

Computerized quantification of psoriasis lesions with colour calibration: preliminary results

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Summary

An evaluation was made of a fully automated index of psoriasis, termed Computer-assisted Area and Severity Index (CASI). This method requires taking digital photographs of the target skin area(s) with a colour reference marker, Casmatch[®]. The CASI evaluates the severity of the psoriasis from the size and redness of the lesion(s). In five patients with mild psoriasis vulgaris mainly observed on their trunk, 18 photographs of the trunk were taken every 2 weeks. Three of the five patients [Psoriasis Area and Severity Index (PASI) of 3.0, 3.6 and 10.1, respectively] were treated with oral ciclosporin 3 mg/kg/day for 4 weeks. The mean \pm SD area of lesion selected by a dermatologist was $2.3 \pm 1.3\%$ of the total skin area. This method achieved extraction performance for psoriasis of $72.1 \pm 19.4\%$ for sensitivity and $97.4 \pm 2.0\%$ for specificity. CASI correlated strongly with PASI ($r = 0.92$), but not with Skindex16[®] ($r = 0.35$). Although only erythema was evaluated, our preliminary results indicate that this method is capable of quantifying psoriasis lesions.

Introduction

The Psoriasis Area And Severity Index (PASI)¹ allows dermatologists to make a quantitative assessment of psoriasis lesions; however, the results are sometimes inconsistent and observer-dependent. Although many studies^{2–5} have been reported on this topic to overcome this issue, they have required some time-consuming manual operations or special equipment. In addition, as quantification of the disease is basically performed using colour information, colour calibration for the focused area has not been previously addressed adequately.

We report the development of a fully automatic psoriasis quantification method with colour calibration.

It requires only taking a photograph using a commonly used digital camera of the target skin areas and a colour reference marker, and therefore does not require any special devices. Note that this method currently focuses only on erythema.

Methods

Five volunteer patients with mild psoriasis vulgaris mainly on the trunk participated in this clinical trial (Table 1). Three of the five patients [patients 1–3 with Psoriasis Area and Severity Index (PASI) of 0.1, 3.0 and 3.6, respectively] were treated with oral ciclosporin 3 mg/kg/day for 4 weeks and their PASI and Skindex16[®] were determined (12 of 18 photographs). For patient 3, photographs from both sides ($3 \times 2 = 6$) were used because psoriasis was present on both the front and back of the trunk. Patients 4 and 5 were treated with ultraviolet B phototherapy.

The patients' trunks were photographed with a reference marker (Casmatch[®]; Bear Medic Corp., Chiba, Japan) (Fig. 1) on days 0, 14 and 28 during treatment

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Table 1 Summary of results.

Patient	Photo-graphs (n)	Treatment	Score	Day 0	Day 14	Day 28
1	3	Ciclosporin	PASI	10.1	5.2	2.1
			CASI	0.70	0.42	0.26
			Skindex16	30	6	13
2	3	Ciclosporin	PASI	3.0	2.0	1.5
			CASI	0.49	0.29	0.23
			Skindex16	39	18	31
3*	6 (3 + 3)	Ciclosporin	PASI	3.6	0.7	0.3
			CASI*	0.43	0.20	0.12
			Skindex16	72	21	5
4	3	Ultraviolet B	CASI	0.12	0.07	0.07
5	3	Ultraviolet B	CASI	0.55	0.41	0.25

CASI, Computer-assisted Area and Severity Index; PASI, Psoriasis Area and Severity Index. Both front and back photographs were used (total of six); *CASI was estimated by averaging front and back scores.

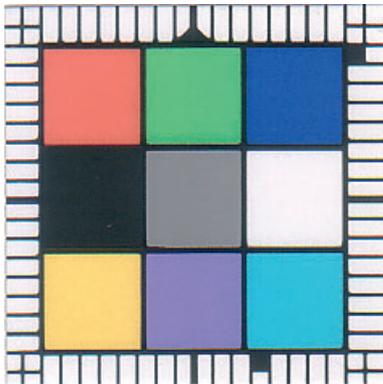


Figure 1 Casmatch® (Bear Medic Corporation, Chiba, Japan) is a stiff sticker used for colour calibration.

(total of 18 photographs). For this method, photographs should be taken with a ring flash and a dark-coloured uniform background to obtain uniform light conditions and avoid false detection.

