From Clinical Need to Evaluation: A Fully In-House AI Solution

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The Challenge

Scaphoid fractures are the most common carpal bone fracture.[1] Prompt and accurate diagnosis is important in preventing severe long-term complications.[2] Their appearance on first-line X-ray imaging can be subtle, and fracture diagnosis often requires confirmatory imaging with Magnetic Resonance Imaging (MRI).[3] MRI is a comparatively expensive resource and is not always available. Reducing the burden on MRI by improving fracture diagnosis is important to manage resources effectively and diagnose patients faster.

The CSC Advantage: In-House Expertise for Real-World Solutions

The CSC team brings together clinical scientists, clinicians, and data scientists, fostering a collaborative environment that facilitates the whole AI development pipeline within the hospital itself. This structure offers the advantage of developing:

Targeted Solutions

- Deep understanding of the clinical context allows the CSC team to develop AI solutions for clinical challenges identified by clinicians working on the frontline.

Models Optimised for Local Clinical Pathways

- Models are designed and optimised for the specific nuances of the local clinical pathway, improving the experience of clinicians and patients.

The In-House Solution: ScaphX

The development of our in-house fracture detection model went through four phases:

1. Data Curation

- The CSC team curated a comprehensive dataset of historical X-ray images from patients presenting with suspected scaphoid fractures at GSTT, who underwent confirmatory MRI.
- Each X-ray image was paired with the corresponding MRI report from a musculoskeletal (MSK) specialist radiologist.
- Since every patient with an indeterminate X-ray at GSTT receives an MRI, this data source provided a representative dataset to train ScaphX.

2. Model Development

The CSC developed a model with 2 steps:

a) **Detection Layer**: Identifies and isolates the scaphoid bone within the X-ray image.
b) **Classifier Layer**: Analyzes the image and assigns a probability score between 0 and 1, indicating the likelihood of a fracture

To ensure generalisability and robustness, the model was carefully validated using a subset of the data held out specifically for this purpose.

3. Deployment Strategy

ScaphX was designed to assist ED clinicians in real-time decision-making:

- It integrates seamlessly with the existing PACS system, presenting a PDF of ScaphX's results alongside the X-ray images.
- The model provides a diagnosis and a recommendation for further management, specific to the local clinical pathway.

4. Clinical Evaluation

A retrospective, multi-reader, multi-case crossover study was conducted at GSTT to assess ScaphX's impact on diagnostic accuracy. Critically, the study mirrored the existing clinical pathway to ensure a realistic assessment.

- Six ED clinicians participated, including a mix of junior and senior staff.
- Each clinician reviewed 100 anonymised cases **twice**: once without and once with ScaphX assistance.
- A two-week washout period separated the two review sessions to minimise carryover effects.
- For each case, readers chose between:
  - "I cannot see a fracture - Refer for MRI"
  - "There is a fracture - Send to fracture clinic"
- Readers then rated their decision confidence on a 1-5 Likert scale

Results and Discussion

Diagnostic Performance

Sensitivity: ScaphX assistance **increased sensitivity** of ED clinicians from 36.33% to 47% (p-value = 0.01)
Specificity: ScaphX assistance **decreased specificity** of ED clinicians from 72.33% to 66.33% (p-value = 0.1).
Accuracy: ScaphX assistance increased overall diagnostic accuracy of ED clinicians from 54.33% to 56.67%.

Clinical Implications

Increased sensitivity suggests ScaphX has the potential to reduce missed fractures, potentially leading to earlier treatment and improved patient outcomes.
Decreased specificity and the identification of 56 false positives with the use of ScaphX requires further consideration. These false positives may lead to unnecessary patient anxiety, additional imaging, and increased healthcare costs.

Economic Analysis

Our economic analysis revealed that while ScaphX helped diagnose 14 more fractures, resulting in potential cost savings of £504, the 56 false positives led to additional costs of £2,016. Overall, in this initial evaluation, ScaphX resulted in a net cost of £1,512.

Sensitivity of Scaphoid Fracture Diagnosis by Reader (alone vs with ScaphX assistance)

All Readers (+ScaphX)		Actual Diagnosis	
		Fracture	No Fracture
Predicted Diagnosis	Fracture	144 (173)	**48 (104)**
	No Fracture	156 (127)	252 (196)

Next Steps

Model Enhancement: Incorporate an "apparent fracture model" trained on X-rays explicitly labelled by MSK radiologists as showing X-ray apparent fractures. This addresses the current model's limitation of primarily encountering inconclusive X-rays that led to confirmatory MRIs.
Iterative Validation: Following the development of the apparent fracture model, a new retrospective diagnostic accuracy study will be conducted to evaluate ScaphX's overall performance.

References

1. Hove, L. M. Epidemiology of scaphoid fractures in Bergen, Norway. *Scand. J. Plast. Reconstr. Surg. Hand Surg.* **33**, 423–426 (1999). 2. Hackney, L. A. & Dodds, S. D. Assessment of scaphoid fracture healing. *Curr. Rev. Musculoskelet. Med.* **4**, 16–22 (2011). 3. De Zwart, A. D. *et al.* MRI as a reference standard for suspected scaphoid fractures. *Br. J. Radiol.* **85**, 1098–1101 (2012).