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What score on the Vancouver Scar Scale constitutes a hypertrophic scar? Results from a survey of North American burn-care providers

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Abstract

Introduction—Reliable characterization of a hypertrophic scar (HTS) is integral to epidemiologic studies designed to identify clinical and genetic risk factors for HTS. The Vancouver Scar Scale (VSS) has been widely used for this purpose; however, no publication has defined what score on this scale corresponds to a clinical diagnosis of HTS.

Methods—In a survey of 1000 burn care providers, we asked respondents what VSS score indicates a HTS and asked them to score scar photos using the VSS. We used receiver-operating-characteristic (ROC) curves to evaluate VSS subscores and their combinations in diagnosis of HTS.

Results—Of 130 responses (13.5%), most were physicians (43.9%) who had worked in burn care for over 10 years (63.1%) and did not use the VSS in clinical practice (58.5%). There was no consensus as to what VSS score indicates a diagnosis of HTS. VSS height score (0–3) performed best for diagnosis of HTS; using a cut-off of ≥1, height score was 99.5% sensitive and 85.9% specific for HTS.

Conclusions—Burn clinicians do not routinely use the VSS and perceptions vary widely regarding what constitutes a HTS. When a dichotomous variable is needed, the VSS height score with a cut-off of ≥1 may be optimal. Our findings underscore the need for an objective tool to reproducibly characterize HTS across burn centers.

Keywords

Vancouver Scar Scale; hypertrophic scar; burn injury

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Introduction

Advances in the treatment of thermal injuries have reduced morbidity and mortality. However, patients who have survived burn injuries face long-term functional, psychological and aesthetic sequelae that may create barriers to recovery. Hypertrophic scarring after injury remains a significant challenge for patients with burn injuries, burn-care providers, and burn researchers. The published incidence of hypertrophic scarring after thermal injury ranges from 32–91% [1,2]. This wide range in incidence may reflect variation in perception of what constitutes a hypertrophic scar (HTS). One contributing obstacle to achieving a better estimate of the natural occurrence of excessive fibroproliferative scarring is the absence of a universally accepted scar definition both to strengthen our understanding of the data, enable multi-center trials, and build multi-center registries.

Burn scar-rating scales that objectively evaluate scar properties have been developed to track changes in scars over time. These scores can subsequently be used to evaluate risk factors for the development of HTS and to assess the effectiveness of treatment of HTS. The Vancouver Scar Scale (VSS; Table 1) was first introduced in 1990 [3] and has been validated [4–8] and extensively described in the literature [9–13]. However, publications do not address what score constitutes a diagnosis of HTS. Although raised scar height is the defining feature of HTS[14], this single criterion may not be sufficient for diagnosis in all cases. For instance, a scar that is only slightly raised but has normal pliability, vascularity, and pigmentation may not be considered to be hypertrophic, whereas another scar of the same height that is red, hyperpigmented, and firm would represent HTS. Hence, we hypothesized that using the entire VSS score would allow for greatest accuracy in diagnosing HTS and that clinicians would reach consensus in their opinions about what score on the VSS constitutes HTS. We report the results of a survey of burn-care providers designed to determine whether the widely used VSS could be used to define hypertrophic scarring in an objective, binary manner.

Methods

Survey Administration

After approval from our Institutional Review Board, we distributed an email with a link to an anonymous Catalyst survey (University of Washington, Seattle, WA; Appendix 1) to 1000 burn care providers from North America. The list was compiled by manually extracting email addresses from the member directory of the American Burn Association without regard for specialty or area of expertise; as such, recipients may have been critical care intensivists, therapists, nurses, anesthesiologists, general surgeons, plastic surgeons, or nutritionists. The individuals analyzing the data were blinded to this list of recipients. Photos did not contain identifying patient characteristics. A complete copy of the survey can be found in the Appendix.

Respondents were asked for their job title, years in burn care, and whether they use the VSS in practice. They were asked what total score on the VSS they believed constituted HTS. Five photos (Fig. 1) with varying degree of scar pigmentation, height, and vascularity were presented for evaluation. Respondents were asked to state whether the scar constituted a

HTS and then they were asked to rate the scar for each component of the VSS (Table 1). The survey was structured so that answering all questions was a requisite of survey completion. Partially completed surveys were not saved and were unavailable for review. The survey was open for approximately three months.

