Post-Splinting Radiographs of Minimally Displaced Fractures: Good Medicine or Medicolegal Protection?

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**Background:** Many institutions perform radiographic documentation following splint application even when no manipulation had been performed. The purpose of this study was to evaluate the utility of post-splinting radiographs of acute non-displaced or minimally displaced fractures that did not undergo manipulation. Our hypothesis was that post-splinting radiographs do not demonstrate changes in fracture alignment or impact the management of the patient.

**Methods:** After institutional review board exemption had been granted, consultations performed by orthopaedic residents at a level-I trauma center from September 2008 to April 2010 were reviewed. Of 2862 consultations, 1321 involved acute fractures that were splinted. Radiographs revealed that 342 (25.9%) of the fractures were non-displaced or minimally displaced and angulated (defined as <5 mm and <10°, respectively) and 204 of them had been assessed with radiographs after splinting. Consults were reviewed to ensure that the patients had not undergone manipulation prior to or during splinting. Consult notes and radiographs obtained in the emergency room (ER), as well as follow-up radiographs, were reviewed to assess ultimate outcome.

**Results:** None of the 204 fractures (134 non-displaced and seventy minimally displaced) changed alignment following splinting. Two splints were reapplied, and the fractures sites were reimaged for undocumented reasons. Patients were subjected to an average of ten radiographs (range, four to twenty-five radiographs) of their extremities in the acute setting. On average, three post-splinting radiographs (range, one to ten radiographs) were obtained. The mean time between the initial and post-splinting radiographs was three hours and thirty minutes (range, nine minutes to twenty-four hours). The most common injury was a fracture about the hand or wrist. The 122 patients with that type of injury waited an average of almost three hours for an average of three post-splinting radiographs, contributing to a total of nine radiographs performed acutely. ER visits tended to be longer for patients with post-splinting radiographs compared with those without them (p = 0.06). Follow-up radiographs were available for eighty-two patients. All fractures demonstrated maintained alignment.

**Conclusions:** Post-splinting radiographs of non-displaced and minimally displaced fractures that do not undergo manipulation before or during immobilization are associated with longer ER waits, additional radiation exposure, and increased health-care costs without providing helpful information. While certain circumstances call for additional imaging, routine performance of post-splinting radiography of non-displaced or minimally displaced fractures should be discouraged.

**Level of Evidence:** Therapeutic Level II. See Instructions for Authors for a complete description of levels of evidence.

Acute fractures are often initially managed in the emergency room (ER), by emergency physicians and/or orthopaedic specialists with various levels of training. While displaced fractures often undergo closed reduction prior to immobilization, non-displaced fractures may be treated with a cast or splint without manipulation. Although post-splinting radiographs following fracture manipulation are necessary to ensure acceptable alignment and fracture reduction, their role in the treatment of non-manipulated, minimally displaced fractures has not been determined. Justification for obtaining these additional, post-splinting radiographs includes documentation of splint application, resident education, assurance that the

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fracture has not displaced, and medicolegal protection against claims of unintended harm. The absence of a protocol for these common injuries leads to increased radiographs and costs. It has become customary practice in our orthopaedic community to obtain these studies for the aforementioned reasons without evidence to support this practice.

The purpose of this study was to investigate the medical necessity of post-splinting radiographs obtained for non-manipulated non-displaced or minimally displaced fractures. Our hypothesis was that repeat radiographs following in situ splinting would not demonstrate changes in fracture alignment or alter patient management.

Materials and Methods

After institutional review board exemption was obtained, 2862 orthopaedic consultations for musculoskeletal care performed at a large urban medical center between September 2008 and April 2010 were retrospectively reviewed, and 1321 patients who had presented acutely for fracture management and treated with splinting were identified. Reviewed consultations included those for all patients who either had presented to the ER or had been otherwise referred to the orthopaedic surgeon on call. All handwritten consultation notes were evaluated for inclusion in the analysis. Digital radiographs and radiology reports for each consultation were also reviewed.

The inclusion criteria were acute presentation within fourteen days after injury, an initial radiographic assessment, a fracture with no or minimal displacement, and closed management with a splint. Fractures were classified as non-displaced or minimally displaced if radiographs demonstrated <5 mm of displacement and <10° of angulation in any direction, as established in a previous analysis. Displacement and angulation were measured with use of digital radiograph software (GE Healthcare, Waukesha, Wisconsin). All imaging was performed by licensed technologists familiar with orthopaedics. Patients were excluded if they had undergone closed fracture reduction or other manipulation.

