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Original Research

Are Routine Post–Cast Removal Radiographs and a Second Follow-up Appointment Necessary in the Management of Nondisplaced or Minimally Displaced Distal Radius Fractures?

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ABSTRACT

Background: The effectiveness of routine follow-up radiographs and appointments after cast removal when managing minimally displaced pediatric distal radius fractures has not been conclusively proven. This study aims to assess how often follow-up appointments and radiographs taken after cast removal alter management of patients with minimally displaced distal radius fractures.

Methods: A single-center retrospective chart review was conducted on patients under 18 years of age with minimally displaced distal radius fractures between 2017 and 2023. Demographic information, fracture characteristics, time to follow-up, and each appointment outcome were recorded. A change in patient management following post–cast removal radiographs was defined as a need for closed reduction, operative intervention, or prolonged immobilization. The second follow-up appointment was considered to modify management if it necessitated a physical therapy referral or an additional office visit. Unscheduled appointments and any changes in fracture alignment during follow-up visits were also noted.

Results: Ninety-three patients met the inclusion criteria; 1.1% (1 of 93) of patients had their management changed following their post–cast removal radiographs according to our criteria. One patient was indicated for prolonged immobilization for a visible fracture line; no patients were indicated for surgery or closed reduction. Thirty-eight patients who underwent cast removal attended their 2nd follow-up appointment; 2.6% (1 of 38) of patients had their management changed according to our criteria. One patient required an additional follow-up appointment for a physeal check; no patient required a physical therapy referral. Two patients had an unscheduled appointment after discharge of care, due to parental desire of recovery confirmation before returning to gym play. No changes in fracture alignment were observed during any follow-up radiographs.

Conclusions: This study suggests that post–cast removal radiographs and second follow-up appointments rarely alter management of minimally displaced distal radius fractures. Limiting unnecessary visits and imaging could reduce costs and ease the burden on patients and families.

Key Concepts:

1) Post–cast removal radiographs rarely altered management for minimally displaced pediatric distal radius fractures.
2) Only 1.1% of patients required prolonged immobilization, with no cases needing surgery or closed reduction.
3) Second follow-up appointments infrequently changed management, with only 2.6% of patients requiring an additional visit.
4) Unscheduled visits were primarily driven by parental concerns rather than clinical necessity.
5) No changes in fracture alignment were observed in any follow-up radiographs.

Level of Evidence: Level IV – case series

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Introduction

Distal radius fractures are frequently occurring injuries among children and comprise 20% to 30% of all pediatric orthopaedic fractures, making it the most common type of fracture in children [1,2]. Among pediatric patients, these fractures most often affect males within the 10- to 14-year age range [3]. These fractures typically occur when a child uses an outstretched hand to break a fall, leading to a fracture at the distal end of the radius [4]. Most individuals with nondisplaced or minimally displaced distal radius fractures (MDRFs) can undergo nonsurgical treatment using only short-arm cast immobilization, leading to excellent functional outcomes. Typically, patients wear a short-arm cast for four to six weeks followed by radiographic and clinical monitoring to ensure proper healing and restoration of range of motion (ROM), before resuming normal activity [5]. The necessity of standard radiographs in managing pediatric fractures is under scrutiny. Bochang et al. found that post–cast removal radiographs provided no added clinical benefit for closed forearm fractures in children [6]. Weil et al. demonstrated that follow-up radiographs altered the management of distal radius fractures in only 2.6% of cases [7]. While the effectiveness of regular follow-up x-rays in managing distal radius fractures has been well studied, the collective impact of follow-up radiographs and office visits on managing these fractures in pediatric patients remains undetermined. This study aims to assess the impact of both routine radiographs and follow-up appointments after cast removal in managing minimally displaced distal radius fractures in pediatric patients. We hypothesize that post–cast removal imaging and follow-up visits will seldom alter the management of these fractures.

Materials and methods

Patient selection

This retrospective study examined pediatric patients with MDRFs treated at a single Level 1 trauma center between 2017 and 2023. After obtaining institutional review board approval, patients were identified using the following Current Procedural Terminology (CPT) codes: 25600 (closed treatment of distal radial fracture [e.g., Colles or Smith type] or epiphyseal separation, with or without fracture of ulnar styloid; without manipulation); International Classification of Diseases, Ninth Revision (ICD-9) code: 813.42 (Other closed fractures of distal end of radius [alone]); and ICD-10 S52.XXX (fracture of forearm) and S59.XXX (other and unspecified injuries of elbow and forearm), with the latter digits providing information regarding laterality and specific fracture characteristics.

