Wound photography for evaluation of surgical site infection and wound healing after lower limb trauma

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Competing interests:

MLC reports membership of the UK NIHR HTA general board.

Role of each author

MLC is Chief Investigator and responsible for study conception for NIHR-funded WOLLF and WHIST clinical trials. JB, NP and JA are grant co-applicants. JB was responsible for wound photography and SSI data collection protocols. JA and MC oversaw trial management and delivery. NP and RK undertook data analyses. Image assessment was undertaken by AV, JB, RB, JBRo and MCL. All authors were involved in the interpretation of data and contributed to the manuscript. JB drafted and vouches for the paper.

Abstract

Aims

Deep surgical site infection (SSI) is common after lower limb fracture. We compared deep SSI using alternative methods of data collection and examined agreement of photography compared to Centres for Disease Control (CDC)-defined SSI after lower limb fracture surgery.

Methods

Data from two large UK multicentre randomised controlled major trauma trials investigating SSI and wound healing after surgical repair of open lower limb fractures that could not be primarily closed, (UK WOLLF) and surgical incisions for fractures that were primarily closed (UK WHIST). Trial interventions were standard wound care management and negative pressure wound therapy after initial surgical debridement. Wound outcomes were collected from 30 days to six weeks. We compared level of agreement (%; Cohen's kappa (*k*)) between blinded independent assessors, wound photography and CDC-defined SSI.

Results

Rates of CDC-defined deep SSI were 7.6% (35/460) after open fracture and 6.3% (95/1519) after closed incisional repair. Photographs were obtained for 77% and 73% of WOLLF and WHIST cohorts respectively (all participants n=1478). Agreement between photographic-SSI and CDC-SSI was fair for open fracture wounds (83%; *k*=0.27; 95% CI 0.14, 0.42) and for closed incisional wounds (88%; *k*=0.29, 95% CI 0.20, 0.37) although rate of photographically-detected deep SSIs was twice as high as CDC-SSI (12% vs 6%). Agreement between different assessors for photographic-SSI (WOLLF 88%, *k*=0.63, 95% CI 0.52, 0.72; WHIST 89%; *k*=0.61, 95% CI 0.54, 0.69) and wound healing was good (WOLLF 90% *k*=0.80; 95% CI 0.73, 0.86; WHIST 87%; *k*=0.57, 95% CI 0.50, 0.64).

Conclusion

Although wound photography was feasible within the research context and inter-rater assessor agreement substantial, digital photographs used in isolation overestimated deep SSI rates compared to CDC criteria. Wound photography should not replace clinical assessment in pragmatic trials but may be useful for screening purposes where surgical infection outcomes are paramount.

Key findings

- We compared deep surgical site infection rates determined by wound photography only compared to clinically determined Centres for Disease Control-SSIs, one month after lower limb fracture surgery.
- Although clinicians agreed on the rate of photographic-determined SSIs, these rates were double that of CDC-SSIs. Wound photography was feasible but should not replace detailed clinical assessment.

Introduction

Deep surgical site infections (SSI) are one of the most common and costly healthcare associated infections, associated with prolonged hospital length of stay, morbidity and mortality.[1 2] Postoperative SSIs are widely used as indicators of healthcare quality and are routinely captured within national and international surveillance systems. Most national, mandatory systems use Centers for Disease Control (CDC) definitions, or modifications of these definitions, comprising detailed diagnostic criteria for incisional superficial, deep and organ-space SSI.[2 3] Post-discharge SSI surveillance remains a challenge although digital imaging is being used more frequently, driven by the availability of smartphones and opportunities for remote monitoring. Early studies examined the utility of wound imaging to track healing of chronic wounds, such as venous ulcers[4], but recently focus has shifted to postoperative monitoring after elective surgery.[5] Studies have investigated the acceptability, uptake, and accuracy of technology-based monitoring after surgery, to determine whether wound photography can inform treatment-based decision-making.[6 7]

