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"A picture tells a thousand words" smartphone-based secure clinical image transfer improves compliance in open fracture management

Martin Ka-Ho Li*, Daniel P. Howard, Richard King

University Hospital Coventry and Warwickshire NHS Trust, Department of Trauma and Orthopaedics, Clifford Bridge Road, Coventry, CV2 2DX, United Kingdom

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ABSTRACT

Background: BOAST (British Orthopaedic Association Standards for Trauma) and NICE (National Institute of Clinical Excellence) guidelines recommend clinical photography of all open fractures on admission and at key stages of patient care for objective wound documentation and to avoid repeated examination. Recording and handling photographs in a compliant and confidential manner in the setting of acute trauma management can prove challenging. To facilitate clinical photography at our Major Trauma Centre (MTC) institution, a smartphone-based Secure Clinical Image Transfer (SCIT) app was introduced and integrated with the existing clinical photography database to allow clinicians to take photographs, which are saved directly to patient records.

Objectives: To compare rates of information governance (IG)-compliant clinical photography of wounds of patients with open fractures before and after introduction of departmental smartphones loaded with the clinical photography app SCIT.

Methods: Admission lists were inspected retrospectively for patients admitted with open fractures between August and October 2016, before SCIT was introduced. The Trust clinical photography database was searched for corresponding patient images and where present, graded out of three for clarity, comprehensiveness and context. The procedure was repeated prospectively from August to October 2017 after rollout of SCIT. The uptake and quality of photography were statistically compared (Fisher's exact test, significance level $p < 0.05$).

Results: 42 open fractures were identified in the 2016 period and 40 in the 2017 period. None of the 42 patients in the 2016 cohort had records of IG-compliant clinical photography on admission. 16 of 40 patients in the 2017 cohort had IG-compliant clinical photography on admission. This was statistically significant ($p < 0.0001$). 5 of 42 patients in the 2016 cohort and 8 of 40 patients in the 2017 cohort had photographs after first debridement. This was statistically insignificant ($p = 0.375$). All five photographs in the 2016 cohort scored 3/3. 18 of 21 photographs in the 2017 cohort scored 3/3, one scored 2/3 and two scored 1/3.

Conclusions: Integrating commonplace smartphone technology with a secure platform for taking and storing photographs can improve rates of IG-compliant clinical photography of open fractures. This may improve documentation, communication and patient care.

Introduction

Clinical photography provides invaluable graphic detail for objective wound documentation. Well-taken, appropriately stored photography avoids need for repeated clinical examination and allows changes in wounds to be easily tracked over time [1,2]. Indeed, current BOAST (British Orthopaedic Association Standards for Trauma) and NICE [3,4] guidelines recommend photography pre-debridement and at other key stages of patient care, for management of open fractures. Images can then be shared within or between institutions to facilitate handover of clinical care. Furthermore, medical images form an important part of patients' healthcare records and must be treated in the same manner as other records (General Medical Council, 2013).

Before the advent of smartphones, clinical photography generally required a hospital camera, often stored centrally in the clinical photography suite, to confidentially take photographs. In 2001, a survey of 51 hospitals revealed that whilst 46 hospitals

* Corresponding author at: Department of Trauma and Orthopaedics, University Hospital Coventry and Warwickshire NHS Trust, Clifford Bridge Road, Coventry, CV2 2DX, United Kingdom.
E-mail address: martin.li@btinternet.com (M.K.-H. Li).

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(or 90%) possessed departmental cameras, only 36 of these had 24 - h access. Of these 36, 16 were non-functional at the time of contact due to lack of film, theft or breakage [5]. A newer survey in 2007 found that 35 of the 44 randomly surveyed A&E departments possessed a working polaroid or digital camera [6]. An audit of BOAST 4 guideline compliance conducted between 2002–2007 found that only 19 of 101 open fractures had associated clinical photographs, but there was a statistically significant trend to better photography in Gustilo-Anderson III fractures (14/38) over I and II fractures (5/63) [7].

The development of smartphones has greatly simplified photography in general by allowing users to photograph their surroundings at will, without the need to carry a camera. In the healthcare setting, this raises ethical issues of confidentiality. Whilst a survey of 140 hand trauma patients revealed that 97% of patients had positive attitudes to sharing images of their wounds with the hand specialist teams [8], there are ongoing concerns with information governance (IG) and calls for tighter regulation [9]. Doctors are under both ethical and legal duties to protect patients' personal information from improper disclosure, but appropriate information sharing is an essential part of the provision of safe and effective care (General Medical Council, GMC, 2013). The GMC are clear that serious or persistent failure to follow their guidance will put a clinician's registration at risk.

