Detection of clinically suspected scaphoid bone fractures using a dedicated cone-beam CT (CBCT). A retrospective study of 139 patients.

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Purpose

The scaphoid is the most frequently injured carpal bone, mostly due to a fall on an outstretched hand. Scaphoid fractures are often occult on initial radiographs. Since scaphoid fractures may be implicated by a process of non-union with instability, avascular necrosis, and late osteoarthritis, patients with suspected fractures will be immobilized routinely, until (repeat) imaging confirms or denies the presence of a fracture [1,2]. This approach will however result in needless immobilization in a number of patients, having a negative impact on their daily activity and representing a high economic cost.

Cone beam Computed Tomography (CBCT) has been widely adopted for dental 3D-imaging since the late 1990s [3]. Compared with multi-detector computed tomography (MDCT) imaging, CBCT offers higher resolution with a relatively low radiation dose.

Besides use in dental and ORL applications on the first commercially available CBCT systems, modern CBCT units afford examinations in seated or lying position, therefore permitting high-resolution CBCT imaging of other body parts, such as the wrist, the elbow, foot or ankle [4,5,6].

We investigated the potential role of low-dose cone-beam CT in the assessment of patients who sustained a trauma clinically suspicious for scaphoid fracture. Therefore, we examined whether CBCT potentially could identify supposedly occult scaphoid fractures, thereby enabling accurate treatment for fractures at risk for osteonecrosis (proximal pole fractures) or for nonunion on the one hand, and avoiding overtreatment in cases who definitely did not sustain a fracture on the other hand.
Methods and Materials

139 patients (Male/female: 80/59; age range 7-83 years), clinically suspicious for scaphoid fracture, were examined within 6 days after the event with radiographs, followed by a CBCT examination.

A series of three standard projection views (posteroanterior, lateral and posteroanterior view with ulnar deviation) was performed.

The CBCT was performed on a NewTom 5G CBCT scanner (QR, Italy) with the patient sitting behind the gantry, with the arm in horizontal position through the gantry opening, with wrist and hand fixated in order to prevent motion artifacts. Anode voltage is maximum 110 kV at 3 mA current. Measured field of view is 8x8 cm. The scan time is about 7 seconds.

The CT images are generated by rotating an x-ray source around the wrist creating a series of flat panel detector radiographs with the patient sitting behind the gantry. This results in an axial data set of 659 raw data images. The reconstructed 3D-volume is displayed on a 19" screen, which is used to manage image acquisition and data processing/reformatting. Coronal, sagittal oblique, true sagittal and axial orthogonal 1 mm slices are reconstructed and sent by DICOM communication to a PACS system (Impax, AGFA Healthcare, Belgium).

All images were randomised and retrospectively reviewed, blinded to the other examination.
Results

In 20 patients, a fracture seen on conventional radiographs is confirmed upon CBCT.

In 33 out of 89 patients (i.e. in 37 %) who were initially scored negative on radiographs, at least 1 carpal fracture was detected on CBCT (16 scaphoid, 5 hamulus of the hamate, 5 trapezium, and one capitate, one lunate, one hamate, one trapezoid, and in 3 patients a combination of lunate, capitate trapezium, triquetral, or hamate fractures). Thus, using CBCT, 37 fractures were detected in this subgroup initially being interpreted radiographically negative.

Sixteen out of these (i.e. 18 % of initially misdiagnosed fractures) were scaphoid fractures, representing so-called "occult" scaphoid fractures (Figs. 1-5).

Besides detection of these fractures, CBCT furthermore enabled to install correct treatment as a function of fracture type; as acute fractures of the distal scaphoid pole and tubercle are treated conservatively with casting, whereas nondisplaced acute waist fractures may be treated with a short or long arm cast or operatively, and on the contrary, likewise displaced scaphoid waist fractures-, proximal pole fractures are typically treated surgically, CBCT afforded to choose prompt optimal treatment in these 16 patients with occult scaphoid fractures.

If not being examined with CBCT, all of these 89 patients would have undergone standard conservative treatment with casting and repeat radiographs in two weeks. This procedure however would have implied an unnecessary temporarily immobilization in 56 out of these 89 patients with potential negative impact on professional activities and daily life.

The same holds true in 27 out of 30 cases where radiographs were equivocal in whom CBCT could exclude a wrist fracture (i.e. in 90 %). Only in three out of these 30 patients, a fracture of the trapezium and scaphoid was found upon CBCT in respectively one and two cases, thereby enabling adequate treatment in these, but avoiding unneccesary casting and follow-up in 27 other patients (Figs.6-11).
Fig. 1: Male patient; 22-years-old. Plain radiograph of the left wrist - posteroanterior view. No fracture is noted.

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Fig. 2: Male patient; 22-years-old. Plain radiograph of the left wrist - lateral view. No carpal fracture is noted.

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Fig. 3: Male patient; 22-years-old. Cone beam CT of the left wrist, showing a fracture at the distal pole of the scaphoid bone (coronal reformatted image; 1 out of 2).

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**Fig. 4:** Male patient; 22-years-old. Cone beam CT of the left wrist, showing a fracture at the distal pole of the scaphoid bone (coronal reformatted image; 2 out of 2).

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Fig. 5: Male patient; 22-years-old. Cone beam CT of the left wrist, showing a fracture at the distal pole of the scaphoid bone (sagittal reformatted image).

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**Fig. 6:** Male patient; 26-years-old. Plain radiograph of the right wrist; posteroanterior view. No fracture is noted.

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Fig. 7: Male patient; 26-years-old. Plain radiograph of the right wrist; posteroanterior view with ulnar deviation. There is some doubt about a smooth, unsharp line traversing the waist of the scaphoid bone.

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**Fig. 8:** Male patient; 26-years-old. Cone beam CT of the right wrist; coronal reformatted image (first out of four). A fracture through the waist of the scaphoid bone is confirmed.

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Fig. 9: Male patient; 26-years-old. Cone beam CT of the right wrist; coronal reformatted image (second out of four). A fracture through the waist of the scaphoid bone is confirmed.

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**Fig. 10:** Male patient; 26-years-old. Cone beam CT of the right wrist; coronal reformatted image (third out of four). A fracture through the waist of the scaphoid bone is confirmed.

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Fig. 11: Male patient; 26-years-old. Cone beam CT of the right wrist; coronal reformatted image (fourth out of four). A fracture through the waist of the scaphoid bone is confirmed.

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Conclusion

CBCT is a new low-dose imaging modality highly effective in detecting scaphoid fractures, enabling early adequate treatment, and omitting the need of unnecessary immobilization in patients without fracture.

Furthermore, it may demonstrate concomitant fractures notoriously difficult to see on radiographs.
References