To date, no studies have examined the use of wound photography after orthopaedic trauma surgery. Trauma injuries can be severe and complex, with initial surgery typically aiming for debridement of contaminated material to reduce risk of deep SSI, fracture stabilisation and viable closure. Rates of deep SSI after open fracture may be high (>10%), due to skin breach and bone exposure, although rates vary widely depending on definition, method and duration of surveillance.[8] Deep SSI of the lower limb is debilitating, associated with prolonged reduced health-related quality of life and high healthcare and social costs.[9]

We undertook methodological sub-studies embedded within two large UK multicentre randomised controlled trials investigating deep SSI, wound and health-related outcomes after surgical repair of lower limb fracture after major trauma: UK Wound management of Open Lower Limb Fractures (WOLLF)[10] and Wound Healing in Trauma (WHIST)[11]. We used the ‘study within a trial’[12] model to investigate whether wound photography was a useful adjunct to clinical data collection in identifying SSI, and to assess level of agreement between wound photography and clinically determined-SSI at 30-days. Our primary aim was to examine the level of agreement between photography-determined SSI and clinically determined CDC-SSI, after lower limb trauma surgery. Secondary aims were to i) examine inter-observer agreement between assessors appraising photographic images and to ii) compare photographically-determined wound healing with clinically and patient-reported opinion of wound healing.

Patients and methods

Study participants and setting

Protocols and main findings have been published for both trials.[10 11 13 14] In brief, the WOLLF trial recruited 460 participants with open fractures of the lower limb (Gustilo and Anderson (GA) >2) that could not be closed during the first surgical wound debridement (no 'primary closure'). Participants were recruited from 17 NHS major trauma centres between 2012 and 2016. WHIST recruited 1548 participants, with a lower limb fracture requiring a surgical incision that could be closed primarily, from 24 NHS major trauma centres between 2016 and 2018. All participants required stabilisation of their fracture with internal or external fixation. Each trial compared alternative wound management interventions, either negative pressure wound therapy (NPWT) applied to wounds after open fractures (WOLLF) or incisional NPWT (WHIST) versus standard wound care after initial surgical debridement. However, as neither trial found evidence of a difference in deep SSI between the intervention groups, the trial participants are treated as single cohorts for the purposes of this study. Ethical approval was obtained for each clinical trial and signed consent obtained from each participant (WOLLF REC 10/57/20, WHIST NREC 16/WM/0006).

Definition of SSI

We adhered to CDC definitions for clinically determined deep SSI; for the trial where open fractures could not be closed primarily, deep SSIs were defined as those occurring within 30 days after surgery. For the closed incisional wound trial, the primary outcome was deep SSI at 30-days. Although infection surveillance, as per CDC recommendations, continued for longer time periods in both studies[2], these analyses focus on SSI outcomes captured at or near to 30 days postoperatively. For superficial SSIs, we used the CDC-definition for superficial SSI (WOLLF) and also applied a stricter definition of whether or not antibiotics were prescribed for suspected wound SSI (WOLFF/WHIST).

Direct wound observation at 30-days postoperative

Standardised wound assessment protocols were developed. Research staff, independent of the clinical team and blind to treatment allocation, were trained to visually observe and record all signs and symptoms relating to the index trial wound on the day of assessment. For trial participants discharged before 30 days, we accepted all infection symptoms detected up to face-to-face follow-up at hospital outpatient clinic within six weeks postoperatively, to reflect usual routine surgical practice in the UK NHS. Research staff reviewed clinical records to screen for all wound-related symptoms and record whether a surgeon/doctor had diagnosed SSI any time from debridement surgery to the day of assessment and whether antibiotics were prescribed for suspected wound infection. Infection criteria were recorded as individual signs and symptoms, derived from CDC definitions. For the outcome of wound healing, we asked research staff to appraise the index trial wound was healed (yes/no) and staff then asked participants for their judgement of whether their own wound was healed (yes/no).

