Can pin site inflammation be detected with thermographic imaging? A cross-sectional multicenter study of patients treated with external fixators

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INTRODUCTION:

The aim of this study was to investigate whether thermography can detect different grades of inflammation around pin sites. 1) Can a maximum temperature cut-off value be established to distinguish between pin sites with a low and a high suspicion of infection based on inflammation grading? 2) Does the maximum temperature within the region of the pin site measured by thermography differ between different inflammation grades classified according to the Modified Gordon classification System (MGS)? 3) What is the correlation between the maximum temperature and the MGS score of the pin site when adjusting for the anatomical location of the pin and ambient room temperature?

METHODS:

This was an international cross-sectional multi-center study. All patients showing up at the outpatient clinic with an external ring fixator were eligible for recruitment. Patients who underwent surgery less than 14 days prior were excluded. A clinical visual grading system was used to assess all pin sites for signs of infection using the Modified Gordon classification System (MGS) on a 0-4 scale (Figure 1). MGS score was done by a surgeon and an experienced orthopedic nurse blinded to each other's score. All pin sites with inflammation were assumed to have an MGS score above 0, since MGS 0 is defined as a clean pin site with no erythema and no discharge. Only the visual appearance of pus at the pin site (MGS 4) would be a visible sign included in the MGS classification scale that clinicians consider as a certain confirmatory sign of infection. Each pin site was then examined with an infrared thermographic camera (FLIR T540, FLIR Systems AB, Sweden), and simultaneously, a digital image was captured. The maximum temperature within the region of interest (MaxTp) was used as a primary outcome measure. To evaluate the performance of thermography as a screening tool for inflammation detection, ROC-curves based on probabilities from a logistic regression were plotted. AUC values were calculated and presented with standard error and 95% CI. The Youden empirically optimal cut-off value of MaxTp, and associated sensitivity and specificity was established. The effect of pin-site location and ambient room temperature on the association was calculated using logistic regression (Poisson).

RESULTS:

Assessment of 2023 pin sites were done. Missing data were identified from 53 pins sites. For statistical analysis, data from 1970 pin sites, collected at 168 examination sessions of 83 different patients were included. The inter-rater reliability of the Modified Gordon Score estimated from 1159 pin sites assessed by two different raters was 0.79 (Cohen kappa) (Std Error 0.02, Z-value 29.08). The distribution of visual signs of infection using the MGS score was; Grade 0: n=1739 (88%), Grade 1: n=42 (2%), Grade 2: n=119 (6%), Grade 3: n=36 (2%), Grade 4: n=34 (2%). The empirically optimal temperature cut-off value was calculated to be 34,1°C (Sensitivity=65%, Specificity72%) for distinguishing between pins without (MGS=0) and pins with visual signs of inflammation (MGS>0). The empirically optimal temperature cut-off value was calculated to be 34.3°C (Sensitivity=76%, Specificity72%) for distinguishing between pins without (MGS<4) and pins with visual signs of infection (MGS=4). The crude-RR (Relative Risk) was estimated for MGS>0 and MGS=4. A 1°C increase in MaxTp increased the RR of inflammation (MGS>0) by 1.5 (95% CI: 1.3; 1.7) and RR of infection (MGS=4) by 2.0 (95% CI: 1.1; 3.7). Adjusting for anatomical location of the pin and ambient room temperature did not produce a clinically significant effect, although statistically significant ($p<0.05$).

DISCUSSION AND CONCLUSION:

Thermographic imaging could distinguish between pin sites with and without visual signs of inflammation with a sensitivity of 65% and a specificity of 72%, and between pin sites with and without visual signs of infection with a sensitivity of 76% and a specificity of 72%, For any given pin site, an increase in maximum temperature was associated with an increased risk of visual signs of inflammation or infection. In addition, we did not find that adjusting for the anatomical location, temperature of the pin site or ambient room temperature had any effect on the association.

Table 1. The Modified Gordon Pin site infection Score (MGS)

MGS Grade	Visual description
0	Clean
1	Serous drainage, no erythema *
2	Erythema, no drainage *
3	Erythema and serous drainage
4	Erythema and purulent drainage (pus)

*Grade 1-2 Erythema is judged as a clinical redness suspicious of inflammation (a continuum with signs of infection) in contrast to redness from scarring around the pin-site which is not graded as erythema. Both the Nurse/Assistant and the Surgeon need to ask/look for pins with drainage today to do the MGS score. If the pin is dry today the score is either 0 or 2.