Inclusion and exclusion criteria

Patients were included if they were under the age of 18 years, had documentation of a nondisplaced or minimally displaced distal radius fracture treated with immobilization, and received radiographs at their first follow-up. For the purposes of this study, distal diaphyseal fractures were included in this study. Additionally, Colles, Smith, greensticks (with minimal angulation), and complete bicortical fractures (with nondisplacement or minimal displacement) were included. Fractures were classified as greenstick when the tension-side cortex was fractured but the opposite side remained intact and as complete bicortical when both cortices were fractured in a single view. Fractures were classified as Colles fractures if they exhibited dorsal displacement or angulation of the distal fracture fragment. In contrast, Smith fractures were identified by volar displacement or angulation of the distal fragment. Minimal displacement was defined using Lindstrom's criteria, including dorsal angulation of less than 15°, volar tilt under 20°, radial inclination below 15°, ulnar variance of less than 5 mm, and an articular step-off measuring less than 2 mm [23]. Exclusion criteria included buckle fractures, displaced distal radius fractures, ulnar injury, bilateral distal radius fractures, failure to follow-up with their provider, and fractures that required manipulation or operative intervention based on initial radiographs prior to immobilization.

Data collection

Electronic medical records were examined at the initial orthopaedic consultation. Collected demographic data included age, biological sex assigned at birth, body mass index (BMI), hand dominance, side of injury, age at the time of injury, and history of prior distal radius fractures. Details of the fractures were documented, such as the time from injury to presentation, injured hand, physeal involvement, radiologic fracture classification, ulnar involvement, tenderness to palpation (TTP), ROM, and type of initial immobilization. Physeal fractures were classified according to the Salter-Harris (SH) classification system [25] (i.e., SH1, SH2, SH3, SH4, and SH5), nonphyseal fractures were classified as "Greenstick," "Colles," "Smith," or "complete bicortical."

Initial presentation and treatment

The initial presentation location was noted, including direct visits to our medical center, transfers from other facilities, and evaluations at urgent care or outside hospitals. The type of initial immobilization (short-arm cast, long-arm cast, or splint) was also recorded. The diagnosis was confirmed through orthopaedic clinic documentation, and treatment decisions along with the frequency of follow-up were determined by the pediatric orthopaedic surgeon in charge.

First follow-up: cast removal appointment

Each chart was reviewed at the scheduled appointment for cast removal. At the cast removal appointment, radiographs (routinely administered) were considered to alter patient management if clinical documentation indicated that a closed reduction or prolonged immobilization was necessary, or if operative intervention was required. Prolonged immobilization was defined as a need for additional cast or sugar-tong splint immobilization time following a minimum of 21 days (approximately 3 weeks) for recovery from the time of the initial immobilization to the first follow-up appointment. Transition to a Velcro splint after cast removal was not considered prolonged immobilization. Patients who required continued immobilization due to inadequate time from injury to their first follow-up appointment (less than 3 weeks) were not included in the analysis assessing changes in management, as this did not reflect a true alteration in clinical decision-making by our criteria.

Follow-up appointments after discontinuation of immobilization

Follow-up appointments after cast removal for ROM evaluation were also reviewed. Documented ROM was recorded for each patient, as determined via visual inspection by the evaluating provider. Similar to the initial orthopaedic evaluation, information collected from these follow-up appointments included days from the initial casting, whether radiographs were taken (performed on a case-by-case basis), any changes in fracture alignment, TTP, and ROM. The appointment was considered to change clinical management if it resulted in a formal physical therapy referral being given, or if an additional follow-up appointment was recommended. Any additional follow-up appointments within the study period that were not scheduled, and occurred after the first post–cast removal appointment during the study period were also recorded.

Statistical analysis

Continuous variables were evaluated using mean and standard deviation and categorical variables were evaluated with count and percentage.

