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ORIGINAL ARTICLE

Is there a need for standardized postoperative radiographs after operative treatment of wrist or ankle fractures?

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Abstract

Purpose The purpose of this study was to evaluate the frequency of changes in treatment plan due to standardized postoperative radiographs. A secondary aim was to compare our results with a national benchmark.

Methods This is a single-center retrospective case series of 167 consecutive patients, operated with open reduction and internal fixation (ORIF) for distal radius or ankle fractures in 2014. Changes in the treatment protocol were defined as additional CT-imaging, reoperation or other changes as stated in the postoperative instructions. In addition, a national survey was conducted assessing differences between surgeons in different hospitals concerning revision rates.

Results In 7.2% (12/167) of the patients, a change in the treatment plan was recorded after the standardized postoperative radiographs. 10 patients (6%) were reoperated (three without additional imaging, seven after additional imaging with CT). The results from our survey showed a good assessment concerning the quality of intraoperative imaging (7.85 on a scale from 0 to 10). Concerning the revision rate, there was a trend to lower revision rate of 8.1% in the six observers.

Conclusions Standard postoperative radiographs could improve quality of care. Intraoperative standardized radiographic documentation is needed and the perception and acceptance of quality may vary between hospitals.

Keywords Radius fracture · Ankle fracture · Postoperative radiograph · Treatment plan change

Introduction

Adequate surgical treatment of fractures of the distal radius and ankle is considered as an essential operative skill of orthopedic trauma surgeons. However, adequate reduction of the fracture is not only ensured by the expertise of the surgeon, but also through the standard intraoperative radiological control using a mobile image intensifier (C-arm). Intraoperative radiograph documentation, if adequately performed, has the potential to document the quality of reduction and fixation in a reproducible way [1]. Furthermore, intraoperative radiation exposure decreases if the c-arm control is carried out by an experienced trauma surgeon [2]. Haddad [3] and Harrish [4] recognized the possibility of a flawless documentation of reduction through the correct application of the image intensifier.

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There remains a lack of evidence concerning the additional value of standardized postoperative imaging. Initial studies in 1996 [5] showed a lack of additional information gained by the postoperative radiograph [6]. Considering a trend towards cost-effective medicine [7] and keeping the cumulative radiation exposure in mind, it is not surprising that these standardized postoperative radiographs are under debate [8], especially as there is an increase in incidence of distal radius fractures and an increase in ankle fractures in an overweight and more active elderly society [9–11].

In many countries, current protocols recommend standardized postoperative radiographs as part of a routine control within the first postoperative days, although first changes in the standardisation of postoperative radiographs have already taken place [8]. Currently, there is a lack of evidence concerning the additional benefits of these standardized postoperative radiographs [12].

The primary aim of this study was to analyze the consequences of standardized radiographs after surgical treatment of radius and ankle fractures.

Secondary aim was to evaluate the quality of intraoperative imaging using a national survey. Moreover does this survey address the question if revision rates in another hospital would be different?

Methods

This article was written in accordance with the STROBE-statement [13].

Patients

This study is a retrospective case series of all consecutive patients treated with an open reduction and internal fixation for a distal radius or ankle fracture in a level 1 trauma centre in Switzerland in 2014. All patients had preoperative plain radiographs (AP and lateral). An additional CT scan was performed if requested by the treating trauma surgeon.

Exclusion criteria were patients treated with a temporary external fixator. In addition, we excluded patients who did not receive standardized postoperative radiograph controls and those who did not attend the first postoperative control (6 weeks) in the outpatient clinic.

Standard postoperative protocol

A standardized postoperative radiograph is routinely performed on the first postoperative day. For radius fractures a standard posterior-anterior view and a 20° lateral view is obtained. For ankle fractures a "Mortise" view and a lateral view is obtained. All radiographs are evaluated in a multidisciplinary rapport (radiologist and trauma surgeon). All radiographs are digitally stored and analyzed using the PACS©-System.

Data analysis

All data were collected by an independent surgeon. The fractures were classified using the AO and Gustilo and Anderson classification systems [14]. Basic patient-related data [age, gender, American Society of Anesthesiologists classification, duration and time of surgery (daytime or out of office hours)] were evaluated. Moreover was the experience of the main surgeon [resident, junior (< 10 years experience) or senior consultant (> 10 years experience)] evaluated?

Intraoperative radiographs were not standardized. The treating surgeon stores intraoperatively the relevant images digitally.

National survey

Using a national survey, we questioned the quality of our intraoperative radiographs and the consequences.