Analysis of Survey Data

After closing the survey, data were analyzed using Stata 13 (StataCorp, College Station, TX). Nonsensical responses, such as those identifying a VSS score that does not exist (e.g., assigning a scar a score of 5 for height) were adjusted to the closest actual VSS score. Additionally, responses were grouped by respondent characteristics for descriptive analysis. One-way analysis of variance (ANOVA) models were fit to compare responses across groups of respondents. The Student's *t*-test was used to test for difference in mean VSS scores according to response to the question, "Is this scar hypertrophic?"

In order to objectively determine the optimal VSS score to define HTS, we performed receiver-operating-characteristic (ROC) curve analysis based on survey respondents' scores of the five scar photos. By author consensus, three scars were hypertrophic (Fig. 1a, 1b, and 1d) and two were not (Fig. 1c and 1e). The survey response data were divided in half using a random-number generator in order to separate the data into "training" and "testing" sets. Using the training set, we constructed ROC curves for the individual sub-scores of the VSS as well as the following combinations of sub-scores: (1) height and pliability; and (2) height, pliability, and vascularity. Of note, these combinations did not include the pigmentation sub-score, since pigmentation is scored on a nominal rather than an ordinal scale; i.e., hyperpigmentation (2 points) is not necessarily more severe than hypopigmentation (1 point).

We compared the score combinations by measuring the area under the ROC curves (AUCs) and testing for statistical significance after Bonferroni adjustment for multiple testing. For each score or combination of scores, we determined the optimal cut point maximizing sensitivity and specificity by choosing the point that maximized Youden's index [15] defined as

$$J = \text{Sensitivity} + \text{Specificity} - 1.$$

Using the testing set, we estimated the sensitivity, specificity, and number correctly classified by each score or combination of scores (using the optimal cutpoints determined using the training set).

Results

We received 130 survey responses (13.5%) from a total of 1000 North American recipients. Forty were undeliverable via electronic mail. Although this appears to be a poor response, we anticipated a low response rate, recognizing that many members listed in the American Burn Association database may not have expertise in scar management. Only 9 recipients (0.4%) responded that they could not complete the survey because they could not assess pliability from a photograph. The majority of respondents were physicians, therapists, or registered nurses (Table 2). Most respondents had worked with burn patients for more than

10 years indicating that they represented experienced burn providers (Table 3). Less than half of respondents use the VSS in practice (54, 41.5%). There was no difference in the respondents that use the VSS in practice when grouped by role ($p = 0.11$) or length of time in burn care ($p = 0.08$). The top five reasons given for not using the VSS in practice were: "irrelevant" (15, 19.7%), "nonspecific" (14, 18.4%), "unfamiliar" (13, 17.1%), "poor inter-rater reliability" (7, 9.2%), and "time consuming" (6, 7.9%).

Responses to the question "What score on the VSS constitutes HTS?" demonstrated wide variability (Fig. 2). The mean response did not vary according to job title ($p = 0.67$), years in burn care ($p = 0.61$), or use of VSS in practice ($p = 0.37$). In accordance with the authors' consensus, the majority of respondents designated three of the five scars in the photographs as HTS (Fig. 1a, 1b, and 1d) with corresponding mean VSS scores of 8.4, 9.9, and 7.6. Two scars deemed not to be HTS by the majority of respondents (Fig. 1c and 1d) had mean VSS scores of 2.7 and 3.7 (Table 4). For scars a-c (Fig. 1), there was no difference in the mean total VSS score assigned by respondents regardless of whether or not the individual deemed the scar hypertrophic. However, for scars d and e, the mean total VSS score was significantly higher for the individuals that classified the scar as hypertrophic compared to those that did not (Table 5).

Given the lack of consensus of survey respondents, we generated ROC curves in order to determine which VSS sub-score(s) might be most reliable in diagnosing HTS (Fig. 3a). Because pigmentation is scored on a nominal rather than ordinal scale, we did not test any combinations that included pigmentation score, as the interpretability of such a score would be limited; indeed, this consideration may have contributed to the highly variable responses of the survey respondents (Fig. 2). Curves were constructed for each VSS sub-score as well as two combinations of sub-scores using half of the survey data. Based on area-under-the-curve analysis, the height score (AUC 0.97) was the best-performing individual VSS sub-score, performing significantly better than both the vascularity (AUC 0.78; $p<0.001$) and pigmentation (AUC 0.72; $p<0.001$) scores (Fig. 3b). It also had a higher AUC than the pliability score (AUC 0.95), although this difference did not reach statistical significance after correction for multiple testing ($p = 0.099$). Compared to the height score alone, combining height with pliability ($p = 0.672$) or with pliability and vascularity ($p = 1.00$) did not increase diagnostic performance. Based on maximizing the Youden index [15] a height-score threshold of ≥1 was determined to provide optimal diagnostic accuracy (Fig. 3b). Using the second half of our data as a testing set, we estimated that dichotomizing the height score as 0 or ≥1 resulted in nearly 100% sensitivity and 85.9% specificity, correctly classifying the photos in 94.2% of cases and matching or out-performing all other VSS sub-scores or combinations (Fig. 3b).