Results

A total of 366 patients under the age of 18 years who had sustained distal radius fractures were identified through CPT and ICD codes. Of these patients, 69 had an associated ulnar injury. Five patients had a bilateral distal radius fracture, 25 had buckle (i.e., Torus) fractures, and 6 had fractures that required manipulation or operative intervention prior to the first follow-up. A total of 121 patients had inadequate follow-up or incomplete identifying information, and 29 patients did not receive radiographs at their first follow-up visit. (Fig. 1). In total, 111 patients received radiographic evaluation at their first follow-up appointment after being immobilized and thus met inclusion criteria for this study. The average age of patients at the time of injury was 10.7 ± 3.8 years (range: 3-18 years) and 31 patients (27.9%) were female. The average BMI was 22.6 ± 5.2 kg/m^2. Demographic information is summarized in Table 1. Most patients presented to a hospital for the initial evaluation—32.3% directly to our hospital. A total of 56.7% of patients presented at an outside hospital for the initial evaluation and 11.0% of patients presented at an urgent care. A short-arm cast was utilized as the initial immobilization in 79.3% of patients (Table 2). Seven patients who received splints as their initial immobilization were later casted at their first clinic follow-up. The average time from injury to presentation at our hospital was 5.53 ± 5.6 days. The average time

Table 1.
Demographic and clinical characteristics of the study population.

Demographic information	
Continuous variables	**Mean (SD)**
Age	10.7 (3.8)
BMI	22.6 (5.2)
Categorical variables	**N (%)**
Sex (n = 111)	
Male	80 (72.1)
Female	31 (27.9)
Hand dominance (n = 65)	
Right	55 (84.6)
Left	10 (15.4)

BMI, *body mass index*; *SD*, *standard deviation*.
This table presents the demographic and clinical characteristics of the patients included in the study. The data include the average age and body mass index (BMI) of the participants, as well as the distribution of gender (number of males and females) and hand dominance (number of patients with right-hand versus left-hand dominance).