Digital wound photography at 30-days postoperative

Digital photographs were taken at the same time as clinical data collection, by research staff or medical photography departments. A Samsung ES9 digital camera (Samsung Electronics Limited, Surrey UK) or Fujifilm Finepix JV300 digital camera was provided to participating sites. Cameras had

14-16 mega-pixel resolution, with automatic settings for flash, optical zoom and focus. Research staff followed a trial specific photography protocol to ensure standardisation of procedures and image quality. Training was given in simple photography tips relating to angles, lighting and exposure, although left to user discretion regarding flash and distance from wound. Ward staff were asked to remove wound dressings before photography and place a 15-cm disposable paper ruler, with date and trial identification number, adjacent to the wound for scaling. All images were password-protected and returned electronically to the central trial office. No maximum limit on the number of images per wound was applied. Images were held centrally and an independent assessment was undertaken on completion of participant follow-up. Participant informed consent was obtained for collection and storage of digital images.

Photographic image assessment

Image reviews were undertaken using high-definition computer monitors with a pixel density of 1920 x 1080 pixels (aspect ratio 16:9). Four assessors appraised the wound images independently: for open fracture wounds (WOLLF), a tissue viability nurse (TVN) with 17 years' experience (A-1) and a senior researcher with clinical background (A-2); for WHIST, two senior TVNs (B-1, B-2), each with 20 years' experience. A third clinician, consultant trauma surgeon (MC), adjudicated cases where two assessors could not reach a final decision. All assessors were blinded to treatment allocation. In a pilot phase for WOLLF to test the process of acquiring and judging images, images for the first twenty participants were assessed by the two assessors independently, then agreement checked (wound healing 18/22 (82%); infection 17/22; (77%)). We made minor adjustments to the wording on the assessment protocol. For the main trial, final decisions were made for outcomes of 'wound healed' (yes/no) and 'wound infected' (yes/no), based on wound images alone and without knowledge of any clinical, radiological or patient-reported criteria recorded at any point after randomisation. In WHIST, the image assessment protocol was adapted during piloting to allow TVNs to record other characteristics (wound discharge; skin colour around wound; wound colour; swelling; slough; wound edge separation; granulation). These items were added to inform discussion where two assessors disagreed. Final binary judgements for healing/SSI outcomes were mandatory, thus we did not accept ‘possible infection’ or ‘unsure’ classifications.

Statistical analysis

We used an algorithm combining individual criterion to generate CDC-SSI definitions.[2,3] Outcome data by intervention arm have been reported previously, with no statistically significant nor clinically important differences between intervention arms, hence for these analyses, we report SSI rates for trial cohorts. Agreement between assessors for infected/not infected and healed/non-healed, was cross-tabulated and quantified using Cohen’s kappa statistic, which measures inter-rater agreement for categorical responses and percentage agreement.[15] We recorded ‘disqualified’ where it was not possible to make a judgement because of image quality. We used recommended interpretations of coefficients (<0.20 indicates slight agreement; 0.21–0.40 as fair; 0.41–0.60 as moderate; 0.61–0.80 as substantial, and 0.81–1 as almost perfect agreement).[15] Kappa values were presented along with associated bootstrapped 95% confidence intervals. We used a similar approach to compare assessment of photographically determined SSI at 30-days with CDC-defined deep SSI (WOLLF/WHIST), whereby CDC-defined SSI was considered gold standard. For superficial SSIs, in WOLLF we used two approaches, examining agreement with photographs with the CDC definition but also using a stricter definition of prescribed antibiotics only for suspected wound infection. In WHIST, we compared agreement with photographs against the stricter definition of antibiotics prescribed only. Statistical analysis was performed using R and Stata® 15.0 (StataCorp, College Station, TX, USA).

Results

A high number of digital images were captured, with useable images obtained for 355/460 (77%)[16] and 1123/1548 (73%)[17] of trial participants, respectively. A total of 1515 images were available for 355 participants with open fracture repair (mean 4.3 images per participant), and 2213 for 1123 participants with closed incisional fracture surgery (mean 2.0 per participant).

