as swelling of the fingers in the second week. It is generally believed that circumferential casting causes increased pain and swelling of the fingers due to the limited space available for soft-tissue swelling. Overall, the results suggest that circumferential casting may be as safe and effective as splinting, as was also supported by a recent retrospective trial.[8] Lastly, there was an increased rate of CRPS and carpal tunnel syndrome in the circumferential casting group. Although this was clearly an important finding, the rate was not large enough to assume a causal relation with the type of casting. Future research should further explore this possible relationship.

The clinical outcomes at three months were generally good and in line with previous studies involving conservatively treated distal radial fractures.[21,22] The ROM of the wrist varied between 69% and 92% of that of the unaffected side. Grip strength was most affected in both groups, being a mean of 54% and 55% of those of the unaffected side, respectively. These results are comparable to those of previous smaller studies in which grip strength varied between 57% and 68% of the unaffected side, at the three-month follow-up.[21,23,24]

The QuickDASH and PRWHE scores did not differ significantly between the groups at any time during follow-up. The scores were relatively high after six weeks and comparable with those reported in previous randomized trials.[21,25] These high scores represent a large burden for patients. This finding, combined with the high pain scores in the first weeks, emphasizes the importance of managing patients' expectations from the beginning of the treatment, as previously suggested.[26] The PROMs improved most during the first six months but slight improvements were seen beyond six months, as also previously reported.[21,25,27] In order to determine whether patients were satisfied with the final outcome, the results can be compared using the patient-acceptable symptom state (PASS) of both the QuickDASH and PRWHE scores. The QuickDASH PASS is estimated to be < 15.9 and the PRWHE PASS is < 22.[28,29] We found that QuickDASH and PRWHE scores were below the PASS thresholds at one-year follow-up, suggesting that patients were satisfied with the outcome.

This trial has strengths. First, it is, to our knowledge, the largest randomized controlled trial (RCT) involving patients with a conservatively treated reduced distal radial fracture. Second, due to the cluster randomization at the hospital level and the large number of participating hospitals (n = 10), it offers a reliable and generalizable representation of the patients who sustain this fracture. It could be argued that randomization at the patient level would be more appropriate. We decided not to do this, as the 24-hour-a-day availability of the emergency

Table V. Serious adverse events.

Event	Plaster splint	Circumferential cast
Patients, n	213	207
Serious adverse events, n (%)		
Redisplaced and ORIF*	25 (28)	24 (27)
Acceptably aligned and ORIF†	17 (17)	18 (19)
Implant removal	1 (0.5)	2 (1)
Corrective osteotomy	4 (2)	2 (1)
CTS release surgery	0	4 (2)
Compartment syndrome	0	0
Adverse events, n (%)		
Unplanned extra hospital visits	42 (20)	48 (23)
Cast being replaced once	14 (7)	8 (4)
Dysaesthesia‡	48 (25)	53 (28)
CRPS‡	1 (0.5)	5 (2)
CTS	4 (2)	8 (4)

*Frequency in redisplaced sample (PS: 88, CC: 90).
†Frequency in acceptably aligned sample (PS: 98 CC: 95)
‡Concerns subset of sample who participated in physical examination (PS: 195, CC: 192).
CC, circumferential casting; CRPS, complex regional pain syndrome; CTS, carpal tunnel syndrome; ORIF, open reduction and internal fixation; PS, plaster splinting.

department leads to a high number of treating physicians, and many violations of protocol could be expected. Cluster randomization at the hospital level allowed correction for confounding by casting experience with one of the two interventions, and secures a comparable case mix in both groups. Third, as the CAST study was a pragmatic trial, the results are applicable to daily practice. Lastly, our study had very little missing data. Only 18 patients (4%) were lost to follow-up for the analyses of the primary outcome; 387 patients (92%) had a physical examination, and the response rate for questionnaires was between 86% and 94% at different times during the follow-up visits.

The trial, however, has limitations. First, we underestimated the rate of redisplacement in our sample size calculations. These were based on the rate of redisplacement in our previous retrospective study, which was 29% for those treated with a plaster splint and 17% for those treated with a circumferential cast.[10] However, follow-up in that cohort was only to one week. In retrospect, we should have searched the literature for studies with comparable follow-up, as the follow-up in this prospective design was extended to the time of removal of the cast at five weeks. About 20% of the fractures redisplaced during the first week, in line with previous results,[10] but many redisplaced later, which we did not take into consideration. Second, due to the many unacceptably aligned fractures after reduction, which had to be excluded, we did not reach our target sample size.