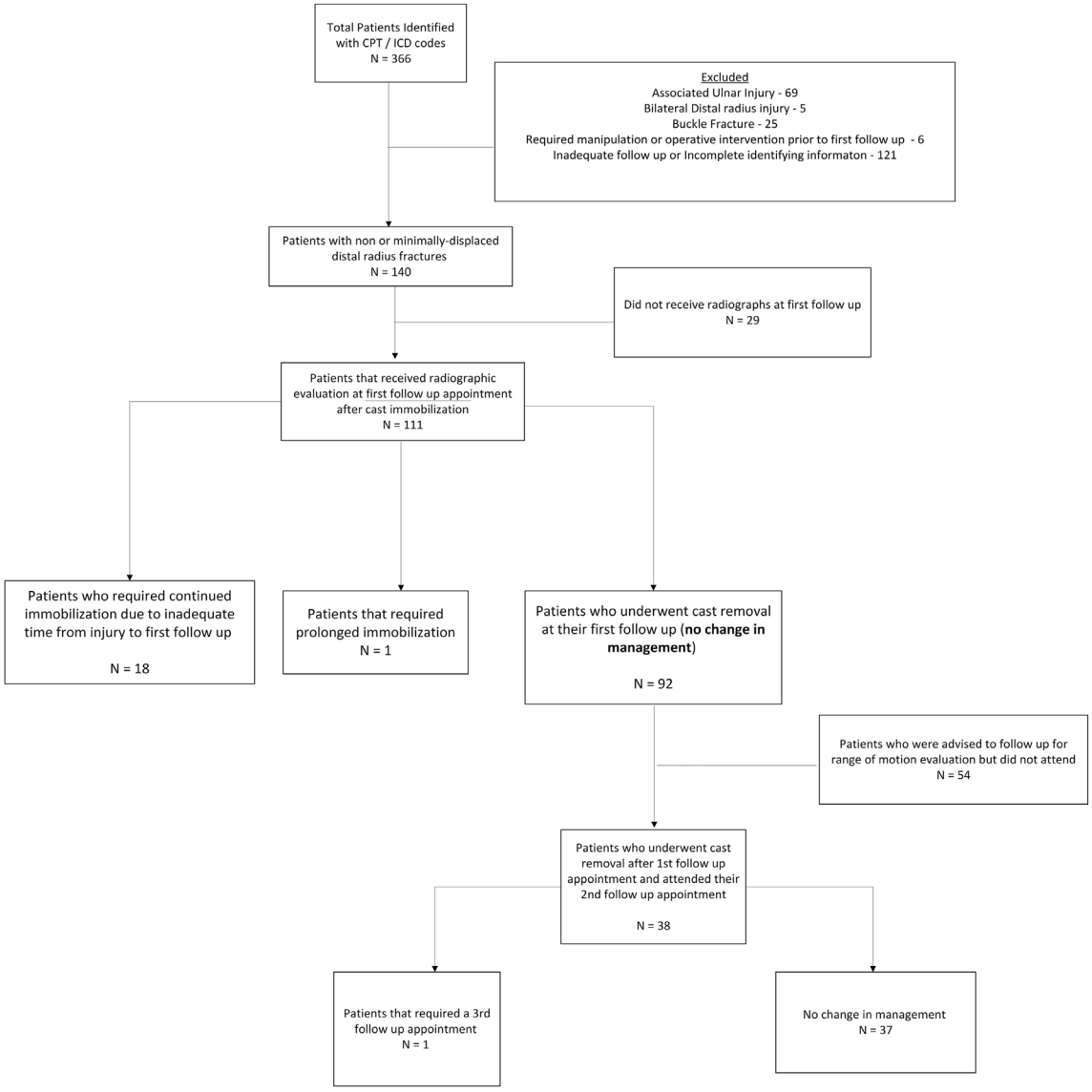

Figure 1. Patient selection flow chart. CPT: Current Procedural Terminology; ICD: International Classification of Diseases.

Table 2
Injury and clinical characteristics at the initial presentation and first follow-up.

Injury information	
Injured side (n = 111)	**N (%)**
Right	54 (48.6)
Left	57 (51.4)
Salter-Harris (SH) classification of physeal injuries (n = 12 out of 111)	
SH 1	5 (4.5)
SH 2	6 (5.4)
SH 3	1 (0.9)
Classification of non-physeal injuries (n = 99 out of 111)	
Colles fracture	29
Smith fracture	20
Greenstick fracture	34
Complete bicortical fracture	16
Initial immobilization (n = 111)	
Short-arm cast	88 (79.3)
Long-arm cast	8 (7.2)
Splint	15 (13.5)
Tenderness to palpation on the initial presentation (n = 111)	
TTP present	99 (89.2)
TTP absent	10 (9.0)
Unknown	2 (1.8)
Range of motion on the initial presentation (n =111)	
Limited range of motion	52 (46.5)
Full range of motion	45 (40.9)
Unknown	14 (12.6)
Tenderness to palpation on the first follow-up (n = 111)	
TTP present	29 (26.1)
TTP absent	72 (64.9)
Unknown	10 (9.0)
Range of motion on the first follow-up (n = 111)	
Limited range of motion	13 (11.7)
Full range of motion	64 (57.7)
Unknown	34 (30.6)

TTP, tenderness to palpation.
This table provides an overview of injury characteristics and clinical findings among patients, including the distribution of injuries by side, radiographic fracture classification, and initial immobilization methods. Additionally, fracture angulation types, as well as tenderness to palpation (TTP) and range of motion (ROM) assessments at both initial presentation and first follow-up are demonstrated.

from the initial casting to the first follow-up for the entire cohort was 26.6 ± 11.9 days (range: 4-49).

Changes to management at the first follow-up (cast removal appointment)

Eighteen patients required continued immobilization due to insufficient time between injury and their first follow-up (average: 9.5 ± 2.6 days; range: 4-11) and were excluded from the analysis of management changes. Among the remaining patients, none were indicated for operative fixation, or a closed reduction based on radiographs taken at their scheduled cast-removal appointment. One patient with a nondisplaced complete bicortical fracture was indicated for prolonged immobilization due to their fracture line still being visible on the radiograph. Casts were removed at this first follow-up appointment for the remaining 92 patients (average time from injury to the first follow-up: 29.9 ± 9.0 days; range: 20-49). According to our criteria, 1.1% of the 93 patients with sufficient immobilization time (at least 3 weeks) who presented for their scheduled cast removal appointment had a change in management following post–cast removal radiographs.