Rates of deep CDC-SSI at 30-days after lower limb fracture surgery

Rate of deep CDC-SSI, determined clinically, at 30-days after open fracture repair in WOLLF was 7.6% (35/460) and after open and closed incisional repair (WHIST), deep SSI rate was 6.3% (95/1519) at 30-days.

Agreement between CDC-deep SSI and photographic-SSI at 30-days

For open lower limb fractures that were not primarily closed (WOLFF), there was evidence of fair agreement between CDC-deep SSI and photographic-determined SSI at 30-days (*k*=0.27; 95% 0.14 to 0.42) (Table 1). For primary closed incisional wounds (WHIST), there was evidence of fair agreement between CDC deep SSI and photographic SSI at 30-days (*k*=0.29; 95% CI 0.20 to 0.37). Final SSI rates for closed incisional wounds from photographs only were 12.5% (138/1108), double that of CDC-determined SSI (6.3%) (Table 1).

Inter-rater reliability of image assessment at 30-days

For open lower limb fractures that were not primarily closed (WOLLF), there was substantial agreement between assessors appraising the photographs for the outcome 'wound infected' (*k*=0.63, bootstrapped 95% CI 0.52 to 0.72) (Table 2). Agreement was higher between assessors for 'wound healed' (*k*=0.80; bootstrapped 95% CI 0.73 to 0.86). Less than half (43%) of these surgical wounds were considered healed by one month postoperatively (Table 2).

For surgical wounds primarily closed (WHIST), there was evidence of substantial agreement between assessors for wound infection (*k*=0.61, bootstrapped 95% CI 0.54 to 0.69) and moderate agreement for outcomes of wound healing (*k*=0.57, bootstrapped 95% CI 0.50 to 0.64) (Table 2). Almost 80% of wounds were independently appraised by assessors as healed at 30 days to six weeks postoperatively (Table 2). In WHIST, assessors agreed that 85% of closed incisional wounds were considered healed by 30 days to six weeks (949/1113; 85.3%). Of the 1223 participant images, 16 (1.4%) were not assessed for SSI and 12 (1.1%) not assessed for wound healing due to poor image quality (disqualified).

Agreement between wound healing outcomes

We found fair agreement between photographically-determined wound healing and assessment by the clinical researcher (82%; *k*=0.34; 95% CI 0.26, 0.41) and when compared with patient self-assessment of their own wounds (80%; *k* =0.26; 95% CI 0.19, 0.34; Table 3).

Agreement between superficial SSI and photographic-SSI at 30 days

For open lower limb fractures that were not primarily closed (WOLLF), there was only slight agreement between CDC-superficial SSI and photographic-determined SSI (*k*=0.11; bootstrapped 95% CI -0.01 to 0.23) but this improved using the stricter non-CDC definition of antibiotics prescribed for suspected wound SSI (versus photographic-determined SSI at 30-days: *k*=0.26; bootstrapped 95% CI 0.13, 0.39; Table 1). For closed incisional wounds (WHIST), there was only very slight agreement between the non-CDC definition of antibiotic-treated infections superficial SSI and photographic SSI at 30-days (*k*=0.08; 95% CI 0.00 to 0.15).

Discussion

This is the first study to assess the utility of digital photography in determining SSI and wound healing after trauma surgery of the lower limb. We embedded methodological sub-studies within large RCTs to compare digital image assessment to the gold standard, clinically determined deep CDC-SSI at 30-days postoperatively, to ascertain whether images alone would yield comparable infection incidence. Although inter-rater agreement was substantial between trained experienced tissue viability nurse assessors, agreement between digital images only and CDC-SSI was fair at best. Importantly, rate of photography-determined SSI, was double that of CDC-determined SSI.