All radiographs were anonymously obtained from the patients' electronic records after the inclusion phase, to ensure anonymity and reduce the workload of the radiology departments. We did not consider beforehand that this many patients would be lost due to inadequate reduction, and we did not account for this in our protocol. It would have been impossible to prevent these exclusions beforehand, since the intervention is applied immediately after closed reduction, before the alignment is established radiologically. However, the differences between the groups for the main outcomes were small and non-significant. It is unlikely that a larger sample would have resulted in significant and clinically important differences between the types of casting.

Third, the Dutch guidelines for the management of distal radial fractures were updated at the end of the inclusion phase of the trial.[14] Unacceptable dorsal angulation was changed from ≥ 15° to ≥ 10°. We decided to analyze results according to the previous guidelines because these thresholds were used by clinicians at the time of inclusion.

Finally, according to Dutch privacy law, it is forbidden to screen the electronic records of patients who are not included in the analysis, and thus we cannot confirm the total number of potentially eligible patients. The decision to invite a patient to participate could therefore have been subject to treatment bias.

In conclusion, in this large prospective RCT, we found that circumferential casting was not superior to plaster splinting in reducing the rate of redisplacement in adults with a reduced distal radial fracture. We also found no significant differences in clinical outcomes after three months, or in PROMs or adverse events up to one year after injury. We conclude that both casting techniques are equally effective and that the decision to use either should be based on the preference of the person applying the cast. The high rate of redisplacement, and the high number of extra hospital visits and complaints relating to the cast, should be considered during shared decision-making when choosing between conservative and primary surgical treatment. Further research should focus on identifying modifiable risk factors that predict redisplacement of the fracture, and optimizing treatment to reduce the high rate of failed initial reductions.



Take home message

- We studied if casting type affects the redisplacement risk of reduced adult distal radius fractures, and if casting type influences patient-reported outcomes.
- The CAST study found that circumferential casting was not superior to plaster splinting in reducing the fracture redisplacement risk.
- No statistically significant differences in clinical outcomes, patient-reported outcomes, or adverse events up to one year were found.

Social media

Follow P. Miranda Afonso on X @p_m_afonso
Follow J. A. N. Verhaar on X @janverhaar

Supplementary material



The list of recruitment hospitals and a table with descriptions of the drop-out population.

