The potential of the ICUC® documentation concept

Part II: Radiation monitoring

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Introduction

The ICUC documentation concept offers advantages, like the potential to secondarily analyze technical aspects of surgical procedures *(5)*. Among these, soft tissue handling is particularly relevant and has been described in the ICUC newsletter of February 2017 *(4)*. Radiation hazards during surgery are a further field where improvements, using the ICUC documentation concept, are possible. Standard documentation does not provide adequate information and Radiation Hazards, although accepted as relevant, are usually underestimated *(2, 3, 6)*. The use of fluoroscopy is routine in surgical fracture treatment. However, the resulting radiation is not measured and documented as should be to comply with the principle of "as low as reasonably achievable" (ALARA). Documentation is not adequate, if only selected fluoroscopy shots – if any – are archived. The ease of intra-operative fluoroscopy controls helps to improve suboptimal fracture reduction without undue time loss but seduce to radiation overuse.

To analyze radiation hazards both the patients and the crew working in the operation theatre have to be considered in addition to fluoroscopy handling.

The potential of the ICUC® documentation concept to assess radiation

According to the ICUC concept *(5)* all C-arm images are archived (in the ICUC app [4], a chapter with the "Full Set of C-arm Shots" is available for all cases in the ICUC Library section). Amazing differences can be found using the concept for cases appearing very similar with conventional documentation only (Figures 1 to 3). Similarly handling errors cannot be appreciated, if only selected C-arm shots are archived (Fig. 4). A significant reduction of the radiation dose to both patients and operation crew is possible by correct C-arm handling (Figures 5 and 6).

Discussion

Today's legal documentation requirements do not include any image documentation *(1, 7)*. Thus, a lot of information about technical aspects of the procedure are not available for secondary analysis. A valuable source of learning is thereby lost. An ICUC-type documentation is not simple to realize but offers this information. Its prerequisites are described in a previous publication *(5)*.

Not only the absolute number of C-arm shots are relevant for the dose absorbed by patients and OR crew. Disciplined use of protection equipment, pulsed and not continuous radiation, correct relative position of source and receiver to the patient and especially the respect of the minimum distance of 2 m to the radiation source are equally important. Inadequate use of the C-arm (Fig. 4) due to insufficient knowledge of standard settings are also important factors impeding the observation of the ALARA rules *(7)*. Documentation according to the ICUC concept supplement dosimeter-data.

Repetitive C-arm shots are justified to control and improve fracture reduction. However, care must be taken to limit radiation both to the patient and to the surgical crew (Figures 4 to 6). Correct positioning of the C-arm is part of the planning (Fig. 5). Thereafter, the relative position of the surgical crew is crucial with regard to radiation absorbed (Fig. 6).

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Summary

Conventional documentation of surgical procedures, using only pre-and postoperative x-ray images and possibly a few intra-operative pictures, does not allow secondary analysis of the technical performance quality. Many important elements of the procedure like radiation hazards due to improper use of the C-arm are not sufficiently documented.

Intra-operative fluoroscopy is a routine; the ease of C-arm controls helps to improve suboptimal fracture reduction but seduces to radiation overuse.

Following ICUC documentation principles all fluoroscopy shots and images of the C-arm positioning are included. Thereby, adherence to ALARA rules can be checked. This supplements the eventual use of dosimeters.