Splint application was performed as follows. After the extremity was assessed for neurovascular status, swelling, and additional injuries, the patient was given pain medication and placed on a stretcher. Depending on the ability to comply, the patient either presented the extremity (i.e., held the forearm up or lay prone and bent the knee to raise the ankle) or had the limb suspended from an intravenous pole with finger traps or stretch cotton. The skin was then covered with two layers of cotton Webril (Kendall, Mansfield, Massachusetts) to prevent thermal injury, and osseous prominences were additionally padded. Plaster of Paris of varying width was then rolled to make ten to twelve-layer slab(s), balancing the strength required and the heaviness that could be tolerated. The plaster was dipped in temperate water, rubbed to allow the calcium phosphate to interdigitate into the matrix, and applied to the extremity. This construct was then overwrapped with Webril followed by ACE wraps (3M; St. Paul, Minnesota) or gauze bandages. All splints were then allowed ten minutes of set time for hardening. For certain phalangeal fractures, AlumaFoam (Hartmann USA, Rock Hill, South Carolina) was utilized alone or incorporated into plaster splints.

Splints were classified as slabs if they covered only one side of the extremity. Additional splints that were considered to be slabs included ulnar and radial gutter splints used to immobilize ulnar shaft and radial/ulnar styloid fractures and AlumaFoam splints used to treat phalangeal fractures or, in conjunction with plaster, metacarpal fractures. Other splint categories included sugar tong, posterior long arm, short leg, and long leg.

Of the 1321 acute fractures, 342 (25.9%) had received no manipulation and met the criteria for inclusion in the study. Of these, 204 (59.6%) were evaluated with repeat radiographs immediately following acute fracture assessment and splinting (and form the basis of this report) and 138 (40.4%) were not evaluated with post-splinting radiographs (Fig. 1). The anatomic region of the fracture location was used to group the injuries. No other classification systems were utilized as they did not contribute meaningfully to the data analysis. Radiographs were assessed for a change in osseous alignment by two orthopaedic surgeons as well as by a review of the radiologist’s report.

Data collected included patient age, injury location, initial fracture displacement and angulation, immobilization type, number of radiographs obtained prior to immobilization, number of radiographs obtained immediately after splinting, and the time interval between the first and last radiographs obtained in the ER. ER charts were reviewed to assess the times of the orthopaedic consultation request, performance of the consultation, and patient discharge. Excluding patients for whom data were unavailable or invalid (twenty-three patients were admitted to the hospital, one was transferred to another facility, and one eloped), ER waiting times were available for 269 patients.

All patients were advised to return for follow-up in our clinic, at the private offices of the attending physicians, or with an outside orthopaedist in one to two weeks (depending on the nature of the fracture). Of the 204 patients who received post-splinting radiographs, eighty-two had at least one follow-up radiograph documented in our PACS (Picture Archiving and Communication System). These were evaluated for changes in osseous alignment as well. The ultimate outcome was defined as a change in fracture alignment on available radiographs.

Statistical Methods

A one-tailed unpaired t test was performed for statistical analysis. Power analysis was performed to determine the number of patients needed for inclusion; however, given the lack of data on the rate of displacement of these injuries, no definite sample-size requirement could be determined.

Source of Funding

There was no external funding for this study.

Results

Of the 204 patients in the post-splinting-radiograph cohort, 130 were male and seventy-four were female. One hundred and fifty-one (74.0%) presented on the day of injury, twenty-five (12.3%) presented on the following day, and twenty-eight (13.7%) presented between two and twelve days after injury. Patients with open physes (ninety-five) had an average age of 9.5 years. The remaining 109 patients were skeletally mature, with an average age of 43.7 years. A table in the Appendix summarizes patient characteristics. All splints were applied by orthopaedic trainees under the supervision of an orthopaedic attending physician in an academic training program. 
The most commonly applied splint type was a slab (seventy-two patients). Sugar-tong splints, most often used for the treatment of distal radial fractures, were the next most frequently applied (sixty-one patients). The remainder of the patients received a posterior long arm splint (twenty-one patients) to immobilize an elbow fracture, a short leg splint (forty-six patients) for an ankle fracture, or a long leg splint (four patients) for a tibial fracture.

On average, a total of ten radiographs (range, four to twenty-five) were made in the ER for each of the 204 patients to assess the non-displaced or minimally displaced fracture. An average of three post-splinting radiographs (range, one to ten) were obtained. The mean time from the initial injury radiographs to the post-splinting radiographs was three hours and thirty minutes (range, nine minutes to twenty-four hours). The numbers of radiographs and the time intervals according to the locations of the fractures are provided in a table in the Appendix.

The three most common sites of the fractures were the distal parts of the radius and ulna (sixty-seven), the metacarpals and phalanges (fifty-five), and the foot and ankle (forty-four). Figure 2 shows the numbers of radiographs made for these fractures. Of these three fracture types, distal radial and ulnar fractures were associated with the shortest average time between the injury and post-splinting radiographs (173 minutes).