To facilitate the uptake of clinical photography and to do so in compliance with IG requirements, our department acquired two baton smartphones in 2017 loaded with a Secure Clinical Image Transfer app (SCIT) (University Hospitals Birmingham NHS Foundation Trust, United Kingdom) to be carried and used by the on-call Orthopaedic team. This app allows patient consent and clinical images to be taken through it and instantly uploaded via the Trust network directly onto the patient's medical records for viewing (see Figs. 1 and 2). Importantly, the photograph is not stored on the photo album of the smartphone, instead being encrypted within the "sandbox" component of the app. Prior to the introduction of SCIT, a photography service was available through

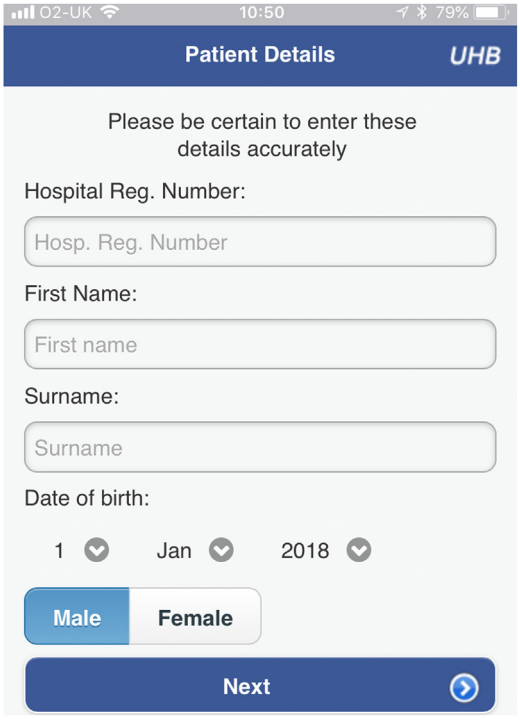

Fig. 1. After logging in to SCIT, three forms of patient identification: full name, date of birth and hospital number are required to access clinical photography.

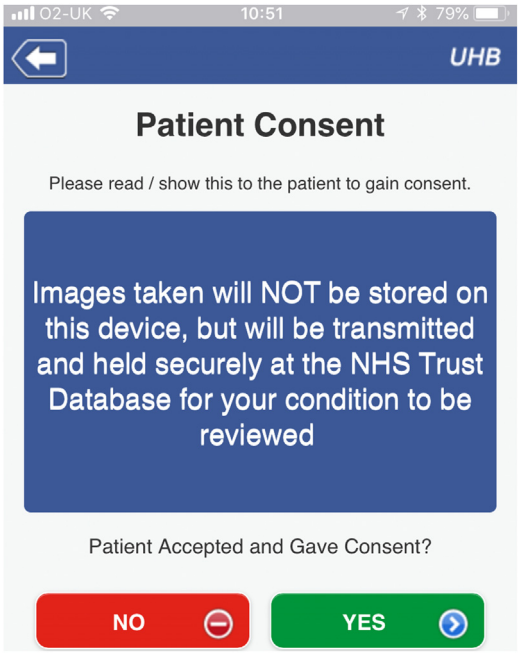

Fig. 2. Verbal patient consent is required before the camera can be accessed through SCIT.

the Trust medical illustration department, which included a digital camera locked securely in a cupboard in the Emergency Department with periodic uploads to the online photography database or an 'on-request' service by a professional medical illustrator during normal working hours.

The aim of this study was to investigate the impact SCIT had on our compliance with BOAST 4 and NICE guidelines of taking clinical photographs in patients presenting acutely with open fractures. In this retrospective observational study, patients with open fractures formed the participant group and rates and quality of clinical photography were the outcome measures.

Materials and methods

All open fractures presenting to our home institution were identified retrospectively from on-call lists between August and October 2016 before introduction of SCIT. Exclusion criteria applied to hand or forefoot fractures, which are explicitly excluded from BOAST 4 guidelines, and any wound without underlying fracture.

Hospital numbers were used to search the two portals on our hospital informatics systems to view images: WABA and CRRS. WABA (Wilde and Betts Agency ®) is the dedicated clinical image database used within the Trust, to which all photographs taken on SCIT or via the clinical photography service are uploaded. Our Trust moved exclusively to paperless photography prior to 2016. Some clinicians prefer to move photographs taken on SCIT directly onto their operation note or clinical correspondence. This was available on CRRS (Clinical Results and Reporting System ®), the hospital's online results reporting platform. This setting generally occurs after debridement as opposed to pre-debridement, when senior clinicians wish to add post-debridement photographs onto their operation notes, and so this was noted in data collection.