Changes to management following the second follow-up appointment

Of the 92 patients who underwent cast removal at their first follow-up appointment and were advised to return for a second follow-up, only 38 attended the second follow-up appointment (41.3%). Of the patients who did not attend their second follow-up, two patients had nondisplaced fractures with physeal involvement (SH2). The average number of days from the initial casting to the second follow-up appointment was 55.3 ± 38.7 days (range: 28-149). No patients were indicated for a physical therapy referral following their second appointment; a third follow-up appointment was indicated for one patient due to need for a physeal check. A total of 1 out of 38 patients (2.6%) had their management changed following their second follow-up visit according to our criteria. Two patients had an unscheduled presentation to the clinic after discharge of care; one patient's parent had noticed a bump on the distal left forearm and came in for medical opinion. The other patient's mother desired medical confirmation of recovery prior to removing her child's brace. Twenty-eight out of 38 patients received radiographs at this second follow-up appointment (14 complete bicortical, 10 Greenstick, 1 SH-3, 1 SH-1, and 2 Colles). No patients had a change in fracture alignment or angulation noted during any post–cast removal radiographs.

Discussion

To our knowledge, this study is the first to investigate the impact of post–cast removal follow-up appointments in addition to radiographs on management of MDRFs in pediatric patients. There is a growing trend in using conservative measures to manage MDRFs [4,8]. Routine radiographs are commonly used to monitor healing, though their necessity is increasingly being questioned [7]. In certain cases, a patient's cast can be removed once the fracture site is no longer painful [4]. Follow-up visits are recommended to monitor healing and ensure proper alignment. These visits are performed to determine if changes in the treatment plan, such as prolonging cast wear or surgical intervention, are needed. In this study, we assessed how often radiographs taken after cast removal altered patient treatment and examined the necessity of routine follow-up appointments in managing these fractures. Only 1.1% of patients in our study had a change in management following the initial follow-up radiographs, and only 2.6% had a change in management after a second follow-up visit. Out of the patients who had adequate immobilization time and attended their first follow-up appointment, none required operative fixation or closed reduction, and no changes in fracture alignment were observed. These findings suggest that the routine administration of post–cast removal radiographs may not be necessary for minimally displaced fracture types. While it is common practice to obtain follow-up imaging for fractures such as nondisplaced complete bicortical or minimally displaced greenstick fractures—given their perceived instability and higher risk of late displacement compared to buckle fractures—there may be value in reconsidering the routine use of these radiographs at the first follow-up appointment. In cases where patients and families have adhered to rehabilitation protocols and sufficient time has elapsed since the injury, imaging could instead be performed selectively. A case-by-case approach may be more appropriate, with radiographs reserved for instances of clinical concern, suspected

misalignment, noncompliance with protocol, or when families request confirmation of healing.

Complications associated with MDRFs in children are relatively rare, but they can include malunion, growth disturbances, and residual deformities [9,10]. These complications occur infrequently due to the excellent healing capacity and bone remodeling potential in pediatric patients [11–13]. The incidence of complications requiring operative intervention is exceptionally low, with some studies reporting less than 5% of cases necessitating surgical correction [8]. Evidence suggests that many of these fractures heal without complication and that reducing unnecessary follow-up appointments may lower healthcare costs and ease the burden on patients and families.

Our findings align with established literature on the necessity of routine imaging in distal radius fractures. In adult patients with distal radius fractures, Weil et al. found routine radiographs during follow-up to seldom affect clinical decision-making, despite being the customary practice [7]. Similarly, Eastley et al. demonstrated that eliminating routine radiographs from guidelines would not result in missed late displacements for extra-articular distal radius fractures [14]. Even with physeal involvement, routine radiographs rarely alter the management of MDRFs. In asymptomatic children with uncomplicated SH 2 fractures of the distal radius, the detection of a physeal bridge, and subsequent potential growth disturbance, on follow-up radiographs was found to be rare, but the financial burden of the said follow-up radiographs is significant [15]. Conversely, SH types 3 and 4, which are intra-articular fractures that commonly affect multiple layers of the physis, increase the risk of physeal arrest. If displaced, these fractures require follow-up and monitoring for at least 1 year or until the patient is skeletally mature [24].

The utility of radiographs for other upper extremity fracture types has also been studied, highlighting that routine radiographs minimally impact clinical decision-making but elevate healthcare costs [16–18]. Nihalani et al. found that routine imaging did not alter the management of type 1 supracondylar fractures and resulted in an additional cost of $752.49 per patient [18]. Aside from financial strain, routine imaging poses potential harm to pediatric patients due to the risks associated with radiation exposure. Efforts should be made to minimize this exposure whenever possible [19–21].