Discussion

Functional and psychological outcomes have been identified as important markers of recovery from burn injuries and may represent critical barriers to return to work or school. An important contributor to both long-term outcomes is the development of hypertrophic scarring in healed burns and donor sites. Unfortunately, progress in understanding the pathophysiology of hypertrophic scars has been limited. One barrier is the sporadic nature of the condition, which cannot be traced across generations, unlike cancers or heart disease. Creating a risk prediction model of scar outcome after burn injury using epidemiologic and genetic data depends on consensus regarding the definition of a hypertrophic scar. We recently elected to utilize the Vancouver Scar Scale in a prospective observational study of risk factors for HTS, but realized in our analysis that there is no precedence for dichotomizing scores into hypertrophic and non-hypertrophic scars. In a previous analysis we identified 7 as the median score of 300 subjects and chose to define scars with scores higher than the median as HTS [16]. In this study, we aimed to determine the optimal method to dichotomize VSS scores for diagnosis of HTS in order to promote generalization of research practices in the burn community.

In spite of multiple published VSS validations [17–19], North American burn providers do not commonly use the VSS in clinical practice due to a variety of explanations including irrelevance, non-specificity, non-familiarity, poor inter-rater reliability, and time consumption. Our results do not support our original hypothesis that burn providers who had practiced longer would demonstrate more inter-rater reliability with the VSS than those with less experience supporting the widely held view that the scoring system is subjective. Furthermore, the wide data spread, even between experienced providers, suggests that wide variation exists in perception of what VSS score constitutes HTS. Although scars that respondents labeled as hypertrophic (Fig. 1a, 1b, and 1d), received higher VSS scores and scars that were labeled as non-hypertrophic (Fig. 1c and 1e) were assigned lower VSS scores, there was no clear consensus as to a score on the VSS that would allow us to dichotomize the analysis and analyze the data as a binary outcome.

Despite a disappointing lack of consensus, our survey data allowed us objectively estimate the performance of VSS sub-scores for HTS diagnosis. In our ROC analysis, we identified the height score (with a cut-off of ≥1) as the most accurate VSS component for a photographic assessment of HTS. This intuitive result reflects the fundamental characteristic that a hypertrophic scar is raised above the level of the surrounding tissue [14], even though raised height alone is not necessarily sufficient to constitute a HTS. Although pigmentation, vascularity, and pliability are essential features of hypertrophic scars, inclusion of these additional variables in the ROC analysis did not considerably improve diagnostic accuracy (Fig. 3). Hence, our results support the use of the VSS height score alone categorized as 0 vs. ≥1 when a binary variable is needed for epidemiologic studies. Given that this conclusion is based on photographic assessment of scars, validation of our results using data based on in-person scar assessments will be necessary.

Our study had several limitations. Whereas our low response rate raises concerns about the reliability of our survey, we had anticipated that recipients would include an array of multidisciplinary providers who are likely to be involved in early management of patients with burns (e.g. intensivists, acute care nurses, etc.) and may not be familiar with evaluation of late effects of burn injury such as scar assessments. We anticipated that recipients who were unfamiliar with the VSS would not respond to the survey, contributing to the overall low response rate. We were also not surprised by respondents who reported that they were unable to adequately assess pliability or vascularity from a photograph and abstained from completing the survey. Inability to assess pliability and height from photo documents has been a frequently perceived limitation of the VSS [20,21]. In 1997, Engrav and colleagues introduced a burn scar rating scale utilizing photographs with good inter-rater reliability [22]. Whereas that scar assessment tool has the advantage that it did not require the patient to be present for scar assessment and lends itself to use in multicenter trials in which a blinded, independent investigator can rate scars, it has not been widely adapted or validated.