References

1. **Bruce KK**, **Merenstein DJ**, **Narvaez MV**, **et al**. Lack of agreement on distal radius fracture treatment. *J Am Board Fam Med*. 2016;29(2):218–225.
2. **Chung KC**, **Shauver MJ**, **Yin H**, **Kim HM**, **Baser O**, **Birkmeyer JD**. Variations in the use of internal fixation for distal radial fracture in the United States medicare population. *J Bone Joint Surg Am*. 2011;93-A(23):2154–2162.
3. **Jung H-W**, **Hong H**, **Jung HJ**, **et al**. Redisplacement of distal radius fracture after initial closed reduction: analysis of prognostic factors. *Clin Orthop Surg*. 2015;7(3):377–382.
4. **Mackenney PJ**, **McQueen MM**, **Elton R**. Prediction of instability in distal radial fractures. *J Bone Joint Surg Am*. 2006;88-A(9):1944–1951.
5. **Makhni EC**, **Ewald TJ**, **Kelly S**, **Day CS**. Effect of patient age on the radiographic outcomes of distal radius fractures subject to nonoperative treatment. *J Hand Surg Am*. 2008;33(8):1301–1308.
6. **Alemdaroğlu KB**, **Iltar S**, **Aydoğan NH**, **Say F**, **Kilinç CY**, **Tiftikçi U**. Three-point index in predicting redisplacement of extra-articular distal radial fractures in adults. *Injury*. 2010;41(2):197–203.
7. **Chaudhury S**, **Hazlerigg A**, **Vusirikala A**, **Nguyen J**, **Matthews S**. Lower limb intracast pressures generated by different types of immobilisation casts. *World J Orthop*. 2017;8(2):170–177.
8. **Jorgensen A**, **Kahan J**, **Moran J**, **Halim A**. Assessment of complications associated with casting of acute distal radius fractures in adults. *Am J Emerg Med*. 2022;56:124–126.
9. **Ekwall A**, **Carlberg E**, **Palmberg G**, **Sloberg R**. An audit of complications of fiberglass cast and hybrid cast for fractures of the foot, ankle and forearm in a Swedish emergency department. *Int J Orthop Trauma Nurs*. 2018;31:32–34.
10. **Berger AC**, **Barvelink B**, **Reijman M**, **et al**. Does circumferential casting prevent fracture redisplacement in reduced distal radius fractures? A retrospective multicentre study. *J Orthop Surg Res*. 2021;16(1):722.
11. **Handoll HH**, **Madhok R**. Conservative interventions for treating distal radial fractures in adults. *Cochrane Database Syst Rev*. 2003;2:CD000314.
12. **Barvelink B**, **Reijman M**, **Schep NWL**, **et al**. The CAST study protocol: a cluster randomized trial assessing the effect of circumferential casting versus plaster splinting on fracture redisplacement in reduced distal radius fractures in adults. *BMC Musculoskelet Disord*. 2021;22(1):370.
13. **Baker SP**, **O'Neill B**, **Haddon W**, **Long WB**. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*. 1974;14(3):187–196.
14. **No authors listed**. [Distal radius fractures]. Federatie Medisch Specialisten. 2021. https://richtlijnendatabase.nl/richtlijn/distale_radiusfracturen/startpagina_-_distale_radiusfracturen.html (date last accessed 28 May 2024). [Website in Dutch].
15. **Kapandji A**. [Clinical test of apposition and counter-apposition of the thumb.] *Ann Chir Main*. 1986;5(1):67–73. [Article in French].

16. **Gofton WT**, **Gordon KD**, **Dunning CE**, **Johnson JA**, **King GJW**. Soft-tissue stabilizers of the distal radioulnar joint: an in vitro kinematic study. *J Hand Surg Am*. 2004;29(3):423–431.
17. **Harden NR**, **Bruehl S**, **Perez R**, **et al**. Validation of proposed diagnostic criteria (the "Budapest Criteria") for Complex Regional Pain Syndrome. *Pain*. 2010;150(2):268–274.
18. **Hudak PL**, **Amadio PC**, **Bombardier C**, **et al**. Development of an upper extremity outcome measure: The DASH (disabilities of the arm, shoulder, and head). [corrected]. *Am J Ind Med*. 1996;29(6):602–608.
19. **MacDermid JC**, **Turgeon T**, **Richards RS**, **Beadle M**, **Roth JH**. Patient rating of wrist pain and disability: a reliable and valid measurement tool. *J Orthop Trauma*. 1998;12(8):577–586.
20. **Sirniö K**, **Leppilahti J**, **Ohtonen P**, **Flinkkilä T**. Early palmar plate fixation of distal radius fractures may benefit patients aged 50 years or older: a randomized trial comparing 2 different treatment protocols. *Acta Orthop*. 2019;90(2):123–128.
21. **Mulders MAM**, **Walenkamp MMJ**, **van Dieren S**, **Goslings JC**, **Schep NWL**, **VIPER Trial Collaborators**. Volar plate fixation versus plaster immobilization in acceptably reduced extra-articular distal radial fractures: a multicenter randomized controlled trial. *J Bone Joint Surg Am*. 2019;101-A(9):787–796.
22. **Eraslan U**, **Usta H**, **Demirkan AF**, **Kitis A**, **Baskoc A**. Association between perceived and objective hand-wrist function in distal radius fracture. *Hand Surg Rehabil*. 2022;41(5):582–588.
23. **Arora R**, **Lutz M**, **Deml C**, **Krappinger D**, **Haug L**, **Gabl M**. A prospective randomized trial comparing nonoperative treatment with volar locking plate fixation for displaced and unstable distal radial fractures in patients sixty-five years of age and older. *J Bone Joint Surg Am*. 2011;93-A(23):2146–2153.
24. **Sharma H**, **Khare GN**, **Singh S**, **Ramaswamy AG**, **Kumaraswamy V**, **Singh AK**. Outcomes and complications of fractures of distal radius (AO type B and C): volar plating versus nonoperative treatment. *J Orthop Sci*. 2014;19(4):537–544.
25. **Plant CE**, **Ooms A**, **Cook JA**, **et al**. Radiological outcomes following surgical fixation with wires versus moulded cast for patients with a dorsally displaced fracture of the distal radius: a radiographic analysis from the DRAFFT2 trial. *Bone Jt Open*. 2024;5(2):132–138.
26. **Quax MLJ**, **Krijnen P**, **Schipper IB**, **Termaat MF**. Managing patient expectations about recovery after a distal radius fracture based on patient reported outcomes. *J Hand Ther*. 2023;36(4):903–912.
27. **Hassellund SS**, **Williksen JH**, **Laane MM**, **et al**. Cast immobilization is non-inferior to volar locking plates in relation to QuickDASH after one year in patients aged 65 years and older: a randomized controlled trial of displaced distal radius fractures. *Bone Joint J*. 2021;103-B(2):247–255.
28. **Stjernberg-Salmela**, **Karjalainen T**, **Juurakko J**, **et al**. Minimal important difference and patient acceptable symptom state for the Numerical Rating Scale (NRS) for pain and the Patient-Rated Wrist/Hand Evaluation (PRWHE) for patients with osteoarthritis at the base of thumb. *BMC Med Res Methodol*. 2022;22(1):127.
29. **Hubbard J**, **Rogers MJ**, **Cizik AM**, **Zhang C**, **Presson AP**, **Kazmers NH**. Establishing the patient acceptable symptom state in a nonshoulder hand and upper extremity population for the QuickDASH and PROMIS UE computer adaptive tests. *J Hand Surg Am*. 2022;49(3).