Presence or absence of clinical photography was recorded for all open fractures. A professional photographer within our Medical Illustration department graded all images for quality within the SCIT backend interface. There was no universally recognized grading system for clinical photographs identified in the literature, so the below scoring system was devised in conjunction with the

professional medical illustrators within our department. Three domains were deemed important for accurate interpretation of photographs, each scored either 0 for low quality, or 1 for acceptable quality:

1 Clarity: The photograph must be of meaningful resolution and granularity, without glare or blur.
2 Context: The wound in relation to its limb must be discernible on the photographs.
3 Comprehensiveness: The whole of the wound must be photographed without segments hidden from view.

SCIT was then introduced to all incoming clinicians in August 2017. Illustrations of the interface are highlighted in Figs. 1 and 2. All clinicians were shown the baton devices, the app logistics, and were supplied with individual accounts for use. After its introduction, the above procedure was performed prospectively from August to October 2017.

The uptake and quality of clinical photography between the two cohorts was statistically compared using Fisher's exact test (GraphPad Instat, two-tailed, $p < 0.05$ significance level).

Results

In the period August to October 2016, 42 open fractures were identified, compared to 40 in August-October 2017. The baseline characteristics are illustrated in Table 1.

In August-October 2016 no clinical photographs were identified for any open fracture and only five of 42 patients had post-debridement photographs. This improved significantly to 16/40 on introduction of SCIT ($p < 0.0001$; Fisher's exact test, significance level $p < 0.05$). 5 of 42 open fractures had clinical photographs at first debridement, compared with 8 of 40 in 2017. This was statistically insignificant ($p = 0.3745$) (Table 2). The majority of clinical photographs were of good clarity, context and comprehensiveness.

A post-hoc power calculation (G*Power, Universität Düsseldorf) was performed based upon a two-tailed Fisher's exact test. Group sizes of 42 and 40, and observed proportions of 0.0 and 0.4, representing pre- and post- introduction of SCIT, were utilised. This yielded an alpha value of 0.040 and a statistical power of 0.99, validating our sample sizes.

Discussion

Our study has demonstrated that the supply of smartphones preinstalled with a secure photography app that uploads directly to the patient record improves rates of IG-compliant clinical photography in open fracture management. We are aware that other hospitals have adopted SCIT, or similar solutions. To our knowledge no study has investigated smartphone app impact on clinical photography of open fractures or wounds in general.

Despite facilitating photography using a portable smartphone, we still did not achieve full compliance with clinical photography. There are several possible explanations for this. Many open fracture patients have concomitant polytrauma and arrive either systemically unstable or in extremis. In these setting it can be impractical to photograph wounds when the overwhelming priority focuses on resuscitative efforts for the patient. Similarly, where systemically stable but locally unstable (for instance where further skin tenting is impending or there is neurovascular compromise), there is an urgency to reduce and splint open fractures. Photography may be omitted inadvertently if the workload is too great or the puncture wound is small. There is evidence that higher Gustilo-Anderson grades are likelier to be photographed, probably due to ostentatiousness [7]. However, a survey of doctors' attitudes reveals the majority (84%) of those that had a departmental camera available to them would photograph known open fractures on arrival [10], showing the motivation to photographically document open fractures is present. The vast majority of photographs were of good quality, and the few that were of suboptimal quality were generally wounds in difficult places such as the posterior thigh or knee. In addition, to enable traceability of photographs to the clinician, the SCIT app requires a username and password. Thus, while smartphones make clinical photography more accessible, this is partly offset by the barrier of individual clinicians needing to recall their login details for the device, and to keep track of all clinicians so that they are each supplied their own personal login details.

An additional opportunity for wound imaging would be in theatre at the time of debridement, but as the baton smartphones are carried by the on-call team, they would not therefore be readily available in theatre. Although SCIT was available for clinicians for download onto their own personal smartphones, but uptake was incomplete at the time of this study and would therefore not always be available at first debridement by this means.

One limitation of SCIT is that its photographs cannot be shared between clinicians from within the app, instead relying on PC availability within the department to view images. Indeed, there remains the temptation for clinicians to photograph open fractures using personal smartphones and communicate these images via messaging. A South African survey of Orthopaedic clinicians found the vast majority (99%) use personal smartphones with variable rates of digital hygiene [11]. Conversely, previous reports have shown messaging to be an efficient decision-making tool for radiographs, combined with clinical history and examination [12–14].

Table 1
Baseline characteristics of included patients.

	August-October 2016	August-October 2017
Number of open fractures	42	40
Average age (years)	45.1	46.0
Male:Female ratio	29:13	28:12
Composition of open fractures by anatomical location *	Humerus: 5 Elbow and forearm: 14 Pelvis: 1 Femur: 4 Patella and knee: 4 Tibia: 13 Ankle: 3	Humerus: 2 Elbow and forearm: 8 Pelvis: 1 Femur: 6 Patella and knee: 1 Tibia: 14 Ankle: 9

* In 2016 includes one patient with concomitant open femoral, forearm and tibial fractures. In 2017 includes one patient with concomitant open femoral and ankle fractures.