Although Casmatch® requires manual operation for colour calibration, we developed a fully automated calibration procedure. After colour calibration was performed, the data from the skin area were automatically extracted by image-processing techniques.⁶ To extract the psoriasis lesion data, we focused on the 'a' component of the L*a*b colour system, which represents the degree of redness.⁷ Firstly, our algorithm creates a grey-scale image of the taken photograph with the 'a' component. Secondly, normal skin colour is automatically determined from the photograph and its 'a' component is subtracted from the grey-scale 'a' photograph. Finally, the area of psoriasis lesions was

determined when the subtracted 'a' value exceeded predefined threshold.

The method, which we term Computer-assisted Area and Severity Index (CASI), was defined as follows.

$$\text{CASI} = \frac{\text{sum of subtracted "a" value}}{\text{size of total focused skin area}}$$

A dermatologist selected the area of lesions for each clinical photograph by manual tracing on a tablet PC and the selected areas were used as a standard. The extraction results generated by this computer-based method were evaluated by calculating the sensitivity and specificity for all 18 images. The results of the CASI, PASI and Skindex16® were compared and the correlations between them were evaluated from the results of patients 1–3 (12 images).

Results

Fig. 2 shows samples of results. The photograph in Fig. 2d was taken 28 days after that in Fig. 2a. In these figures, the photographs on the left represent those prepared after colour calibration, and the middle sections show the area of lesions selected by the dermatologist. On the right are the lesion areas extracted by our software and their intensity (grey-white) represents the subtracted 'a' value, which corresponds to the numerator of the definition of CASI.

Based on the lesions extracted by the dermatologist, the mean \pm SD area of lesion was $2.3 \pm 1.3\%$ of the skin area. CASI achieved a sensitivity of $72.1 \pm 19.4\%$ and specificity of $97.4 \pm 2.0\%$. In the example shown in Fig. 2, the results of day 28 showed a relatively low sensitivity compared with those of days 0 and 14. The sensitivity of days 0 and 28 were $79.8 \pm 6.3\%$ and $63.9 \pm 20.6\%$, respectively.

For all three cases treated with ciclosporin, both CASI and PASI improved throughout therapy. The correlation between CASI and PASI was 0.922. Skindex16® showed a different trend and its correlation with CASI and PASI was 0.35 and 0.22, respectively. The processing time was only 1 second per image (computer with 3.0 GHz Pentium 4 processor).

Discussion

CASI estimates severity of psoriasis objectively based on the size and the intensity of redness of the lesions linearly from the photograph alone. The redder and larger the lesions are, the higher the CASI. In this study, the denominator indicates the size of the photographed