We selected 30 cases with operative-treated radius and ankle fractures. In eight of these patients (27%) we performed a revision operation (four patients each in the radius and ankle group) and in seven patients (23.3%) an additional CT. The remaining 22 patients were randomly chosen from a cohort of 155 patients in which our postoperative course was uneventful. All images were blinded. Basic patient-related information was provided to the observers concerning age, employment and high/low-demanding life style. High-demanding life style was defined as patients had either a physical active leisure or physical hard work.

A standard scoring system grading the quality of intraoperative imaging from 0 (poor) to 10 (excellent) was designed. Moreover was the necessity of additional postoperative radiographs, CT or a revision operation evaluated?

The survey was send to six trauma surgeons in two hospitals in Switzerland.

Statistic analysis

Statistical analyses have been performed with Statistical Package for the Social Science (SPSS) version 21 (IBM). In comparative analysis between patients with and without postoperative treatment plan changes, in terms of experience of the surgeon or preoperative CT scans, we used the chi-square test. Mean values between patients with and without postoperative treatment plan change were compared using a one-way repeated measures at a significance level of $\alpha = 0.05$. There were no missing data in the analysis.

Analyzing the survey, we used an inter-rater reliability approach. We assessed the inter-rater reliability according to Fleiss Kappa.

Results

A total of 144 patients with a distal radius fracture and 84 patients with an ankle fracture were treated with an open reduction and internal fixation in 2014. In total, 61 patients were excluded because no standard postoperative radiographs or no radiographic control after 6 weeks was obtained. An overview is shown in Fig. 1.

Patient`s demographics

Patients demographics are presented in Table 1.

What are the consequences of standardized postoperative radiographs in patients operated for distal radius or ankle fracture?

The primary endpoint was a change in the treatment protocol due to the standard postoperative radiograph. This was seen in 12 cases (7.2%). 10 patients (6%) were reoperated (three without additional imaging, seven after additional imaging with CT). Of these ten, eight required a reosteosynthesis and two patients a screw removal or change. Two patients had additional imaging (CT) without further consequences. No difference between the groups in terms of frequency of reosteosynthesis was seen [five patients (8.9%) in the ankle group and seven patients (6.3%) in the radius group] ($p=0.536$). Rates for additional imaging and revision rates are shown in Table 2.

Analysis of risk factors

During the study period, 46 patients (41, 44%) were operated during out of office hours with a radius fracture and 9 patients (15, 79%) with an ankle fracture ($p=0.001$). A deviation from standard postoperative course occurred in two patients operated during out of office hours. In contrast, ten patients operated during daytime had a deviation in the postoperative course ($p=0.34$).

Moreover, we analyzed if the type of fracture or the time of operation was a risk factor. We were not able to show any influence of type of fracture or time of reduction on rate of postoperative treatment plan changes with respect to our regression analysis.

Further on, we analyzed the revision rate in patients with and without intraoperative 3D-rotation CT (3D-RX). There

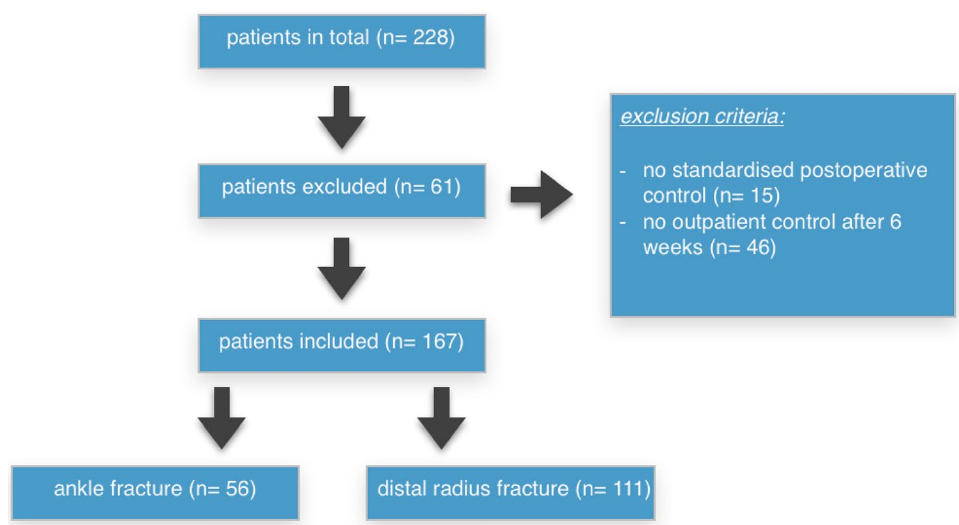

Fig. 1 Inclusion and exclusion criteria

Table 1 Basic patient data

Patient-related variable	Wrist fracture (%)	Ankle fracture (%)	Significance (p)
Numbers of patients	144	84	
Included patients	111	56	0.087
Sex distribution			
Male	35 (31.5%)	24 (42.9%)	0.143
Female	76 (68.5%)	32 (57.1%)	
Mean age (years)	56.35	51.64	0.135
Cut–suture time (min)	115.54	113.98	0.866