We found that rigorous blinded assessment of surgical wounds by independent assessors was feasible within the context of multicentre research studies. These are the largest trauma trials to date that have carefully examined SSI outcomes, including over 2000 trial participants, with images obtained for 75% of those recruited. Our analyses of clinical vs photography assessment on approximately 1500 patients exceeds sample sizes hitherto reported in the literature. Although feasible, data management was considerable and required administrative resource for collection of images, data cleaning and safe storage, as well as clinical input for image review. Time estimates for image assessment were 1.5 to two minutes per participant. No upper limit was applied to number of images per participant, and for WOLLF, >1500 images were received for 355 participants. Trauma patients often have extensive injuries, sustained from high energy falls, road traffic accidents, crush, or sporting injuries. Many participants had stabilizing external metalware, which presents additional challenges for photography and multiple images from different angles were required for these more complex wounds. Insertion, and duration of metalwork is an independent risk factor for deep SSI, osteomyelitis and flap failure.[18]

Some have advocated that photographic evaluation by experts represents the best available method for studying blinded evaluation of wound healing progression.[4 19] In WOLLF, agreement between assessors was better for wound healing than for SSI, possibly due to the type of injury. The ability to refer back to previous photographs to progress and inform therapeutic strategies is particularly useful for chronic ulcers and non-surgical wounds,[20] although has also been advocated for vascular surgery wounds.[21] We did not investigate serial images or wound healing over time, but whether two-dimensional (2D) images were useful to judge healing in the acute postoperative period. Evaluation of static 2D images is challenging and dependent upon image quality. Although agreement was good between assessors for healing and infection outcomes, agreement was slight to moderate at best when comparing photographs with detailed CDC-criteria. It was difficult for experienced assessors to appraise levels of oedema, exudate, and surface wound 'slough', also assessors were blind to dressings removed, wound odour and patient-reported wound pain.[22] Digital images capture a single snapshot in time and those assessed within the 30-day to six week follow-up period, without knowledge of prior clinical symptoms, may miss early infections already treated successfully within the time-period or those infections yet to be diagnosed. Interestingly, patient-reported assessment of wound healing was reasonable. We opted not to examine whether patients correctly interpreted symptoms of infection as a recent review concluded that patient self-assessment strategies overestimated SSIs.[23]

Findings in context

Interest in the use of telemedicine, mobile health (mHealth) and remote monitoring for routine clinical follow-up has proliferated, driven by the rise in smartphone ownership and accelerated by Covid-19. Studies have examined telemedicine for routine clinical follow-up after vascular[5 24], general[25] and colorectal surgery[26]. Smartphone digital image assessment was found to be comparable to in-person agreement after vascular surgery, suggesting that remote SSI diagnosis was reliable.[5] In a study of clean-contaminated vascular surgery, Totty et al[24] examined inter-rater reliability between photographic assessors and clinical assessors for ASEPSIS-symptoms at 30-days for symptoms of wound erythema (*k* 0.05–0.67), serous exudate (*k* 0.25 – 0.39), purulent exudate (*k* 0.66, 1.0) and wound edge separation (*k* 0.04-0.44). They reported high specificity (90%) for photographic review although only 2/53 patients developed SSI at 30-days, limiting evaluation of sensitivity. Others have examined whether photography, used in combination with clinical data, can enhance rather than replace diagnosis and decision-making. In a phased simulation study with abdominal surgery wounds, Sanger[7] asked 83 surgeons to firstly assess clinical symptoms, finding that after addition of photographs, confidence in SSI diagnosis improved and overall diagnostic accuracy increased slightly from 67% to 76%. Surgeons ranked skin colour around as the most important symptom. Importantly, addition of images decreased overtreatment (from 48% to 16%), reducing unnecessary antibiotic prescription.[7] A Dutch study also found that, using case vignettes, adding a photograph to clinical information improved specificity and decreased the likelihood of treatment or escalation of care; although despite increasing confidence in diagnosing infection, sensitivity of SSI detection declined amongst surgeons.[6]