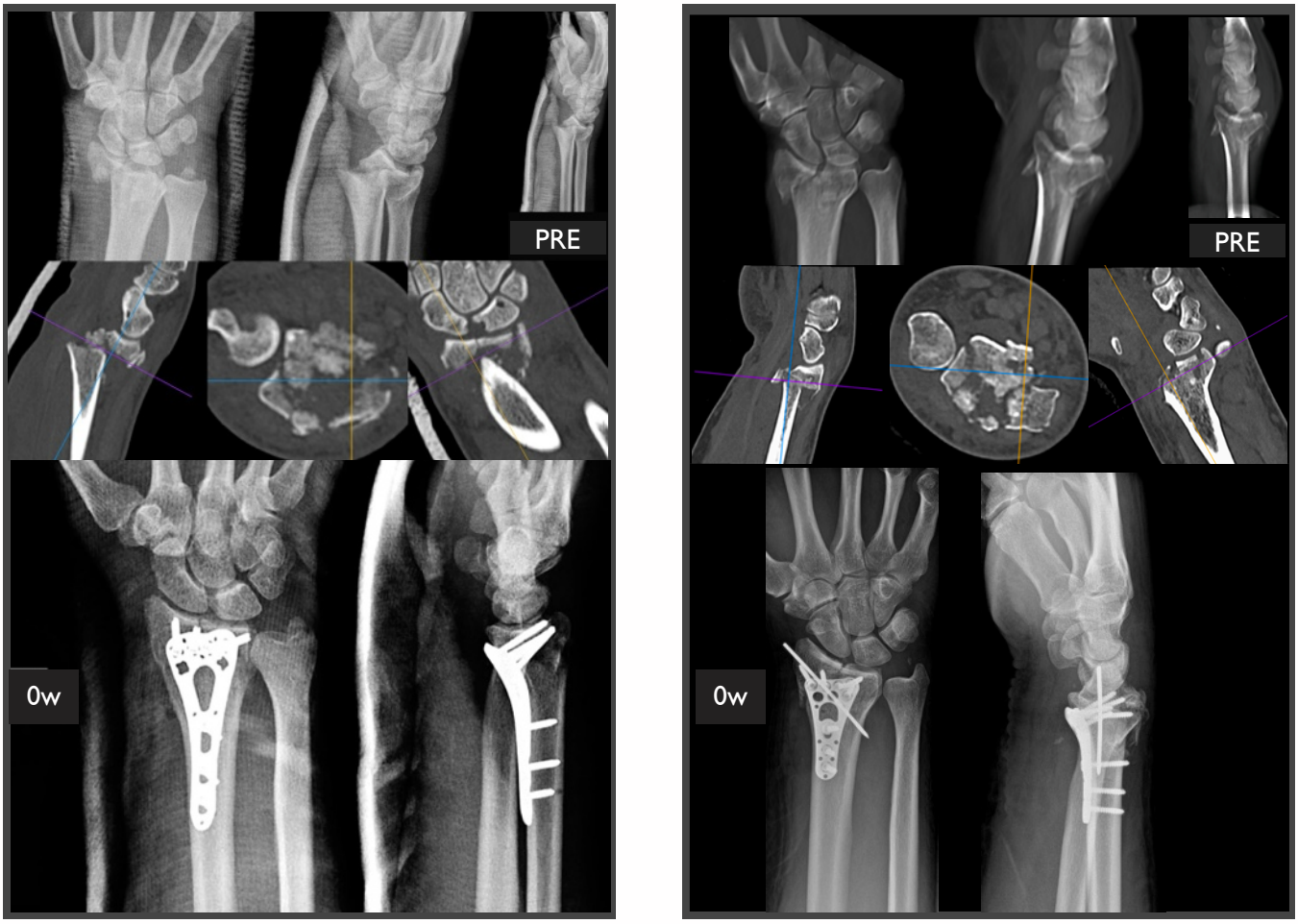

***Fig. 1:* Two very similar cases (matched pairs) of distal radius fractures fixed with volar plates.** However, significant differences exist in the radiation used (Figures 2 and 3) and in the quality of the resulting reduction. Both cases are ICUC cases. The case on the left is already in the ICUC app (case *ID: 23-DC-613*), the case on the right will be included soon.

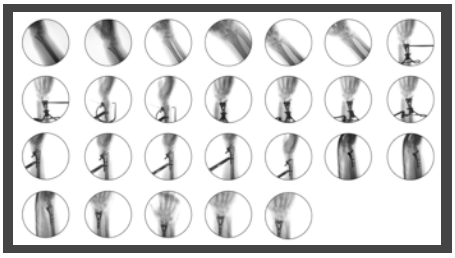

Fig. 2: C-arm shots used for the case on the left in Fig. 1. 26 C-arm shots seem adequate considering the complexity of the fracture (details can be found in the ICUC app, case *ID: 23-DC-613).*