Table 2 Postoperative consequences

Perioperative findings	Wrist fracture	Ankle fracture	Significance (*p*)
Number of patients	111 (100%)	56 (100%)	
Preoperative CT	27 (24.3%)	11 (19.6%)	0.561
Average number of images performed intra-operatively	54	71	0.274
Changes after postoperative radiograph	7 (6.3%)	5 (8.9%)	0.536
Additional CT	1 (0.9%)	1 (1.8%)	
Reoperation with preoperative CT	4 (3.6%)	3 (5.4%)	
Reoperation without preoperative CT	2 (1.8%)	1 (1.8%)	
Type of revision			
Reosteosynthesis	4 (3.6%)	4 (7.1%)	
Screw change	1 (0.9%)	0	
Screw removal	1 (0.9%)	0	
Type of fracture (AO)	AO 23-	AO 44-	
A-fracture	38	4	< 0.001
B-fracture	13	39	< 0.001
C-fracture	57	13	< 0.001

was a trend to a higher revision rate if during the operation a 3D-X-ray was taken ($p = 0.148$).

Using a national survey: do other observers rate the quality of intraoperative radiographs different and does this influence the postoperative course?

6 trauma surgeons in two different hospitals rated the 30 selected cases using a standard scoring sheet. Two of these six observers were in the year 2014 working as senior consultants in the index hospital.

Quality of intraoperative radiographs

The six observers rated the quality of our intraoperative radiographs with a 7.85 [Scale 0 (poor)–10 (excellent)] and a Fleiss Kappa of 0.31 (fair agreement). Separated for both hospitals in Switzerland a better rating of the quality of the radiographs was seen in the index hospital with 8.27 compared to the other hospital with 7.43. The two observers who were initially present in the index hospital rated the radiographs better (8.82) compared to the other 4 (7.36). An overview concerning these results is shown in Table 3.

Changes in treatment plan

The second part of the survey addressed the question to which extent revision operations would have been performed based on the intraoperative radiographs alone. We analyzed all 30 patients and the corresponding answers from the different hospitals, with a given revision rate (reoperation rate) of 26.6% based on our retrospective analysis in the index hospital. In the survey in 23.1% of the cases, the trauma surgeons decided to perform an additional CT and in 8.1% they would have performed a revision operation without additional imaging, being not statistically significant compared to this given subgroup (*p* value 0.08).

Table 3 Quality results of survey

Variable (survey subgroup)	Quality[a]	Inter-observer reliability (Kappa)
Overall survey (6)[b]	7.85	0.31
Observer initially at index hospital (2)[b]	8.82	0.61
Time the observer works in Switzerland		
< 5 years (4)[b]	7.36	0.30
> 5 years (2)[b]	8.82	0.61
Index hospital in survey (3)[b]	8.27	0.25
Control hospital in survey (3)[b]	7.43	0.31

[a]Scale 0 (poor)–10 (Excellent)

[b]In brackets are the number of observer in the given subgroup

In the national survey, a minor difference between the hospitals with respect to the rate of postoperative CT rate was seen (24.7 and 21.5%) and a minor difference with respect to the revision rate (6.5 and 9.7%). These results are much lower than the number of revisions (27%) performed in the index hospital initially in this given subgroup.

The two observers who were initially present in the index hospital decided to less frequently perform a revision operation (3.2%) compared to the remaining four (10.5%). Results concerning the consequences given in the survey compared to the retrospective results are shown in Table 4.

Table 4 Results of consequences during the survey

Variable (survey subgroup)	CT (%)	Reoperation (%)
Baseline (index hospital 2014)	23.3	26.6
Survey (6 observers)	23.1	8.1
Index hospital in survey	24.7	6.5
Control hospital in survey	21.5	9.7
2 observers initially at index hospital	24.2	3.2

Discussion

Which proportions of changes in treatment plan are based on the evaluation of postoperative standardized radiographs?