Hedrick[26] reported poor agreement amongst three surgeons in identifying CDC-SSI after colorectal surgery, even when supplemented with serial wound photography, with SSI diagnosis ranging from 6% to 14% in 171 patients (k=0.55). Agreement was higher using ASEPSIS, although this scale is more detailed, requires daily assessment over time and is cumbersome to complete (SSI 2% to 4%; k=0.83). Others have reported huge variability when applying different definitions to the same wounds, resulting in SSI rates ranging from 7% using ASEPSIS to 19% using CDC.[27] We used a stricter definition to examine rates of superficial SSI across both studies, using only 'antibiotics prescribed for suspected wound infection', rather than the CDC algorithm for superficial SSI incorporating clinical signs and symptoms. We minimised risk of measurement bias by applying the same algorithm for deep SSI consistently across all participants from both trials. Although research staff may still interpret symptoms differently, measurement error should be equally distributed by treatment arm. Use of remote photography, using smartphone apps, combined with telephone interview is being encouraged for screening purposes, to definitely exclude those without SSI and avoid unnecessary attendance for clinical review.[24] Technology undoubtedly has the potential to transform post-discharge surveillance of SSI, with some advocating image databanks for customised image analysis, to allow machine learning techniques and computational algorithms for SSI detection and monitoring.[28]

Strengths

Our trials employed rigorous methodology and triangulated multiple data collection methods. Given the large sample size, we are confident that surgical wounds were representative of these injuries at one month to six weeks postoperatively, despite data missingness. Clinical assessments and digital photographs were undertaken concurrently using trained research staff, blinded to treatment allocation. CDC definitions are lengthy and complex, thus staff were asked to record individual symptoms and definitions were then generated by trial statisticians, to avoid measurement error. Photography protocols and instructions for image assessment were carefully piloted before implementation. A further strength is the high SSI event rate relative to other surgical literature reporting diagnostic accuracy in surgical patients.

Weaknesses

We acknowledge data missingness, with up to a quarter of participants either refusing consent for an image to be taken or images not taken by research staff. We used a pragmatic definition of 'useable' image rather than examine detailed technical aspects relating to camera exposure settings. We did not set out to examine utility of patient-generated photographs, although a few images were returned by trial participants who were unable to travel or return for face-to-face clinical follow-up. Patient-generated images present further challenges due to image quality, an area for future research. We did not explore treatment decisions using images alone, or assess whether and how SSI diagnosis changed with knowledge of clinical symptomology. We focused on a dichotomous outcome of infection, as per surveillance data, rather than use a continuous scoring scale to generate probability of likelihood of infection (e.g. ASPESIS)[24 26]. More information on diagnostic criteria would be obtained by asking assessors to rank individual SSI symptoms, but this would be costly and time-consuming given the sample size.

Conclusion

In conclusion, we examined the level of agreement regarding the diagnosis of infection between photographic and clinical diagnosis based upon CDC criteria at 30 days after lower limb trauma surgery. Although photography-based, blinded evaluation by independent reviewers was feasible to incorporate within large-scale research studies, infection estimates were double those determined using accepted surveillance criteria. Wound photography in isolation was not sufficiently reliable to replace clinical assessment of SSI outcomes. This finding is particularly relevant for clinical trials and routine surveillance studies where postoperative infection is the primary outcome of interest.

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Table 1. Agreement between clinically determined CDC-SSI and wound photography at 30-days