As Brusselaers and colleagues observed in their review of scar assessment tools, digital image capture combined with in-person scar assessment using a validated scar scale may be the most useful way to classify scarring [10]. Similarly, the Matching Assessment of Scars and Photographs (MAPS) method also describes combining in-person assessments with digital photography [21]. The Patient and Observer Scar Assessment Scale (POSAS) [23,24] includes not only the clinician assessment but also patient reported outcomes as part of the assessment. This resolves the frequently noted limitation of the VSS that it does include patient symptoms of pain or pruritus into account is as a limitation of the VSS. However, given the lack of consensus as to what scores on the POSAS constitute HTS, we are again presented with our original challenge. Other researchers have suggested that various devices to evaluate scar characteristics may be the most reliable [25]. Fearmonti and colleagues provide an excellent review of the various scar assessment tools including pneumatonometers or cutometers for pliability, durometers for firmness, colorimeters for pigment, and ultrasound for thickness [26]. Nedelec et al. evaluated the ability of the Cutometer, Mexameter, and DermaScan C to discriminate scar characteristics relative to the VSS and found them to be adequate substitutes, though the Cutometer and Mexameter have limitations in their ability to evaluate hypertrophic scar [27]. Ultimately our understanding of the contribution of hypertrophic scars to long-term burn functional and psychological outcomes will require multi-center contribution to a national burn registry as proposed in the 2013 American Burn Association Burn Quality Consensus Statements [28].

In summary, our work suggests that the VSS is not widely used by burn clinicians and that even among those that do use the scale, there is no consistency regarding what constitutes a HTS. Based on ROC analysis of scar-photo data, it seems that using the height score alone with a cut-off of ≥1 may provide good diagnostic accuracy when a dichotomous variable is needed for epidemiologic studies of HTS. However, this finding requires confirmation in clinical- (rather than photo-based) studies. Hence, this study together with multiple published analyses of available scar assessment tools underscores the dire need for a multi-center burn community effort to develop a validated scar assessment tool with excellent inter-user reliability.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- We sought to determine what Vancouver Scar Scale score indicates a hypertrophic scar.
- A survey of burn care providers showed lack of consensus.
- Height score ≥1 was highly sensitive and specific for diagnosis of hypertrophic scar.
- Better objective tools are needed for epidemiologic studies of hypertrophic scar.

Figure 1.
Scar photos that survey respondents were asked to score using the Vancouver Scar Scale.