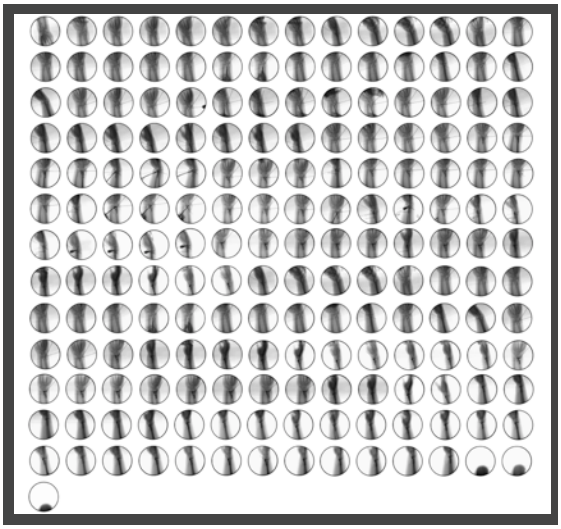

Fig. 3: C-arm shots used for the case on the right in Fig. 1 151 C-arm shots reflect the technical the difficulties encountered, producing a much higher radiation dose. In addition the reduction is less good compared to case on the left of Fig. 1.

Looking only at the postoperative images of both cases (Fig. 1) they seem very similar. The difference in the radiation dose does not appear. Only complete documentation of all C-arm shots allows to scroll through and appreciate the relevant and significant differences (Figures 2 and 3).

Fig. 4: **Malleolar fracture** with Volkmann fragment**.** (details can be found in the ICUC app, Ankle, Reference Cases, Posterolateral). Difficult reduction justifies many C-arm shots and attempts to obtain an anatomical reduction. However it cannot be accepted to see the surgeon's fingers.

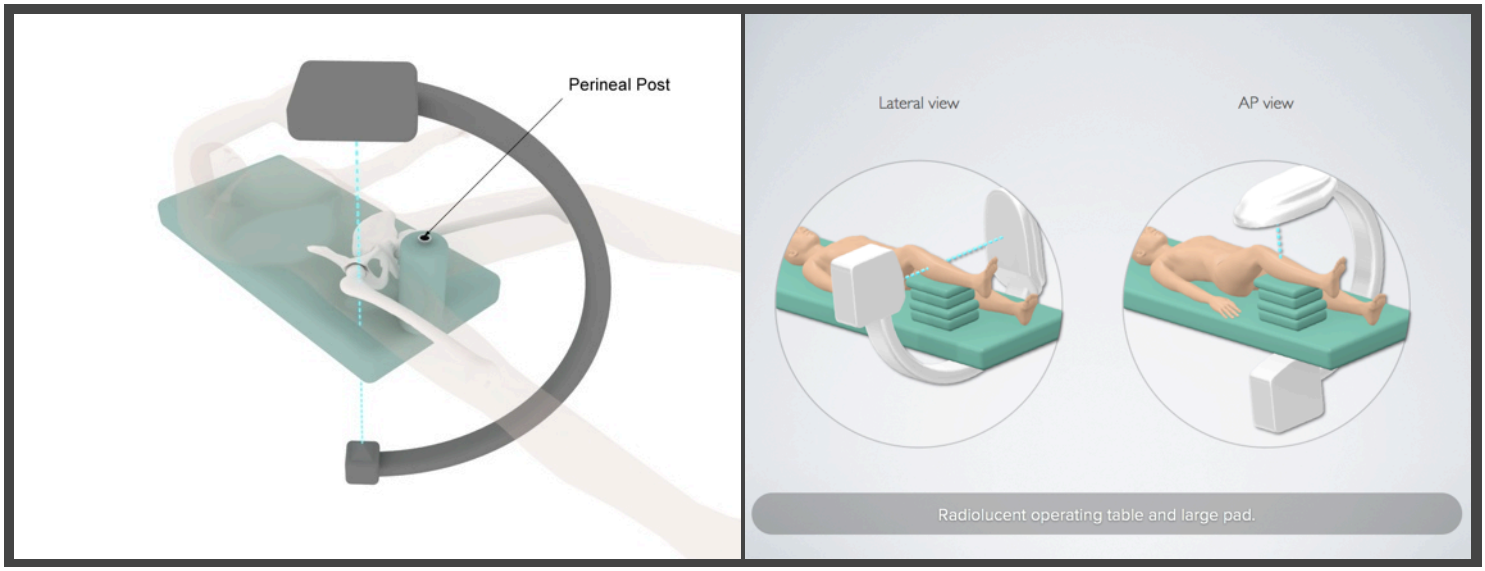

Fig. 5: **Diagram of correct position of C-arm.** The position of the imaging modality is part of the planning and must be correctly communicated to the OR personnel preoperatively in order not to lose time and to correctly position radiation source and receiver allowing to reduce radiation. *(RIGHT: ICUC App/Tibial shaft/Expert opinions/Patient positioning. LEFT: ICUC App/Proximal Femur/Expert Opinions/ X-Ray tips 1)*