Lastly, this study also examined the overall impact of follow-up appointments after cast treatment is discontinued, setting it apart from previous studies on this topic. At an average of 54 days post the initial casting, none of our patients were indicated for a physical therapy referral, and only one was recommended an additional follow-up for a physeal check. A mere 2.6% of patients had their management changed because of routine follow-up. Additionally, only two unscheduled appointments were made after discharge solely for parental reassurance before returning to physical activities, with no changes in fracture alignment noted during any follow-up radiographs. These findings raise questions about the necessity and efficiency of routine follow-up appointments, consistent with existing literature on various uncomplicated upper extremity fractures [16,17]. Zakrzewski et al. concluded that early post–cast removal radiographs and follow-up appointments did not affect management of minimally displaced supracondylar humerus fractures and could potentially be omitted, enhancing appointment availability and reducing medical expenses [18,22]. In light of our results, easing the routine nature of follow-ups after immobilization discontinuation should be considered. These appointments can be reserved for cases with clinical concerns, such as persistent pain, restricted ROM, or suspected complications and offered upon family request. Clear guidance on home exercises and return-to-activity timelines should be provided at cast removal. Furthermore, as an alternative to in-person follow-ups, telehealth presents a viable option for families seeking reassurance or provider input before resuming activities. Silva et al. [26] demonstrated that telehealth is an effective tool for follow-up in children with nondisplaced upper extremity fractures. In a randomized trial of 52 patients with type I supracondylar humeral fractures or occult elbow injuries, clinical outcomes—including fracture displacement, ROM, pain, and patient family satisfaction—were comparable between those who underwent cast removal at the clinic and those who did so at home via telehealth. However, the mean duration of the fourth-week follow-up appointment was significantly shorter for the telehealth group (17.6 vs 47.2 min; $P < .001$). Thus, virtual follow-ups can serve as a valuable resource for families seeking confirmation of recovery or provider guidance, offering convenience and efficiency without compromising patient satisfaction.

This study has several limitations. As a single-center retrospective chart review, its findings may not be generalizable to other settings or populations and could be biased due to incomplete records. The relatively small sample size of 111 patients may not fully represent the variability in clinical practice. Additionally, patients were treated by multiple surgeons at a single institution, introducing potential bias from variations in treatment protocols. However, the use of standardized institutional protocols for fracture management likely minimized differences in treatment approaches. Our study's definition of management changes and the exclusion of outcomes such as pain management and patient satisfaction also limit the scope of our findings. Clinical decision-making inherently involves varying degrees of subjectivity, particularly regarding physical therapy referrals, additional follow-up appointments, and decisions to prolong cast immobilization. These management changes may be influenced by parental preferences or provider discretion, rather than strictly clinical indications. However, we imagine that such factors reflect real-world clinical practice, where patient and family dynamics often influence management decisions. Two patients with SH2 fractures were lost to follow-up and may have sought care elsewhere for growth arrest concerns; however, the risk of growth arrest is likely low, given their nondisplaced fractures. Similarly, excluding 41% of patients from our study due to inadequate follow-up and missing radiographic data may introduce selection bias and limit the accuracy of complication and management change rates. While complications in this group are possible, they are likely rare due to the favorable healing of these fracture types. Additionally, changes in clinical guidelines or practices during the study period and the lack of long-term outcome data may also affect our findings. Despite these limitations, the study provides valuable insights into the use of routine radiographs and follow-up appointments for the management of pediatric fractures. It also underscores the need for prospective research to validate these results and assess a broader range of clinical outcomes.

Conclusion

This study highlights that routine radiographs and follow-up appointments following cast-removal rarely lead to changes in management for pediatric patients with MDRFs. With only a minimal percentage of cases requiring adjustments such as prolonged immobilization or additional follow-up visits, the findings suggest that such practices may not significantly impact patient outcomes. Considering the financial implications and disruption to daily life caused by unnecessary appointments, there is a compelling argument to reconsider the necessity of routine radiographs and follow-up visits in these cases. Future guidelines should aim to balance clinical benefit with practical considerations to optimize patient care efficiently.

Consent for publication

Institutional Review Board has granted approval and waived the requirement for informed consent for this study.

Author Contributions

Brian Molokwu: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Fareeda Eraky:** Writing – original draft, Data curation, Conceptualization. **Matthew Weintraub:** Writing – original draft, Formal analysis. **Ian Briggs:** Writing – original draft. **Candice Legister:** Methodology, Formal analysis, Data curation, Conceptualization. **Katie Otero:** Writing – review &

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Declaration of competing interests

The authors of this study have no conflicts of interest to disclose.

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