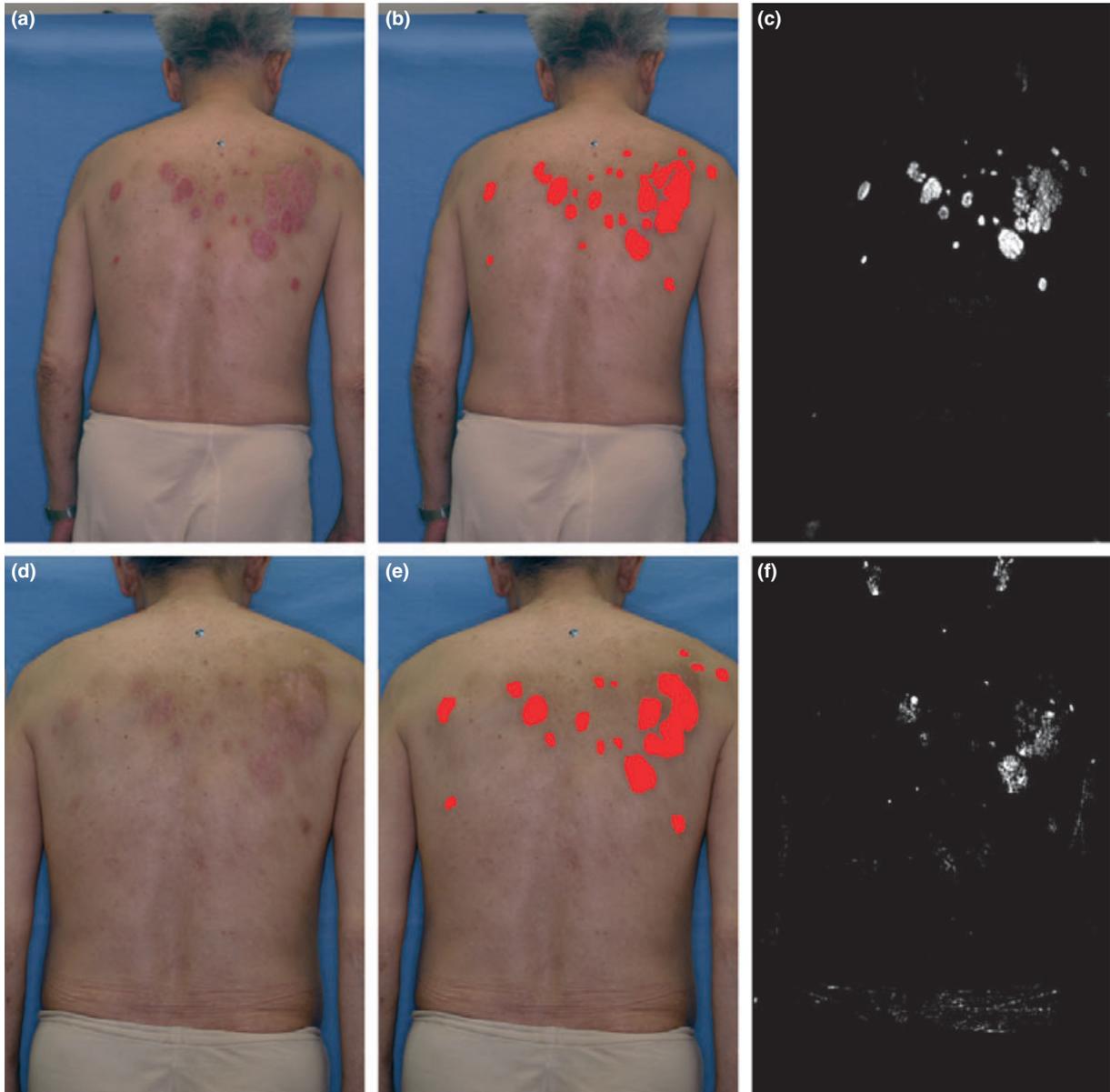


Figure 2 Example of extraction results of psoriasis (a–c) before treatment and 4 weeks later (d–f). Patient 1. (a,d) Input image; (b,c) area of lesion determined by dermatologist [PASI of (b) 10.1; (e) 2.1]; (c, f) area of lesion extracted by image analysis (CASI = 0.67). Extraction performance for psoriasis lesion: 85.4% and 44.2% sensitivity; 98.0% and 97.7% for specificity, respectively. CASI, Computer-assisted Area and Severity Index; PASI, Psoriasis Area and Severity Index.

trunk area. Because the predefined trunk area was entirely photographed in each picture and its skin size was used as the denominator, the difference of the camera-to-body distance among photographs was automatically considered. In this study, because the psoriasis area was only 1–3% of the total target skin, achieving high specificity was necessary to keep false negative areas as small as possible. When handling such cases,

the size of nonlesional red-coloured areas such as the nipples or any scratches, especially around the chest and neck, cannot be ignored. However, we believe these errors can be reduced with further consideration.

Our algorithm had a relatively low sensitivity and large SD compared with specificity. For the results of days 28, the reference included almost healed pigmented area of psoriasis lesions (Fig. 2e). Consequently,

our computer-based method did not select these pigmented areas and there was a resultant degradation in sensitivity. Observation by the naked eye considers these areas as lesions rather than healed. Correct detection even by dermatologists of area of a psoriasis lesion is sometimes difficult because the partly healed areas appear in various colours. Note that other dermatologists diagnosed these areas as nonlesional. These results emphasize the subjectivity of estimation of psoriasis area by a single dermatologist and thus this cannot be considered the gold standard method.

CASI correlated strongly with PASI ($r = 0.92$) whereas Skindex16[®] did not. This is because Skindex16[®] depends largely on how the patient feels and therefore it varies among individuals even if comparable lesions are observed.

Even though the results were based on analysis of limited data, we can conclude that the image analysis system successfully extracted the data from the area of psoriasis lesions and that CASI is capable of estimating the severity of the lesions. However, this study did not include cases with silver-white scaly lesions or those with areas of erythema much larger than areas of normal skin. This may lead to inappropriate results with the current format. We are planning to collect more clinical data, especially from patients with silver-white scales, to refine the method. However, we would recommend the use of CASI instead of PASI in the future, as it is less time-consuming and more objective.

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