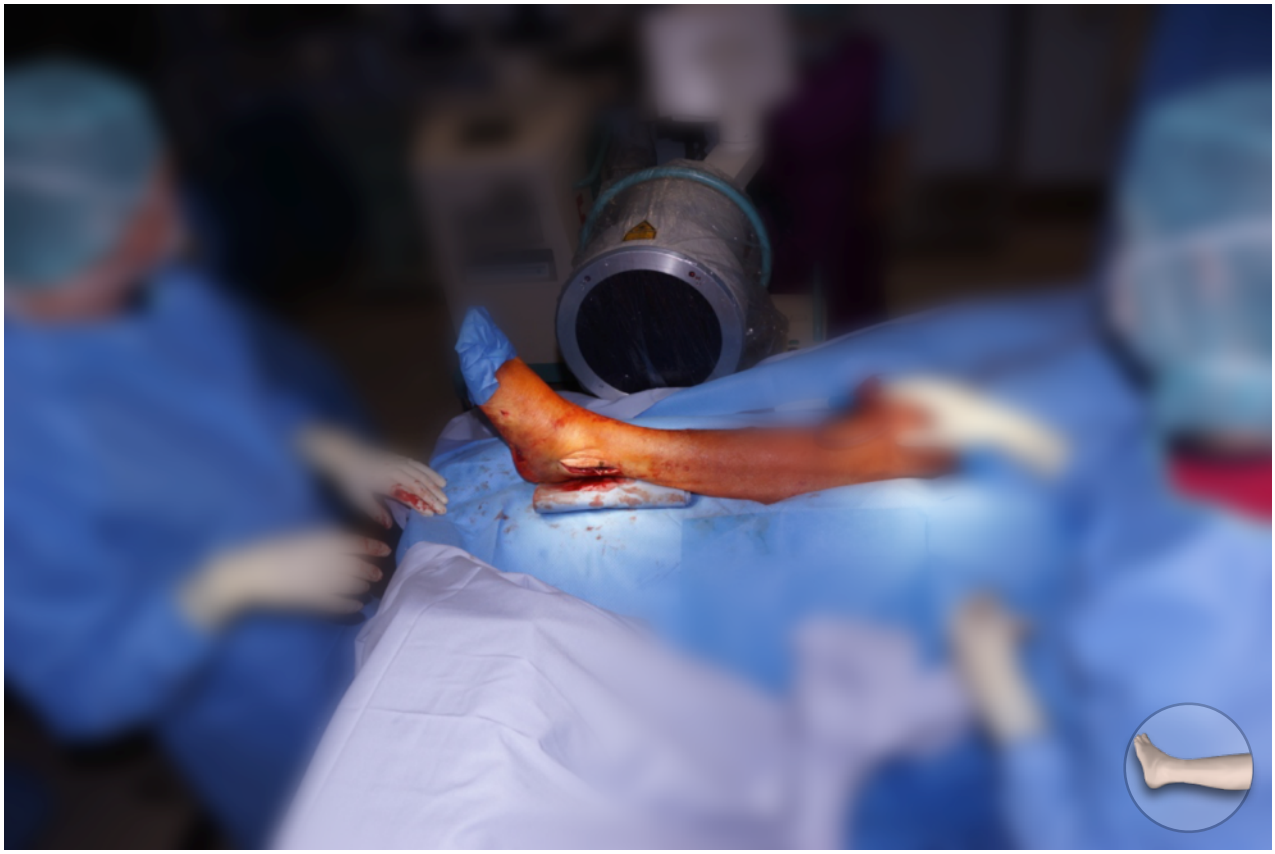

Fig. 6: **Position of OR crew.** (details can be found in the ICUC app, case *ID: 44-TS-673*). The relative position of the operating crew to the C-arm is crucial for the radiation dose absorbed. Keeping to the minimum distance of 2 m is a question of discipline.

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