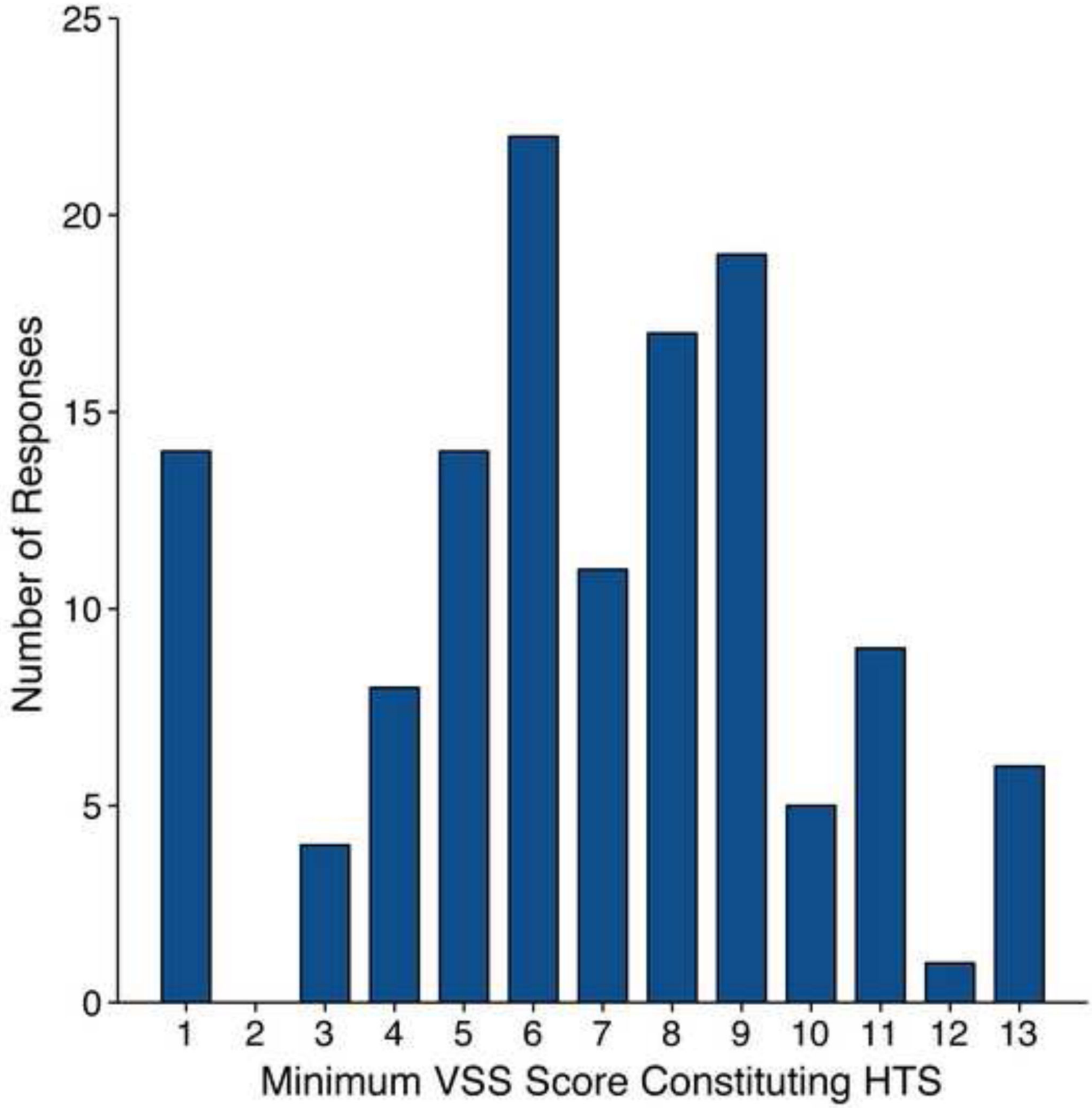
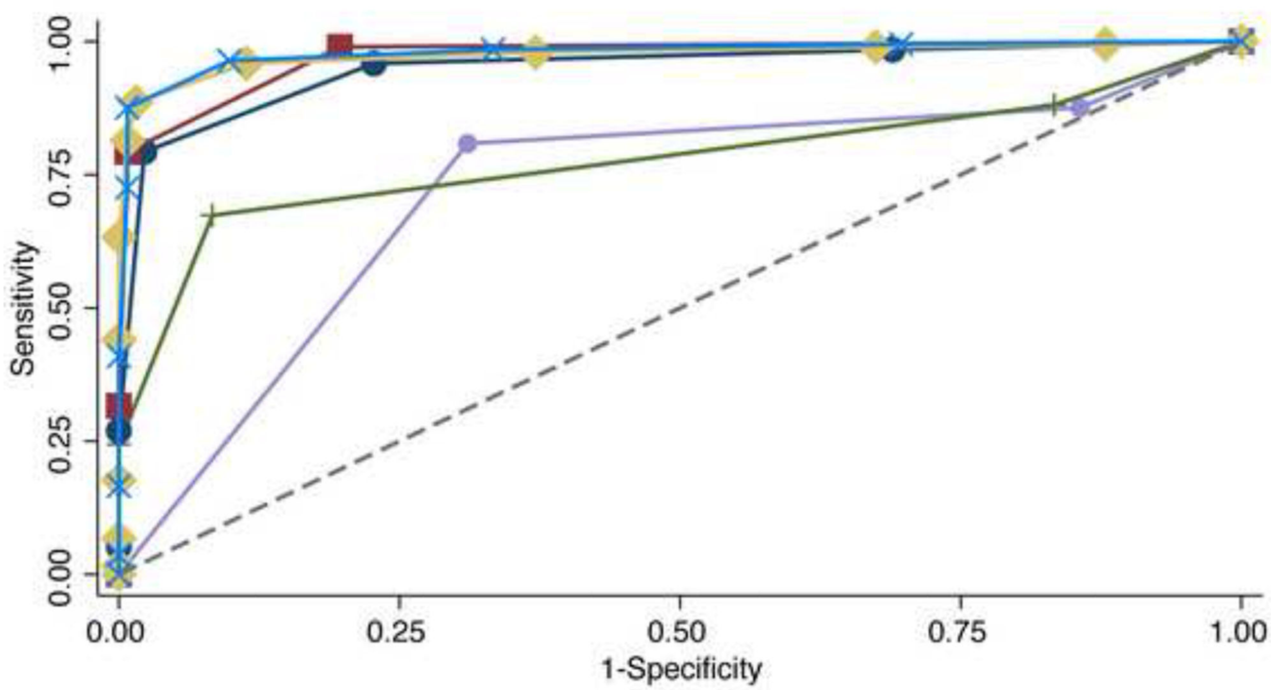