The average total number of upper-extremity radiographs made for these sixty-one distal radial fractures was eleven (range, four to twenty). Skeletally immature patients waited an average of two hours and twenty-three minutes and mature patients waited an average of four hours and twenty-nine minutes between the injury and post-splinting radiographs.

The average length of the ER stay for the patients for whom post-splinting radiographs were obtained was eight hours and thirty minutes. This is longer than the seven hours and thirty minutes for the patients who did not have repeat radiographs in the ER ($p = 0.06$). However, confounding factors for delays in discharge such as bed availability, admission with observational time, and transportation arrangements for discharge were unable to be factored into this comparison, precluding a multivariate analysis.

None of the fractures in this study demonstrated an acute change in osseous alignment following splint application. Furthermore, none of the eighty-two patients with follow-up radiographs available demonstrated fracture displacement. As the rate of displacement of minimally displaced fractures is unknown, the sensitivity of post-splinting radiographs for detecting displacement cannot be determined; however, radiographs remain the standard of care for evaluating minimally displaced fractures and can therefore be assumed to be accurate. Two splints were reapplied for undocumented reasons. Figures in the Appendix demonstrate a typical series of radiographs for a single non-displaced fracture.
Discussion

In our study, we found that post-splinting radiographs had been obtained for 60% of the minimally displaced fractures that underwent immobilization without manipulation; this contributed to patients receiving an average of ten radiographs acutely and spending eight hours and thirty minutes in the emergency department. The application of a splint without fracture manipulation did not cause any shift in fracture alignment, and radiographs obtained to document this did not add to any clinical decision-making.

Recent interest in optimizing health-care expenditures without compromising clinical decision-making and patient care makes the current study quite relevant to today’s practice environment. The utility of repeat radiographs for fractures in the acute care setting has been examined in a few smaller studies. Farbman et al. examined seventy torus fractures, of which 34% were assessed immediately post-casting studies, which demonstrated no change in osseous alignment. Radiology charges alone averaged $389 per torus fracture, and relying on clinical examination and a single follow-up study would have saved $10,000 for their seventy patients, translating into substantial savings if a similar protocol were more universally applied. Jain et al. reported on ER management of stable ankle fractures before and after institution of a management protocol and observed that costs decreased by 58%, mostly due to reduction in repeat radiographs and outpatient visits. In the United Kingdom, the cost of wrist radiographs accounts for 60% of the cost of treating distal radial fractures of all types, including the price of splints, casts, and implants. In the United States, a university hospital trauma series of ankle radiographs costs roughly $98. Applying this cost to our average of eleven views of the ankle for minimally displaced ankle fractures, with three views per study, results in a cost of $392 for acute imaging alone, which adds to the cost of serial imaging to monitor healing during follow-up.

Streamlining health care also involves efficient treatment and discharge of patients. Our average wait time of three and a half hours between the injury and post-splinting radiographs includes time for ER physicians to review the radiographs and obtain an orthopaedic consultation, orthopaedic residents to evaluate the patient and apply the splint, technicians to repeat the radiographs, and orthopaedic residents to review the additional radiographs. While we do not have data on the breakdown of wait time for each step, waiting for post-splinting radiographs, along with subsequent interpretation by the orthopaedic resident, would logically add substantial time to the length of the ER stay compared with the time for those who do not have post-splinting radiographs made. Both x-ray technicians and radiologists are inundated with more studies to perform and interpret in already busy ER or urgent-care settings. Any delay creates a backflow leading to longer wait times in waiting rooms.

Matching the trend of increasing health-care expenditure, medical radiation exposure increased by 600% from 1982 to 2006. The average yearly public ionizing radiation exposure is 360 mrem, of which 60 mrem is from diagnostic radiographs. Since we cannot control exposure to ambient/background radiation, it is imperative that we limit unnecessary medical exposure. It is important, however, to be cognizant of the relatively low contribution of extremity radiographs to the overall yearly exposure. The average effective doses for shoulder and knee radiographs are only 0.01 mSv and 0.005 mSv. While the data support a linear no-threshold relationship between radiation and cancer risk, probably due to DNA damage, statistical limits make it difficult to estimate the cancer risk below 100 mSv. It would take 10,000 shoulder radiographs to incur an additional 100 mSv, which would then result in a 1/100 chance of cancer from said radiation, while the risk of developing cancer from other causes would be 42/1000.

While it is clear that limiting radiographs in the ER setting would decrease health-care expenditures, the duration of ER visits, and radiation exposure, the impetus to repeat imaging may stem from a lack of evidence-based guidelines for treatment of non-displaced and minimally displaced fractures. Common injuries such as non-displaced distal radial fractures received differing treatments in our study, with 73% placed in a sugar-tong splint and 27% placed in a volar slab. Additionally, post-splinting radiographs were not obtained for 138 (40%) of the 342 patients. The fact that residents from a single training program at a single hospital did not consistently forego or obtain post-splinting radiographs or splint minimally displaced fractures in a consistent way highlights the lack of a standardized protocol. The dearth of definitive evidence on the utility of post-splinting radiographs causes practitioners to base decisions solely on the opinions of their attendings and themselves, which may account for the non-uniformity in several aspects of fracture management.