Table 2
Number of open fractures, number of documented clinical photographs and quality of clinical photographs.

	August-October 2016	August-October 2017
Number of open fractures	42	40
Photos on admission *	0	16**
Photos on debridement	5	8**
Number of 3/3 quality photos	5	18
Number of 2/3 quality photos	0	1
Number of 1/3 quality photos	0	2

* Statistically significant $p < 0.0001$; Fisher's exact test, two-tailed, significance level $p < 0.05$.
** Three patients had photographs both on admission and then at first debridement so these photographs were included in both counts. Only the initial admission photographs were used to grade quality of images.

The Gustilo-Anderson classification for some open fractures was not documented on any operation note and could not be directly inferred from the note to enable subgroup analysis. At the time of writing, informatics teams were updating SCIT to include better resolution photography with a view to permitting confidential message sharing. It would be interesting to assess the impact on clinical practice when this upgraded app is introduced into our institution.

A notable limitation to this study is that we did not search for images taken on clinician personal smartphones. It is possible that personal smartphones were used to overcome the limitations described above and aid clinical handover (with high possibility prior to the introduction of SCIT), but practical and interpersonal difficulty in accurately tracing non-IG-compliant photographs back to individual patients from all potential clinician's devices was anticipated. The true incidence of all photography methods is therefore likely to have been underestimated, however, the purpose of this study was to identify those images that were taken in an IG-compliant manner – the very reason that this technical solution to a known problem was first sought.

Conclusion

Supplying a clinician-led clinical photography package, by means of smartphones and a secure photography app uploading images directly to the patient record, improves compliance with national guidelines on the management of open fractures in an IG-compliant manner.

Conflict of interest statement

The three authors of this work claim no conflict of financial or personal interest with this work.

References

[1] Houghton PE, Kincaid CB, Campbell KE, Woodbury MG, Keast DH. Photographic assessment of the appearance of chronic pressure and leg ulcers. Ostomy Wound Manage 2000;26:28–30.
[2] Swann G. Photography in wound care. Nursing Times 2000;96(45):9.
[3] BOAST 4 (2017) British Orthopaedic Association & British Association of Plastic, Reconstructive and Aesthetic Surgeons Audit Standards for Trauma: Open Fractures [ONLINE] Available at: https://www.boa.ac.uk/wp-content/uploads/2017/12/BOAST-Open-Fractures.pdf [Accessed 7 October 2018].
[4] NICE (2016) Fractures (complex): assessment and management [ONLINE] Available at: https://www.nice.org.uk/guidance/ng37 [Accessed 7 October 2018].
[5] Solan MC, Calder JDF, Gibbons CE, Ricketts DM. Photographic wound documentation after open fracture, Injury. Int J Care Injured 2001;vol 32:33–5.
[6] Morgan BW, Read JR, Solan MC. Photographic wound documentation of open fractures: an update for the digital generation. Emerg Med J 2007;24:841–2.
[7] Walton R, Manara J, Elamin S, Braithwaite I, Wood E. Immediate Care of Open Extremity Fractures: Where Can We Improve? BioMed Res Int 2014 Article ID 807694.
[8] Tomlinson JK, Myers AJ, Meads BM. Letters: To the Editor (in response to "click first care second photography". Med J Aust 2013;198(1):22.
[9] Coiera EW, Kidd MR, Haikerwal MC. A call for national e-health clinical safety governance. Med J Aust 2012;196(7):430–1.
[10] Ahmad R, Annamalai SKM, Ahmed SMY, Joseph SA, Bould M. Photographic documentation of open fractures. A survey of current practice and proposed recommendations. Br J Med Pract 2009;2(1):32–4.
[11] Farrell P, Ferreira N. Digital photography in orthopaedics: Ethical considerations. SA Orthop J 2016;15(1):91–4.
[12] Syed TA, Sadiq Z, Shah YR, Al-Saeed M, Wetherill MH. Role of mobile multimedia messaging service (MMS) in trauma and orthopaedic telediagnosis. Eur J Orthop Surg Traumatol 2007;17(6):603–7.
[13] Korim MT, Soobrah R, Hull P. To admit or not: the use of camera mobile phone in trauma and orthopaedics at night. Eur J Orthop Surg Traumatol 2009;19:217.
[14] Eranki V, Munt J, Lim MJ, Atkinson R. Consultation of Orthopaedics Cases Using Multimedia Messaging Services. Open Orthopaed J 2010;4:164–8.