This study examined and analyzed the change in treatment plan due to standardized postoperative radiographs in patients operated for a distal radius or ankle fracture. Over 7% of our patients received a deviation in the standard postoperative course due to standard postoperative radiographs. In a national survey the quality of our images was rated as good. Despite the quality of intraoperative images being good, a revision operation has been performed in 27% based on additional post-op imaging in this subgroup. This survey demonstrated, however, that revisions would have been made less frequent.

In international studies reosteosynthesis rates of 1% are published [15]. In our study a revision osteosynthesis was performed in nearly 6% of the patients. However, most of these studies evaluate the value of later (2 weeks) postoperative control radiographs. Similar studies comparing initial postoperative radiographs (24–48 h postoperative) are currently missing.

There are several possible explanations for our high rate of revisions. The quality of intraoperative radiographs must be named in the first place. Different trauma surgeons handle the c-arm in different ways and they check the results of reduction in different ways. This results in a variety in the quality of intraoperative radiographic documentation. Second, the variability in acceptance of quality of radiographs and reduction between different surgeons can be an explanation for high rates of postoperative treatment plan changes.

To underline this as a critical point, we performed a national survey with six observers from two hospitals. In the first place the quality of intraoperative radiographs was evaluated. High acceptance of the quality of our intraoperative radiographs was found among the observers.

Another possible explanation could be a more liberal approach concerning revision operations in other hospitals. As we showed in our survey, only 8.1% of the cases would have been reoperated. We performed a revision operation in 26.6% of the cases, being nearly a statistical significant difference (p value 0.08). A critical point should, however, be raised that the observers in the survey could have been biased. Additional information concerning the patients and their demands was provided, however, this information cannot be compared to true clinical information. This is underlined by the fact that the two observers who were initially present in the index hospital would perform less reoperations based on the data presented in the national survey.

Increasing the quality of imaging and standardisation of intraoperative radiographs could contribute to fewer changes in postoperative treatment plan. Subsequently a standardisation of radiographs could be a main point in improving patient care. Advanced imaging (intraoperative 3D C-arm, navigation-guided reduction and fixation) could be another point of debate. As shown in different studies, intraoperative 3D-rotation CT (3D-RX) contributes to a decrease in revision rate due to improved imaging [16–20]. Interestingly, revision rates were not lower when an intraoperative 3D-RX was used. This could be biased as it is not routinely being used in our clinic and mainly used in more complex cases.

This study showed that standardized postoperative radiographs were not exclusively sufficient to decide for a revision surgery. Additional imaging (CT) was needed in five patients with a radius fracture and in four patients with an ankle fracture. In seven of the patients with a CT, a revision operation was being performed which contributes to the assumption that plain radiographs are not sufficient alone in evaluating the quality of the reduction and osteosynthesis [21, 22]. This raises the question whether postoperative radiographs contain more information than standardized intraoperative radiographs. Due to the retrospective design of this study, this issue can not be addressed satisfactorily.

The survey showed similar results. In 23.1% of the cases, a postoperative CT was requested compared to 26.6% who were reoperated in the survey subgroup. This leads to the assumption that in cases where the quality of reduction could not be clarified using the intraoperative radiographs, a postoperative CT scan is needed. Therefore, a possible interpretation of these data could be that postoperative radiographs should be replaced by CT scan in cases where the reduction remains unclear in the intraoperative fluoroscopy documentation.

There are further inherent limitations of the retrospective study design. There is an increased risk for recall bias especially concerning patient data and operation variables. As presenting data from a single center, generalization of our results is limited. In addition, the heterogeneity of our patients (radius and ankle fractures) contributes to a limitation in generalizing a statement. After a review of our results, a profit in patient care must be expected from standardized postoperative radiographs. It remains, however, unknown if the radiographic improvement also leads to an improved clinical outcome.

Conclusions

In conclusion, standardized postoperative radiographs lead to a high rate of changes in treatment plan in our institution. There seems to be a flaw in intraoperative c-arm control. A national survey shows that different standards are being used in different hospitals concerning outcome, which could influence revision rate.

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Compliance with ethical standards

Conflict of interest F. Oehme, B. C. Link, H. Frima, T. Schepers, S. J. Rhemrev, R. Babst and F. J. P. Beeres declare that they have no conflict of interest.

Research involving human participants and/or animals No animals were included in this trial.

Informed consent There was no informed consent requested in this trial. No personal or confidential data were included in this analysis.

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