Trainees are often instructed on the dogmatic practice of ordering additional studies to document any intervention, whether for the educational purpose of evaluating splint quality or because of medicolegal concerns about fracture alignment and splint application. We would argue, however, that post-splinting radiographs are a poor way to examine splint quality. Splint padding is radiolucent and best visualized at the time of application. Additionally, when imaging of the splinted fracture is repeated, the ends of the splint are often not visualized, even though immobilization of the proper joints and leaving the remaining joints free are perhaps the most important aspects of splinting. As only two of the 204 patients examined underwent repeat splinting for undocumented reasons, it would seem that these radiographs are not a cost-effective way to monitor splint quality. We recommend increased attention to detail with manual inspection of applied splints and education on proper splinting techniques.

Another cited reason for repeating radiographs is medicolegal documentation of splint application and maintenance of fracture alignment. Defensive medicine is estimated to cost several billion dollars annually. A recent survey in Massachusetts showed that 22% of radiographs are ordered defensively. Fractures account for five of the ten most common conditions for which orthopaedic surgeons are sued. However, as stated previously, we suggest that post-splinting radiographs are not superior to visual inspection of splint characteristics and that focus should be on proper technique and documentation. A recent study demonstrated immediate post-casting radiographs as showing no changes in the alignment of fifty-eight stable ankle fractures. This is in keeping with our study of 204 non-displaced or minimally
displaced fractures, in which we found that post-splinting radiographs neither detected a change in alignment nor altered the treatment plan. These studies hopefully provide clinical and medicolegal justification for not obtaining these radiographs.

Lastly, the transition to electronic medical records allows for non-radiographic methods of documenting splint application and splint quality. In specific instances, such as when patients are noncompliant or litigious, it may be desirable to supplement written documentation of splinting with a digital clinical photograph uploaded to the electronic medical record. Additionally, one may wish to introduce residents to the demonstration of their splinting, such as by showing that the metacarpal heads are free to flex down in a sugar-tong splint immobilizing the wrist. However, just as we would not suggest that every bandaged wound and laceration closure should be documented pictorially, we are not suggesting that post-splinting photographs be made routinely. Rather, we are saying that specific instances for which pictures of the splint are indicated should not be a reason to further irradiate and charge patients or to increase the workload of radiology technicians and radiologists.

The results of this study do not suggest uniformly abandoning additional imaging in cases in which the treating physician thinks some alteration in alignment may have occurred. In fact, uniform application of any practice risks obtaining too few or too many studies. Instead, we advocate examining each case individually, applying reason and evidence, and then determining if any meaningful clinical data will be gleaned from a study before it is ordered. Distal-third radial fractures in children are an excellent example. Minimally displaced fractures with volar angulation in this patient population have been reliably shown to maintain acceptable alignment; however, those with dorsal deformity of even $<10^\circ$ can angulate further, and repeated radiographs within a week are appropriate in these instances. As several studies have now demonstrated that the routine use of post-splinting radiographs neither detected a change in alignment nor altered the discharge. Longer stays may be attributable to patients waiting for transportation or escorts, time for detoxification, or mandatory observation of patients with suspected head injuries, to name a few reasons. Patients who were admitted to the hospital would have ER lengths of stays related to bed availability and time of acceptance by the admitting medical service. As we were unable to perform a multivariate analysis, a prolonged ER stay can only be associated with, not attributed to, obtaining additional post-splinting radiographs.

Delays in obtaining post-splinting radiographs and durations of ER stays are multifactorial. It is likely that a larger prospective study specifically examining confounding variables would be necessary to further investigate the role and impact of dogmatically obtaining post-splinting radiographs. However, it may be considered unethical to perform such an investigation as several studies have now demonstrated that the routine use of additional radiographs does not alter patient management.

In conclusion, post-splinting radiographs of non-displaced and minimally displaced fractures that do not undergo manipulation before or during immobilization result in longer waits in the ER, additional radiation exposure, and increased health-care costs without providing helpful information. While certain circumstances may call for additional imaging, routinely obtaining post-splinting radiographs of non-displaced or minimally displaced fractures should be discouraged.

Appendix

A typical series of radiographs made for an acute minimally displaced radial fracture, a table showing characteristics of the patients evaluated with post-splinting radiographs, and a table showing the fracture distribution in patients evaluated with post-splinting radiographs are available with the online version of this article as a data supplement at jbjs.org.

References