Author information:
B. Barvelink, MD, PhD Candidate
M. Reijman, PhD, Associate Professor
S. Smidt, MD, Orthopaedic Resident
J. A. N. Verhaar, MD, PhD, Em. Professor of Orthopaedics
J. W. Colaris, MD, PhD, Orthopaedic Surgeon
Department of Orthopaedics and Sports Medicine, Erasmus MC, University Medical Center Rotterdam, Rotterdam, Netherlands.

P. Miranda Afonso, MSc, Statistician, Department of Biostatistics, Erasmus MC, University Medical Center Rotterdam, Rotterdam, Netherlands; Department of Epidemiology, Erasmus MC, University Medical Center Rotterdam, Rotterdam, Netherlands.

Author contributions:
B. Barvelink: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft.
M. Reijman: Conceptualization, Data curation, Funding acquisition, Project administration, Supervision, Writing – review & editing.
S. Smidt: Data curation, Formal analysis, Investigation, Writing – review & editing.
P. Miranda Afonso: Formal analysis, Methodology, Writing – review & editing.
J. A. N. Verhaar: Conceptualization, Funding acquisition, Project administration, Supervision, Writing – review & editing.
J. W. Colaris: Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – review & editing.

Funding statement:
The authors disclose receipt of the following financial or material support for the research, authorship, and/or publication of this article: a grant for conducting the CAST study from ZonMw, a Dutch organization for health research and care innovation. ZonMw had no role in the study design, data collection, data analysis, data interpretation, or writing of the report (grant number: 852002021).

Data sharing:
The data that support the findings for this study are available to other researchers from the corresponding author upon reasonable request.

Acknowledgements:
The authors would like to thank Eline van Es for allocating the initial starting treatments amongst the participating hospitals.

Ethical review statement:
All patients included gave written informed consent to participate in the study. The medical ethical board of the Erasmus MC University Medical Center approved the trial in 2019 (MEC-2019-0528).

Open access funding:
The open access fee for this article was funded by a ZonMw grant (project number: 852002021). ZonMw is a Dutch organization for health research and care innovation. ZonMw was not involved in the study design, data collection, analysis and interpretation of data, nor in writing the manuscript.

Open access statement:
This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (CC BY-NC-ND 4.0) licence, which permits the copying and redistribution of the work only, and provided the original author and source are credited. See https://creativecommons.org/licenses/by-nc-nd/4.0/

Trial registration number:
ClinicalTrials.gov (NL8311).

This article was primary edited by J. Scott.