Figure 2.
Histogram of responses to the question: “What score on the Vancouver Scar Scale constitutes a hypertrophic scar?”

a



b

	Score	AUC	95% CI	*p*	Score range	Optimal cut-point	Sens.	Spec.	Correctly classified (%)
(red square)	Height (H)	0.97	0.96-0.99	Ref	0-3	≥1	99.5	85.9	94.2
(dark blue circle)	Pliability (Pli)	0.95	0.93-0.97	0.099	0-5	≥2	97.0	81.3	90.8
(green plus)	Vascularity (V)	0.78	0.73-0.83	<0.001	0-3	≥2	68.5	92.2	77.9
(purple circle)	Pigmentation (Pig)	0.72	0.68-0.77	<0.001	0-2	≥2	83.3	69.5	77.9
(blue cross)	H + Pli	0.98	0.96-0.99	0.672	0-8	≥3	97.0	90.6	94.5
(yellow diamond)	H + Pli + V	0.97	0.96-0.99	1.000	0-11	≥4	93.4	89.8	92.0

Figure 3.

Receiver-operating-characteristic (ROC) curve analysis of VSS for the diagnosis of HTS. (**a**) ROC curves for individual VSS sub-scores and combinations of sub-scores, constructed from training-set data [N = (130 respondents × 5 photos)/2 = 325 ratings]. Dashed line indicates line of no discrimination (i.e., a useless test). (**b**) Performance of each VSS sub-score/combination of scores. Using the training-set data, area under the ROC curve (AUC) was estimated for each VSS sub-score/combination and compared to that for the height score alone; *p*-values were adjusted for multiple testing. The optimal cut-off for each sub-score/combination was the point on the ROC curve that maximized Youden's index (see Methods). Sensitivity, specificity, and % correctly classified were evaluated using the testing-set data.

Table 1

The Vancouver Scar Scale

Pigmentation (0–2)	Normal	0
	Hypopigmentation	1
	Hyperpigmentation	2
Vascularity (0–3)	Normal	0
	Pink	1
	Red	2
	Purple	3
Pliability (0–5)	Normal	0
	Supple	1
	Yielding	2
	Firm	3
	Banding	4
	Contracture	5
Height (0–3)	Normal (flat)	0
	0–2 mm	1
	2–5 mm	2
	>5 mm	3

Table 2

Roles of respondents

Job Title	Count	(%)
Physician	57	(43.9)
Therapist	27	(20.8)
Registered Nurse	25	(19.2)
Nurse Practitioner	9	(6.9)
Physician Assistant	5	(3.8)
Research Nurse	5	(3.8)
Other	2	(1.5)

Table 3

Experience of respondents

Time in burn care	Count	(%)
<1 year	5	(3.8)
1–5 years	14	(10.8)
5–10 years	29	(22.3)
>10 years	82	(63.1)

Table 4

Results from assessment of scar photos

	Scar a	Scar b	Scar c	Scar d	Scar e
Is this a HTS? (% Yes)	97.7	98.5	3.8	82.3	16.2
Total VSS	8.4±1.5	9.9±1.5	2.7±1.3	7.6±2.0	3.7±1.5
Pigmentation	1.3±0.8	1.6±0.7	1.0±0.3	2.0±0.2	1.4±0.8
Pliability	3.1±0.6	3.7±0.7	0.7±0.8	2.4±0.8	1.0±0.8
Height	2.3±0.6	2.5±0.6	0.1±0.4	1.4±0.6	0.3±0.5
Vascularity	1.5±0.6	2.1±0.5	0.8±0.5	1.8±1.4	1.0±0.4

Respondents were asked to use the Vancouver Scar Scale to score the photos shown in Fig. 1. Scores are mean ± standard deviation.

Table 5

Results of Vancouver Scar Scale scoring according to response to the question, “Is this scar hypertrophic?”

Scar Photo	Yes	No	p*
a	8.4±1.5	8.7±1.5	0.78
b	9.9±1.5	11.0±1.4	0.32
c	3.4±1.7	2.6±1.2	0.18
d	7.8±1.8	6.3±2.5	<0.01
e	4.9±1.3	3.5±1.5	<0.01

Scores are mean ± standard deviation.

*Student’s *t*-test.