WOLLF n=355		**CDC Superficial SSI, (%)**				% agreement	Kappa (95% CI)
		Uninfected	Infected	Missing	Total		
Photographs	Uninfected	255 (72)	42 (12)	0 (0)	297	76%	0.11 (-0.01, 0.23*)
	Infected	42 (12)	14 (4)	2 (0.6)	58		
	Total	297 (84)	56 (16)	2 (0.6)	355		
WOLLF n=355		**Superficial SSI (antibiotics prescribed), N (%)**				76%	0.26 (0.13, 0.39*)
		Uninfected	Infected	Missing	Total		
Photographs	Uninfected	247 (54)	38 (8)	12 (3)	297		
	Infected	32 (7)	22 (5)	4 (1)	58		
	Total	279 (79)	60 (17)	16 (5)	355		
WOLLF n=355		**CDC Deep SSI, N (%)**				83%	0.27 (0.14, 0.42*)
		Uninfected	Infected	Missing	Total		
Photographs	Uninfected	280 (79)	17 (5)	0 (0)	297		
	Infected	40 (11)	16 (5)	2 (0.6)	58		
	Total	320 (90)	33 (9)	2 (0.6)	355		
WHIST n=1052		**Superficial SSI (antibiotics prescribed), N (%)**				88%	0.08 (0.00,0.15)
		Uninfected	Infected	Missing	Total		
Photographs	Uninfected	903 (86)	93 (9)	12 (1)	1008		
	Infected	31 (3)	9 (1)	2 (0)	42		
	Disqualified	2 (0)	0 (0)	0 (0)	2		
	Total	936 (89)	102 (10)	14 (1)	1052		
WHIST n=1123		**CDC Deep SSI, N (%)**					
		Uninfected	Infected	Missing	Total		

Photographs	Uninfected	935 (83)	33 (3)	1 (0.1)	968	88%	0.29 (0.20, 0.37)
	Infected	102 (9)	36 (3)	0 (0)	138		
	Disqualified	14 (1)	2 (0.2)	0 (0)	16		
	Total	1051 (94)	71 (6.3)	1 (0.1)	1123		

*bootstrapped 95% CI. Missing photographic images: WOLLF n=105; WHIST n=425.

Table 2. Clinical assessor agreement assessors for photographically-determined infection and wound healing outcomes at 30-days

WOLLF: SSI	**Assessor A-2, N (%)**				% agreement	Kappa (95%*)
Assessor A-1	Infected	Uninfected	Disqualified	Total		
Infected	40 (12)	14 (4)	0 (0)	54	88%	0.63 (0.52, 0.72)
Uninfected	11 (3)	256 (76)	4 (1)	271		
Disqualified	4 (1)	7 (2)	2 (1)	13		
Total	55	277	6	338		
WOLLF: healing	**Assessor A-2, N (%)**				90%	0.80 (0.73, 0.86
Assessor A-1	Healed	Not healed	Disqualified	Total		
Healed	146 (43)	10 (3)	2 (1)	158		
Not healed	20 (6)	157 (46)	0 (0)	177		
Disqualified	1 (0)	2 (1)	0 (0)	3		
Total	167	169	2	338		
WHIST: SSI	**Assessor B-2, N (%)**				89%	0.61 (0.54, 0.69)
Assessor B-1	Infected	Uninfected	Disqualified	Total		
Infected	85 (8)	26 (2)	2 (0)	113		
Uninfected	63 (6)	916 (82)	19 (2)	998		
Disqualified	3 (0)	5 (0)	4 (0)	12		

Total	151	946	25	1123		
WHIST: healing	**Assessor B-2, N (%)**				87%	0.57 (0.50, 0.64)
Assessor B-1	Healed	Not healed	Disqualified	Total		
Healed	881 (78)	75 (7)	17 (2)	973		
Not healed	37 (3)	96 (9)	3 (0)	136		
Disqualified	6 (1)	4 (0)	4 (0)	14		
Total	924	175	24	1123		

Table 3. Agreement of wound healing between wound photographs and direct wound observation at 30 days by a) clinical researcher, and b) WHIST trial participants

Photographs	**Clinical opinion, N (%)**				% agreement	Kappa (95%*)
	Healed	Not healed	Missing	Total		
Healed	826 (74)	108 (10)	15 (1)	949	82%	0.34 (0.26, 0.41)
Not healed	85 (8)	76 (7)	3 (0)	164		
Missing	5 (0)	5 (0)	0 (0)	10		
Total	916	189	18	1123		
	Patient opinion, N (%)				80%	0.26 (0.19, 0.34)
Photographs	Healed	Not healed	Missing	N		
Healed	807 (72)	134 (12)	8 (1)	949		
Not healed	92 (8)	71 (6)	1 (0)	164		
Missing	6 (1)	3 (0)	1 (0)	10		
Total	905	208	10	1123		